FM 6-40
MCRP 3-10E.4 (Formerly MCWP 3-16.4)

Tactics, Techniques, and Procedures for the Field Artillery Manual Cannon Gunnery

U.S. Marine Corps

DISTRIBUTION RESTRICTION A: Approved for public release; distribution is unlimited.

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2 May 2016

ERRATUM

to

MCWP 3-16.4

TACTICS, TECHNIQUES AND PROCEDURES FOR FIELD ARTILLERY MANUAL CANNON GUNNERY

1. Change all instances of MCWP 3-16.4, *Tactics, Techniques and Procedures for Field Artillery Manual Cannon Gunnery*, to MCRP 3-10E.4, *Tactics, Techniques and Procedures for Field Artillery Manual Cannon Gunnery*.

2. Change PCN 143 000003 00 to PCN 144 000267 00.

3. File this transmittal sheet in the front of this publication.

PCN 144 000267 80

FOREWARD

This publication may be used by the US Army and US Marine Corps forces during training, exercises, and contingency operations.

General, USA Commanding Training and Doctrine Command	Lieutenant General, USMC Commanding General Marine Corps Combat Development Command

PREFACE

This field manual (FM) explains all aspects of the cannon gunnery problem and presents a practical application of the science of ballistics. It includes step-by-step instructions for manually solving the gunnery problem and applies to units organized under tables of organization and equipment (TOE) of the L series. The material concerns nonnuclear solutions to the gunnery problem. Automated procedures are covered in ST 6-40-2, ST 6-40-31, and ST 6-50-60.

This publication is a guide for field artillery (FA) officers (commanders and fire direction officers [FDOs]), FA noncommissioned officers (NCOs), and enlisted personnel in the military occupational specialty (MOS) of cannon gunnery (MOS 13E; United States Marine Corps [USMC] MOS 0844/48).

This publication implements the following North Atlantic Treaty Organization (NATO) Standardization Agreements (STANAGs)/Quadripartite Standardization Agreements (QSTAGs):

STANAG	**QSTAG**	**TITE**
2934 (Chap 10) (Ed 1)	182 (Ed 2)	Artillery Procedures, Battlefield Illumination
2934 (Chap 6) (Ed 1)	255 (Ed 3)	Artillery Procedures, Call for Fire Procedures
2934 (Chap 7) (Ed 1)	221 (Ed 2)	Artillery Procedures, Target Numbering System (Nonnuclear)
2934 (Chap 5) (Ed 1)	246 (Ed 3)	Artillery Procedures, Radio Telephone Procedures for the Conduct of Artillery Fire
2934 (Chap 3) (Ed 1)	217 (Ed 2)	Artillery Procedures, Tactical Tasks and Responsibilities for Control of Artillery
2963 (Ed 1)	802 (Ed 1)	Coordination of Field Artillery Delivered Scatterable Mines
4119 (Ed 1)	220 (Ed 2)	Adoption of a Standard (Cannon) Artillery Firing Table Format
none	224 (Ed 2)	Manual Fire Direction Equipment, Target Classification, and Methods of Engagement for Post-1970
4425 (Ed 1)	none	Procedure to Determine the Degree of Interchangeability of NATO Indirect Fire Ammunition-APO-29

The proponent of this publication is Headquarters (I-IQ), US Army Training and Doctrine Command (TRADOC). Send comments and recommendations on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Commandant, US Army Field Artillery School (USAFAS), ATTN: ATSF-GD, Fort Sill, OK 73503-5600.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

Change
No.1

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 1 October 1999

Tactics, Techniques, and Procedures for
FIELD ARTILLERY MANUAL CANNON GUNNERY

FM 6-40/MCWP 3-16.4, April 1996, is changed as follows:

1. Change the following paragraphs or sections (changes are in bold type):

Replace Paragraph 6-1, Page 6-1 with the following:

6-1. Description

A firing chart is a graphic representation of a portion of the earth's surface used for determining distance **(or range)** and direction **(azimuth or deflection).** The chart may be constructed by using a map, a photomap, a gridsheet, or other material on which the relative locations of batteries, known points, targets, and observers can be plotted. Additional positions, fire support coordinating measures, and other data needed for the safe and accurate conduct of fire may also be recorded.

Replace Step 5, Table 6-6, Page 6-19 with the following:

5	Place a plotting pin opposite the number on the azimuth scale (**blue** numbers) on the arc of the RDP corresponding to the last three digits of the azimuth in which the arm of the RDP is oriented. The location of the pin represents a temporary index and will not be replaced with a permanent index. The value of the pin is the value of the first digit of the azimuth in which the arm of the RDP is oriented. Use the rules outlined in step 4 of Table 6-5 to determine where the pin should be placed. In Figure 6-15, the azimuth of lay is 1850, so the RDP has been oriented east (1600 mils).

Replace Figure 7-1, Page 7-1 with the following:

STANDARD CONDITIONS	
WEATHER	
1	AIR TEMPERATURE 100 PERCENT (59° F)
2	AIR DENSITY 100 PERCENT (1,225 gm/m^3)
3	NO WIND
POSITION	
1	GUN, TARGET AND MDP AT SAME ALTITUDE
2	ACCURATE RANGE
3	NO ROTATION OF THE EARTH
MATERIAL	
1	STANDARD WEAPON, PROJECTILE, AND FUZE
2	PROPELLANT TEMPERATURE (70° F)
3	LEVEL TRUNNIONS AND PRECISION SETTINGS
4	FIRING TABLE MUZZLE VELOCITY
5	NO DRIFT
LEGEND: gm/m^3 - grams per cubic meter	

Replace Table C-6, page C-18, with the following

Table C-6. Target Acquisition Method.

TLE = 0 Meters (CEP)	TLE = 75 Meters (CEP)	TLE = 150 Meters (CEP)	TLE = 250 Meters (CEP)
Forward observer with laser Target area base Photointerpretation Airborne target location	Counterbattery Radar Airborne infrared system Flash ranging Countermortar radar	Sound ranging	Forward observer w/o laser Air observer Tactical air Forward observer (non FA) Long-range patrol Side-looking airborne radar Communications intel Shell reports

2. Remove old pages and insert new pages indicated below:

REMOVE PAGES	INSERT PAGES
8-16	8-16
15-7 TO 15-25 (Including Figure 15-22 on page 15-26)	15-7 TO 15-45

3. Insert new pages as indicated below:

INSERT PAGES

13-77 to 13-82

4. File this transmittal sheet in the front of the publication for reference.

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FM 6-40
MCWP 3-16.4
1 October 1999

By Order of the Secretary of the Army:

ERIK K. SHINSEKI
General, United States Army
Chief of Staff

Official:

Joel B Hudson
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By Direction of the Commandant of the Marine Corps:

J.E. Rhodes

J. E. RHODES
Lieutenant General, US Marine Corps
Commanding General
Marine Corps Combat Development Command

DISTRIBUTION:

Active Army, Army National Guard, and U.S. Army Reserve: To be distributed in accordance with initial distribution number 110044, requirements for FM 6-40/MCWP 3-16.4.

8-15. Determination of 10-Mil Site Factor Without a High-Angle GFT

The 10-mil site factor is the value of high angle site for every 10 mils of angle of site. The 10-mil site factor can be determined manually by solving two equal equations for the 10-mil site factor.

SI = < SI + CAS (FOR LOW AND HIGH ANGLE)
SI = < SI + (| < SI | X CSF)

FOR POSITIVE ANGLES OF SITE:

HIGH ANGLE SITE = < SI (1 + CSF)

FOR NEGATIVE ANGLES OF SITE:

HIGH ANGLE SITE = < SI (1 - CSF)

USING THE HIGH ANGLE GFT:

HIGH ANGLE SITE = (< SI / 10) X 10-MIL SI FACTOR

HOW TO DETERMINE 10-MIL SI FACTOR WITHOUT A GFT:

FOR POSITIVE ANGLES OF SITE: 10-MIL SI FACTOR = 10 (1 + CSF)
FOR NEGATIVE ANGLES OF SITE: 10-MIL SI FACTOR = 10 (1 - CSF)

NOTE: If the 10-mil site factor is not listed on the high angle GFT, use the last listed value or change charges

The FDC can compute high angle site by manually determining the 10-mil site factor for those situations when a high angle GFT is not available. The 10-mil site factor from the GFT actually reflects the complementary angle of site for a positive VI. Therefore, this method will introduce a slight inaccuracy when estimating for negative VI's

13-42. Sense And Destroy Armor (SADARM M898)

The M898 SADARM projectile is a base ejecting munition carrying a payload of two target sensing submunitions. The projectile is a member of the DPICM family, and is ballistically similar to the M483A1. The technical fire direction computations are similar to those used for the ADAM projectile, in that low level wind corrections must be applied to the firing solution (because of the high Height of Burst) in order to place the payload at the optimal location over the target area.

13-43. M898 Firing Data Computations

Firing data are computed for SADARM by using the FT 155 ADD-W-0 or FT 155 ADD-W-1 in conjunction with the FT 155 AN-2. The difference between the ADD-W-0 and ADD-W-1 is the Height of Burst of the projectile. The ADD-W-1 increases the HOB to correct for changes in the operational parameters of the projectile. The ADD-W-1 is the preferred method of producing data, although the ADD-W-0 procedure may be used in lieu of the FT ADD 155-W-1 if it is unavailable. (Note: BCS Version 11 will incorporate the ADD-W-1 solution. BCS Version 10 has the incorrect HOB, and automated firings must also incorporate the change in HOB discussed in the ADD-W-0 method).

13-44. Technical Fire Direction Procedures

Technical fire direction procedures consist of four steps (following the Fire Order):

a. Determine chart data to the target location. Chart range, chart deflection, and angle "T" are recorded on the DA-4504 (Record of Fire) in the Initial Fire Commands portion of the form. AN-2 site, elevation, QE, and angle "T" are determined to this target location. **Fire commands are not determined from this data!** (See Figures 13-33 and 13-34, Sample Records of Fire for SADARM)

b. Offset aimpoint for low level winds. The HCO places a target grid over the target location from step 1. He then applies the Direction of Wind from the Meteorological Message (Extracted from Line 3) and offsets the aimpoint by the distance determined by multiplying the Wind Speed (Extracted from Line 3) times the correction factor from Table "A", Column 5, expressed to the nearest 10 meters. *This is the offset aimpoint which is used to determine firing data for SADARM.*

c. Determine AN-2 graze burst data to the corrected aimpoint. The HCO announces chart range and deflection to the corrected aimpoint from step 2. These values are recorded in the Subsequent Fire Commands portion of the DA-4504. AN-2 graze burst data are determined to this offset aimpoint, to include Fuze Setting, Deflection to fire, and Quadrant Elevation (Site and angle "T" were determined in step (a.)).

d. Determine SADARM firing data from the ADD-W-0 or ADD-W-1. If data are being determined with the ADD-W-0, use paragraph (1.) below. If data are being determined with the ADD-W-1, then use paragraph (2.) below.

(1) ADD-W-0. First determine SADARM firing data from the ADD-W-0. Then the Height of Burst correction must be applied. Table 13-33 contains the HOB corrections by charge and AN-2 Quadrant Elevation. To extract values from the table, enter with Charge on the left, and with the AN-2 graze burst Quadrant Elevation on the top. If your Quadrant Elevation is less than or equal to the QE listed in Column 2, then use the up correction in Column 2. If it is greater than the value listed in column 3 and less than 800 mils, apply the up correction from column 3. If it is greater than 800 mils, apply the up correction from column 4. The extracted up correction is used to determine the change in Quadrant Elevation (from Table "A", Column 3) and change in Fuze Setting (from Table "B", Column 3) for the change in HOB. These values are then algebraically added to the ADD-W-0 data to determine the data to fire. The FT 155 ADD-W-0 use the following formulas:

DEFLECTION TO FIRE

AIMPT CHT DF+ADD-W-0 DF CORR+GFT DF CORR+AN-2 DFT=M898 DF

FUZE SETTING TO FIRE

AN-2 FS+ADD-W-0 FS CORRECTION+HOB FS CORRECTION=M898 FS

QUADRANT ELEVATION TO FIRE

AN-2 QE+ADD-W-0 QE CORRECTION+HOB QE CORRECTION=M898 QE

Table 13-33, FT 155 ADD-W-0 HOB Corrections

Column 1	Column 2	Column 3	Column 4
CHARGE	**AN-2 QE <=**	**AN-2 QE> and <800**	**AN-2 QE >800**
3G (M3A1)	QE<=498, U200	QE>498, U200	U250
4G (M3A1)	QE<=430, U100	QE>430, U150	U250
5G (M3A1)	QE<=366, U100	QE>366, U150	U250
3W (M4A2)	QE<=434, U100	QE>434, U200	U250
4W (M4A2)	QE<=388, U150	QE>388, U150	U250
5W (M4A2)	QE<=343, U150	QE>343, U150	U250
6W (M4A2)	QE<=305, U100	QE>305, U200	U300
7W (M4A2)	QE<=251, U100	QE>251, U200	U300
7R/8W (M119/A1/A2)	QE<=205, U100	QE>205, U200	U300
8S (M203/A1)	QE<=173, U100	QE>173, U200	U300

Table 13-34 contains the specific step action drill required to compute SADARM firing data using the ADD-W-0 method.

Table 13-34. SADARM employment procedures (FT 155 ADD-W-0)

STEP	ACTION
1	The call for fire is received
2	FDO issues Fire Order
3	The computer records the target information on the Record of Fire. (Note: All fire commands are announced as they are determined)
4	The HCO plots the target location on the firing chart and determines chart range, chart deflection, and angle "T" to the target.
5	The VCO determines and announces AN-2 site to the target location.
6	The Computer determines and announces the data for the offset aimpoint by extracting the Wind Direction and Wind Speed from line 3 of the meteorological message. The Wind Direction is announced in hundreds of mils. The aimpoint shift correction is determined by multiplying the windspeed times the value from column 5, Table "A" of the Firing Table Addendum. (Note, the entry argument for the addendum is the AN-2 data determined to the target location)
7	The HCO places a target grid over the target location and applies the Wind Direction announced by the Computer in step 5. The aimpoint shift correction is applied **into the wind**. (Note: the Wind Direction from the MET MSG is the direction the wind is blowing *from*.)
8	The HCO determines and announces chart range and chart deflection to the offset aimpoint. The target grid is then reoriented to the OT direction announced by the observer, as all corrections will be based on this aimpoint. Angle "T", however, is determined to the actual target location in step 4.
9	The computer determines AN-2 data to the corrected aimpoint.
10	The computer uses the data from step 9 to determine SADARM data.
11	The computer determines the FS HOB correction necessary by dividing the HOB correction from table 13-33 by 50. This value is then multiplied times the correction factor from Table "B", Column 3 of the ADD-W-0 addendum to determine the **HOB FS CORRECTION.**
12	The computer determines fuze setting to fire. The fuze setting to fire is determined with the following formula: **AN-2 FS+ADD-W-0 FS CORR+HOB FS CORR=M898 FS**
13	The computer determines the deflection to fire. The deflection to fire is determined with the following formula: **AIMPT CHT DF+ADD-W-0 DF CORR+GFT DF CORR+AN-2 DFT=M898 DF**
14	The computer determines the QE HOB correction necessary by dividing the HOB correction from table 13-33 by 50. This value is then multiplied times the correction factor from Table "A", Column 3 of the ADD-W-0 addendum to determine the **HOB QE CORRECTION.**
15	The computer determines the Quadrant Elevation to fire. The QE to fire is determined with the following formula: **AN-2 QE+ADD-W-0 QE CORR+HOB QE CORR =M898 QE**

FDC: K36 LAST TGT # AA7201 **RECORD OF FIRE** SADARM FT 155 ADD-W-0 BTRY ALT 405

CALL FOR FIRE

Observer H42 **AF/FFE/IS/S** [✓ FFE] **Tgt**
Grid: 442 783
Polar: Dir **Dis** **U/D** **VA**
Shift **Dir** **L/R** **+/-** **U/D**
T-72 Platoon i/o, SADARM

TGT ALT 445
-BTRT ALT 405
VI +40

∡ Si ÷ 10 **10m Si**

△ FS	
100/R	23
/R	
20/R	5
HOB Corr	
Si	+ 9
El	232
QE	(241)
Ammo Exp	

FIRE ORDER ②

Df Corr

INITIAL FIRE COMMANDS [✓ **FM**] **MF** BTRY ② **Rg** 4500 **Cht Df** 3270

Sp Instr **Sh** SAD **Lot** S/G **Chg** 5 **Fz** **Ti** **Df**

MTO K, ② TGT # AA7202 **∡ T** (200) **PE_R** (< 38) **TF** (15) **In Eff**

Tgt	**Location**	**Priority ✓**	**Firing Unit**	**SUBSEQUENT FIRE COMMANDS**												
Dir, MF Sh, Fz	**Dev**	**Rg**	**HOB Corr**	**MF, Sh, Chg, Fz**	**FS Corr**	**Ti**	**Chart Df**	**Df Corr ( )**	**Df Fired**	**Chart Rg**	**HOB Corr**	**Si (+9)**	**El**	**QE**	**Exp**	**Type**
AN-2 AIMPOINT DATA						(15.3)	3260	L9	(3269)	4640		+9	241	(250)		
DRIFT (L4) + GFT (L5) =																
SADARM AIMPOINT DATA					-2.0	(13.3)		L0	(3269)				+ 129	(379)		
ADD-W-0, TBL B, COL 2						TBL A, COL 8				TBL A, COL 2						
HOB CORRECTION DATA (U100/50 =2 INC)					+0.2	13.5			3269				+32	411	⑫	SAD
ADD-W- 0 TBL B, COL 3 X INC (0.1 X 2) =									TBL A COL 3 X INC (16.1 X 2) =							
			EOM	**EOM**												

MET MSG LINE 03 19 KTS (From Met Msg) AN-2 GFT SETTING: GFT B, CHG5, LOT D/G, RG 5000, EL 264, TI 16.7 (M577)
Wind Dir 2400 Mils X 9.9 M/KT (TBL A, Col 5) GFT DF CORR L5
Wind Speed 19 Knots = 188.1~190 Meter Aimpt shift

Btry B **DTG** 241022SFEB98 **Tgt** AA7202 **Replot Grid** **Replot Alt**

Figure 13-33. Sample Record of Fire for SADARM, FT 155 ADD-W-0 Method

(2) ADD-W-1. No corrections to the Height of Burst are required. The AN-2 graze burst data are used as entry arguments into the ADD-W-1 and the corrections to DF, FS, and QE are and applied. The FT 155 ADD-W-1 use the following formulas:

FUZE SETTING TO FIRE
AN-2 FS+ADD-W-1 FS CORRECTION=M898 FS
DEFLECTION TO FIRE
AIMPT CHT DF+ADD-W-1 DF CORR+GFT DF CORR+AN-2 DFT=M898 DF
QUADRANT ELEVATION TO FIRE
AN-2 QE+ADD-W-1 QE CORRECTION=M898 QE

Table 13-35. SADARM employment procedures (FT 155 ADD-W-1)

STEP	ACTION
1	The call for fire is received
2	FDO issues Fire Order
3	The computer records the target information on the Record of Fire. (Note: All fire commands are announced as they are determined)
4	The HCO plots the target location on the firing chart and determines chart range, chart deflection, and angle "T" to the target.
5	The VCO determines and announces AN-2 site to the target location.
6	The Computer determines and announces the data for the offset aimpoint by extracting the Wind Direction and Wind Speed from line 3 of the meteorological message. The Wind Direction is announced in hundreds of mils. The aimpoint shift correction is determined by multiplying the windspeed times the value from column 5, Table "A" of the Firing Table Addendum. (Note, the entry argument for the addendum is the AN-2 data determined to the target location)
7	The HCO places a target grid over the target location and applies the Wind Direction announced by the Computer in step 5. The aimpoint shift correction is applied **into the wind**. (Remember, the Wind Direction from the Meteorological Message is the direction the wind is blowing *from*.)
8	The HCO determines and announces chart range and chart deflection to the offset aimpoint. The target grid is then reoriented to the OT direction announced by the observer, as all corrections will be based on this aimpoint. Angle "T", however, is determined to the actual target location in step 4.
9	The computer determines the FS to fire. The FS to fire is determined with the following formula: **AN-2 FS+ADD-W-1 FS CORR = M898 FS**
10	The computer determines the DF to fire. The DF to fire is determined with the following formula: **AIMPT CHT DF+ADD-W-1 DF CORR+GFT DF CORR+AN-2 DFT=M898 DF**
11	The computer determines the QE to fire. The QE to fire is determined with the following formula: **AN-2 QE+ADD-W-1 QE CORR=M898 QE**

FDC: K36 LAST TGT # AA7201 **RECORD OF FIRE** SADARM FT 155 ADD-W-1 METHOD BTRY ALT 405

CALL FOR FIRE

Observer H42 **AF/**[✓ **FFE**]**/S/S** **Tgt**

Grid: 442 783

Polar: Dir **Dis** **U/D** **VA**

Shift **Dir** **L/R** **+/-** **U/D**

T-72 Platoon i/o, SADARM

TGT ALT 445
-BTRT ALT 405
VI +40

∡ Si ÷ 10 **10m Si**

△ FS	
100/R	23
/R	
20/R	5
HOB Corr	
Si	+ 9
El	232
QE	(241)
Ammo Exp	

FIRE ORDER ②

INITIAL FIRE COMMANDS [✓ **FM**] **MF** BTRY ② **Rg** 4500

Df Corr

Cht Df 3270

Sp Instr **Sh** SAD **Lot** S/G **Chg** 5 **Fz** **Ti** **Df**

MTO K, ② TGT # AA7202 **∡ T** (200) **PE$_R$** (< 38) **TF** (15) **In Eff**

Tgt	**Location**	**Priority ✓**	**Firing Unit**	**SUBSEQUENT FIRE COMMANDS**												
Dir, MF Sh, Fz	**Dev**	**Rg**	**HOB Corr**	**MF, Sh, Chg, Fz**	**FS Corr**	**Ti**	**Chart Df**	**Df Corr ( )**	**Df Fired**	**Chart Rg**	**HOB Corr**	**Si (+9)**	**El**	**QE**	**Exp**	**Type**
AN-2 AIMPOINT DATA						(15.3)	3260	L9	(3269)	4640		+9	241	(250)		
				DRIFT (L4) + GFT (L5) =												
SADARM AIMPOINT DATA					-1.8	13.5		L0	3269				+161	411	⑫	SAD
		ADD-W-1, TBL B, COL 2				TBL A, COL 8				TBL A, COL 2						
			EOM	**EOM**												

MET MSG LINE 03 19 KTS (From Met Msg) AN-2 GFT SETTING: GFT B, CHG5, LOT D/G, RG 5000, EL 264, TI 16.7 (M577)
Wind Dir 2400 Mils X 9.9 M/KT (TBL A, Col 5) GFT DF CORR L5
Wind Speed 19 Knots = 188.1~190 Meter Aimpt shift

Btry B **DTG** 241022SFEB98 **Tgt** AA7202 **Replot Grid** **Replot Alt**

Figure 13-34. Sample Record of Fire for SADARM, FT 155 ADD-W-1 Method

Section II

Manual Computation of Safety Data

Minimum and maximum quadrant elevations, deflection limits, and minimum fuze settings must be computed to ensure that all rounds fired impact or function in the target area. These data are presented and arranged in a logical manner on a safety T. This section describes the manual computation of safety data by use of tabular and graphical equipment. As stated earlier, the range officer gives the OIC the lateral safety limits and the minimum and maximum ranges of the target areas. These data must be converted to fuze settings, deflections, and quadrants. The computations discussed in this section should be done by two safety-certified personnel working independently.

15-4. Manual Computational Procedures

Manual safety computations are accomplished in four steps, beginning with receipt of the range safety card and ultimately ending with the production of the safety T. These steps are listed in Table 15-1.

Table 15-1. Four Steps of Manual Safety Production.

STEP	ACTION
1	Receive the Range Safety Card (Produced by unit or from Range Control).
2	Construct the Safety Diagram in accordance with Table 15-2.
3	Construct and complete the computation matrix using Figure 15-3 for Low Angle Safety and Figure 15-12 for High Angle Safety.
4	Construct the Safety T and disseminate in accordance with unit SOP

NOTE: Figures 15-16 and 15-17 are reproducible safety computation forms

15-5. Safety Card

A Range Safety Card (Figure 15-1), which prescribes the hours of firing, the area where the firing will take place, the location of the firing position, limits of the target area (in accordance with AR 385-63/MCO P3570) and other pertinent data is approved by the range officer and sent to the OIC of firing. The OIC of firing gives a copy of the safety card to the position safety officer, who constructs the safety diagram based on the prescribed limits.

NOTE: The range safety card depicted in Figure 15-1 is used for all safety computation examples in this chapter.

Range Safety Card

Unit/STR **K 3/11** ScheduledDateIn **05/30/98** ScheduledDate Out **05/30/98**
TimeIn **07:00** TimeOut **23:59**

Firing Point 185 (6026 4110) HT 370.0 Impact Area S. CARLTON AREA
Weapon M198 (155) Ammunition M107, M110, M116, M825, M485, M557, M582, M732,M577

Type of Fire LOW ANGLE: HE, WP, M825, ILA, M116
Type of Fire HIGH ANGLE: HE, M825, ILA
Direction Limits: (Ref GN): Left 1340 MILS Right 1900 MILS
Low Angle PD Minimum Range 3900 METERS Min Charge 3GB
Fuze TI and High Angle Minimum Range 4000 METERS Min Charge 3GB
To Establish MIN Time for Fuze VT Apply +5.5 seconds to the Low Angle PD Min Rg
Maximum Range to Impact 6200 METERS Max Charge 4GB

COMMENTS

From AZ 1340 TO AZ 1500 MAXIMUM RANGE IS 5700

SPECIAL INSTRUCTIONS

1. SHELL ILLUMINATION (ALL CALIBERS)
   A. MAX QE WILL NOT EXCEED QE FOR MAXIMUM RANGE TO IMPACT
   B. ONE INITIAL ILLUMINATION CHECK ROUND WILL BE FIRED TO INSURE ILLUMINATION FLARE REMAINS IN IMPACT AREA
   C. IF INITIAL ILLUMINATION FLARE DOES NOT LAND IN IMPACT AREA, NO FURTHER ILLUMINATION WILL BE FIRED AT THAT DF AND QE.
   D. INSURE THAT ALL SUCCEEDING ROUNDS ARE FIRED AT A HOB SUFFICIENT TO PROVIDE COMPLETE BURNOUT BEFORE REACHING THE GROUND.
   E. FOR 155MM HOWITZER, CHARGE 7 NOT AUTHORIZED WHEN FIRING PROJ ILLUM , M485.

UNCLEARED AMMUNITION(FUZES, PROJECTILES, POWDER) WILL NOT BE USED

Figure 15-1. Example of a Range Safety Card

15-6. Basic Safety Diagram

a. The FDO, on receipt of the safety card, constructs a basic safety diagram. The basic safety diagram is a graphical portrayal of the data on the safety card or is determined from the surface danger zone (AR 385-63, Chapter 11) and need not be drawn to scale. Shown on the basic safety diagram are the minimum and maximum range lines; the left, right, and intermediate (if any) azimuth limits; the deflections corresponding to the azimuth limits; and the azimuth of lay.

b. The steps for constructing a basic safety diagram are shown in table 15-2. An example of a completed safety diagram is shown in Figure 15-2.

Table 15-2. Construction of a Basic Safety Diagram.

STEP	ACTION
1	On the top third of a sheet of paper, draw a line representing the AOL for the firing unit. Label this line with its azimuth and the common deflection for the weapon system. **NOTE**: If the AOL is not provided, use the following procedures to determine it: Subtract the maximum left azimuth limit from the maximum right azimuth limit. Divide this value by two, add the result to the maximum left azimuth limit, and express the result to the nearest 100 mils. Expressing to the nearest 100 mils makes it easier for the aiming circle operator to lay the howitzers.
2	Draw lines representing the lateral limits in proper relation to the AOL. Label these lines with the corresponding azimuth from the range safety card.
3	Draw lines between these lateral limits to represent the minimum and maximum ranges. Label these lines with the corresponding ranges from the range safety card. These are the *Diagram Ranges.* **NOTE:** If the minimum range for fuze time is different from the minimum range, draw a dashed line between the lateral limits to represent the minimum range for fuze time. Label this line with the corresponding range from the range safety card. This is the minimum time *Diagram Range.*
4	Compute the angular measurements from the AOL to each lateral limit. On the diagram, draw arrows indicating the angular measurements and label them.
5	Apply the angular measurements to the deflection corresponding to the AOL (Common Deflection) and record the result. This will be added to the *Drift* and GFT Deflection Correction determined in the Safety Matrices to produce the *Deflection Limits* on the Safety T. **(Note: If no GFT Deflection Correction has been determined, then the Deflection Limits = Drift + Diagram Deflection. If a GFT setting has been determined, then the Deflection Limits = Drift + GFT Deflection Correction + Diagram Deflection).** Drift is applied to the Basic Safety Diagram by following the "least left, most right" rule. The lowest (least) drift is applied to all left deflection limits, and the highest (greatest) drift is applied to all right deflection limits.
6	Label the diagram with the following information from the range safety card: firing point location (grid and altitude), charge, shell, fuze, angle of fire, and azimuth of lay.

c. When the basic safety diagram is complete, it will be constructed to scale, in red, on the firing chart. Plot the firing point location as listed on the range safety card. Using temporary azimuth indexes, an RDP, and a red pencil to draw the outline of the basic safety diagram. To do this, first draw the azimuth limits to include doglegs. Then, by holding the red pencil firmly against the RDP at the appropriate ranges, connect the azimuth lines.

d. Only after drawing the basic safety diagram on the firing chart may the base piece location be plotted and deflection indexes be constructed. Should the diagram be drawn from the base piece location, it would be invalid unless the base piece was located over the firing point marker.

e. After the basic safety diagram has been drawn on a sheet of paper and on the firing chart, it is drawn on a map of the impact area using an RDP and a pencil. These limits must be drawn accurately, because they will be used to determine altitudes for vertical intervals. Determine the maximum altitude along the minimum range line. This is used to ensure that the quadrant fired will cause the round to clear the highest point along the minimum range line and impact (function) within the impact area. At the maximum range, select the minimum altitude to ensure that the round will not clear the lowest point along the maximum range. Once the altitudes have been selected, label the basic safety diagram with the altitudes for the given ranges.

NOTE: The rule for determining the correct altitude for safety purposes is called the **mini-max rule.** At the minimum range, select the maximum altitude; at the maximum range, select the minimum altitude. If the contour interval is in feet, use either the GST or divide feet by 3.28 to determine the altitude in meters. (Feet ÷ 3.28 = Meters) This rule applies to both manual and automated procedures.

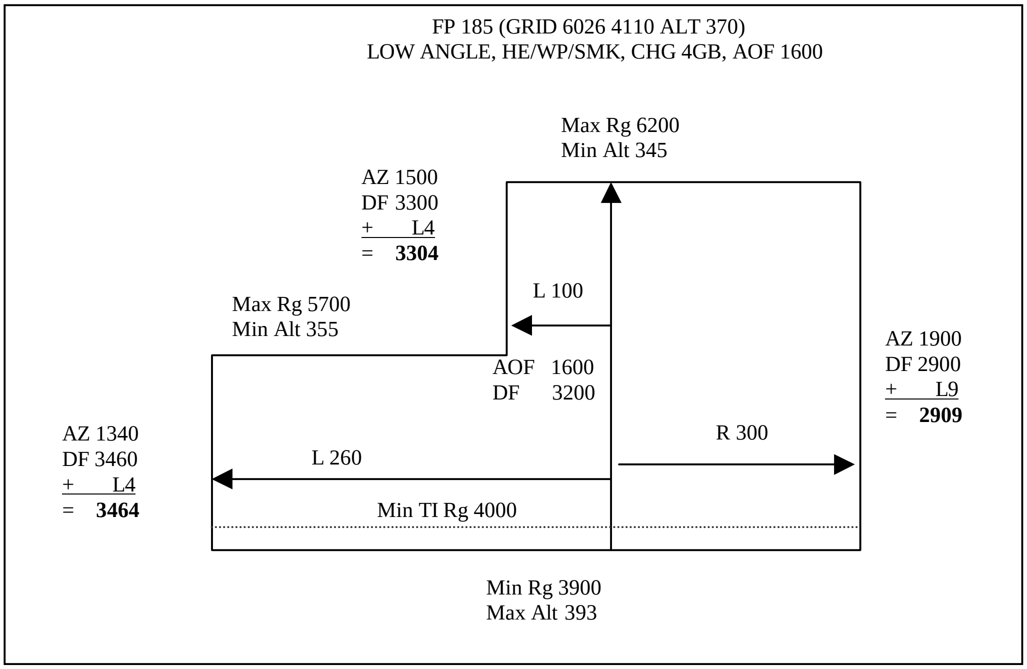


Figure 15-2. Example of a Completed Safety Diagram, HE/WP/SMK

15-7. Computation of Low Angle Safety Data

Use the steps outlined in Table 15-3 and in the matrix in Figure 15-3 as examples for organizing computations. The Low Angle Safety Matrix is used for all munitions except M712 CLGP (Copperhead). Paragraph 15-13 describes M712 safety computations. The data are determined by either graphical or tabular firing tables. In the case of expelling charge munitions, the Safety Table located in the Firing Tables or Firing Table Addendums is utilized to determine Elevation, Time of Flight, Fuze Setting, and Drift. (Note: the Safey Tables used for computing the examples in this chapter are located after the Illum and M825 Low Angle examples). **Use artillery expression for all computations except where noted.**

Table 15-3: Low Angle Procedures

STEP	ACTION
1	On the top third of a blank sheet of paper, construct the basic safety diagram
2	In the middle third of the sheet of paper, construct the Low Angle Safety Matrix
3	Record the *Diagram Ranges* from the basic safety diagram.
4	Record the *Charge* from the range safety card.

5	Enter the *Range Correction*, if required. This range correction is only necessary if a nonstandard condition exists and is not already accounted for in a GFT setting, such as correcting for the always heavier than standard White Phosphorous projectile. See figure 2, paragraph (b) to determine range correction. **If a range correction is required, it is expressed to the nearest 10 meters. If no range correction is required, enter 0 (zero).**
6	Determine the *Total Range*. Total range is the sum of the Diagram Range and the Range Correction. **Total Range is expressed to the nearest 10 meters**.
7	Enter the *Range K*. Range K is only required if a GFT setting has been obtained but cannot be applied to a GFT (i.e., determining Illumination safety with a HE GFT setting). Range K is simply the Total Range Correction from the GFT setting expressed as a percentage. This percentage, when multiplied by the Total Range, produces the Entry Range. **If no GFT setting is available (i.e., pre-occupation safety), then enter 1.0000 as the Range K. If a GFT setting is available, (i.e., post occupation safety), then enter the Range K expressed to four decimal places (i.e., 1.1234).** Step 7a demonstrates how to compute Range K.
7a	Divide Range ~ Adjusted Elevation by the Achieved Range from the GFT setting to determine Range K: $\frac{\text{Range} \sim \text{Adjusted Elevation}}{\text{Achieved Range}}$ = Range K, expressed to four decimal places.
8	Determine the *Entry Range*. Multiply the Total Range times Range K to determine the Entry Range. If Range K is 1.0000, then the Entry Range will be identical to the Total Range. **Entry Range is expressed to the nearest 10 meters**.
9	Following the Mini-Max rule, determine the *Vertical Interval* by subtracting the unit altitude from the altitude corresponding to the Diagram Range, and record it. (**Note:** Diagram Range is used for computations of VI and Site because this is the actual location of the minimum range line. VI is not computed for minimum time range lines. The Range Correction, Total Range, and Range K are used to compensate for nonstandard conditions, and represent the aimpoint which must be used to cause the round to cross the Diagram Range.) **VI is expressed to the nearest whole meter.**
10	Compute and record *Site* to the Diagram Range. Use the GST from the head of the projectile family whenever possible. **Site is expressed to the nearest whole mil.**
11	Determine the *Elevation* from Table C (base ejecting) or TFT/GFT (bursting), and record it. (Note: GFT Settings are not used to determine Elevation, as Range K represents total corrections, and to use a GFT setting would double the effects of those corrections**). Elevation is expressed to the nearest whole mil**.
12	Compute the *Quadrant Elevation* and record it. Quadrant Elevation is the sum of Elevation and Site. **Quadrant Elevation is expressed to the nearest whole mil.**
13	Determine and record the minimum fuze setting for *M564/M565* fuzes. These fuze settings correspond to the Entry Range and are extracted from Table C (base ejecting) or TFT/GFT. (**Note**: Minimum Fuze Settings are only determined for minimum range lines, and may be computed for separate minimum fuze range lines). **Fuze Settings are expressed to the nearest tenth of a fuze setting increment.**
14	Determine and record the minimum fuze setting for *M582/M577* fuzes. These fuze settings correspond to the Entry Range and are extracted from Table C (base ejecting) or TFT/GFT. (**Note**: Minimum Fuze Settings are only determined for minimum range lines, and may be computed for separate minimum fuze range lines). **Fuze Settings are expressed to the nearest tenth of a second.**
15	Determine and record the *Time of Flight* corresponding to the entry range from Table C, (base ejecting) or TFT/GFT. **Time of Flight is expressed to the nearest tenth of a second.**
16	Determine the minimum fuze setting for *M728/M732* fuzes. Add 5.5 seconds to the time of flight, and express to the next higher whole second. The VT fuze is designed to arm 3.0 seconds before the time set. They have been known to arm up to 5.5 seconds before the time set. That is why this value is added and always expressed up to the next whole second. (**Note**: Minimum Fuze Settings are only determined for

	minimum range lines, and may be computed for separate minimum fuze range lines). **VT Fuze Settings are expressed up to the next higher whole second.**
17	Determine and record *Drift* corresponding to the Entry Range from Table C (base ejecting) or TFT/GFT. Drift is applied to the Basic Safety Diagram by following the "least left, most right" rule. The lowest (least) drift is applied to all left deflection limits, and the highest (greatest) drift is applied to all right deflection limits. **Drift is expressed to the nearest whole mil.**
18	Ensure computations are verified by a second safety-certified person.
19	On the bottom third of the sheet of paper, record the data on the safety T.

(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**	**(l)**	**(m)**	**(n)**	**(o)**	**(p)**
DIAGRAM	**RG**	**TOT**	**RG**	**ENTRY**						**M564/**	**M582**			**M728/**	
RG +	**CORR =**	**RG x**	**K =**	**RG**	**CHG**	**VI**	**SI +**	**EL =**	**QE**	**M565**	**M577**	**TOF +**	**5.5 =**	**M732**	**DFT**

(a) This is the minimum or maximum range from the range safety diagram.

(b) This is the range correction for nonstandard conditions from Table F, if required. This is typically for preoccupation safety or corrections for nonstandard conditions not included in the Range K factor in column (d), such as WP [] weight. Examples of nonstandard conditions accounted for in (b) include, but are not limited to, difference in projectile square weight, difference in muzzle velocity, or any nonstandard condition accounted for prior to determining a Range K factor. If there is no change from standard, or all nonstandard conditions are accounted for in the Range K factor, this value is zero (0).

To determine a range correction from Table F, use the following formula:

NONSTANDARD STANDARD CHANGE IN RG CORR RANGE
RANGE CHG CONDITION - CONDITION = STANDARD x FACTOR = CORRECTION

(c) This is the sum of the Diagram Range and the Range Correction. If there is no range correction, then the Total Range will be the same as the Diagram Range.

(d) This is the Range K factor determined by using Technique 2, Appendix F, Page F-5 in the FM 6-40/MCWP 3-16.4. This is for post occupation safety.

It represents total corrections for a registration, MET + VE, or other subsequent MET technique. It represents all nonstandard conditions (unless a separate nonstandard condition such as change in square weight for WP is listed separately in column (b)). It is multiplied times the Total Range to determine Entry Range. If there is no Range K, enter 1.0000.

(e) This is the sum of the Total Range times the Range K factor. If there is no Range K factor, then the Entry Range will be the same as the Total Range. Entry Range is the range to which Elevation is determined.

(f) This is the charge from the range safety card for this set of safety computations.

(g) This is the Vertical Interval from the range safety diagram.

(h) This is the site determined to the Diagram Range by using the GST or TFT from the head of the projectile family; e.g., site for the M110 WP projectile is determined with the AM-2, M825 site is computed using the AN-2. Site is computed to the Diagram Range, as that is where the Vertical Intervals are determined.*

(i) This is the elevation from Table C (base ejecting), or GFT/TFT (bursting).*

(j) This is the sum of Elevation and Site. It is the minimum or maximum Quadrant Elevation corresponding to the Minimum or Maximum Range.

(k) This is the Minimum Fuze Setting for the M564/565 fuze from Table C (base ejecting), or GFT/TFT (bursting), corresponding to the Entry Range. */**

(l) This is the Minimum Fuze Setting for the M582/M577 fuze from Table C (base ejecting), or GFT/TFT (bursting), corresponding to the Entry range. */** (Note, this also applies to the M762, M767, and MOFA fuzes)

(m) This is the Time Of Flight from Table C (base ejecting), or GFT/TFT (bursting), corresponding to the Entry Range. */**

(n) This is the safety factor applied to the Time of Flight to determine VT fuze data. **

(o) This is the sum of TOF + 5.5. It is the Minimum Fuze Setting for M728/M732 VT fuzes. **

(p) This is the Drift corresponding to the Entry Range from Table C (base ejecting), or GFT/TFT (bursting). Drift is applied to the range safety diagram by using the "Least, Left; Most Right, " rule. The "least" or lowest drift is applied to all left deflection limits, and the "Most" or greatest drift is applied to all right deflection limits.

* - See Table 15-4 to determine the correct source table or addendum for computations.
** - Computed only for minimum Entry Ranges, and only if applicable to the ammunition and the range safety card.

Figure 15-3. Low Angle Safety Matrix

4[] HE/SMK (M116) LOW ANGLE CHG 4GB

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+ 5.5	=	M728/ M732	DFT
3900	+	0	=	3900	x	1.0000	=	3900	4GB	+23	+6	+	225	=	**231**	--	13.7	/	19.2	~	**20.0**	L4
4000	+	0	=	4000	x	1.0000	=	4000	4GB	--	--		--		--	--	**14.1**	--			--	--
5700	+	0	=	5700	x	1.0000	=	5700	4GB	-15	-3	+	362	=	**359**	--	--	--			--	--
6200	+	0	=	6200	x	1.0000	=	6200	4GB	-25	-5	+	408	=	**403**	--	--	--			--	L9

WP (M110, Weight Unknown) Low Angle Chg 4GB

Determining Range Correction for [] Weight Unknown Projectile

RANGE	CHG	NONSTANDARD CONDITION	-	STANDARD CONDITION	=	CHANGE IN STANDARD	x	RG CORR FACTOR	=	RANGE CORRECTION
3900	4GB	8[]	-	4[]	=	I 4[]	x	+28	=	+112 ~ +110
4000	4GB	8[]	-	4[]	=	I 4[]	x	+28	=	+112 ~ +110

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+ 5.5	=	M728/ M732	DFT
3900	+	(+110)	=	4010	x	1.0000	=	4010	4GB	+23	(+6)	+	232	=	**238**	--	--	--			--	--
4000	+	(+110)	=	4110	x	1.0000	=	4110	4GB	--	--		--		--	--	**14.6**	--			--	--

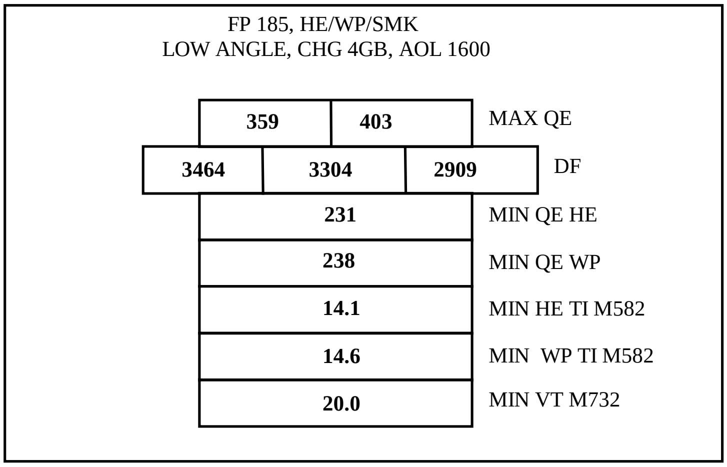
Figure 15-4. Completed Low Angle Safety Matrix, HE/WP/SMK

15-8. Safety T

a. The safety T is a convenient method of arranging safety data and is used to verify the safety of fire commands (Figure 15-5). The information needed by the FDO, XO, or platoon leader, and section chief is organized in an easy to read format. The safety T is labeled with a minimum of firing point location, charge, projectiles(s), fuze(s), angle of fire, and AOL. Other optional entries are subject to unit SOP. Any time new safety data are determined, new safety Ts are constructed and issued only after the old safety Ts have been collected (that is, after a move or after a registration or MET + VE). **Use only one charge per Safety T.** (**Note**: The examples in this demonstrate which data is transferred from the Safety Matrix to the Safety Tee. This data is in bold type in the matrix and the associated safety T).

b. It is the FDO's responsibility to ensure that all data transmitted from the FDC is within the limits of the safety T. It is the section chief's responsibility to ensure that all data applied to the ammunition or howitzer is within the limits of the safety T. The FDO must ensure that deflection to fire is between the deflections listed on the safety T. He then must determine if the quadrant elevation corresponding to that deflection is between the minimum and maximum QE on the safety T. Finally, he must ensure that the fuze setting is equal to or greater than the minimum fuze setting listed on the safety T for the specific fuze type.

NOTE: A reproducible copy of DA Form 7353-R (Universal Safety T) is included at the end of this manual, in the reproducible forms section.



FP 185, HE/WP/SMK
LOW ANGLE, CHG 4GB, AOL 1600

359 **403** MAX QE
3464 **3304** **2909** DF
231 MIN QE HE
238 MIN QE WP
14.1 MIN HE TI M582
14.6 MIN WP TI M582
20.0 MIN VT M732

Figure 15-5. Example of a Completed Safety T.

Table 15-4. Tables and Addendums required for Safety Computations

Weapon System	**Safety Required for:**	**Base Projectile**	**Firing Table for Base Projectile**	**Firing Table Addendum**
M101A1	M314	HE	105-H-7	N/A
	M444	HE	105-H-7	ADD-B-2
M102/ M119	M314	HE	105-AS-3	N/A
	M444	HE	105-AS-3	ADD-F-1
M198 or M109A3/A5/A6	M485	HE	155-AM-2	N/A
	M449	HE	155-AM-2	ADD-I-2
	M483A1	HE	155-AM-2	ADD-R-1
	M483A1	DPICM	155-AN-2	ADD-J-2
	M825	HE	155-AM-2	ADD-T-0 w/ch1
	M825	DPICM	155-AN-2	ADD-Q-O w/ch1,2
	M825A1	HE	155-AN-2	ADD-T-0 w/ch1
	M825A1	DPICM	155-AN-2	ADD-Q-0 w/ch1,2
	M692/M731	DPICM	155-AN-2	ADD-L-1 w/ch1,2
	M718/M741	DPICM	155-AN-2	ADD-N-1 w/ch1
	M898	DPICM	155-AN-2	ADD-W-0

15-9. Updating Safety Data after Determining a GFT Setting

a. After a GFT setting is determined (result of registration or MET + VE technique), the FDO must compute new safety data. The GFT setting represents all nonstandard conditions in effect at the time the GFT setting was determined (Chapter 10 and 11 discuss Total Corrections in detail). The effect on safety is that the data determined before the GFT setting was determined no longer represent the safety box, and could result in an unsafe condition if not applied to safety computations. In order to update safety, new elevations are determined which correspond to the minimum and maximum ranges. Deflections are modified by applying the GFT deflection correction to each lateral limit. Minimum fuze settings are also recomputed. The basic safety diagram drawn in red on the firing chart **does not change.** It was drawn on the basis of azimuths and ranges, and it represents the actual limits.

b. There are two techniques which can be used to update safety computations: The Range K Method and Applying a GFT setting to a GFT. Both methods use the same safety matrices, and apply to both low and high angle fire. The preferred technique for updating safety is to apply a GFT setting to the appropriate GFT. Unfortunately, not all munitions have associated GFTs. Application of Total Corrections is the same as for normal mission processing. The Total Corrections, in the form of a GFT setting or Range K, must be applied in accordance with the data on which they were determined (i.e., the GFT setting for a HE registration applies to all projectiles in the HE family, while a MET + VE for DPICM would apply to all projectiles in the DPICM family). If automation is available a false registration with M795 graze burst data may be used to determine total corrections for all projectiles in the DPICM family (see ST 6-40-2 for procedures). The principle difference between the two techniques is the manner in which minimum fuze setting is determined.

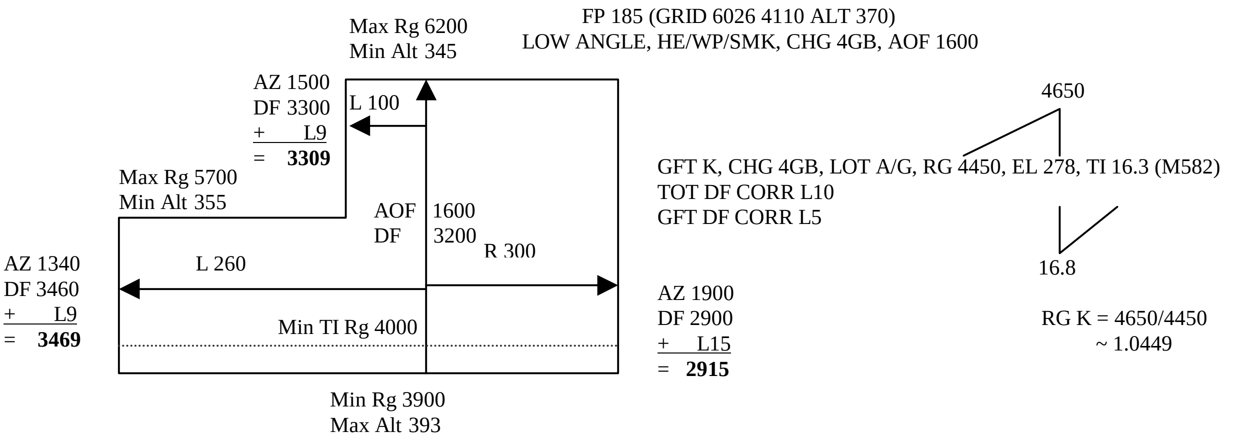
(1) Determining Minimum Fuze Setting with a GFT with a GFT Setting Applied: When a GFT setting is applied and a fuze setting is to be determined, it is extracted opposite the Time Gage Line (if it is the fuze listed on the GFT setting) or as a function of elevation (for all others). Use the procedures in Table 15-5 to update safety using a GFT with a GFT setting applied.

(2) Determining Fuze Setting using the Range K Technique: **In order to simplify updating safety, the Range K technique determines all fuze settings as a function of elevation**. The difference between registered fuze settings and fuze settings determined using the Range K technique in actual firings and computer simulations varies by only zero to two tenths (0.0 – 0.2) of a Fuze Setting Increment/Second. The safety requirements in the AR 385-63 and incorporation of Minimum Fuze Setting Range Lines adequately compensate for the difference in computational techniques. Figure 15-7 demonstrates how to update safety when no GFT is available, utilizing the Range K technique. Use the procedures in Table 15-3 (Low Angle) or Table 15-8 (High Angle) to update safety using the Range K method.

Table 15-5: Low Angle Procedures using a GFT with GFT Setting applied

STEP	ACTION
1	On the top third of a blank sheet of paper, construct the basic safety diagram in accordance with the range safety card. (See Table 15-1 for procedures)
2	In the middle third of the sheet of paper, construct the Low Angle Safety Matrix (Figure 1).
3	Record the *Diagram Ranges* from the basic safety diagram.
4	Record the *Charge* from the range safety card.
5	Enter the *Range Correction*, if required. This range correction is only necessary if a nonstandard condition exists which requires a change in aimpoint and is not already accounted for in a GFT setting, such as correcting for the always heavier than standard White Phosphorous projectile. See figure 2, paragraph (b) to determine range correction. **If a range correction is required, it is artillery expressed to the nearest 10 meters. If no range correction is required, enter 0 (zero).**

6	Determine the *Total Range*. Total range is the sum of the Diagram Range and the Range Correction. **Total Range is expressed to the nearest 10 meters**.
7	*Range K*. This is **not** used when determining data with a GFT with a GFT setting applied, as the Elevation Gage line represents Range K.
8	*Entry Range*. This value is the same as the Total Range. **Entry Range is artillery expressed to the nearest 10 meters**.
9	Following the Mini-Max rule, determine the *Vertical Interval* by subtracting the unit altitude from the altitude corresponding to the Diagram Range, and record it. (Note: Diagram Range is used for computations of VI and Site because this is the actual location of the minimum range line. VI is not determined for minimum fuze range lines. The Range Correction, Total Range, and Range K are used to compensate for nonstandard conditions, and represent the aimpoint which must be used to cause the round to cross the Diagram Range). **VI is artillery expressed to the nearest whole meter.**
10	Compute and record *Site* to the Diagram Range. Use the GST from the head of the projectile family whenever possible. **Site is artillery expressed to the nearest whole mil.**
11	Place the MHL on the Entry Range and determine the *Elevation* from the Elevation Gage Line on the GFT and record it. **Elevation is artillery expressed to the nearest whole mil**.
12	Compute the *Quadrant Elevation* and record it. Quadrant Elevation is the sum of Elevation and Site. **Quadrant Elevation is artillery expressed to the nearest whole mil.**
13	Using the procedures from Appendix G, determine and record the minimum fuze setting for *M564/M565* fuzes. These fuze settings correspond to the Entry Range. If the GFT Setting was determined using the M564/M565 fuze, then determine the fuze setting opposite the Time Gage Line. If the GFT setting was not determined using the M564/M565 fuze, then extract the fuze setting corresponding to adjusted elevation. (**Note**: Minimum Fuze Settings are only determined for minimum range lines, and may be computed for separate minimum fuze range lines). **Fuze Settings are artillery expressed to the nearest tenth of a fuze setting increment.**
14	Using the procedures from Appendix G, determine and record the minimum fuze setting for *M582/M577* fuzes. These fuze settings correspond to the Entry Range. If the GFT Setting was determined using the M582/M577 fuze, then determine the fuze setting opposite the Time Gage Line. If the GFT setting was not determined using the M582/M577 fuze, then extract the fuze setting corresponding to adjusted elevation. (**Note**: Minimum Fuze Settings are only determined for minimum range lines, and may be computed for separate minimum fuze range lines). **Fuze Settings are artillery expressed to the nearest tenth of a second.**
15	Using the procedures from Appendix G, determine and record the *Time of Flight* corresponding to the Entry Range. Extract the Time of Flight corresponding to adjusted elevation from the TOF scale. **Time of Flight is artillery expressed to the nearest tenth of a second.**
16	Using the procedures in Appendix G, determine the minimum fuze setting for *M728/M732* fuzes. Add 5.5 seconds to the time of flight, and express to the next higher whole second. (**Note**: Minimum Fuze Settings are only determined for minimum range lines, and may be computed for separate minimum fuze range lines). **VT Fuze Settings are expressed up to the next higher whole second.**
17	Determine and record *Drift* corresponding to adjusted elevation. Drift is applied to the Basic Safety Diagram by following the "least left, most right" rule. The smallest (least) drift is applied to all left deflection limits, and the greatest (most) drift is applied to all right deflection limits. **Drift is artillery expressed to the nearest whole mil.**
18	Ensure computations are verified by a second safety-certified person.
19	On the bottom third of the sheet of paper, record the data on the safety T.



FP 185 (GRID 6026 4110 ALT 370)
LOW ANGLE, HE/WP/SMK, CHG 4GB, AOF 1600

GFT K, CHG 4GB, LOT A/G, RG 4450, EL 278, TI 16.3 (M582)
TOT DF CORR L10
GFT DF CORR L5

RG K = 4650/4450
~ 1.0449

4▯ HE/SMK (M116) Low Angle Chg 4GB

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+	5.5	=	M728/ M732	DFT
3900	+	0	=	3900	x	1.0449	=	4080	4GB	+23	+6	+	238	=	**244**	--	14.5		/	20.0	~	**20.0**	L4
4000	+	0	=	4000	x	1.0449	=	4180	4GB	--	--		--		--	--	**14.8**	--				--	--
5700	+	0	=	5700	x	1.0449	=	5960	4GB	-15	-3	+	386	=	**383**	--	--	--				--	--
6200	+	0	=	6200	x	1.0449	=	6480	4GB	-25	-5	+	436	=	**431**	--	--	--				--	L10

WP (M110, Weight Unknown) LOW ANGLE CHG 4GB

Determining Range Correction for ▯ Weight Unknown Projectile

RANGE	CHG	NONSTANDARD CONDITION	-	STANDARD CONDITION	=	CHANGE IN STANDARD	x	RG CORR FACTOR	=	RANGE CORRECTION
3900	4GB	8▯	-	4▯	=	I 4▯	x	+28	=	+112 ~ +110
4000	4GB	8▯	-	4▯	=	I 4▯	x	+28	=	+112 ~ +110

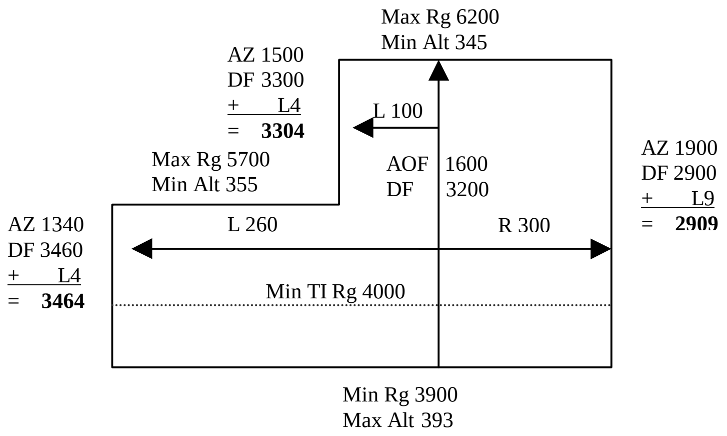
DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+	5.5	=	M728/ M732	DFT
3900	+	(+110)	=	4010	x	1.0449	=	4190	4GB	+23	(+6)	+	245	=	**251**	--	--	--				--	--
4000	+	(+110)	=	4110	x	1.0449	=	4290	4GB	--	--		--		--	--	**15.3**	--				--	--

FP 185, HE/WP/SMK LOW ANGLE, CHG 4GB, AOL 1600
GFT K, CHG 4GB, LOT A/G, RG 4450, EL 278, TI 16.3 (M582)
TOT DF CORR L10, GFT DF CORR L5

383	**431**		MAX QE
3469	**3309**	**2915**	DF
244			MIN QE HE
251			MIN QE WP
14.8			MIN HE TI (M582)
15.3			MIN WP TI (M582)
20.0			MIN VT (M732)

Figure 15-6. Post Occupation Low Angle Safety, Range K Method, HE/WP/SMK

FP 185 (GRID 6026 4110 ALT 370)
LOW ANGLE, M825, CHG 4GB, AOF 1600



M825 LOW ANGLE CHG 4GB

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+	5.5	=	M728/ M732	DFT
3900	+	0	=	3900	x	1.0000	=	3900	4GB	+23	+6	+	254	=	**260**	--	--	--				--	L4
4000	+	0	=	4000	x	1.0000	=	4000	4GB	--	--		--		--	--	**15.1**	--				--	--
5700	+	0	=	5700	x	1.0000	=	5700	4GB	-15	-3	+	423	=	**420**	--	--	--				--	--
6200	+	0	=	6200	x	1.0000	=	6200	4GB	-25	-6	+	486	=	**480**	--	--	--				--	L9

FP 185, M825
LOW ANGLE, CHG 4GB, AOL 1600

	420	**480**	MAX QE
3464	**3304**	**2909**	DF
	260		MIN QE M825
	15.1		MIN M825 TI (M577)

Figure 15-7. Example of Low Angle Safety Shell M825

Ballistic Data for Safety Computations
FT ADD-T-0 Projectile Improved Smoke M825
Projectile Family = DPICM

EXPLANATION:

These tables contain ballistic data for safety computations. They are not to be used for computation of firing data, as they do not account for submunition/payload delivery. These tables are to be used in conjunction with Chapter 15 of the FM 6-40 for safety computations only.

TABLE DATA:

The tables are arranged by charge, as follows:

CHARGE:	PAGE:
3G = Charge 3, M3A1	2
4G = Charge 4, M3A1	5
5G = Charge 5, M3A1	8
3W = Charge 3, M4A2	12
4W = Charge 4, M4A2	15
5W = Charge 5, M4A2	19
6W = Charge 6, M4A2	23
7W = Charge 7, M4A2	28
7R = Charge 7, M119A2	34

COLUMNAR DATA:

COLUMN:

1. **Range** - The distance, measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the level point.

2. **Elevation** - The angle of the gun in the vertical plane required to reach the range tabulated in column 1. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of met and material.

3. **Fuze Setting M577** - Fuze setting for a graze burst - numbers to be set on the fuze, MTSQ, M577 or ET, M762 that will produce a graze burst at the level point when firing under standard conditions. This setting will produce a graze burst at the time of flight listed in column 4.

4. **Time of Flight** - The projectile travel time, under standard conditions, from the muzzle to the level point at the range in column 1. Time of flight is used as fuze setting for fuze MTSQ M577 and fuze ET M762.

5. **Azimuth correction to compensate for Drift** - Because of the right hand twist of the tube, the drift of the projectile is to the right of the vertical plane of fire. This drift must be compensated for by a correction to the left.

Figure 15-8. Safety Table Data for M825 Example

Ballistic Data for Safety Computations
FT ADD-T-0 Projectile Improved Smoke M825
Projectile Family = DPICM

Charge 4G				
Range	Elevation	Fuze Setting	Time of Flight	Drift
m	mil	M577	sec	mil
0	0.0		0.0	0.0

3800	246.4	14.2	14.2	3.9
3900	254.3	14.6	14.6	4.0
4000	262.3	15.1	15.1	4.2
4100	270.4	15.5	15.5	4.3
4200	278.6	16.0	16.0	4.4
4300	287.0	16.4	16.4	4.6
4400	295.5	16.9	16.9	4.8
4500	304.1	17.3	17.3	4.9
4600	312.9	17.8	17.8	5.1
4700	321.8	18.3	18.3	5.2
4800	330.9	18.8	18.8	5.4
4900	340.2	19.3	19.3	5.6
5000	349.7	19.8	19.8	5.8
5100	359.4	20.3	20.3	6.0
5200	369.3	20.8	20.8	6.2
5300	379.5	21.3	21.3	6.4
5400	389.9	21.9	21.9	6.6
5500	400.5	22.4	22.4	6.8
5600	411.5	23.0	23.0	7.0
5700	422.8	23.5	23.5	7.3
5800	434.5	24.1	24.1	7.5
5900	446.5	24.7	24.7	7.8
6000	459.0	25.4	25.4	8.1
6100	472.0	26.0	26.0	8.4
6200	485.5	26.7	26.7	8.7
6300	499.7	27.3	27.3	9.0
6400	514.6	28.1	28.1	9.4
6500	530.4	28.8	28.8	9.8
6600	547.3	29.6	29.6	10.2
6700	565.4	30.5	30.5	10.7
6800	585.2	31.4	31.4	11.2
6900	607.3	32.4	32.4	11.8

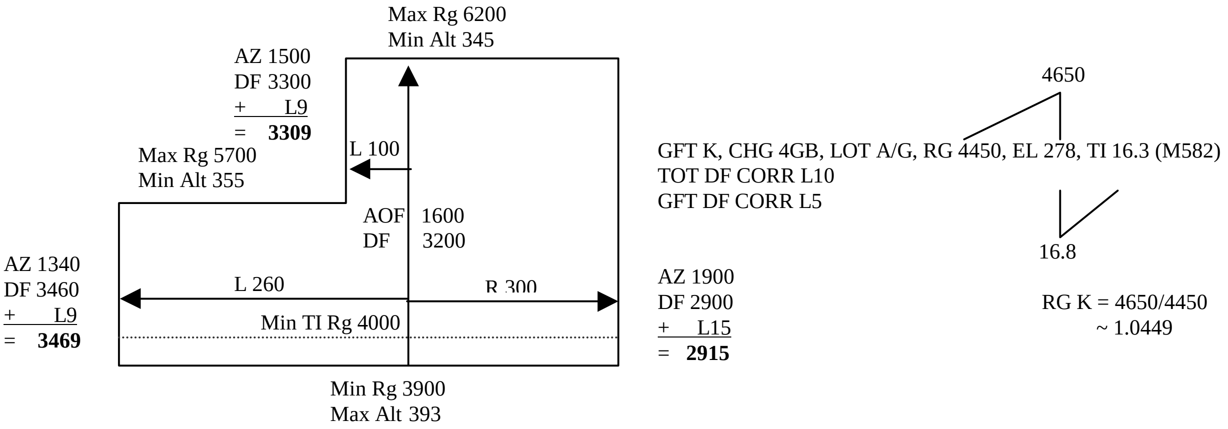
Figure 15-8. Safety Table Data for M825 Example (Cont'd)

Ballistic Data for Safety Computations
FT ADD-T-0 Projectile Improved Smoke M825
Projectile Family = DPICM

7000	632.5	33.5	33.5	12.5
7100	663.2	34.9	34.9	13.5
7200	705.5	36.7	36.7	14.9
**************	************	***************	****************	************
7200	852.1	42.4	42.4	21.0
7100	894.3	44.0	44.0	23.2
7000	924.8	45.0	45.0	25.0
6900	950.0	45.9	45.9	26.6
6800	971.9	46.6	46.6	28.2
6700	991.6	47.2	47.2	29.7
6600	1009.7	47.8	47.8	31.2
6500	1026.4	48.3	48.3	32.6
6400	1042.1	48.7	48.7	34.1
6300	1056.9	49.2	49.2	35.6
6200	1071.0	49.6	49.6	37.2
6100	1084.4	49.9	49.9	38.7
6000	1097.3	50.3	50.3	40.3
5900	1109.7	50.6	50.6	42.0
5800	1121.6	50.9	50.9	43.7
5700	1133.2	51.2	51.2	45.6
5600	1144.3	51.5	51.5	47.5
5500	1155.2	51.8	51.8	49.5
5400	1165.7	52.1	52.1	51.7
5300	1175.9	52.3	52.3	54.0
5200	1185.9	52.5	52.5	56.6
5100	1195.6	52.8	52.8	59.3
5000	1205.1	53.0	53.0	62.3
4900	1214.3	53.2	53.2	65.6
4800	1223.3	53.4	53.4	69.3
4700	1232.1	53.6	53.6	73.4
4600	1240.7	53.8	53.8	78.1
4500	1249.1	54.0	54.0	83.4
4400	1257.2	54.2	54.2	89.4
4300	1265.2	54.4	54.4	96.4
4200	1272.9	54.6	54.6	104.5
4100	1280.4	54.8	54.8	113.9
4000	1287.7	55.0	55.0	124.9
3900	1294.7	55.2	55.2	138.0
3800	1301.5	55.4	55.4	153.3
3700	1308.0	55.6	55.6	171.2
3669	1310.0			

Figure 15-8. Safety Table Data for M825 Example (Cont'd)

FP 185 (GRID 6026 4110 ALT 370)
LOW ANGLE, M825, CHG 4GB, AOF 1600



M825 LOW ANGLE CHG 4GB

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+ 5.5 =	M728/ M732	DFT
3900	+	0	=	3900	x	1.0449	=	4080	4GB	+23	+6	+	269	=	**275**	--	--	--		--	L4
4000	+	0	=	4000	x	1.0449	=	4180	4GB	--	--		--		--	--	**15.9**	--		--	--
5700	+	0	=	5700	x	1.0449	=	5960	4GB	-15	-3	+	454	=	**451**	--	--	--		--	--
6200	+	0	=	6200	x	1.0449	=	6480	4GB	-25	-6	+	527	=	**521**	--	--	--		--	L10

FP 185, M825
LOW ANGLE, CHG 4GB, AOL 1600

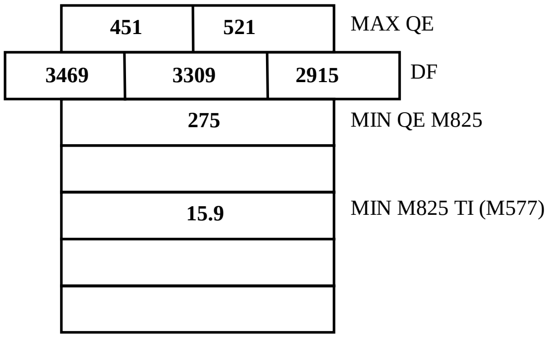
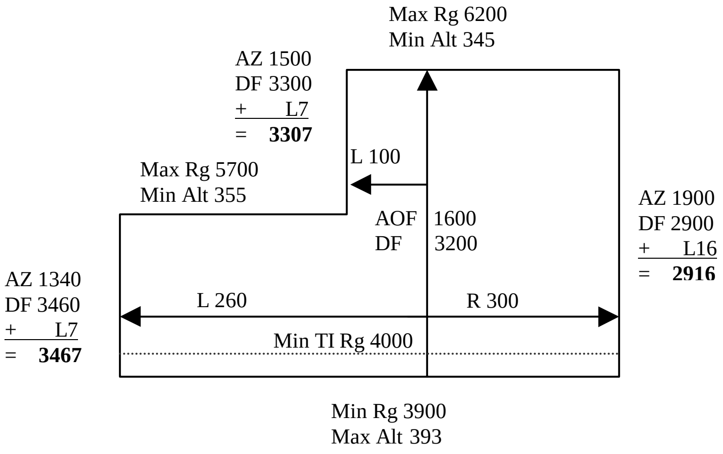


Figure 15-9. Example of Post Occupation Low Angle Safety with Range K applied, Shell M825

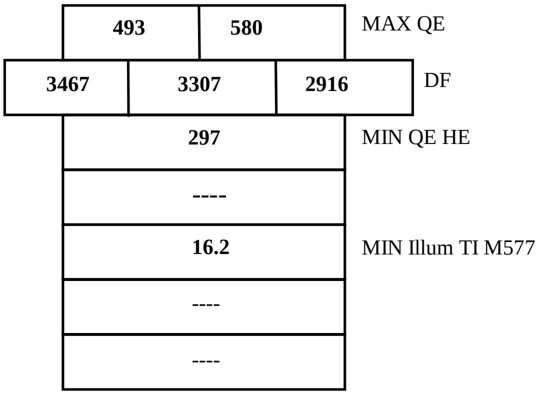
FP 185 (GRID 6026 4110 ALT 370)
LOW ANGLE, ILLUM, CHG 3GB, AOF 1600



ILLUM LOW ANGLE CHG 3GB

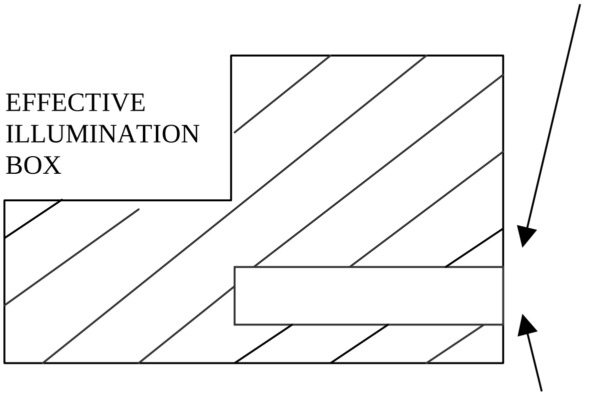
DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+	5.5	=	M728/ M732	DFT
3900	+	0	=	3900	x	1.0000	=	3900	3GB	+23	+7	+	290	=	297	--	--	--				--	L7
4000	+	0	=	4000	x	1.0000	=	4000	3GB	--	--	+	--	=	--	--	**16.2**	--				--	--
5700	+	0	=	5700	x	1.0000	=	5700	3GB	-15	-4	+	497	=	**493**	--	--	--				--	--
6200	+	0	=	6200	x	1.0000	=	6200	3GB	-25	-7	+	587	=	**580**	--	--	--				--	L16

FP 185, ILLUM
LOW ANGLE, CHG 3GB AOL 1600


493 **580** MAX QE
3467 **3307** **2916** DF
297 MIN QE HE

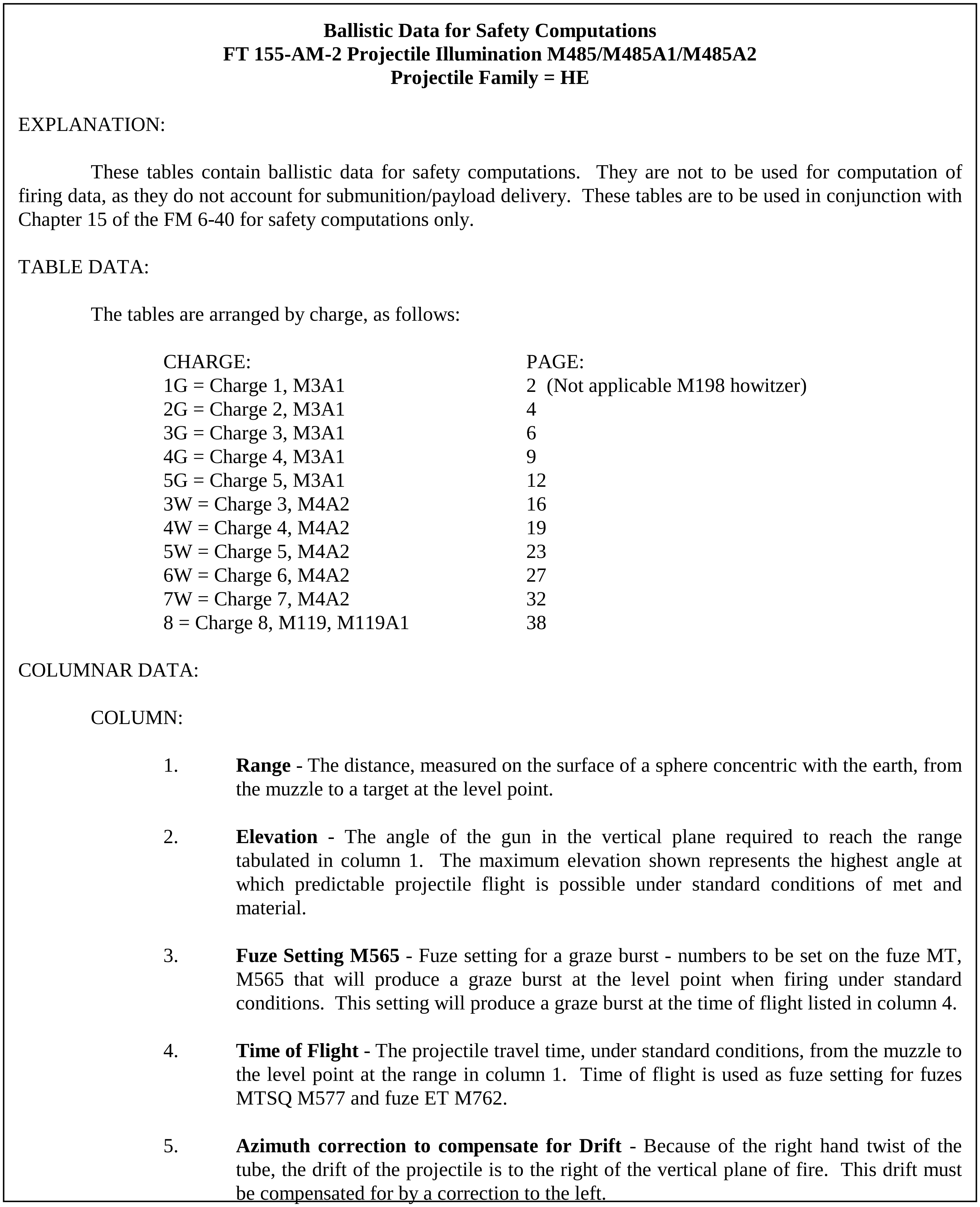
16.2 MIN Illum TI M577

Rg 4800 Col 7 (Max Rg) RTI ~ 6196



Col 3 (FS) 16.0 M565 ~ RTI 4120
Entry for Col 3 is really 16.0 after converting to M565.
FDOs Call!

Figure 15-10. Example of Low Angle Safety, Shell Illum



Ballistic Data for Safety Computations
FT 155-AM-2 Projectile Illumination M485/M485A1/M485A2
Projectile Family = HE

EXPLANATION:

These tables contain ballistic data for safety computations. They are not to be used for computation of firing data, as they do not account for submunition/payload delivery. These tables are to be used in conjunction with Chapter 15 of the FM 6-40 for safety computations only.

TABLE DATA:

The tables are arranged by charge, as follows:

CHARGE:	PAGE:
1G = Charge 1, M3A1	2 (Not applicable M198 howitzer)
2G = Charge 2, M3A1	4
3G = Charge 3, M3A1	6
4G = Charge 4, M3A1	9
5G = Charge 5, M3A1	12
3W = Charge 3, M4A2	16
4W = Charge 4, M4A2	19
5W = Charge 5, M4A2	23
6W = Charge 6, M4A2	27
7W = Charge 7, M4A2	32
8 = Charge 8, M119, M119A1	38

COLUMNAR DATA:

COLUMN:

1. **Range** - The distance, measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the level point.

2. **Elevation** - The angle of the gun in the vertical plane required to reach the range tabulated in column 1. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of met and material.

3. **Fuze Setting M565** - Fuze setting for a graze burst - numbers to be set on the fuze MT, M565 that will produce a graze burst at the level point when firing under standard conditions. This setting will produce a graze burst at the time of flight listed in column 4.

4. **Time of Flight** - The projectile travel time, under standard conditions, from the muzzle to the level point at the range in column 1. Time of flight is used as fuze setting for fuzes MTSQ M577 and fuze ET M762.

5. **Azimuth correction to compensate for Drift** - Because of the right hand twist of the tube, the drift of the projectile is to the right of the vertical plane of fire. This drift must be compensated for by a correction to the left.

Figure 15-11. Safety Table Data for M485 Illumination Example

Ballistic Data for Safety Computations
FT 155-AM-2 Projectile Illumination M485/M485A1/M485A2
Projectile Family = HE

Charge 3G				
Range	Elevation	Fuze Setting	Time of Flight	Drift
m	mil	M565	sec	mil
0	0.0		0.0	0.0
100	6.4		0.4	0.1
3800	280.9	15.1	15.2	6.5
3900	290.0	15.5	15.7	6.7
4000	299.4	16.0	16.2	7.0
4100	308.8	16.5	16.6	7.2
4200	318.5	17.0	17.1	7.5
4300	328.3	17.5	17.6	7.7
4400	338.4	18.0	18.1	8.0
4500	348.6	18.5	18.7	8.3
4600	359.1	19.0	19.2	8.6
4700	369.8	19.5	19.7	8.9
4800	380.8	20.1	20.3	9.2
4900	392.0	20.6	20.8	9.5
5000	403.6	21.2	21.4	9.8
5100	415.5	21.8	21.9	10.1
5200	427.8	22.3	22.5	10.5
5300	440.5	23.0	23.2	10.9
5400	453.7	23.6	23.8	11.3
5500	467.4	24.2	24.4	11.7
5600	481.7	24.9	25.1	12.1
5700	496.7	25.6	25.8	12.6
5800	512.4	26.3	26.5	13.1
5900	529.1	27.1	27.3	13.6
6000	547.0	27.9	28.1	14.2
6100	566.2	28.7	28.9	14.9
6200	587.3	29.6	29.9	15.6
6300	610.9	30.6	30.9	16.5
6400	638.3	31.8	32.1	17.5

Figure 15-11. Safety Table Data for M485 Illumination Example (Cont'd)

Ballistic Data for Safety Computations
FT 155-AM-2 Projectile Illumination M485/M485A1/M485A2
Projectile Family = HE

Charge 3G				
Range	Elevation	Fuze Setting	Time of Flight	Drift
m	mil	M565	sec	mil
6500	672.1	33.2	33.5	18.8
6600	722.3	35.2	35.5	21.0
*************	************	*****************	****************	************
6600	842.7	39.7	40.0	27.1
6500	892.6	41.4	41.7	30.2
6400	926.2	42.5	42.8	32.5
6300	953.2	43.4	43.7	34.5
6200	976.6	44.1	44.4	36.5
6100	997.4	44.7	45.0	38.3
6000	1016.4	45.2	45.6	40.1
5900	1033.9	45.7	46.1	42.0
5800	1050.3	46.2	46.5	43.8
5700	1065.8	46.6	47.0	45.6
5600	1080.4	47.0	47.3	47.5
5500	1094.4	47.4	47.7	49.5
5400	1107.7	47.7	48.0	51.5
5300	1120.6	48.0	48.4	53.6
5200	1132.9	48.3	48.7	55.8
5100	1144.8	48.6	48.9	58.2
5000	1156.2	48.9	49.2	60.7
4900	1167.3	49.1	49.5	63.4
4800	1178.1	49.3	49.7	66.3
4700	1188.5	49.6	49.9	69.4
4600	1198.6	49.8	50.2	72.9
4500	1208.4	50.0	50.4	76.7
4400	1217.9	50.2	50.6	81.0
4300	1227.1	50.4	50.8	85.8
4200	1236.0	50.6	51.0	91.3
4100	1244.7	50.8	51.2	97.5
4000	1253.0	51.0	51.3	104.8
3900	1261.1	51.2	51.5	113.1
3800	1268.8	51.3	51.7	123.0

Figure 15-11. Safety Table Data for M485 Illumination Example (Cont'd)

15-10. Determination of Maximum Effective Illumination Area

All illumination safety data are for graze burst. Therefore, when illumination fire mission data are computed, the QE determined includes the appropriate HOB. This will prevent achieving a 600 meter HOB (750 meter HOB for 105 mm) at the minimum and maximum range lines. Before processing illumination fire mission, it is beneficial to determine the maximum effective illumination area for the current range safety card. This area should be plotted on the firing chart to help determine if illumination can be fired and to let the Forward Observers know where they can fire illumination effectively. This area will always be significantly smaller than the HE safety area. See Table 15-6 for steps outlining the general procedure. This area can be increased by computing High Angle data.

NOTE: The procedures used to determine the Maximum Effective Illumination Area can be used to for all expelling charge munitions to depict their Maximum Effective Engagement Area.

Table 15-6. Procedures to Determine Maximum Effective Illumination Area

STEP	ACTION
1	Enter the TFT, Part 2, Column 7 (RTI) with the nearest range listed without exceeding the maximum range.
2	Determine the corresponding range to target in column 1. This is the maximum range the unit can achieve a 600 meter (155mm) HOB and keep the projectile in the safety box if the fuze fails to function.
3	Determine the minimum range for which a 600 meter (155 mm) HOB is achieved and have the fuze function no earlier than the minimum range line. Enter the TFT, Part 2, Column 3, with the nearest listed FS that is not less than the determined minimum FS. Column 3 is the Fuze Setting for the M565 Fuze, so if M577 is to be used, the fuze setting must be corrected by using Table B. Determine the corresponding range to target in Column 1.
4	The area between these two lines is the maximum effective illumination area where a 600 meter HOB (155mm) is achieved, the fuze functions no earlier than the minimum range line, and the round does not exceed the maximum range line if the fuze fails to function. **Note:** High Angle fire produces a much greater effective illumination area. The FDO must use Column 6, Range to Fuze Function, to determine the minimum effective illumination range line. The maximum effective illumination range line is determined by using fuze setting corresponding to Column 7, Range to Impact.

15-11. Safety Considerations for M549/M549A1 RAP

RAP safety data are computed using the Low Angle Safety or High Angle Safety matrix, as appropriate. The only difference is that a safety buffer must be incorporated for rocket failure or rocket cap burn through. For firing in the Rocket-Off Mode, a 6000 meter buffer must be constructed beyond the maximum range line to preclude the projectile exceeding the maximum range line. For firing in the Rocket-On Mode, a 6000 meter buffer must be constructed short of the minimum range line to preclude the projectile falling short of the minimum range line.

15-12. Safety Considerations for M864 Base Burn DPICM/M795A1 Base Burn HE

Base Burn safety data are computed using the Low Angle Safety or High Angle Safety matrix, as appropriate. The only difference is that a safety buffer must be incorporated for Base Burn Element Failure. A 5000 meter buffer must be constructed short of the minimum range line to preclude the projectile falling short of the minimum range line.

15-13. Safety Procedures for M712 Copperhead

a. Copperhead safety data are determined from ballistic data developed specifically for the Copperhead projectile. Computations are much like those for normal projectiles. The Copperhead round should never be fired with standard data. Therefore, the computation of safety data requires the solving of a Copperhead Met to Target technique for each listed range using the FT 155-AS-1, as covered in Chapter 13, Section 1. See Table 15-7 for steps to compute Copperhead safety. Surface Danger Zones (SDZs) for shell Copperhead are significantly different than normal indirect fire SDZs. AR 385-63 (MCO P3570), chapter 11, contains the SDZs for Copperhead.

b. All ranges listed on the range safety card may not fall within the ranges listed in the TFT charge selection table for that charge and mode. Therefore, additional safety computations may be required for additional charge(s) and mode(s) to adequately cover the impact area. If ranges listed on the range safety card overlap charge and mode range limitations in the charge selection table, then safety for both affected charges and modes must be computed.

Table 15-7. Copperhead Safety Data Procedures

STEP	ACTION
1	Construct the basic safety diagram.
2	For low angle, circle the lower left hand corner of the safety diagram. Proceed in a clockwise manner, and circle every other corner. For high angle, start in the lower right hand corner and circle every other corner in a clockwise manner.
3	Complete a Copperhead Met to Target technique for each circled corner. Record the FS, deflection, and QE in the safety T. The lower left hand corner will provide the minimum FS, maximum left deflection, and minimum QE. The upper right hand corner will provide the maximum right deflection and maximum QE. Intermediate deflections and ranges will provide intermediate deflection limits.

15-14. Computation of High Angle Safety

a. The safety data for high angle fire is computed in much the same manner as that for low angle fire except for the ballistic variations caused by the high trajectory. Site is computed differently (by using the 10 mil Site Factor and the Angle of Site/10), and mechanical or electronic fuze settings are not determined. (**Note**: It is the FDO's responsibility to ensure that all High Angle Fuze Settings will cause the fuze to function within the safety box). Table 15-8 contains the steps required for computation of High Angle Safety.

b. Use the steps outlined in Table 15-8 and in the matrix in Figure 15-12 as examples for organizing computations. The High Angle Safety Matrix is used for all munitions except M712

CLGP (Copperhead). The data are determined by either graphical or tabular firing tables. In the case of expelling charge munitions, the Safety Table located in the Firing Tables or Firing Table Addendums is utilized to determine Elevation, Time of Flight, Fuze Setting, and Drift. (**Note**: The Safety Tables which are used to compute the High Angle examples are located after the Low Angle Safety examples). **Use artillery expression for all computations except where noted.**

Table 15-8. High Angle Procedures

STEP	ACTION
1	On the top third of a blank sheet of paper, construct the basic safety diagram in accordance with the range safety card. (See Table 15-1 for procedures)
2	In the middle third of the sheet of paper, construct the High Angle Safety Matrix (Figure 2)
3	Record the *Diagram Ranges* from the basic safety diagram.
4	Record the *Charge* from the range safety card.
5	Enter the *Range Correction*, if required. This range correction is only necessary if a nonstandard condition exists which requires a change in aimpoint and is not already accounted for in a GFT setting, such as correcting for the always heavier than standard White Phosphorous projectile. See figure 2, paragraph (b) to determine range correction. **If a range correction is required, it is artillery expressed to the nearest 10 meters. If no range correction is required, enter 0 (zero).**
6	Determine the *Total Range*. Total range is the sum of the Diagram Range and the Range Correction. **Total Range is expressed to the nearest 10 meters**.
7	Enter the *Range K*. Range K is only required if a GFT setting has been obtained but cannot be applied to a GFT (i.e., determining Illumination safety with a HE GFT setting). Range K is simply the Total Range Correction from the GFT setting expressed as a percentage. This percentage, when multiplied by the Total Range, produces the Entry Range. **If no GFT setting is available (i.e., pre-occupation safety), then enter 1.000 as the Range K. If a GFT setting is available, (i.e., post occupation safety), then enter the Range K expressed to four decimal places (i.e., 1.1234).** Step 7a demonstrates how to compute Range K.
7a	Divide Range ~ Adjusted Elevation by the Achieved Range from the GFT setting to determine Range K: $\frac{\text{Range ~ Adjusted Elevation}}{\text{Achieved Range}}$ = Range K, expressed to four decimal places.
8	Determine the *Entry Range*. Multiply the Total Range times Range K to determine the Entry Range. If Range K is 1.0000, then the Entry Range will be identical to the Total Range. **Entry Range is artillery expressed to the nearest 10 meters**.
9	Following the Mini-Max rule, determine the *Vertical Interval* by subtracting the unit altitude from the altitude corresponding to the Diagram Range, and record it. (**Note**: Diagram Range is used for computations of VI and Site because this is the actual location of the minimum range line. The Range Correction, Total Range, and Range K are used to compensate for nonstandard conditions, and represent the aimpoint which must be used to cause the round to cross the Diagram Range). **VI is artillery expressed to the nearest whole meter.**
10	Determine and record the *Angle of Site divided by 10* to the Diagram Range. This is performed by dividing the Angle of Site (use the appropriate GST, if possible) by 10. **<SI/10 is artillery expressed to the nearest tenth of a mil, and has the same sign as the VI.**
11	Determine and record the *10 mil Site Factor* from the GFT or TFT which heads the projectile family. (Note: Remember to use the Diagram Range to compute 10 mil Si Fac). **10 mil Si Fac is artillery expressed to the nearest tenth of a mil and is always negative.**
12	Compute and record *Site*. Site is the product of <SI/10 times 10 mil Si Fac. **Site is artillery expressed to the nearest whole mil.**
13	Determine the *Elevation* from Table C (base ejecting) or TFT/GFT (bursting), and

	record it. (**Note**: GFT Settings are not used to determine Elevation, as Range K represents total corrections, and to use a GFT setting would double the effects of those corrections**). Elevation is artillery expressed to the nearest whole mil**.
14	Compute the *Quadrant Elevation* and record it. Quadrant Elevation is the sum of Elevation and Site. **Quadrant Elevation is artillery expressed to the nearest whole mil.**
15	Determine and record *Drift* corresponding to the Entry Range from Table C (base ejecting) or TFT/GFT. Drift is applied to the Basic Safety Diagram by following the "left least, right most" rule. The lowest (least) drift is applied to all left deflection limits, and the highest (greatest) drift is applied to all right deflection limits. Drift is artillery expressed to the nearest whole mil.
16	Ensure computations are verified by a second safety-certified person.
17	On the bottom third of the sheet of paper, record the data on the safety T.

NOTE: Minimum fuze settings are not computed for High Angle safety. It is the FDO's responsibility to ensure that all fuze settings will cause the projectile to function in the impact area.

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(I)	(j)	(k)	(l)	(m)
DIAGRAM	**RG**	**TOT**	**RG**	**ENTRY**								
RG	**+ CORR**	**= RG x**	**K =**	**RG**	**CHG**	**VI**	**<SI/10**	**X10mil Si Fac =**	**SI +**	**EL =**	**QE**	**DRIFT**

(a) This is the minimum or maximum range from the range safety diagram.

(b) This is the range correction for nonstandard conditions from Table F, if required. This is typically for reoccupation safety or corrections for nonstandard conditions not included in the Range K factor in column (d), such as WP [] weight. Examples of nonstandard conditions accounted for in (b) include, but are not limited to, difference in projectile square weight, difference in muzzle velocity, or any nonstandard condition accounted for prior to determining a Range K factor. If there is no change from standard, or all nonstandard conditions are accounted for in the Range K factor, this value is zero (0).
To determine a range correction from Table F, use the following formula:

	NONSTANDARD		STANDARD		CHANGE IN		RG CORR		RANGE
RANGE CHG	CONDITION	-	CONDITION	=	STANDARD	x	FACTOR	=	CORRECTION

(c) This is the sum of the Diagram Range and the Range Correction. If there is no range correction, then the Total Range will be the same as the Diagram Range.

(d) This is the Range K factor determined by using technique 2 in the FM 6-40/MCWP 3-16.6. This is for post occupation safety. It represents total corrections for a registration, MET + VE, or other subsequent MET technique. It represents all nonstandard conditions (unless a separate nonstandard condition such as change in square weight for WP is listed separately in column (b)). It is multiplied times the Total Range to determine Entry Range. If there is no Range K, enter 1.0000

(e) This is the sum of the Total Range times the Range K factor. If there is no Range K factor, then the Entry Range will be the same as the Total Range. Entry Range is the range to which Elevation is determined.

(f) This is the charge from the range safety card for this set of safety computations.

(g). This is the Vertical Interval from the range safety diagram.

(h). This is the Angle of Site divided by 10, determined by dividing Vertical Interval by Entry Range in Thousands.
(i). This is the 10 mil Site Factor, determined from the GFT or TFT from the head of the projectile family; e.g., 10 mil Site Factor for the M110 WP projectile would be determined with the AM-2, M825 10 mil Site Factor would be computed using the AN-2. *

(j). This is Site, the product of <Site/10 X 10 Mil Site Factor (Note: Site is determined for the Diagram Range). *

(k). This is the elevation to impact from Table C (base ejecting), or GFT/TFT (bursting). *

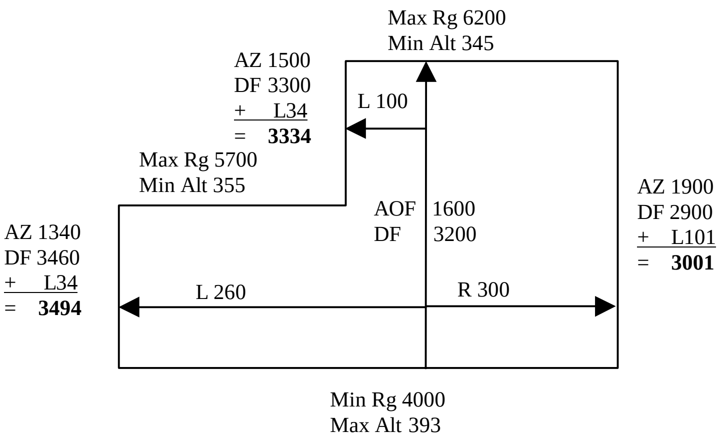
(l). This is the sum of Elevation and Site. It is the minimum or maximum Quadrant Elevation corresponding to maximum or minimum range.

(m). This is the Drift corresponding to Table C (base ejecting), or GFT/TFT (bursting), Drift is applied to the range safety diagram by using the "Least, Left; Most, Right;" rule. The "least" or lowest drift is applied to all left deflection limits, and the "most" or greatest drift is applied to all right deflection limits.

* - see Table 15-8 to determine the correct source table or addendum for computations/

Figure 15-12. High Angle Safety Matrix

FP 185 (GRID 6026 4110 ALT 370)
HIGH ANGLE, HE, CHG 3GB, AOF 1600



4□ HE HIGH ANGLE CHG 3GB

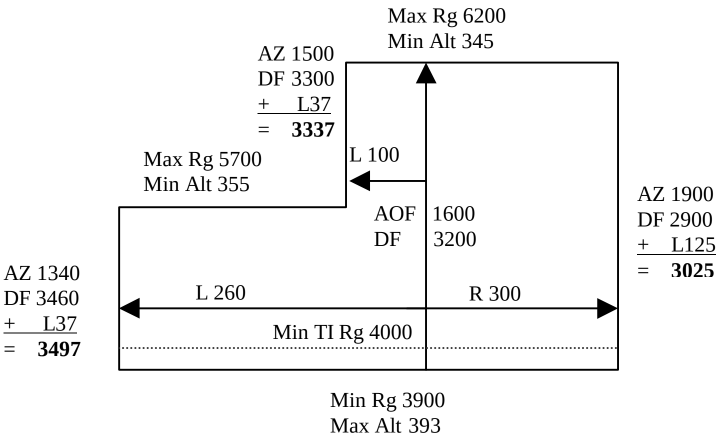
DIAGRAM RANGE	+	RANGE CORR	=	TOTAL RANGE	X	RANGE k	=	ENTRY RANGE	CHG	VI	<SI/10	X	10mil Si Fac	=	SI	+	EL	=	QE	DRIFT
4000	+	0	=	4000	x	1.0000	=	4000	3GB	+23	+0.6	x	-1.0	=	-1	+	1247	=	**1246**	L101
5700	+	0	=	5700	x	1.0000	=	5700	3GB	-15	-0.3	x	-5.2	=	+2	+	1052	=	**1054**	--
6200	+	0	=	6200	x	1.0000	=	6200	3GB	-25	-0.4	x	-15.0	=	+6	+	954	=	**960**	L34

FP 185, HE
HIGH ANGLE, CHG 3GB, AOL 1600

	1246		MAX QE
3494	**3334**	**3001**	DF
	1054	**960**	MIN QE

Figure 15-13. Example of High Angle Safety, Shell HE

FP 185 (GRID 6026 4110 ALT 370)
HIGH ANGLE, M825, CHG 4GB, AOF 1600



M825 HIGH ANGLE CHG 4GB

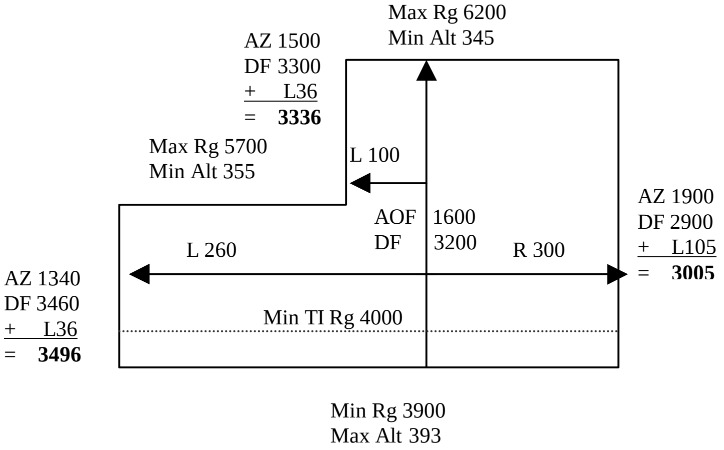
DIAGRAM RANGE	+	RANGE CORR	=	TOTAL RANGE	X	RANGE k	=	ENTRY RANGE	CHG	VI	<SI/10	X	10mil Si Fac	=	SI	+	EL	=	QE	DRIFT
4000	+	0	=	4000	x	1.0000	=	4000	4GB	+23	+0.6	x	-0.7	=	0	+	1288	=	**1288**	L125
5700	+	0	=	5700	x	1.0000	=	5700	4GB	-15	-0.3	x	-2.8	=	+1	+	1133	=	**1134**	--
6200	+	0	=	6200	x	1.0000	=	6200	4GB	-25	-0.4	x	-4.4	=	+2	+	1071	=	**1073**	L37

FP 185, M825
HIGH ANGLE, CHG 4GB, AOL 1600

1288			MAX QE
3497	**3337**	**3025**	DF
1134	**1073**		MIN QE

Figure 15-14. Example of High Angle Safety, Shell M825

FP 185 (GRID 6026 4110 ALT 370)
HIGH ANGLE, ILLUM, CHG 3GB, AOF 1600



ILLUM HIGH ANGLE CHG 3GB

DIAGRAM RANGE	+	RANGE CORR	=	TOTAL RANGE	X	RANGE k	=	ENTRY RANGE	CHG	VI	<SI/10	X	10mil Si Fac	=	SI	+	EL	=	QE	DRIFT
4000	+	0	=	4000	x	1.0000	=	4000	3GB	+23	+0.6	x	-1.0	=	-1	+	1253	=	**1252**	L105
5700	+	0	=	5700	x	1.0000	=	5700	3GB	-15	-0.3	x	-5.3	=	+2	+	1066	=	**1068**	--
6200	+	0	=	6200	x	1.0000	=	6200	3GB	-25	-0.4	x	-15.0	=	+6	+	977	=	**983**	L36

FP 185, ILLUM
HIGH ANGLE, CHG 3GB, AOL 1600

1252			MAX QE
3496	**3336**	**3005**	DF
1068	**983**		MIN QE

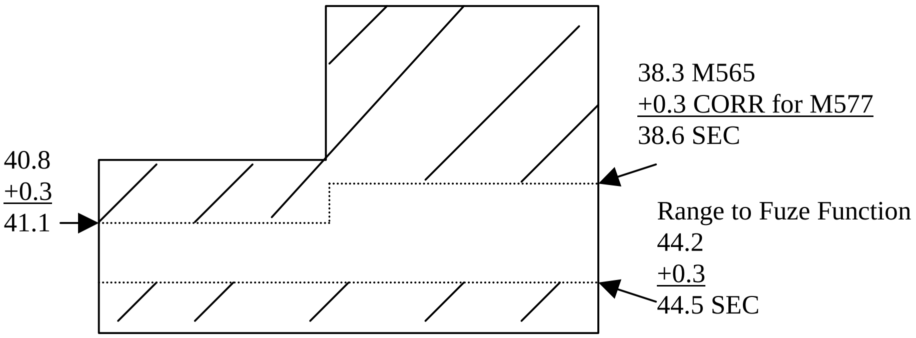


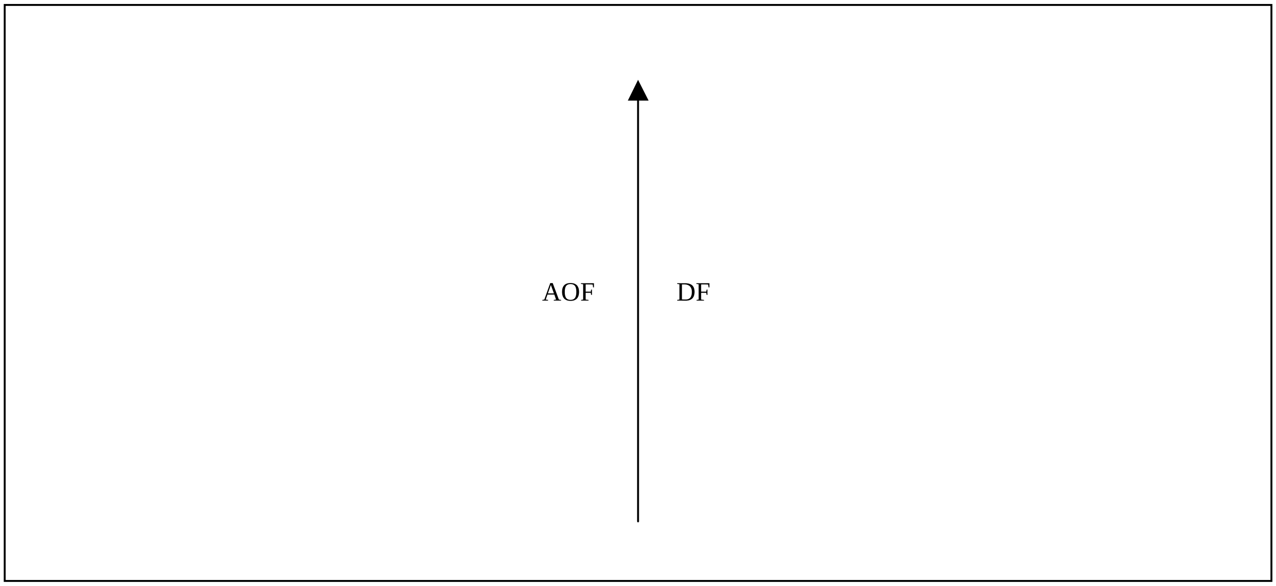
Figure 15-15. Example of High Angle Safety, Shell Illum

FIGURE 15-16: LOW ANGLE SAFETY COMPUTATIONS

Safety Diagram

Location (Grid/Alt): **Charge:** **Shell(s):** **Fuze(s):** **Angle of Fire:**

AOL:



Low Angle Safety Matrix

Chg:_____ Shell(s):__________ Fuze(s):__________ Projectile Family:__________

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY RG	CHG	VI	SI	+	EL	=	QE	M564/ M565	M582 M577	TOF	+	5.5	=	M728/ M732	DFT

Safety T

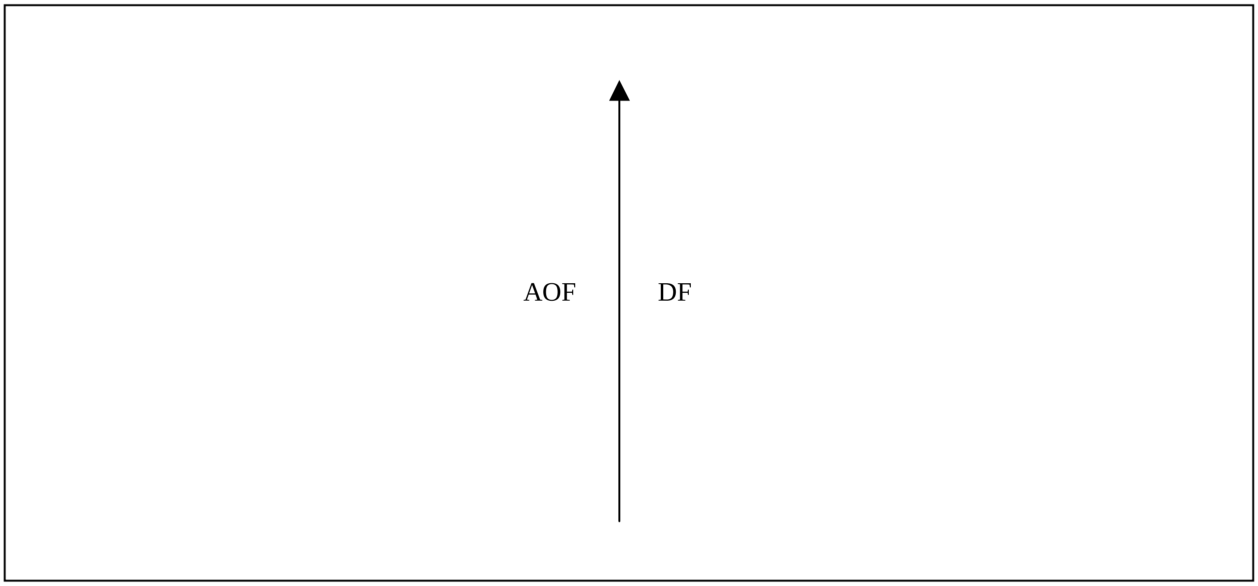
Location:____________Charge: _____Shell(s):___________Fuze(s):__________Angle of Fire:___ AOL: ____

FIGURE 15-17: HIGH ANGLE SAFETY COMPUTATIONS

Safety Diagram

Location (Grid/Alt): **Charge:** **Shell(s):** **Angle of Fire:**

AOL:



High Angle Safety Matrix

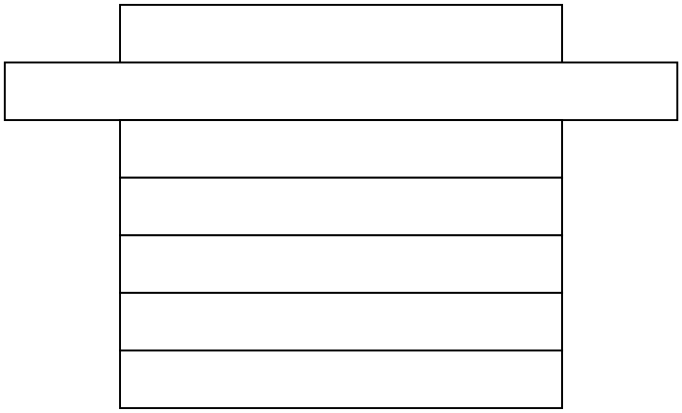
Chg:_____ Shell(s):__________ Projectile Family:__________

DIAGRAM RG TOT RG ENTRY

RG + CORR = RG x K = RG CHG VI <SI/10 x 10 mil Si Fac = SI + EL = QE DFT

Safety T

Location:_________________Charge: _____Shell(s):__________Angle of Fire:_____AOL:________



Section III

Minimum Quadrant Elevation

The XO or platoon leader is responsible for determining the lowest QE that can be safely fired from his position that will ensure projectiles clear all visible crests (minimum QE).

15-15. Elements of Computation

A minimum quadrant for EACH howitzer is ALWAYS determined. The maximum of these minimum quadrants is the XO's minimum quadrant. Use of the rapid fire tables in ST 6-50-20 is the fastest method of computing minimum QE. The QE determined from ST 6-50-20 is always equal to or greater than (more safe) than manual computations. Manual computations are more accurate than the rapid fire tables and are used if the sum of the site to crest and the angle needed for a 5-meter vertical clearance is greater than 300 mils. Figure 15-18 shows the elements of minimum QE.

a. Piece-to-crest range (PCR) is the horizontal distance between the piece and the crest, expressed to the nearest 100 meters. Procedures for measurement are discussed in paragraph 15-16.

NOTE: All angles are determined and expressed to the next higher mil.

b. Angle 1 (Figure 15-18) is the angle of site to crest measured by the weapons. See paragraph 15-16 for procedures.

c. Angle 2 (Figure 15-18) is the vertical angle required to clear the top of the crest. For quick, time, and unarmed proximity (VT) fuzes, a vertical clearance of 5 meters is used. For armed VT fuzes, see paragraph 15-19.

d. Angle 3 (Figure 15-18) is the complementary angle of site. It is the complementary site factor (TFT, Table G) for the appropriate charge at the piece to crest range mulitiplied by the sum of angles 1 and 2. Site is the sum of angles 1, 2, and 3.

NOTE: The entry argument for Table G is PCR. If it is not listed, do not interpolate, use the next higher listed value.

e. Angle 4 (Figure 15-18) is the elevation (TFT, Table F) for the appropriate charge corresponding to the PCR.

f. Angle 5 (Figure 15-18) is a safety factor equivalent to the value of 2 forks (TFT, Table F) for the appropriate charge at the PCR.

g. The sum of angles 1 through 5 (Figure 15-18) is the minimum QE for the weapon and the charge computed.

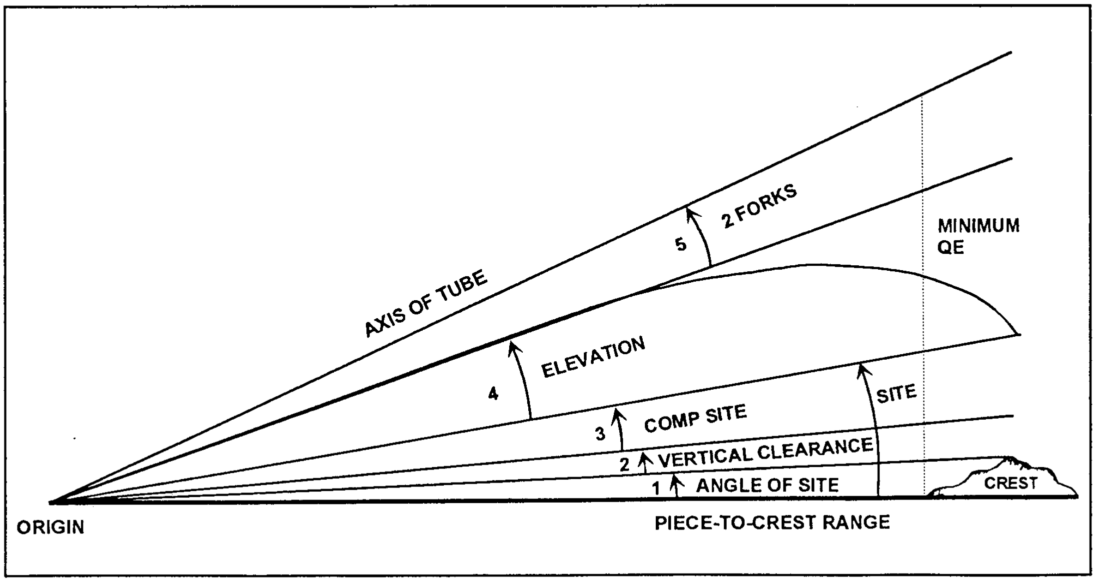


Figure 15-18. Angles of Minimum QE

15-16. Measuring Angle of Site to Crest

As soon as the piece is "safed", prefire checks conducted, and ammunition prepared , position improvement begins with verification of site to crest as measured by the advance party. The advance party measures site to crest with an M2 compass or aiming circle. The section chief measures the angle of site to crest and reports it to the XO or platoon leader. To measure the angle of site to crest, the section chief sights along the bottom edge of the bore, has the tube traversed across the probable field of fire, and has the tube elevated until the line of sight clears the crest at the highest point. He then centers all bubbles on the elevation mount and reads the angle of site to the crest from the elevation counter. This angle of site and the PCR are reported as part of the section chief's report.

15-17. Measuring Piece-To-Crest Range

a. There are five methods that can be used to measure piece-to-crest range:

(1) Taping. This is the most accurate method; however, it is normally too time-consuming.

(2) Subtense. This method is fast and accurate.

(3) Map Measurement. This method is fast and accurate if the obstacle can be accurately located (for example, a lone tree will not appear on a map).

(4) Pacing. This method is time-consuming and depends on the distance and accessibility to the crest.

(5) Estimation. This method is least accurate, but it is used when other methods are not feasible.

b. Regarless of the method used to measure PCR, the XO or platoon leader must verify PCR before he computes QE. He can do this by using any of the five methods.

15-18. Computation of Fuzes Other Than Armed VT

a. The XO or platoon leader does the computations indicated in this section if the sum of angles 1 and 2 (Figure 15-18) exceeds 300 mils or if the rapid firing tables (RFTs) are not available. **All angles are determined and expressed to the next higher mil.** Table 15-9 lists the steps and solves an example of an XO's or platoon leader's manual computations.

Table 15-9. Manual Minimum QE Computations.

STEP	ACTION
1	Howitzer 1 (M109A3) reports a site to crest of 16 mils at a PCR of 1,100 meters. Charge 3GB is used.
2	**э1** = site to crest = **16 mils**
3	**э2** = (VI x 1.0186) + PCR (in 1,000s) = (5 x 1.0186) + 1.1 = 4.6 λ **5 mils** This VI is a 5-meter vertical clearance safety factor. It can also be computed using one of the following methods: • Use the GST. Solve in the same way as angle of site **(4.6 λ 5).** • Use ST 6-50-20, page 2-7 **(5).**
4	**э3** = (э1 + э2) x CSF = (16 + 5) x 0.010 = (0.210) λ **1 mil**
5	**э4** = EL = 74.1 λ **75 mils**
6	**э5** = 2 Forks (TFT, Table F, Column 6) = 2 x 2 = **4 mils**
7	Min QE = э1 + э2 + э3 + э4 + э5 = 16 + 5 + 1 + 75 + 4 = **101 mils**

b. The same example is solved in Table 15-10 by using RFTs in the ST 6-50-20, Appendix B.

Table 15-10. RFT Minimum QE Computations.

STEP	ACTION
1	Determine if the RFT can be used **(э1 + э2 [300 mils).** Use the ST 6-50-20, page A-1. Since the sum of angles 1 and 2 is less than or equal to 300 **(16 +5 = 21),** the RFT can be used.
2	Determine RFT value. Enter the appropriate RFT. The entry arguments are howitzer (M109A3), propellant (M3A1, GB), fuze (PD), PCR (1100), and charge (3). The correct table is on page A-7. The RFT value is 86. This value equals the sum of angles 2, 3, 4, and 5 **(э2 + э3 + э4 + э5).**
	NOTE: Use the RFT labeled "M557, M564" for **all** minimum QE computations except armed VT. For armed VT, use the RFT labeled "M728."
3	Determine the RFT minimum QE. This value equals the sum of angle 1 and the RFT value **(16 + 86 = 102).**

c. One howitzer section may report a site to crest that is unusually high. If the XO or platoon leader determines that it is the result of a single narrow obstruction (such as a tree), the piece can be called out of action when firing a deflection that would engage the obstruction. This would enable the platoon to use the next lower site to crest. Other alternatives are to remove the obstruction or move the weapon.

d. Table 15-11 illustrates why minimum QE is computed for all guns, regardless of which has the largest site to crest.

Table 15-11. RFT Example for Howitzer Platoon.

GUN	CHG	PCR	SITE TO CREST	+	RFT	=	MIN QE
1	3GB	800	128		64		192
2	3GB	1000	105		80		185
3	3GB	1500	92		116		208
4	3GB	1200	115		93		208

15-19. Computations for Armed VT Fuze (Low-Angle Fire)

a. The method of computing the XO's minimum QE for firing a projectile fuzed with an M728 or M732 fuze depends on the method in which the fuze is used. **The proximity (VT) fuze is designed to arm 3 seconds before the time set on the fuze; however, some VT fuzes have armed as early as 5.5 seconds before the time set on the fuze. Because of the probability of premature arming, a safety factor of 5.5 seconds is added to the time of flight to the PCR.** Since time on the setting ring is set to the whole second, the time determined in computing minimum safe time is expressed up to the nearest whole second. A VT fuze is designed so that it will not arm earlier than 2 seconds into its time of flight, which makes it a bore-safe fuze.

b. In noncombat situations, the XO or platoon leader determines the minimum safe time by adding 5.5 seconds to the time of flight to the minimum range line as shown on the range safety card. The minimum QE determined for fuzes quick and time is also valid for fuze VT.

c. In combat situations, the XO or platoon leader determines the minimum QE and a minimum safe time for fuze VT. The minimum QE determined for PD fuzes is safe for VT fuzes if the fuze setting to be fired equals or is greater than the minimum safe time determined in paragraph a above. If the XO or platoon leader finds it necessary to fire a VT fuze with a time less than the minimum safe time, he must modify the minimum QE. He does this by increasing the vertical clearance to ensure that the fuze will not function as it passes over the crest. In addition, he must ensure the fuze will not function over any intervening crests along the gun-target line (See paragraph 15-21).

d. If the projectile is to be fired with the VT fuze set at a time less than the minimum safe time, allowance must be made for vertical clearance of the crest. Vertical crest clearances for armed M728 and M732 VT fuzes fired over ordinary terrain for all howitzer systems is 70 meters.

e. If the projectile is to be fired over marshy or wet terrain, the average height of burst will increase. The vertical clearance is increased to 105 meters. If the projectile is fired over water, snow, or ice, the vertical clearance is 140 meters.

f. The minimum QE for armed fuze VT when a fuze setting less than the minimum safe time is fired is based on the piece-to-crest range and a vertical clearance as indicated in paragraphs d and e above.

g. Figure 15-19 shows a decision tree for application of armed VT minimum QE.

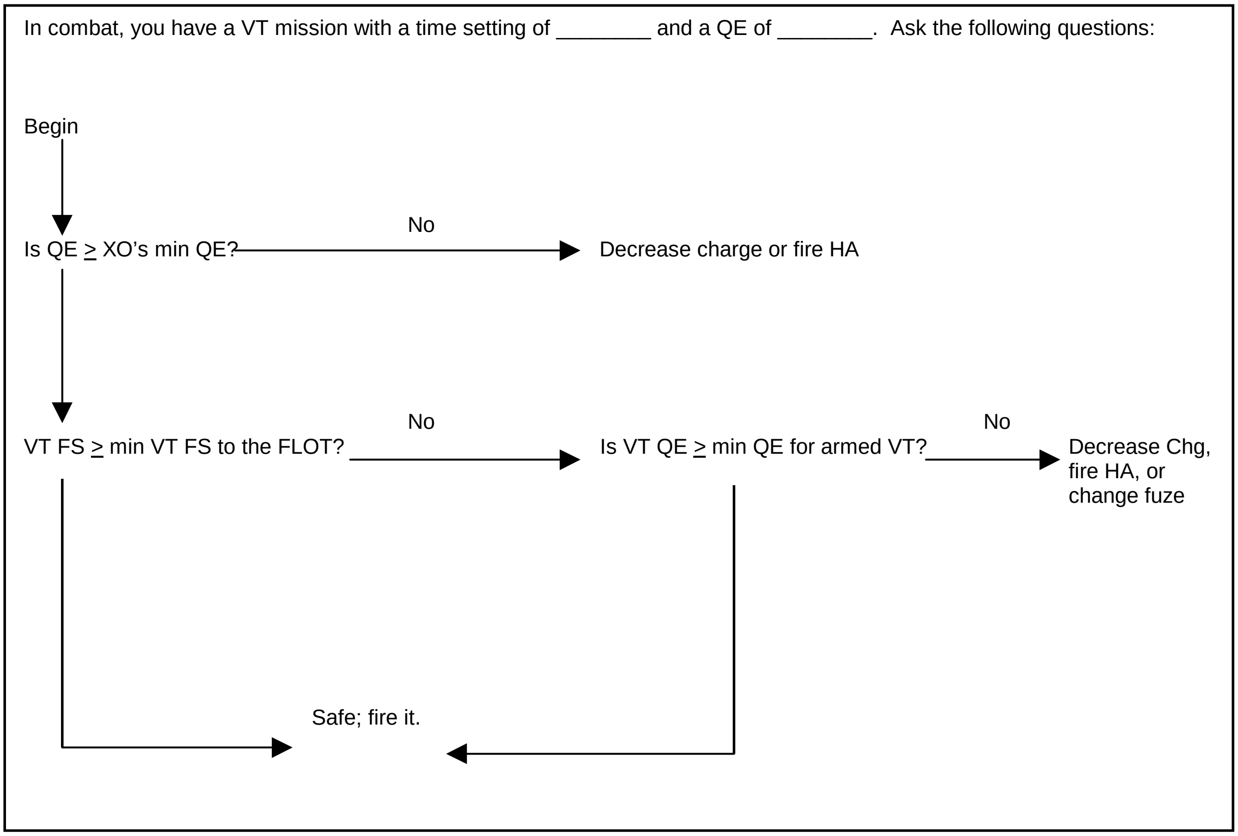


Figure 15-19. Armed VT Decision Tree.

h. Table 15-12 is an example of computations to determine minimum QE for an armed VT fuze.

Table 15-12. Manual Armed VT Minimum QE Computations.

STEP	ACTION
1	Howitzer 1 (M109A3) reports a site to crest of 16 mils at a PCR of 1,100 meters. Charge 3GB is used.
2 3	э1 = site to crest = **16 mils** э2 = (VI x 1.0186) + PCR (in 1,000s) =(70 x 1.0186) + 1.1 = 64.8 λ **65 mils** This VI is a 70-meter vertical clearance safety factor. It can also be computed by using the GST. Solve in the same way as angle of site **(64.7 λ 65).**
4	э3 = (э1 + э2) x CSF (TFT, Table G) = (16 + 65) x 0.010 = 0.710 λ **1 mil**
5	э4 = EL = 74.1 λ **75 mils**
6	э5 = 2 Forks (TFT, Table F, Column 6) = 2 x 2 = **4 mils**
7	Min QE = э1 + э2 + э3 + э4 + э5 = 16 + 65 + 1 + 75 + 4 = **161 mils**
8	Determine minimum safe time. This value is the sum of TOF to PCR and 5.5 expressed up to the next higher second **(4.1 + 5.5 = 9.6 λ 10.0 sec).**

i. The same example is solved in Table 15-13 by using the RFT in the ST 6-50-20, Appendix A.

Table 15-13 RFT Minimum QE Computations.

STEP	ACTION
1	Determine if the RFT can be used (э1 + э3 [300 mils). This is done manually, since page A-1 uses a vertical clearance of 5 meters. See step 3 in table 15-12 for э2. Since the sum of angles 1 and 2 is less than or equal to 300 **(16 +65 = 81)**, the RFT can be used.
2	Determine RFT value. Enter the appropriate RFT. The entry arguments are howitzer (M109A3), propellant (M3A1, GB), fuze (M728 or M732), PCR (1100) and charge (3). The correct table is on page A-13. The RFT value is 147. This value equals the sum of angles 2, 3, 4, and 5.
	NOTE: Use the RFT labeled "M557, M564" for **all** minimum QE computations except armed VT. For armed VT, use the RFT labeled "M728."
3	Determine the RFT minimum QE. This value equals the sum of angle 1 and the RFT value **(16 + 147 = 163).**
4	Determine the minimum safe time. Use the same entry arguments as in step 2. The minimum safe time is **10.0**.

j. If the VT fuze setting to be fired is equal to or greater than the minimum safe VT time, the minimum QE for fuzes quick and time applies. If the VT fuze setting to be fired is less than the minimum safe VT time, the minimum QE determined for armed VT applies.

15-20. Using Minimum Quadrant Elevation

After computing minimum QE for each charge authorized, the XO or platoon leader must compare the minimum QE to the QE required to clear the minimum range line. The XO must then select the highest quadrant for each charge to be used as the minimum QE to be fired from that position.

15-21. Intervening Crest

a. FDOs must ensure that artillery fires clear intervening crests. Intervening crests are defined as any obstruction between the firing unit and the target not visible from the firing unit. The following are the possible options, listed in order of preference.

(1) Determine firing data to the crest (include all nonstandard conditions) and add 2 forks (Table 15-12).

(2) Determine a minimum QE in a similar manner as XO's minimum QE (Table 15-13).

(3) Use the trajectory tables in the appendix of the TFT.

b. Option 1 is preferred because it incorporates all current nonstandard conditions that will affect the projectile along the trajectory. **The FDO has the responsibility to determine on the basis of availability of corrections for nonstandard conditions if this really is the best option.** Table 15-12 lists the steps.

Table 15-14. Intervening Crest, Option 1.

STEP	ACTION
1	Upon occupation, the FDO analyzes the terrain for intervening crests.
2	Upon determining the altitude of this crest, he computes firing data to this point (QE). The best solution includes all available corrections for nonstandard conditions (current and valid GFT setting).
3	Add the value of 2 forks (TFT, Table F, Column 6) to the QE determined in step 2 to ensure that round-to-round variations (probable errors) will clear the crest.
4	The FDO then records this QE and charge on his situation map as a check to ensure that rounds will clear the intervening crest.
5	Upon receipt of a fire mission, the FDO will compare his intervening crest QE to his fire mission quadrant. One of the three following situations will occur: 1) The target is located short of the intervening crest. The FDO does not consider the effects of the crest at this time. 2) The mission QE exceeds intervening crest QE by a significant margin, indicating the rounds will clear the crest. 3) Fire mission QE exceeds intervening crest QE by only a small margin or is less than intervening crest QE, indicating the round may or may not clear the crest. The FDO must determine if the round will clear after considering the following:

Table 15-14. Intervening Crest, Option 1 (Continued).

STEP	ACTION
	• Have all nonstandard conditions been accounted for? • How old is the current met message? • Are registration corrections being applied to this mission? Upon realizing that the round may not or will not clear the crest, the FDO can either fire high angle or a reduced charge. The quickest choice would be to fire high angle, but tactical situations may prevent this. Firing a lower charge will increase dispersion more than high angle. For example, at a range of 6,000 meters, the following applies: • Low angle, charge 5: Probable error in range = 15 meters. • High angle, charge 5: Probable error in range = 17 meters. • Low angle, charge 4: Probable error in range = 23 meters. If a lower charge is selected, steps 2 through 5 must be repeated.
6	If VT fuzes are to be fired (M700 series), the FDO must take additional steps to ensure that the VT fuze does not arm before passing over the crest. Follow the steps for determining armed VT minimum QE and FS in paragraph 15-15.

c. Option 2 does not include current conditions for all nonstandard conditions. Table 15-20 lists the steps.

Table 15-15. Intervening Crest, Option 2.

STEP	ACTION
1	Upon occupation, the FDO analyzes the terrain for intervening crests.
2	The FDO determines and announces the grid and map spot altitude to the crest.
3	The HCO plots the grid and determines and announces range to crest.
4	The VCO computes angle of site to the crest. This is the same as determining site to crest with a howitzer
5	Determine if RFT can be used **(э1 + э2 [300 mils)**. Angle 1 equals angle of site to the crest. Refer to ST 6-50-20, page A-1. Since э1 and э2 decrease with range, this should not be a problem.
6	Determine RFT value. Enter the appropriate RFT. The entry arguments are howitzer, propellant, fuze, PCR (chart range to the crest), and charge. This value equals the sum of angles 2, 3, 4, and 5.
	NOTE: Use the RFT labeled “M557, M564” for **all** minimum QE computations except armed VT. For armed VT, use the RFT labeled “M728.”
7	Determine RFT intervening crest QE. This value is the sum of the angle of site to the crest and the RFT value.
8	If VT is fired, enter the appropriate table and extract the correct information.
9	Follow steps 4 and 5 of table 15-14.

d. The least preferred option is using the trajectory charts in the appendix of the TFT. This offers a quicker but less accurate method to clear the intervening crest since it is based off of standard conditions. The FDO must make a judgment call when to use these charts. **The FDO must use caution when making this decision.**

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Tactics, Techniques, and Procedures for

FIELD ARTILLERY MANUAL CANNON GUNNERY

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Chapter 1

THE GUNNERY PROBLEM AND THE GUNNERY TEAM

The mission of the Field Artillery is to destroy, neutralize, or suppress the enemy by cannon, rocket, and missile fires and to help integrate all fire support assets into combined arms operations. Field artillery weapons are normally employed in masked or defilade positions to conceal them from the enemy. Placing the firing platoon in defilade precludes direct fire on most targets. Consequently, indirect fire must be used when FA weapons fire on targets that are not visible from the weapons. The gunnery problem is an indirect fire problem. Solving the problem requires weapon and ammunition settings that, when applied to the weapon and ammunition, will cause the projectile to achieve the desired effects on the target.

1-1. Gunnery Problem Solution

a. The steps in solving the gunnery problem areas follows:

(1) Know the location of the firing unit, and determine the location of the target.

(2) Determine chart (map) data (deflection, range from the weapons to the target, and altitude of the target).

(3) Determine vertical interval (VI) and site (si).

(4) Compensate for nonstandard conditions that would affect firing data (meteorological [met] procedures).

(5) Convert chart data to firing data (shell, charge, fuze, fuze setting, deflection, and quadrant elevation).

(6) Apply the firing data to the weapon and ammunition.

b. The solution to the problem provides weapon and ammunition settings that will cause the projectile to function on or at a predetermined height above the target. This is necessary so the desired effects will be achieved.

1-2. Field Artillery Gunnery Team

The coordinated efforts of the field artillery gunnery team are required to accomplish the solution of the gunnery problem outlined in paragraph 1-2. The elements of the team must be linked by an adequate communications system.

NOTE: The terms *battery* and *platoon* used throughout this manual are synonymous, unless otherwise stated.

a. Observer. The observer and/or target acquisition assets serve as the "eyes and ears" of all indirect fire systems. The mission of the forward observer is to detect and locate suitable indirect fire targets within his zone of observation and bring fires on them. When a target (tgt) is to be attacked, the observer transmits a call for fire and adjusts the fires onto the target as necessary. An observer provides surveillance data of his own fires and any other fires in his zone of observation. Field artillery observers include the following:

- Aerial observers (AOs).
- Forward observers (F0s).
- Fire support teams (FISTs).
- Combat observation/lasing teams (COLTs).
- Air and naval gunfire liaison company (ANGLICO).
- Firepower control teams (FCTs).
- Any other friendly battlefield personnel.

b. Target Acquisition. Target acquisition assets also function as observers. They provide accurate and timely detection, identification, and location of ground targets, collect combat and/or target information, orient and/or cue intelligence sources, and permit immediate attack on specific areas. Field artillery target acquisition (TA) assets include the following:

- Weapons-locating radar sections.
- Aircraft radar systems.

NOTE: See FM 6-121 for a discussion of TA assets. See FMs 100-2-1, 100-2-2, and 100-2-3 for information on target characteristics.

c. Fire Direction Center. The fire direction center (FDC) serves as the "brains" of the gunnery team. It is the control center for the gunnery team and is part of the firing battery headquarters. The FDC personnel receive calls for fire directly from an observer or they maybe relayed through the initial fire support automated system (IFSAS) at battalion level. The FDC will then process that information by using tactical and technical fire direction procedures.

(1) Tactical fire direction includes processing calls for fire and determining appropriate method of fire, ammunition expenditure, unit(s) to fire, and time of attack. The fire direction officer's decision on how to engage the target is concisely stated as a **FIRE ORDER.**

(2) Technical fire direction is the process of converting weapon and ammunition characteristics (muzzle velocity, propellant temperature, and projectile weight), weapon and target locations, and met information into firing data. Firing data consist of shell (sh), charge (chg), fuze (fz), fuze setting (FS), deflection (df), and quadrant elevation (QE). The FDC transmits firing data to the guns as **fire commands.**

d. Firing Battery. The firing battery serves as the “muscle” of the gunnery team. The firing battery includes the battery HQ, the howitzer sections, the ammunition section, and the FDC. The howitzer sections apply the technical firing data to the weapon and ammunition. Organization and employment considerations of the firing sections are discussed in FM 6-50.

1-3. Five Requirement for Accurate Predicted Fire

To achieve accurate first-round fire for effect (FFE) on a target, an artillery unit must compensate for nonstandard conditions as completely as time and the tactical situation permit. There are five requirements for achieving accurate first-round fire for effect. These requirements are accurate target location and size, firing unit location, weapon and ammunition information, met information, and computational procedures. If these requirements are met, the firing unit will be able to deliver accurate and timely fires in support of the ground-gaining arms. If the requirements for accurate predicted fire cannot be met completely, the firing unit maybe required to use adjust-fire missions to engage targets. Adjust-fire missions can result in less effect on the target, increased ammunition expenditure, and greater possibility that the firing unit will be detected by hostile TA assets.

a. Target Location and Size. Establishing the range (rg) from the weapons to the target requires accurate and timely detection, identification, and location of ground targets. Determining their size and disposition on the ground is also necessary so that accurate firing data can be computed. Determining the appropriate time and type of attack requires that the target size (radius or other dimensions) and the direction and speed of movement be considered. Target location is determined by using the TA assets mentioned in paragraph 1-2.

b. Firing Unit Location. Accurate range and deflection from the firing unit to the target requires accurate weapon locations and that the FDC knows this location. The battalion survey section uses the position and azimuth determining system (PADS) to provide accurate survey information for the battery location. Survey techniques available to the firing battery may also help in determining the location of each weapon. The FDC can determine the grid location of each piece by using the reported direction, distance, and vertical angle for each piece from the aiming circle used to lay the battery.

c. Weapon and Ammunition Information. The actual performance of the weapon is measured by the weapon muzzle velocity (velocity with which the projectile leaves the muzzle of the tube) for a projectile-propellant combination. The firing battery can measure the achieved muzzle velocity of a weapon and correct it for nonstandard projectile weight and propellant temperature. This is done by using the M90 velocimeter and muzzle velocity correction tables (MVCT M90-2) for each type of charge and projectile family. Calibration should be conducted continuously by using the M90 velocimeter. Firing tables and technical gunnery procedures allow the unit to consider specific ammunition information (weight, fuze type, and propellant temperature); thus, accurate firing data are possible.

d. Meteorological Information. The effects of weather on the projectile in flight must be considered, and firing data must compensate for those effects. Firing tables and technical gunnery procedures allow the unit to consider specific met information (air temperature, air density, wind direction, and wind speed) in determining accurate firing data.

e. Computational Procedures. The computation of firing data must be accurate. Manual and automated techniques are designed to achieve accurate and timely delivery of fire. The balance between accuracy, speed, and the other requirements discussed in this chapter should be included in the computational procedures.

f. Nonstandard Conditions. If the five requirements for accurate predicted fire cannot be met, registrations can be conducted or a met + VE technique can be completed to compute data that will compensate for nonstandard conditions. Applying these corrections to subsequent fire missions will allow the unit to determine accurate firing data. Accuracy of these fires will be a direct function of the observer's target location.

Chapter 2

FIRING BATTERY AND BATTERY FDC ORGANIZATION

The FA cannon battery is firing unit within the cannon battalion and is organized in one of two ways: a battery-based unit (3 x 6 organization) or a platoon-based unit (3 x 8 organization). In either case, they have the personnel and equipment needed to shoot, move, and communicate. This chapter describes the organization of the firing battery and the battery FDC.

2-1. Firing Battery Organization

a. The organization of all cannon batteries is basically the same. Differences in organization stem from differences in weapon caliber, whether the weapon is towed or self-propelled (SP), and whether the battery is in a divisional or nondivisional battalion. The cannon battery is organized as follows:

(1) Battery-based unit--consists of a battery headquarters and a firing battery.

(a) The battery HQ has the personnel and equipment to perform command and control; food service; supply; communications; nuclear, biological, chemical (NBC), and maintenance functions. (In some units, food service, communications, and maintenance may be consolidated at battalion level.)

(b) The firing battery has the personnel and equipment to determine firing data, fire the howitzers, and resupply ammunition. (In some units, ammunition assets may be consolidated at battalion level.)

(2) Platoon-based unit--consists of a battery HQ and two firing platoons.

(a) The battery HQ has the personnel and equipment to perform command and control, food service, supply, communications, NBC, and maintenance functions. (In some units, food service, communications, and maintenance may be consolidated at battalion level.)

(b) Each firing platoon has the personnel and equipment to determine firing data, fire the howitzers, and resupply ammunition. (In some units, ammunition assets maybe consolidated at battalion level.)

2-2. Battery or Platoon FDC

a. The battery or platoon FDC is the control center, or brains, of the gunnery team. The FDC personnel receive fire orders from the battalion FDC or calls for fire from observers and process that information by using tactical and technical fire direction procedures (Chapter 1). The battery FDC performs the technical fire direction, while the battalion FDC performs tactical fire direction. If the FDC is operating without a battalion FDC, the battery FDC conducts both tactical and technical fire direction. The battery FDC receives the call for fire and converts the request into firing data. The firing data are then sent to the howitzer sections as fire commands. In addition to an FDC, USMC batteries have a battery operations center (BOC), which is organized and equipped to perform technical fire direction. BOCs enhance unit survivability, simplify displacements, and enable split-battery operations. In battery positions, BOC personnel may augment the FDC to facilitate 24-hour operations.

b. The FDC is organized to facilitate 24-hour operations (Appendix A). Duties of manual FDC personnel are described below

(1) Fire direction officer. The FDO is responsible for all FDC operations. He is responsible for the training of all FDC personnel, supervises the operation of the FDC, establishes standing operating procedure (SOP), checks target location, announces fire order, and ensures accuracy of firing data sent to the guns. USMC batteries also include an assistant fire direction officer-assistant executive officer (AFDO-AXO). The AFDO-AXO leads the BOC, assists the battery commander during displacement and stands duty in the FDC to enable 24-hour operations.

(2) Chief fire direction computer. The chief fire direction computer is the technical expert and trainer in the FDC. He ensures that all equipment is on hand and operational, supervises computation of all data, ensures that all appropriate records are maintained, and helps the FDO as needed. He ensures smooth peformance of the FDC in 24-hour operations and functions as the FDO in the FDO's absence. The equivalent USMC billet description is operations chief.

(3) Fire direction computer. The fire direction computer operates the primary means of computing firing data. He determines and announces fire commands. He also records mission-related data and other information as directed. The equivalent USMC billet description is operations assistant. There is an operations assistant in both the FDC and the BOC.

(4) Fire direction specialist. There are two fire direction specialists per FDC to facilitate 24-hour operations. In a manual FDC, they serve alternately as horizontal control operator (HCO) and vertical control operator (VCO). The equivalent USMC billet description is fire control man. There are five fire control men in a USMC FDC and three more in a BOC to facilitate 24-hour operations. These fire control men may perform the duties of the HCO, VCO, radio operator, or driver as needed in either the FDC or BOC.

(a) The HCO constructs and maintains the primary firing chart and determines and announces chart data.

(b) The VCO constructs the secondary firing chart checks chart data, plots initial target location on the situation map, and determines and announces site.

(c) The radiotelephone operator (RATELO) or driver is normally the operator of the FDC vehicle. He maintains the vehicle and the FDC-associated generators. In a manual FDC, he may also act as the recorder.

2-3. Definitions

a. Fire direction is the employment of firepower. The objectives of fire direction are to provide continuous, accurate, and responsive fire support under all conditions. Flexibility must be maintained to engage all types of targets over wide frontages, to mass the fires of all available units quickly, and to engage a number and variety of targets simultaneously.

b. The fire direction center is the element of the gunnery team with which the commander directs artillery firepower. The accuracy, flexibility, and speed in the execution of fire missions depend on the following:

- Rapid and clear transmission of calls for free.
- Rapid and accurate computations.
- Rapid and clear transmission of fire commands.
- Integration of automated and manual equipment into an efficient mutually supporting system.
- Efficient use of communications equipment.

2-4. Relationship Between Battery or Platoon and Battalion FDC

There are two modes of operation under which fire direction can be conducted: battalion directed and autonomous.

a. Battalion Directed. In battalion-directed operations, calls for fire are transmitted from the observer to the battalion FDC. The battalion FDO is responsible for tactical fire direction and selects the unit(s) to fire. A fire order is transmitted to the firing units that are responsible for technical fire direction. The battalion FDC is responsible for transmitting all fire mission related messages (that is, message to observer, ready [if applicable], shot, splash, and rounds complete) to the observer. The firing units are responsible for transmitting all fire mission related messages to the battalion FDC.

b. Autonomous. In autonomous operations, calls for fire are transmitted from the observer to the firing unit FDC. The firing unit FDC is responsible for tactical and technical fire direction. The firing unit is responsible for transmitting the message to observer, ready (if applicable), shot, splash, and rounds complete to the observer. The battalion FDC and the battalion fire support officer (FSO) monitor the calls for fire. The equivalent USMC billet description for FSO is artillery liaison officer. The battalion FDC may take over control of the mission if the target warrants the massing of two or more batteries. The battalion FDC monitors the battery's message to observer (MTO) to ensure that the battery has selected the appropriate ammunition and method of fire. The battalion FDC may change the battery's plan of attack. If the target requires battalion fire, the firing unit FDO can request reinforcing fires from the battalion FDC.

2-5. Battalion FDC Personnel

A battalion FDC is composed of a fire direction officer, a chief computer, an assistant chief computer, three computers, a horizontal control operator, a vertical control operator, and a radiotelephone operator. USMC battalion FDCs are composed of a fire direction officer, operations chief, two operations assistants, and 10 fire control men to facilitate 24-hour operations. The operations chief is the equivalent of the chief computer, and the operations assistants are the equivalent of the assistant chief computer. The fire control men may perform the duties of computer, HCO, VCO, radio operator, or driver as needed.

a. Fire Direction Officer's Duties. The FDO's duties areas follows:

(1) Is responsible for the overall organization and functioning of the battalion FDC.

(2) Coordinates with the battalion S3 to ensure that all information regarding the tactical situation, unit mission, ammunition status, and commander's guidance on the method of engagement of targets and control of ammunition expenditures is known and ensures that all information is passed to battery FDOs.

(3) Ensures that all communications are properly established.

(4) Coordinates with the chief computer concerning data input, chart verification, transfer of registration corrections, average site or altitude, terrain gun position corrections (TGPCs) sectors, and any other special instructions.

(5) Inspects target locations and monitors messages to observer when a mission is received by a battery FDC and intercedes when necessary.

(6) Controls all battalion missions.

b. Chief Computer's Duties. The chief computer's duties areas follows:

(1) Serves as the battalion FDO's technical expert (the actual supervisor and/or trainer of battalion FDC personnel) and assumes the duties of the battalion FDO in his absence.

(2) Ensures that all battalion FDC equipment is operational and emplaced correctly.

(3) Ensures coordination of all data throughout the battalion, to include current registration settings.

(4) Ensures that the HCO's and VCO's charts include all pertinent known data.

(5) Ensures that the situation map is properly posted, to include fire support coordinating measures and the current tactical situation.

c. Assistant Chief Computer's Duties. The assistant chief computer's duties are as follows:

(1) Monitors all operations performed by the HCO.

(2) Supervises maintenance and care of the generators.

(3) Assumes the duties of the chief computer when he is absent.

d. Battery Computers' Duties. The battery computers' duties areas follows:

(1) Provide communications link with the battery FDCs.

(2) Monitor the appropriate fire direction net for their battery.

(3) Exchange information with the battery FDCs and pass battalion fire orders to the battery.

(4) Record all data pertinent to fire missions that are sent to their battery.

(5) Compute data for their battery when directed by the chief computer.

(6) Use their fire direction net to communicate with the observer when battalion missions are conducted.

(7) Assume the duties of the assistant chief computer when he is absent.

e. Horizontal Control Operator's Duties. The HCO's duties areas follows:

(1) Plots known data as directed by the assistant chief computer.

(2) Determines chart data as appropriate.

(3) Maintains equipment and associated generators.

(4) Plots the initial target location when a mission is received.

f. Vertical Control Operator's Duties. The VCO's duties areas follows:

(1) Plots known data as directed by the assistant chief computer.

(2) Plots the initial target location when a mission is received.

(3) Checks chart data with the HCO.

(4) Plots the initial target location on the situation map and determines and announces site for the appropriate battery.

g. Radiotelephone Operator's Duties. The RTO's duties areas follows:

(1) Establishes and maintains communications on the battalion command/fue direction (CF) net.

(2) Determines and transmits the messages to observer when battalion missions are conducted on the battalion CF net.

(3) Encodes and decodes messages, target lists, and fire plans.

(4) Ensures proper authentication of appropriate messages and all fire missions.

Chapter 3

BALLISTICS

Ballistics is the study of the firing, flight, and effect of ammunition. A fundamental understanding of ballistics is necessary to comprehend the factors that influence precision and accuracy and how to account for them in the determination of firing data. Gunnery is the practical application of ballistics so that the desired ejects are obtained by fire. To ensure accurate predicted fire, we must strive to account for and minimize those factors that cause round-to-round variations, particularly muzzle velocity. Ballistics can be broken down into four areas: interior, transitional, exterior, and terminal. Interior, transitional, and exterior ballistics directly affect the accuracy of artillery fire and are discussed in this chapter. Terminal ballistics are discussed in Appendix B.

3-1. Interior Ballistics

Interior ballistics is the science that deals with the factors that affect the motion of the projectile within the tube. The total effect of all interior ballistic factors determines the velocity at which the projectile leaves the muzzle of the tube, which directly influences the range achieved by the projectile. This velocity, called muzzle velocity (MV), is expressed in meters per second (m/s). Actual measurements of the muzzle velocities of a sample of rounds corrected for the effects of nonstandard projectile weight and propellant temperature show the performance of a specific weapon for that projectile family-propellant type-charge combination. The resulting measurement(s) are compared to the standard muzzle velocity shown in the firing table(s). This comparison gives the variation from standard, called muzzle velocity variation (MVV), for that weapon and projectile family-propellant type-charge combination. Application of corrections to compensate for the effects of nonstandard muzzle velocity is an important element in computing accurate firing data. (For futher discussion of muzzle velocity, see Chapter 4.) The following equation for muzzle velocity is valid for our purposes:

MVV (m/s) = SHOOTING STRENGTH OF WPN + AMMUNITION EFFICIENCY

Tube wear, propellant efficiency, and projectile weight are the items normally accounted for in determination of a muzzle velocity. Other elements in the equation above **generally** have an effect not exceeding 1.5 m/s. As a matter of convenience, the other elements listed below are not individually measured, but their effects are realized to exist under the broader headings of shooting strength and ammunition efficiency.

SHOOTING STRENGTH OF WEAPONS

1. Tube wear
2. Manufacturer tolerances
3. Reaction to recoil

AMMUNITION EFFICIENCY

1. Propellant efficiency
2. Projectile efficiency
    a. Projectile weight (fuzed)
    b. Construction of
        (1) Rotating band
        (2) Bourrelet
        (3) Obturating band

a. Nature of Propellant and Projectile Movement.

(1) A propellant is a low-order explosive that burns rather than detonates. In artillery weapons using separate-loading ammunition, the propellant burns within a chamber formed by the obturator spindle assembly, powder chamber, rotating band, and base of the projectile. For cannons using semifixed ammunition, the chamber is formed by the shell casing and the base of the projectile. When the propellant is ignited by the primer, the burning propellant generates gases. When these gases develop enough pressure to overcome initial bore resistance, the projectile begins its forward motion.

(2) Several parts of the cannon tube affect interior ballistics. (See Figure 3-l.)

(a) The caliber of a tube is the inside diameter of the tube as measured between opposite lands.

(b) The breech recess receives the breechblock. The breech permits loading the howitzer from the rear.

(c) The powder chamber receives the complete round of ammunition. It is the portion of the tube between the gas check seat and the centering slope.

- The **gas check seat** is the tapered surface in the rear interior of the tube on weapons firing separate-loading ammunition. It seats the split rings of the obturating mechanism when they expand under pressure in firing. This expansion creates a metal-to-metal seal and prevents the escape of gases through the rear or the breech. Weapons firing semifixed ammunition do not have gas check seats since the expansion of the ease against the walls of the chamber provides a gas seal for-the breech.

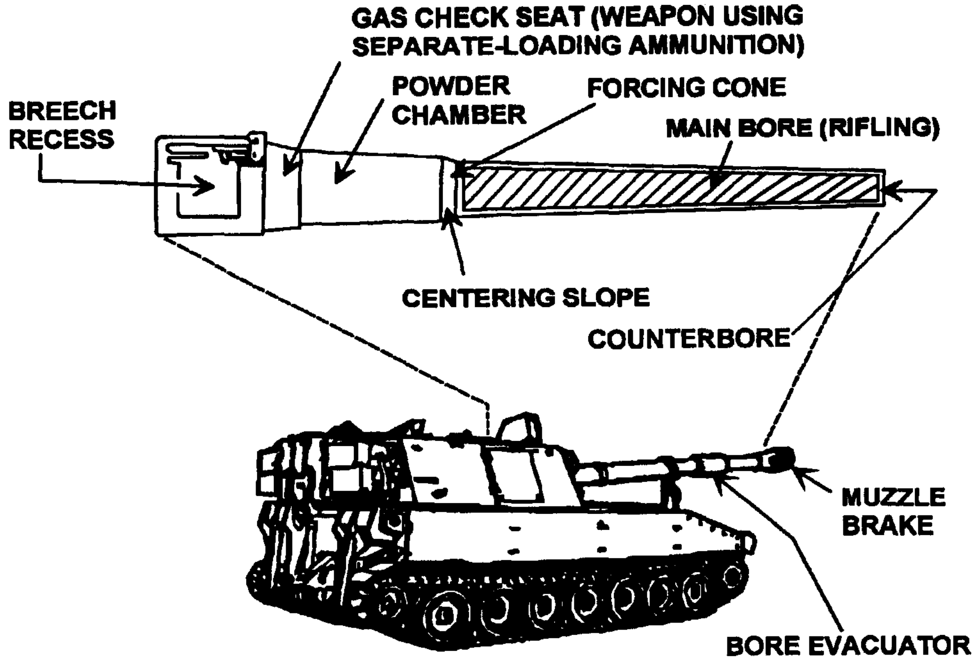


Figure 3-1. Cannon Tube.

- The **centering slope** is the tapered portion at or near the forward end of the chamber that causes the projectile to center itself in the bore during loading.

(d) The forcing cone is the tapered portion near the rear of the bore that allows the rotating band to be gradually engaged by the rifling, thereby centering the projectile in the bore.

(e) The bore is the rifled portion of the tube (lands and grooves). It extends from the forcing cone to the muzzle. The rifled portion of the tube imparts spin to the projectile increasing stability in flight. The grooves are the depressions in the rifling. The lands are the raised portions. These parts engrave the rotating band. All United States (US) howitzers have a right-hand twist in rifling.

(f) The bore evacuator is located on enclosed, self-propelled howitzers with semiautomatic breech mechanisms. It prevents contamination of the crew compartment by removing propellant gases from the bore after firing. The bore evacuator forces the gases to flow outward through the bore from a series of valves enclosed on the tube.

(g) The counterbore is the portion at the front of the bore from which the lands have been removed to relieve stress and prevents the tube from cracking.

(h) The muzzle brake is located at the end of the tube on some howitzers. As the projectile leaves the muzzle, the high-velocity gases strike the baffles of the muzzle brake and are deflected rearward and sideways. When striking the baffles, the gases exert a forward force on the baffles that partially counteracts and reduces the force of recoil.

(3) The projectile body has several components that affect ballistics. (See Figure 3-2.) Three of these affect interior ballistics--the bourrelet the rotating band and the obturating band.

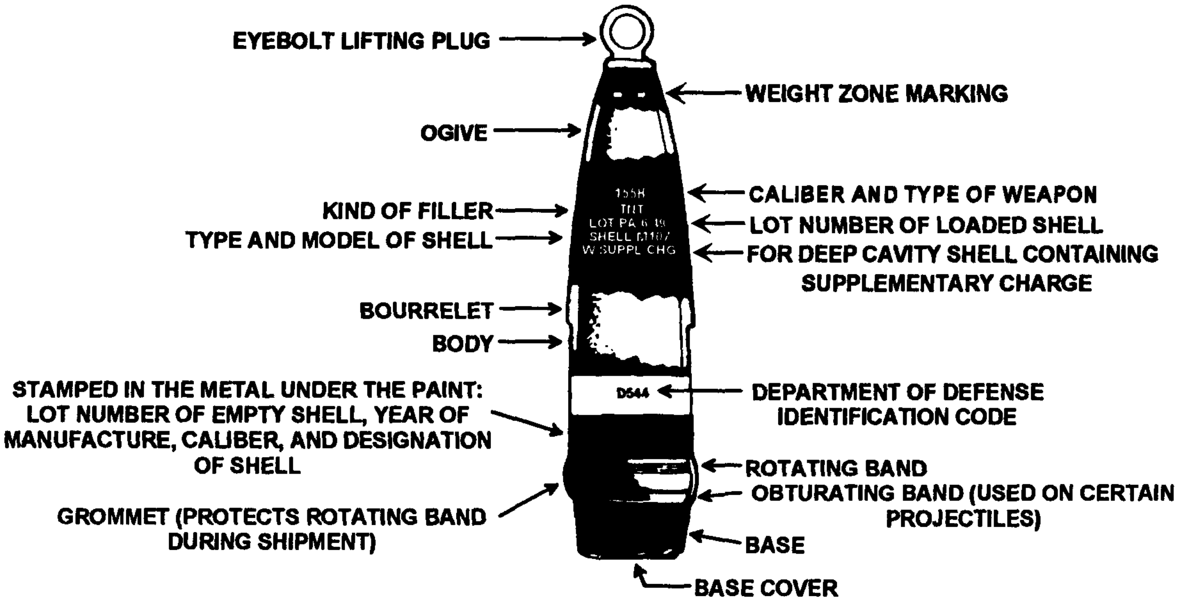


Figure 3-2. Projectile.

(a) The bourrelet is the widest part of the projectile and is located immediately to the rear of the ogive. The bourrelet centers the forward part of the projectile in the tube and bears on the lands of the tube. When the projectile is fired, only the bourrelet and rotating band bear on the lands of the tube.

(b) The rotating band is a band of soft metal (copper alloy) that is securely seated around the body of the projectile. It provides forward obturation (the forward gas-tight seal required to develop pressure inside the tube). The rotating band prevents the escape of gas pressure from around the projectile. When the weapon is fired, the rotating band contacts the lands and grooves and is pressed between them. As the projectile travels the length of the cannon tube, over the lands and grooves, spin is imparted. The rifling for the entire length of the tube must be smooth and free of burrs and scars. This permits uniform seating of the projectile and gives a more uniform muzzle velocity.

(c) The obturating band is a plastic band on certain projectiles. It provides forward obturation by preventing the escape of gas pressure from around the projectile.

(4) The sequence that occurs within the cannon tube is described below.

(a) The projectile is rammed into the cannon tube and rests on the bourrelet. The rotating band contacts the lands and grooves at the forcing cone.

(b) The propellant is inserted into the chamber.

(c) The propellant explosive train is initiated by the ignition of the primer. This causes the primer, consisting of hot gases and incandescent particles, to be injected into the igniter. The igniter burns and creates hot gases that flow between the propellant granules and ignite the granule surfaces; the igniter and propellant combustion products then act together, perpetuating the flame spread until all the propellant granules are ignited.

(d) The chamber is sealed, in the rear by the breech and obturator spindle group and forward by the projectile, so the gases and energy created by the primer, igniter, and propellant cannot escape. This results in a dramatic increase in the pressure and temperature within the chamber. The burning rate of the propellant is roughly proportional to the pressure, so the increase in pressure is accompanied by an increase in the rate at which further gas is produced.

(e) The rising pressure is moderated by the motion of the projectile along the barrel. The pressure at which this motion begins is the shot-start pressure. The projectile will then almost immediately encounter the rifling, and the projectile will slow or stop again until the pressure has increased enough to overcome the resistance in the bore. The rotating band and obturating band (if present) or the surface of the projectile itself, depending on design, will be engraved to the shape of the rifling. The resistance decreases, thereby allowing the rapidly increasing pressure to accelerate the projectile.

(f) As the projectile moves forward, it leaves behind an increasing volume to be filled by the high-pressure propellant gases. the propellant is still burning, producing high-pressure gases so rapidly that the motion of the projectile cannot fully compensate. As a result, the pressure continues to rise until the peak pressure is reached. The peak pressure is attained when the projectile has traveled about one-tenth of the total length of a full length howitzer tube.

(g) The rate at which extra space is being created behind the rapidly accelerating projectile then exceeds the rate at which high-pressure gas is being produced; thus the pressure begins to fall. The next stage is the all-burnt position at which the burning of the propellant is completed. However, there is still considerable pressure in the tube; therefore, for the remaining motion along the bore, the projectile continues to accelerate. As it approaches the muzzle, the propellant gases expand, the pressure falls, and so the acceleration lessens. At the moment the projectile leaves the howitzer, the pressure will have been reduced to about one sixth of the peak pressure. Only about one-third of the energy developed pushes the projectile. The other two-thirds is absorbed by the recoiling parts or it is lost because of heat and metal expansion.

(h) The flow of gases following the projectile out of the muzzle provides additional acceleration for a short distance (transitional ballistics), so that the full muzzle velocity is not reached until the projectile is some distance beyond the muzzle. The noise and shock of firing are caused by the jet action of the projectile as it escapes the flow of gases and encounters the atmosphere. After this, the projectile breaks away from the influence of the gun and begins independent flight.

(i) This entire sequence, from primer firing to muzzle exit, typically occurs within 15 milliseconds but perhaps as much as 25 milliseconds for a large artillery howitzer.

(5) Pressure travel curves are discussed below.

(a) Once the propellant ignites, gases are generated that develop enough pressure to overcome initial bore resistance, thereby moving the projectile. Two opposing forces act on a projectile within the howitzer. The first is a propelling force caused by the high-pressure propellant gases pushing on the base of the projectile. The second is a frictional force between the projectile and bore, which includes the high resistance during the engraving process, that opposes the motion of the projectile. The peak pressure, together with the travel of the projectile in the bore (pressure travel curve), determines the velocity at which the projectile leaves the tube.

(b) To analyze the desired development of pressure within the tube, we identify three types of pressure travel curves:

- An elastic strength pressure travel curve represents the greatest interior pressure that the construction of the tube (thickness of the wall of the powder chamber, thickness of the tube, composition of the tube or chamber, and so on) will allow. It decreases as the projectile travels toward the muzzle because the thickness of the tube decreases.

- A permissible pressure travel curve mirrors the elastic strength pressure travel curve and accounts for a certain factor of safety. It also decreases as the projectile travels through the tube because tube thickness decreases.

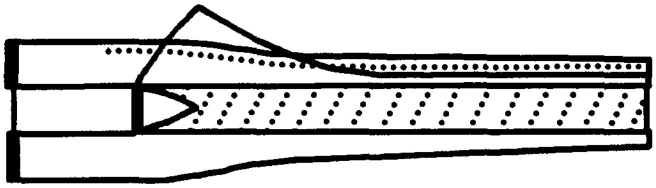
- An actual pressure travel curve represents the actual pressure developed during firing within the tube. Initially, pressure increases dramatically as the repelling charge explosive train initiated and the initial resistance of the rammed projectile is overcome. After that resistance is overcome, the actual pressure gradually decreases because of the concepts explained by Boyle's Law. (Generally, as volume increases, pressure decreases.) The actual pressure should never exceed the permissible pressure.

Figure 3-3 depicts different actual pressure travel curves that are discussed below.

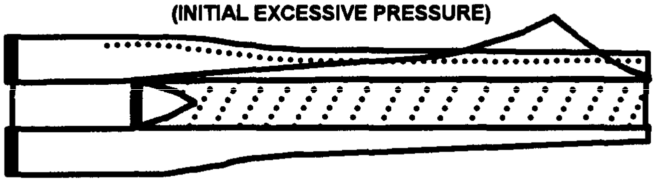
- **Initial Excessive Pressure.** This is undesirable pressure travel curve. It exceeds the elastic strength pressure and permissible pressure. Causes of this travel curve would be an obstruction in the tube, a dirty tube, an "extra" propellant placed in the chamber, an unfuzed projectile, or a cracked projectile.

- **Delayed Excessive Pressure.** This is an undesirable pressure travel curve. It exceeds the elastic strength pressure and remissible pressure. Causes that would result in this travel curve would be using wet powder or powder reversed.

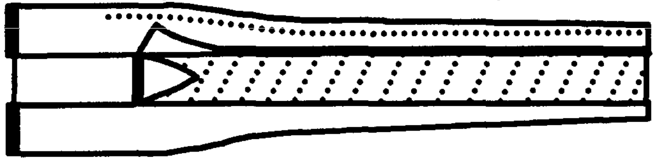
- **Desirable Pressure Travel Curve.** This curve does not exceed permissible pressure. It develops peak pressure at about one-tenth the length of the tube.



1 UNDESIRABLE PRESSURE TRAVEL CURVE
(INITIAL EXCESSIVE PRESSURE)



2 UNDESIRABLE PRESSURE TRAVEL CURVE
(DELAYED EXCESSIVE PRESSURE)



3 DESIRABLE PRESSURE TRAVEL CURVE

Figure 3-3. Pressure Travel Curves.

(6) The following general rules show how various factors tiect the velocity performance of a weapon projectile family-propellant type-charge combination

(a) An increase in the rate of propellant burning increases the resulting gas pressure developed within the chamber. An example of this is the performance of the multiperforated propellant grains used in white bag (WB) propellants. The result is that more gases are produced, gas pressure is increased, and the projectile develops a greater muzzle velocity. Damage to propellant grains, such as cracking and splitting from improper handling, also affect the rate of burn and thus the muzzle velocity.

(b) An increase in the size of the chamber without a corresponding increase in the amount of propellant decreases gas pressure; as a result, muzzle velocity will be less (Boyles Law).

(c) Gas escaping around the projectile decreases chamber pressure.

(d) An increase in bore resistance to projectile movement before peak pressure increases the pressure developed within the tube. Generally, this results in a dragging effect on the projectile, with a corresponding decrease in the developed muzzle velocity. Temporary variations in bore resistance can be caused by excessive deposits of residue within the cannon tube and on projectiles and by temperature differences between the inner and outer surfaces of the cannon tube.

b. Standard Muzzle Velocity.

(1) Applicable firing tables list the standard value of muzzle velocity for each charge. These standard values are based on an assumed set of standard conditions. These values are points of departure and not absolute standards. Essentially, we cannot assume that a given weapon projectile family-propellant type-charge combination when fired will produce the standard muzzle velocity.

(2) Velocities for each charge are indirectly established by the characteristics of the weapons. Cannons capable of high-angle fire (howitzers) require a greater choice in the number of charges than cannons capable of only low-angle fire (guns). This choice is necessary to achieve range overlap between charges in high-angle fire and the desired range-trajectory combination in low-angle fire. Other factors considered are the maximum range specified for the weapon, the maximum elevation and charge, and the maximum permissible pressure that the weapon can accommodate.

(3) Manufacturing specifications for ammunition include a requirement for velocity performance to meet certain tolerances. Ammunition lots are subjected to test firings, which include measuring the performance of a tested lot and comparing it to the performance of a control (reference) lot that is tested concurrently with the same weapon. An assumption built into the testing procedure is that both lots of ammunition will be influenced in the same manner by the performance of the tube. This assumption, although accurate in most instances, allows some error to be introduced in the assessment of the performance of the tested lot of propellant. In field conditions, variations in the performance of different projectile or propellant lots can be expected even though quality control has been exercised during manufacturing and testing of lots. In other words, although a howitzer develops a muzzle velocity that is 3 meters per second greater (or less) than standard with propellant lot G, it will not necessarily be the same with any other propellant lot. The optimum method for determining ammunition performance is to measure the performance of a particular projectile family-propellant lot-charge combination (calibration). However, predictions of the performance of a projectile family-propellant lot-charge group combination may be inferred with the understanding that they will not be as accurate as actual performance measurements.

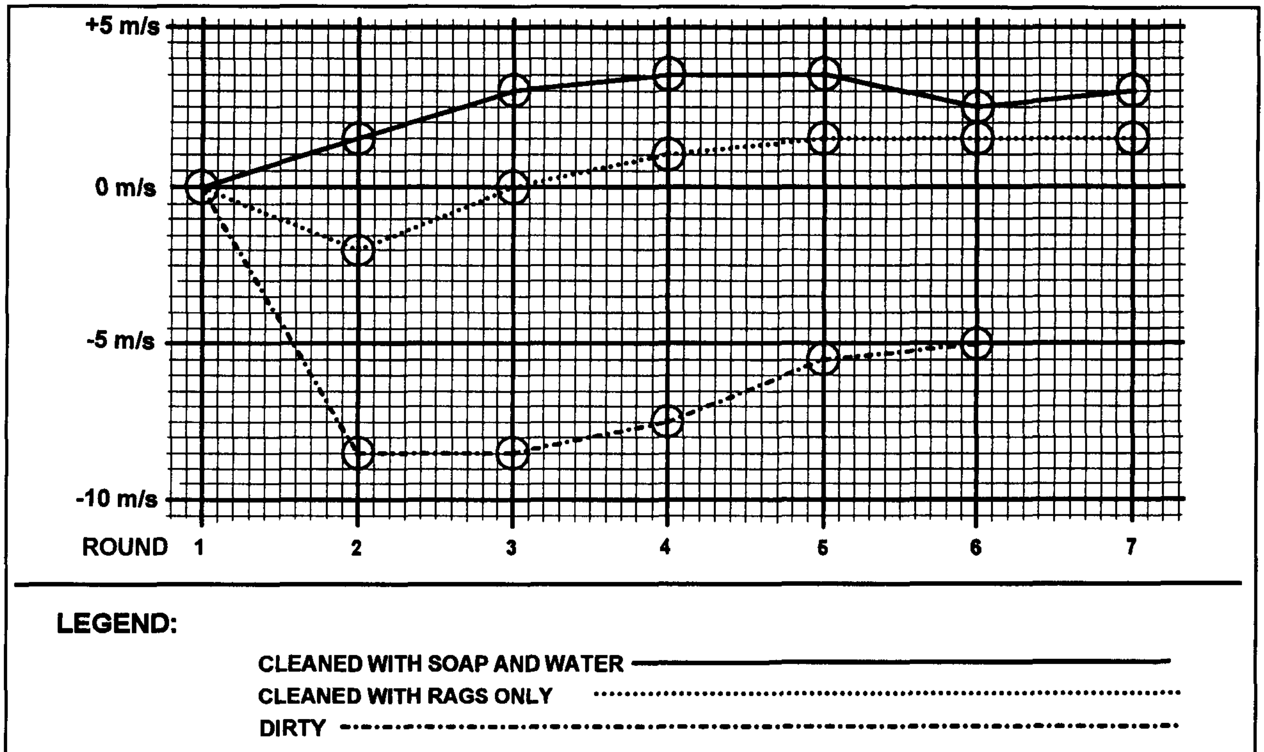
c. Factors Causing Nonstandard Velocities. Nonstandard muzzle velocity is expressed as a variation (plus or minus so many meters per second) from the accepted standard. Round-to-round corrections for dispersion cannot be made. Each of the following factors that cause nonstandard conditions is treated as a single entity assuming no influence from related factors.

(1) Velocity trends. Not all rounds of a series fired from the same weapon and using the same ammunition lot will develop the same muzzle velocity. Under most conditions, the first few rounds follow a somewhat regular pattern rather than the random pattern associated with normal dispersion. This phenomenon is called velocity trends (or velocity dispersion), and the magnitude varies with the cannon, charge, and tube condition at the time each round is fired. Velocity trends cannot be accurately predicted; thus, any attempt to correct for the effects of velocity trends is impractical. Generally, the magnitude and duration of velocity trends can be minimized when firing is started with a tube that is clean and completely free of oil. (See Figure 3-4.)

(2) Ammunition lots. Each ammunition, projectile, and propellant lot has its own mean performance level in relation to a common weapon. Although the round-to-round variations within a given lot of the same ammunition (ammo) types are similar, the mean velocity developed by one lot may differ significantly in comparison to that of another lot. With separate-loading ammunition, both the projectile and propellant lots must be identified. Projectile lots allow for rapid identification of weight differences. Although other projectile factors affect achieved muzzle velocity (such as, diameter and hardness of rotating band), the cumulative effect of these elements generally does not exceed 1.5 rids. As a matter of convenience and speed, they are ignored in the computation of firing data.

(3) Tolerances in new weapons. All new cannons of a given caliber and model will not necessarily develop the same muzzle velocity. In a new tube, the mean factors affecting muzzle velocity are variations in the size of the powder chamber and the interior dimensions of the bore. If a battalion equipped with new cannons fired all of them with a common lot of ammunition a variation of 4 meters per second between the cannon developing the greatest muzzle velocity and the cannon developing the lowest muzzle velocity would not be unusual. Calibration of all cannons allows the firing unit to compensate for small variations in the manufacture of cannon tubes and the resulting variation in developed muzzle velocity. The MVV caused by inconsistencies in tube manufacture remains constant and is valid for the life of the tube.

(4) Tube wear. Continued firing of a cannon wears away portions of the bore by the actions of hot gases and chemicals and movement of the projectile within the tube. These erosive actions are more pronounced when higher charges are fired. The greater the tube wear, the more the muzzle velocity decreases. Normal wear can be minimized by careful selection of the charge and by proper cleaning of both the tube and the ammunition.



NOTE: Tube at round 1 was cold and previously fired with charge 5.

Figure 3-4. Velocity Changes From Round 1, 105-mm Howitzers Firing Charge 5.

(5) Nonuniform ramming. Weak ramming decreases the volume of the chamber and thereby theoretically increases the pressure imparted to the projectile. This occurs because the pressure of a gas varies inversely with volume. Therefore, only a partial gain in muzzle velocity might be achieved. Of greater note is the improper seating of the projectile within the tube. Improper seating can allow some of the expanding gases to escape around the rotating band of the projectile and thus result in decreased muzzle velocity. The combined effects of a smaller chamber and escaping gases are difficult to predict. **Weak, nonuniform ramming results in an unnecessary and preventable increase in the size of the dispersion pattern.** Hard, uniform ramming is desired **for all** rounds. When semifixed ammunition is fired, the principles of varying the size of the chamber and escape of gases still apply, particularly when ammunition is fired through worn tubes. When firing semifixed ammunition, rearward obturation is obtained by the expansion of the cartridge case against the walls of the powder chamber. Proper seating of the cartridge case is important in reducing the escape of gases.

(6) Rotating bands. The ideal rotating band permits proper seating of the projectile within the cannon tube. Proper seating of the projectile allows forward obturation, uniform pressure buildup, and initial resistance to projectile movement within the tube. The rotating band is also designed to provide a minimum drag effect on the projectile once the projectile overcomes the resistance to movement and starts to move. Dirt or burrs on the rotating band may cause improper seating. This increases tube wear and contributes to velocity dispersion. If excessively worn, the lands may not engage the rotating band well enough to impart the proper spin to the projectile. Insufficient spin reduces projectile stability in flight and can result in dangerously erratic round performance. When erratic rounds occur or excessive tube wear is noted, ordnance teams should be requested to determine the serviceability of the tube.

(7) Propellant and projectile temperatures. Any combustible material burns more rapidly when heated before ignition. When a propellant burns more rapidly than would be expected under standard conditions, gases are produced more rapidly and the pressure imparted to the projectile is greater. As a result, the muzzle velocity will be greater than standard and the projectile will travel farther. Table E in the tabular firing tables lists the magnitude of change in muzzle velocity resulting from a propellant temperature that is greater or less than standard. Appropriate corrections can be extracted from that table; however, such corrections are valid only if they are determined relative to the true propellant temperature. The temperature of propellant in sealed containers remains fairly uniform though not necessarily at the standard propellant temperature (70 degrees Fahrenheit [F}). Once propellant has been unpacked, its temperature more rapidly approaches the air temperature. The time and type of exposure to the weather result in temperature variations from round to round and within the firing unit. It is currently impractical to measure propellant temperature and apply corrections for each round fired by each cannon. Positive action must be taken to maintain uniform projectile and propellant temperatures. Failure to do this results in erratic firing. The effect of an extreme change in projectile or propellant temperature can invalidate even the most recent corrections determined from a registration.

(a) Ready ammunition should be kept off the ground and protected from dirt, moisture, and direct rays of the sun. At least 6 inches of airspace should be between the ammunition and protective covering on the sides, 6 inches of dunnage should be on the bottom, and the roof should be 18 inches from the top of the stack. These precautions will allow propellant and projectile temperatures to approach the air temperature at a uniform rate throughout the firing unit.

(b) Propellant should be prepared in advance so that it is never necessary to fire freshly unpacked ammunition with ammunition that has been exposed to weather during a fire mission.

(c) Ammunition should be fired in the order in which it was unpacked.

(d) Propellant temperature should be determined from ready ammunition on a periodic basis, particularly if there has been a change in the air temperature.

(8) Moisture content of propellant. Changes in the moisture content of propellant are caused by improper protection from the elements or improper handling of the propellant. These changes can affect muzzle velocity. Since the moisture content cannot be measured or corrected for, **the propellant must be provided maximum protection from the elements and improper handling.**

(9) Position of propellant in the chamber. In fixed and semifixed ammunition the propellant has a relatively fixed position with respect to the chamber, which is formed by the cartridge case. In separate-loading ammunition, however, the rate at which the propellant burns and the developed muzzle velocity depends on how the cannoneer inserts the charge. To ensure proper ignition of the propellant he must insert the charge so that the base of the propellant bag is flush against the obturator spindle when the breech is closed. The cannoneer ensures this by placing the propellant flush against the Swiss groove (the cutaway portion in the powder chamber). The farther forward the charge is inserted, the slower the burning rate and the lower the subsequent muzzle velocity. An increase in the diameter of the propellant charge can also cause an increase in muzzle velocity. Loose tie straps or wrappings have the effect of increasing the diameter of the propellant charge. **Propellant charge wrappings should always be checked for tightness, even when the full propellant charge is used.**

(10) Weight of projectile. The weights of like projectiles vary within certain zones (normally termed square weight). The appropriate weight zone is stenciled on the projectile (in terms of so many squares). Some projectiles are marked with the weight in pounds. In general terms, **a heavier-than-standard projectile normally experiences a decrease in muzzle velocity.** This is because more of the force generated by the gases is used to overcome the initial resistance to movement. A lighter-than-standard projectile generally experiences an increase in velocity.

NOTE: Copperhead projectiles are not marked with weight in pounds. The precision manufacturing process used guarantees a weight of 137.6 pounds.

(11) Coppering. When the projectile velocity within the bore is great, sufficient friction and heat are developed to remove the outer surface of the rotating band. Material left is a thin film of copper within the bore and is known as coppering. This phenomenon occurs in weapons that develop a high muzzle velocity and when high charges are fired. The amount of copper deposited varies with velocity. Firing higher charges increases the amount of copper deposited on the bore surfaces, whereas firing lower charges reduces the effects of coppering. Slight coppering resulting from firing a small sample of rounds at higher charges tends to increase muzzle velocity. Erratic velocity performance is a result of excessive coppering whereby the resistance of the bore to projectile movement is affected. Excessive coppering must be removed by ordnance personnel.

(12) Propellant residue. Residue from burned propellant and certain chemical agents mixed with the expanding gases are deposited on the bore surface in a manner similar to coppering. Unless the tube is properly cleaned and cared for, this residue will accelerate tube wear by causing pitting and augmenting the abrasive action of the projectile.

(13) Tube conditioning. The temperature of the tube has a direct bearing on the developed muzzle velocity. A cold tube offers a different resistance to projectile movement and is less susceptible to coppering, even at high velocities. **In general, a cold tube yields more range dispersion; a hot tube, less range dispersion.**

(14) Additional effects in interior ballistics. The additional effects include tube memory and tube jump.

(a) Tube memory is a physical phenomenon of the cannon tube tending to react to the firing stress in the same manner for each round, even after changing charges. It seems to “remember” the muzzle velocity of the last charge fired. For example, if a fire mission with charge 6 M4A2 is followed by a fire mission with charge 4 M4A2, the muzzle velocity of the first round of charge 4 may be **unpredictably** higher. The inverse is also true.

(b) Tube jump occurs as the projectile tries to maintain a straight line when exiting the muzzle. This phenomenon causes the tube to jump up when fired and may cause tube displacement.

3-2. Transitional Ballistics

Sometimes referred to as intermediate ballistics, this is the study of the transition from interior to exterior ballistics. Transitional ballistics is a complex science that involves a number of variables that are not fully understood; therefore, it is not an exact science. What is understood is that when the projectile leaves the muzzle, it receives a slight increase in MV from the escaping gases. Immediately after that, its MV begins to decrease because of drag.

3-3. Exterior Ballistics

Exterior ballistics is the science that deals with the factors affecting the motion of a projectile after it leaves the muzzle of a piece. At that instant, the total effects of interior ballistics in terms of developed muzzle velocity and spin have been imparted to the projectile. Were it not for gravity and the effects of the atmosphere, the projectile would continue indefinitely at a constant velocity along the infinite extension of the cannon tube. The discussion of exterior ballistics in the following paragraphs addresses elements of the trajectory, the trajectory in a vacuum, the trajectory within a standard atmosphere, and the factors that affect the flight of the projectile.

a. Trajectory Elements. The trajectory is the path traced by the center of gravity of the projectile from the origin to the level point. The elements of a trajectory are classified into three groups--intrinsic, initial, and terminal elements.

(1) Intrinsic elements. Elements that are characteristic of any trajectory, by definition, are intrinsic elements. (See Figure 3-5.)

(a) The origin is the location of the center of gravity of the projectile when it leaves the muzzle. It also denotes the center of the muzzle when the piece has been laid.

(b) The ascending branch is the part of the trajectory that is traced as the projectile rises from the origin.

(c) The summit is the highest point of the trajectory.

(d) The maximum ordinate is the difference in altitude (alt) between the origin and the summit.

(e) The descending branch is the part of the trajectory that is traced as the projectile is falling.

(f) The level point is the point on the descending branch that is the same altitude as the origin.

(g) The base of the trajectory is the straight line from the origin to the level point.

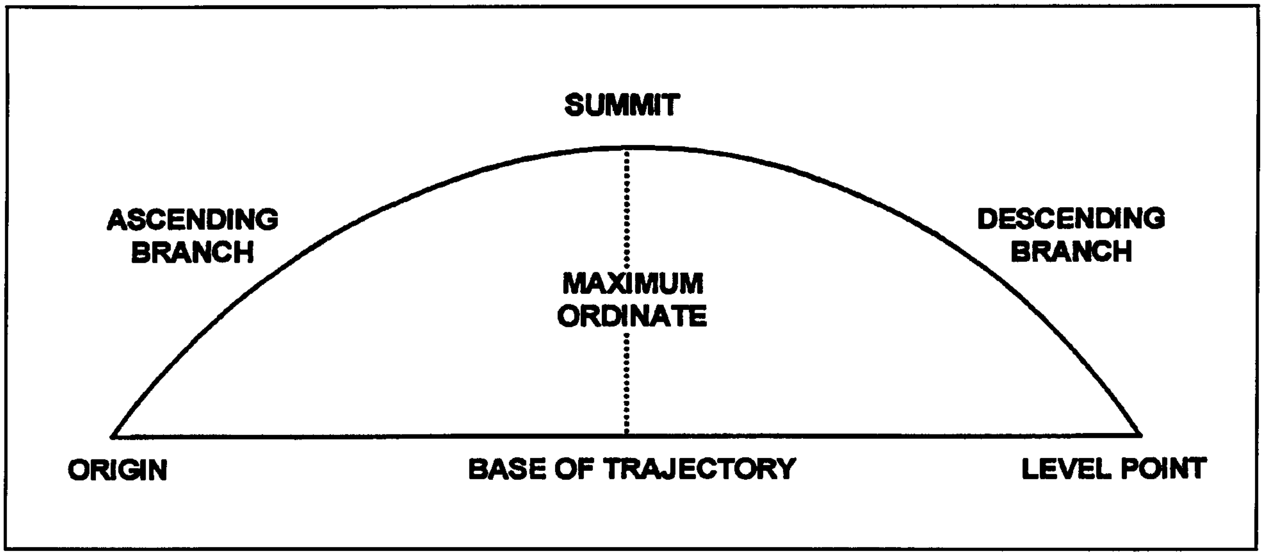


Figure 3-5. Intrinsic Elements of the Trajectory.

(2) Initial elements. Elements that are characteristic at the origin of the trajectory are initial elements. (See Figure 3-6.)

(a) When the piece is laid, the line of elevation is the axis of the tube extended.

(b) The line of departure is a line tangent to the trajectory at the instant the projectile leaves the tube.

(c) Jump is the displacement of the line of departure from the line of elevation that exists at the instant the projectile leaves the tube.

(d) The angle of site is the smaller angle in a vertical plane from the base of the trajectory to a straight line joining the origin and the target. Vertical interval is the difference in altitude between the target and the origin.

(e) The complementary angle of site is an angle that is algebraically added to the angle of site to compensate for the nonrigidity of the trajectory.

(f) Site is the algebraic sum of the angle of site and the complementary angle of site. Site is computed to compensate for situations in which the target is not at the same altitude as the battery.

(g) Complementary range is the number of meters (range correction) equivalent to the number of mils of complementary angle of site.

(h) The angle of elevation is the vertical angle between the base of the trajectory and the axis of the bore required for a projectile to achieve a prescribed range under standard conditions.

(i) The quadrant elevation is the angle at the origin measured from the base of the trajectory to the line of elevation. It is the algebraic sum of site and the angle of elevation.

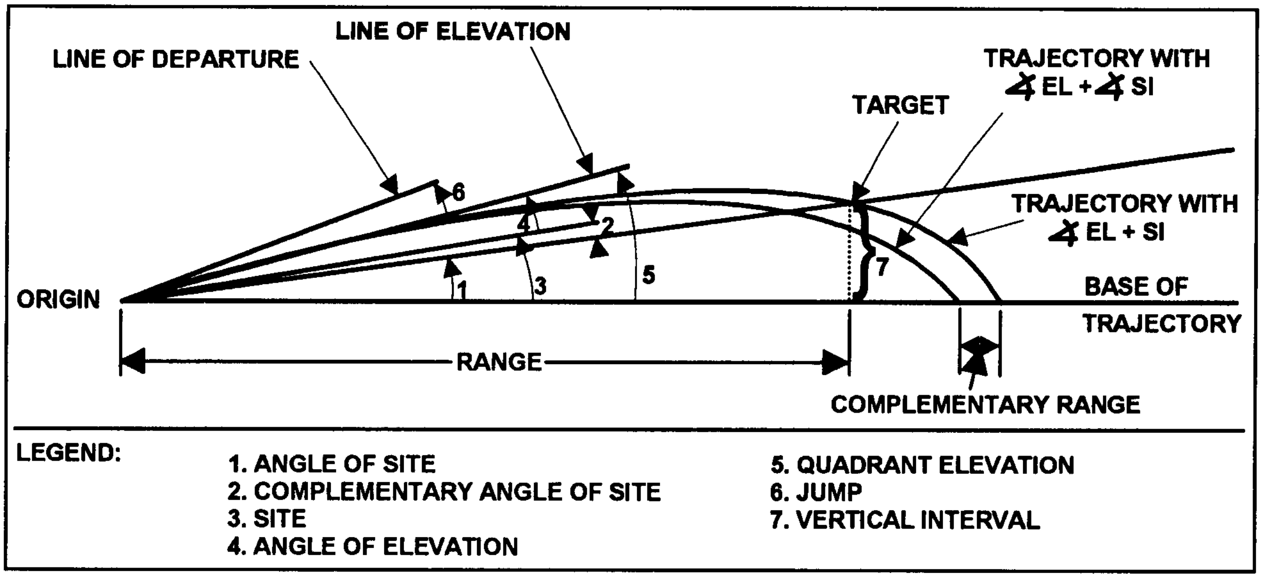


Figure 3-6. Initial Elements of the Trajectory.

(3) Terminal elements. Elements that are characteristic at the point of impact are terminal elements. (See Figure 3-7.)

(a) The point of impact is the point at which the projectile strikes the target area. (The point of burst is the point at which the projectile bursts in the air.)

(b) The line of fall is the line tangent to the trajectory at the level point.

(c) The angle of fall is the vertical angle at the level point between the line of fall and the base of the trajectory.

(d) The line of impact is a line tangent to the trajectory at the point of impact.

(e) The angle of impact is the acute angle at the point of impact between the line of impact and a plane tangent to the surface at the point of impact. This term should not be confused with angle of fall.

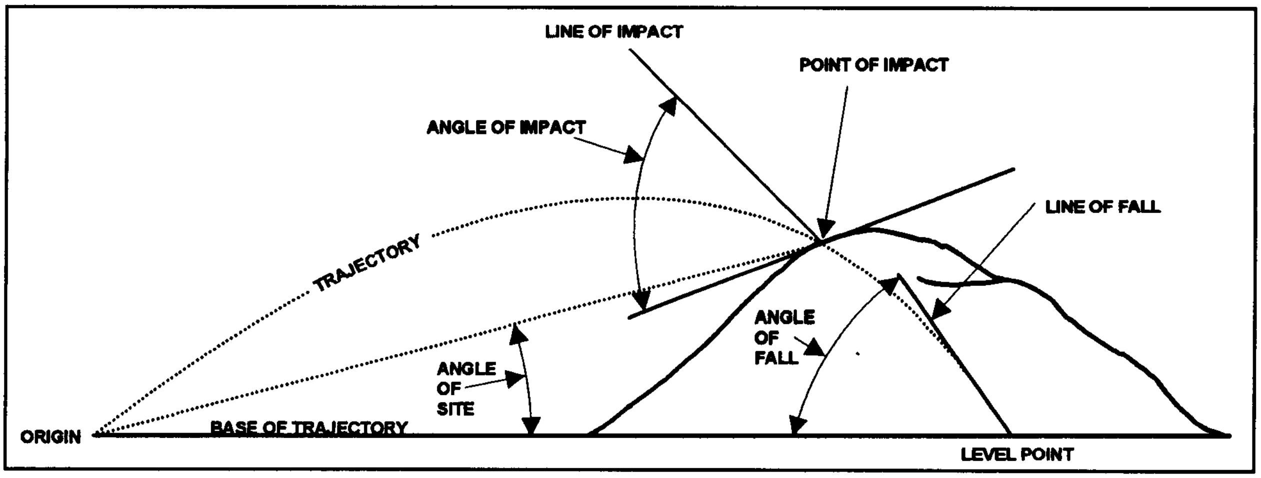


Figure 3-7. Terminal Elements of the Trajectory.

b. Trajectory in a Vacuum.

(1) If a round were fired in a vacuum, gravity would cause the projectile to return to the surface of the earth. The path or trajectory of the projectile would be simple to trace. All projectiles, regardless of size, shape, or weight, would follow paths of the same shape and would achieve the same range for a given muzzle velocity and quadrant elevation.

(2) The factors used to determine the data needed to construct a firing table for firing in a vacuum are the angle of departure, muzzle velocity, and acceleration caused by the force of gravity. The initial velocity imparted to a round has two components--horizontal velocity and vertical velocity. The relative magnitudes of horizontal and vertical components vary with the angle of elevation. For example, if the elevation were zero, the initial velocity imparted to the round would be horizontal in nature and there would be no vertical component. If, on the other hand, the elevation were 1,600 mils (disregarding the effects of rotation of the earth), the initial velocity would be vertical and there would be no horizontal component.

(3) Gravity causes a projectile in flight to fall to the earth. Because of gravity, the height of the projectile at any instant is less than it would be if no such force were acting on it. In a vacuum, the vertical velocity would decrease from the initial velocity to zero on the ascending branch of the trajectory and increase from zero to the initial velocity on the descending branch, Zero vertical velocity would occur at the summit of the trajectory. For every vertical velocity value on the upward leg of the ascending branch there is an equal vertical velocity value downward on the descending branch. Since there would be no resistance to the forward motion of the projectile in a vacuum, the horizontal velocity component would be a constant. The acceleration caused by the force of gravity (9.81 m/s) affects only the vertical velocity.

c. Trajectory in a Standard Atmosphere.

(1) The resistance of the air to projectile movement depends on the air movement, density, and temperature. As a point of departure for computing firing tables, assumed conditions of air density and air temperature with no wind are used. The air structure is called the standard atmosphere.

(2) The most apparent difference between the trajectory in a vacuum and the trajectory in the standard atmosphere is a net reduction in the range achieved by the projectile. A comparison of the flight of the projectile in a vacuum and in the standard atmosphere is shown in Figure 3-8.

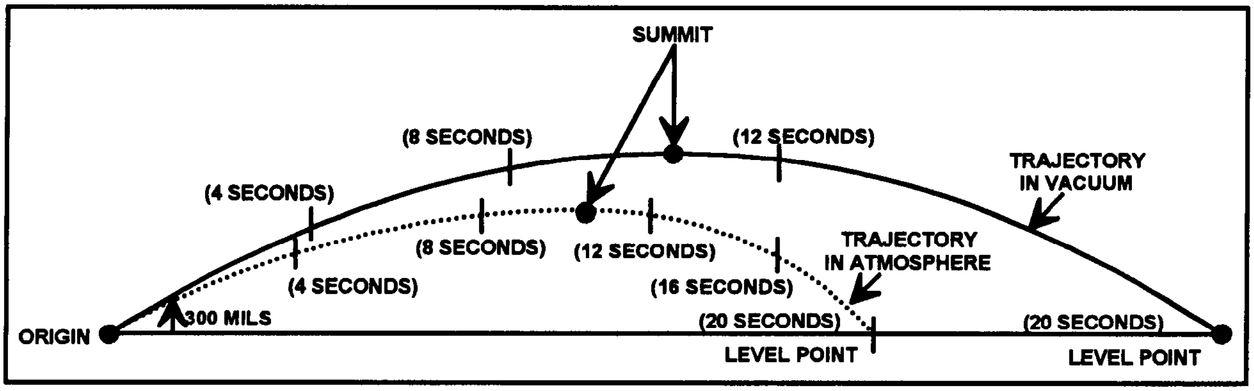


Figure 3-8. Trajectory in a Standard Atmosphere and in a Vacuum.

(3) The difference in range is due to the horizontal velocity component in the standard atmosphere no longer being a constant value. The horizontal velocity component is continually decreased by the retarding effect of the air. The vertical velocity component is also afected by air resistance. The trajectory in the standard atmosphere has the following characteristic differences from the trajectory in a vacuum:

(a) The velocity at the level point is less than the velocity at the origin.

(b) The mean horizontal velocity of the projectile beyond the summit is less than the mean velocity before the projectile reaches the summit; therefore, the projectile travels a shorter horizontal distance. Hence, the descending branch is shorter than the ascending branch. The angle of fall is greater than the angle of elevation.

(c) The spin (rotational motion) initially imparted to the projectile causes it to respond differently in the standard atmosphere because of air resistance. A trajectory in the standard atmosphere, compared to a trajectory in a vacuum, will be shorter and lower at any specific point along the trajectory for the following reasons:

- Horizontal velocity is not a constant value; it decreases with each succeeding time interval.
- Vertical velocity is affected by both gravity and the effects of the atmosphere on the projectile.
- The summit in a vacuum is midway between the origin and the level point; in the standard atmosphere, it is actually nearer the level point.
- The angle of fall in a vacuum is equal to the angle of elevation; in the standard atmosphere, it is greater.

d. Relation of Air Resistance and Projectile Efficiency to Standard Range.

(1) This paragraph concerns only those factors that establish the relationship between the standard range, elevation, and achieved range.

(a) The standard (chart) range is the range opposite a given elevation in the firing tables. It is assumed to have been measured along the surface of a sphere concentric with the earth and passing through the muzzle of a weapon. For all practical purposes, standard range is the horizontal distance from the origin of the trajectory to the level point.

(b) The achieved range is the range attained as a result of firing the cannon at a particular elevation. If actual firing conditions duplicate the ballistic properties and met conditions on which the firing tables are based, then the achieved range and the standard range will be equal.

(c) The corrected range is the range corresponding to the elevation that must be fired to reach the target.

(2) Air resistance affects the flight of the projectile both in range and in direction. The component of air resistance in the direction opposite that of the forward motion of the projectile is called drag. Because of drag, both the horizontal and vertical components of velocity are less at any given time along the trajectory than they would be if drag was zero (as it would be in a vacuum). This decrease in velocity varies directly in magnitude with drag and inversely with the mass of the projectile. Several factors considered in the computation of drag areas follows:

(a) Air density. The drag of a given projectile is proportional to the density of the air through which it passes. For example, an increase in air density by a given percentage increases drag by the same percentage. Since the air density at a specific place, time, and altitude varies widely, the standard trajectories reflected in the firing tables were computed with a fixed relationship between air density and altitude.

(b) Velocity. The faster a projectile moves, the more the air resists its motion. Examination of a set of firing tables reveals that given a constant elevation, the effect of a 1 percent change in air density (and corresponding 1 percent increase in drag) increases with an increase in charge (with the greater muzzle velocity). The drag is approximately proportional to the square of the velocity except when velocity approaches the speed of sound. At the speed of sound, drag increases more rapidly because of the increase in pressure behind the sound wave.

(c) Projectile diameter. Two projectiles of identical shape but of different size will not experience the same drag. For example, a large projectile will offer a larger area for the air to act upon; thus, its drag will be increased by this factor. The drag of projectiles of the same shape is assumed to be proportional to the square of the projectile diameter.

(d) Ballistic coefficient. The ballistic coefficient of a projectile is a measure of its relative efficiency in overcoming air resistance. An increase in the ballistic coefficient reduces the effect of drag and consequently increases range. The reverse is true for a decrease in the ballistic coefficient. The ballistic coefficient can be increased by increasing the ratio of the weight of the projectile to the square of its diameter. It can also be increased by improving the shape of the projectile.

(e) Drag coefficient. The drag coefficient combines several ballistic properties of typical projectiles. These properties include yaw (the angle between the direction of motion and the axis of the projectile) and the ratio of the velocity of the projectile to the speed of sound. Drag coefficients, which have been computed for many projectile types, simplify the work of ballisticians. When a projectile varies slightly in shape from one of the typical projectile types, the drag coefficient can be determined by computing a form factor for the projectile and multiplying the drag coefficient of a typical projectile type by the form factor.

e. Deviations From Standard Conditions. Firing tables are based on actual firings of a piece and its ammunition correlated to a set of standard conditions. Actual firing conditions, however, will never equate to standard conditions. These deviations from standard conditions, if not corrected for when computing firing data will cause the projectile to impact at a point other than the desired location. Corrections for nonstandard conditions are made to improve accuracy.

(1) Range effects. Some of the deviations from standard conditions affecting range are:

- Muzzle velocity.
- Projectile weight.

- Range wind.
- Air temperature.
- Air density.
- Rotation of the earth.

(2) Deflection effects. Some of the deviations from the standard conditions affecting deflection are:

- Drift.
- Crosswind.
- Rotation of the earth.

3-4. Dispersion and Probability

If a number of rounds of ammunition of the same caliber, lot, and charge are fired from the same position with identical settings used for deflection and quadrant elevation, the rounds will not all impact on a single point but will fall in a scattered pattern. In discussions of artillery fire, this phenomenon is called dispersion, and the array of bursts on the ground is called the dispersion pattern.

3-5. Causes of Dispersion

a. The points of impact of the projectiles will be scattered both in deflection and in range. Dispersion is caused by inherent (systemic) errors. It should never be confused with round-to-round variations caused by either human or constant errors. Human errors can be minimized through training and supervision. Corrections to compensate for the effects of constant errors can be determined from the TFT. Inherent errors are beyond control or are impractical to measure. Examples of inherent errors are as follows:

(1) Conditions in the bore. The muzzle velocity achieved by a given projectile is affected by the following:

- Minor variations in the weight of the projectile, form of the rotating band, and moisture content and temperature of the propellant grains.
- Differences in the rate of ignition of the propellant.
- Variations in the arrangement of the propellant grains.
- Differences in the rate of ignition of the propellant.
- Variations in the ramming of the projectile.
- Variations in the temperature of the bore from round to round.

For example, variations in the bourrelet and rotating band may cause inaccurate centering of the projectile, which can result in a loss in achieved range because of instability in flight.

(2) Conditions in the carriage. Deflection and elevation are affected by the following:

- Play (looseness) in the mechanisms of the carriage.
- Physical limitations of precision in setting values of deflection and quadrant elevation on the respective scales.
- Nonuniform reactions to firing stress.

(3) Conditions during flight. The flight of the projectile may be affected by the difference in air resistance created by variations in the weight, achieved muzzle velocity, and projectile. Also, the projectile may be affected by minor variations in wind, air density or air pressure, and air temperature from round to round.

b. The distribution of bursts (dispersion pattern) in a given sample of rounds is roughly elliptical (Figure 3-9) in relation to the line of fire.

c. A rectangle constructed around the dispersion area (excluding any erratic rounds) is called the dispersion rectangle, or 100 percent rectangle. (See Figure 3-10.)

3-6. Mean Point of Impact

For any large number of rounds fired, the average (or mean) location of impact can be determined by drawing a diagram of the pattern of bursts as they appear on the ground. A line drawn perpendicular to the line of fire can be used to divide the sample rounds into two equal groups. Therefore, half of the rounds will be over this line when considered in relation to the weapon. The other half of the rounds will be short of this line in relation to the weapon. This dividing line represents the mean range of the sample and is called the mean range line. A second line can be drawn parallel to the line of fire, again dividing the sample into two equal groups. Half of the rounds will be to the right of this line, and half will be to the left. This line represents the mean deflection of the sample and is called the mean deflection line. (See Figure 3-9.) The intersection of the two lines is the mean point of impact (MPI). (See Figure 3-10.)

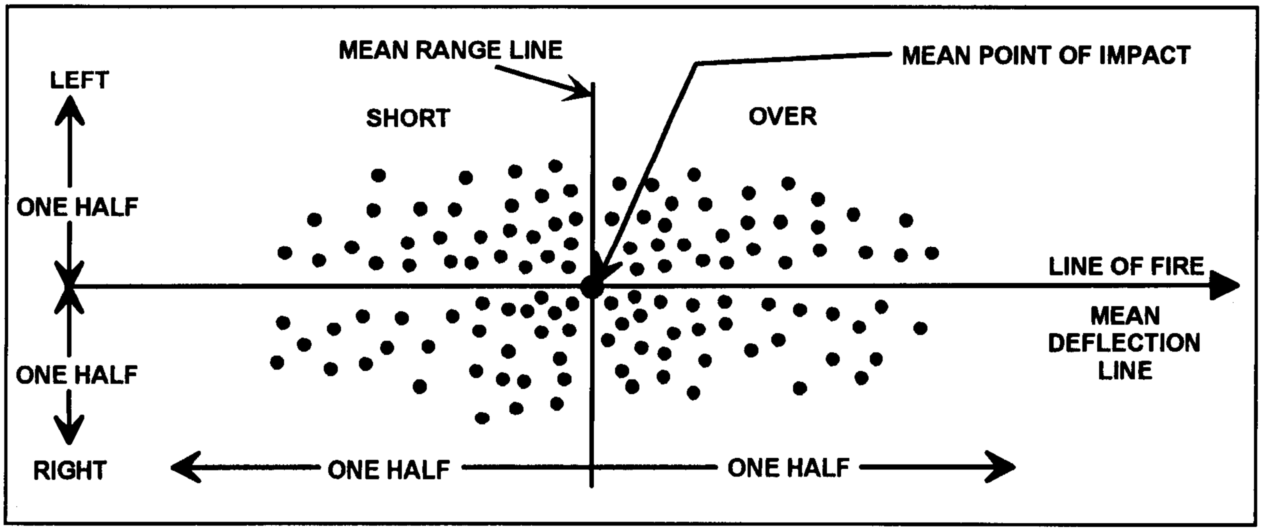


Figure 3-9. Dispersion Pattern.

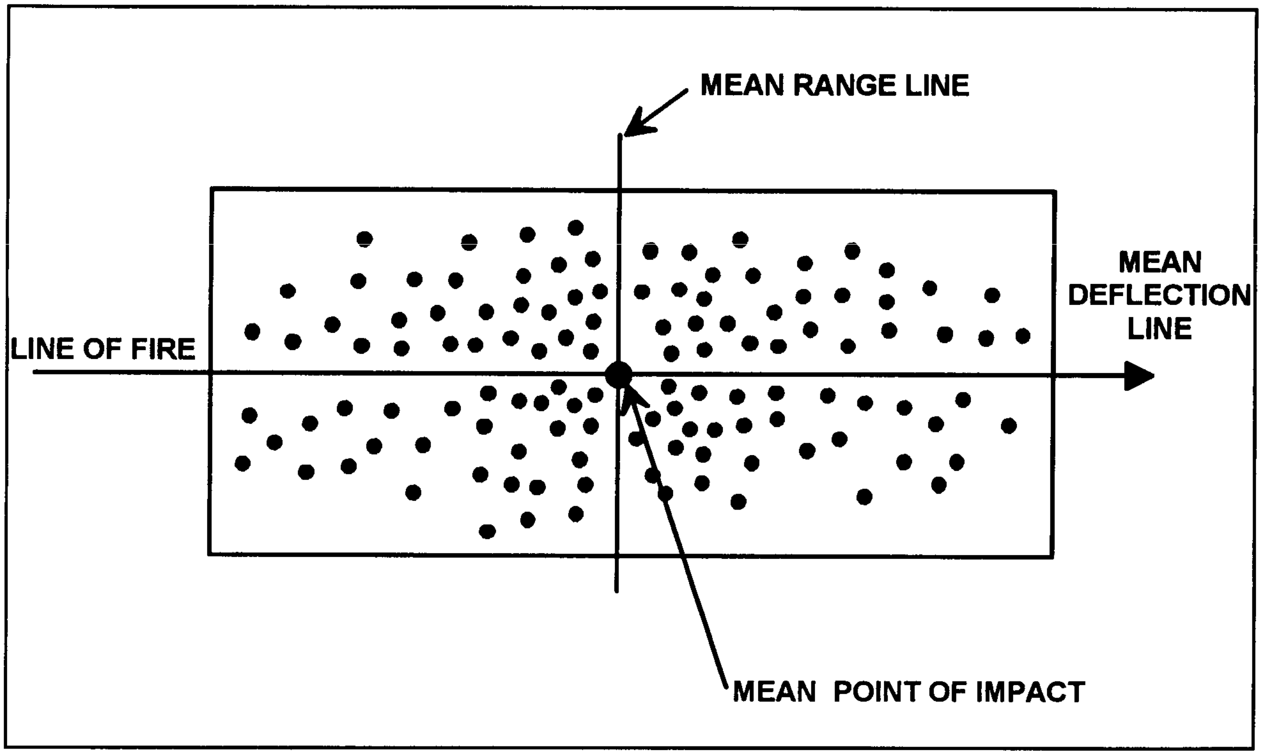


Figure 3-10. Dispersion (100 Percent) Rectangle.

3-7. Probable Error

Probable error is nothing more than an error that is exceeded as often as it is not exceeded. For example, in Figure 3-11, consider only those rounds that have impacted over the mean range line (line AB). These rounds all manifest errors in range, since they all impacted over the mean range line. Some of the rounds are more in error than others. At a point beyond the MPI, a second line can be drawn perpendicular to the line of fire to divide the "ovens" into two equal groups (line CD, Figure 3-11). When the distance from the MPI to line CD is used as a measure of probable error, it is obvious that half of the overs show greater magnitude of error than the other half. This distance is one probable error in range. The range probability curve expresses the following:

a. In a large number of samples, errors in excess and errors in deficiency are equally frequent (probable) as shown by the symmetry of the curve.

b. The errors are not uniformly distributed. Small errors occur more frequently than large errors as shown by the greater number of occurrences near the mean point of impact.

3-8. Dispersion Zones

If the dispersion rectangle is divided evenly into eight zones in range with the value for 1 probable error in range (PER) used as the unit of measure, the percentage of rounds impacting within each zone is as indicated in Figure 3-12. The percentage of rounds impacting within each zone has been determined through experimentation. By definition of probable error, 50 percent of all rounds will impact within 1 probable error in range or deflection of the mean point of impact (25 percent over and 25 percent short or 25 percent left and 25 percent right).

3-9. Range Probable Error

The values for range probable error at various ranges are given in Table G of the tabular firing tables (TFT). These values may be used as an index of the precision of the piece at a particular charge and range. The values for range probable error are listed in meters. Firing Table (FT) values have been determined on the basis of actual firing of ammunition under controlled conditions. For example, FT 155-AM-2 shows that the value of range probable error for charge 5 green bag (GB) at a range of 6,000 meters is 15 meters. On the basis of the 100 percent rectangle, 50 percent of the rounds will impact within 15 meters (over and short) of the mean range line, 82 percent will impact within 30 meters (over and short), 96 percent will impact within 45-meters (over and short), and 100 percent will impact within 60 meters.

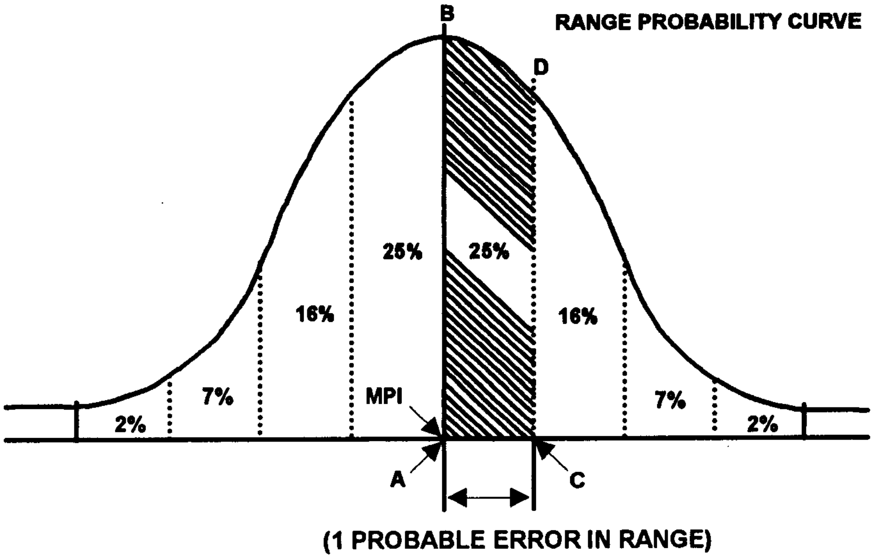
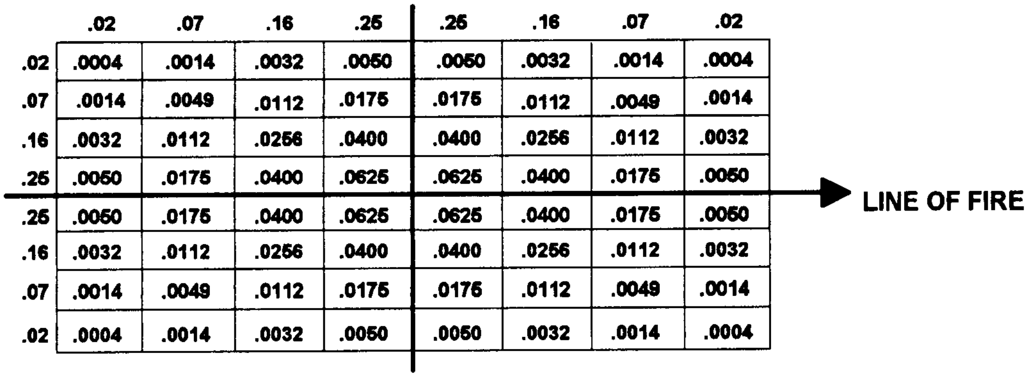


Figure 3-11. Probable Error.



	.02	.07	.16	.25	.25	.16	.07	.02
.02	.0004	.0014	.0032	.0050	.0050	.0032	.0014	.0004
.07	.0014	.0049	.0112	.0175	.0175	.0112	.0049	.0014
.16	.0032	.0112	.0256	.0400	.0400	.0256	.0112	.0032
.25	.0050	.0175	.0400	.0625	.0625	.0400	.0175	.0050
.25	.0050	.0175	.0400	.0625	.0625	.0400	.0175	.0050
.16	.0032	.0112	.0256	.0400	.0400	.0256	.0112	.0032
.07	.0014	.0049	.0112	.0175	.0175	.0112	.0049	.0014
.02	.0004	.0014	.0032	.0050	.0050	.0032	.0014	.0004

Figure 3-12. Dispersion Zones.

3-10. Fork

The term *fork* is used to express the change in elevation (in mils) needed to move the mean point of impact 4 probable errors in range. The values of fork are listed in Table F of the firing tables. For example, FT 155-AM-2 shows that the value of fork for a howitzer firing charge 5GB at a range of 6,000 meters is 4 mils. On the basis of the value for probable error in range (paragraph 3-9), adding 4 mils to the quadrant elevation would cause the MPI to move 60 meters. Fork is used in the computation of safety data (executive officer's minimum QE).

3-11. Deflection Probable Error

The values for probable error in deflection (PED) are listed in Table G of the firing tables. For artillery cannons, the deflection probable error is considerably smaller than the range probable error. Values for PED are listed in meters. With the same parameters as those used in paragraph 3-9, the deflection probable error is 4 meters. Therefore, 50 percent of the rounds will impact within 4 meters of the mean deflection line (left and right); 82 percent, within 8 meters (left and right); 96 percent, within 12 meters (left and right); and 100 percent, within 16 meters.

3-12. Time-To-Burst Probable Error

The values of time-to-burst probable error (PETB) (Figure 3-13) are listed in Table G of the firing tables. Each of these values is the weighted average of the precision of a time fuze timing mechanism in relation to the actual time of flight of the projectile. For example, if a 155-mm howitzer fires charge 5GB at a range of 6,000 meters, the value for probable error in time to burst is 0.11 second. As in any other dispersion pattern, 50 percent of the rounds will function within 0.11 second; 82 percent, within 0.22 second; 96 percent, within 0.33 second; and 100 percent within 0.44 second of the mean fuze setting.

3-13. Height-Of-Burst Probable Error

With the projectile fuzed to burst in the air, the height-of-burst probable error (PEHB) (Figure 3-13) is the vertical component of 1 time-to-burst probable error. The height-of-burst probable error reflects the combined effects of dispersion caused by variations in the functioning of the time fuze and dispersion caused by the conditions described in paragraph 3-5(a). The values listed (in meters) follow the same pattern of distribution as for those discussed for range dispersion. These values are listed in Table G of the firing tables.

3-14. Range-To-Burst Probable Error

Range-to-burst probable error (PERB) (Figure 3-13) is the horizontal component of 1 time-to-burst probable error. When this value is added to or subtracted from the expected range to burst, it will produce an interval along the line of fire that should contain 50 percent of the rounds fired. These values are listed in Table G of the firing tables.

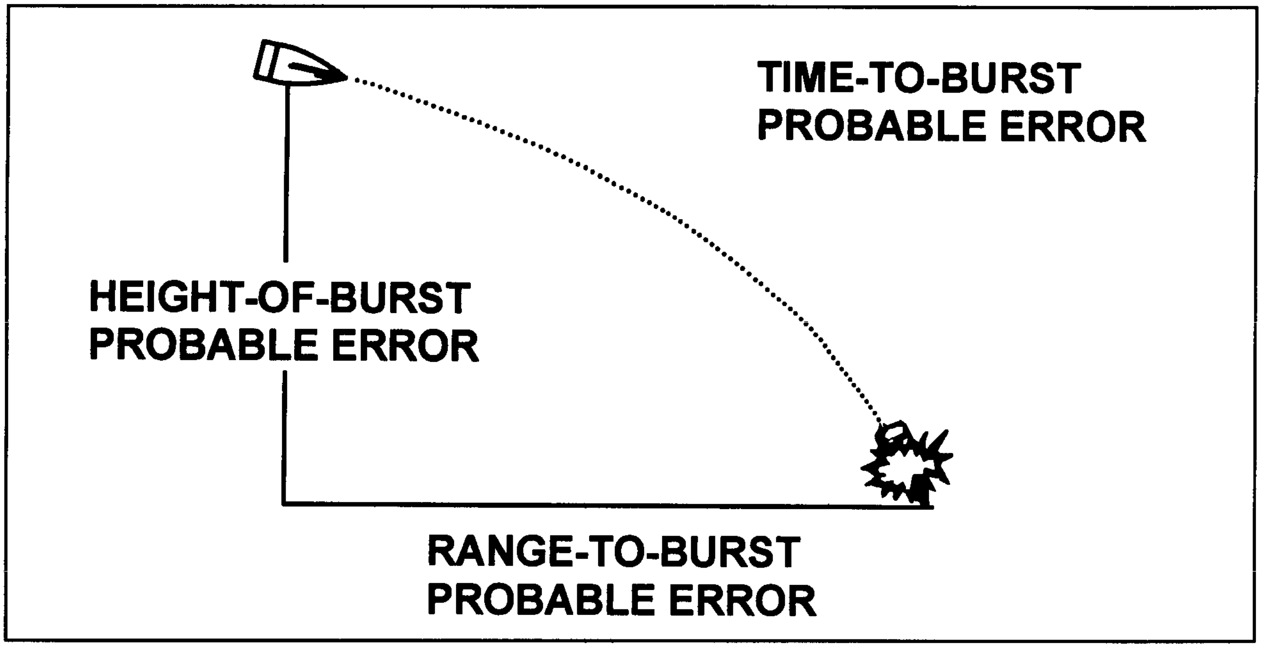


Figure 3-13. Comparison of PE_{HB}, PE_{RB}, and PE_{TB}.

Chapter 4

MUZZLE VELOCITY MANAGEMENT

The achieved muzzle velocity is the result of forces acting on the projectile. To obtain accurate artillery fire, the performance of the weapon projectile family-propellant type-charge combination must be known. If it is not known, the result can be reduced effects on the target or friendly casualties (for example, danger close, final protective fire [FPF], converged sheafs, and so on). Firing tables give standard muzzle velocities for a standard weapon firing standard ammunition under standard conditions. However, muzzle velocities achieved in actual firing may differ from the standard muzzle velocities because of variations in the manufacture of the weapon and ammunition, wear in the weapon tube, projectile weight, propellant temperature, propellant lot efficiency, or a combination of these factors. The M90 velocimeter enables a firing unit to continually update muzzle velocity data. This chapter describes muzzle velocity management with the M90 velocimeter.

4-1. Muzzle Velocity Terms

The following terms are associated with muzzle velocity management.

a. Muzzle velocity-- the velocity achieved by a projectile as it leaves the muzzle of the weapon (measured in meters per second).

b. Standard muzzle velocity-- An established muzzle velocity used for comparison. It is dependent upon the weapon system, propellant type, charge, and projectile. It is also referred to as reference muzzle velocity.

c. Muzzle velocity variation-- the change in muzzle velocity of a weapon (expressed in meters per second) from the standard muzzle velocity.

d. Projectile family-- a group of projectiles that have exact or very similar ballistic characteristics. Projectile types within the family are identified by model number.

e. Propellant type-- the nomenclature of the propellant used for a particular charge.

f. Charge group-- the charges within the propellant type associated with a projectile family, within which MVVs can be transferred. (See Table 4-1.) This has been referred to as propellant model or powder model in the past and in other references. In separate-loading ammunition (155 mm) these terms are synonymous, but in 105-mm ammunition, three charge groups are within a propellant type.

g. Preferred charges-- the charges preferred for measuring and transferring muzzle velocities. These charges produce consistent predictable muzzle velocities. The MVVs they produce **should** not vary more than 1.5 meters per second for the same charge or other charges of the same charge group. Therefore, the MVV determined for one charge of a propellant type will be similar (1.5 rids) to another charge of the same propellant type and lot. Preferred charges are identified in Table 4-1.

NOTE: The principle of MWs not varying by more than 1.5 m/s **generally** holds true within **preferred subsonic charges** of a propellant type. However, the convenience gained by this assumption more than offsets losses in accuracy, and it is sufficiently valid to allow for accurate massing.

h. Restricted charges-- those charges within a charge group to which it is not preferred to transfer measured MVVs or for which it is not authorized to fire (is based on the weapon TM). The performance of a restricted charge is not indicative of the performance of other charges within the charge group.

i. Adjacent charge-- charges within a charge group which are 1 charge increment greater or less than the charge calibrated. Used in the conduct of a calibration and subsequent lot inference techniques.

j. Propellant lot-- a group of propellants made by the same manufacturer at the same location with the same ingredients.

k. Calibration-- measuring the muzzle velocity of a weapon and then performing a comparison between the muzzle velocity achieved by a given piece and the accepted standard. There are two types of calibration--absolute and comparative.

(1) In absolute calibration, the weapon muzzle velocity is compared to the firing table reference muzzle velocity.

(2) In a comparative calibration, the achieved muzzle velocities of two weapons are compared.

l. M90 Readout average-- the average MV measured by the M90 which has not been corrected to standard projectile weight and standard propellant temperature.

m. Calibrated muzzle velocity-- an M90 readout average that has been corrected to standard projectile weight and propellant temperature.

n. Historical muzzle velocity-- a calibrated muzzle velocity which has been recorded in a muzzle velocity logbook.

o. Inferred calibration-- the MV of a weapon is determined through mathematical procedures by using data from a first lot calibration (baseline data) and the relative efficiency of a second lot of propellant.

p. Erosion-- the wear in a howitzer tube that is the result of firing rounds. It is measured from a pullover gauge reading, which is described in inches, or estimated by computing the equivalent full charges (EFCs) for erosion. This is determined by multiplying the number of rounds fired with a given charge and the number of EFCs per round for that charge and projectile.

q. Shooting strength-- the change in the achieved muzzle velocity of a howitzer over time caused by erosion, which is a function of erosion and projectile family ballistics.

r. Ammunition efficiency-- the change in velocity which is the sum of the projectile efficiency and propellant efficiency.

s. Projectile efficiency-- known deviations from the standard for a particular projectile which effect the achieved velocity. For example, a high-explosive (HE) Ml 07 projectile which weighs 3◙, 93.9 pounds, vice the standard 4 ◙, 95.0 pounds, would have a predictable change in velocity, depending on the charge fired.

t. Propellant efficiency-- known deviations from the standard for a particular propellant which effects the velocity of the projectile. For example, a lot of M3A1 propellant may perform differently than the standard for that propellant type but is still acceptable for firing.

Table 4-1. Projectile Families, Propellant Types, and Charge Groups.

105 MM			
PROJECTILE FAMILY	**PROPELLANT**	**CHARGE GROUPS**	**PREFERRED CHARGES**
HE	M67	1-2	1-2
		3-5	3-5
		6-7	6-7
	M200	8	8
RAP	M176	3-5	3-5
		6-7	6-7
155 MM			
HE	M3A1	1-5	3-5
	M4A2	3-7	5-7
	M119A1	8	8
	M119A2	7	7
DPICM	M3A1	3-5	3-5
	M4A2	3-7	5-7
	M119A1	8	8
	M119A2	7	7
RAP	M4A2	7	7
	M119A1	8	8
	M119A2	7	7
	M203	8R	8R
Copperhead	M3A1	4-5	4-5
	M4A2	3-7	5-7
	M119A1	8	8
	M119A2	7	7

LEGEND:

DPICM = dual-purpose improved conventional munitions
RAP = rocket-assisted projectile

NOTE: Refer to ST 6-40-16 for information on the chare group and preferred charges for the 8-inch (203-mm) howitzer.

4-2. Calibration

Three techniques can be used to determine calibration data. The accuracy and complexity of these different techniques varies greatly. Each of the techniques must be understood and applied correctly to the tactical situation. The following order of preference can be used as a guideline. The techniques are listed in order of decreasing preference.

- M90 chronograph calibration or baseline calibration.
- Subsequent lot inferred calibration.
- Predictive muzzle velocity techniques.

a. M90 Chronograph Calibration.

(1) Determine calibration data. The howitzer section installs the M90 velocimeter and records the administrative (admin) data at the top of the M90 Velocimeter Work Sheet (DA Form 4982-l-R). The M90 readout values are recorded in the center portion of the form. Normally, data from six usable rounds, all preferably fired within 20 minutes, are used to ensure the most accurate calibration data. These six rounds can be from any fire mission conducted by the firing unit. Specially conducted calibration missions are not required. If the howitzer tube is cold (that is, has not been engaged in firing or in low air temperatures) the firing of warm-up rounds is recommended. Fewer than six rounds can be used. In these situations, the calibration validity is reduced in the same way that the validity of a registration is reduced when the number of rounds fired is less than normal. In these situations, refer to Chapter 10, Table 10-1 for validity information and the effect of reduced rounds on the calibration data. Powder temperature differences between rounds decrease the validity of the calibration. To reduce powder temperature changes from round to round, use proper propellant handling and storing procedures in the firing unit and fire all rounds measured for a calibration within a 20-minute period. Follow these procedures in the calibration of all weapons. When the admin data and the M90 velocimeter readout data are entered on DA Form 4982- l-R for all weapons, the form is given to the fire direction center.

(2) Determine M90 readout average. The FDO inspects the readout values for all rounds and deletes any invalid readout values, those exceeding the readout average by ±3.0 m/s. This ±3.O m/s approximates 4 PER in the target area for the given charge. The FDC personnel then determine the new readout average for the usable rounds by adding all usable readout values and dividing the sum by the number of usable rounds. This value includes the effects of nonstandard propellant temperature and projectile weight.

(3) Correct to standard. The M90 velocimeter readout average is not used in its original form because it includes the effects of projectile weight and propellant temperature on the muzzle velocity. The MV can be used when the corrections for projectile weight and propellant temperature are applied by extracting the value from the appropriate table in the MVCT M90-2 manual and applying that value to the readout average. The correction tables contain data to correct the readout average to what it would have been if the reading had been determined with a standard square-weight projectile and a standard propellant temperature of 70°F. **Enter MVCT M90-2 for the appropriate weapon system and projectile family. Locate the page containing the table for the same charge fired in the calibration.** Enter the table with the average propellant temperature and the weight of the projectile fired. Interpolate the value to correct the readout average to standard, and apply that value to the readout average. The result is the calibrated muzzle velocity for the weapon.

(4) Complete HE M90 velocimeter worksheet. Once the velocity of the rounds fired has been determined, FDC personnel are responsible for verifying and completing the DA Form 4982-l-R. This will include the steps in Table 4-2. A completed DA Form 4982- l-R is shown in Figure 4-1.

Table 4-2. Steps for Completing DA Form 4982-1-R.

STEP	ACTION
1	Verify the admin data.
2	Verify the weapon bumper number.
3	Verify the weapon tube number.
4	Verify the starting powder temperature for each howitzer.
5	Verify the ending powder temperature for each howitzer.
6	Determine and record the average powder temperature for each howitzer to the nearest degree.
7	Verify the M90 velocimeter readout by round for each howitzer.
8	Average all the usable measured muzzle velocities for each howitzer.
9	Compare the average of the usable measured muzzle velocities with each measured muzzle velocity for each howitzer.
10	If any measured muzzle velocity is more than ±3.0 m/s from the average, discard it. Discarding more than one velocity at a time may be necessary.
11	If any muzzle velocities were discarded, repeat steps 8 through 10 above. If no further rounds are discarded, this is the readout average.
12	Record the readout average for each howitzer.
13	Locate the portion of the MVCT M90-2 for the weapon system fired.
14	Locate the portion of the MVCT M90-2 for the projectile family of the projectile fired.
15	Locate the page of the MVCT M90-2 for the charge of the propellant type used.
16	Find the projectile◙ weight across the top of the table.
17	Find the average powder temperature on the left or right edge of the table.
18	Find where the projectile weight and the powder temperature intersect in the table. This is the correction for the nonstandard condition(s).
	NOTE: If the average powder temperature is not listed but is within the temperatures listed, interpolation is required. If it is not within the temperatures listed, then use the last listed value (that is, -40° or +130°F).
19	Determine and record the calibrated muzzle velocity by algebraically applying the correction determined in step 18 to the readout average from step 12.

(5) Complete the Muzzle Velocity Record (DA FORM 4982-R).

(a) DA Form 4982-R is the record of a calibration kept in the **battery or platoon muzzle velocity log book.** The top part of the form **(FIRST-LOT CALIBRATION)** is used to determine the weapon MVV for a specific charge, when corrected to standard. For future reference, place the completed muzzle velocity record into the unit muzzle velocity logbook under the appropriate weapon projectile family-propellant type-charge group. Ensure this information is given to the platoon leader or XO for entry on DA Form 2408-4 (Weapon Record Data) or NAVMC 10558 (Weapon Record Book, Part 1) and 10558A (Weapon Record Book, Part H) for the weapon.

(b) The determined MVV is used in the solution of concurrent and subsequent met techniques and terrain gun position corrections. The lower part of the form (SECOND-LOT CALIBRATION AND SECOND-LOT INFERENCE) is used to infer muzzle velocity data for a second lot of propellant and / or ammunition.

(c) Table 4-3 provides the steps for completing DA Form 4982-R, and Figure 4-2 shows the form completed through the first nine steps.

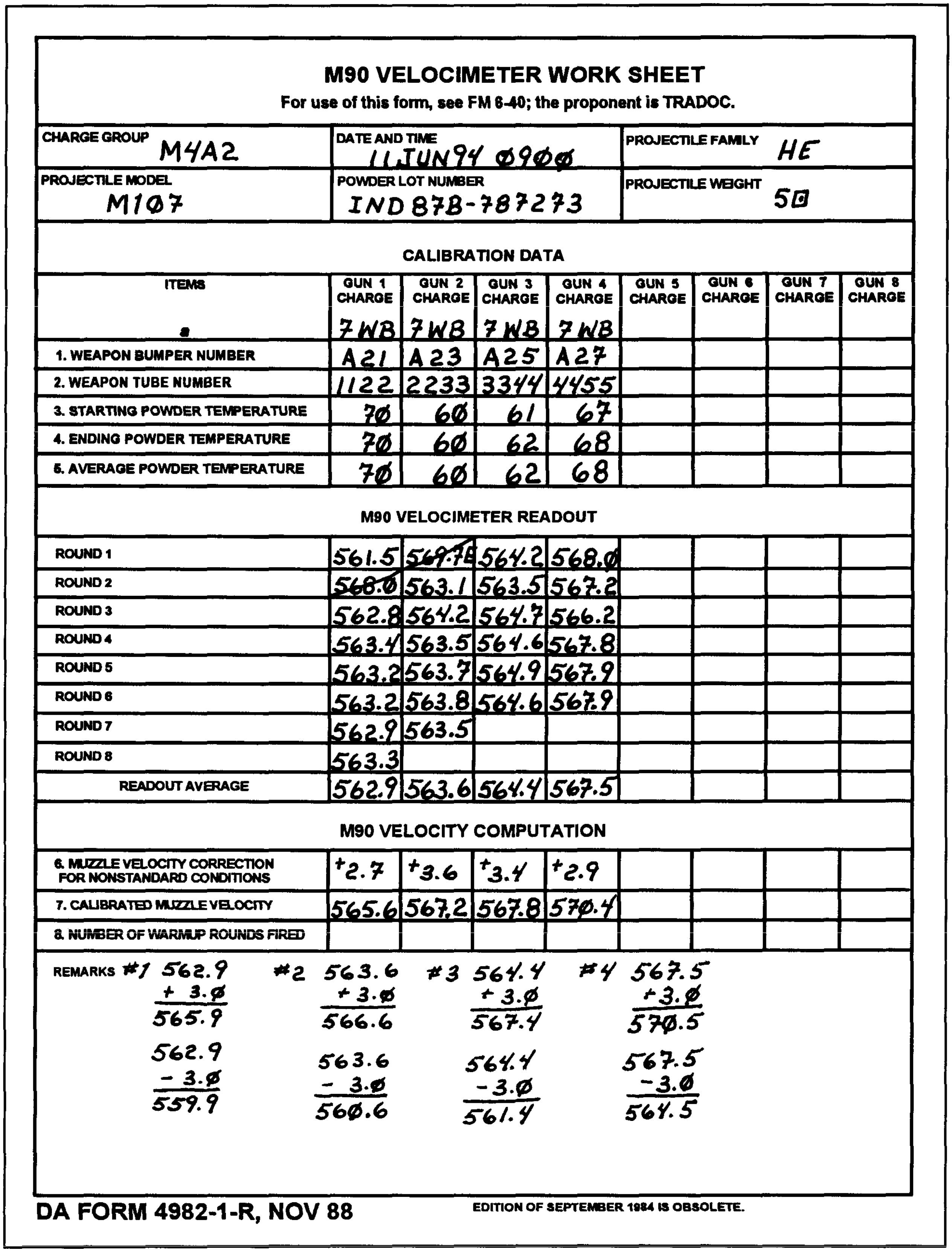
b. Subsequent Lot Inferred Calibration.

(1) Inferred subsequent lot calibration techniques allow a firing unit to quickly update muzzle velocity information for a given projectile family-propellant type combination, when firing a new lot of propellant. Subsequent lot calibration is used to isolate the difference in efficiency between two propellant lots for one howitzer firing the same projectile family. This difference is applied to the first lot calibration data for the other howitzers to determine calibration data for the second lot. This technique can be used when the situation does not permit the calibration of the new lot with all guns.

(2) To accomplish this technique, the following requirements must be met:

- Calibration of the first lot must be completed for the entire unit.
- Calibration of a second lot must be completed for one gun.

(3) A calibration should be completed with all howitzers as soon as the situation allows. Table 4-4 provides the steps for conducting a subsequent lot calibration. Figure 4-3 shows DA Form 4982- 1-R completed for a second-lot inferred calibration. Figure 4-4 shows DA Form 4982-R completed for a second-lot inferred calibration.



M90 VELOCIMETER WORK SHEET

For use of this form, see FM 6-40; the proponent is TRADOC.

CHARGE GROUP M4A2	DATE AND TIME 11JUN94 0900	PROJECTILE FAMILY HE
PROJECTILE MODEL M107	POWDER LOT NUMBER IND 878-787273	PROJECTILE WEIGHT 5□

CALIBRATION DATA

ITEMS	GUN 1 CHARGE	GUN 2 CHARGE	GUN 3 CHARGE	GUN 4 CHARGE	GUN 5 CHARGE	GUN 6 CHARGE	GUN 7 CHARGE	GUN 8 CHARGE
	7WB	7WB	7WB	7WB				
1. WEAPON BUMPER NUMBER	A21	A23	A25	A27				
2. WEAPON TUBE NUMBER	1122	2233	3344	4455				
3. STARTING POWDER TEMPERATURE	70	60	61	67				
4. ENDING POWDER TEMPERATURE	70	60	62	68				
5. AVERAGE POWDER TEMPERATURE	70	60	62	68				
M90 VELOCIMETER READOUT								
ROUND 1	561.5	~~569.7~~	564.2	568.0				
ROUND 2	~~568.0~~	563.1	563.5	567.2				
ROUND 3	562.8	564.2	564.7	566.2				
ROUND 4	563.4	563.5	564.6	567.8				
ROUND 5	563.2	563.7	564.9	567.9				
ROUND 6	563.2	563.8	564.6	567.9				
ROUND 7	562.9	563.5						
ROUND 8	563.3							
READOUT AVERAGE	562.9	563.6	564.4	567.5				
M90 VELOCITY COMPUTATION								
6. MUZZLE VELOCITY CORRECTION FOR NONSTANDARD CONDITIONS	+2.7	+3.6	+3.4	+2.9				
7. CALIBRATED MUZZLE VELOCITY	565.6	567.2	567.8	570.4				
8. NUMBER OF WARMUP ROUNDS FIRED								

REMARKS

#1	#2	#3	#4
562.9	563.6	564.4	567.5
+ 3.0	+ 3.0	+ 3.0	+3.0
565.9	566.6	567.4	570.5
562.9	563.6	564.4	567.5
- 3.0	- 3.0	- 3.0	-3.0
559.9	560.6	561.4	564.5

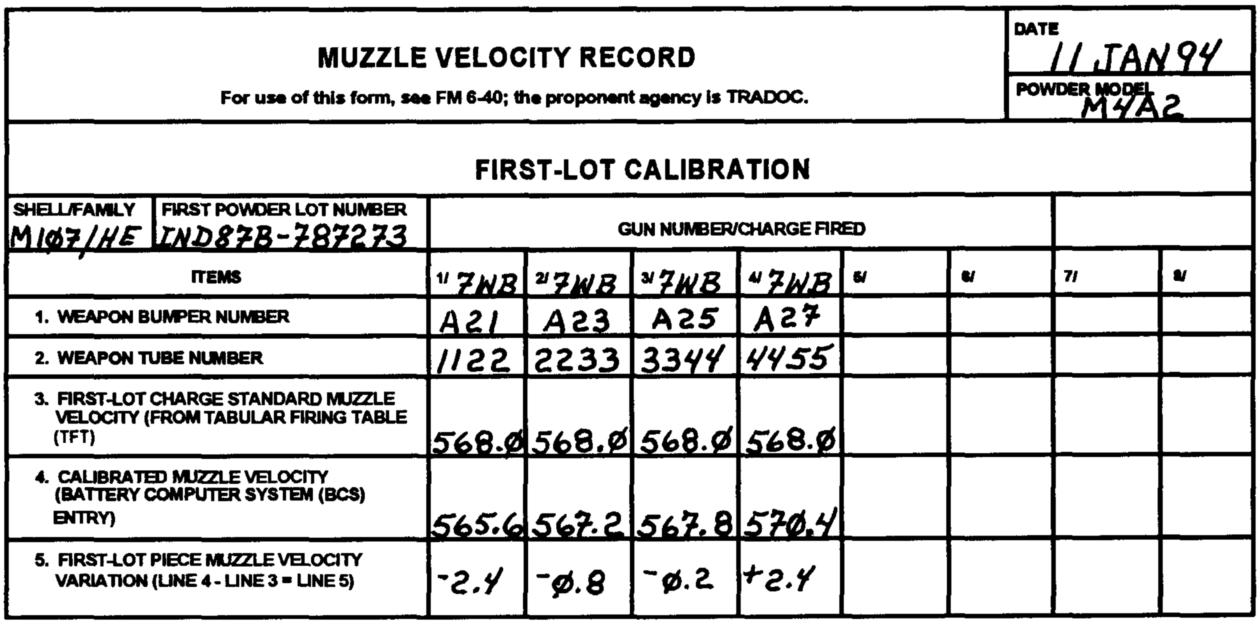
DA FORM 4982-1-R, NOV 88

EDITION OF SEPTEMBER 1984 IS OBSOLETE.

Figure 4-1. Completed M90 Velocimeter Work Sheet.

Table 4-3. Completing DA Form 4982-R for a First-Lot Calibration.

STEP	ACTION
1	DATE and POWDER MODEL blocks. Record date and powder model in the appropriate blocks in the upper right corner of the form.
2	SHELL/FAMILY block. Record the projectile model and family.
3	FIRST POWDER LOT NUMBER block. Record the manufacturer's number that identifies this particular lot of powder.
4	GUN NUMBER/CHARGE FIRED block. Record the particular charge increment fired next to the appropriate weapon number.
5	WEAPON BUMPER NUMBER block (Line 1). Record the weapon bumper number.
6	WEAPON TUBE NUMBER block (Line 2). Record the serial number of the tube.
7	FIRST-LOT CHARGE STANDARD MUZZLE VELOCITY block (Line 3). From the TFT, extract the standard MV for the charge fired in the calibration.
8	CALIBRATED MUZZLE VELOCITY block (Line 4). Record the calibrated muzzle velocity from line 7 of the M90 work sheet.
9	FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (Line 5). Compare the calibrated MV to the standard MV, and record the MVV (line 4 - line 3 = MVV).



MUZZLE VELOCITY RECORD

For use of this form, see FM 6-40; the proponent agency is TRADOC.

DATE 11 JAN 94

POWDER MODEL M4A2

FIRST-LOT CALIBRATION

SHELL/FAMILY M107/HE

FIRST POWDER LOT NUMBER IND87B-787273

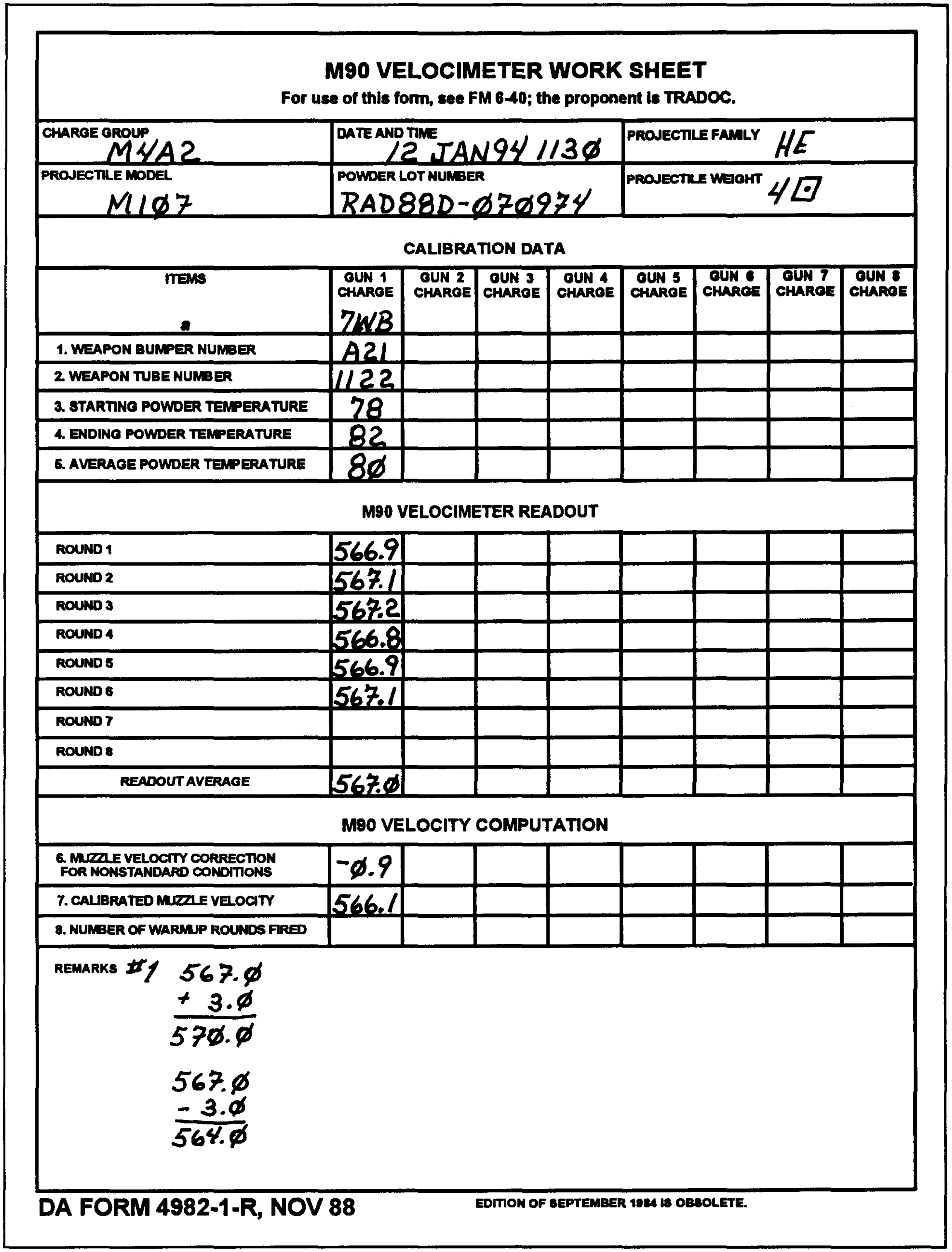
GUN NUMBER/CHARGE FIRED

ITEMS	1/ 7WB	2/ 7WB	3/ 7WB	4/ 7WB	5/	6/	7/	8/
1. WEAPON BUMPER NUMBER	A21	A23	A25	A27				
2. WEAPON TUBE NUMBER	1122	2233	3344	4455				
3. FIRST-LOT CHARGE STANDARD MUZZLE VELOCITY (FROM TABULAR FIRING TABLE (TFT)	568.0	568.0	568.0	568.0				
4. CALIBRATED MUZZLE VELOCITY (BATTERY COMPUTER SYSTEM (BCS) ENTRY)	565.6	567.2	567.8	570.4				
5. FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 4 - LINE 3 = LINE 5)	-2.4	-0.8	-0.2	+2.4				

Figure 4-2. MV Record (Steps 1 Through 9).

Table 4-4. Subsequent Lot Calibration.

STEP	ACTION
1	Calibration, first lot. Conduct a calibration for all howitzers for the first lot of propellant. Complete DA Form 4982-1-R in accordance with Table 4-2.
2	Calibration, second lot. Conduct a calibration for one howitzer for the second lot of propellant. Complete DA Form 4982-1-R in accordance with Table 4-2.
NOTE: The data for the following steps are recorded on DA Form 4982-R. (See Figure 4-4.)	
3	Administrative information. Record the admin information on DA Form 4982-R, to include the date, powder model, shell/family, and first powder lot number.
4	FIRST-LOT CALIBRATION section. Record the data from the first calibration for each howitzer on lines 1 through 5 from the first DA Form 4982-1-R (Figure 4-1).
5	SECOND-LOT CALIBRATION section. Enter the date, time, and powder lot number. (There is no specific block in which to do this on the form; enter this information above the SHELL/FAMILY block).
6	SHELL/FAMILY block. Enter the projectile model and family.
7	SECOND-LOT POWDER GROUP block. Enter the second-lot powder group.
8	GUN NUMBER/CHARGE FIRED block. Enter the calibrated charge fired for the howitzer.
9	SECOND-LOT CHARGE STANDARD MUZZLE VELOCITY block (Line 6). Enter the second-lot standard muzzle velocity for the calibrated charge.
10	SECOND-LOT CALIBRATED MUZZLE VELOCITY block (Line 7). Enter the second-lot calibrated muzzle velocity from line 7 of the M90 work sheet.
11	SECOND-LOT PIECE MUZZLE VELOCITY VARIATION block (Line 8). Compute the second-lot muzzle velocity variation (line 7 - line 6 = line 8).
12	FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (block) (line 9). Enter the first-lot piece muzzle velocity variation from line 5.
13	CHANGE IN MUZZLE VELOCITY VARIATION (line 10). Determine the change in muzzle velocity variation from the first lot to the second lot (line 8 - line 9 = line 10).
14	SECOND-LOT STANDARD MUZZLE VELOCITY block (line 11). For all weapons, enter the second-lot standard muzzle velocity from the TFT.
15	CHANGE IN MUZZLE VELOCITY VARIATION block (line 12). Enter the change in muzzle velocity variation from line 10 from the weapon that calibrated the second lot. This value allows us to compensate for propellant efficiency differences between the two lots.
16	FIRST-LOT MUZZLE VELOCITY VARIATION block (line 13). Enter the first-lot muzzle velocity variation for each weapon from line 5.
17	SECOND-LOT CALIBRATED MUZZLE VELOCITY VARIATION block (line 14). Record the sums of lines 12 and 13. This gives an inferred muzzle velocity variation to be used for the second lot for each gun (line 12 + line 13 = line 14).
18	CALIBRATED MUZZLE VELOCITY (Line 15). Record the sum of lines 11 and 14. (Apply the inferred MVV plus the standard MV from the TFT to determine an MV.) These are **inferred muzzle velocities** (line 11 + line 14 = line 15).



M90 VELOCIMETER WORK SHEET

For use of this form, see FM 6-40; the proponent is TRADOC.

CHARGE GROUP M4A2	DATE AND TIME 12 JAN94 1130	PROJECTILE FAMILY HE
PROJECTILE MODEL M107	POWDER LOT NUMBER RAD88D-070974	PROJECTILE WEIGHT 40

CALIBRATION DATA

ITEMS a	GUN 1 CHARGE 7WB	GUN 2 CHARGE	GUN 3 CHARGE	GUN 4 CHARGE	GUN 5 CHARGE	GUN 6 CHARGE	GUN 7 CHARGE	GUN 8 CHARGE
1. WEAPON BUMPER NUMBER	A21							
2. WEAPON TUBE NUMBER	1122							
3. STARTING POWDER TEMPERATURE	78							
4. ENDING POWDER TEMPERATURE	82							
5. AVERAGE POWDER TEMPERATURE	80							
M90 VELOCIMETER READOUT								
ROUND 1	566.9							
ROUND 2	567.1							
ROUND 3	567.2							
ROUND 4	566.8							
ROUND 5	566.9							
ROUND 6	567.1							
ROUND 7								
ROUND 8								
READOUT AVERAGE	567.0							
M90 VELOCITY COMPUTATION								
6. MUZZLE VELOCITY CORRECTION FOR NONSTANDARD CONDITIONS	-0.9							
7. CALIBRATED MUZZLE VELOCITY	566.1							
8. NUMBER OF WARMUP ROUNDS FIRED								

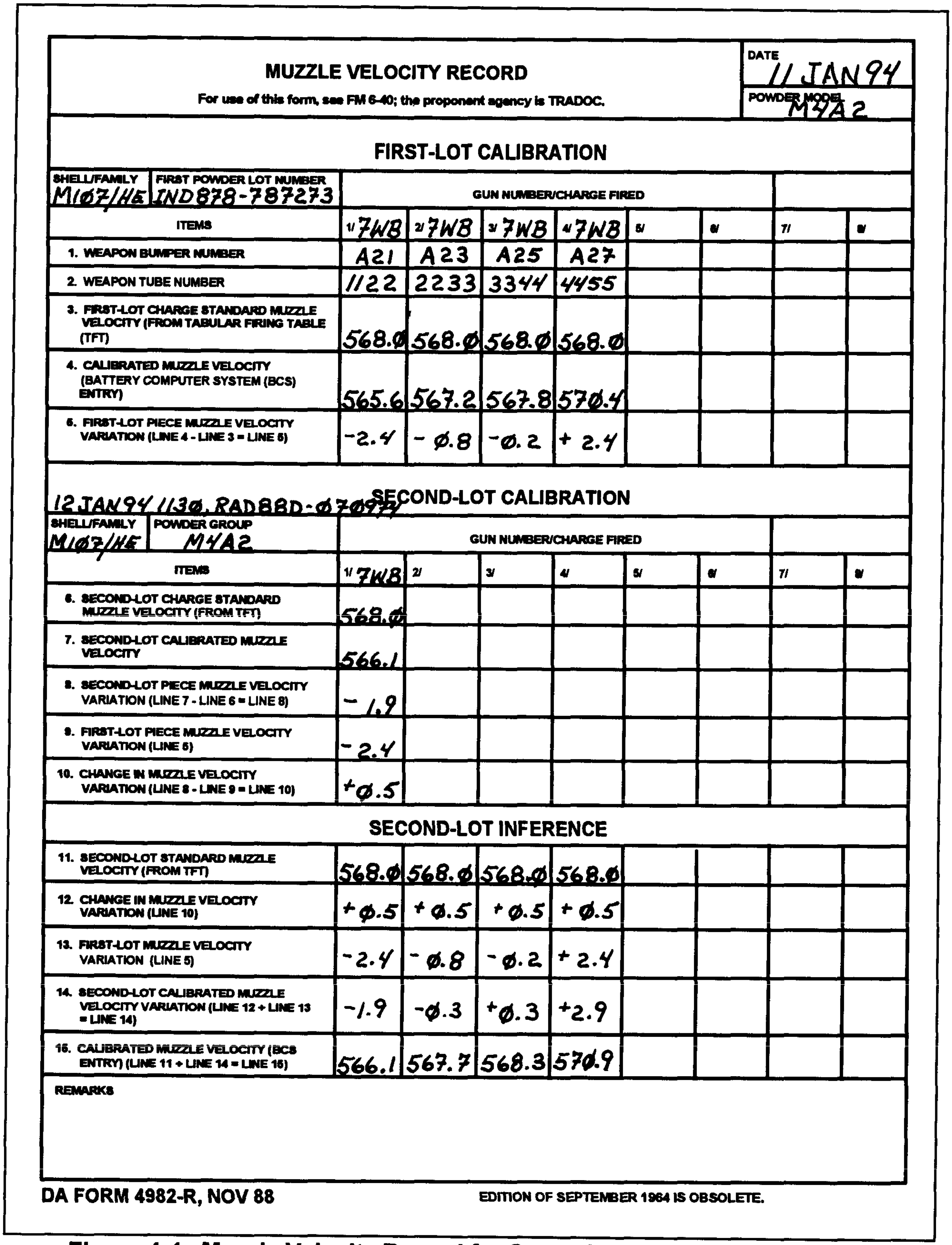
REMARKS #1

$$\begin{array}{r} 567.0 \\ +\ 3.0 \\ \hline 570.0 \end{array}$$

$$\begin{array}{r} 567.0 \\ -\ 3.0 \\ \hline 564.0 \end{array}$$

DA FORM 4982-1-R, NOV 88 EDITION OF SEPTEMBER 1984 IS OBSOLETE.

Figure 4-3. M90 Velocimeter Work Sheet for Second-Lot Inferred Calibration.



MUZZLE VELOCITY RECORD

For use of this form, see FM 6-40; the proponent agency is TRADOC.

DATE 11 JAN 94

POWDER MODEL M4A2

FIRST-LOT CALIBRATION

SHELL/FAMILY M107/HE

FIRST POWDER LOT NUMBER IND878-787273

ITEMS	GUN NUMBER/CHARGE FIRED							
	1/ 7WB	2/ 7WB	3/ 7WB	4/ 7WB	5/	6/	7/	8/
1. WEAPON BUMPER NUMBER	A21	A23	A25	A27				
2. WEAPON TUBE NUMBER	1122	2233	3344	4455				
3. FIRST-LOT CHARGE STANDARD MUZZLE VELOCITY (FROM TABULAR FIRING TABLE (TFT)	568.0	568.0	568.0	568.0				
4. CALIBRATED MUZZLE VELOCITY (BATTERY COMPUTER SYSTEM (BCS) ENTRY)	565.6	567.2	567.8	570.4				
5. FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 4 - LINE 3 = LINE 5)	-2.4	- 0.8	-0.2	+ 2.4				

12 JAN94 1130, RAD88D-07097

SECOND-LOT CALIBRATION

SHELL/FAMILY M107/HE

POWDER GROUP M4A2

ITEMS	GUN NUMBER/CHARGE FIRED							
	1/ 7WB	2/	3/	4/	5/	6/	7/	8/
6. SECOND-LOT CHARGE STANDARD MUZZLE VELOCITY (FROM TFT)	568.0							
7. SECOND-LOT CALIBRATED MUZZLE VELOCITY	566.1							
8. SECOND-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 7 - LINE 6 = LINE 8)	- 1.9							
9. FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 5)	- 2.4							
10. CHANGE IN MUZZLE VELOCITY VARIATION (LINE 8 - LINE 9 = LINE 10)	+0.5							

SECOND-LOT INFERENCE

11. SECOND-LOT STANDARD MUZZLE VELOCITY (FROM TFT)	568.0	568.0	568.0	568.0				
12. CHANGE IN MUZZLE VELOCITY VARIATION (LINE 10)	+0.5	+ 0.5	+ 0.5	+ 0.5				
13. FIRST-LOT MUZZLE VELOCITY VARIATION (LINE 5)	-2.4	- 0.8	- 0.2	+ 2.4				
14. SECOND-LOT CALIBRATED MUZZLE VELOCITY VARIATION (LINE 12 + LINE 13 = LINE 14)	-1.9	-0.3	+0.3	+2.9				
15. CALIBRATED MUZZLE VELOCITY (BCS ENTRY) (LINE 11 + LINE 14 = LINE 15)	566.1	567.7	568.3	570.9				

REMARKS

DA FORM 4982-R, NOV 88

EDITION OF SEPTEMBER 1964 IS OBSOLETE.

Figure 4-4. Muzzle Velocity Record for Second-Lot Inferred Calibration.

c. Predictive Muzzle Velocity Technique. While it is not practical to predict (within 0.1 m/s) the velocity of every round, it is possible to approximate velocities to within 1 or 2 m/s with current available information. This may be useful when calibration is not possible, when updating calibration data, or when trying to increase the accuracy of inferred MV techniques.

(1) When calibration is not possible, the shooting strength of the howitzer can be used as the MVV. While this may be enough when no other data are available, it is important to understand that an MVV consists of more than just shooting strength. An equation can be created for determining an MVV by using its basic parts. (See Figure 4-5.)

MVV = Shooting Strength + Ammunition Efficiency + Round to Round Variation

Figure 4-5. Muzzle Velocity Equation.

(2) If all three elements are known, it is possible to determine a value for MVV. It is neither practical nor necessary to quantify round-to-round variation. This element is usually small and subject to rapid change. Projectile efficiency, as a part of ammunition efficiency, is accounted for in solving the concurrent and subsequent met techniques. Therefore, if the round-to-round variation and the projectile efficiency are eliminated from the equation, the howitzer shooting strength and the propellant efficiency of the propellant lot to be fired can approximate the MVV. (See Figure 4-6.)

MVV = Shooting Strength + Propellant Efficiency

Figure 4-6. MVV Approximation.

(3) If calibration is not possible, adding the propellant efficiency to the shooting strength will result in a more accurate MVV for determining firing data than if the shooting strength is considered alone. This MVV can be used as the MVV for manual fire missions. Each howitzer has a value for shooting strength for each projectile family. Also, the value of propellant efficiency applies to any projectile family with which the propellant lot is fired.

4-3. Estimating Shooting Strength

a. There may be times when calibration is not possible. If the M90 is not available or there is not time to conduct a calibration, it may be necessary to determine the shooting strength of the howitzer by other means. The shooting strength of a howitzer can be determined by using pullover gauge readings and/or **erosion EFC** service round effects with the appropriate TFT for the weapon-projectile combination to be fired. (See Table 4-5.) DA Form 2408-4 provides the information to determine the shooting strength of each howitzer. (See Figure 4-7.)

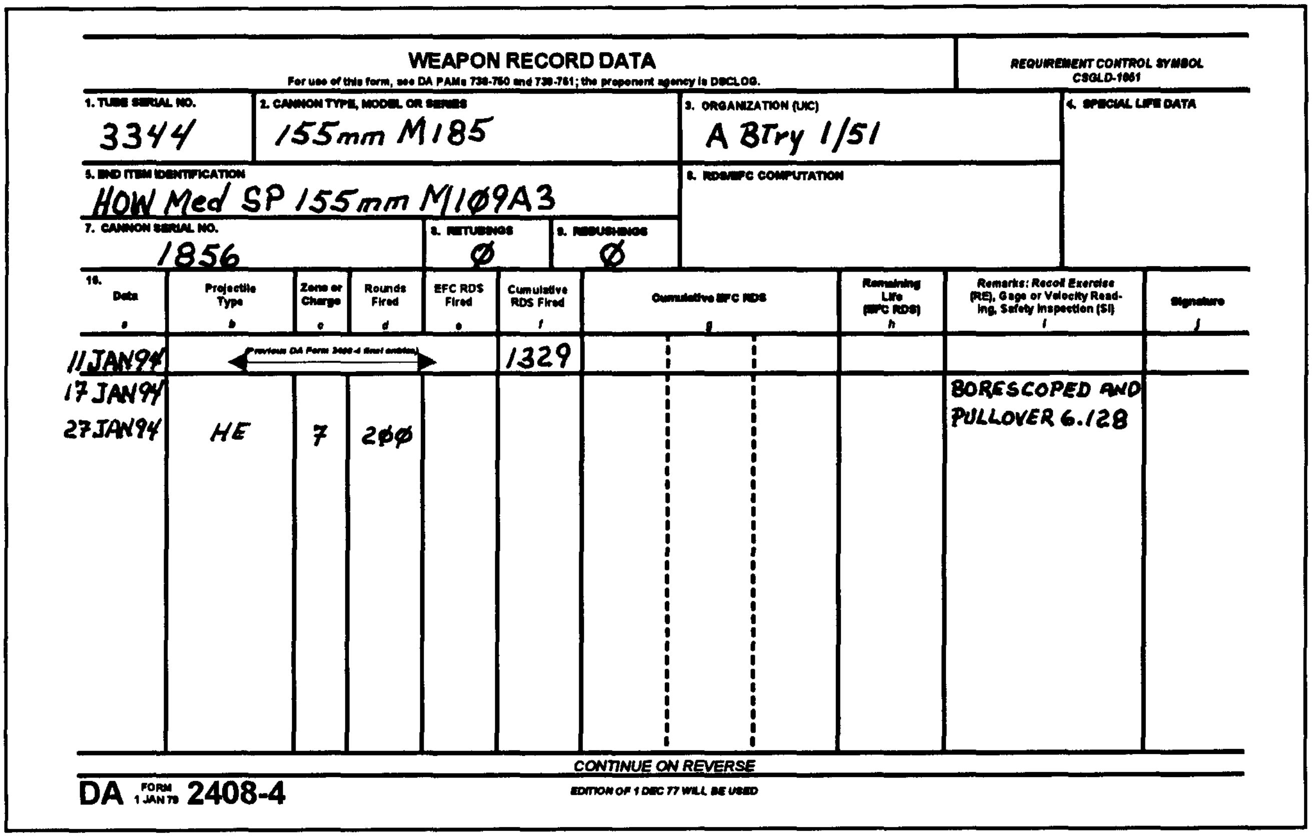
b. The number of EFCs is determined by multiplying the number of rounds fired for a specific projectile and propellant by the equivalent erosion effect in decimals for the charge fired listed in the introduction of the TFT. Different projectile families have different TFTs and consequently different values for equivalent erosion effect in decimals. Pullover gauge readings can be determined regularly by the maintenance section in conjunction with borescoping the howitzer. The most accurate technique is to combine the pullover gauge reading and the erosion EFCs fired after the pullover gauge reading to determine an expected loss in muzzle velocity. The most recent pullover gauge reading or total erosion EFCs may be used to determine the approximate loss in muzzle velocity. Table 4-6 provides the steps for determining the pullover gauge reading.

Table 4-5. Estimating Shooting Strength.

STEP	ACTION
1	Determine the pullover gauge reading from DA Form 2408-4 (NAVMC 10558A) for the specific howitzer if available. If no pullover gauge reading is available, go to step 6.
2	Determine the equivalent number of EFCs by entering the Approximate Losses in Muzzle Velocity table for the correct weapon in the introduction of the appropriate TFT and extracting the number of EFCs equivalent to the pullover gauge reading. Interpolate as necessary.
3	Determine the total number of erosion EFCs since the pullover gauge reading. Multiply the number of rounds fired by the erosion factor for the appropriate projectile-propellant charge combination. If unknown, use the pullover gauge reading.
4	Determine the equivalent **cumulative** number of EFCs for the specific howitzer by adding the value in step 2 to the value in step 3.
5	Determine the loss in muzzle velocity by entering the table with the equivalent **cumulative** number of EFCs; interpolate as necessary. Go to step 8.
6	Determine the cumulative number of EFCs from DA Form 2408-4 (NAVMC 10558A) for the specific howitzer.
7	Determine the loss in muzzle velocity by entering the approximate loss in muzzle velocity table with the cumulative number of EFCs (step 6); interpolate as necessary.
8	The value determined approximates the shooting strength of the howitzer and can be used as an MVV if no other data are available. Repeat steps 1 through 8 for all projectile families to be fired.

Table 4-6. Determining Pullover Gauge Reading.

STEP	ACTION
1	Determine the pullover gauge reading from the DA Form 2408-4 (NAVMC 10558A). The value should be 6.128. (See Figure 4-7.)
2	Determine the equivalent number of EFCs by entering the Approximate Losses in Muzzle Velocity table, page XIV, in the introduction of the FT 155-AM-2 and extracting the number of EFCs equivalent to the pullover gauge reading. Interpolate as necessary. The value should be 800.
3	Determine the total number of **erosion EFCs** since the pullover gauge reading. Multiply the number of rounds fired, 200, by the erosion factor for charge 7WB, cannon M185. The value should be .30 (200 x .30 = 60).
4	Determine the equivalent cumulative number of EFCs for Howitzer Number 3 by adding the value in step 2 to the value in step 3 (800 + 60 = 860).
5	Determine the loss in muzzle velocity by entering the table with the equivalent cumulative number of EFCs, 860; interpolate as necessary. The value should be -1.5. The value -1.5 m/s approximates the shooting strength of the howitzer and can be used as an MVV if no other data are available.



WEAPON RECORD DATA

For use of this form, see DA PAMs 738-750 and 738-751; the proponent agency is DCSLOG.

REQUIREMENT CONTROL SYMBOL CSGLD-1051

1. TUBE SERIAL NO. 3344

2. CANNON TYPE, MODEL OR SERIES 155mm M185

3. ORGANIZATION (UIC) A BTry 1/51

4. SPECIAL LIFE DATA

5. END ITEM IDENTIFICATION HOW Med SP 155mm M109A3

6. RDS/EFC COMPUTATION

7. CANNON SERIAL NO. 1856

8. RETUBINGS 0

9. REBUSHINGS 0

10.

Date a	Projectile Type b	Zone or Charge c	Rounds Fired d	EFC RDS Fired e	Cumulative RDS Fired f	Cumulative EFC RDS g	Remaining Life (EFC RDS) h	Remarks: Recoil Exercise (RE), Gage or Velocity Reading, Safety Inspection (SI) i	Signature j
11JAN94	← (Previous DA Form 2408-4 final entries) →				1329				
17JAN94								BORESCOPED AND PULLOVER 6.128	
27JAN94	HE	7	200						

CONTINUE ON REVERSE

DA FORM 1 JAN 79 2408-4

EDITION OF 1 DEC 77 WILL BE USED

Figure 4-7. DA Form 2408-4.

4-4. Updating MVV Data

Once determined, the calibration data represent the best indicator of the expected MVV. But the MVV is not valid forever since the howitzer shooting strength changes as more rounds are fired. Calibration data can be made indefinitely valid if the shooting strength is continually updated. If the shooting strength of the howitzer is determined at the time of calibration, the changes in shooting strength can be added to the calibrated MVV over time. The current shooting strength can be determined from the Approximate Losses in Muzzle Velocity table in the TFT introduction on the basis of the pullover gauge readings and/or EFCs. The change in shooting strength is determined by subtracting the shooting strength at the time of calibration from the current shooting strength. This difference is then applied to the calibrated MVV to determine a current or updated MVV.

4-5. Other Applications

a. The possible applications of the basic equation, Figure 4-6, provide enough flexibility to determine any of the three parts of the equation (MVV, shooting strength, and propellant efficiency). If any two parts are known, the third can be determined. For example, if a replacement howitzer is received without its DA Form 2408-4, its shooting strength would be unknown. However, if it was calibrated and the propellant efficiency of the calibrated propellant lot is known, the shooting strength can be approximated (a modification of the formula found in Figure 4-6). This approximated shooting strength could then be applied by using the techniques described in paragraphs 4-2 and 4-3.

b. A useful application of the basic equation is the ability to solve for the propellant efficiency of a given propellant lot. The propellant efficiency could then be used to predict an MVV for a different projectile family. (See the example below.)

EXAMPLE

Weapon:	M109A3
Projectile:	M107 HE, Lot A M712 CPH, Lot C
Propellant:	M4A2, Lot W
Calibration Information:	Chg 6, Lot AW, MVV -8.2 m/s
Current Pullover Gauge Reading:	6.163

Enter TFT 155-AM-2, and determine the estimated loss in shooting strength by using the current pullover gauge reading. The estimated shooting strength at the time of the calibration is -7.0 m/s (interpolate as necessary). Using the basic equation for an MVV, solve for the estimated propellant efficiency. **MVV (-8.2) - SHOOTING STRENGTH (-7.0) = PROPELLANT EFFICIENCY (-1.2).**

Enter TFT 155-AS-1, and predict an MVV for shell Copperhead. The estimated shooting strength (using the current pullover gauge reading) is -4.7 m/s. Use the basic equation **SHOOTING STRENGTH (-4.7) + PROPELLANT EFFICIENCY (-1.2) = MVV (-5.9)**. This predicted MVV can now be used to solve the met-to-target subsequent met technique for shell Copperhead. (See Chapter 13.)

4-6. MVV Logbook

Once MV data have been determined, these data are used for numerous techniques. MV data must be recorded on DA Form 4982-R which is then filed in an MV logbook. The MV logbook allows for quick referencing of howitzer performance when firing a particular projectile family-propellant lot-charge combination. The major sections in the MV logbook are for the projectile families. Each one of the sections should be tabbed for each authorized propellant type-charge group for the projectile family.

4-7. Frequency of Calibration

Ideally, calibration occurs continuously. If that is impractical or impossible, the following methods identify when to consider calibrating.

a. Initial Receipt or Retubing. All new pieces of a given caliber and model will not necessarily develop the same muzzle velocity because of the tolerances that are allowed in the size of the powder chamber and in the dimensions of the bore. Therefore, pieces should be calibrated as soon as possible after receipt or when retubed. Muzzle velocities should be recorded on DA Form 2408-4.

b. Change in Propellant Lot. Calibration should be conducted as soon as possible after an uncalibrated propellant lot is received.

c. New Projectile Family. Calibration should be conducted if a new projectile; for example, M825 smoke (projectile family DPICM), is received for which there are no previous MV records for that projectile family.

d. Annually. Any piece in service should be recalibrated at least annually. The primary factor contributing to the loss in muzzle velocity for a piece is the number of rounds that have been fired through the tube and the charges used in firing them. Higher charges increase tube wear, which, in turn, tends to decrease muzzle velocity. Guns, because of their higher velocities, tend to display tube wear more quickly than howitzers. If a great deal of firing takes place, recalibration will be needed more often than annually. Methods of determining when recalibration may be needed are outlined below. The following situations assume that firing takes place with a previously calibrated projectile family-propellant lot.

e. Changes in VE. If an accurate record of the changes in VE determined from concurrent met solutions is maintained, it may be used as a guide for determining the need for recalibration. When the velocity loss since the last calibration is equivalent to 2 range probable errors, the need for recalibration is indicated. (An indicator of this is a loss of 1.5 m/s, which generally approximates 2 probable errors in range.)

f. Tube Wear. The extent of tube wear near the beginning of the rifling of the bore indicates the loss in muzzle velocity and the remaining tube life. Precise measurement of the distance between the lands in the bore near the start of the rifling can be made with a pullover gauge. Organizational or direct support maintenance has this gauge and makes the measurement. The wear measurement, when compared with the data in the "wear" table (Approximate Losses in Muzzle Velocity table) in the introduction of each firing table, can be used in estimating the loss in muzzle velocity.

g. EFCs. A change in the number of **erosion** EFC service rounds as depicted in the weapon record book may also indicate a need for recalibration. (Refer to paragraph 4-3 for more information about EFCs.) The change in erosion EFC rounds compared with data in the Approximate Losses in Muzzle Velocity table (in the introduction of each TFT) that corresponds to a loss of 1.5 m/s in muzzle velocity may indicate a need for recalibration. A loss of 1.5 m/sin MV generally equates to the effects of 2 probable errors in range (2 PER).

4-8. Transferring MVVs

a. Ideally, every charge should be calibrated. However, this may not always be feasible. Therefore, the calibration of a few charges, one within each charge group that results in an MVV applicable to other charges within a charge group, is imperative. For calibration purposes, there are two categories of charges within a charge group. These are preferred charges and restricted charges. The following guidance is established as an order of preference when selecting a charge to calibrate:

(1) If you know the charge you will be firing calibrate that charge.

(2) If the charge you will be shooting is unknown, calibrate the middle charge of the preferred charge group.

b. Calibration data determined should only be applied to a subsequent fire mission when the mission meets the following requirement: It is the same calibrated howitzer firing the same calibrated projectile family-propelant lot combination. Once calibration data are determined for a particular charge, these data can be transferred to other charges in the same lot. The order of preference for transferring is as follows:

(1) Transfer down **1** charge.

(2) Transfer up **1** charge.

NOTE: Shooting strength and ammo efficiency make up the achieved MV. With higher charges, there is more erosion but less variance in ammo efficiency. For lower charges, there is less erosion but more variance in ammo efficiency. Therefore, the general overall effect is less variance when transferring down as opposed to up.

(3) Transfer down **2** charges within the preferred charges.

(4) Transfer up **2** charges within the preferred charges.

(5) Transfer from a preferred charge to a restricted charge.

NOTE: MWs should not be transferred from a restricted charge to any other charge on the basis of the nature (large round-to-round variances) of restricted charges.

Chapter 5

FIRE MISSION MESSAGES

The processing of a fire mission involves three essential messages. These are the fire order, message to observer, and fire commands. These messages contain the necessary information to tactically engage the target, control the mission, and transmit technical fire direction to the howitzers.

Section I

Fire Order

This section implements STANAG 2934, Chapter 7, and QSTAG 221.

In the fire order, the FDO specifies how the target will be attacked. This is tactical fire direction.

5-1. Overview

When the FDC receives a call for fire (CFF), the FDO must determine if and how the target will be attacked. This decision (part of tactical fire direction) may be made at the battalion or battery or platoon FDC. In battalion missions, the battalion FDO is responsible for issuing the fire order. In autonomous operations, the battery or platoon FDO is responsible for issuing the fire order. A fire order is the FDO's decision on what unit(s) will fire and how much and what type of ammunition will be fired. It is based on the FDO's analysis of the target.

5-2. Target Attack Considerations

In determining how, if at all, to attack a target, the FDO must consider several factors.

a. Location of the Target. The FDO must check the location relative to friendly forces, fire support coordinating measures, and zones of responsibility. Target location accuracy must also be considered. The range to the target will affect the choice of unit(s) to fire and charge. The terrain around the target may influence ammunition selection and type of trajectory. High intermediate crests may require selection of a lower charge or high-angle fire.

b. Nature of the Target. The size and type of target (for example, troops, vehicles, hard, soft, and so on) will affect the following:

- Number of units to fire.
- Type of sheaf.
- Selection of ammunition.
- Number of rounds in fire for effect.
- Priority.
- Whether surprise fire (for example, time on target [TOT]) is possible.

c. Ammunition Available. The FDO must consider the amount and type of ammunition available and the controlled supply rate (CSR).

d. Units Available. The number of units available will not only affect which units will be used, but also the type of attack. Sweep and/or zone fire or other techniques may be needed to cover large targets when enough units are not available.

e. Commander's Guidance or Standing Operating Procedures. Restrictions on ammunition, the operations order, and SOPs may govern the selection of units and ammunition, target priority, and method of attack.

f. Call for Fire. The FDO must consider the observer's request carefully since he is observing the target and talks directly to the maneuver commander. The observer's request should be honored when possible.

g. Munitions Effects. The FDO may use the joint munitions effectiveness manual (JMEM) to determine the type munition and volume of fire to be delivered. The FDO will rely most often on the graphical munitions effectiveness table (GMET), attack guidance matrixes, commander's guidance, and/or experience.

h. Availability of Corrections. The availability of corrections to firing data for nonstandard conditions is a guiding factor in the choice of charge and munitions, since it directly affects accuracy.

i. Enemy Target Acquisition Capability. Knowledge of the current enemy counterbattery radar and sound-ranging capabilities allows the FDO to attack the target in a manner most likely to avoid detection of the unit's location.

NOTE: For a more detailed discussion, refer to Appendix B.

5-3. Fire Order Elements

In autonomous operations, the battery or platoon FDO must issue a fire order. The fire order will address all information needed to conduct the mission. The fire order is issued in a prescribed sequence. It consists of 10 elements:

- Unit to fire.
- Adjusting element and/or method of fire (MOF) of adjusting element.
- Basis for corrections.
- Distribution.
- Special instructions.
- Method of FFE.
- Projectile in effect (I/E).
- Ammunition lot and charge in effect.
- Fuze in effect.
- Target number.

If not standardized by unit SOP, the elements in Figure 5-1 will be addressed in the fire order.

a. UNIT TO FIRE. Indicates the units to follow the mission and to fire for effect. Normally, BATTERY or PLATOON is announced as the unit to fire.

b. ADJUSTING ELEMENT AND/OR METHOD OF FIRE OF THE ADJUSTING ELEMENT (if applicable). Indicates the weapon(s) that will adjust. Normally, the base piece is selected and will fire one round in adjustment.

(1) Projectile in adjustment. This is the type of shell to be fired by the adjusting piece in an adjust-fire mission.

(2) Lot and charge in adjustment. This is the ammunition lot (for the shell and propellant) and the charge to be fired by the adjusting piece in an adjust-fire mission.

(3) Fuze in adjustment. This is the type of fuze to be fired by the adjusting piece in an adjust-fire mission.

ELEMENTS
UNIT TO FIRE
ADJUSTING ELEMENT AND/OR MOF Projectile in adj Lot and charge in adj Fuze in adj
BASIS FOR CORRECTIONS
DISTRIBUTION
SPECIAL INSTRUCTIONS
METHOD OF FIRE FOR EFFECT
PROJECTILE I/E
AMMUNITION LOT AND CHARGE I/E
FUZE I/E
TARGET NUMBER

Figure 5-1. Fire Order Elements.

c. BASIS FOR CORRECTIONS. This element dictates how data will be determined. Normally, the fastest method is designated.

d. DISTRIBUTION. This element describes the pattern of bursts (sheaf) in or around the target area. The assumed sheaf is a parallel sheaf, which resembles the arrangement of the pieces in the firing position. The sheaf computed may vary from the assumed sheaf on the basis of the number of howitzers available, target size, attitude, and description received from the observer (obsr). If the FDO desires a sheaf other than the assumed sheaf, he will announce it here.

e. SPECIAL INSTRUCTIONS. This element is any method of control or coordinating instructions deemed appropriate by the FDO.

f. METHOD OF FIRE FOR EFFECT. This element indicates the number of rounds in the fire for effect phase of a mission. This element will always be announced by the FDO.

g. PROJECTILE IN EFFECT. This element is the projectile to be freed in effect.

h. AMMUNITION LOT AND CHARGE I/E. This element is the ammunition lot(s) and charge used in fire for effect.

i. FUZE I/E. This element is the fuze to be fired in effect.

j. TARGET NUMBER. This element is the specific target number assigned to a fire mission.

5-4. Battery or Platoon Fire Orders

The guidance in Table 5-1 will be used in issuing the fire order.

Table 5-1. Battery or Platoon Fire Orders.

STEP	ACTION
1	**UNIT TO FIRE**. This element is the unit that the FDO desires to fire in effect. In an adjust-fire mission, the unit to fire will be those pieces that follow the mission. The possible selections for UNIT TO FIRE are: BTRY (battery). PLT (platoon). LEFT. CENTER. RIGHT. Any gun number or combination of gun numbers.
2	**ADJUSTING ELEMENT AND/OR METHOD OF FIRE OF THE ADJUSTING ELEMENT.** **Projectile in adj** **Ammo Lot and Charge in adj** **Fuze in adj** This element indicates the piece or pieces that will conduct the adjustment in an adjust fire mission and the number and type of rounds to be fired per tube for each adjustment. The possible selections for ADJUSTING ELEMENT are: BTRY. PLT. LEFT. CENTER. RIGHT. Any gun number or combination of gun numbers. In an adjust-fire mission, it may be necessary to adjust with a projectile other than HE. When that happens, the projectile, lot, and fuze to be fired in adjustment will be addressed by the FDO as part of the method of fire in adjustment. The possible selections for METHOD OF FIRE OF THE ADJUSTING ELEMENT are: ANY NUMBER OF ROUNDS (usually one round). PROJECTILE (usually HE). LOT AND CHG. FUZE (usually QUICK).

Table 5-1. Battery or Platoon Fire Orders (Continued).

STEP	ACTION
3	**BASIS FOR CORRECTIONS**. This element indicates the method that will be used to compute firing data for the mission. The possible selections for BASIS FOR CORRECTIONS are: Use TFT. Use GFT (graphical firing table). Met + VE.
4	**DISTRIBUTION**. This element describes the desired pattern of bursts (sheaf) in the target area. The possible selections for DISTRIBUTION are: PARALLEL. CONVERGED. OPEN. RANGE or LATERAL SPREAD. SPECIAL (any other type of sheaf [that is, linear, circular, rectangular]). Additional information may be required for situations in which a special sheaf is to be fired. Immediately following the announcement of **SPECIAL**, any additional instructions concerning the sheaf will be announced. This pertains especially to family of scatterable mines (FASCAM) procedures. For example, the announcement **SPECIAL 3 AIMPOINTS**.
NOTE: Converged, open, and special sheafs will require that a special instruction of **SPECIAL CORRECTIONS** be announced in the fire commands at the fire-for-effect stage of the mission.	
5	**SPECIAL INSTRUCTIONS.** This element provides a place for the FDO to control the time of opening fire and special methods of attack. The possible selections for SPECIAL INSTRUCTIONS are discussed below. **WHEN READY (WR) is not** a special instruction. It is the standard time of opening fire unless a special instruction is imposed. This indicates that the howitzers may fire at the section chief's command. **AT MY COMMAND (AMC)** is a restrictive command that allows the FDO to control the time of firing from the FDC. When announced in the special instructions of the fire order, AMC will indicate that each round in the adjustment stage **and the first volley of fire for effect** will be at the FDC's command. AMC will be announced to the howitzers as a special instruction in the fire commands. **BY PIECE AT MY COMMAND (BPAMC)** is a restrictive command which is used to control the firing of the unit by howitzer at the FDO's discretion. BPAMC is announced as a special instruction in the fire commands. **BY ROUND AT MY COMMAND (BRAMC)** is a restrictive command that allows the FDO to control the time of firing of a group of rounds by volley. BRAMC is announced to the howitzers as a special instruction in the fire commands and will pertain only to the FFE stage of the mission. **BY PIECE, BY ROUND, AT MY COMMAND (BPBRAMC)** is a restrictive command which combines both BY PIECE and BY ROUND with AT MY COMMAND control. BPBRAMC is announced as a special instruction in the fire commands.

Table 5-1. Battery or Platoon Fire Orders (Continued).

STEP	ACTION
5	**TIME ON TARGET** allows the FDO to control the time of firing by indicating the time the rounds will impact at the target area. This method will be used most frequently to mass the fires of different units. AMC is announced as a special instruction in the fire commands. **RIGHT (or left) BY PIECE AT (interval)** is a restrictive command which will cause the pieces to fire at an announced interval beginning at either end of the gun line. This is used to allow the observer to examine the impacts and determine pieces that are placing rounds outside the sheaf. **AZIMUTH** may be included in the fire order when the FDO examines the plot of the target and finds that the howitzers must shift trails. The command **AZIMUTH (four-digit value)** is announced as a special instruction in the fire commands. **DO NOT LOAD (DNL)** is a restrictive fire command that prohibits loading and firing the howitzer. The howitzer section may prepare the ammunition, lay the howitzer for deflection, and set the quadrant elevation (or loading elevation). This command will be used when a long period of time may elapse before the firing of the mission. This allows other missions to be processed. DNL is announced as a special instruction in the fire commands. **CANCEL DO NOT LOAD (CDNL)** is the supplementary command of DNL. It allows the howitzers to load the ammunition. When quadrant is used, it will also be announced. Other restrictive commands may be necessary; for example, **CANCEL DO NOT LOAD, TARGET NUMBER AC4000 [if applicable], AMC, QUADRANT 347**). **CANCEL TERRAIN GUN POSITION CORRECTIONS (CTGPC)** is announced by the FDO when he does not want the howitzers to apply the TGPCs previously announced. CTGPC applies only to the mission in which the command is announced. CTGPC is announced as a special instruction in the fire commands. **PRIMARY, LEFT, RIGHT SECTOR** allows the FDO to instruct the FDC personnel that TGPCs are changed to the sector indicated. The change to the corrections of another sector will follow a shift in direction of fire (shift of trails). This command is announced to the howitzers as a special instruction and will remain in effect until the howitzers are directed to shift sectors. **HIGH ANGLE (HA)** indicates the target will be engaged with high-angle fire. HA is announced as a special instruction in the fire commands. **SWEEP AND/OR ZONE** indicates that the FDO desires to attack the target by one or both of these methods. The FDO will not try to announce the number of mils or number of deflections or quadrants. The FDC chief or computer will determine this on the basis of the size of the target and FDO's distribution. **USE GUNNER'S QUADRANT** indicates that the FDO wants the gunner's quadrant used to set or check the quadrant elevation. It is most commonly used during the firing of a registration, destruction mission, or danger close mission. USE GUNNER'S QUADRANT is announced as a special instruction in the fire commands.
6	**METHOD OF FIRE FOR EFFECT**. This element indicates the number of rounds to be fired by each howitzer in the FFE phase of a mission. It will always be announced by the FDO.

Table 5-1. Battery or Platoon Fire Orders (Continued)

STEP	ACTION
7	**PROJECTILE IN EFFECT**. This element indicates the projectile to be fired in fire for effect.
8	**AMMUNITION LOT AND CHARGE IN EFFECT**. This element indicates the lot and charge to be fired in fire for effect.
	NOTE: The range-deflection protractor (RDP) can be marked along the range arm to indicate the appropriate charge for a given range. A guide for marking the RDP is to segment the RDP in the same manner as indicated by the charge selection tables in the introduction of each TFT. The FDO should consider the tactical situation (primary target engagement ranges and counterfire threat), munition effects (as related to the angle of fall), probable error, tube wear, and surrounding terrain in selecting the **best** charge to fire. The announcement of **RANGE** and **CHARGE (such-and-such)** by the HCO significantly speeds mission processing times. Refer to Appendix C for ammunition planning ranges.
9	**FUZE IN EFFECT**. This element indicates the fuze to be fired in fire for effect. When shell HE is fired in effect, only the fuze needs to be announced. When shells other than HE are fired, the fuze is not announced, except when white phosphorus (WP) or time (ti) is desired.
10	**TARGET NUMBER**. The target number consists of six characters comprised of two alphabetic characters followed by four numerical positions. This element allows a target number from the firing unit's target number block to be assigned to the mission. The computer assigns the target number and records it on DA Form 4504 (Record of Fire). It is transmitted by the RATELO (in the message to observer) to help the observer identify all fire mission-related messages to a particular mission. This facilitates mission processing. All missions must have a target number.

5-5. Fire Order Standing Operating Procedures

a. In most cases, a particular element of the fire order may remain the same from one mission to the next. On the basis of the tactical situation, type and amount of ammunition available, and commander's guidance, the FDO establishes an SOP for each element, which should be displayed in the FDC. When the FDO does not address an element in his fire order, the standard for that element will apply. The FDO need only announce what has changed from the standard. However, the method of fire for effect must be announced.

b. The FDO must ensure that the fire order is clear, concise, and in the proper format. The fire order format is designed to disseminate information clearly and rapidly with minimal discussion. It is impossible to provide a textbook solution for every conceivable situation, but a combination of technical knowledge and common sense should be enough to avoid confusion. It is better, if any confusion exists, to be redundant rather than too brief.

c. The use of a good SOP to clarify certain missions is essential. Immediate suppression, immediate smoke, illumination (illum), and mixed shell missions (HE and WP, for instance), can be handled more responsively when governed by an SOP. For example, an FDO needs only to say **IMMEDIATE SUPPRESSION** to mean a platoon will fire two volleys of HE/variable time (VT).

d. The example below shows the fire order elements and the fire order SOP for a four-howitzer platoon. (See Figure 5-2.)

EXAMPLE	
Recorded call for fire:	**K38 de C19, AF k** **GRID 364239 k** **BTR-70, ICM I/e k**
FDO decision: The FDO decides to attack the target and fire platoon 1 round, shell HE/fuze VT I/E with a converged sheaf with chg 4, lot AG, and to adjust with Howitzer Number 2.	

(See Figure 5-3, which shows all elements addressed in the previous example.

UNIT TO FIRE	BATTERY/PLATOON
ADJUSTING ELEMENT AND/OR MOF Projectile in adj Lot and charge in adj Fuze in adj	#3 1 ROUND HE LOT AG/FDO or COMPUTER SELECT[1] Q
BASIS FOR CORRECTIONS	USE GFT
DISTRIBUTION	PARALLEL
SPECIAL INSTRUCTIONS	WR
METHOD OF FIRE FOR EFFECT	FDO ANNOUNCE
PROJECTILE I/E	OBS/FDO SELECT[2]
AMMUNITION LOT AND CHARGE I/E	FDO/COMPUTER SELECT[1]
FUZE I/E	OBS/FDO SELECT[2]
TARGET NUMBER	NEXT AVAILABLE

NOTE: The FDO has the final decision-making authority in the FDC and can override any standard by announcing his choice. He will also make any additional announcements that he feels are necessary to avoid confusion and allow him to maintain control.

[1] The FDO/computer must select a charge that will allow the engagement of the majority of targets within the area of operations. This provides the charge to register and the one to be used in the computation of TGPCs. If the fire for effect lot(s) and charge are the same as in the adjustment phase, they will not be addressed in the AMMUNITION LOT AND CHARGE I/E block.

[2] The standard **OBSERVER/FDO SELECT** allows the FDO to agree with the observer's selection as announced, or implied in the call for fire, by making no announcement. This should result in a shorter fire order. In most cases, the FDO should try to fulfill the observer's request. The FDO overrides the observer's request by announcing his choice.

Figure 5-2. FDC Fire Order SOP.

(Elements in parentheses are SOP and are not announced.)

	ELEMENT	DECISION	EXPLANATION
1	UNIT TO FIRE	(PLT)	SOP
2	ADJUSTING ELEMENT AND/OR MOF Projectile in adj Lot and charge in adj Fuze in adj	#2 1 ROUND (HE) (AG/4) (Q)	Differs from SOP SOP Does not differ from SOP SOP
3	BASIS FOR CORRECTIONS	(Use GFT)	SOP
4	DISTRIBUTION	Converged	Differs from observer's implied choice
5	SPECIAL INSTRUCTIONS	(WR)	SOP
6	METHOD OF FIRE FOR EFFECT	1 ROUND	FDO must announce
7	PROJECTILE I/E	(HE)	Differs from the observer's request but is not announced as HE. Since fuze VT will be fired in effect, it is understood it is HE.
8	AMMUNITION LOT AND CHARGE I/E	(AG/CHG 4)	Same as adjustment
9	FUZE I/E	VT I/E	Differs from observer's request
10	TARGET NUMBER	(AA7000)	Assigned by the computer

Thus the fire order is: **#2, 1 round, converged sheaf, 1 round VT I/E.**

Figure 5-3. Example Fire Order.

5-6. Battalion Fire Order

Battalion fire orders must be issued to mass the fires of the battalion on a single target. The battalion fire order differs from the battery or platoon fire order since all the units of the battalion may not be able to receive the call for fire. The battalion fire order must be able to convey all information to cause the units to engage the target. A battalion fire order (Figure 5-4) follows the same basic format as a battery or platoon fire order except for the following:

a. WARNING ORDER. A warning order is issued to indicate the type of mission (AF or FFE) to be fired (not standardized).

b. UNIT TO FIRE. This is the unit to fire for effect. If the fire order originates at the battalion FDC and the FDO decides to fire the entire battalion, the element is announced as **BATTALION.** To designate less than the entire battalion, the individual elements are announced (for example, **ALPHA** and **CHARLIE).** When the designation of the unit to fire is transmitted outside the FDC, the unit call sign should be used.

c. UNIT TO ADJUST or METHOD OF FIRE OF THE ADJUSTING UNIT. This is the battery that conducts the adjustment. The battalion FDC will not try to direct a specific piece to adjust; however, the adjusting battery's base piece should be the adjusting piece. When the battalion fire order is transmitted, the last letter of the unit call sign will be used (can be standardized). The battalion may specify the number of rounds, projectile type, lot, charge, and fuze to use in the adjustment by the adjusting unit.

d. BASIS FOR CORRECTIONS. This is the same as the battery-or platoon-level fire order (can be standardized).

e. DISTRIBUTION or TARGET LOCATION. This is the FO's target location, to include target altitude, from the call for fire. If adjustment is necessary, the nonadjusting units will follow the adjustment and fire for effect on the adjusted grid. In adjust-fire missions, the battalion FDO may direct the adjusting unit to transmit the replot location and altitude to the battalion FDC after the completion of the adjustment. The battalion FDC may choose to segment the target, sending aimpoints to the units of the battalion, before fire for effect or direct the units to mass on the adjusted grid by sending the adjusted or replot grid (not standardized).

NOTE: The remaining elements of the battalion fire order are similar to the battery or platoon fire order except for standards.

f. SPECIAL INSTRUCTIONS. This element can be standardized.

g. METHOD OF FIRE FOR EFFECT. This element is not standardized.

h. PROJECTILE I/E. This element can be standardized.

i. AMMUNITION LOT AND CHARGE I/E. This element can be standardized; however, normally the battery or platoon FDO will select it.

j. FUZE I/E. This element can be standardized.

k. TARGET NUMBER. This element is not standardized.

ELEMENT		STANDARD
1	WARNING ORDER	Indicated (Not Standardized)
2	UNIT TO FIRE	Battalion
3	ADJUSTING ELEMENT AND/OR MOF	"A"
4	BASIS FOR CORRECTIONS	Fastest Method
5	DISTRIBUTION	Location (Grid and Altitude)
6	SPECIAL INSTRUCTIONS	WR
7	METHOD OF FIRE FOR EFFECT	Always Announced
8	PROJECTILE I/E	DPICM
9	AMMUNITION LOT AND CHARGE I/E	Battery/Platoon FDO Selects
10	FUZE I/E	Time
11	TARGET NUMBER	Next Available From the Battalion Target Block Number

Figure 5-4. Example Battalion Fire Order.

5-7. Massing of Fires

a. Massing. What does an artilleryman mean when he uses the word *massing?* By definition, it means simultaneous execution of two or more firing elements to achieve maximum effects on a critical target. The 3 x 8 battery bringing its two platoons to bear on a single target, a battalion massing on one point, and even a division artillery (divarty) or corps artillery commander bringing all his battalions onto a single target are all examples of massing. Regardless of the level of command, certain fundamental requirements must be met for two or more units to engage targets **effectively** together.

(1) The first requirement for massing is that all firing units must be on a common location and azimuth system; that is, **common survey.** This includes all platoons, radars, met stations, and observers. The survey control should extend into the target area as well.

(2) The second requirement is accurate MV information for each weapon. Manual corrections for MVVs will occur during concurrent and subsequent met procedures and through determining TGPCs with the Ml 7 plotting board.

(3) The third requirement is valid met corrections considered by each of the firing platoons. This includes the met message valid for the firing platoon, propellent temperature, projectile weight, vertical interval, and corrections for earth rotation.

(4) The final requirement is accurate location. This is the reason the target-locating assets must be on common survey with the firing units. Ensure the target location determined by the observer is the same location plotted by the FDC.

(5) If the target is accurately located and the first three requirements are satisfied, then you can mass without having to adjust each unit onto the target. However, if it is an adjust-fire mission, the adjusting unit must determine the accurate target location and then announce it to the other units. To determine the accurate target location, the adjusting FDC must perform replot procedures discussed in Appendix D. The FDC must then announce the replot grid. The controlling FDC is responsible for the fire order and control of the mission.

b. Control of Battalion Mass Missions.

(1) When massing the fires of more than one battery either firing for effect or adjusting, **AT MY COMMAND, TIME ON TARGET,** or **WHEN READY** can be used. The most effective technique is **TIME ON TARGET,** which achieves the greatest surprise to the enemy.

(2) Control of FFE mass missions on stationary targets can best be affected by using TOT techniques. Accurate time coordination is essential to ensure the simultaneous impact of all initial rounds; lengthy countdowns are unnecessary.

(a) The TOT may be announced as a specific time (for example, TOT 0915). The battalion would announce a time check to synchronize the units designated to fire. This is done by using the following procedure:

- The battalion FDC will announce the time (for example, **AT MY MARK THE TIME WILL BE 0908).**
- The battalion FDC will give a short countdown starting 5 seconds before the mark (for example, **5, 4, 3, 2, 1, MARK).**
- Each FDC would start its clock at **MARK.** From that moment, each FDC would control its own firing.

- Each FDC would respond to the battalion FDC with **ROGER OUT** if they received a **good mark.**
- If a good mark was not received, the unit FDC will request a new mark and the previous four steps will be done again.

(b) Another technique to execute a TOT is to specify the amount of time before it is to occur (for example, **TOT 5 MINUTES FROM MY MARK).** Each FDC would start its stopwatch at **MARK.** From that moment, each FDC would control its own firing.

(c) The preferred technique is the short countdown TOT (for example, **TOT 40 SECONDS FROM MY MARK).** The short countdown allows the FDO to decrease the amount of time between receiving a call for fire and massing on the target. The FDO will announce as part of the special instructions in his fire order **SHORT COUNT TOT FOLLOWS.** This alerts the firing units that the mission is **AT MY COMMAND** and that they will report **READY, TOF** to the battalion FDC. The battalion FDO will add 10 seconds (reaction time) to the longest time of flight reported. If the longest TOF is 30 seconds, he will announce **TOT 40 SECONDS FROM MY MARK, 5, 4, 3, 2, 1 MARK.** The firing units will quickly subtract their TOF from the number of seconds the battalion FDO announced. The result is the number of seconds after **MARK** until they command **FIRE.**

(3) Control of an FFE mass mission on moving targets is best achieved by using **AT MY COMMAND** or **WHEN READY.** The time consumed during a TOT countdown may result in the rounds missing the target.

(a) **AT MY COMMAND.** All units will fire at the same time. The battalion FDO will select this technique if he is willing to accept some loss of surprise caused by varying times of flight to get the rounds on the target quickly. This technique is particularly effective when the unit's times of flight as reported by each FDC are similar.

(b) **WHEN READY.** Unless otherwise specified, each battery will fire when ready. This technique is used more often with adjust-fire missions (particularly those with lengthy adjustment phases) than with fire-for-effect missions. (When surprise has been lost, the difference in reaction times and times of flight between units is less significant.)

(4) Control of the FFE phase in an adjust-fire mass mission can be achieved by the same means as an FFE mass mission.

(a) **TIME ON TARGET.** If the observer is able to enter the FFE phase with one correction and he judges that the target has not been warned, a **TIME ON TARGET** (paragraph (2) above) may be used to control time of firing in effect. If the battalion FDO decides a TOT is unsuitable (for example, loss of time outweighs simultaneous impacting of all initial FFE rounds), he will direct use of **AT MY COMMAND** or **WHEN READY.** It is rare, however, that a target would not be warned during adjustment. Therefore, TOT to control time of firing in effect after adjustment is not normally used.

(b) **AT MY COMMAND.** The considerations for the selection of this technique are the same as in paragraph (3)(a) above. In addition, it is useful if the observer is able to enter the FFE phase with a large correction.

(c) **WHEN READY.** In most adjust-fire mass missions, no control of time of firing in effect will be used. Since most targets would be warned during adjustment, the battalion FDO would allow units to fire when ready.

c. Examples of Battalion Fire Orders. Examples of battalion fire orders are shown below.

EXAMPLE 1

The battalion FDC is using voice communications to pass the fire order to the platoon FDCs. The call signs are as follows:

BN FDC	G6H38
1/A	J3D38
2/A	J3E38
1/B	H5K38
2/B	H5M38
1/C	C2R38
2/C	C2T38

The following call for fire is received by the battalion FDC:

> **HOTEL THREE EIGHT, THIS IS CHARLIE ONE NINE, ADJUST FIRE BATTALION, OVER.**
> **GRID THREE FIVE FOUR TWO TWO THREE, OVER.**
> **BATTALION ASSEMBLY AREA, ICM IN EFFECT, OVER.**

The battalion FDO decides to have 2/C adjust and 1/A, 2/A, 2/B, 1/C, and 2/C to fire for effect. The battalion FDO decides to honor the observer's request for improved conventional munitions (ICM). Notice the battalion FDO decided to announce those units not firing for effect. In this case, the adjusting element (T38) is not followed by the word *adjust*. If the battalion FDO wanted to eliminate the possibility of confusion that may result from announcing a platoon call sign after the unit to fire, the adjusting element (T38) would be followed by the word *adjust*.

ELEMENT	FIRE ORDER WITHOUT STANDARDS	FIRE ORDER WITH STANDARDS
WARNING ORDER	___de H38, AF	___ de H38, AF
UNIT TO FIRE	H LESS K	H LESS K
ADJUSTING ELEMENT AND/OR METHOD OF FIRE	T	T
BASIS FOR CORRECTIONS	FASTEST METHOD	
DISTRIBUTION	GRID 354223 ALT 400	GRID 354223 ALT 400
SPECIAL INSTRUCTIONS	TOT 0915	TOT 0915
METHOD OF FFE	10 ROUNDS I/E	10 ROUNDS I/E
PROJECTILE I/E	ICM I/E	
AMMUNITION LOT AND CHARGE I/E	PLT FDO SELECT	
FUZE I/E		
TARGET NUMBER	AB7022	AB7022

EXAMPLE 2

The battalion FDO is controlling the battalion on a single, secure voice net. A replot must be performed because of the mountainous terrain in which the battalion is now operating. The call signs are as follows:

BN FDC	G6H38
A	J3D38
B	H5E38
C	C2R38

The following call for fire is received by Battery B:

ECHO THREE EIGHT, THIS IS TANGO ZERO THREE, ADJUST FIRE, POLAR, OVER.
DIRECTION THREE FOUR FIVE ZERO, DISTANCE THREE EIGHT ZERO ZERO, UP SIX ZERO, OVER.
BATTALION BIVOUAC, ICM IN EFFECT, OVER.

The battalion FDO decides to mass the battalion with Battery B adjusting (battalion SOP indicates that the battery FDO will decide which howitzer will adjust). The battalion will fire 5 rounds, VT I/E. After the adjustment is complete, the adjusting battery sends the replot grid to battalion. The replot grid and altitude are then transmitted to the remainder of the battalion.

ELEMENT	FIRE ORDER WITHOUT STANDARDS	FIRE ORDER WITH STANDARDS
WARNING ORDER	ADJUST FIRE	ADJUST FIRE
UNIT TO FIRE	BATTALION	BATTALION
ADJUSTING ELEMENT AND/OR METHOD OF FIRE	BRAVO	BRAVO
BASIS FOR CORRECTIONS	FASTEST METHOD	
DISTRIBUTION	REPLOT GRID AND ALTITUDE	REPLOT GRID AND ALTITUDE
SPECIAL INSTRUCTIONS	AMC	AMC
METHOD OF FFE	5 ROUNDS	5 ROUNDS
PROJECTILE I/E		
AMMUNITION LOT AND CHARGE I/E	BTRY FDO SELECT	
FUZE I/E	VT I/E	VT I/E
TARGET NUMBER	AB7023	AB7023

Section II

Message to Observer

This section implements STANAG 2934, Chapter 5, and QSTAG 246.

After the FDC receives the call for fire, the FDO analyzes the target. If the target is to be attacked the FDO issues the fire order as his decision on how the target will be attacked. The observer is informed of this decision through the message to observer.

5-8. Description

The message to observer consists of four elements and is composed by the RATELO.

a. Units to Fire. The first element is the unit(s) that will fire the mission. It is always announced. If a battalion is firing in effect with one battery or platoon adjusting, the MTO will designate the FFE unit (battalion) and the adjusting unit (battery or platoon). The units to fire are identified by their radio call signs, using long call signs, short call signs, or the first letter of the short call sign. Some examples are listed below.

EXAMPLES
The mission is an adjust-fire mission with the battalion firing for effect. The battalion FDC call sign is G6H38. Battery B, 1st Platoon FDC call sign is H5K38. Battery B, 1st Platoon will adjust, and the battalion will fire for effect. The RATELO would announce **MTO HK**.
NOTE: The RATELO would use the phonetic alphabet to announce units to fire. For example, the announcement in the paragraph above would be given as **MIKE, TANGO, OSCAR HOTEL, KILO**.
The mission is a battalion FFE mission. The battalion FDC call sign is G6H38. The RATELO would announce **H**. In autonomous operations, Battery B, 1st Platoon receives a call for fire for an adjust-fire mission. The RATELO would announce **K**.

b. Changes or Additions to the Call for Fire. The second element of the MTO allows the FDC to inform the observer of changes and/or additions made by the FDO to the call for fire. If high-angle fire is to be used, **HIGH ANGLE** must be included in the MTO if the observer did not request it. The following examples use the previously stated call signs.

EXAMPLES
The observer requests VT in effect, and the FDO decides to fire fuze time in effect. The RATELO for battalion would announce **MTO H, K, TIME IN EFFECT**. For the battery or platoon, it would be announced as **MTO, K, TIME IN EFFECT**.
The observer requests time in effect, and the FDO decides to fire high-angle using fuze VT in effect. The RATELO for battalion would announce **MTO H, K, HA, VT IN EFFECT**. For the battery or platoon, it would be announced as **MTO, K, HA, VT IN EFFECT**.

c. Number of Rounds. The third element is the number of volleys in fire for effect. The number of rounds to be fired in effect is **always** announced. The following example uses the previously stated call signs and change to the call for fire.

EXAMPLE

The battalion FDO decides to fire three rounds in effect. The RATELO would announce **MTO, H, K, TIME IN EFFECT, 3 ROUNDS**. For the battery or platoon, it would be announced as **MTO, K, TIME IN EFFECT, 3 ROUNDS**.

d. Target Number. The last element is the target number assigned to the mission for reference purposes, it is always announced. This is done to avoid confusion if multiple missions are being fired or if more than one observer is operating on the radio net. Target numbers are used in sequential order based on the units target block. The following example uses the previously stated call signs, change(s) to the call for fire, and number of rounds.

EXAMPLE

The next available target number for the battalion FDC is AA7000. The RATELO would announce, **MTO, H, K, TIME IN EFFECT, 3 ROUNDS, TARGET NUMBER AA7000**. The next available target number for the battery or platoon is AA7300. The RATELO would announce **MTO, K, TIME IN EFFECT, 3 ROUNDS, TARGET NUMBER AA7300**.

5-9. Additional Information

The following additional information may be announced with or after the message to observer.

a. Probable Error in Range. If the probable error in range for an area fire mission is equal to or greater than 38 meters, the FDC will inform the observer. For precision fire, the FDC will inform the observer if the probable error in range is equal to or greater than 25 meters. The actual value is not announced. For example, the RATELO would announce **PROBABLE ERROR IN RANGE GREATER THAN 38 METERS.**

b. Angle T. Angle T is sent to the observer when it is equal to or greater than 500 mils or if the observer requests it. It is announced to the nearest 100 mils. For example, if angle T is 580 mils, it is expressed and announced as **ANGLE T 600.**

c. Pulse Repetition Frequency Code. The pulse repetition frequency (PRF) code for a Copperhead mission is transmitted in voice operations; for example, the RATELO will announce **PRF CODE 241.** The range and direction of approach (left or right of the observer-target line) are needed to orient the footprint.

d. Time of Flight. Time of flight (TOF) is announced to the nearest whole second. It is announced to observers when targets are engaged with Copperhead, when moving targets are engaged, when conducting high-angle missions, when using an aerial observer, or when requested by the observer. For example, the RATELO would announce **TIME OF FLIGHT 34 SECONDS.**

e. Splash. Splash informs the observer that the round(s) fired will impact in 5 seconds. It must be sent to aerial observers and during high-angle fire missions. It can also be sent at the observer’s request.

f. Shot and Rounds Complete. SHOT is announced to the observer to report when a round has been fired. Rounds complete is announced to the observer when all rounds for a particular mission have been fired. During an adjust-fire mission **SHOT** is announced after each round. Once the FFE phase is initiated, **SHOT** is announced only on the initial round. Once all rounds have been fired, rounds complete is announced to the observer. For an FFE mission, **SHOT** is announced only on the initial round; once all rounds have been fired, rounds complete is announced to the observer.

Section III

Fire Commands

Fire commands are used by the FDC to give the howitzer sections all the information needed to conduct a fire mission. Initial fire command include all elements needed for orienting, loading, and firing the howitzer. Subsequent fire commands include only those elements that have changed from the previous command(s), except quadrant elevation. Quadrant elevation is announced in every set of fire commands and allows the howitzer section to fire if in a WR status.

5-10. Fire Command Elements

a. The elements of fire commands are always announced in the same sequence (Table 5-2). This saves time and eliminates confusion; each member of the howitzer section knows the sequence and should be ready for the next command.

b. Certain elements of the fire commands may be standardized. Once the standards are established and announced to the howitzer sections, the standard (std) elements will not be announced. Quadrant elevation may never be standardized. It is announced in-each set of fire commands.

Table 5-2. Fire Command Sequence.

ELEMENT		WHEN ANNOUNCED	WHEN ANNOUNCED
Commands		**Initial Fire Commands**	Subsequent Fire Commands
1	WARNING ORDER	Always	Never
2	PIECES TO FOLLOW	When applicable	When changed
	PIECES TO FIRE[1]	When other than std	When changed
	METHOD OF FIRE[1]	When other than std	When changed
3	SPECIAL INSTRUCTIONS ● DO NOT LOAD ● AMC (BPAMC, BRAMC, BPBRAMC) ● HIGH ANGLE ● USE GUNNER'S QUADRANT ● AZIMUTH ● SPECIAL CORRECTIONS ● SWEEP AND/OR ZONE FIRE	When applicable	When changed
4	PROJECTILE[1]	When other than std	When changed
5	AMMUNITION LOT[1]	When other than std	When changed
6	CHARGE	Always	When changed
7	FUZE[1]	When other than std	When changed
8	FUZE SETTING	When applicable	When changed
9	DEFLECTION	Always	When changed
10	QUADRANT	Always	Always
11	METHOD OF FFE	When applicable	When changed

[1] These elements may be standardized. Elements that are standardized will be announced only when something other than standard is to be fired.

5-11. Battery or Platoon Fire Commands

The procedures and sequence for announcing fire commands are in Table 5-3; all other fire commands are in Table 5-4.

Table 5-3. Battery or Platoon Fire Commands.

STEP	ACTION
1	**WARNING ORDER**. This element is always announced to alert the firing unit to the mission. The warning order **"FIRE MISSION"** is announced. The warning order is not announced in subsequent commands.
2	**PIECES TO FOLLOW, PIECES TO FIRE, AND METHOD OF FIRE**. This element designates the weapon(s) that will follow the mission, the weapon(s) that will fire initially, and with how many rounds they will engage the target. **PIECES TO FOLLOW** tells the howitzers who will follow the mission for an adjust-fire mission. The command **BATTERY** or **PLATOON ADJUST** indicates that the mission will be an adjust-fire mission and that all weapons will copy the commands, follow the mission, and participate in the FFE phase. Any weapon or number of weapons may be announced in this element; for example, **FIRE MISSION, PLATOON ADJUST** or **FIRE MISSION, NUMBER 1 AND NUMBER 3 ADJUST**. If the mission is an FFE mission, **PIECES TO FOLLOW** is not announced. **PIECES TO FIRE** indicates which weapon(s) will fire the data announced in the initial fire commands. For example, **FIRE MISSION, PLATOON ADJUST, NUMBER 3** indicates that during an adjust-fire mission, Number 3 will fire the adjustment. **METHOD OF FIRE** tells the firing piece(s) how many rounds to fire. For example, **FIRE MISSION, PLATOON ADJUST, NUMBER 3, 1 ROUND** indicates that during an adjust-fire mission, Number 3 will fire one round with the data announced in the fire commands. **PLATOON 1 ROUND** indicates an FFE mission with all weapons firing one round with the data announced in the initial fire commands.
3	**SPECIAL INSTRUCTIONS**. This element is used when actions that are different from normal are required. The FDC must announce the words ***SPECIAL INSTRUCTIONS*** followed by the special instruction. When more than one special instruction applies, **restrictive** commands should be announced first. **DO NOT LOAD** is a restrictive fire command that prohibits loading and firing of the howitzer. The howitzer section may prepare the projectile, charge, and fuze; lay the howitzer for deflection; and set the quadrant elevation (or loading elevation). For example, the command from the FDC would be **FIRE MISSION, PLATOON 1 ROUND, SPECIAL INSTRUCTIONS DO NOT LOAD"** **To fire the round(s), the FDC would command CANCEL DO NOT LOAD, QUADRANT (so much)**. This command allows the guns to load and fire the round(s) as long as no other restrictions have been imposed. The target number may be used in place of the command **QUADRANT** to allow loading and firing of preplanned targets and scheduled fires. For example, the FDC would command **CANCEL DO NOT LOAD, FIRE TARGET BLUE**. **AT MY COMMAND** (or **BY PIECE [BY ROUND] AT MY COMMAND)** are restrictive commands that prohibit the howitzer(s) from firing until directed to do so by the FDC. **An example of the command AT MY COMMAND** from the FDC would be **FIRE MISSION, PLATOON 3 ROUNDS, SPECIAL INSTRUCTIONS AT MY COMMAND**. To have the howitzers fire the rounds, the FDC could use one of the following methods. **The FDC could announce PLATOON STANDBY, FIRE**. This would allow the howitzer sections to fire the first volley; the remaining volleys would then be fired at the howitzer section chief's command.

Table 5-3. Battery or Platoon Fire Commands (Continued).

STEP	ACTION
	Another method the FDC could use is to announce CANCEL AT MY COMMAND, QUADRANT (so much). This would allow the howitzer sections to fire the first volley; the remaining volleys would then be fired at the howitzer section chief's command. **An example of the command BY PIECE AT MY COMMAND** from the FDC would be **FIRE MISSION, PLATOON 3 ROUNDS, SPECIAL INSTRUCTIONS BY PIECE AT MY COMMAND**. This would direct the howitzers that all rounds specified would be fired by howitzer at the FDC's command. **An example of the command BY ROUND AT MY COMMAND** from the FDC would be, **FIRE MISSION, PLATOON 3 ROUNDS, SPECIAL INSTRUCTIONS BY ROUND AT MY COMMAND**. This would direct the howitzers that each volley would be fired at the FDC's command. The command **BY PIECE, BY ROUND, AT MY COMMAND** combines the control of both commands explained above. **NOTES: AT MY COMMAND** remains in effect until the FDC commands **CANCEL AT MY COMMAND** (or **BY PIECE** or **BY ROUND AT MY COMMAND**). **AT MY COMMAND** may be canceled at any time. If the FDC has announced **QUADRANT**, the command would be **CANCEL AT MY COMMAND, QUADRANT (so much)**. The Copperhead target of opportunity missions are **AT MY COMMAND** missions. **HIGH ANGLE** is announced to alert the howitzers that the mission to be fired is at an angle of elevation approximately 800 mils or greater. Light artillery weapons can be elevated before loading. Medium and heavy artillery weapons must be loaded at the specified loading elevation for their particular weapon system. An example of the command **HIGH ANGLE** from the FDC would be **FIRE MISSION, PLATOON 3 ROUNDS, SPECIAL INSTRUCTIONS HIGH ANGLE**. **USE GUNNER'S QUADRANT** is announced when the FDC wants the gunner's quadrant used to set or check quadrant elevation. It is most commonly used during the firing of a registration, destruction mission, or danger close mission. An example of the command **USE GUNNER'S QUADRANT** from the FDC would be, **FIRE MISSION, PLATOON 3 ROUNDS, SPECIAL INSTRUCTIONS USE GUNNER'S QUADRANT**. **AZIMUTH** is announced to alert the howitzers to a large shift in the direction of fire. The command **AZIMUTH** is followed by the azimuth in mils. An example of the command **AZIMUTH** from the FDC would be **FIRE MISSION, PLATOON 3 ROUNDS, SPECIAL INSTRUCTIONS AZIMUTH (so many mils)**. **SPECIAL CORRECTIONS** is announced to alert the howitzers that an individual fuze setting, deflection, and/or quadrant will be announced for each howitzer section. **The words *SPECIAL CORRECTION(s)*** should precede any special corrections that apply in the fire commands. This command prevents misunderstanding and unnecessary repetition of missed special corrections. If **SPECIAL CORRECTIONS** is announced alone, it alerts the sections that separate firing data will be sent to one or more sections. Unit SOP and degree of training dictate how this should be implemented. **SPECIAL CORRECTION, NUMBER (so-and-so), LEFT** or **RIGHT (so many mils)** may be announced. These corrections are applied by the specified piece to the announced deflection and remain in effect until changed (within a fire mission) or until the command **END OF MISSION** is given. This command may be announced administratively, apart from fire commands, or it may be announced in the special instructions element of a fire command. These corrections are in addition to any corrections currently on the gunner's aid.

Table 5-3. Battery or Platoon Fire Commands (Continued).

STEP	ACTION
	SPECIAL CORRECTION, ON NUMBER (so-and-so), OPEN or **CLOSE (so many mils)** may be announced. Each howitzer (other than the howitzer specified) applies a correction to the announced deflection on the gunner's aid. Each section chief determines his correction by multiplying the number of mils announced by the number of howitzers his howitzer is removed from the one announced. For example, the command **SPECIAL CORRECTION, ON NUMBER 3, CLOSE 4 MILS** is given. Number 3 applies no correction. Number 1 applies left 8 mils. Number 2 applies left 4 mils. Number 4 applies right 4 mils. All howitzers will fire the announced deflection after applying their corrections to the gunner's aid. These corrections are applied to any correction already on the gunner's aid and remain in effect until changed (within a fire mission) or until the command **END OF MISSION** is given. **SPECIAL CORRECTIONS, LEFT, CENTER,** or **RIGHT SECTOR** is announced when terrain gun position corrections for other than the primary sector are being used. If TGPCs are computed, the corrections for the primary sector are set on the gunner's aid of all weapons. These corrections are announced administratively and recorded on the gunner's reference card. To change sectors, the FDC commands **SPECIAL CORRECTIONS, LEFT, CENTER** or **RIGHT SECTOR.** **CANCEL TERRAIN GUN POSITION CORRECTIONS** indicates that all howitzer sections are to set their gunner's aid counters to zero. At the end of the mission, the TGPCs that were in effect before the mission (usually the primary sector) will be reapplied unless the FDC instructs otherwise. **SWEEP (so many) MILS, (so many) DEFLECTIONS** is used when the standard sheaf does not adequately cover the target and more width is required. Sweep fire provides for firing several deflections with one quadrant. For example, the FDC would command **SWEEP 10 MILS, 5 DEFLECTIONS**. The howitzer section chiefs compute the required deflections and, after firing the initial deflection, fire the remaining deflections in any order or as directed by unit SOP. **ZONE (so many) MILS, (so many) QUADRANTS** is used when the standard sheaf does not adequately cover the target and more depth is required. Zone fire provides for firing one deflection with several quadrants. For example, the FDC would command **ZONE 5 MILS, 3 QUADRANTS.** The howitzer section chiefs compute the required quadrants and, after firing the initial quadrant, fire the remaining quadrants in any order or as directed by unit SOP. **SWEEP (so many) MILS, (so many) DEFLECTIONS; ZONE (so many) MILS, (so many) QUADRANTS** is used when combining sweep fire and zone fire. Sweep and zone fire provides for firing several deflections and quadrants. The howitzer sections fire all combinations of computed deflections and quadrants in any order or as directed by unit SOP.
4	**PROJECTILE.** This element designates the type of projectile to be used in the fire mission. The projectile must be announced when it differs from standard.
5	**AMMUNITION LOT.** This element designates the projectile and propellant to be used in the fire mission. Ammunition lot numbers should be coded with alphabetic characters for simplicity. Separate-loading ammunition (155 mm and 203 mm) requires two designators--the first letter for the projectile and the second letter for the propellant. Semifixed ammunition has only a one-letter designator. Lot designators are established as directed by unit SOP. The lot designators must be announced if they differ from standard.
6	**CHARGE.** This element indicates the amount of propellant to be used in the fire mission. It also grants permission for the howitzer crew to cut the propellant. Charge is never standardized.

Table 5-3. Battery or Platoon Fire Commands (Continued).

STEP	ACTION
7	**FUZE**. This element designates the type of fuze to be used in the fire mission. If fuze quick is to be fired in the delay mode, the FDC would announce **FUZE DELAY**. Fuze is only announced if it differs from standard. In subsequent fire commands, it is only announced when a change in type is desired.
8	**FUZE SETTING**. This element designates the fuze setting for a mechanical time (MT), mechanical time super quick (MTSQ), or proximity (VT) fuze. For example, the FDC would announce **FUZE TIME, TIME 17.6** or **FUZE VT, TIME 17.0**.
	NOTE: If shell DPICM is to be fired in the self-registration (SR) mode, fuze setting black triangle 98.0 must be announced. For example, the FDC would announce **SHELL DPICM-SR, LOT FG, CHARGE 4, FUZE TIME, TIME BLACK TRIANGLE 98.0**.
9	**DEFLECTION**. This element tells the howitzer sections what direction (left or right) to traverse the tube. Deflection is always announced as four digits; for example, the FDC would announce **DEFLECTION 3321** (announced as three three two one) or **DEFLECTION 3300** (announced as three three hundred).
10	**QUADRANT ELEVATION**. This element gives the howitzer section chief permission to load and fire the round unless otherwise restricted by special instructions or unsafe conditions. Quadrant elevation is announced in the same manner as the deflection. For example, the FDC would announce **QUADRANT 421** (announced as four two one) or **QUADRANT 500** (announced as five hundred).
11	**METHOD OF FIRE FOR EFFECT**. This element indicates the number of rounds and type of ammunition (shell, lot, fuze, [if required]) to be used in the FFE phase of an adjust-fire mission. It allows the howitzer crews following the mission to prepare the ammunition for the FFE phase. It is announced in the initial fire commands after quadrant elevation. For example, the FDC would announce **2 ROUNDS, VT IN EFFECT**.

Table 5-4. Other Fire Commands.

STEP	ACTION
1	**SPECIAL METHODS OF FIRE** include those listed below. **CONTINUOUS FIRE** is announced when it is desired that the howitzer crews continue to fire within the prescribed rates of fire for their howitzers and will do so until the command **CHECK FIRING** or **CEASE LOADING** is announced. **FIRE AT WILL** is used in a direct-fire role, primarily for perimeter defense. The command is **TARGET (so-and-so), FIRE AT WILL**. Howitzer sections fire under the control of their section chief.
2	**CHECK FIRING**. The command **CHECK FIRING** may be announced by **anyone**, but it should be used only in emergencies or if a safety violation is noted. **All firing ceases immediately**. The command may be announced by voice and/or given by hand signals all at the same time. Immediate action must be taken to determine the nature of the check firing and to correct the situation.
	NOTE: To give the hand signals, raise your hand in front of your forehead, palm to the front, and swing your hand and forearm up and down several times in front of your face.

Table 5-4. Other Fire Commands (Continued).

STEP	ACTION
3	**CANCEL CHECK FIRING**. The command **CANCEL CHECK FIRING** will be announced once the situation requiring check firing has been corrected. The command will be given by the FDC. Once the check firing imposed during a fire mission is canceled, all firing data not announced will be announced. At a minimum, the quadrant elevation will be announced again. For example, the FDC would announce **CANCEL CHECK FIRING, QUADRANT 422**.
4	**CEASE LOADING**. The command **CEASE LOADING** allows the howitzer sections to fire rounds that have already been loaded but not to load any additional rounds.
5	**END OF MISSION**. The command **END OF MISSION** (EOM) means that the fire mission has been terminated. The howitzer sections should return to the azimuth of lay or priority target data.
6	**PLANNED OR PRIORITY TARGETS**. The battery or platoon may be assigned planned or priority targets for which current firing data must be maintained. Each target is assigned a number or name, and the howitzer sections lay on their assigned planned or priority target. In such cases, unit SOP usually designates a command or a prearranged signal to fire on the planned or priority target, bypassing the usual sequence of fire commands. **Either example may be used:** Target AC7343 is designated as a planned target by the battalion FDC. Firing data were computed and transmitted to Howitzers Number 1 and 2 (in a four-howitzer platoon, they would be the right platoon). On the command **SUPPRESS AC7343**, the right platoon engages Target AC7343 with the previously arranged method of fire. Target AC7424 is designated as a priority target by the battalion FDC. Firing data were computed and transmitted to all the howitzers. The FDC code named target AC7424 TARGET BLUE. On the command **FIRE TARGET BLUE**, the howitzers engage Target AC7424 with the previously arranged method of fire. In defensive operations, the command **FIRE THE FPF** would cause the howitzer sections to fire the FPF on which their howitzers were laid.
7	**REPETITION AND CORRECTION OF FIRE COMMANDS.** One section (normally the base piece) should be designated to read back all fire commands (each howitzer section will read back their own special corrections) to ensure that the howitzer sections have received the commands correctly. When a command has not been heard or has been misunderstood, the request for repetition is stated as a question by the howitzer section. When the FDC replies, the repetition of a command is always preceded by the number of the howitzer and the statement **THE COMMAND WAS.** For example, the howitzer section would announce **DEFLECTION NUMBER 2?**, and the FDC would reply with **NUMBER 2, THE COMMAND WAS DEFLECTION 2768**. If an incorrect fire command has been given but the command **QUADRANT** has not been announced, the FDC commands **CORRECTION** followed by the correct fire command and all subsequent elements. If **QUADRANT** has been announced, the FDC commands **CHECK FIRING** and then announces **CANCEL CHECK FIRING** followed by the corrected command and all subsequent elements.

Table 5-4. Other Fire Commands (Continued).

STEP	ACTION
8	**FIRING REPORTS**. The section chief reports to the FDC all actions that affect the firing of his weapon in support of the unit's mission. During firing, the following specific reports are made: When the special instruction **DO NOT LOAD** has been commanded by the FDC, the howitzer sections will report by voice **LAID, NUMBER (so-and-so)**. This report is sent when the projectile, charge, and fuze have been prepared; the howitzer has been laid for deflection; and the quadrant (or loading elevation) has been set. When the special instruction **AT MY COMMAND** or **BY PIECE** or **BY ROUND AT MY COMMAND** has been commanded by the FDC, the section chief reports **READY, NUMBER (so-and-so)**. This report is sent when the howitzer is ready to fire (in compliance with the fire commands). **SHOT NUMBER (so-and-so)** is reported after each round has been fired. If, however, the method of fire is more than one round, **SHOT** is announced only after the initial round. **ROUNDS COMPLETE NUMBER (so-and-so)** is announced when the final round designated in the method of fire has been fired. If, however, only one round is to be fired, **ROUNDS COMPLETE** will not be reported after **SHOT**. **MISFIRE NUMBER (so-and-so)** is announced when a misfire has occurred. The howitzer section will inform the FDC as to what caused the misfire. **AMMUNITION REPORTS**. The number of projectiles, propellants, and fuzes expended, received, or transferred to another howitzer by type and lot number is reported when requested by the FDC. **INCORRECT OR UNSAFE DATA FIRED**. The chief of the howitzer section reports to the FDC the actual data fired in error; for example, **NUMBER 2 FIRED DEFLECTION (so much)**.

5-12. Examples of Fire Commands

a. Following is an example of an adjust-fire mission without fire command standards applied for a four-howitzer platoon.

EXAMPLE

FIRE MISSION, PLATOON ADJUST, NUMBER 3, 1 ROUND, SHELL HE, LOT AG, CHARGE 4, FUZE QUICK, DEFLECTION 3024, QUADRANT 247, 2 ROUNDS IN EFFECT.

Number 3 is announced as the adjusting weapon. It fires one round (shell HE, lot AG, fuze quick) with the announced charge and at the announced deflection and quadrant. Nonadjusting pieces prepare two rounds of HE with fuze quick and follow the mission.

The first subsequent fire command is as follows: **DEFLECTION 2978, QUADRANT 218**. Number 3 fires one round (shell HE, lot AG, charge 4, fuze quick) at the new deflection and quadrant.

The second subsequent fire command is as follows: **PLATOON 2 ROUNDS, DEFLECTION 2950, QUADRANT 210**. The entire platoon fires two rounds at the announced deflection and quadrant. **END OF MISSION** is announced as appropriate, and ammunition expended is updated.

b. Following is an example of an FFE mission without fire command standards applied.

EXAMPLE

FIRE MISSION, NUMBER 3 AND NUMBER 4, 3 ROUNDS, SHELL WP, LOT WW, CHARGE 7, FUZE QUICK, DEFLECTION 2870, QUADRANT 320.

Number 3 and Number 4 each fire three rounds as commanded. **END OF MISSION** is announced as appropriate, and ammunition expended is updated.

5-13. Standardizing Elements of the Fire Commands.

Certain elements of the fire commands may be standardized after the tactical situation, weapon and personnel capabilities, ammunition status, and enemy counterfire threat have been considered. As shown in Table 5-2, the following elements of the fire commands may be designated as standard: pieces to fire, method of fire, projectile, ammunition lot, and fuze. Only one set of standards can be in effect at any particular time. Once standards are placed in effect, the unit will fire the standard data unless the fire commands specify something different.

EXAMPLE

The FDO or platoon leader considers the tactical situation and the other factors mentioned above and determines that the fire command elements designated to be standard are as follows:

- Projectile: HE.
- Ammunition lot: AG.
- Fuze: Quick.

These standards tell the howitzer sections that if not stated in the fire commands, the projectile, lot, and fuze will be shell HE, lot AG, and fuze quick.

Adjust-Fire Mission With Fire Command Standards Applied

Elements designated as standard in this example are shell HE, lot AG, and fuze quick.

FIRE MISSION, PLATOON ADJUST, NUMBER 3, 1 ROUND, CHARGE 5, DEFLECTION 2938, QUADRANT 200, 2 ROUNDS WP, LOT WG, TI IN EFFECT.

Number 3 fires one round (shell HE, lot AG, fuze quick) with the announced charge and at the announced deflection and quadrant. Nonadjusting pieces prepare two rounds of white phosphorus and follow the mission. Adjustment continues.

When fire for effect is entered, the commands are as follows:

PLATOON 2 ROUNDS, SHELL WP, LOT WG, FUZE TIME, TIME 25.2, DEFLECTION 3008, QUADRANT 225.

All howitzers fire two rounds of shell WP with the announced time and at the announced deflection and quadrant. **END OF MISSION** is announced as appropriate.

FFE Mission With Fire Command Standards Applied

Elements designated as standard in this example are shell HE, lot AG, and fuze quick.

FIRE MISSION, PLATOON 3 ROUNDS, CHARGE 4, DEFLECTION 3111, QUADRANT 400.

Each howitzer fires three rounds (shell HE, lot AG, fuze quick) with the announced charge and at the announced deflection and quadrant. **END OF MISSION** is announced as appropriate.

Chapter 6

FIRING CHARTS

One of the elements to the solution of the gunnery problem is the determination of chart data. Chart data consist of chart range, chart deflection, and angle T. The determination of chart data requires the construction and operation of firing chart.

Section I

Types of Firing Charts

This section implements a portion of QSTAG 224.

Two types of firing charts may be constructed in the FDC. They are surveyed firing charts and observed firing charts. Regardless of the type constructed two firing charts are maintained in a manual FDC. The horizontal control operator (HCO) maintains the primary firing chart, and the vertical control operator (VCO) maintains a backup, or check, chart and a 1:50,000-scale situation map with tactical overlay(s).

6-1. Description

A firing chart is a graphic representation of a portion of the earth's surface used for determining distance and direction. The chart may be constructed by using a map, a photomap, a grid sheet, or other material on which the relative locations of batteries, known points, targets, and observers can be plotted. Additional positions, fire support coordinating measures, and other data needed for the safe and accurate conduct of fire may also be recorded.

6-2. Firing Chart Construction

The most commonly used materials for constructing firing charts are as follows:

a. Grid Sheet. A grid sheet is a plain sheet of paper or plastic (mylar) on which equally spaced horizontal and vertical lines, called grid lines, are printed. The intervals between these grid lines will create 1,000-meter grid squares on a scale of 1:25,000. This scale provides the best compromise between accuracy and convenience and is therefore the scale for which standard plotting equipment is graduated. The locations of all points plotted on the grid sheet must be determined either by survey data, map inspection, or firing. The grid sheet is numbered to correspond to the map area of the zone of operation of the supported force. The FDO assigns the lower left-hand corner casting and northing coordinates, and the direction of the long axis (east-west or north-south) also is specified. The rightmost and topmost grid lines are not labeled because data are not determined from these grid lines.

b. Map. A map is a graphic representation, drawn to scale, of a portion of the earth's surface. Only maps based on accurate ground survey should be used for constructing firing charts. If the map scale is other than 1:25,000, the range readings obtained from plotting equipment must be adjusted. For example, if a 1:50,000-scale map is used, the ranges determined with the RDP must be doubled. Deflections and azimuths are not affected. If a map is not based on accurate and adequate ground survey control, it should be used only to obtain approximate locations and vertical control to supplement a grid sheet firing chart.

c. Photomap. A photomap is a reproduction of an aerial photograph or a mosaic of aerial photographs on which grid lines, marginal information, and place names are superimposed. A photomap must not be considered exact until its accuracy has been verified. Photomaps may include errors caused by tilt, distortion caused by relief, and errors caused by poor assembly, If points cannot be located on the photomap by inspection, the photomap scale must be determined before points can be located on the photomap survey. Normally, vertical control can be established by estimation only. Determination of the scale of vertical control of photographs is discussed in FM 21-26. Some photomaps have spot altitudes, but interpolation for altitude is difficult and inaccurate.

Section II

Plotting Equipment and Firing Chart Preparation

To ensure the accuracy of the data shown on the firing chart, FDC personnel should construct and plot from a standing position directly above the chart. Plotting pins must be kept perpendicular to the firing chart. Personnel, equipment and the firing chart should be kept as clean as possible at all times. If two charts are present in the FDC, they must be checked against each other for accuracy. If one chart is a backup for another system, it should be verified against that system for accuracy. (Refer to Appendix E for automated FDC procedures.)

6-3. Pencils

a. 6H Pencil. The 6H (hard lead) pencil is sharpened to a wedge point and is used to draw fine index lines from which measurements are made. If a 6H pencil is not available, a 5H pencil is an acceptable substitute. (See Figure 6-1.) Place a 1-inch piece of tape on the end to differentiate between a 4H pencil.

b. 4H Pencil. The 4H pencil is sharpened to a conical point and is used to label and construct tick marks and to label azimuth and deflection indexes. If a 4H pencil is not available, a 3H pencil is an acceptable substitute. (See Figure 6-2.)

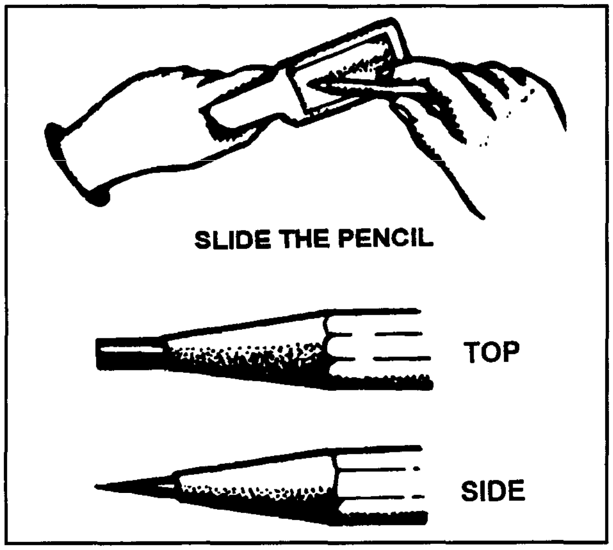


Figure 6-1. The 6H Pencil (Wedge Point).

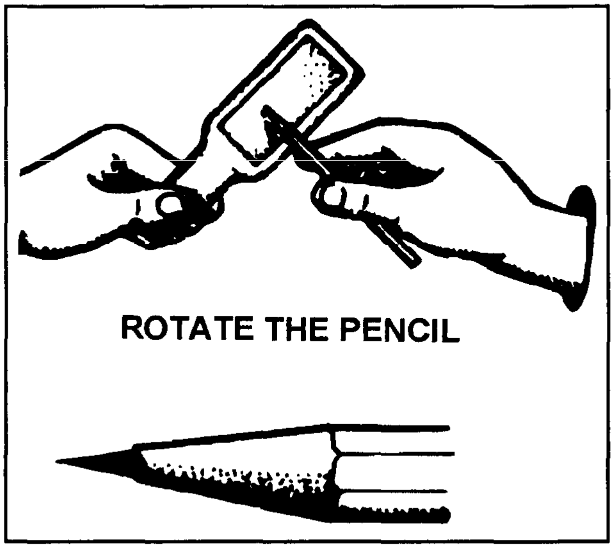


Figure 6-2. The 4H Pencil (Conical Point).

c. Red and Blue Pencil. The red and blue pencil is sharpened to a conical point and is used to label and construct tick marks and label deflection indexes, as required by the color code. (See Figure 6-2.)

d. Orange Pencil. The orange pencil is sharpened to a conical point and is used to label tick marks and deflection indexes, as required by the color code. (See Figure 6-2.)

e. Green Pencil. The green pencil is sharpened to a conical point and is used to label tick marks for radars, as required by the color code. (See Figure 6-2.)

6-4. Plotting Pins

Plotting pins are used to mark indexes and temporary positions on the firing chart. On a 1:25,000-scale chart, the thickness of the plotting pin shaft equals 20 meters.

6-5. Plotting Scale

The plotting scale is a square-shaped scale used to plot or determine grid coordinates. The scale is graduated in meters and yards at scales of 1:25,000 and 1:50,000. Using the four-step plotting method, locations are normally plotted to an accuracy of 10 meters with the plotting scale. Personnel must be careful not to confuse the meter and yard scales on this instrument (newer plotting scales only have meter scales on them). (See Figure 6-3.) If there is a yard scale, tape over it so this scale is not accidentally used.

NOTE: Ten-digit grid coordinates are expressed to an 8-digit grid coordinate when plotting because of the limitations of the plotting scale.

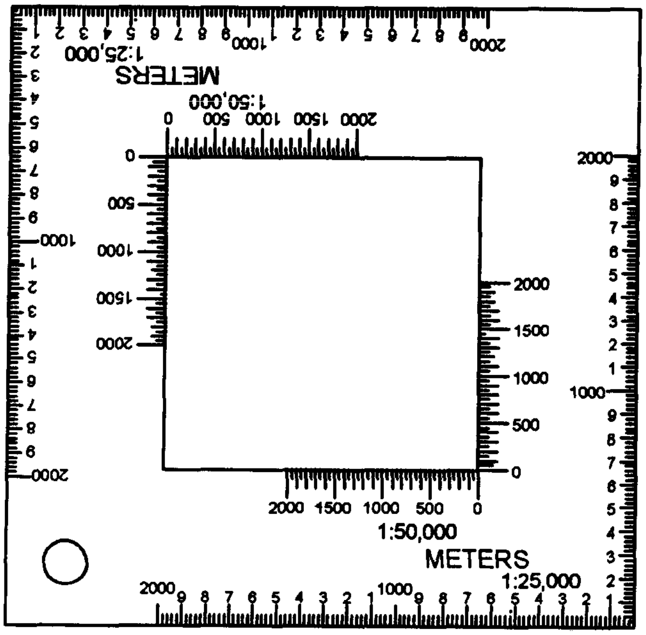


Figure 6-3. Plotting Scale.

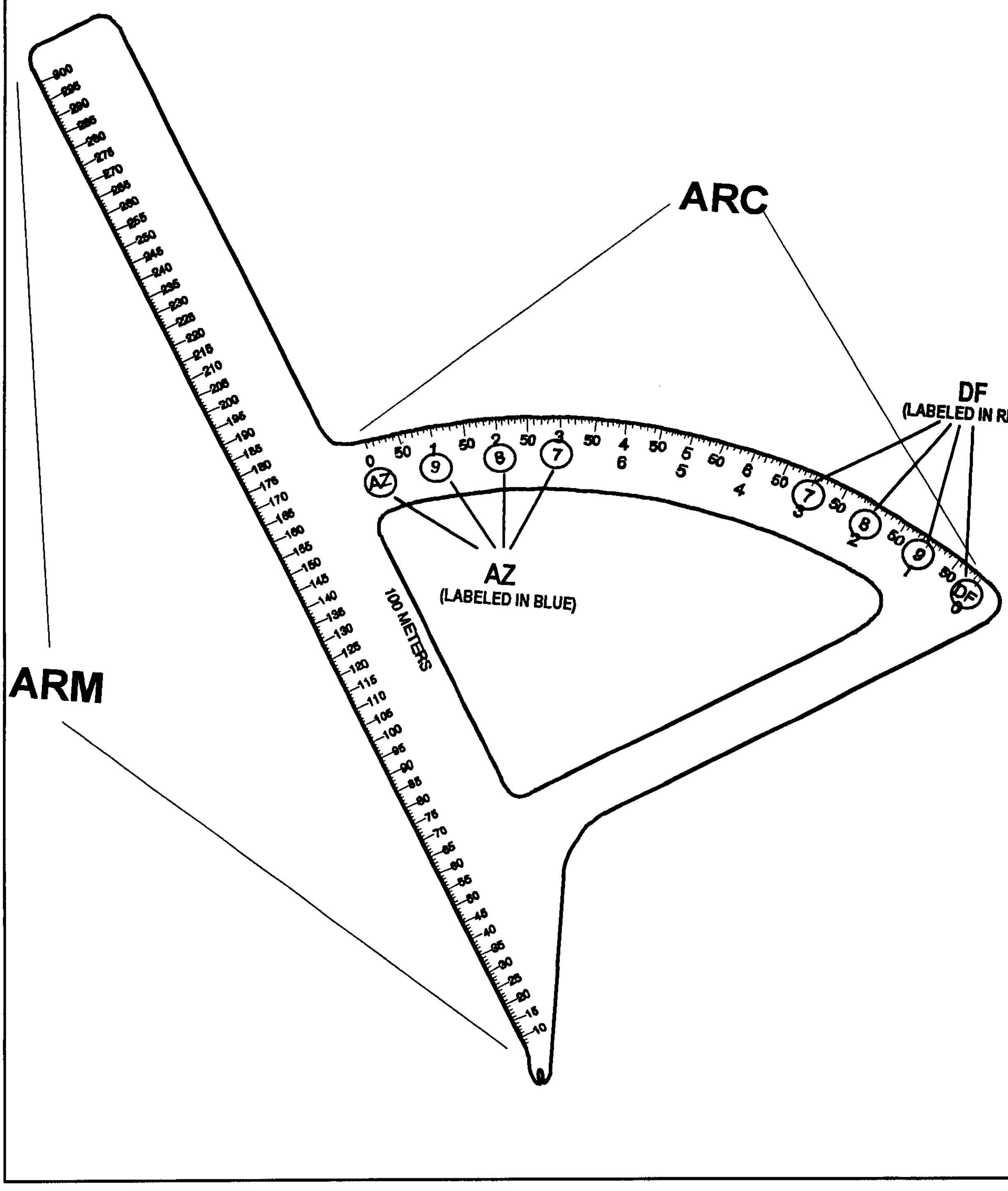


Figure 6-4. Range-Deflection Protractor.

6-6. Range-Deflection Protractor

The RDP is used to measure angles in mils and distances in meters. Range and deflection are measured from a firing unit to a target. Direction and distance are measured from an observer to a target. (See Figure 6-4.)

a. The left edge of the instrument is the arm and is used to measure range or distance. It is graduated in 50-meter increments and labeled every 500 meters on a scale of 1:25,000. Ranges and distances are visually interpolated to an accuracy of 10 meters. The arm can be labeled to represent charge or range spans and other pertinent data to aid the FDO.

b. The 1,000-mil arc of the RDP is graduated in 5-mil increments. The 50-mil increments are indicated by longer graduations and are permanently numbered. The are is visually interpolated to an accuracy of 1 mil.

c. The vertex, the slotted portion of the RDP, is placed against a plotting pinto properly position the RDP for determining data.

d. There are four different RDP models. They differ by the maximum range of the arm (12,000, 15,000,25,000, and 30,000 meters).

e. RDPs are also available on a 1:50,000 scale.

NOTE: When labeling the RDP, label azimuth values in blue and deflection values in red.

6-7. Target Grid

The target grid is a circular paper device on which grid lines are printed. Normally, the target grid used is DA Form 4176 (Target Plotting Grid, Field Artillery). Grid lines on the target grid match the scale of the 1:25,000 firing chart, dividing a 1,000-meter grid square into 100-meter squares. An azimuth scale is printed around the outer edge of the target grid. It is graduated in 10-mil increments and is numbered every 100 mils. An arrow extends across the center of the target grid and is used to indicate the observer-target line (or other line of known direction). The target grid should be labeled as shown in Figure 6-5. **(The L and - are written in blue pencil; the R and +, in red.)** Transparent tape should be applied to the reverse side of the target grid to prevent the center hole from becoming enlarged. The target grid is used for three distinct operations:

- Plotting the position of targets located by a shift from a known point.
- Plotting observer subsequent corrections.
- Determing angle T.

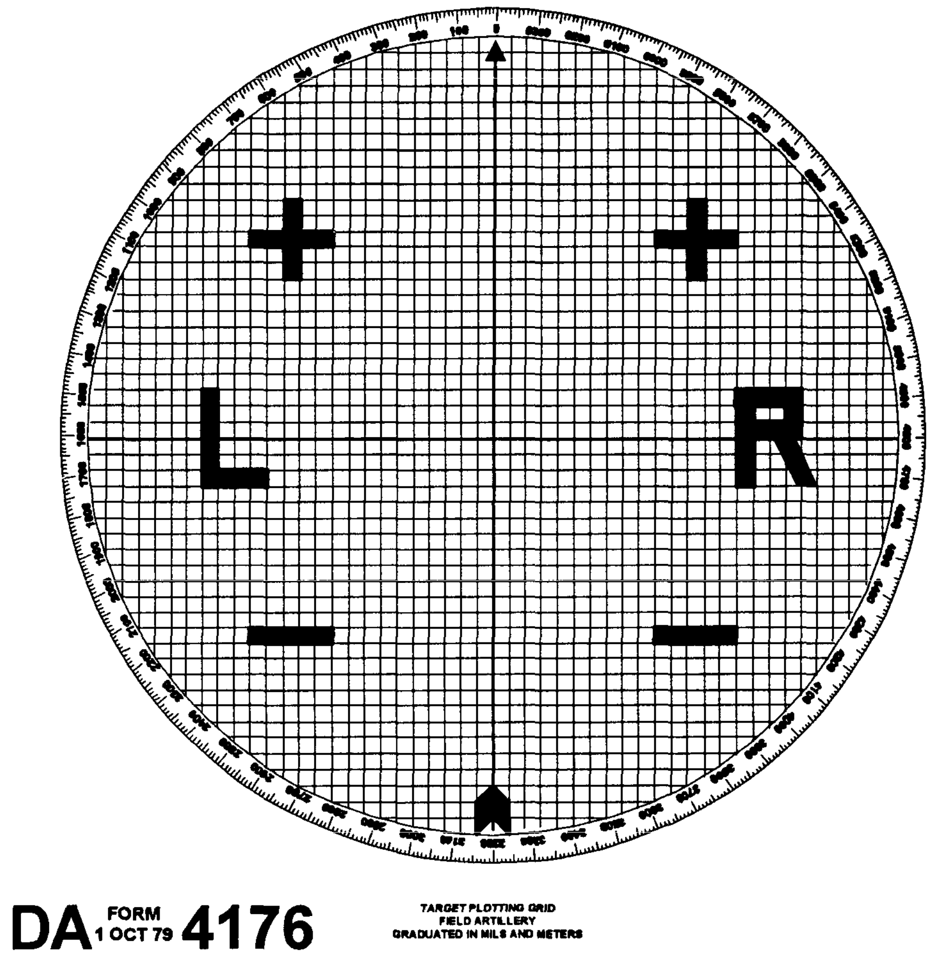


Figure 6-5. Labeling the Target Grid.

Section III

Surveyed Firing Chart

A surveyed firing chart is a chart on which the location of all required points (battery or platoon positions, known points, and OPs) are plotted. These locations can be based on survey or map inspection. All plotted points are in correct relations to one another and reflect actual map coordinates.

6-8. Selection of Lower Left-Hand Corner and Azimuth of Lay

For the chart operator to construct a firing chart correctly, he needs to be provided guidance on what coordinates to assign to the lower left-hand corner (LLHC) of the grid sheet and the azimuth of lay. The FDO is responsible for providing this information. The azimuth of lay can be determined on the basis of the zone of operations or the guidance from the battery commander or higher HQ. After the azimuth of lay is determined, the LLHC coordinates need to be carefully selected. The selected LLHC coordinates should include all critical points on the firing chart and allow full use of the RDP. The steps in Table 6-1 will help to serve as a guide in determining the LLHC and azimuth of lay.

Table 6-1. Selection of LLHC and Azimuth of Lay.

STEP	ACTION
1	Plot the unit location on the map.
2	Plot the center of the zone of operations. This can be done by visual inspection of the map.
3	Determine the azimuth from the unit location to the center of the zone of operations. This can be done by using a protractor or other instrument. For ease of mathematical computations, the determined value can be expressed to the nearest 100 mils.
4	Before selecting the LLHC coordinates, approximate the unit location on the grid sheet in the general area of the firing chart where it will be located. The FDO or chief computer should verify that the RDP can be used effectively from this location. The LLHC coordinates are selected so that all critical points in the zone of operations can be plotted.
5	Once the values are determined, give them to the HCO or VCO so they can begin to construct the firing charts.
	NOTE: If the chart table is not permanently affixed in the FDC, the FDO will also need to provide guidance on the orientation of the long axis of the firing chart. The long axis of the firing chart should be oriented to allow for maximum coverage of the zone of operations. If the general direction to the zone of operations is east or west, the long axis should be oriented east-west. If the general direction to the zone of operations is north-south, the long axis should be oriented north-south.

6-9. Firing Chart Preparation

The steps in Table 6-2 are the recommended sequence for the preparation of a firing chart.

Table 6-2. Firing Chart Preparation.

STEP	ACTION
1	Choose a suitable smooth surface on which the firing chart will be constructed, and place the grid sheet on this surface.
2	Tape one corner of the grid sheet down. Be sure that the tape does not cover any grid lines.
3	Smooth out the grid sheet, and tape down the corner opposite of the first corner that was taped down.
4	Repeat steps 2 and 3 for the remaining two corners.
	NOTE: The grid sheet is numbered to correspond to the map area of the zone of operations in which the unit will be operating. The FDO will inform the chart operators of the coordinates of the lower left-hand corner of the firing chart. The first two digits represent the easting; the second two digits represent the northing. The FDO will also inform the chart operators if the long axis of the firing chart should be oriented north-south or east-west.
5	Orient the long axis of the firing chart north-south or east-west according to the FDO's guidance. (Disregard this step if using a permanently mounted chart table.)
6	Using a 4H pencil, label the leftmost vertical grid line with the easting of the LLHC as specified by the FDO. The numbers should be beneath and divided by the vertical grid line but will not touch them. Number the remaining vertical grid lines so that the value increases from left to right. The last vertical grid line is not labeled because measurements will not be made from it. (See Figure 6-6.)
7	Using a 4H pencil, label the bottommost horizontal grid line with the northing of the LLHC as specified by the FDO. The numbers should be to the left and centered on the horizontal grid lines but will not touch them. Number the remaining horizontal grid lines so that the value increases from bottom to top. The last horizontal grid line is not labeled because measurements will not be made from it. (See Figure 6-6.)

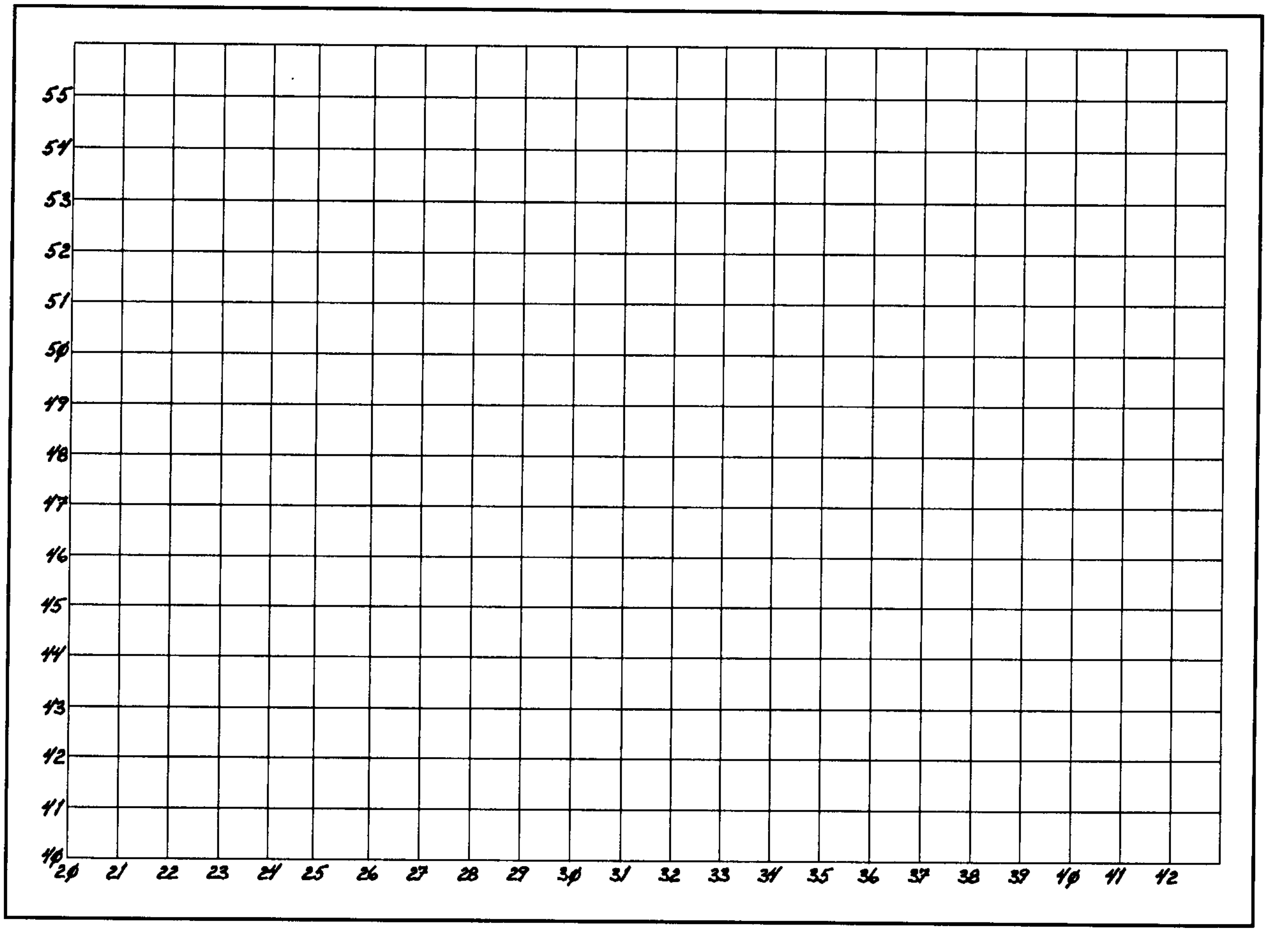


Figure 6-6. LLHC 2040, With the Long Axis Oriented East-West.

6-10. Four-Step Plotting Method

Points commonly plotted on a firing chart include battery or platoon base piece locations, known points, targets, observer locations, and maneuver checkpoints. Base piece locations can be determined by using the M17 plotting board and protractor. To plot points located by grid coordinates, use the steps in Table 6-3.

Table 6-3. Four-Step Plotting Method.

STEP	ACTION
1	Place a plotting pin in the upper right-hand corner of the grid square where the point is to be plotted. This pin will prevent the incorrect plotting of the point in the wrong grid square.
2	Place the plotting scale along the left edge of the grid square so that the 0 on the bottom scale is at the lower left-hand corner of the grid square. (See Figure 6-7.)

Table 6-3. Four-Step Plotting Method (Continued).

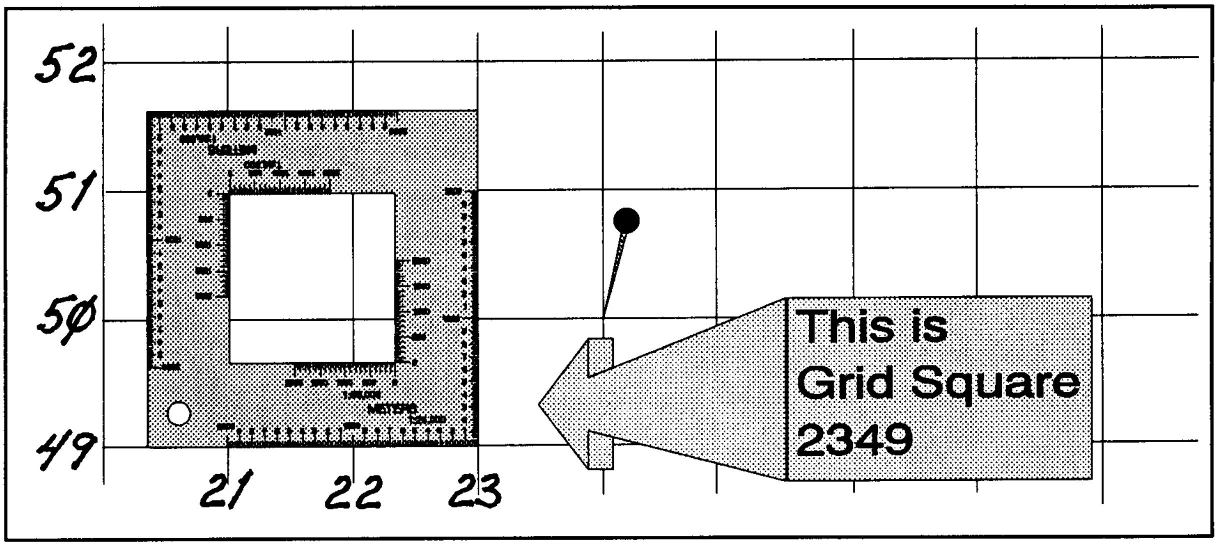


Figure 6-7. Position Plotted in Grid Square 2349.

STEP	ACTION
3	Slide the plotting scale to the right, and read the easting (for example, 23478) on the plotting scale by using the north-south (vertical) grid line as an index. Easting 23478 is expressed to 2348. (See Figure 6-8.)

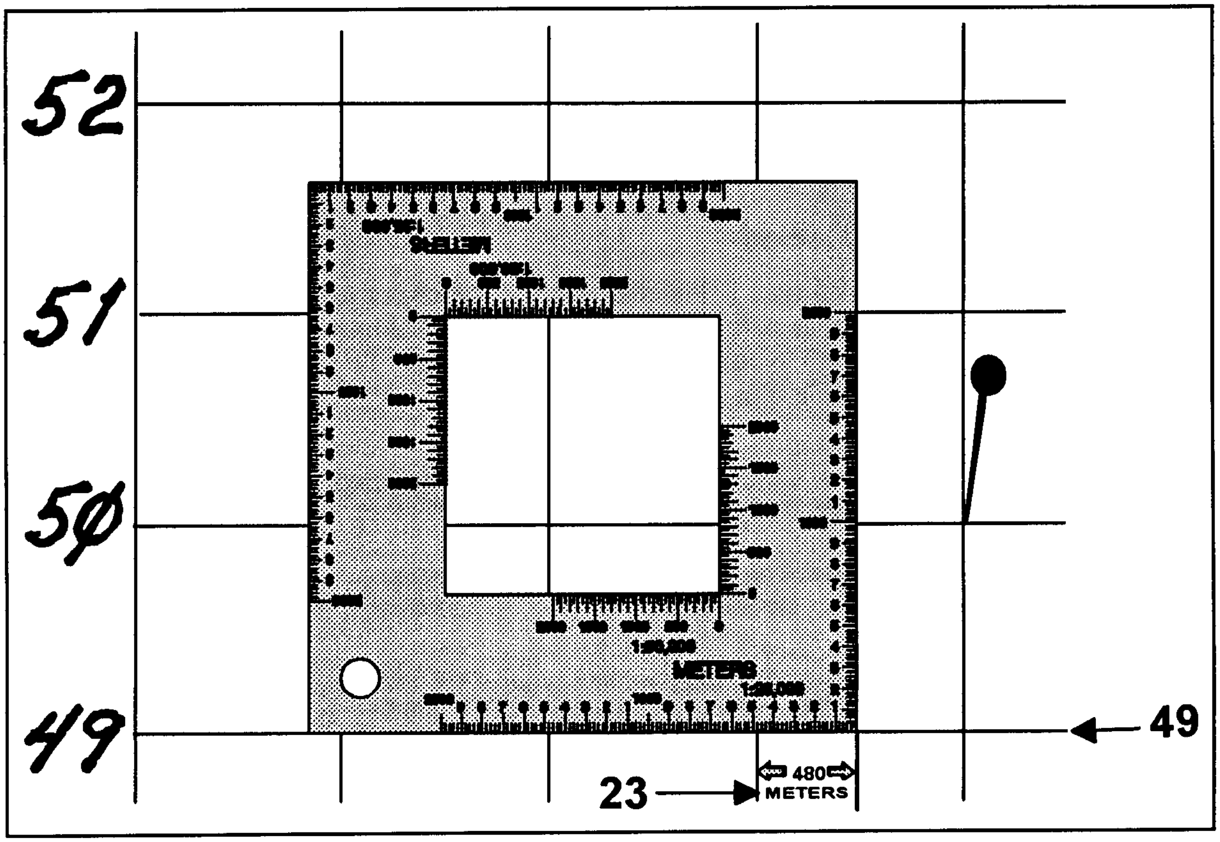


Figure 6-8. Easting 2348.

Table 6-3. Four-Step Plotting Method (Continued).

STEP	ACTION
4	With the bottom edge of the plotting scale aligned precisely on the east-west (horizontal) grid line, remove the pin from the upper right-hand corner and plot the northing on the vertical scale with a plotting pin. Set the pin at a 45° slant, slide the plotting scale away, rotate the head of the pin to vertical, and push the pin into place. As shown in Figure 6-9, 49859 is the plotted location. Northing 49859 is expressed to 4986.

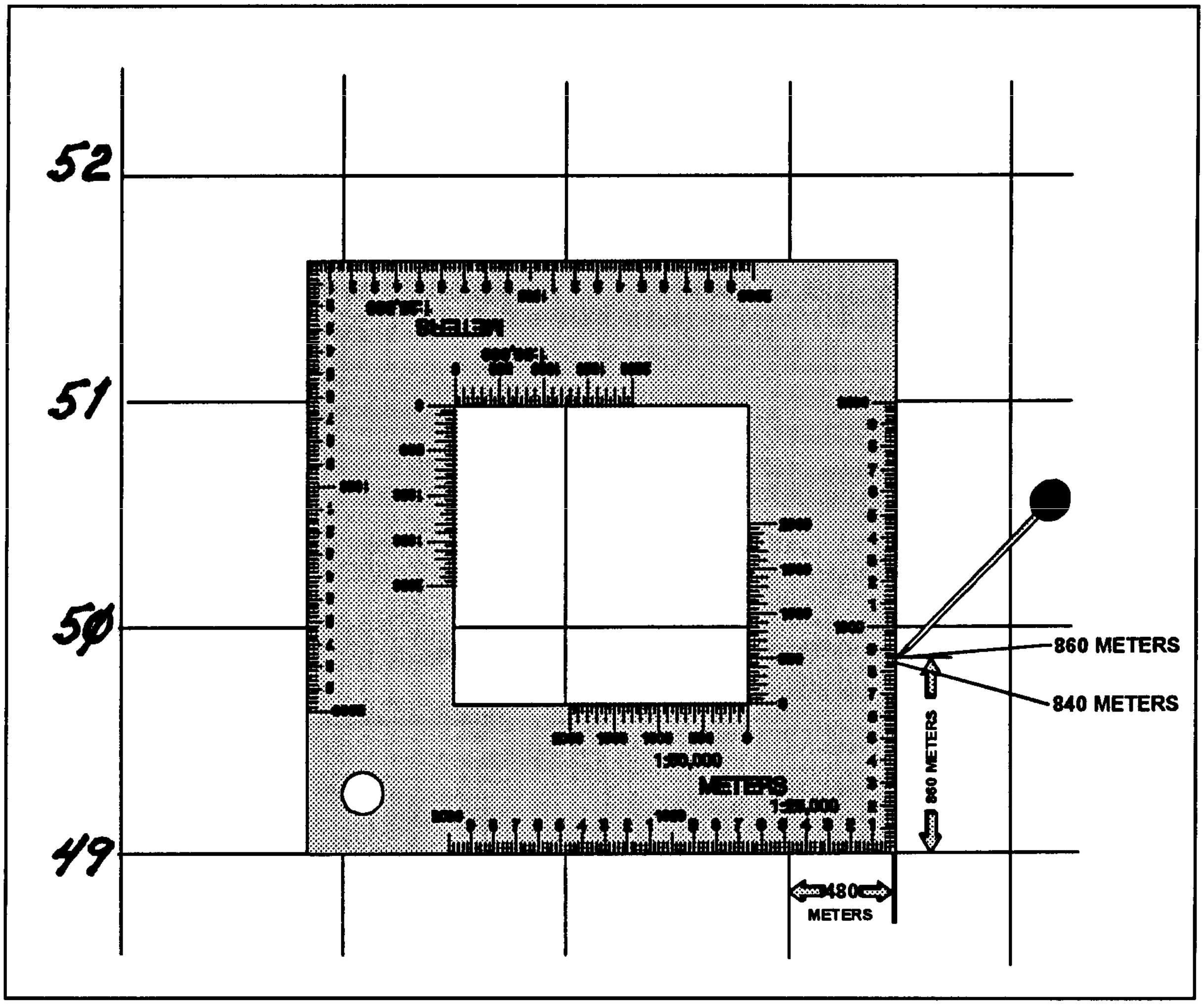


Figure 6-9. Northing 4986.

6-11. Tick Marks

The tick mark is the symbol used to mark and identify the location of a point plotted on a firing chart. The tick mark is constructed in the form of a cross with each arm beginning 40 meters from the pinhole on the chart and extending 160 meters in length (1:25,000 scale).

> **NOTE:** Tick marks will be constructed with a 4H pencil with the following exception: To construct a tick mark for a target that has been located through firing, use a red pencil.

Table 6-4 uses the 3,5,7, method to construct a tick mark.

Table 6-4. Constructing a Tick mark.

STEP	ACTION
1	Align the right-hand edge of the plotting scale so that 5 on the METERS scale is next to the pinhole and the edges of the plotting scale are parallel to the grid lines.
2	Using the appropriate color of pencil for the type of position that is being plotted, draw a line beginning 40 meters above the pinhole and extend it to the closest 7 on the meters scale.
3	Using the same color of pencil as in step 2 above, draw a line beginning 40 meters below the pinhole and extend it to the closest 3 on the METERS scale.
4	Move the plotting scale so that 5 on the bottom METERS scale is aligned above the pinhole and the edges of the plotting scale are parallel to the grid lines.
5	Using the same color of pencil as in step 2 above, draw a line beginning 40 meters right of the pinhole and extend it to the closest 3 on the METERS scale.
6	Using the same color of pencil as in step 2 above, draw a line beginning 40 meters left of the pinhole to the closest 7 on the METERS scale. (See Figure 6-10.)
	NOTE: The tick mark should bisect the pinhole.

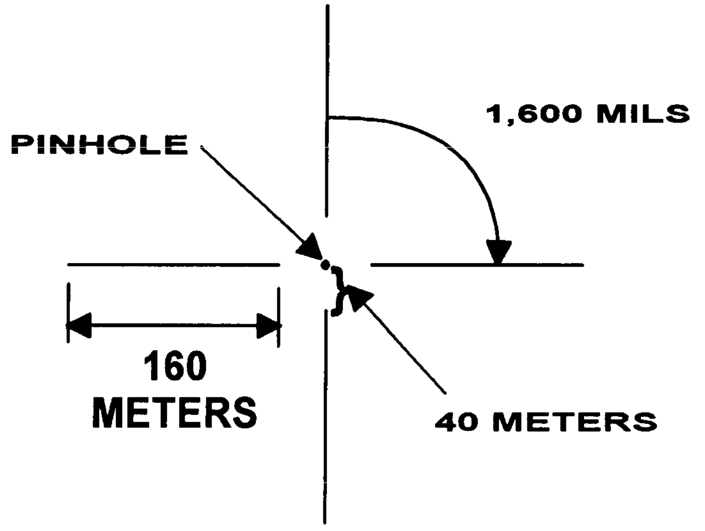


Figure 6-10. Dimensions of a Completed Tick Mark.

Table 6-4. Constructing a Tick Mark (Continued).

STEP	ACTION
	NOTE: If the plotted position is within 80 meters of a grid line (on a scale of 1:25,000) or the tick mark that is to be constructed interferes with a previously constructed tick mark, the new tick mark should be canted 800 mils counterclockwise to avoid confusion. (See Figure 6-11.)

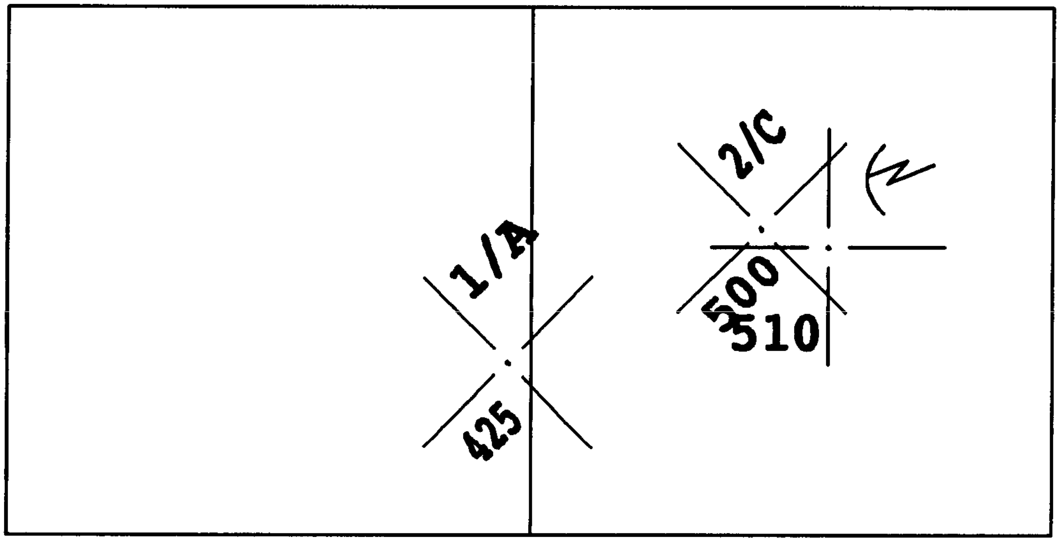


Figure 6-11. Canted Tick Marks.

STEP	ACTION
7	Label the tick mark by centering the identification of the point in the upper right-hand quadrant and by centering the altitude in the lower left-hand quadrant of the tick mark. Examples of each type are in Figure 6-12. Use the following rules: **NOTE**: Labeling of tick marks will not extend outside the length of the radial arms. At a minimum, the identification and the altitude are required on all tick marks. **Radar.** The military symbol for radar is drawn in green. (See Figure 6-12a.) **Battery or Platoon.** The battery or platoon identification is recorded by using the following color code: ● Alpha is red. ● Bravo is black. ● Charlie is blue. ● Delta is orange. **NOTE**: If more than four batteries are shown on the firing chart, the color coding starts over again with red. In 3 x 8 operations, platoon identifications (for example, 1/A) are recorded by using the same color code. (See Figure 6-12b.)

Table 6-4. Constructing a Tick Mark (Continued).

STEP	ACTION
	Observation Posts. Observation posts (OPs) can be represented by using one of the following methods: Label the tick marks by using the military symbol for an OP (a triangle with a dot in the middle) and the long or short call sign that the observer uses to identify himself (for example, W6T03 or T03). (See Figure 6-12c.) Label the tick marks with the observer's assigned number (for example, O1). (See Figure 6-12c.) **Known Points**. Use a 4H pencil to record in the upper right-hand quadrant the number assigned to the known point. Also, use a 4H pencil to record in the lower left-hand quadrant the altitude. (See Figure 6-12d.) **Targets**. Use a 4H pencil to record in the upper right-hand quadrant the assigned target number. Also, use a 4H pencil to record in the lower left-hand quadrant the altitude. (See Figure 6-12e.) **NOTE**: If the plotted position is a target that has been located through firing, the **fuze used in the fire for effect** may be recorded by centering the fuze in the lower right-hand quadrant of the tick mark. The **charge used in the mission and/or HA** (if mission was an HA mission) may be recorded and centered in the upper left-hand quadrant of the tick mark. (See Figure 6-12e.)

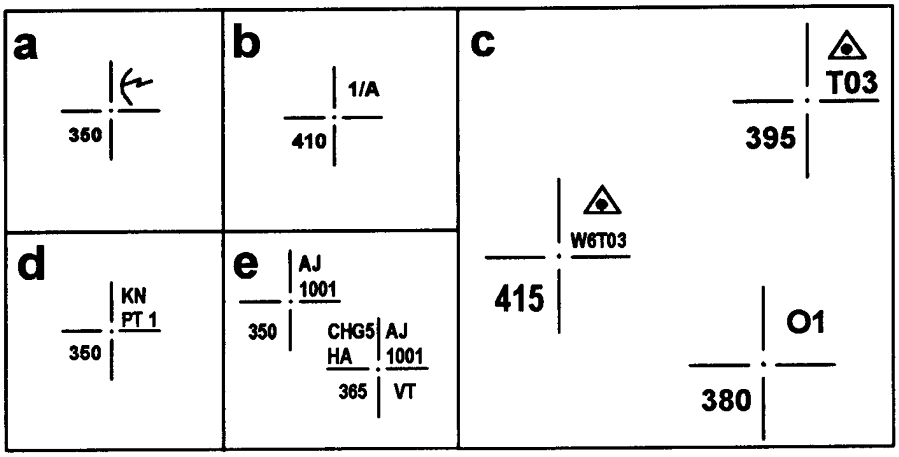


Figure 6-12. Example of Different Tick Marks.

STEP	ACTION
8	Repeat steps 1 through 7 for all plotted locations. When plotting known points, construct north indexes for ease of processing shift from known point fire missions (steps 9 through 17.)
9	Insert a plotting pin through the center of the target grid.

Table 6-4. Constructing a Tick Mark (Continued).

STEP	ACTION
10	Insert the pin through the center of the target grid, and then insert the pin in the known point location.
11	Orient the target grid until the lines on the target grid are parallel to the grid lines. The arrow on the target grid should be oriented to the north.
12	Insert a pin at the target grid graduation corresponding to azimuth 0. This is a temporary north index for the known point.
13	Remove the target grid, and reinsert a pin in the known point location.
14	With the vertex of the RDP on the known point location, align the arm of the RDP with the pin in the north index.
15	Remove the north index pin.
16	With a 6H pencil, draw a line along the arm of the RDP beginning at range 2050 through the north index pinhole out to range 3300.
17	Using a 4H pencil, label the line with an "N." Place the N immediately above the end of the line.

6-12. Construction of Azimuth Indexes

Azimuth indexes are constructed for points located on the firing chart from which the polar method of target location may be expected. The RDP is prepared by numbering the 100-mil azimuth graduations in blue as shown in Figure 6-4. Azimuths are always read as four digits. The first digit (thousands of mils) is read from an index that is constructed on the firing chart. The last three digits are read from the arc of the RDP. Azimuth indexes are constructed on the firing chart in 1,000-mil intervals throughout the target area, except the 6000 and 0 indexes, which are 400 mils apart. The steps for constructing azimuth indexes can be found in Table 6-5.

NOTE: To help determine the four digits of a deflection or azimuth, use the memory aid CLUE.

C - Chart index/pin is first digit.

L - Label on RDP arc is second digit.

U - Unit graduation is third digit.

E - Estimate (visually) to nearest mil is fourth digit.

Table 6-5. Constructing Azimuth Indexes.

STEP	ACTION
1	Place a plotting pin in the observer location.
2	Place the vertex of the RDP against the pin.

Table 6-5. Constructing Azimuth Indexes (Continued).

STEP	ACTION
3	Align the arm of the RDP with a convenient grid line. To ensure the arm of the RDP is parallel to the grid line, use the following steps: ● If you are using a north-south grid line, plot the observer's easting with a plotting pin and move the RDP until the arm is against the pin. - If the arm of the RDP is oriented north, it is oriented on an azimuth of 0 or 6400, and the 0 and 6000 azimuth indexes can be constructed. - If the arm of the RDP is oriented south, it is oriented on an azimuth of 3200, and the 3000 index can be constructed. ● If you are using an east-west grid line, plot the observer's northing with a plotting pin and move the RDP until the arm is against the pin. - If the arm of the RDP is oriented east, it is oriented on an azimuth of 1600 and the 1000 index can be constructed. - If the arm of the RDP is oriented west, it is oriented on an azimuth of 4800 and the 4000 index can be constructed.
	NOTE: Eastings and northings should be plotted as far from the plotted location as possible. This improves the accuracy of the orientation.
4	Place a plotting pin opposite the number on the azimuth scale (blue numbers) on the arc of the RDP corresponding to the last three digits of the azimuth in which the arm of the RDP is oriented.
	If the RDP is oriented north (6400 mils or 0 mils)-- Place a pin opposite the blue 4 on the arc; this represents the 6,000-mil azimuth index. Place a pin opposite the blue 0 on the arc; this represents the 0-mil azimuth index. If the RDP is oriented east (1,600 mils), place a pin opposite the blue 6 on the arc; this represents the 1,000-mil azimuth index. If the RDP is oriented south (3,200 mils), place a pin opposite the blue 2 on the arc; this represents the 3,000-mil azimuth index. If the RDP is oriented west (4,800 mils), place a pin opposite the blue 8 on the arc; this represents the 4,000-mil azimuth index.
	NOTE: The pin represents a temporary index. Its value is the value of the first digit of the azimuth in which the arm of the RDP is oriented. Figure 6-13 is an example. The RDP is oriented north (0 or 6,400 mils), so a pin was inserted at the 4 on the azimuth scale. The pin represents the 6,000-mil azimuth index.

Table 6-5. Constructing Azimuth Indexes (Continued).

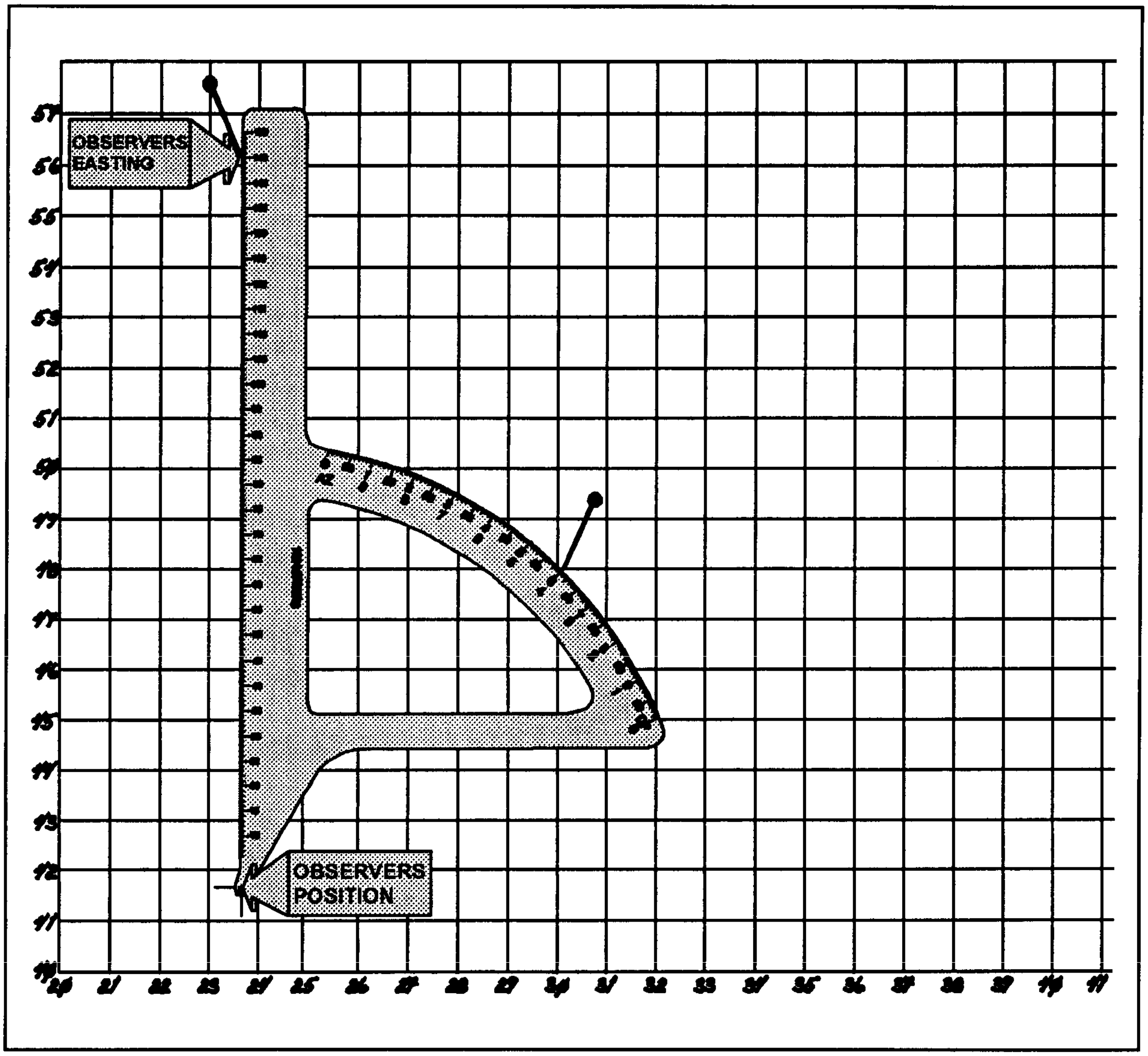
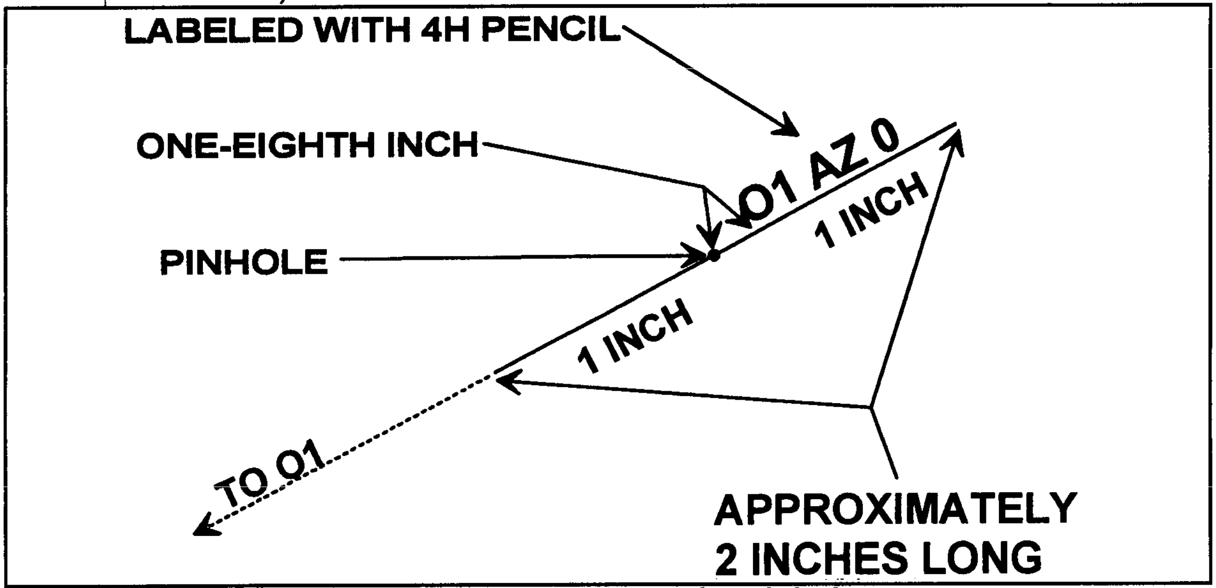
STEP	ACTION
	 **Figure 6-13. Orienting the RDP.**

Table 6-5. Constructing Azimuth Indexes (Continued).

STEP	ACTION
5	Remove the plotting pin that is along the arm of the RDP.
6	Place the arm of the RDP against the plotting pin representing the azimuth index.
7	Remove the plotting pin.
8	Using a 6H pencil, construct a fine line along the arm of the RDP from range 8250 to range 9520. Ensure that the line goes through the center of the pinhole. The distance between these two ranges is about 2 inches.
9	Move the RDP away from the azimuth index.
10	Label the azimuth index with its identification and azimuth value beginning one-eighth inch beyond the pinhole (above the index). Label with the same colors and symbols that were used to label tick marks. For azimuth values, first write the observer's identification as it is in the observer tick mark. Then write the letters "AZ" followed by the actual value for the azimuth index (0, 1000, 2000,...6000). (Figure 6-14 shows a completed 0 azimuth index for observer O1.)  **Figure 6-14. Labeling Azimuth Index.** **NOTE**: Other azimuth indexes can be constructed by measuring successive 1,000-mil increments to the left and right of the initial index. These indexes should have the same labeling as the initial index except, the azimuth values should reflect the 1,000-mil change in azimuth. If the index is to the right of the initial index, the azimuth value will reflect an increase in azimuth. If the index is to the left of the initial index, the azimuth value will reflect a decrease in azimuth. This is done because azimuth increases to the right and decreases to the left. An easy rule to remember is the RALS rule (right, add; left, subtract). Construct as many azimuth indexes for each observer as will fit on the firing chart or as instructed by the FDO.
11	Complete steps 1 through 10 for each observer location.

6-13. Construction of Deflection Indexes

Direction from a battery or platoon to a target normally is measured and announced in terms of deflection. Deflection is the horizontal clockwise angle from the line of fire, or the rearward extension of the line of fire, to the line of a designated aiming point with the vertex of the angle at the sight. In addition to the deflection as a fire command, the firing battery is concerned with common deflection. The RDP will be used to measure deflection so it must be prepared by numbering the graduations of the arc in red as shown in Figure 6-4. Orient the RDP on the azimuth of fire, and place a pin opposite the common deflection for that weapon system. Table 6-6 contains the steps required for constructing deflection indexes.

Table 6-6. Constructing Deflection Indexes.

STEP	ACTION
1	Place a plotting pin in the base piece location.
2	Place the vertex of the RDP against the pin at the base piece location.
3	Orient the RDP in the cardinal direction closest to the azimuth of lay.
4	Align the arm of the RDP parallel to a convenient grid line. To ensure the arm of the RDP is parallel to the grid line, use one of the following procedures: If you are using a north-south grid line, plot the base piece easting with a plotting pin and move the RDP until the arm is against the pin. If you are using an east-west grid line, plot the base piece northing with a plotting pin and move the RDP until the arm is against the pin. **NOTE**: Eastings and northings should be plotted as far from the plotted location as possible. This improves the accuracy of the orientation.
5	Place a plotting pin opposite the number on the azimuth scale (black numbers) on the arc of the RDP corresponding to the last three digits of the azimuth in which the arm of the RDP is oriented. The location of the pin represents a temporary index and will not be replaced with a permanent index. The value of the pin is the value of the first digit of the azimuth in which the arm of the RDP is oriented. Use the rules outlined in step 4 of Table 6-5 to determine where the pin should be placed. In Figure 6-15, the azimuth of lay is 1850, so the RDP has been oriented east (1,600 mils).

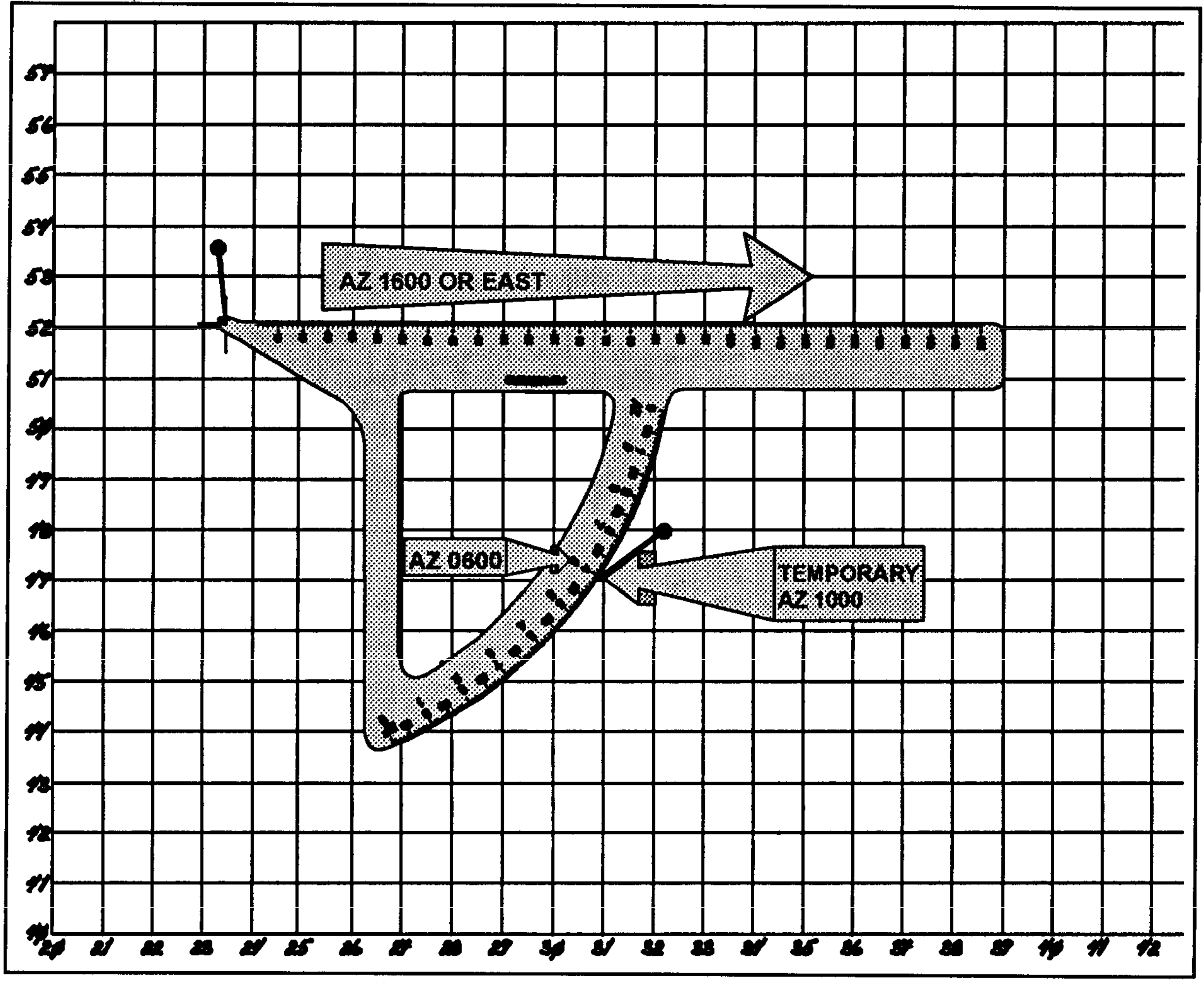


Figure 6-15. Temporary Index.

Table 6-6. Constructing Deflection Indexes (Continued).

STEP	ACTION
6	Move the RDP until the last three digits of the azimuth of lay (read on the azimuth scale of the RDP) are opposite the temporary pin. The arm of the RDP is now oriented on the azimuth of lay. If the RDP cannot be moved to the azimuth of lay, measure 1,000 mils from the initial pin to establish a temporary index appropriate to the azimuth of lay. Continue to follow the procedures as listed in this step until the RDP is oriented on the azimuth of lay. An example is shown in Figure 6-16.
7	Remove the pin that was against the arm of the RDP. **NOTE:** To help determine the four digits of a deflection or azimuth, use the memory aid CLUE. **C** - Chart index/pin is first digit. **L** - Label on RDP arc is second digit. **U** - Unit graduation is third digit. **E** - Estimate (visually) to nearest mil is fourth digit.

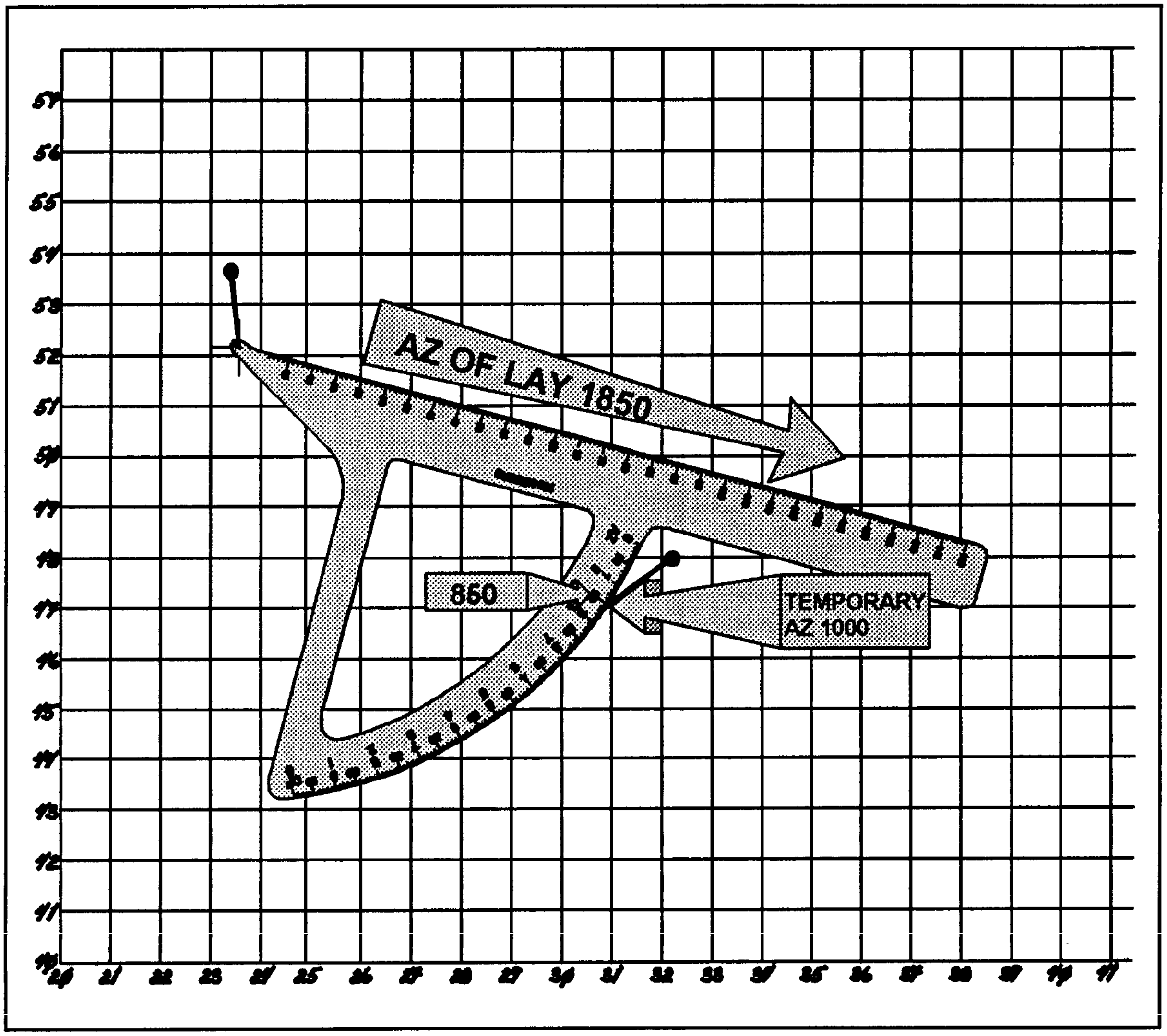


Figure 6-16. Azimuth of Lay.

Table 6-6. Constructing Deflection Indexes (Continued).

<table>
<tr><th>STEP</th><th>ACTION</th></tr>
<tr><td>8</td><td>Once the RDP is oriented on the azimuth of lay, place a plotting pin opposite the appropriate graduation on the deflection scale (red numbers) that represents the last three digits of the common deflection for the weapon system. (See below.)
<table>
<tr><th>Weapon</th><th>Common Deflection</th></tr>
<tr><td>M109A3/A4/A5/A6</td><td>3200</td></tr>
<tr><td>M198, M119, M102</td><td>3200</td></tr>
<tr><td>M101A1</td><td>2800</td></tr>
</table>
NOTE: The plotting pin represents the first digit in the common deflection and is a temporary deflection index. Figure 6-17 shows a common deflection of 3200.</td></tr>
</table>

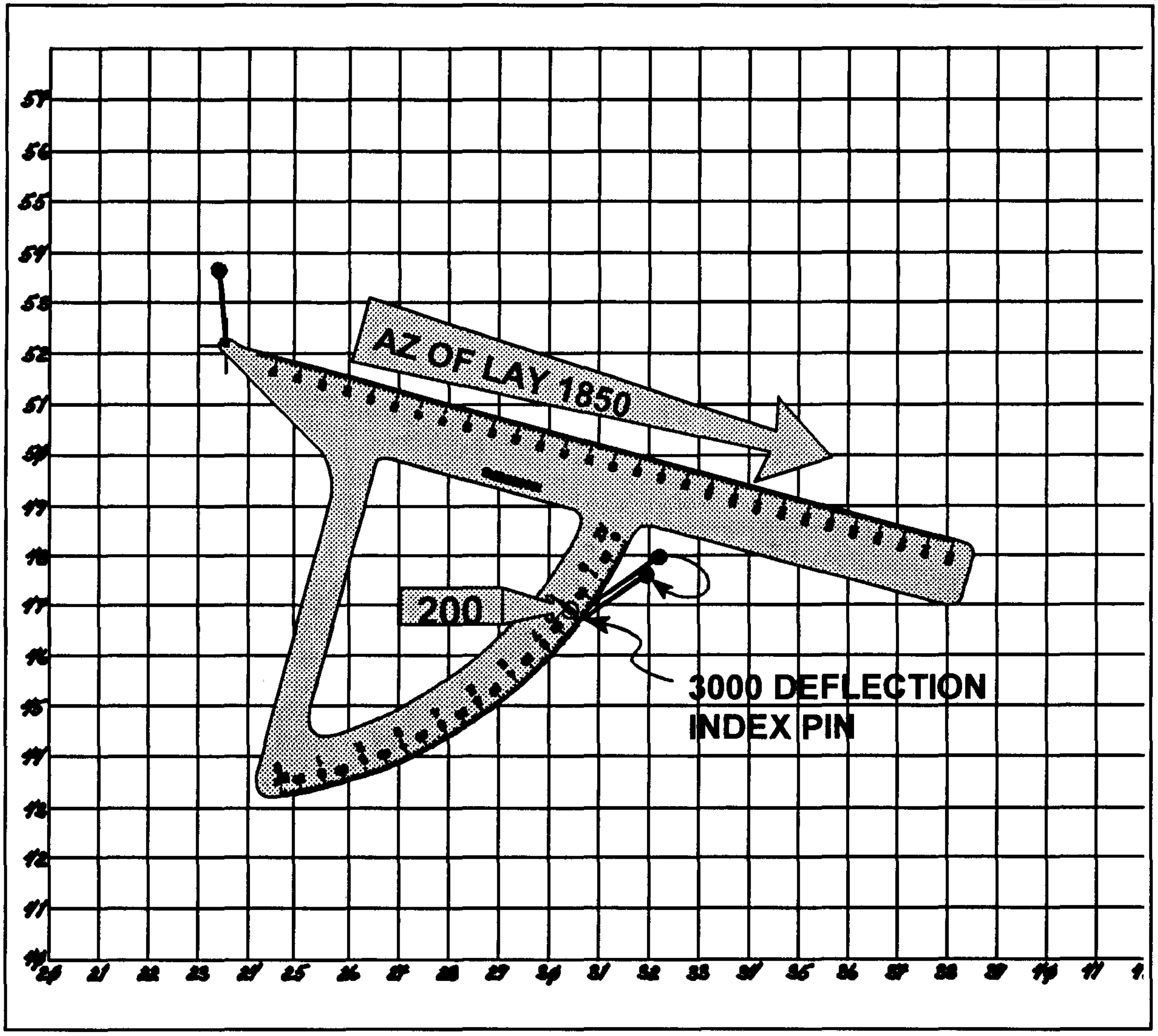


Figure 6-17. Common Deflection.

Table 6-6. Constructing Deflection Indexes (Continued).

STEP	ACTION
9	Move the arm of the RDP against the plotting pin representing the deflection index.
10	Remove the pin.
11	Using a 6H pencil, draw a fine line along the arm of the RDP from range 8250 to range 9520. Ensure that the line bisects the center of the pinhole. The distance between these two ranges is equal to about 2 inches. This is the primary deflection index.
12	Move the RDP away from the deflection index.
	NOTE: The same color code used for tick marks is used when labeling deflection indexes.
13	Using the appropriate color of pencil, draw an arrowhead one-eighth of an inch above the pinhole. The arrowhead should point toward the base piece location.
14	Label the deflection index with the appropriate unit designation and deflection value. (The deflection value is written by using the first digit only.) Unit designation is written immediately above and to the left of the index. Deflection values are written immediately above and to the right of the index. Figure 6-18 shows a 3,000-mil deflection index for Battery B, 1st Platoon.

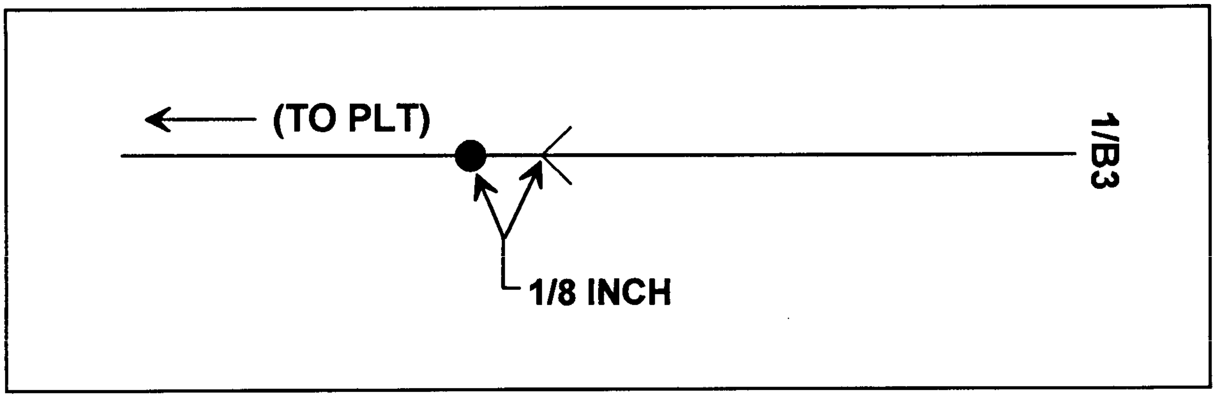
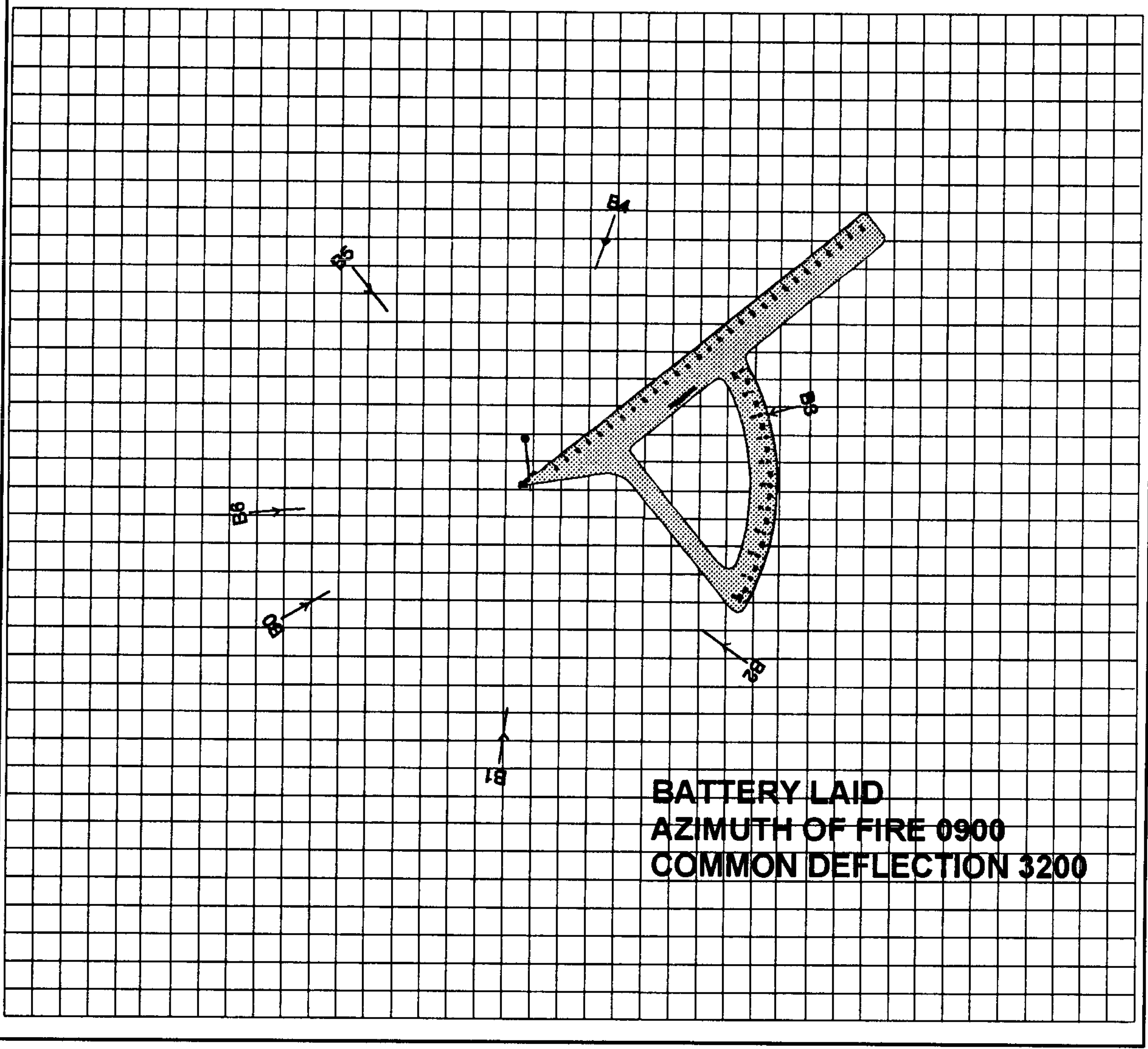


Figure 6-18. Deflection Index.

STEP	ACTION
	NOTE: The deflection index just constructed is the primary deflection index. Other deflection indexes are constructed by measuring successive 1,000-mil increments to the left and right of the primary index. These supplementary deflection indexes have the same color labeling as the primary index, and the deflection value should reflect the 1,000-mil change in deflection. If the supplementary index is to the right of the primary index, it will decrease in deflection. If the supplementary index is to the left of the primary index, it will increase in deflection. This is done because deflection increases to the left and decreases to the right. An easy rule to remember is the **LARS rule** (left, add; right, subtract). Figure 6-19 shows a plotted position with seven deflection indexes. The M101A1 uses the M12-series sight. The M12-series sight is only capable of measuring deflection from 0 to 3,200 mils. For the M101A1, with a common deflection of 2800, place the pin at the 8 along the RDP deflection scale (red numbers), and label the initial index with a 2.
15	Repeat steps 1 through 14 for all firing units.

Table 6-6. Constructing Deflection Indexes (Continued).

STEP	ACTION
	 Figure 6-19. Deflection Index for Seven Positions.

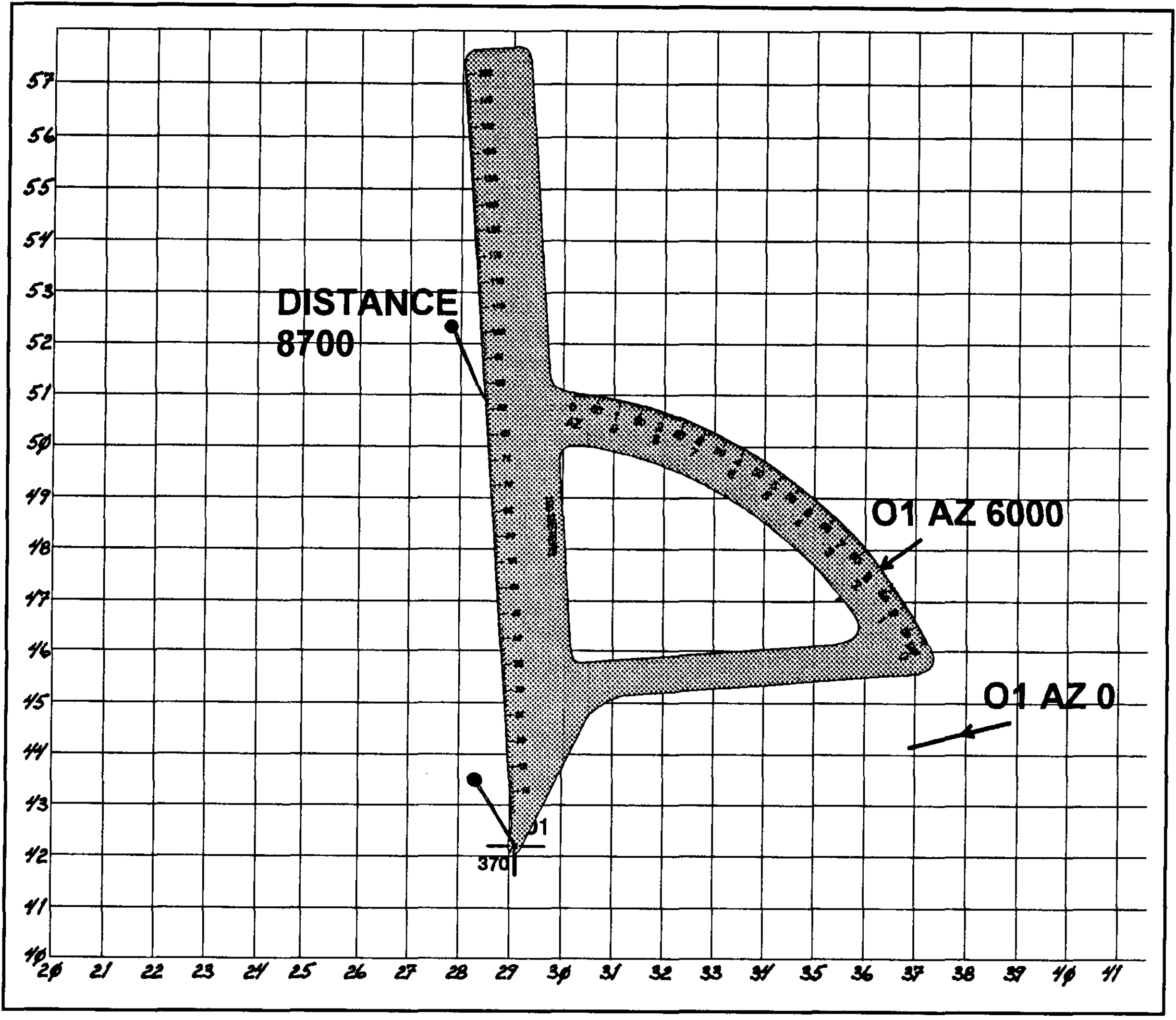
6-14. Plotting Targets

The observer can use three methods of target location: grid coordinate, polar plot, and shift from a known point. The steps for plotting targets on a firing chart are listed in Table 6-7.

Table 6-7. Plotting Targets.

STEP	ACTION
Grid Coordinate Method	
1	Place a plotting pin in the upper right-hand corner of the grid square where the point is to be plotted.
2	Place the plotting scale along the left edge of the grid square so that the 0 on the bottom scale is at the lower left-hand corner of the grid square.
3	Slide the plotting scale to the right, and set off the target easting by using the vertical grid line as an index.
4	With the bottom edge of the plotting scale precisely aligned on the horizontal grid line, plot the target northing on the vertical scale with a plotting pin. This is the target location.
Polar Plot Method of Target Location	
5	Place a plotting pin at the observer's location.
6	Place the vertex of the RDP against the pin.
7	Align the RDP in the direction announced by the observer. Use the appropriate azimuth index for that observer and the arc of the RDP.
8	Place a pin along the arm of the RDP at the distance reported by the observer. This is the target location. Figure 6-20 shows a polar plot method of target location where the call for fire was received from Observer 1 for direction 6200 and distance 8700.
Shift From a Known Point Method of Target Location	
9	Insert a pin through the center of the target grid.
10	Place the pin in the pinhole marking the point from which the observer is shifting.
11	Align the arrow on the target grid so that it is parallel to a north-south grid line. If a permanent north index has been constructed for the known point, orient the target grid so that the 0 graduation is at the north index and go to step 13.
12	Place a pin opposite the 0 on the outer scale of the target grid. This is a temporary north index.
13	Rotate the target grid until the announced direction is at the north index (pin or permanent index). Once the target grid is oriented for direction, a minimum of two pins should be used to secure it to avoid unintentional movement.
14	Plot the left or right shift given by the observer by measuring the appropriate number of squares left or right of the pin. Each square represents 100 meters and can be visually interpolated to the nearest 10 meters.
15	Plot the add or drop correction given by the observer by measuring the appropriate number of squares (plus or minus) from the point plotted in step 14, and insert the plotting pin. This is the initial target location. Reorient the target grid over this location to determine angle T.
	NOTE: If the initial shift plots the point off the target grid, plot the portion of the shift that will fit on the target grid and **then** reorient on the last plotted point and plot the remaining portion of the shift.

Table 6-7. Plotting Targets (Continued).

STEP	ACTION
	 Figure 6-20. Polar Plot Method of Target Location.

6-15. Determining and Announcing Chart Data

Chart data consist of chart range and chart deflection from the firing unit to the target and angle T. In a manual FDC, two firing charts will be constructed and will be used to check each other. Use the steps in Table 6-8 to determine chart data.

Table 6-8. Determining and Announcing Chart Data.

STEP	ACTION
1	Place a plotting pin in the base piece location.
2	Place the vertex of the RDP against the pin.
3	Move the RDP so that the left edge of the arm is against the pin at the target location.
4	Read the range, to the nearest 10 meters, along the arm opposite the pin in the target location.
5	Announce the range. The platoon identification is announced followed by the range; for example, **1/A RANGE 3250 (ONE ALPHA, RANGE THREE, TWO, FIVE, ZERO)**.

Table 6-8. Determining and Announcing Chart Data (Continued).

STEP	ACTION
6	Read the chart deflection from the arc of the RDP opposite the appropriate deflection index. To determine the deflection, combine the 1,000-mil designation of the index with the reading on the arc. Deflection is determined to the nearest 1 mil.
7	Announce the determined deflection. The platoon designation is not announced; for example, **DEFLECTION 3288 (deflection three, two, eight, eight)**.
	NOTE: If the data announced by the HCO is greater than ±30 meters in range and/or ±3 mils in deflection from the VCO's data, the VCO will announce **HOLD (and the difference between his data and the data that the HCO announced)**. If the data are within tolerance, the VCO simply announces **CHECK**.
8	Move the RDP away from the target location.
9	Attach and orient the target grid over the target location by inserting a pin through the center of the target grid and inserting the pin in the pinhole marking the target location. Orient the target grid as in the shift from known point method of plotting target location (Table 6-7). Once the target grid is oriented for direction, a minimum of two pins is inserted along the outer edge of the target grid to keep it from slipping when subsequent corrections are plotted. The pins should be positioned so that they do not interfere with the RDP. **If shift from a known point method of target location is used, the target grid must be reoriented over the target location.**
10	With the vertex of the RDP still at the base piece location, move the RDP so that the left edge of the arm of the RDP is against the pin at the target location.
	NOTE: Angle T is the angle formed by two rays beginning at the target and extending to the firing unit and observer locations. (See Figure 6-21.) Angle T will never be greater than 3,200 mils. An easy rule to remember when determining Angle T is to read **head-to-head or tail-to-tail**. (See Figure 6-22.)

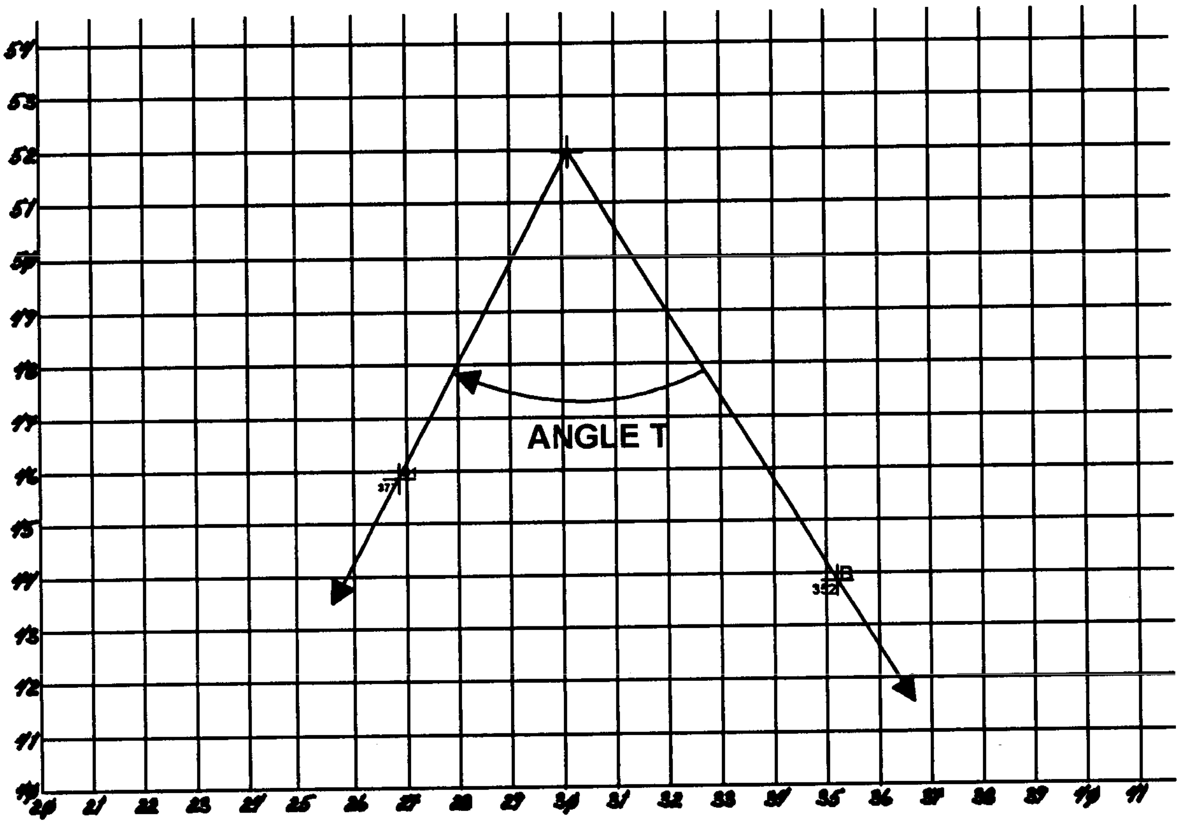


Figure 6-21. Angle T.

Table 6-8. Determining and Announcing Chart Data (Continued).

STEP	ACTION
11	Determine the number of mils between the head of the arrow on the target grid and the upper left-hand edge of the RDP or the tail of the arrow on the target grid and the lower left-hand edge of the RDP (Figure 6-22). Angle T is determined to the nearest 10 mils.

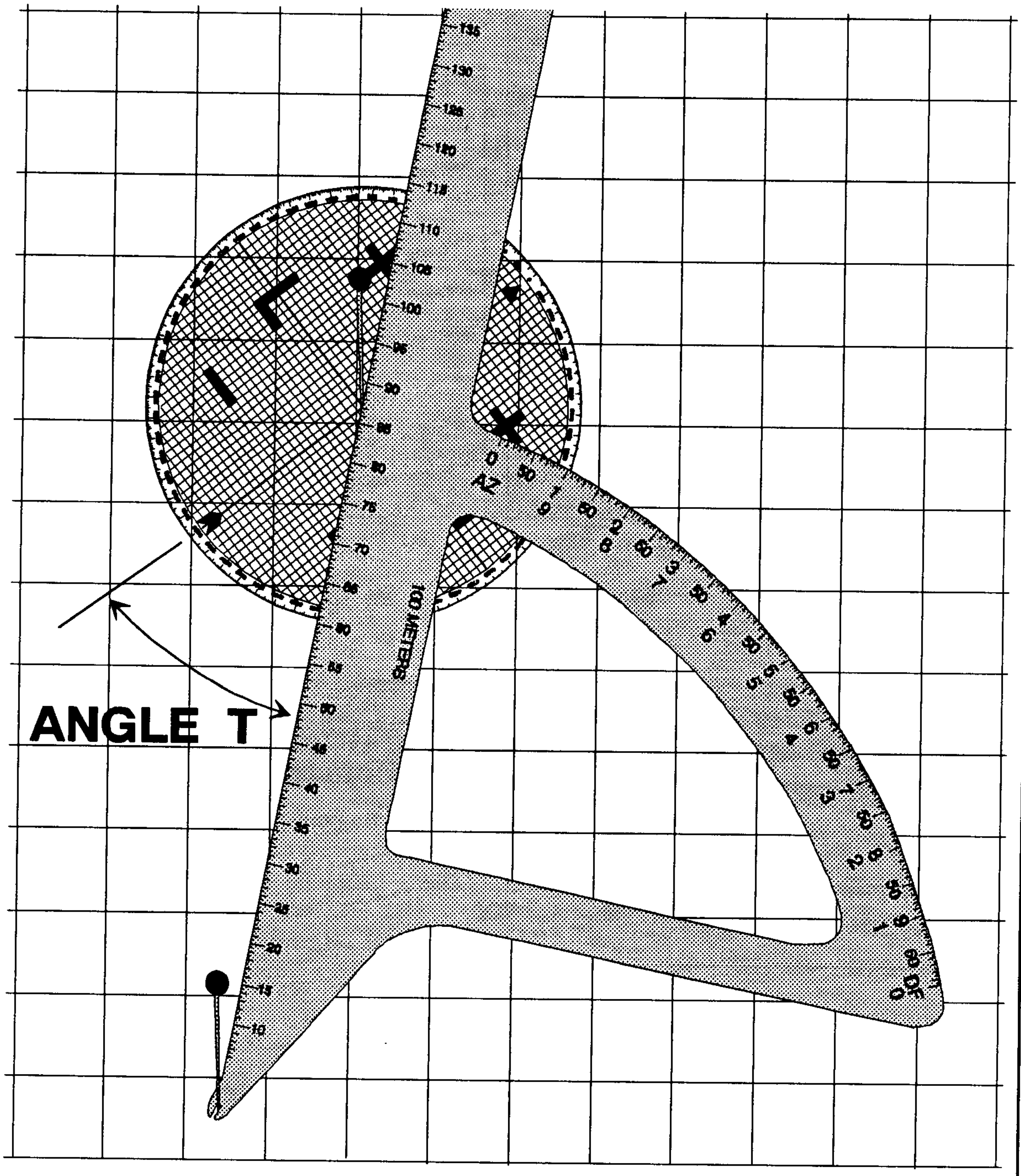


Figure 6-22. Angle T (Tail-To-Tail).

Table 6-8. Determining and Announcing Chart Data (Continued).

STEP	ACTION
12	The chart operator announces the determined angle T; for example, **ANGLE T 560 (ANGLE T FIVE, SIX, ZERO)**.
	NOTE: If the angle T announced by the HCO is greater than ±30 mils from what the VCO determines, the VCO will announce **HOLD (and the difference between his data and the data that the HCO announced)**. If the data are within tolerance, the VCO simply announces **CHECK**.
13	Plot left or right corrections by measuring the appropriate number of squares left or right of the last plotted location.
14	Plot add or drop corrections by measuring the appropriate number of squares (plus or minus) from the point plotted in step 13, and insert a pin. This is the adjusted aimpoint.
15	Determine and announce chart range and deflection as in steps 1 through 7.
	NOTE: If the observer or target is moving, the observer will report changes of direction to the target to the FDC if the change is 100 mils. If this occurs, the chart operator reorients the target grid over the last plotted location on the new direction, then plots the subsequent corrections as announced by the observer, and redetermines angle T. After the initial correction is made from the target location, all further corrections are made from the last pin (aimpoint) location. The observer's final refinement that is sent with end of mission need not be plotted by the chart operator unless the observer requests **RECORD AS TARGET** or unless the chart operator **is instructed to do so by the FDO**.

6-16. Chart-to-Chart Checks

a. One chart may differ slightly from another because of small differences in construction caused by human limitations in reading the graphical equipment. Because of these differences, the following tolerances between charts are permissible:

- Range and/or distance ±30 meters.
- Azimuth and/or deflection ±3 mils.
- Angle T ±30 mils.

b. All firing unit locations must be checked for accuracy. For checking the accuracy of two or more charts, plot the same grid intersection on all charts. Determine range and deflection to that grid intersection. If all ranges agree within ±30 meters in range and ±3 mils in deflection, the charts are accurate for that firing unit location. If not, all charts must be checked for errors.

c. To ensure accuracy, enough points in the zone of operation of a firing unit should be checked. For example, an error in plotting the unit location on one chart could compensate for an error in constructing the deflection index on the other chart. Checking at least two points will reveal the error. This should be done as a matter of unit SOP.

Section IV

Observed Firing Charts

When survey control and maps are not available, delivery of indirect fires is possible by using observed firing charts. An observed firing (OF) chart is a firing chart on which all units and targets are plotted relative to each other from data determined by firing a registration. Observed firing charts are an expedient method that should only be use under emergency conditions and every attempt should be made to construct a surveyed firing chart as soon as possible. Since all locations are based upon firing data, observed firing charts contain errors because of nonstandard conditions.

6-17. Overview

a. All observed firing charts are based on a registration. Once a registration is complete, the unit location is polar plotted from the point of registration (normally assumed to be a grid intersection) by using the direction that is based on the back azimuth to the point and a range corresponding to the adjusted elevation, or more preferably, a range corresponding to the adjusted time.

b. Because maps and survey are not available, altitudes cannot be accurately determined. When vertical interval and site are assumed to be zero, a false range is introduced into the polar plot range. This inaccuracy can be reduced by trying to determine site. Site may be determined by estimating vertical interval or by conducting an XO's high burst.

c. The general procedures for constructing an OF chart are listed below:

(1) Mark the center of sector for observers.

(2) The observer selects a point in the center of the sector of fire that can be identified on the ground.

(3) Assign the point an arbitrary grid coordinate and altitude. Plot this location on the firing chart. The grid coordinates assigned to the point are completely arbitrary. A grid intersection is preferred for simplicity. The grid coordinates of the known point will serve as the basis for establishing a common grid system. For example, the point could be assigned the grid coordinates of easting (E):20000 northing (N):40000, altitude 400 meters. (See Figure 6-23.)

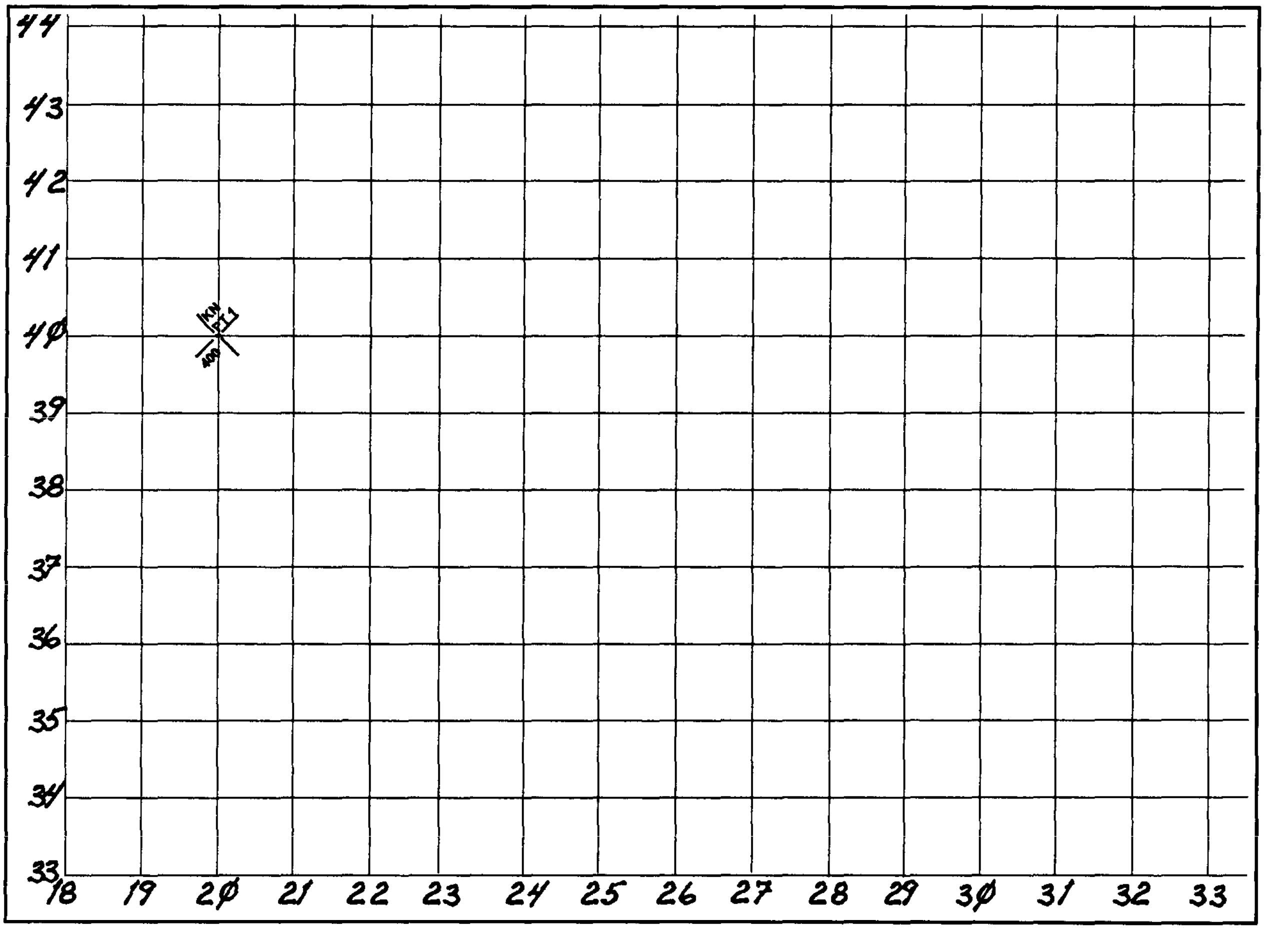


Figure 6-23. Observed Firing Chart Grid.

(4) Conduct a precision registration (fuze time, if possible) on the point by using emergency firing chart procedures. (See Chapter 14.)

(5) Determine the adjusted data (to include orienting angle, if possible).

(6) From the adjusted data, determine direction (azimuth) and distance (range) from the point to the unit.

(7) Polar plot the base piece from the point.

6-18. Methods of Determining Polar Plot Data

a. All observed firing charts are constructed by using polar plot data. The method for obtaining these data depends on the type of registration conducted and whether site can be estimated or whether it is unknown.

b. Percussion plot is used when an impact registration has been conducted.

(1) When VI is not known and cannot be estimated, the method is known as **percussion plot, VI unknown.**

(2) When vertical interval can be estimated, a site can be determined and inaccuracies reduced. This method is known as **percussion plot, VI estimated.**

c. Time plot is used when a time registration has been conducted.

(1) When VI is not known, the method is known as **time plot, VI unknown.**

(2) When VI can be determined by using an XO's high-burst registration, the method is known as **time plot, VI known.**

6-19. Constructing Observed Firing Charts

The step-by-step procedures for construction of an observed firing chart are listed in Table 6-9.

Table 6-9. Constructing an Observed Firing Chart.

STEP	ACTION
1	Construct an emergency firing chart. (See Chapter 14.)
2	The FDC must mark the center of sector. The observer will select a point in the center of his sector. The FDO will assign this point an arbitrary grid and altitude. To orient the observer, the FDO will have the registering howitzer fire 1 round, center of sector (COS).
	NOTE: The following example is shown in Figure 6-24.
	EXAMPLE The unit was laid on grid azimuth 6100. The FDO estimates range to the forward line of own troops (FLOT) to be 2,000 meters. The FDO determines the COS as the center direction and adds 2,000 meters to the estimated distance to the FLOT. The addition of 2,000 meters is for safety. The FDO issues the fire order for marking COS (for example, **MARK COS FOR T03, RANGE 4000, #3 1 ROUND, SHELL WP, LOT WG, CHG 4, AMC**). The RATELO transmits the MTO (for example, **MTO OBSERVE 1 ROUND, COS, REPORT WHEN READY TO OBSERVE**).

Table 6-9. Constructing an Observed Firing Chart (Continued).

STEP	ACTION
	The computer determines firing data to mark COS by placing the manufacturer's hairline (MHL) of the appropriate GFT over the COS range announced in the fire order. The HE elevation and drift are determined by using the appropriate scales.
	NOTE: The WP weight correction is ignored for speed. The weight correction may be applied at the FDO's discretion.
	The computer determines the deflection to fire by adding drift to the center deflection. An example is as follows: **CENTER DEFLECTION 3200** **+ DRIFT L4** **DEFLECTION TO FIRE 3204**
	The computer determines the quadrant elevation to fire. This is the elevation corresponding to the range announced in the fire order. Site is 0. Elevation corresponding to range 4000 equals 232. An example is as follows: **ELEVATION 232** **+SITE 0** **QE 232**
	The computer announces the fire commands (for example, **FIRE MISSION, NUMBER 3 1 ROUND, AMC, SHELL WP, LOT WG, CHG 4, DF 3204, QE 232**) and commands **FIRE** when the observer reports **READY**.
3	The HCO will construct the known point as directed by the FDO.
4	The grid sheet will now be numbered on the basis of the known point grid.
5	Conduct a precision registration by using emergency firing procedures. (See Chapter 14.)
	NOTE: The purpose of the precision registration in observed firing charts is to accurately locate a point. This is done by moving the MPI over the observer's known point. The more **met corrections** that the FDC can account for, the more **accurate** the chart becomes. It does not lose any accuracy as met corrections change if we continue to account for nonstandard conditions.
	The FDO issues the fire order for the precision registration, and directs the observer to conduct a precision registration. Fuze time will yield the most accurate results for the observed firing chart polar plot data and is therefore preferred (for example, **PRECISION REGISTRATION, WITH T03, SELECT KNOWN POINT, VICINITY COS, NUMBER 3, 1 ROUND, Q AND TI**).
	The RATELO issues the MTO (for example, **MTO SELECT KNOWN POINT, VICINITY COS, Q AND TI**).
	NOTE: Since no known point exists, the observer will select one near the center of sector and locate it for the FDC as a shift from the COS.
	The HCO plots the direction and shift announced by the observer and determines chart data. The computer records the observer's correction on the record of fire (for example, **DIRECTION 5820, LEFT 430, ADD 800**).
	The HCO centers the target grid over the new target location and determines angle T.
	The FDC processes the registration by using the procedures outlined in Chapter 10 for a precision registration.
6	The computer will determine the adjusted time (if applicable), the adjusted deflection, and the adjusted quadrant elevation.

6-20. Determination of Direction for Polar Plotting

a. Once the registration has been completed, the azimuth of the line of fire must be determined. No matter what technique (percussion or time plot) is used, the direction (azimuth) of the firing unit from the known point is computed in the same manner.

b. There are two methods to determine the azimuth of the line of fire. They are as follows:

(1) The XO or platoon leader will determine the azimuth of the line of fire in accordance with FM 6-50 and report it to the FDC.

(2) The drift corresponding to the adjusted elevation is stripped out of the adjusted deflection; the result is the chart deflection. The chart deflection is then converted to an azimuth. For example in Figure 6-24, the firing unit was laid on grid azimuth 6100; common deflection 3200. The adjusted deflection was 3346, and the adjusted elevation was 272.

ADJUSTED DEFLECTION	**3346**
-DRIFT ~ ADJUSTED ELEVATION	**- L5**
CHART DEFLECTION	**3341**

CHART DEFLECTION	**3341**
COMMON DEFLECTION	**-3200**
DIFFERENCE IN DEFLECTIONS	**L141**
(USE LARS RULE FOR DEFLECTION)	

GRID AZIMUTH	**6100**
+DIFFERENCE IN DEFLECTIONS	**+L141**
(USE RALS RULE FOR AZIMUTH)	
AZIMUTH OF THE LINE OF FIRE	**5959**

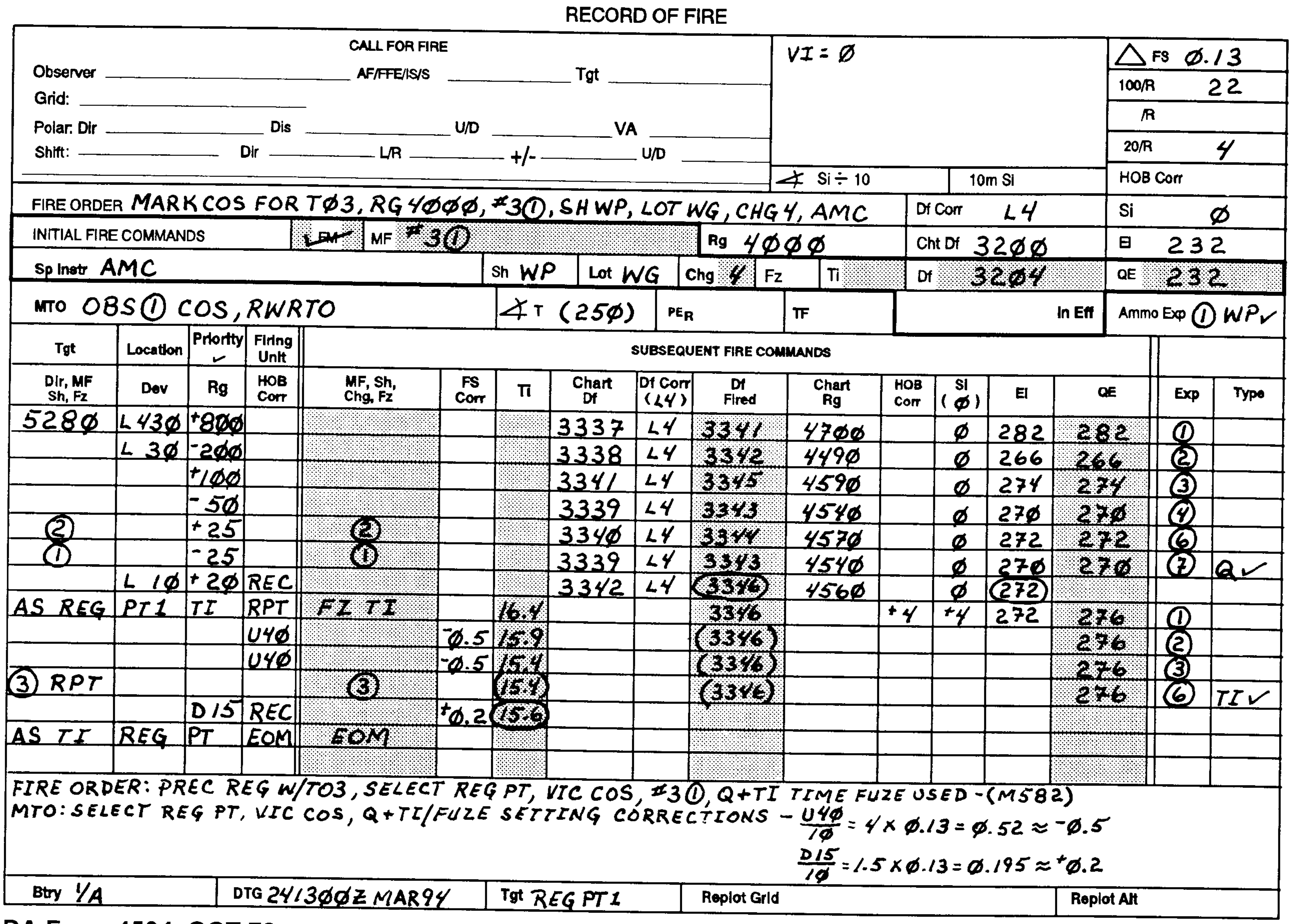
c. Because the firing unit will be polar plotted from the known point, the FDC must convert the azimuth of the line fire to a back azimuth. The polar plot direction is simply the back azimuth of fire to the known point. The polar plot direction equals the azimuth of the line of fire ±3,200 mils. If the adjusted (adj) azimuth of fire is less than 3,200 mils, add 3,200 mils to it. If the adjusted azimuth of fire is greater than 3,200 mils, subtract 3,200 mils from it.

AZIMUTH OF THE LINE OF FIRE	**5959**
±3200 MILS	**-3200**
POLAR PLOT DIRECTION	**2759**

NOTE: When the azimuth of the line of fire is measured, the howitzer is aimed with the adjusted deflection. This will result in a polar plot azimuth that compensates for drift. If the drift corresponding to the adjusted elevation is removed and a chart deflection is determined, all nonstandard conditions (other than drift) affecting the deflection are accounted for in the plot of the known point.

d. Once the polar plot direction has been computed, the remaining polar plot data must be computed by using one of the methods listed below.

(1) If the impact registration was conducted and VI is not known and cannot be estimated, use the percussion plot, VI unknown method, as shown in paragraph 6-21.



RECORD OF FIRE

CALL FOR FIRE
Observer ______ AF/FFE/IS/S ______ Tgt ______
Grid: ______
Polar: Dir ______ Dis ______ U/D ______ VA ______
Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______

VI = 0

△ FS 0.13
100/R 22
/R
20/R 4
HOB Corr
Si 0
⊟ 232
QE 232

∡ Si ÷ 10 ______ 10m Si ______

FIRE ORDER MARK COS FOR T03, RG 4000, #3①, SH WP, LOT WG, CHG 4, AMC
Df Corr L4

INITIAL FIRE COMMANDS ✓EM MF #3①
Rg 4000
Cht Df 3200

Sp Instr AMC
Sh WP
Lot WG
Chg 4
Fz
Ti
Df 3204

MTO OBS① COS, RWRTO
∡T (250)
PER
TF
In Eff
Ammo Exp ① WP✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L4)	Df Fired	Chart Rg	HOB Corr	Si (0)	El	QE	Exp	Type
5280	L 430	+800					3337	L4	3341	4700		0	282	282	①	
	L 30	-200					3338	L4	3342	4490		0	266	266	②	
		+100					3341	L4	3345	4590		0	274	274	③	
		-50					3339	L4	3343	4540		0	270	270	④	
②		+25		②			3340	L4	3344	4570		0	272	272	⑥	
①		-25		①			3339	L4	3343	4540		0	270	270	⑦	Q✓
	L 10	+20	REC				3342	L4	(3346)	4560		0	(272)			
AS REG	PT1	TI	RPT	FZ TI		16.4			3346		+4	+4	272	276	①	
			U40		-0.5	15.9			(3346)					276	②	
			U40		-0.5	15.4			(3346)					276	③	
③ RPT				③		(15.4)			(3346)					276	⑥	TI✓
		D15	REC		+0.2	(15.6)										
AS TI	REG	PT	EOM	EOM												

FIRE ORDER: PREC REG W/T03, SELECT REG PT, VIC COS, #3①, Q+TI TIME FUZE USED -(M582)
MTO: SELECT REG PT, VIC COS, Q+TI/FUZE SETTING CORRECTIONS - $\frac{U40}{10} = 4 \times 0.13 = 0.52 \approx -0.5$
$\frac{D15}{10} = 1.5 \times 0.13 = 0.195 \approx +0.2$

Btry 1/A
DTG 241300Z MAR94
Tgt REG PT1
Replot Grid
Replot Alt

DA Form 4504, OCT 78

Figure 6-24. Completed Record of Fire.

(2) If the impact registration was conducted and VI can be estimated, use the percussion plot, VI estimated method, as shown in paragraph 6-22.

(3) If time registration was conducted and VI is unknown, use the time plot, VI unknown method, as shown in paragraph 6-23.

(4) If time registration was conducted and VI is to be determined by using the XO's high burst, use the time plot, VI known method, as shown in paragraph 6-24.

6-21. Percussion Plot, VI Unknown

Percussion plot is used when an impact registration has been conducted. When VI is not known and cannot be estimated, the method is known as percussion plot, VI unknown. The percussion plot technique assumes that site is zero. The range used to polar plot is the range corresponding to the adjusted elevation. Since site is zero, the adjusted quadrant elevation is the same as the adjusted elevation.

UNIT ALTITUDE = KNOWN POINT ALTITUDE

POLAR PLOT RANGE = RANGE CORRESPONDING TO ADJUSTED ELEVATION

6-22. Percussion Plot, VI Estimated

When site is assumed to be zero, a large error can be introduced into the computation of range by using the percussion plot technique. This error can be minimized and the accuracy of the chart improved by estimating a vertical interval between the firing unit and the known point. The firing unit altitude is then determined by applying the estimated VI from the assumed altitude of the known point to the firing unit altitude. (See Figure 6-25.) The estimated VI is used to compute site as shown in Table 6-10.

6-23. Time Plot, VI Unknown

a. The lack of an accurate site and nonstandard conditions are the major sources of error in range on an observed firing chart. If the site is unknown or incorrect, the derived adjusted elevation is in error by the amount of error in site. Determining the polar plot range from the false elevation produces a false range. However, the effect of site on fuze settings is usually small. Therefore, the adjusted time can be used as a good indicator of the adjusted elevation and the polar plot range. Because the adjusted fuze setting is a function of elevation and complementary angle of site (CAS), the angle of site (✈ SI) and hence the VI may be determined after the firing of fuze time.

b. To derive angle of site, subtract the elevation corresponding to the adjusted time plus the CAS from the adjusted quadrant elevation. Using the GST, determine the VI by multiplying the polar plot range by the derived angle of site. To determine range, place the MHL of the GFT over the adjusted time and read range under the MHL from the range scale. Determine altitude of the firing unit by applying the VI to the assumed altitude of the known point.

ADJ QE = (ADJUSTED ELEVATION + CAS) + ✈ SI.

Table 6-10. Computing Site by Using an Estimated VI.

STEP	ACTION
	Percussion Plot, VI Estimated
1	A first apparent site for the unit is computed by using the estimated VI and the range corresponding to the firing unit adjusted quadrant elevation.
2	A first apparent adjusted elevation is derived by subtracting the first apparent site from the adjusted quadrant elevation.
3	A second apparent site is computed by using the same VI and the range corresponding to the first apparent adjusted elevation. If this site is within 1 mil of the previous site, the polar plot range is the range corresponding to the last derived adjusted elevation, which is determined by using the final site computed.
4	If the site varies by more than 1 mil from the previous site, successive approximation is continued until a site is determined that is within 1 mil of the previous site. If the two sites agree within 1 mil, the last site is the true site. The polar plot range is the range corresponding to the last derived adjusted elevation, which is determined by using the final site computed.
5	The firing unit altitude equals the known point altitude minus the VI.
	TRUE SITE = ESTIMATED VI/RANGE ~ ADJ QE (USE SUCCESSIVE APPROXIMATION AND THE GST).
	TRUE ADJUSTED ELEVATION = ADJ QE - TRUE SITE.
	POLAR PLOT RANGE = RANGE ~ LAST DERIVED ADJUSTED ELEVATION.
	VI = TRUE SITE X RANGE ~ LAST DERIVED ADJUSTED ELEVATION. (USE GST.)
	Time Plot, VI Unknown
6	The computer places the MHL over the adjusted fuze setting and extracts the adjusted elevation plus CAS from the elevation scale.
7	An angle of site may be derived by subtracting the elevation corresponding to the adjusted time plus CAS from the adjusted QE.
	ADJ QE **- (ADJ EL + CAS)** **∢SI**
8	Range from the known point to the firing unit is determined at the range corresponding to the adjusted time.
9	By using the GST, determine the vertical interval by multiplying the range from the known point to the firing unit by the derived angle of site.
10	The unit altitude is computed by applying the VI to the assumed altitude of the known point.
	ADJ QE = (ADJ EL + CAS) + ∢ SI.
	FS IS A FUNCTION OF (ADJ EL + CAS).
	∢ SI = ADJ QE - (ADJ EL + CAS).
	POLAR PLOT RANGE = RANGE ~ ADJ TI.
	COMPUTED VI = ∢ SI X POLAR PLOT RANGE IN THOUSANDTHS. (USE GST.)
	UNIT ALTITUDE = KNOWN POINT ALTITUDE - COMPUTED VI.

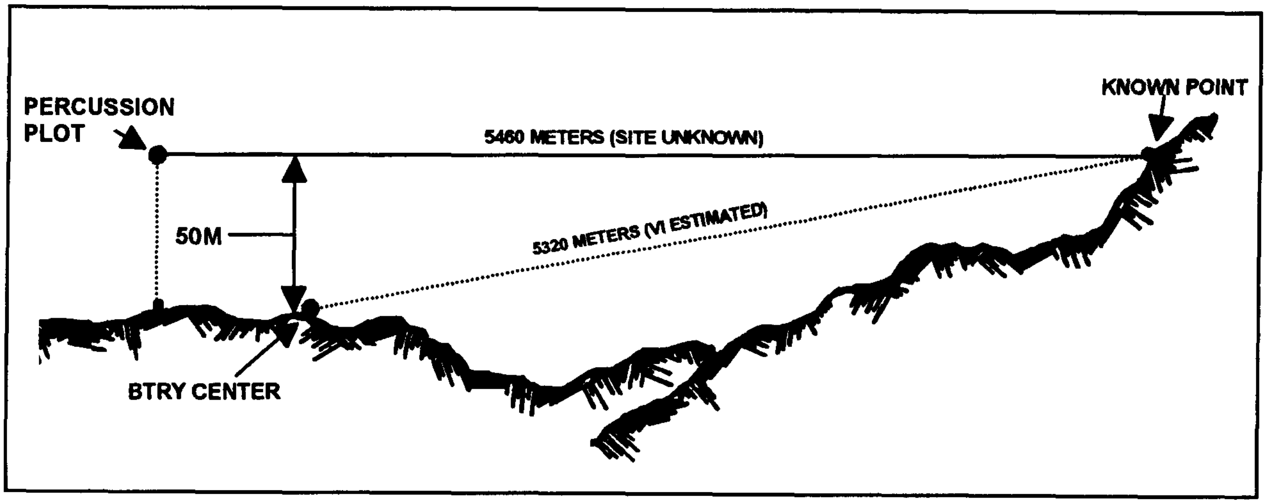


Figure 6-25. Difference in Range Resulting From Difference in Vertical Interval.

6-24. Time Plot, VI Known (Preferred Technique)

a. When site can be determined by using an XO's high-burst (HB) registration, the method is known as time plot, VI known. This provides an even more accurate relative location.

(1) This technique is based on a rough approximation of site. This approximation can be refined to an accuracy approaching survey accuracy by the firing of a modified HB registration after the completion of a precision registration with fuze time.

(2) The objective of an XO's HB registration is to determine precisely what portion of the adjusted QE is angle of site and what portion is elevation plus CAS. (See Figure 6-26.) The vertical interval and site to the known point can be computed by using the angle of site and range corresponding to the adjusted time.

ADJ QE = (ADJ EL + CAS) + ∢ SI

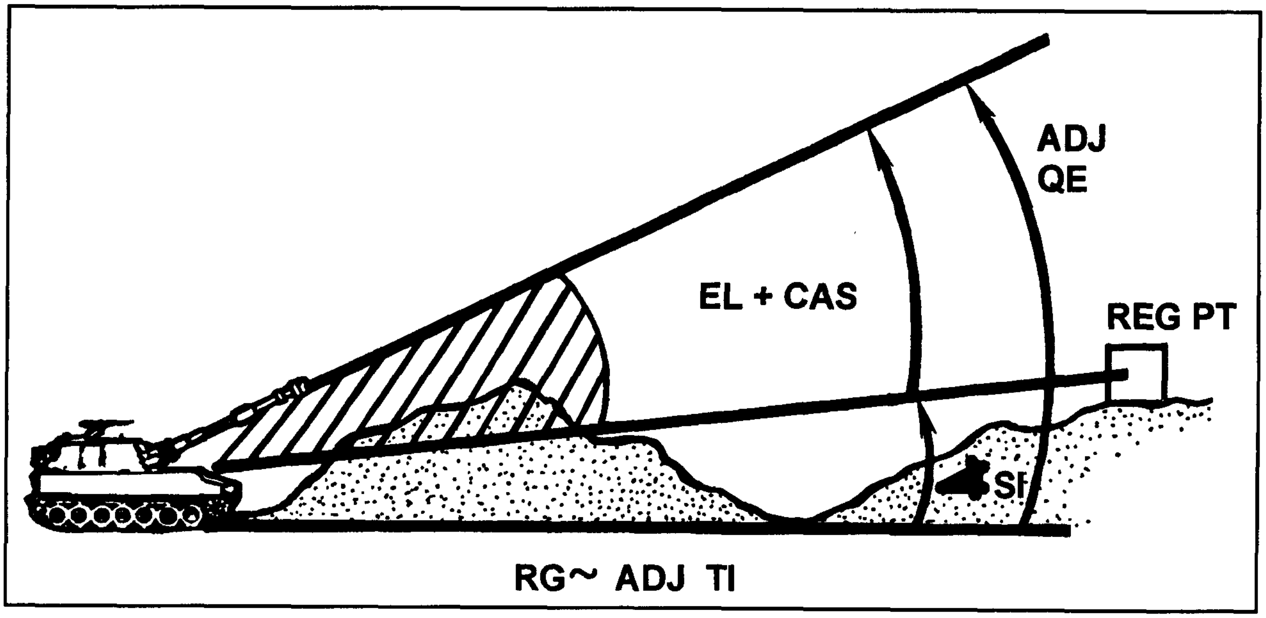


Figure 6-26. Comparison Between the Adjusted QE and EL + CAS.

(3) This XO's HB registration is based on the principle that fuze setting is a fiction of elevation plus CAS. The XO's HB registration is fired immediately after the time portion of the registration is completed. The firing of three such high airbursts is specifically what is called XO's HB registration. The height of burst is raised vertically by an amount sufficient to enable the burst to be seen by an aiming circle located within 30 meters of the registering piece. The burst is raised by increasing quadrant. Three rounds are fired with the adjusted time. The XO measures the angle of site to each burst and determines the average angle of site. Because the fuze setting was not changed (the adjusted time was freed), the elevation plus CAS determined is the true elevation plus CAS. This value is then subtracted from the adjusted QE, yielding a true angle of site. Site is then computed.

b. The procedures for conducting an XO's HB registration are outlined in Table 6-11.

Table 6-11. Conducting an XO's HB Registration.

STEP	ACTION
1	The FDC determines the height of burst (HOB) correction needed to raise the burst so that it may be observed at the aiming circle near the registering piece. There are two methods to determine the needed HOB correction.
50-Meter-Addition Method	
	The FDO directs the VCO to multiply the angle of site to crest for the registering piece by the range corresponding to the adjusted quadrant. The VCO uses the GST to perform this computation.
	The angle of site to crest is extracted from the XO's report.
	The VCO determines the minimum HOB using the "C" and "D" scales of the GST.
	Because the HOB determined in step 3 may not be enough (it will put the round at the site to crest), the FDO adds 50 meters to the minimum HOB and expresses the result to the nearest 10 meters to determine the HOB to fire.
	The adjusted QE must be raised. To compute the HOB correction, the computer converts the HOB to fire announced by the FDO to an HOB correction.
	HOB TO FIRE ÷ RG IN THOUSANDS (RG ~ ADJ QE FROM THE REGISTRATION) = HOB CORR
10-mil Assurance Factor Method	
	The XO or platoon leader measures or extracts the angle of site to crest from the XO's report for the registering piece.
	The XO or platoon leader applies an additional 10-mil assurance factor to the angle of site to crest.
	∢ SI TO CREST **<u>+ 10-MIL ASSURANCE FACTOR</u>** **HOB CORRECTION**
2	The FDO alerts the XO or platoon leader to set up an aiming circle within 30 meters of the registering piece.
3	The FDO announces the fire order (for example, **XO's HB REG, HOB [so many meters], NUMBER 3, 3 ROUNDS, BRAMC**).
4	The computer determines the data to fire. The adjusted time and deflection from the registration will be fired. The computer adds the HOB correction to the adjusted QE to determine the XO's HB QE to fire.
5	The computer sends direction to the target and HOB correction (actually VA) to the XO or platoon leader as orienting data.
6	When the XO or platoon leader reports **READY**, the computer fires the three rounds and records the angle of site (VA) reported for each round.

Table 6-11. Conducting an XO's HB Registration (Continued).

STEP	ACTION
7	The computer determines the average angle of site. Because both the adjusted QE and XO's QE were fired at the same range, the elevation to both remains the same. The difference in QEs is site. Site cannot be accurately determined because accurate range to the known point is not known. The computer is able to determine the elevation plus CAS by subtracting the measured angle of site from the XO's QE.
	XO's HB QE **- XO's AVERAGE SI** **EL + CAS**
8	The angle of site to the known point may be determined by subtracting the elevation plus CAS from the adjusted QE to the known point.
9	Determine the VI by using the GST. Angle of site multiplied by the range corresponding to the adjusted fuze setting equals the VI. Place the M gauge point opposite the angle of site on the D scale of the GST. Move the MHL over the range that corresponds to the adjusted fuze setting on the C scale. Read the VI under the MHL on the D scale.
10	Determine site. Place the MHL over the VI on the D scale of the GST. Set off under the MHL the range corresponding to the adjusted fuze setting on the site-range (target above gun [TAG] or target below gun [TBG]) scale for the selected charge. Determine the site from the D scale opposite the M gauge point.
11	Determine the adjusted elevation. The adjusted QE minus site equals the adjusted elevation.
	ADJ QE **- SITE** **ADJ EL**
12	Determine the firing point altitude. The known point altitude minus the VI equals the firing point altitude.
13	The polar plot range is the range corresponding to the adjusted fuze setting.

c. After understanding the theory on which the determination of site by firing is based, it may be easier to use the **GOT MINUS ASKED FOR** rule to determine the angle of site. As shown in Figure 6-27, the angle of site to the known point equals **got minus(-) asked for.** The procedures for the GOT MINUS ASKED FOR rule are in Table 6-12.

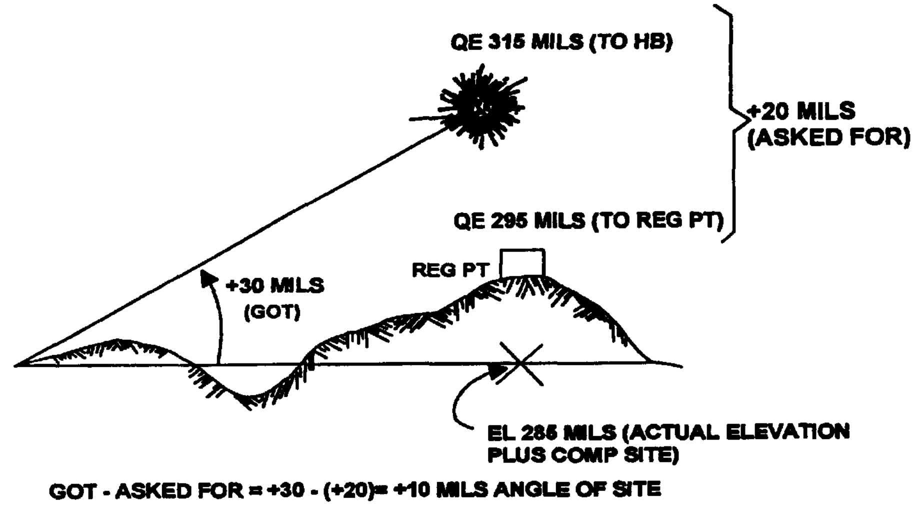


Figure 6-27. GOT MINUS ASKED FOR Diagram.

Table 6-12. Procedure for GOT MINUS ASKED FOR Rule.

STEP	ACTION
1	The FDC determines the HOB correction with either of the two methods discussed in paragraph 6-24b. The HOB correction (angle of site) is the **asked for** angle of site.
2	The **asked for** angle of site is added to the adjusted QE to determine the XO's HB QE.
	ADJ QE **+ ASKED FOR** **XO's HB QE**
3	The **asked for** angle of site is the HOB correction (VA) announced to the XO or platoon leader.
4	Once the three rounds have been fired, the computer determines the XO's HB average angle of site. The average XO's HB angle of site is referred to as "**got**."
5	The computer determines the angle of site to the known point.
	GOT **-ASKED FOR** **∢SI TO KN PT**
6	Once the angle of site to the known point has been determined, polar plot data are computed in the same manner discussed in Table 6-11, steps 9 through 13.

6-25. Setting Up the Observed Firing Chart

At the completion of any of the four techniques demonstrated, the HCO will construct an observed firing chart by using the steps in Table 6-13.

Table 6-13. Construction of an Observed Firing Chart.

STEP	ACTION
1	The HCO selects a grid intersection and tick-marks this location as Known Point 1. An altitude is arbitrarily assigned.
	NOTE: This point should allow space for the plotting of the firing unit.
2	Polar-plot the firing unit center from the known point. Place the vertex of the RDP against the pin in the known point. Using a temporary azimuth index, orient the RDP for direction by using the direction from the known point to the firing unit. Place a pin opposite the polar plot range on the range scale. The pin is the firing unit location.
3	Construct a tick mark at the pin location.
4	Label the tick mark with the firing unit location and altitude.
	FIRING UNIT ALTITUDE = KNOWN PT ALT - VI .
	After the unit has been polar plotted on the chart, the deflection index is constructed by using the adjusted deflection.
5	Construct a deflection index. Place the vertex of the RDP in the firing unit location. Place the arm of the RDP against the known point location. Place a pin opposite the last three digits of the adjusted deflection on the arc of the RDP.
6	Construct a deflection index at the pin location.
7	Label the deflection index with the first digit of the adjusted deflection.

6-26. Example of Percussion Plot, VI Unknown.

A registration was conducted with shell HE, charge 4GB. The site and firing unit altitude are unknown.

a. The following data are known:

Adjusted quadrant elevation:	**272**
Azimuth of the line of fire reported by the XO or platoon leader:	**5959**
Adjusted deflection:	**3346**
Assumed altitude of the known point:	**400**

b. Determine the direction, altitude, and range from the known point to the firing unit.

(1) Determine the polar plot direction. The azimuth of the line of fire ±3200 equals polar plot direction.

5959-3200 = 2759 (BACK AZ OF FIRE)

(2) Determine the firing unit altitude. The firing unit altitude equals the known point altitude.

FIRING UNIT ALTITUDE = 400 METERS

(3) Determine the polar plot range. The polar plot range equals the range that corresponds to the adjusted QE.

POLAR PLOT RG = 4560 TO ADJ QE (272)

6-27. Example of Percussion Plot, VI Estimated

The observer passes the firing unit position on his way to his location and estimates the VI to be +60 meters. Use the known data from paragraph 6-26.

a. Determine the first apparent site. **RG ~ ADJ QE = 4560 METERS.** Using the GST, set +60 underneath the MHL on the D scale. Move the site-range scale for charge 4GB TAG until range 4560 is underneath the MHL. Read site underneath the M gauge point on the D scale.

FIRST APPARENT SITE = +14 MILS

b. Determine the first apparent elevation.

ADJUSTED QE	**272**
- FIRST APPARENT SITE	**+14**
FIRST APPARENT ELEVATION	**258**

RG ~ FIRST APPARENT EL = 4,370 METERS

c. Determine the second apparent site. **RG ~ FIRST APPARENT EL = 4,370 METERS.** Using the GST, set +60 underneath the MHL on the D scale. Move the site-range scale for charge 4GB TAG until range 4370 is underneath the MHL. Read site underneath the M gauge point on the D scale.

SECOND APPARENT SITE = +15

Because the first and second apparent sites are within 1 mil, the last site determined, **+15 mils,** is the **true site.**

d. Determine the true adjusted elevation.

ADJUSTED QE	**272**
- TRUE SITE	**+15**
TRUE ADJUSTED ELEVATION	**257**

RG ~ TRUE ADJ EL = 4360, which is the polar plot range.

e. Using the GST, determine the VI.

POLAR PLOT RANGE	**4360**
x TRUE SITE	**+15**
VI	**+60**

f. Determine the firing unit altitude.

KN PT ALT	**400**
- VI	**+60**
FIRING UNIT ALT	**340**

The introduction of an estimated VI of +60 meters changes the polar plot range from the firing unit to the known point by 200 meters (4560 to 4360). The polar plot direction is determined as shown in paragraph 6-20.

6-28. Example of Time Plot, VI Unknown

NOTE: Use the known data from paragraph 6-26.

a. At the completion of the registration, the adjusted data areas follows:

Adjusted time (M582):	**15.6**
Adjusted deflection:	**3346**
Adjusted quadrant:	**272**

NOTE: The adjusted data come from the example shown in Figure 6-24.

b. Determine the angle of site.

NOTE: EL+ CAS ~ TO ADJ FS = 257.

ADJUSTED QE	**272**
- EL + CAS	**257**
ANGLE OF SITE	**+15**

c. Using the GST, determine the VI.

NOTE: RG ~ ADJ FS = 4360, which is the polar plot range.

ANGLE OF SITE	**+15**
x POLAR PLOT RANGE	**4360 (C scale)**
VI	**+64**

d. Determine the firing unit altitude.

KN PT ALT	**400**
- VI	**+64**
FIRING UNIT ALT	**336**

e. Determine the polar plot direction as discussed in paragraph 6-20.

6-29. Example of Time Plot, VI Known, XO's High Burst

NOTE: Use the known data from paragraph 6-26.

a. The site to crest from the XO's report is +32 mils for the registering piece. This example will demonstrate how to determine the HOB correction by using the 10-mil assurance factor.

b. Determine the asked for HOB correction.

SITE TO CREST	**+32**
+ ASSURANCE FACTOR	**+10**
ASKED FOR HOB CORRECTION	**+42**

c. Determine the XO's high-burst QE.

ADJUSTED QE	**272**
+ ASKED FOR	**+42**
XO's HB QE	**314**

d. The computer announces orienting data to the XO or platoon leader.

DIRECTION 5959, VERTICAL ANGLE +42.

e. Three rounds are fired, and the following angles of site are reported by the XO or platoon leader.

Round 1:	**∢ SI +54**
Round 2:	**∢ SI +54**
Round 3:	**∢ SI +57**
Avg ∢ SI:	**Determined by XO or platoon leader.**

NOTE: AVG∢ SI = +55, which equals GOT.

f. Determine the angle of site to the known point.

GOT	**+55**
- ASKED FOR	**+42**
∢ SI TO KN PT	**+13**

g. Using the GST, determine the VI.

NOTE: RG ~ ADJ FS = 4360, which is the polar plot range.

POLAR PLOT RANGE	**4360**
x ANGLE OF SITE	**+13**
VI	**+56**

h. Determine the firing unit altitude.

KN PT ALT	**400**
- VI	**+56**
FIRING UNIT ALT	**344**

i. Determine the polar plot direction as discussed in paragraph 6-20.

6-30. Locate an Observer

If the observer is equipped with a laser, his location maybe established by resection. The procedures are listed below.

a. The observer lases the known point and determines a direction, distance, and a vertical angle. These are reported to the FDC.

b. The HCO determines the observer location as follows:

- Polar plots the back azimuth to the known point.
- Inserts a plotting pin along the back azimuth at the announced distance.
- Constructs a tick mark and labels it with the observer's call sign.

c. Using the GST, the VCO determines the observer's VI as follows:

- Places the M gauge point opposite the VA on the D scale.
- Moves the MHL over the distance on the C scale.
- Reads the VI under the MHL from the D scale.

d. To determine the observer's altitude, subtract the VI from the known point altitude.

6-31. Battalion Observed Firing Charts

a. Battalion observed firing charts are based on the concept that if any two points can be located by reference to a third point, the two points can be located in reference to each other. All batteries register on the same known point. For example, using the techniques for battery or platoon observed firing charts discussed in Section II of this chapter, firing units can be located in relation to the known point. After all the firing unit locations are plotted on a single firing chart in relation to the known point, the firing chart provides an accurate graphical representation of the location of the firing units in relation to each other. (See Figure 6-28.) This accurate portrayal of the relationship among the firing unit locations allows for the accurate massing of fires within the battalion on any target located by adjustment of one of the firing units, or by a shift from a known point (known to all firing units).

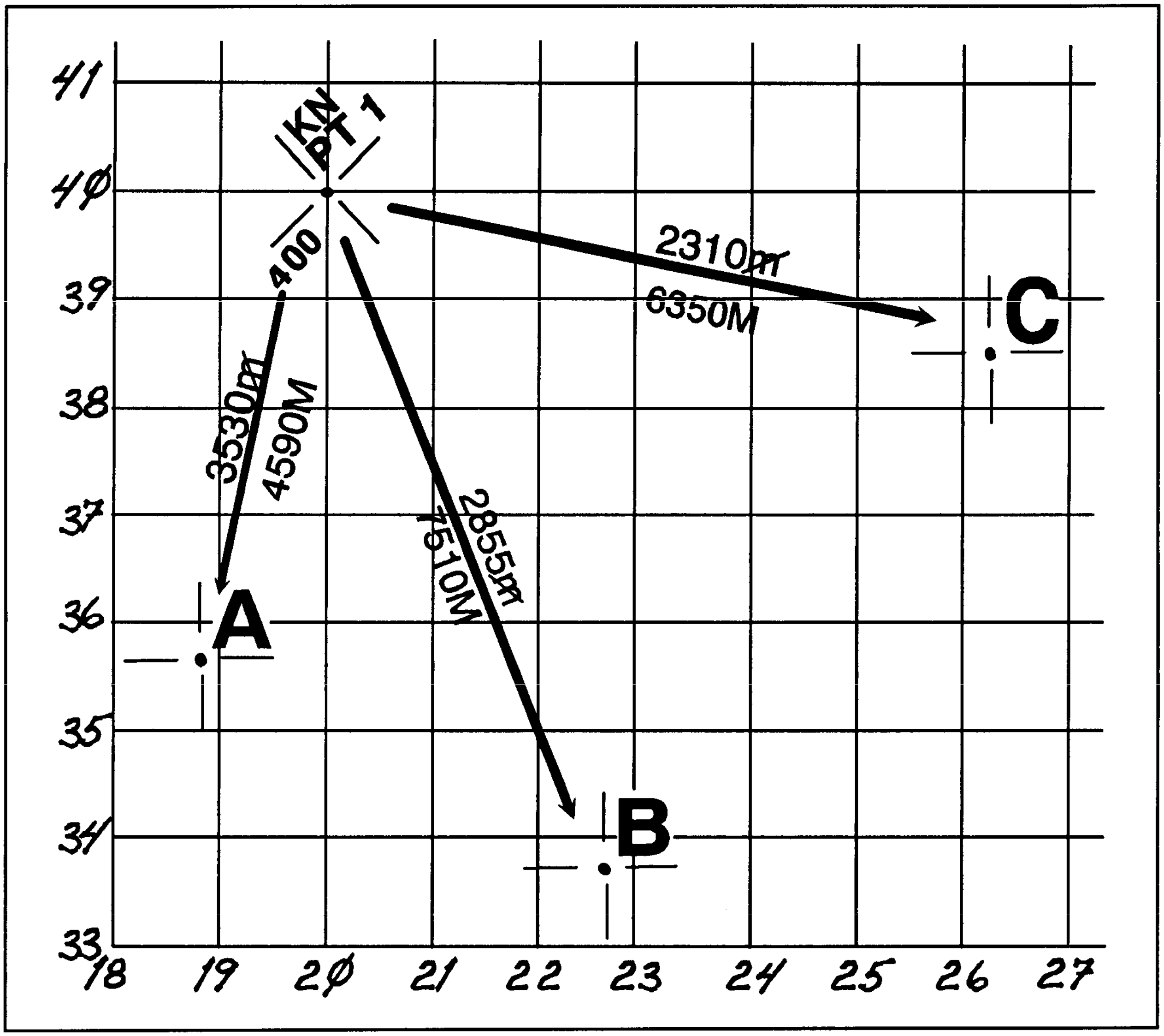


Figure 6-28. Location of Batteries With Respect to the Known Point.

b. The techniques used in the construction of a battalion observed firing chart are very similar to those used for the construction of a single firing unit observed firing chart. The direction used for polar plotting each firing unit is determined by using the same procedures as the battery or platoon observed firing chart.

(1) Percussion Plot, VI Unknown. Range and altitude may be determined for each firing unit by using the procedures in paragraph 6-21. The accurate massing of fires **is not** possible when this method is used.

(2) Percussion Plot, VI Estimated. Range and altitude for each firing unit maybe determined by using the same procedures listed in Table 6-10. If the relative altitude of the firing units can be estimated, the accuracy of the firing chart can be improved. One firing unit is selected as a reference unit and is assigned the same altitude as the known point. The vertical intervals of the other units are estimated and compared with the altitude of the reference firing unit to obtain their altitudes.

(3) Time Plot. Range and altitude for each firing unit may be determined by using the same procedures listed in paragraphs 6-23 and 6-24. This provides a more accurate means of determining relative location. One firing unit is selected as a reference unit. The vertical intervals of the other firing units are estimated and compared with the altitude of the reference firing unit to obtain their altitudes.

6-32. Observed Firing Chart With Incomplete Survey

a. A position area survey maybe used in conjunction with the observed firing chart until the surveyed firing chart is available. The part of the chart established by firing must be plotted to the same scale as the part obtained by survey.

b. The procedure for constructing a battalion observed firing chart that is based on the registration of one unit and that has position area survey is listed in Table 6-14.

Table 6-14. Construction of an Observed Firing Chart, Position Area Survey Only.

STEP	ACTION
1	Establish a common orienting line (OL) for the battalion.
2	Starting at any point, conduct directional traverse to locate all battalion positions horizontally and vertically in relation to each other and to establish common directional control for all orienting lines.
3	Plot all unit positions, altitudes, and orienting lines on tracing paper to the same size as that of the chart to be used. The overlay, including the measured grid azimuth of the orienting lines, constitute the position area survey as given to the fire direction center.
4	Register one unit on the known point. From the adjusted data, start the observed firing chart by plotting the registering unit.
5	Derive the azimuth of fire from the measured azimuth of the line of fire from the registering unit. Use the derived azimuth of fire as the direction of fire of the registering unit on the overlay.
6	Orient the overlay so that the center of the registering unit is over the registering unit's center on the chart. Rotate the overlay until the lines denoting direction of fire on the chart and on the overlay coincide. From the overlay, mark the locations of the nonregistering units on the chart. Label these locations with the proper altitudes in relation to the registering unit.
7	Measure the azimuth on the chart from each nonregistering unit to the known point. The azimuth of the unit's OL minus the measured direction of fire equals the orienting angle for laying the unit.

Section V

Using Map Spot Data to Construct Firing Charts

The surveyed location and azimuth of lay should be established as soon as possible. Surveyed locations can be determined by map spot survey or by normal survey procedures. Map spot is less accurate than actual survey.If survey teams cannot immediately provide the needed data, the firing unit conducts a map spot survey to establish the unit center and azimuth of lay. For a map spot survey, fire direction personnel use hasty survey methods to associate terrain features with the locations of those features on a map and to locate the unit's center in relation to the terrain features.

6-33. Map Spot Survey

a. Map spot survey is the application of basic map and terrain association. It should be as accurate as possible. Three-point resection is the preferred technique for establishing the unit center by map spot survey. The map spotted location of the unit center will include an eight-digit grid coordinate and an altitude in meters.

b. Directional control (an orienting station and the direction to the end of the orienting line [EOL]) also must be provided. Common directional control should be established as soon as possible, preferably by simultaneous observation or directional traverse during daylight or by Polaris-Kochab method at night. If none of these procedures can be done quickly, the firing unit must be laid magnetically.

NOTE: FM 6-50 includes a detailed discussion of hasty survey techniques.

6-34. Constructing a Firing Chart From Map Spot Survey

a. To construct a firing chart based on map spot survey, the FDC must have three items of information:

- Assumed grid coordinates of the firing unit center.
- Assumed altitude of the firing unit.
- Assumed azimuth of lay.

b. When met + VE techniques cannot be used, the firing unit will register as the situation permits.

c. A firing chart based on map spot survey is only as accurate as the following:

- The map spotted location of the unit center and the known point.
- The azimuth of lay.
- The construction of the chart.

d. When a firing chart based on map spot survey is used, the orienting angle must be recorded when the firing unit is laid. This orienting angle is used to determine the actual azimuth of lay when directional control is provided.

e. The FDC replots all fired targets.

6-35. Transferring to a Surveyed Firing Chart

a. When the position and target area surveys are completed, the FDC is provided the following information:

- Firing unit center grid coordinates and altitude to the nearest 0.1 meter and azimuth to the EOL to the nearest 0.1 mil.
- Known point coordinates and altitude to the nearest 0.1 meter.

b. The surveyed firing chart is constructed to show the accurate locations of the firing unit center, the known point, and the actual azimuth of lay.

c. The firing unit was initially laid, and the orienting angle was recorded. When the surveyed azimuth to the EOL is determined, the actual azimuth of lay is computed by using the following formula:

SURVEYED AZ TO EOL - ORIENTING ANGLE = AZ OF THE LINE OF FIRE.

d. The initial (map spot) azimuth of lay may be inaccurate. The actual azimuth of the line of fire may differ from the surveyed azimuth of lay. When survey data are provided, the FDC must--

- Construct a surveyed firing chart.
- Compute GFT settings.

Chapter 7

Firing Tables

This chapter implements a portion of QSTAG 224.

Field artillery firing data are determined by use of various firing tables and equipment. These tables contain the fire control information (FCI) under standard conditions and data correcting for nonstanadard conditions. These tables and equipment include the tabular firing tables, graphical firing tables, and graphical site tables. The tabular firing tables are the basic source of firing data. They present fire control information in a tabular format. The data listed are based on standard conditions. The GFTs and GSTs are graphical representations of the tabular firing tables.

Section I

Tabular Firing Tables

This section implements STANAGs 4119 and 4425 and QSTAG 220.

Tabular firing tables are based on test firings and computer simulations of a weapon and its ammunition correlated to a set of conditions that are defined and accepted as standard (See Figure 7-1.) These standard condition are points of departure. Corrections are used to compensate for variables in the weather-weapon-ammunition combination that are known to exist at a given instant and location. The atmospheric standard accepted in US firing tables reflect the mean annual condition in the North Temperate Zone. TFTs are developed for weapons ranging from crew-served to heavy artillery. The format of artillery firing tables are based on standardized agreements, and with small exceptions, are very similar.

STANDARD CONDITIONS	
1	WEATHER
2	AIR TEMPERATURE 100 PERCENT (59°F)
3	AIR DENSITY 100 PERCENT (1,225 gm/m^3)
4	NO WIND
POSITION	
1	GUN, TARGET, AND MDP AT SAME ALTITUDE
2	ACCURATE RANGE
3	NO ROTATION OF THE EARTH
MATERIAL	
1	STANDARD WEAPON, PROJECTILE, AND FUZE
2	PROPELLANT TEMPERATURE (70°F)
3	LEVEL TRUNNIONS AND PRECISION SETTINGS
4	FIRING TABLE MUZZLE VELOCITY
5	NO DRIFT
LEGEND:	gm/m^3 – grams per cubic meter

Figure 7-1. Standard Conditions.

7-1. Elements and Purpose

a. The principal elements measured in experimental firings include the following:

- Angle of elevation.
- Angle of departure.
- Muzzle velocity.
- Achieved range.
- Drift.
- Concurrent atmospheric conditions.

b. The main purpose of the TFT is to provide the data to bring effective fire on a target under any set of conditions. Data for firing tables are obtained from firings of a weapon conducted at various quadrant elevations. Computed trajectories are based on the equations of motion and are compared with the data obtained in the firings. The computed trajectories are adjusted to the measured results and data are tabulated. Data for elevations not fired are determined by interpolation. Firing table data define the performance of a projectile of known properties under standard conditions.

7-2. Cover Information

The cover of the TFT provides information concerning the weapon system(s) and projectiles to which data in the TFT apply. Projectiles listed on the cover are in the same projectile family because of ballistic similarity.

NOTE: The 155-AM-2 TFT is used as the example throughout this section. Figure 7-2 identifies acronyms and abbreviations for the TFT shown in this section.

Acronyms and Abbreviations

BE = base ejection (fuze) or Belgium
CA = Canada
CP = concrete-piercing (fuze)
DA = Denmark
ET = electronic time (fuze)
FR = France
GE = Germany
H = blister agent (mustard)
HC = hexachloroethane (smoke)
HD = blister agent (distilled mustard)
IT = Italy
lb = pound
mph = miles per hour
NL = Netherlands
NO = Norway
PD = point-detonating (fuze)
prox = proximity
std = standard
TU = Turkey
UK = United Kingdom
VX = nerve agent (persistent)

Figure 7-2. Acronyms and Abbreviations.

a. Introduction. The introduction contains general information about the weapon, ammunition, and the TFT. This information specifically includes the items below.

(1) Table of contents.

(2) Table of symbols and abbreviations (used in the TFT).

(3) General information.

(4) Interchangeability of ammunition. This table shows the ammunition combination held in stock by other NATO nations for a particular weapon caliber that can be used by the US during combined operations, to include training exercises. Because of safety, the ammunition listed in the **shaded portions** may **only** be used in combat operations. (See Figure 7-3.)

(5) Weapon characteristics. (See Figure 7-4.)

(6) Projectile-fuze combinations and mean weights. (See Figure 7-5.)

(7) Equivalent full service rounds. These tables provide information on tube wear and erosion. These data are used to determine the number of equivalent full service rounds fired and the expected muzzle velocity loss due to wear. The values listed in these tables are based on firings of the highest charge used by that weapon system. (See Figure 7-6.)

(8) Approximate losses in muzzle velocity. The tables maybe used as a guide in estimating muzzle velocity variations from the firing table standard that are due to uniform wear in the M185 and the M199 cannon tubes. (See Figure 7-7.)

NOTE: The M199 cannon tube needs to be corrected for certain increases in muzzle velocity, see FT 155-AM-2, page V.

(9) Explanation of tables.

(10) Example of met message and sample problems.

(11) Explanation of the probability table.

(12) Table of natural trigonometric functions.

(13) Charge selection table. This table provides guidance to the FDO on the selection of the charge to fire based on range and probable error. Enter the table with the range to target expressed to the nearest listed value, and choose the charge to fire. The gray shaded area shows those charges with the lowest probable error in range and thereby the charge that should be selected given no other considerations. (See Figure 7-8.)

(14) Table of conversion factors. (See Figure 7-9.)

NATO INTEROPERABILITY OF PROJECTILE / CHARGE SYSTEMS IN THE
155 MM HOWITZERS, M109A1, M109A2, M109A3, M109A1B

NATO INTEROPERABILITY OF PROJECTILE / CHARGE SYSTEMS IN THE
155 MM HOWITZERS, M109A1, M109A2, M109A3, M109A1B

	US	BE	CA	DA	FR	GE	IT	NL	NO	TU	UK	US	
HE	M107 / M3A1	M107 (1,2,3) / M3	M107 / M3A1	M107 / M3A1	M107 (1,2,3) / M3	DM21 (1,4) / DM62	M107 / M3A1	M107C1 M107B2 M107 (1,2) / M3C1	NM28 / M3	M107 / M3A1	M107 / M3A1	M107 / M3A1	HE
	M107 / M4A2	M107 (1,2,3) / M4A1	M107 / M4A2	M107 / M4A2	M107 (1,2,3) / M4A1	DM21 (1,4) / DM42B1	M107 / M4A2	M107C1 M107B2 M107 (1,2) / M4C3	NM28 / NM23	M107 / M4A2	M107 / M4A2	M107 / M4A2	
	M107 / M119 M119A1					DM21 / DM62					M107 / L6A1	M107 / M119 M119A1	
WP	M110 / M3A1	M110 / M3	M110 / M3A1	M110 / M3A1	M110 / M3	M110 / DM62	M110 / M3A1	M110 / M3C1	M110 / M3	M110 / M3A1	M110 / M3A1	M110 / M3A1	WP
	M110 / M4A2	M110 / M4A1	M110 / M4A2	M110 / M4A2	M110 / M4A1	M110 / DM42B1	M110 / M4A2	M110 / M4C3	M110 / NM23	M110 / M4A2	M110 / M4A2	M110 / M4A2	
	M110 / M119 M119A1					M110 / DM52					M110 / L6A1	M110 / M119 M119A1	
SMOKE	M116A1 M116B1 M116 / M3A1	M116 / M3	M116B1/E1 M116 / M3A1	M116E1 M116 / M3A1	M116 / M3	DM25A1 DM52 / DM62	M116 / M3A1	M116C1 / M3C1	M116 / M3	M116 / M3A1	X	M116A1 M116B1 M116 / M3A1	SMOKE
	M116A1 M116B1 M116 / M4A2	M116 / M4A1	M116B1/E1 M116 / M4A2	M116E1 M116 / M4A2	M116 / M4A1	DM25A1 DM52 / DM42B1	M116 / M4A2	M116C1 / M3C3	M116 / NM23	M116 / M4A2	X	M116A1 M116B1 M116 / M4A2	
	M116A1 / M119 M119A1					DM25A1 DM25 / DM62					X	M116A1 / M119 M119A1	
ILLUM	M485A2 M485A1 / M3A1	M485A2 / M3	M485A2 M485A1 / M3A1	M485A2 / M3A1	X	X	X	X	X	X	M485A2 / M3A1	M485A2 M485A1 / M3A1	ILLUM
	M485A2 M485A1 / M4A2	M485A2 / M4A1	M485A2 M485A1 / M4A2	M485A2 / M4A2	X	X	X	X	X	X	M485A2 / M4A2	M485A2 M485A1 / M4A2	
	M485A2 M485A1 / M119 M119A1				X	X	X	X	X	X	M485A2 / L6A1	M485A2 M485A1 / M119 M119A1	

Figure 7-3. Interchangeability of Ammunition Table.

HOWITZER		M109A1 SERIES	M198
CANNON		M185	M199
TOTAL TRAVERSE	MILS	6400	L 400 R 400
MAXIMUM ELEVATION	MILS	1300	1275
MINIMUM ELEVATION	MILS	-36	-75
CHANGE IN ELEVATION FOR ONE TURN ON ELEVATION HANDWHEEL	MILS	5	10
CHANGE IN TRAVERSE FOR ONE TURN OF TRAVERSING HANDWHEEL	MILS	10	10

Figure 7-4. Weapon Characteristics.

FT 155-AM-2

5. PROJECTILE-FUZE COMBINATIONS AND MEAN WEIGHTS

PROJECTILE	FUZE						WEIGHT FUZED PROJECTILE	
	PD	MT	MTSQ	PROX	ET	CP	SQ	LB
HE, M107 NORMAL CAVITY	M557 M572 M739		M564 M520 M520A1 M500A1 M582	M732	M587	M78(2) M78A1(2)	2 3 4(1) 5	92.8 93.9 95.0 96.1
HE, M107 DEEP CAVITY	M557 M572 M739		M564 M520 M520A1 M500A1 M582	M514 M514A1 M514B1 M514A3 M728 M732	M587	M78(2) M78A1(2)	2 3 4(1) 5	92.8 93.9 95.0 96.1
GAS, PERSISTENT, M110 (H AND HD)	M557 M572 M739 M508 M508A1		M564 M520 M520A1 M500A1 M582		M587		2 3 4(1)	92.8 93.9 95.0
GAS, NONPERSISTENT, GB, M121A1	M557 M572 M739 M508 M508A1						6 7 8 9 10	97.2 98.3 99.4 100.5 101.6
GAS, PERSISTENT, VX, M121A1				M514 M514A1 M514B1 M514A3 M728 M732			6 7 8 9 10	97.2 98.3 99.4 100.5 101.6
SMOKE, WP, M110	M557 M572 M739 M508 M508A1		M564 M520 M520A1 M500A1 M582		M587		5 6 7 8	96.1 97.2 98.3 99.4
SMOKE, BE, M116 AND M116B1 (HC)			M501(3) M501A1 (3)				2 3 4(1) 5	92.8 93.9 95.0 96.1
SMOKE, BE, M116 AND M116B1 (COLORED)			M501(3) M501A1 (3)				(4)	
SMOKE, BE, M116A1 (HC)		M565	M548 M577		M724		2 3 4(1) 5	92.8 93.9 95.0 96.1
ILLUMINATING, M485A2, M485A1		M565	M548 M577		M724		NOT WEIGHT ZONED	

(1) STANDARD

(2) WHEN PROJECTILE, HE, M107 IS ARMED WITH FUZES M78 AND M78A1, APPLY AN ADDITIONAL CORRECTION FOA AN INCREASE IN AIR DENSITY OF ONE PERCENT.

(3) COMBINATION LIMITED TO M3 SERIES AND THROUGH ZONE 6 OF THE M4A1 SERIES ONLY.

(4) PROJECTILES, SMOKE, COLORED, BE, M116 AND M116A1 ARE FIRED WITH A MEAN WEIGHT OF 86.4 POUNDS. THIS WEIGHT IS EQUIVALENT TO A DECREASE OF 8 SQUARES BELOW THE STANDARD WEIGHT OF 95.0 POUNDS FOR WHICH THE TABLES ARE PREPARED.

Figure 7-5. Projectile-Fuze Combinations and Mean Weights.

CHARGE	FATIGUE LIFE		EROSION LIFE	
	NO. OF RDS EQUIVALENT IN FATIGUE TO ONE FULL CHG	EQUIVALENT FATIGUE EFFECT IN DECIMALS	NO. OF RDS EQUIVALENT IN FATIGUE TO ONE FULL CHG	EQUIVALENT FATIGUE EFFECT IN DECIMALS
CANNON, 155MM HOWITZER, M185*				
8	1.0	1.00	1.0	1.00
7R	1.0	1.00	1.0	1.00
7W	1.3	.75	3.3	.30
6W	4.0	.25	8.3	.12
5W	4.0	.25	25.0	.04
4W	4.0	.25	***	***
3W	4.0	.25	***	***
5G	4.0	.25	25.0	.04
4G	4.0	.25	***	***
3G	4.0	.25	***	***
2G	4.0	.25	***	***
1G	4.0	.25	***	***
CANNON, 155MM HOWITZER, M199**				
8	1.4	.70	3.0	.33
7R	1.4	.70	3.0	.33
7W	4.0	.25	10.0	.10
6W	4.0	.25	20.0	.05
5W	10.0	.10	***	***
4W	10.0	.10	***	***
3W	10.0	.10	***	***
5G	4.0	.25	***	***
4G	10.0	.10	***	***
3G	10.0	.10	***	***
2G	10.0	.10	***	***
1G		NOT APPLICABLE		

Figure 7-6. Fatigue and Erosion Tables.

APPROXIMATE LOSSES IN MUZZLE VELOCITY*

NUMBER OF EQUIVALENT FULL CHARGE SERVICE ROUNDS	WEAR MEASUREMENT (INCHES)**	LOS IN MUZZLE VELOCITY (METERS PER SECOND)
CANNON, 155MM HOWITZER, M185		
0	6.100	0.0
200	6.109	0.2
400	6.118	0.5
600	6.122	0.7
800	6.128	1.3
1000	6.134	2.0
1200	6.140	3.0
1400	6.146	4.1
1600	6.152	4.7
1800	6.157	5.9
2000	6.163	7.0
2200	6.168	8.2
2400	6.172	9.5
2600	6.177	10.3
2800	6.181	11.7
3000	6.186	13.0
3200	6.190	14.2
3400	6.193	15.4
3600	6.196	16.4
3800	6.200	17.5
4000	6.203	18.7
4200	6.206	20.0
4400	6.208	20.8
4600	6.210	21.8
4800	6.212	22.3
5000	6.214	22.9

Figure 7-7. Loss in Muzzle Velocity Table.

RANGE METERS	CHARGE 1G	2G	3G	4G	5G	3W	4W	5W	6W	7W	8
1000	10	7	6	5	6	9	7	8	9	12	17
2000	20	14	11	8	8	16	10	11	10	11	17
3000	29	21	17	11	9	23	13	14	12	12	17
4000		29	23	14	11	31	16	16	14	13	18
5000			29	18	13	39	20	19	17	14	20
6000			36	23	15	47	24	21	19	17	22
7000				28	18	56	28	23	21	19	24
8000				34	21		34	26	23	21	27
9000					24			29	25	24	30
10000								33	27	26	33
11000									29	27	35
12000									32	29	38
13000										32	40
14000										34	42
15000											44
16000											46
17000											49
18000											52

Figure 7-8. Charge Selection Tables.

CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN	MULTIPLY	BY	TO OBTAIN
YARDS	0.9144	METERS	METERS	1.0936	YARDS
MPH	0.8690	KNOTS	KNOTS	1.1508	MPH
DEGREES	17.7778	MILS	MILS	0.05625	DEGREES
MINUTES	0.2963	MILS	MILS	3.375	MINUTES

PERCENT OF STD TEMP = 100 + 0.1928 (AIR TEMPERATURE - 59)
AIR TEMPERATURE IN DEGREES FAHRENHEIT

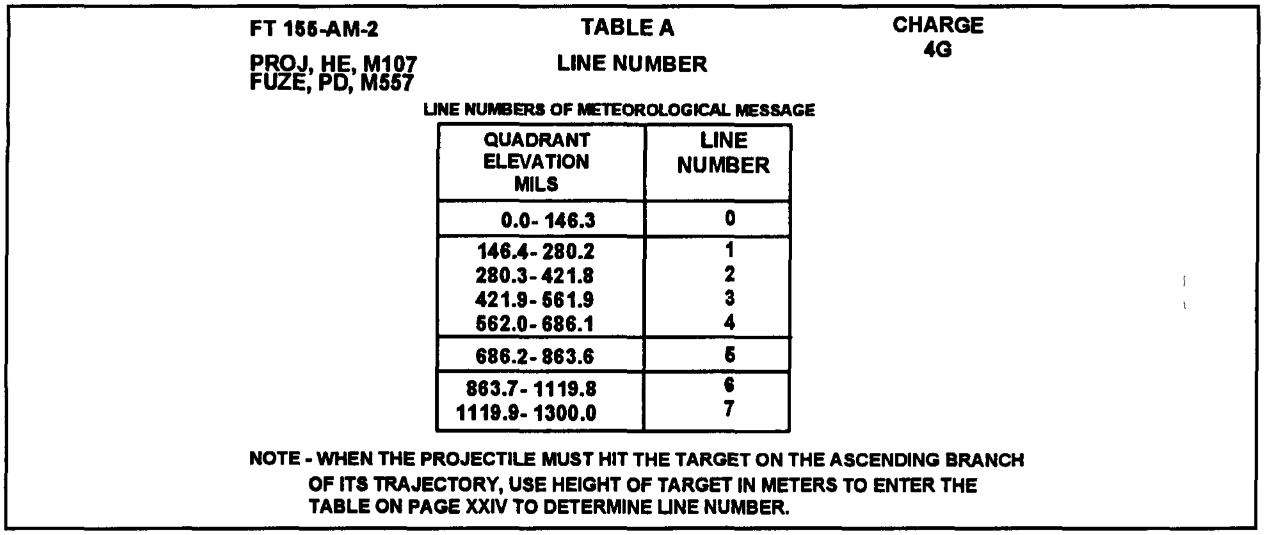
Figure 7-9. Conversion Factors.

b. Part 1. Part 1 of the TFT contains firing data and corrections for the base projectile. It is divided into Tables A through J. Additional Tables K through M may be provided in some TFTs, but the format and content vary.

7-3. Table A

a. Table A is used for the solution of a concurrent met. It is used to select the line number of the met message. The entry argument for this table is quadrant elevation. The QE best describes the maximum ordinate of the trajectory and, thus, the portion of the atmosphere through which the projectile will pass. The height of the trajectory is determined by computer simulation using equations of motion. Table A also assumes that the target is at the level point of the trajectory. If there is a large vertical interval (either positive or negative), the met message line number selected will not exactly describe the atmosphere through which the projectile passes. This will cause only a small error in manual computations.

b. Enter Table A by using the left column with the adjusted quadrant elevation to a target. Extract the line number of the met message from the right column. (See Figure 7-10.)



FT 155-AM-2 TABLE A CHARGE 4G

PROJ, HE, M107
FUZE, PD, M557

LINE NUMBER

LINE NUMBERS OF METEOROLOGICAL MESSAGE

QUADRANT ELEVATION MILS	LINE NUMBER
0.0- 146.3	0
146.4- 280.2	1
280.3- 421.8	2
421.9- 561.9	3
562.0- 686.1	4
686.2- 863.6	5
863.7- 1119.8	6
1119.9- 1300.0	7

NOTE - WHEN THE PROJECTILE MUST HIT THE TARGET ON THE ASCENDING BRANCH OF ITS TRAJECTORY, USE HEIGHT OF TARGET IN METERS TO ENTER THE TABLE ON PAGE XXIV TO DETERMINE LINE NUMBER.

Figure 7-10. Table A.

7-4. Table B.

a. Table B is used in the solution of concurrent and subsequent met. This table is used to determine the value of complementary range (change in range) to correct for the effects of complementary angle of site. Complementary ranges were determined by computer simulations of the trajectory at each listed range and vertical interval. Table B has two entry arguments; they are chart range to a target expressed to the nearest 100 meters and the height of target above gun (vertical interval) expressed to the nearest 100 meters. Table B is entered from the range column along the left side, with the chart range to a target; and along the top of the table with the height of target above gun (vertical interval). Extract the value of complementary range where the two columns intersect. The complementary range is the number of meters of range correction that corresponds to the complementary angle of site. This range correction is measured at the base of the trajectory. The sum of the complementary range and the chart range, expressed to the nearest 10 meters, equals the entry range. This is the most accurate range for entry into Table F to extract firing data and range corrections.

b. Table B is also used to determine the line number from a ballistic met message for use in subsequent met applications. The table is divided by heavy black lines. These lines form the boundaries of the met zone. The line number may be determined by following the lines between which the complementary range is extracted to the outer edge of the table. The bold number in the margin is the met line number. The met message line numbers were determined by the same method used in Table A. (See Figure 7-11.)

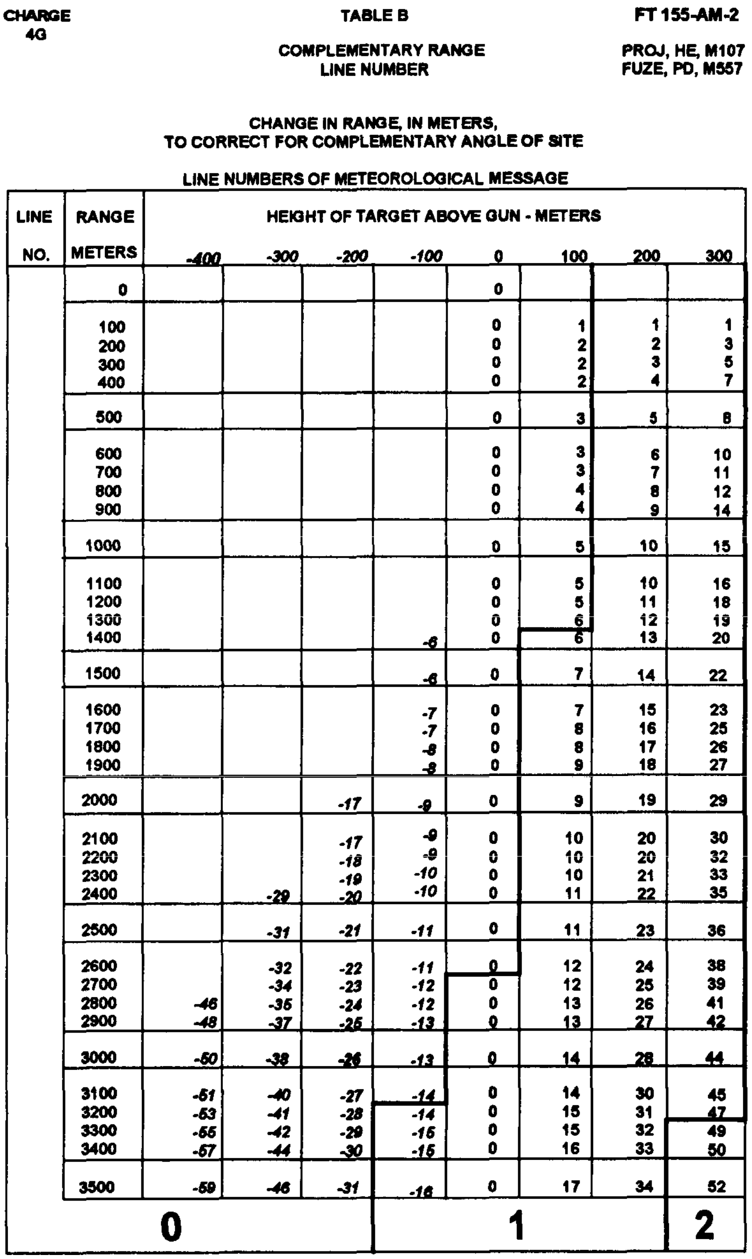
NOTE: Table A is more accurate in the determination of the met message line number to be used in the solution of concurrent met.

7-5. Table C

Table C is used in the solution of concurrent and subsequent met. It is entered with the chart direction of wind. The chart direction of wind is the angle formed by the intersection of the direction of the wind from the met message and the direction of fire (that is, the horizontal clockwise angle from the direction of fire to the direction of the wind). This table divides a 1-knot wind into crosswind and range wind components. Components for crosswind and range wind are then extracted. The extracted values are described as the components of a 1-knot wind.

The range wind component is the percentage of the wind speed that acted as a range factor. The crosswind component is the percentage of the wind force that acts to blow the projectile laterally and is translated into a lateral correction factor. (See Figure 7-12.)

NOTE: Table C is based on chart direction of wind only and, thus, is the same for all charges and all weapons.



CHARGE
4G

TABLE B

COMPLEMENTARY RANGE
LINE NUMBER

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

CHANGE IN RANGE, IN METERS,
TO CORRECT FOR COMPLEMENTARY ANGLE OF SITE

LINE NUMBERS OF METEOROLOGICAL MESSAGE

LINE NO.	RANGE METERS	HEIGHT OF TARGET ABOVE GUN - METERS -400	-300	-200	-100	0	100	200	300
	0					0			
	100					0	1	1	1
	200					0	2	2	3
	300					0	2	3	5
	400					0	2	4	7
	500					0	3	5	8
	600					0	3	6	10
	700					0	3	7	11
	800					0	4	8	12
	900					0	4	9	14
	1000					0	5	10	15
	1100					0	5	10	16
	1200					0	5	11	18
	1300					0	6	12	19
	1400				-6	0	6	13	20
	1500				-6	0	7	14	22
	1600				-7	0	7	15	23
	1700				-7	0	8	16	25
	1800				-8	0	8	17	26
	1900				-8	0	9	18	27
	2000			-17	-9	0	9	19	29
	2100			-17	-9	0	10	20	30
	2200			-18	-9	0	10	20	32
	2300			-19	-10	0	10	21	33
	2400		-29	-20	-10	0	11	22	35
	2500		-31	-21	-11	0	11	23	36
	2600		-32	-22	-11	0	12	24	38
	2700		-34	-23	-12	0	12	25	39
	2800	-46	-35	-24	-12	0	13	26	41
	2900	-48	-37	-25	-13	0	13	27	42
	3000	-50	-38	-26	-13	0	14	28	44
	3100	-51	-40	-27	-14	0	14	30	45
	3200	-53	-41	-28	-14	0	15	31	47
	3300	-55	-42	-29	-15	0	15	32	49
	3400	-57	-44	-30	-15	0	16	33	50
	3500	-59	-46	-31	-16	0	17	34	52
		0			1				2

Figure 7-11. Table B.

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TABLE B

CHARGE
4G

PROJ, HE, M107
FUZE, PD, M557

COMPLEMENTARY RANGE
LINE NUMBER
CHANGE IN RANGE, IN METERS,
TO CORRECT FOR COMPLEMENTARY ANGLE OF SITE

LINE NUMBERS OF METEOROLOGICAL MESSAGE

HEIGHT OF TARGET ABOVE GUN - METERS 400	500	600	700	800	900	1000	RANGE METERS	LINE NO.
							0	3
2	7	8	10	12	13	23	100	
6	10	12	15	17	20	29	200	
7	13	16	19	22	26		300	
10							400	
12	15	19	23	27	31	36	500	
14	18	22	27	32	37	42	600	
15	20	25	31	36	42	48	700	
17	23	28	34	40	47	53	800	
19	25	31	38	44	52	59	900	
21	27	34	41	49	56	64	1000	
23	30	37	44	52	61	70	1100	
25	32	40	48	56	65	75	1200	
26	34	42	51	60	70	80	1300	
28	36	45	55	64	74	85	1400	
30	39	48	58	68	79	90	1500	
32	41	51	61	72	84	95	1600	
34	44	54	65	76	88	101	1700	
36	46	57	68	80	93	106	1800	
38	48	60	72	84	97	111	1900	
40	51	63	75	88	102	116	2000	
41	53	66	79	92	107	122	2100	
43	56	69	82	96	111	127	2200	
45	58	72	86	101	116	132	2300	
47	61	75	90	105	121	138	2400	
49	63	78	93	109	126	143	2500	
51	66	81	97	114	131	149	2600	
53	69	84	101	118	136	155	2700	
56	71	87	105	122	141	160	2800	
58	74	91	108	127	146	166	2900	
60	77	94	112	131	151	172	3000	
62	79	97	116	136	157	178	3100	
64	82	101	120	141	162	184	3200	
66	85	104	125	146	168	191	3300	
69	88	108	129	151	173	197	3400	
71	91	112	133	156	179	203	3500	
2				3				

Figure 7-11. Table B (Continued).

7-6. Table D

a. Table D is used in the solution of concurrent and subsequent met. The values extracted from the table are standard departure of air temperature and density as a function of height. They have been converted to a percentage of standard. This table provides a correction based on a standard departure to correct the temperature and density in the met message (which is measured at the altitude beginning at the meteorological datum plane [MDP]) to values as if they would be measured initially from the unit altitude.

b. Table D is entered with the height of the unit above or below the MDP or met station. The difference in height is entered on the left side in hundreds of meters and along the top of the table in tens of meters. Extract the corrections to density and temperature from the intersection of the two columns. (See Figure 7-13.)

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TABLE C

FT 155-AM-2

WIND COMPONENTS

PROJ, HE, M107
FUZE, PD, M557

COMPONENTS OF A ONE KNOT WIND

CHART DIRECTION OF WIND MIL	CROSS WIND KNOT	RANGE WIND KNOT	CHART DIRECTION OF WIND MIL	CROSS WIND KNOT	RANGE WIND KNOT
0	0	H1.00	3200	0	T1.00
100	R.10	H.99	3300	L.10	T.99
200	R.20	H.98	3400	L.20	T.98
300	R.29	H.96	3500	L.29	T.96
400	R.38	H.92	3600	L.38	T.92
500	R.47	H.88	3700	L.47	T.88
600	R.56	H.83	3800	L.56	T.83
700	R.63	H.77	3900	L.63	T.77
800	R.71	H.71	4000	L.71	T.71
900	R.77	H.63	4100	L.77	T.63
1000	R.83	H.56	4200	L.83	T.56
1100	R.88	H.47	4300	L.88	T.47
1200	R.92	H.38	4400	L.92	T.38
1300	R.96	H.29	4500	L.96	T.29
1400	R.98	H.20	4600	L.98	T.20
1500	R.99	H.10	4700	L.99	T.10
1600	R1.00	0	4800	L1.00	0
1700	R.99	T.10	4900	L.99	H.10
1800	R.98	T.20	5000	L.98	H.20
1900	R.96	T.29	5100	L.96	H.29
2000	R.92	T.38	5200	L.92	H.38
2100	R.88	T.47	5300	L.88	H.47
2200	R.83	T.56	5400	L.83	H.56
2300	R.77	T.63	5500	L.77	H.63
2400	R.71	T.71	5600	L.71	H.71
2500	R.63	T.77	5700	L.63	H.77
2600	R.56	T.83	5800	L.56	H.83
2700	R.47	T.88	5900	L.47	H.88
2800	R.38	T.92	6000	L.38	H.92
2900	R.29	T.96	6100	L.29	H.96
3000	R.20	T.98	6200	L.20	H.98
3100	R.10	T.99	6300	L.10	H.99
3200	0	T1.00	6400	0	H1.00

Figure 7-12. Table C.

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

TABLE D

TEMPERATURE
AND DENSITY CORRECTIONS

CHARGE
4G

CORRECTIONS TO TEMPERATURE (DT) AND DENSITY (DD), IN PERCENT,
TO COMPENSATE FOR THE DIFFERENCE IN ALTITUDE,
IN METERS, BETWEEN THE BATTERY AND THE MDP

DH		0	+10-	+20-	+30-	+40-	+50-	+60-	+70-	+80-	+90-
0	DT	0.0	0.0	0.0	-0.1+	-0.1+	-0.1+	-0.1+	-0.2+	-0.2+	-0.2+
	DD	0.0	-0.1+	-0.2+	-0.3+	-0.4+	-0.5+	-0.6+	-0.7+	-0.8+	-0.8+
+100-	DT	-0.2+	-0.2+	-0.2+	-0.3+	-0.3+	-0.3+	-0.3+	-0.4+	-0.4+	-0.4+
	DD	-1.0+	-1.1+	-1.2+	-1.3+	-1.4+	-1.5+	-1.6+	-1.7+	-1.8+	-1.8+
+200-	DT	-0.5+	-0.5+	-0.5+	-0.6+	-0.6+	-0.6+	-0.6+	-0.7+	-0.7+	-0.7+
	DD	-2.0+	-2.1+	-2.2+	-2.3+	-2.4+	-2.5+	-2.6+	-2.7+	-2.8+	-2.8+
+300-	DT	-0.7+	-0.7+	-0.7+	-0.8+	-0.8+	-0.8+	-0.8+	-0.9+	-0.9+	-0.9+
	DD	-3.0+	-3.1+	-3.2+	-3.3+	-3.4+	-3.5+	-3.6+	-3.7+	-3.8+	-3.8+

NOTES - 1. DH IS BATTERY HEIGHT ABOVE OR BELOW THE MDP.
2. IF ABOVE THE MDP, USE THE SIGN BEFORE THE NUMBER.
3. IF BELOW THE MDP, USE THE SIGN AFTER THE NUMBER.

Figure 7-13. Table D.

7-7. Table E

a. Table E is used in the solution of concurrent and subsequent met. The extracted values list the effect on muzzle velocity (in meters per second) of nonstandard propellant temperatures.

b. Table E is entered with the temperature of the propellant in degrees Fahrenheit by using the left column or Celsius by using the right column. An effect in meters per second is extracted from the center column. This is the change in muzzle velocity because of the temperature of the propellant. Interpolation is needed to determine precise values from this table. (See Figure 7-14.)

7-8. Table F

a. Table F lists information needed to determine firing data to attack a target and for solving concurrent and subsequent met. Table F is comprised of 19 columns. Columns 2 through 7 provide information for the computation of basic firing data and are based on a set of standard conditions. The remaining columns provide corrections to range and deflection for nonstandard conditions. The asterisks extending across the table denote the changeover point from low-angle to high-angle fire. (See Figure 7-15.)

(1) Range (Column 1). This is the distance measured from the muzzle to the target on the surface of a sphere concentric with the earth. When range is used as the entry argument for this table, it is expressed to the nearest 10 meters. Interpolation is necessary.

(2) Elevation (Column 2). This is the angle that the cannon tube is elevated from the horizontal plane (base of trajectory) to cause the round to impact at the level point for a given range. The elevations listed are the elevations required under standard conditions to achieve the ranges listed in column 1.

(3) Fuze setting for a graze burst (M564) (Column 3). This is the number of fuze setting increments necessary to cause the fuze to function at the level point at the given range under standard conditions. The values listed are for fuzes M564 and M565. The values are expressed in fuze setting increments.

(4) Change in fuze setting (ΔFS) per 10-meter decrease in height of burst (Column 4). This is the adjustment to fuze setting required to decrease the height of burst 10 meters along the trajectory. To increase the HOB, change the sign of the value given in the table.

(5) Change in range per 1-mil change in elevation (Column 5). This is the number of meters change in range, along the gun target line, that would result from a 1-mil change in elevation.

TABLE E

PROPELLANT TEMPERATURE

EFFECTS ON MUZZLE VELOCITY DUE TO PROPELLANT TEMPERATURE

TEMPERATURE OF PROPELLANT DEGREES F	EFFECT ON VELOCITY M/S	TEMPERATURE OF PROPELLANT DEGREES C
-40	-6.4	-40.0
-30	-5.6	-34.4
-20	-4.8	-28.9
-10	-4.2	-23.3
0	-3.5	-17.8
10	-2.9	-12.2
20	-2.4	-6.7
30	-1.8	-1.1
40	-1.3	4.4
50	-0.9	10.0
60	-0.4	15.6
70	0.0	21.1
80	0.4	26.7
90	0.8	32.2
100	1.2	37.8
110	1.7	43.3
120	2.1	48.9
130	2.5	54.4

Figure 7-14. Table E.

CHARGE
4G

TABLE F

BASIC DATA

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

1	2	3	4	5	6	7	8	9
RANGE	ELEV	FS FOR GRAZE BURST FUZE M564	DFS PER 10 M DEC HOB	DR PER 1 MIL D ELEV	FORK	TIME OF FLIGHT	AZIMUTH CORRECTIONS	
							DRIFT (CORR TO L)	CW OF 1 KNOT
M	MIL			M	MIL	SEC	MIL	MIL
0	0.0			20	1	0.0	0.0	0.00
100	5.1			20	1	0.3	0.0	0.01
200	10.1			20	1	0.6	0.0	0.01
300	15.2			20	1	1.0	0.1	0.01
400	20.3			20	1	1.3	0.1	0.02
500	25.4			19	1	1.6	0.2	0.02
600	30.6	1.9	1.06	19	1	1.9	0.3	0.03
700	35.8	2.2	0.91	19	1	2.3	0.4	0.03
800	41.1	2.5	0.79	19	1	2.6	0.5	0.04
900	46.4	2.8	0.71	19	1	2.9	0.6	0.04
1000	51.7	3.2	0.63	19	1	3.2	0.7	0.04
1100	57.1	3.5	0.57	19	1	3.6	0.8	0.05
1200	62.5	3.8	0.53	18	1	3.9	0.8	0.05
1300	67.9	4.2	0.48	18	1	4.3	0.9	0.05
1400	73.4	4.6	0.45	18	1	4.6	1.0	0.06
1500	78.9	4.9	0.42	18	1	4.9	1.1	0.06
1600	84.4	5.2	0.39	18	2	5.3	1.2	0.07
1700	90.0	5.5	0.37	18	2	5.6	1.3	0.07
1800	95.6	5.9	0.35	18	2	6.0	1.4	0.07
1900	101.3	6.2	0.33	18	2	6.3	1.6	0.08
2000	107.0	6.6	0.31	17	2	6.7	1.7	0.08
2100	112.8	6.9	0.30	17	2	7.0	1.8	0.08
2200	118.6	7.3	0.28	17	2	7.4	1.9	0.09
2300	124.4	7.6	0.27	17	2	7.7	2.0	0.09
2400	130.3	8.0	0.26	17	2	8.1	2.1	0.09
2500	136.2	8.3	0.25	17	2	8.4	2.2	0.10
2600	142.2	8.7	0.24	17	2	8.8	2.3	0.10
2700	148.2	9.1	0.23	17	2	9.2	2.5	0.10
2800	154.3	9.4	0.22	16	2	9.5	2.6	0.11
2900	160.4	9.8	0.21	16	3	9.9	2.7	0.11
3000	166.6	10.2	0.20	16	3	10.3	2.9	0.12
3100	172.9	10.5	0.20	16	3	10.6	3.0	0.12
3200	179.2	10.9	0.19	16	3	11.0	3.1	0.12
3300	185.5	11.3	0.18	16	3	11.4	3.2	0.13
3400	191.9	11.7	0.18	16	3	11.8	3.4	0.13
3500	198.4	12.0	0.17	15	3	12.2	3.5	0.13

Figure 7-15. Table F.

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PROJ, HE, M107
FUZE, PD, M557

TABLE F

CORRECTION FACTORS

CHARGE
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1	10	11	12	13	14	15	16	17	18	19
RANGE	RANGE CORRECTIONS FOR									
	MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KNOT		AIR TEMP 1 PCT		AIR DENSITY 1 PCT		PROJ WT OF 1 SQ (4 SQ STD)	
	DEC	INC	HEAD	TAIL	DEC	INC	DEC	INC	DEC	INC
M	M	M	M	M	M	M	M	M	M	M
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
100	0.6	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	-1	1
200	1.3	-1.2	0.0	0.0	0.1	-0.1	0.0	0.0	-2	2
300	1.9	-1.7	0.1	0.0	0.2	-0.1	0.0	0.0	-3	3
400	2.5	-2.2	0.1	-0.1	0.3	-0.2	-0.1	0.1	-4	4
500	3.1	-2.7	0.2	-0.1	0.5	-0.2	-0.1	0.1	-5	5
600	3.6	-3.2	0.3	-0.1	0.6	-0.3	-0.1	0.1	-6	6
700	4.2	-3.7	0.4	-0.2	0.9	-0.4	-0.2	0.2	-7	7
800	4.7	-4.1	0.5	-0.2	1.1	-0.5	-0.2	0.2	-7	8
900	5.3	-4.5	0.6	-0.2	1.4	-0.6	-0.3	0.3	-8	8
1000	5.8	-5.0	0.7	-0.3	1.7	-0.8	-0.3	0.3	-9	9
1100	6.3	-5.4	0.8	-0.3	2.0	-0.9	-0.4	0.4	-10	10
1200	6.8	-5.8	0.9	-0.4	2.3	-1.0	-0.4	0.4	-10	11
1300	7.3	-6.2	1.1	-0.4	2.6	-1.1	-0.5	0.5	-11	11
1400	7.9	-6.6	1.2	-0.5	2.9	-1.3	-0.6	0.6	-12	12
1500	8.4	-7.0	1.4	-0.5	3.3	-1.4	-0.7	0.6	-13	13
1600	8.8	-7.3	1.5	-0.6	3.6	-1.6	-0.7	0.7	-13	14
1700	9.3	-7.7	1.7	-0.6	4.0	-1.7	-0.8	0.8	-14	14
1800	9.8	-8.1	1.8	-0.7	4.4	-1.8	-0.9	0.9	-14	15
1900	10.3	-8.4	2.0	-0.8	4.7	-2.0	-1.0	1.0	-15	16
2000	10.8	-8.8	2.2	-0.8	5.1	-2.1	-1.1	1.1	-16	16
2100	11.3	-9.2	2.3	-0.9	0.0	0.0	-1.2	1.2	-16	17
2200	11.7	-9.5	2.5	-1.0	0.1	-0.1	-1.3	1.3	-17	17
2300	12.2	-9.9	2.7	-1.0	0.2	-0.1	-1.4	1.4	-17	18
2400	12.7	-10.2	2.8	-1.1	0.3	-0.2	-1.5	1.5	-18	19
2500	13.1	-10.6	3.0	-1.2	0.0	0.0	-1.7	1.6	-19	19
2600	0.6	-0.6	0.0	0.0	0.0	0.0	-1.8	1.8	-19	20
2700	1.3	-1.2	0.0	0.0	0.1	-0.1	-1.9	1.9	-20	20
2800	1.9	-1.7	0.1	0.0	0.2	-0.1	-2.0	2.0	-20	21
2900	2.5	-2.2	0.1	-0.1	0.3	-0.2	-2.2	2.2	-21	22
3000	0.0	0.0	0.0	0.0	0.0	0.0	-2.3	2.3	-21	22
3100	0.6	-0.6	0.0	0.0	0.0	0.0	-2.5	2.4	-22	23
3200	1.3	-1.2	0.0	0.0	0.1	-0.1	-2.6	2.6	-22	24
3300	1.9	-1.7	0.1	0.0	0.2	-0.1	-2.7	2.7	-23	24
3400	2.5	-2.2	0.1	-0.1	0.3	-0.2	-2.9	2.9	-23	25
3500	0.0	0.0	0.1	-0.1	0.3	-0.2	-3.1	3.1	-24	25

Figure 7-15. Table F (Continued).

(6) Fork (Column 6). This is the change in the angle of elevation needed to produce a change in range, at the level point, equivalent to 4 probable errors in range.

(7) Time of flight (Column 7). This is the number of seconds needed for the round to travel from the muzzle to the level point at the given elevation. This column is also used to determine the fuze setting for mechanical time fuzes M582 and M577 and variable time fuzes M728 and M732.

(8) Azimuth correction for drift (Column 8). This is the number of mils added to deflection to compensate for the drift of the projectile. Because projectiles drift right when fired, the drift correction will be to the left.

(9) Azimuth correction for a crosswind of 1 knot (Column 9). This is the correction, in mils, needed to correct for a 1-knot crosswind.

b. Columns 10 through 19 list range corrections for muzzle velocity, range wind, air temperature, air density, and projectile weight. These corrections are used in the solution of concurrent and subsequent met. Correction factors correspond to increases or decreases in relation to standard values for muzzle velocity, air temperature, air density, and projectile weight, except the correction factors for range wind. The correction factors for range wind are listed for both head and tail winds. The factors listed assume that all other conditions are standard.

(1) Correction for a 1 meter-per-second decrease or increase in muzzle velocity (Columns 10 and 11). This is a correction to range to compensate for a 1 meter-per-second decrease or increase in muzzle velocity.

(2) Correction for a head wind or tail wind of 1 knot (Columns 12 and 13). This is a correction to range to compensate for a head wind or tail wind of 1 knot.

(3) Correction for a 1 percent decrease or increase in air temperature (Columns 14 and 15). This is a correction to range to compensate for a decrease or increase in air temperature of 1 percent of standard.

(4) Correction for a 1 percent decrease or increase in air density (Columns 16 and 17). This is a correction to range to compensate for a decrease or increase in air density of 1 percent of standard.

(5) Correction for a 1 square decrease or increase in projectile weight (Columns 18 and 19). This is a correction to range to compensate for a decrease or increase of 1 square in projectile weight.

7-9. Extracting Basic HE Data From Table F

Data may be extracted from Columns 1 through 8 of Table F to compute firing data. It is necessary to relate the data extracted to an entry argument. An element of data is said to be a fiction of another element when changes in one of the elements will cause a change in the other.

a. Elevation is a Function of Range. Enter Column 1 with range expressed to the nearest 10 meters, and extract the elevation to the nearest 1 mil from Column 2.

b. Fuze Setting is a Function of Elevation. Enter Column 2 with the elevation expressed to the nearest mil, and extract the fuze setting expressed to the nearest 0.1 of an increment from Column 3 for fuzes M564 and M565. Extract the fuze setting expressed to the nearest 0.1 of a second from Column 7 for fuzes M582 and M577.

c. ΔFS for 10-Meter Decrease in HOB is a Function of Fuze Setting. Enter Column 3 for fuzes M564 and M565 or Column 7 for fuzes M582 and M577 with the fuze setting expressed to the nearest 0.1. Extract the ΔFS expressed to the nearest 0.01 from Column 4.

d. D Range for a 1-Mil D Elevation is a Function of Elevation. Enter Column 2 with the elevation expressed to the nearest mil, and extract the change in range for a 1-mil change in elevation expressed to the nearest meter.

e. Time of Flight is a Function of Elevation. Enter Column 2 with the elevation expressed to the nearest mil, and extract the time of flight expressed to the nearest whole second from Column 7.

f. Variable Time Fuze Setting is a Function of Elevation. Enter Column 2 with the elevation expressed to the nearest mil, and extract the time of flight expressed to the nearest 0.1 second from Column 7. Express down to the whole second,

g. Drift is a Function of Elevation. Enter Column 2 with the elevation expressed to the nearest mil, and extract the drift expressed to the nearest 1 mil from Column 8.

7-10. Table G

Table G is the table of supplementary data containing probable error information and certain trajectory elements. For ranges not listed, data can be determined through interpolation. The entry argument for this table is range (Column 1). Elevation corresponding to that range is listed in Column 2 for quick reference. The asterisks extending across the table denote the changeover point from low-angle to high-angle fire. (See Figure 7-16.)

a. Probable Error (Columns 3 through 7). Probable error is defined as the error for a particular charge, and range or elevation that is exceeded as often as it is not exceeded. These errors are based on the standard probability curve and are explained in more detail in Chapter 3.

b. Probable Error in Range to Impact (Column 3). Probable error in range is a value in meters that, when added to and subtracted from the range at the mean point of impact along the gun-target (GT) line, will produce an interval that should contain 50 percent of all rounds fired. PE_R will vary according to the charge and range.

c. Probable Error in Deflection at Impact (Column 4). Probable error in deflection is a value in meters when applied to the right and left of the mean point of impact, will produce an interval parallel to the line of fire that should contain 50 percent of the rounds fired. PE_D will vary based on charge and range.

d. Probable Error in Height of Burst (Column 5). Probable error in height of burst is a value in meters which, when added to and subtracted from the expected height of burst, will define an area that should contain 50 percent of the rounds freed. The factors that contribute to PE_{HB} include variations in the functioning of the time fuze.

e. Probable Error in Time to Burst (Column 6). Probable error in time to burst is a value in seconds, which when added to and subtracted from the expected time to burst, will produce a time interval that should contain 50 percent of the rounds fired.

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TABLE G

SUPPLEMENTARY DATA

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PROJ, HE, M107
FUZE, PD, M577

1	2	3	4	5	6	7	8	9	10	11	12	13
RANGE	ELEV	PROBABLE ERRORS					ANGLE OF FALL	COT ANGLE OF FALL	TML VEL	MO	COMP SITE FOR ANGLE OF SITE	
		R	D	FUZE M564							+1 MIL SITE	-1 MIL SITE
				HB	TB	RB						
M	MIL	M	M	M	SEC	M	MIL		M/S	M	MIL	MIL
0	0.0	4	0				0		316	0	0.000	0.000
500	25.4	4	0				26	39.4	308	0	0.001	0.000
1000	51.7	5	1	1	0.06	18	53	19.1	301	13	0.002	*-0.002*
1500	78.9	7	1	2	0.07	19	83	12.3	296	30	0.005	*-0.005*
2000	107.0	8	1	2	0.07	21	113	9.0	290	54	0.010	*-0.010*
2500	136.2	9	2	3	0.08	22	146	6.9	285	87	0.017	*-0.016*
3000	166.6	11	2	4	0.08	23	180	5.6	280	129	0.026	*-0.024*
3500	198.4	12	2	5	0.09	25	217	4.6	276	181	0.038	*-0.035*
4000	231.7	14	3	7	0.09	26	256	3.9	272	244	0.054	*-0.049*
4500	267.0	16	3	8	0.10	27	297	3.3	268	319	0.075	*-0.068*
5000	304.5	18	4	10	0.11	29	341	2.9	265	410	0.103	*-0.093*
5500	344.9	20	4	12	0.11	30	389	2.5	262	517	0.142	*-0.125*
6000	389.0	23	5	14	0.12	32	441	2.2	259	647	0.199	*-0.171*
6500	438.3	25	5	17	0.13	33	500	1.9	257	804	0.287	*-0.238*
7000	495.5	28	6	20	0.14	35	566	1.6	255	1002	0.445	*-0.347*
7500	566.7	31	7	24	0.15	37	647	1.4	254	1269	0.831	*-0.553*
8000	677.4	34	8	32	0.17	39	768	1.1	255	1714		*-1.191*
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
8000	886.8	37	9	46	0.19	38	977	0.7	260	2597		*2.216*
7500	996.2	35	10	53	0.21	35	1078	0.6	263	3042	*-1.849*	1.576
7000	1066.3	32	10	57	0.21	32	1142	0.5	265	3309	*-1.461*	1.367
6500	1122.1	30	9	60	0.22	30	1193	0.4	267	3508	*-1.301*	1.255
6000	1169.8	27	9	63	0.22	27	1238	0.4	268	3665	*-1.208*	1.183
5500	1211.6	24	9	65	0.22	24	1279	0.3	269	3793	*-1.146*	1.131
5000	1248.5	21	8	67	0.23	21	1317	0.3	269	3897	*-1.101*	1.092
4500	1280.7		8	69	0.23	18	1355	0.2	269	3980	*-1.066*	1.061

Figure 7-16. Table G.

f. Probable Error in Range to Burst (Column 7). Probable error in range to burst is a value in meters which, when added to and subtracted from the expected range to burst, will produce an interval along the line of fire that should contain 50 percent of the rounds fired.

g. Angle of Fall (Column 8). The angle of fall is the value in mils of the least angle measured clockwise from the horizontal to a line tangent to the trajectory at the level point.

h. Cotangent of Angle of Fall (Column 9). The cotangent (cot) angle of fall is the trigonometric function of the angle of fall. When the probable error in range is divided by this factor, the quotient is the vertical probable error. The vertical probable error is the height expected to contain 25 percent of the impacts when firing onto a vertical face.

i. Terminal Velocity (Column 10). The terminal velocity (tml vel) is the speed of the projectile at the level point under standard conditions.

j. Maximum Ordinate (Column 11). The maximum ordinate (MO) is the height of the summit above the origin in meters. This is the height of the trajectory above the howitzer expressed in meters under standard conditions.

k. Complementary Angle of Site for Each Mil of Angle of Site (Columns 12 and 13). This is the correction termed the complementary site factor (CSF) which must be algebraically added to each mil of angle of site to compensate for the nonrigidity of the trajectory. When the CSF is multiplied by the absolute value of the angle of site, the product is the complementary angle of site.

7-11. Table H

a. Table H is used in the solution of concurrent and subsequent met. The extracted value is the correction to range in meters for the rotation of the earth at 0° latitude. A correction for any other latitude is extracted from the small table at the bottom of Table H and is multiplied by the correction from the table. The asterisks extending across the table denote the changeover point from low-angle to high-angle fire.

b. Table H is entered along the left side with the entry range expressed to the nearest 500 meters and along the top or bottom with the **exact azimuth** (to the nearest mil) to the target (direction of fire) expressed to the nearest listed value. For example, if the azimuth to the target is 1,499 mils, enter Table H with 1400. Whenever the solution determined is exactly halfway between two entry arguments for azimuth to the target use the next higher value. (See Figure 7-17.)

7-12. Table I

a. Table I is used in the solution of concurrent and subsequent met. There are tables for every 10° latitude starting from 0° north or south latitude to 70° north or south latitude. The extracted value is the correction to deflection in mils, for the rotation of the earth. The asterisks extending across the table denote the changeover point from low-angle to high-angle free.

b. Table I is entered along the left side with the entry range expressed to the nearest 500 meters and along the top (for northern latitudes), with the **exact azimuth** (to the nearest mil) to the target (direction of fire) expressed to the nearest listed value. For example, if the azimuth to the target is 1,499 mils, enter Table I with 1600. For southern latitudes, you enter from the bottom with the **exact azimuth** (to the nearest mil) to the target (direction of fire) expressed to the nearest listed value. Whenever the solution determined is exactly halfway between two entry arguments for azimuth to the target, use the next higher value. (See Figure 7- 18.)

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PROJ, HE, M107
FUZE, PD, M577

TABLE H

ROTATION - RANGE

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CORRECTIONS TO RANGE, IN METERS, TO COMPENSATE FOR THE ROTATION OF THE EARTH

	AZIMUTH OF TARGET - MILS								
RANGE METERS	0 3200	200 3000	400 2800	600 2600	800 2400	1000 2200	1200 2000	1400 1800	1600 1600
500	0	0	-1+	-1+	-2+	-2+	-2+	-2+	-2+
1000	0	-1+	-2+	-2+	-3+	-4+	-4+	-4+	-4+
1500	0	-1+	-3+	-4+	-5+	-5+	-6+	-6+	-7+
2000	0	-2+	-3+	-5+	-6+	-7+	-8+	-8+	-9+
2500	0	-2+	-4+	-6+	-7+	-9+	-10+	-10+	-10+
3000	0	-2+	-5+	-7+	-9+	-10+	-11+	-12+	-12+
3500	0	-3+	-5+	-8+	-10+	-12+	-13+	-14+	-14+
4000	0	-3+	-6+	-9+	-11+	-13+	-14+	-15+	-15+
4500	0	-3+	-6+	-9+	-12+	-14+	-16+	-16+	-17+
5000	0	-4+	-7+	-10+	-13+	-15+	-17+	-18+	-18+
5500	0	-4+	-7+	-11+	-14+	-16+	-18+	-19+	-19+
6000	0	-4+	-8+	-11+	-14+	-17+	-18+	-20+	-20+
6500	0	-4+	-8+	-11+	-14+	-17+	-19+	-20+	-20+
7000	0	-4+	-8+	-11+	-15+	-17+	-19+	-20+	-21+
7500	0	-4+	-8+	-11+	-14+	-17+	-18+	-20+	-20+
8000	0	-3+	-7+	-10+	-13+	-15+	-16+	-17+	-18+
*******	*********	************	**********	**********	**********	**********	**********	**********	***********
8000	0	-2+	-3+	-5+	-6+	-7+	-8+	-9+	-9+
7500	0	-1+	-1+	-1+	-2+	-2+	-2+	-3+	-3+
7000	0	0	+1-	+1-	+1-	+1-	+2-	+2-	+2-
6500	0	+1-	+2-	+3-	+4-	+5-	+5-	+5-	+5-
6000	0	+2-	+3-	+5-	+6-	+7-	+8-	+9-	+9-
5500	0	+2-	+5-	+7-	+9-	+10-	+11-	+12-	+12-
5000	0	+3-	+6-	+9-	+12-	+14-	+15-	+16-	+16-
4500	0	+4-	+8-	+12-	+15-	+18-	+20-	+21-	+22-
	3200 6400	3400 6200	3600 6000	3800 5800	4000 5600	4200 5400	4400 5200	4600 5000	4800 4800
	AZIMUTH OF TARGET - MILS								

NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.
2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.
3. AZIMUTH IS MEASURED CLOCKWISE FROM NORTH.
4. CORRECTIONS ARE FOR 0 DEGRESS LATITUDE. FOR OTHER LATITUDES MULTIPLY CORRECTIONS BY THE FACTOR GIVEN BELOW.

LATITUDE (DEG)	10	20	30	40	50	60	70
MULTIPLY BY	.98	.94	.87	.77	.64	.50	.34

Figure 7-17. Table H.

CHARGE
4G

TABLE I

ROTATION - AZIMUTH

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PROJ, HE, M107
FUZE, PD, M557

CORRECTIONS TO AZIMUTH, IN MILS, TO COMPENSATE FOR THE ROTATION OF THE EARTH

0 DEGREES LATITUDE

	AZIMUTH OF TARGET - MILS								
RANGE METERS	0 6400	400 6000	800 5600	1200 5200	1600 4800	2000 4400	2400 4000	2800 3600	3200 3200
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3500	R0.1L	R0.1L	0.0	0.0	0.0	0.0	0.0	L0.1R	L0.1R
4000	R0.1L	R0.1L	R0.1L	0.0	0.0	0.0	L0.1R	L0.1R	L0.1R
4500	R0.1L	R0.1L	R0.1L	0.0	0.0	0.0	L0.1R	L0.1R	L0.1R
5000	R0.1L	R0.1L	R0.1L	R0.1L	0.0	L0.1R	L0.1R	L0.1R	L0.1R
5500	R0.2L	R0.2L	R0.1L	R0.1L	0.0	L0.1R	L0.1R	L0.2R	L0.2R
6000	R0.2L	R0.2L	R0.2L	R0.1L	0.0	L0.1R	L0.2R	L0.2R	L0.2R
6500	R0.3L	R0.3L	R0.2L	R0.1L	0.0	L0.1R	L0.2R	L0.3R	L0.3R
7000	R0.4L	R0.3L	R0.3L	R0.1L	0.0	L0.1R	L0.3R	L0.3R	L0.4R
7500	R0.5L	R0.4L	R0.3L	R0.2L	0.0	L0.2R	L0.3R	L0.4R	L0.5R
8000	R0.7L	R0.6L	R0.5L	R0.3L	0.0	L0.3R	L0.5R	L0.6R	L0.7R
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
8000	R1.3L	R1.2L	R0.9L	R0.5L	0.0	L0.5R	L0.9R	L1.2R	L1.3R
7500	R1.7L	R1.6L	R1.2L	R0.7L	0.0	L0.7R	L1.2R	L1.6R	L1.7R
7000	R2.1L	R2.0L	R1.5L	R0.8L	0.0	L0.8R	L1.5R	L2.0R	L2.1R
6500	R2.5L	R2.3L	R1.8L	R0.9L	0.0	L0.9R	L1.8R	L2.3R	L2.5R
6000	R2.8L	R2.3L	R2.0L	R1.1L	0.0	L1.1R	L2.0R	L2.6R	L2.8R
5500	R3.2L	R3.0L	R2.3L	R1.2L	0.0	L1.2R	L2.3R	L3.0R	L3.2R
5000	R3.6L	R3.4L	R2.6L	R1.4L	0.0	L1.4R	L2.6R	L3.4R	L3.6R
4500	R4.0L	R3.7L	R2.8L	R1.5L	0.0	L1.5R	L2.8R	L3.7R	L4.0R
	3200 3200	2800 3600	2400 4000	2000 4400	1600 4800	1200 5200	800 5600	400 6000	0 6400
	AZIMUTH OF TARGET - MILS								

0 DEGREES LATITUDE

Figure 7-18. Table I.

7-13. Table J

a. Table J is used in the solution of concurrent and subsequent met. Data in this table are arranged in 11 columns. Each column lists a fuze setting correction needed to compensate for the effects of nonstandard conditions.

b. The fuze setting used as an entry argument corresponds to the adjusted elevation from a registration (concurrent met) or corresponds to the elevation determined in the solution of a subsequent met. (See Figure 7-19.)

(1) Fuze setting (Column 1). The FS corresponding to the adjusted elevation expressed to the nearest whole increment is the entry argument for Table J.

(2) Correction for a 1 meter-per-second decrease or increase in muzzle velocity (Columns 2 and 3). This is the correction for the FS to compensate for a 1 meter-per-second decrease or increase in muzzle velocity.

(3) Correction for ahead wind or tail wind of 1 knot (Columns 4 and 5). This is the correction to FS to compensate for a head wind or tail wind of 1 knot.

(4) Correction for a 1 percent decrease or increase in air temp (Columns 6 and 7). This is the correction to FS to compensate for a decrease or increase in air temperature of 1 percent of standard.

(5) Correction for a 1 percent decrease or increase in air density (Columns 8 and 9). This is the correction to FS to compensate for a decrease or increase in air density of 1 percent of standard.

(6) Correction for a 1 square decrease or increase in projectile weight (Columns 10 and 11). This is the correction to FS to compensate for a decrease or increase of 1 square in projectile weight.

7-14. Table K

Table K provides corrections to be applied to M564 fuze settings when time fuze M520A1 is being fired. (See Figure 7-20.)

7-15. Illuminating Projectiles

a. Illuminating projectiles are available for the 105-mm and the 155-mm howitzers. They are used to illuminate a designated area for observing enemy night operations, for adjusting artillery fires at night, for marking locations, or for harassment purposes.

b. Illuminating projectiles are base-ejecting projectiles fired with mechanical time fuzes. The filler consists of an illuminating canister and a parachute assembly. The FDO selects the charge to fire, selecting the lowest practical charge to prevent a malfunction caused by the parachute ripping when the flare is ejected from the projectile. The two models of illuminating projectiles for the 105-mm howitzer are the M314A2 and the newer M314A3, which has a slightly longer burning time. The 155-mm howitzer also has two models of illuminating projectiles. These models are the M118 and the newer M485A2, which has a significant increase in illumination time.

NOTE: Data are no longer provided for the M118 projectile. Part 2 of the 155-AM-2 TFT applies to the **M485 series only).**

c. Part 2 of the 105-mm and 155-mm HE TFT provide data for the illuminating projectile. Most illumination data are provided in a single table. However, TFT may contain additional tables to provide corrections for mechanical time fuzes other than that tabulated in the first table. When more than one table is provided, the tables are identified by letters. The shaded portion of Columns 1 and 2 indicate function during the ascending branch.

FT 155-AM-2 | **TABLE J** | **CHARGE 4G**

PROJ, HE, M107
FUZE, MTSQ, M564

FUZE CORRECTION FACTORS

1	2	3	4	5	6	7	8	9	10	11
FS	FUZE CORRECTIONS FOR									
	MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KNOT		AIR TEMP 1 PCT		AIR DENSITY 1 PCT		PROJ WT OF 1 SQ (4 SQ STD)	
	DEC	INC	HEAD	TAIL	DEC	INC	DEC	INC	DEC	INC
35	-.089	.077	-.016	.008	-.043	.017	.019	-.019	.127	-.135
36	-.092	.079	-.016	.008	-.043	.017	.020	-.020	.131	-.139
37	-.094	.082	-.016	.008	-.044	.017	.021	-.021	.135	-.142
38	-.097	.084	-.016	.008	-.045	.018	.022	-.021	.138	-.146
39	-.099	.086	-.016	.008	-.045	.018	.023	-.022	.142	-.149
40	-.102	.089	-.016	.008	-.046	.018	.024	-.023	.146	-.152
41	-.105	.091	-.016	.008	-.046	.018	.025	-.024	.149	-.156
42	-.107	.094	-.016	.009	-.047	.018	.026	-.025	.153	-.160
43	-.110	.096	-.016	.009	-.048	.019	.027	-.026	.157	-.163
44	-.112	.099	-.016	.009	-.048	.019	.027	-.027	.161	-.167
45	-.115	.101	-.016	.009	-.049	.019	.028	-.027	.165	-.171
46	-.118	.104	-.016	.009	-.049	.019	.029	-.028	.169	-.175
47	-.120	.106	-.016	.009	-.050	.019	.030	-.029	.173	-.179
48	-.121	.109	-.015	.009	-.050	.020	.031	-.030	.177	-.182
49	-.126	.111	-.015	.009	-.051	.020	.032	-.031	.182	-.186
50	-.128	.114	-.015	.009	-.051	.020	.033	-.032	.186	-.190
51	-.131	.116	-.014	.009	-.052	.020	.033	-.032	.190	-.194
52	-.134	.119	-.014	.009	-.052	.020	.034	-.033	.195	-.198
53	-.136	.122	-.014	.009	-.053	.020	.035	-.034	.199	-.202
54	-.139	.124	-.013	.010	-.053	.020	.036	-.035	.203	-.206
55	-.142	.127	-.013	.011	-.054	.020	.037	-.036	.208	-.211
56	-.145	.129	-.013		-.054	.020	.038	-.037	.214	-.217
57	-.147	.132	-.014		-.053	.020	.041	-.039	.222	-.226
58	-.147	.134	-.019		-.048	.019		-.047	.252	-.240

Figure 7-19. Table J.

CHARGE
4G

TABLE K

FUZE SETTING

FT 155-AM-2

PROJ, HE, M107
FUZE, MTSQ, M520A1

CORRECTIONS TO FUZE SETTING OF FUZE, MTSQ, M564 FOR FUZE, MTSQ, M520A1

FUZE SETTING FUZE M564		CORRECTIONS
FROM	TO	
2.0	2.2	0.2
2.3	5.9	0.3
6.0	9.7	0.4
9.8	13.5	0.5
13.6	17.3	0.6
17.4	21.1	0.7
21.2	24.9	0.8
25.0	28.7	0.9
28.8	32.5	1.0
32.6	36.3	1.1
36.4	40.1	1.2
40.2	43.9	1.3
44.0	47.7	1.4
47.8	51.5	1.5
51.6	55.3	1.6
55.4	58.0	1.7

Figure 7-20. Table K.

(1) Table A. Table A provides firing data and corrections to firing data for illuminating projectiles.

(a) Range to target (Column 1). This is the distance measured from the muzzle to the target on the surface of a sphere concentric with the earth. When range is used as the entry argument for this table, it is expressed to the nearest 10 meters.

(b) Quadrant elevation (Column 2). This is the angle of the tube in the vertical plane. This QE, when used in conjunction with the fuze setting given in Column 3, produces an airburst such that the ignition of the illuminant occurs 600 meters (105-mm is 750 meters) above the level point at the given range.

(c) Fuze setting (Column 3). This is the fuze setting for the M565 fuze. When used in conjunction with the QE given in Column 2, it produces an airburst such that the ignition of the illuminant occurs 600 meters above the level point at the range (105-mm is 750 meters).

(d) Change in QE and FS for an increase of 50 meters in HOB (Columns 4 and 5). These corrections are added to the QE and FS to increase the height of burst by 50 meters. By changing the sign of the correction, the factor is used to lower the height of burst. This factor is also used to correct the QE and FS from Columns 2 and 3 for the VI. These factors must be applied in conjunction with each other.

(e) Range to fuze function (Column 6). This is the horizontal distance from the gun to the point at which the fuze functions.

(f) Range to impact (Column 7). This is the horizontal distance from the gun to the point at which a nonfunctioning projectile will impact.

(2) Table B. Table B provides corrections to fuze setting for mechanical time (MT), M565 to obtain a fuze setting for fuze MTSQ, M577. The corrections are either added to or subtracted from the fuze setting of the MT, M565 fuze to obtain the fuze setting for fuze MTSQ, M577.

7-16. TFT Part 3 and Part 4

Certain TFTs (for example, FT 105-H-7) provide data in two additional parts. Part 3 contains firing data for cartridge, HEP-T, M327 and consists of one table for a single charge. Part 4 contains firing data for cartridge APERS, M546 and consists of one table for a single charge.

7-17. Appendixes

The last portion of the TFT are the appendixes. They contain trajectory charts for HE projectile. Altitude in meters above the origin is plotted against range in meters for every 100 mils of elevation. Time of flight, by 5-second intervals, is marked on the trajectory.

Section II

Graphical Firing Tables

To eliminate the difficulties in computing firing data that result from the need to interpolate, the graphical firing table was created. The GFT provides all the information needed to compute firing data in a slide rule form.

7-18. Overview

a. Parts. All GFTs are made in two parts (Figure 7-21). The rule is a rectangular wooden base on which is printed one or more sets of scales. With a few exceptions, GFTs are printed on both sides. The second part of the GFT is the cursor. This is a transparent plastic square that slides on the rule. Engraved in the plastic of the cursor is a manufacturer's hairline used to determine values from the scales.

c. Types. The basic GFT format is the same for all weapons. These formats may be divided into three types: low-angle GFTs, high-angle GFTs, and shell illuminating GFTs.

d. Identification. All GFTs are labeled (Figure 7-22) for identification. The first line of the label on low- and high-angle GFTs indicates the type weapon in bold type; that is, **HOW 155mm.** Immediately below the weapon type, in smaller print, is the identification of the TFT on which the GFT is based; for example, "155AM2." This is followed by the projectile type and nomenclature, such as "HEM107." The last line of identification of low-angle GFTs tells the charge for which the GFT may be used, such as "CHARGE 4." High-angle GFTs indicate the trajectory "HIGH ANGLE." Shell illuminating GFTs (Figure 7-23) reverse the label with "PROJECTILE ILLUMINATING" on the top and the weapon type on the bottom.

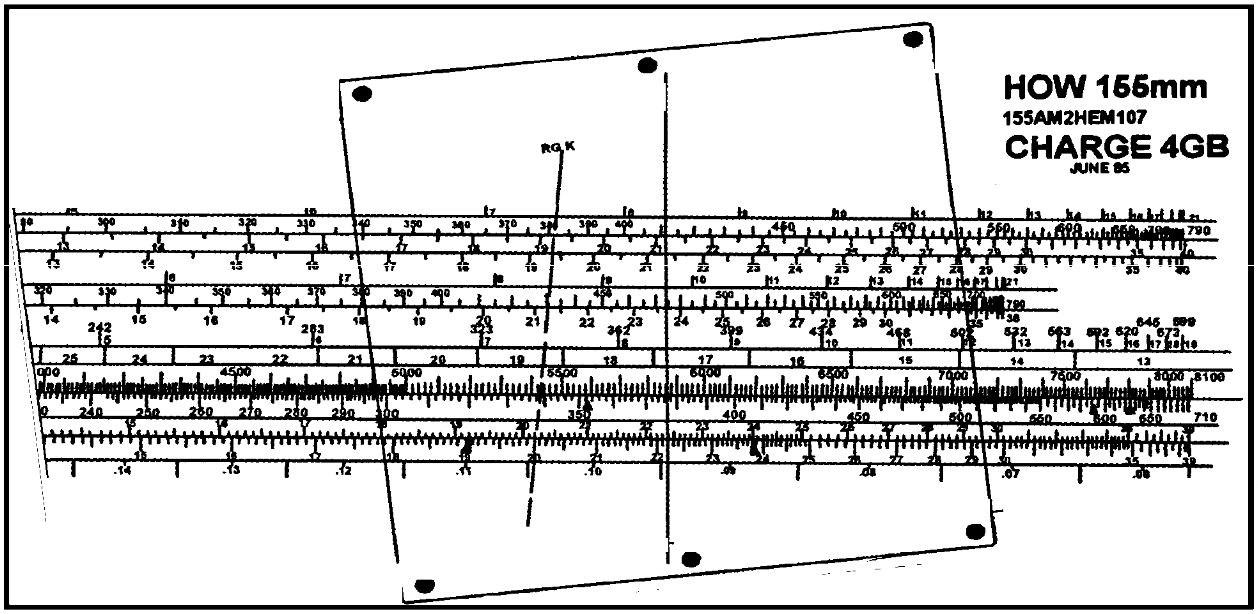


Figure 7-21. Graphical Firing Table.

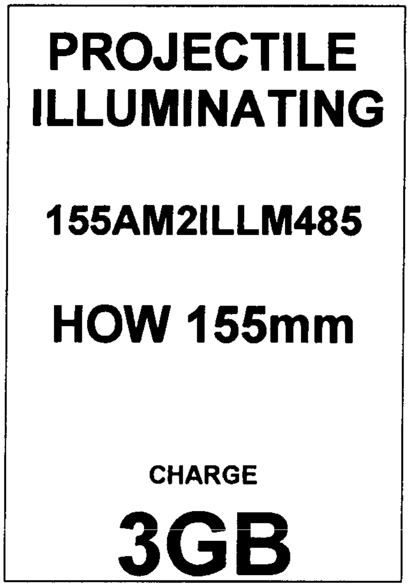
HOW 155mm
155AM2HEM107
CHARGE 4GB
JUNE 85

a

HOW 155mm
155AM2HEM107
HIGH ANGLE
MAY 83

b

Figure 7-22. GFT Label.



PROJECTILE
ILLUMINATING

155AM2ILLM485

HOW 155mm

CHARGE

3GB

Figure 7-23. Illuminating GFT Label.

7-19. Low-Angle GFTs

Low-angle GFTs are available for all weapon systems and were developed from the data contained in the TFT of the weapon and projectile. All GFTs are printed with a base scale which represents the data for the base projectile as indicated on the label; that is, “HEM107.” One or more ICM/M825 scales may be provided above or below the base scale. The scales are as follows:

a. Drift Scale. This scale, which is printed in black, gives the projectile drift in mils. Since the projectile drifts to the right, the drift correction is always made to the left. Each elevation at which the drift is exactly halfway between the values is printed in red. Artillery expression is applied to determine the value of drift at each of these elevations. In determining drift, it is important to note that drift is a function of elevation. The corresponding portion of the TFT is Table F, Column 8.

b. 100/R Scale. This scale lists the number of mils needed to move the burst laterally or vertically 100 meters at a given range. The numbers on this scale are printed in red. The scale is based on the mil relation formula $\not{m}$ = W/R x 1.0186). 100/R is a function of range. There is no corresponding table in the TFT for 100/R.

c. Range Scale. This scale is the base scale, and all other scales are plotted in relation to it. Range is expressed in meters, The range scale was developed to give as large a range spread as possible, and still permit graduations large enough for accurate readings. Range is read to the nearest 10 meters. The corresponding portion of the TFT is Table F, Column 1.

d. Elevation Scale. This scale is graduated in mils and is read to the nearest mil. The numbers on this scale are printed in red and black. The red numbers denote elevations that are within range transfer limits for a one-plot GFT setting. The corresponding portion of the TFT is Table F, Column 2.

e. Time of Flight/Fuze Setting M582 Scale. This scale lists the time of flight and the fuze settings for time fuzes M582, M577, M728, and M732 corresponding to a given elevation. Time of flight is determined to the nearest whole second. Fuze settings for time fuzes M582 and M577 are determined to the nearest 0.1 fuze setting increment. Fuze setting for fuze VT is determined from the TF / M582 scale by vanishing the tenths and applying a .0. Time of flight and the fuze settings for M582, M577, M728, and M732 are functions of elevation. The corresponding portion of the TFT is Table F, Column 7.

f. Fuze Setting M564 Scale. This scale lists the&e settings for time fuzes M564 and M565. The values are read to the nearest 0.1 fuze setting increment. Fuze settings for M564 and M565 are functions of elevation. The corresponding portion of the TFT is Table F, Column 3.

g. FS/10M HOB Scale. This scale lists the corrections to fuze setting for fuzes M582 or M564 that are needed to raise or lower the HOB 10 meters along the trajectory. FS / 10M HOB is a function of fuze setting. The corresponding portion of the TFT is Table F, Column 4.

NOTE: GFTs produced before 1983 include a fork scale. Fork represents the value, in mils, of the change in the angle of elevation needed to produce a change in range of 4 PER at the level point. The corresponding potion of the TFT is Table F, Column 6.

h. Met Check Gauge Points. These are red equilateral triangles above the TF / M582 fuze setting scale. The apex of each triangle points to the QE that under standard conditions results in the maximum ordinate of the trajectory passing through a whole line number of a met message. The range and QE at the met check gauge points are preferred for registration aiming points, for met plus velocity error (met + VE) computations, and for determining GFT settings. There is no corresponding table in the TFT.

NOTE: Chapter 10 explains registrations and determining GFT settings, and Chapter 11 explains met + VE computations.

i. Height-of-Burst Probable Error Gauge Points. These gauge points appear on some GFTs above the fork scale or on the M564 fuze setting scale. They are red right triangles and indicate the range and fuze settings at which the PEHB is 15 meters. Larger HOB dispersion must be expected when time fuzes are used with a particular charge at ranges exceeding the gauge point. Some charges have two such gauge points. The one on the left of the GFT indicates the range at which the PEHB for the next lower charge is 15 meters. The PEHB can be determined from Table G, Column 5, of the TFT.

j. Range Probable Error Gauge Point. This is a black equilateral triangle located above the **ΔFS/Δ10M** HOB scale. It indicates the range at which the range probable error equals 25 meters. Ranges to the left of the gauge point have a PER of less than 25; ranges to the right of the gauge point have a PER of greater than 25. The PER can be determined from Table G, Column 3, of the TFT.

k. Range K and Fuze K Lines. These are based on data derived from computer simulations of artillery firing. The computer program uses 50 sets of weighted nonstandard conditions of temperature, density, range wind, and muzzle velocity. Firing simulations were made by using these 50 sets of nonstandard conditions for each of a number of ranges within the range limits for each charge. Every group of 50 firings for each range provided data to calculate a total average range correction (range K) and total average fuze correction (fuze K) for that particular range. These values of range K and fuze K were graphically plotted versus the corresponding range for all simulated ranges for each charge. These curves were simplified as tight line approximations and were used to create the data to construct the range K and fuze K lines on the GFT. These approximations were considered to be acceptable, up to the point where no more than 1 PER was introduced. This acceptable range area is denoted on the GFT by the elevation numbers printed in red. Those numbers corresponding to an error larger than 1 PER are printed in black. From this is derived the range transfer limits for a one-plot GFT setting. The range K and fuze K lines are ignored for multiplot GFT settings.

l. Improved Conventional Munitions Scales. These scales are on some graphical firing tables. They are located above the DEFL CORR/DRIFT scale. The scales apply to a specific type of ammunition as indicated by the model number at the left end of the scale.

(1) DEFL CORR. This is the top scale on GFT ICM scales. This scale incorporates base scale drift and the ballistic correction as tabulated in Table A of the appropriate addendum.

(2) QE. The next scale (the top scale on older GFTs) is the quadrant scale. This scale provides the quadrant to fire for the ICM projectile. The ICM quadrant is read to the nearest mil by placing the manufacturer's hairline over the base scale quadrant and reading up under the MHL to the appropriate ICM quadrant scale. This QE incorporates the ballistic correction given in Table A of the appropriate addendum.

(3) FS. The last scale provides the fuze setting to fire on the ICM projectile. The ICM FS is read to the nearest 0.1 increment by placing the MHL over the base scale FS and reading up under the MHL to the appropriate ICM FS scale. This FS incorporates the ballistic correction given in Table B of the appropriate addendum.

7-20. High-Angle GFT

a. High-angle fire is delivered at elevations greater than the elevation corresponding to the maximum range for a charge. All howitzers can deliver high-angle fire effectively.

b. The high-angle GFT consists of one rule with ballistic data for multiple charges on each side. The scales on the high-angle GFT from top to bottom are as follows:

(1) 100/R. This scale lists the number of mils needed to move the burst laterally or vertically 100 meters at a given range. The scale increases from right to left, is read to the nearest mil, and applies to all charges. There is no corresponding portion in the TFT.

(2) Range. The range scale is expressed in meters and applies to all charges appearing on that side of the GFT. Range increases from left to right and is read to the nearest 10 meters. The corresponding portion of the TFT is Table F, Column 1.

(3) Elevation. Elevation is expressed in mils and increases from right to left. It is visually interpolated to the nearest mil. The corresponding portion of the TFT is Table F, column 2.

(4) 10-Mil site factor. The values on this scale denote the site for each 10 mils of angle of site. The numbers are printed in red and are negative values. This factor actually reflects the complementary angle of site for a positive VI. Consequently, a slightly more accurate solution for negative angles of site can be determined from the TFT. Because of the minimal effect of site in high-angle fire, these values are acceptable for both a positive and negative VI. The scale increases from left to right and is read to the nearest tenth (0.1) of a mil. There is no corresponding portion in the TFT.

(5) Drift. The values on this scale are in mils. The scale increases from right to left and is read to the nearest mil. The corresponding portion of the TFT is Table F, Column 8.

(6) Time of flight. This scale is graduated in seconds and is used to determine both time of flight (to the nearest whole second) and VT fuze setting (to the next lower whole second). The scale increases from right to left. The corresponding portion of the TFT is Table F, Column 7.

NOTE: Because the scales increase in different directions, the computer must be careful in reading the high-angle GFT. The elevation, 100/R, drift, and TF scales increase from right to left. The range and 10-mil site scales increase from left to right.

7-21. Illuminating Projectile GFT

Graphical firing tables have been developed for use with all 155-mm M485A2 illuminating projectiles and with the 105-mm M314A1, M314A2, and M314A3E1 projectiles. Illumination scales are provided for enough charges to cover the spectrum of range for the shell and weapon.

a. 100/R. This scale is printed along the top edge of the GFT. For a given range, the 100/R scale denotes the number of mils needed to shift the burst 100 meters laterally or vertically. The 100/R is read to the nearest mil. There is no corresponding portion in the TFT.

b. Range. The range scale is the base scale of the illuminating GFT. All other scales are plotted with reference to the range scale. Range is read to the nearest 10 meters. The corresponding portion of the TFT is Part 2, Table A, Column 1.

c. Elevation to Impact. This scale is graduated in mils. Low-angle elevation increases from left to right and is read to the nearest mil. The scale is used to determine the range (on the range scale) to which a nonfunctioning projectile will impact. There is no corresponding portion in the TFT.

d. Height of Burst. These scales are graduated in 50-meter increments. The HOB is determined by expressing the VI to the nearest 50 meters and algebraically applying the VI to the optimum HOB. There is no corresponding portion in the TFT.

e. QE. The QE scale shown for each listed height of burst gives the QE needed to achieve the height of burst at the desired range. The scale is graduated in mils and is visually interpolated to the nearest mil. A heavy black arrow on the QE scale indicates the part of the trajectory that is at or near the summit and that does not exceed by 50 meters the height of burst that it represents. (See Figure 7-24.) The corresponding portion of the TFT for a 600-meter (750 meters for 105 mm) HOB is Part 2, Table A, Column 2.

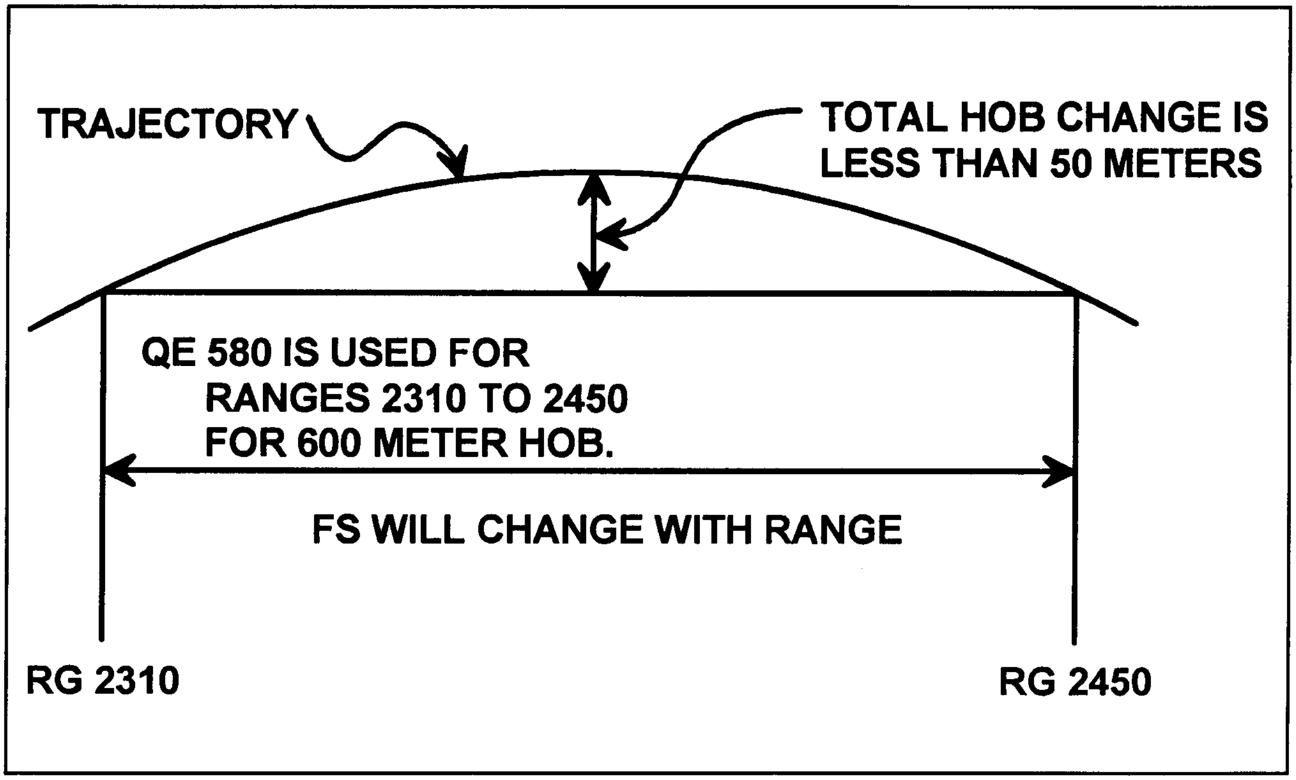


Figure 7-24. Trajectory of an Illuminating Projectile, Charge 2GB.

f. FS M565. This scale consists of a series of red arcs. The scale includes a red line for each whole fuze setting increment for the MT, M565 fuze. The value of each line is printed in red at the bottom of the scale. The fuze setting is read for the desired range and HOB to an accuracy of 0.1 FS increment by visual interpolation. The corresponding portion of the TFT for a 600-meter (750 meters for 105 mm) HOB is Part 2, Table A, Column 3.

Chapter 8

SITE

This chapter implements a portion of QSTAG 224.

Site is computed to correct for situations where the target is not at the same altitude as the unit. To understand site, a brief description of the trajectory is necessary.

8-1. Initial Elements of the Trajectory

a. Vertical Interval. The vertical interval is the difference in altitude between the unit or observer and the target or point of burst. (See Figure 8-1.) The VCO determines the vertical interval by subtracting the altitude of the unit or observer from the altitude of the target or point of burst. The vertical interval is determined to the nearest meter and is a signed value.

b. Angle of Site. The angle of site compensates for the vertical interval. The angle of site is the smaller angle in a vertical plane from the base of the trajectory to the straight line joining the origin and the target. The angle of site has a positive value when the target is above the base of the trajectory and a negative value when the target is below the base of the trajectory. The angle of site is determined to the nearest 0.1 mil and is a signed value. It carries the same sign as the VI.

c. Complementary Angle of Site. The complementary angle of site is an angle that is algebraically added to the angle of site to compensate for the nonrigidity of the trajectory. When large angles of site or greater ranges for any one charge are involved, a significant error is introduced because of changes in the shape of the trajectory. If CAS is not added to angle of site in low-angle fire, the trajectory will pass under the target if the target is at an altitude higher than the unit. The trajectory will pass over the target if the target is at an altitude lower than the unit. Complementary angle of site is dependent on the following:

- Charge.
- Range.
- Angle of site.
- Weapon system.
- Projectile family.
- Angle of fire (high or low).

(1) For a given charge and range, there is a specific complementary angle of site for every 1 mil angle of site. This specific value is listed in Table G of the TFT, Columns 12 and 13, in the form of the complementary site factor (comp site factor or CSF). The CSF must be applied to a particular angle of site to determine complementary angle of site. The CSF must be determined by interpolation for the chart range to the nearest 10 meters. Complementary angle of site is computed to the nearest 0.1 mil and is a signed quantity. The sign is the same as the CSF value.

(2) A study of listed values for the CSF reveals that for short ranges the CSF is negligible. As the range increases, the factor increases for any given charge. Thus, at greater ranges, the CSF is significant even for small angles of site. The CSF also varies with the charge for any given range.

d. Site. Site is the algebraic sum of the angle of site and the complementary angle of site. It is determined to the nearest mil and is a signed value.

e. Angle of Elevation. The angle of elevation is the vertical angle between the horizontal and the axis of the bore required for a projectile to achieve a prescribed range under standard conditions.

f. Quadrant Elevation. Quadrant elevation is the algebraic sum of site and the angle of elevation. It is determined to the nearest mil.

8-2. Site in High-Angle Fire

Site has a relatively small effect in high-angle fire because of the large angle of fall. In high-angle missions, a minus site must be used to compensate for a positive vertical interval and a Plus site must be used to compensate for a negative vertical interval. Therefore, high-angle site will have the opposite sign of the VI.

8-3. Determination of Altitudes

The altitude of the unit or base piece is nomally known by map spot or survey and labeled on the firing chart. To determine the target altitude, the VCO must analyze the call for fire sent by the observer.

a. The observer may report a target location by using the grid coordinate method. This method requires a map of the target area. The easiest way to determine altitude from a map is by reading the contour lines. The VCO plots the grid sent by the observer and extracts the altitude from the map.

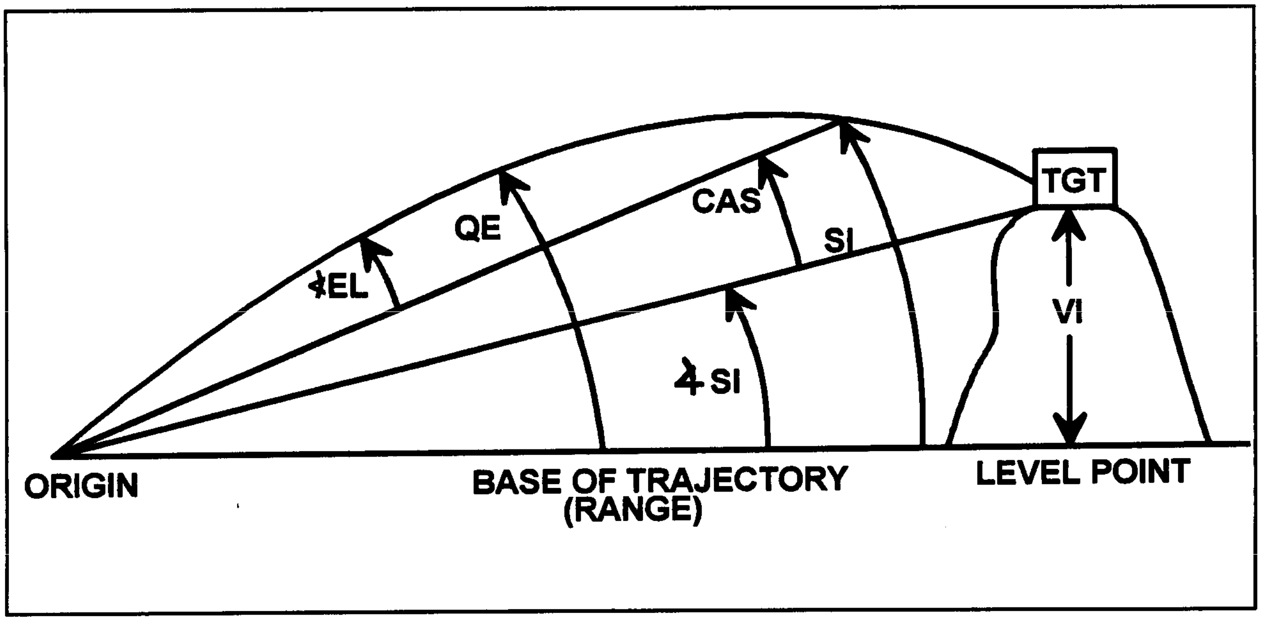


Figure 8-1. Elements of Trajectory.

b. The observer may report a target location by using polar coordinates. He locates the target in relation to his own location by sending a direction and distance to the target. The observer may also transmit an up or down vertical shift from his location. If the observer transmits a vertical shift, the altitude of the target is determined in relation to the observer by applying the vertical shift to the observer's altitude. If not, the grid is plotted and altitude is determined as in paragraph a.

c. The observer may report a target location with reference to a known point plotted on the firing chart. This method of target location is known as shift from a known point. The vertical shift sent by the observer is applied to the known point altitude to determine the target altitude.

8-4. Determination of Site without a Graphical Site Table

In Table 8-1 are the procedures for determining site without a GST.

Table 8-1. Determination of Site Without a GST.

STEP	ACTION
1	Determine the vertical interval. Use the following equation: **TGT ALT** **- UNIT ALT** **VI (±), NEAREST 1 METER**
2	Determine the angle of site. To compute angle of site, use the following equation: $\frac{\textbf{VERTICAL INTERVAL}}{\textbf{RG (IN 1,000s OF M)}}$ **X 1.0186 = ∢ SI(±) ≈ NEAREST 0.1 MIL**
	NOTE: If angle of site is greater than ±100 mils, it must be computed by using the following formula: **TANGENT ∢ SI = VI/R.** The following example will illustrate: **GIVEN:** Vertical Interval: +600 meters Chart Range: 4,000 meters 1. Tangent ∢ SI = +600/4,000 2. Tangent ∢ SI = + 0.15 3. Arctangent (+ 0.15) = ∢ SI (in degrees) 4. ∢ SI (in degrees) = + 8.53076561 5. ∢ SI (in degrees) x (17.7778) = ∢ SI (in mils) 6. 8.53076561 x (17.7778) = + 151.658 mils ≈+151.7 mils
	The arctangent is the inverse tangent function found on most statistical calculators. Arctangent ***X*** = the angle with *tangent* equal to ***X***. The backup computer system (BUCS) will compute this calculation. Just be sure to be in the DEGREES mode and not the RADIANS mode to avoid additional conversion. The calculation can also be done by using TM 6-230.
	NOTE: The angle of site and VA are based on the mil relation formula, which is based on the assumption that an angle of 1 mil will subtend an arc of 1 meter at a distance of 1,000 meters. However, the distance subtended by 1 mil at 1,000 meters is actually only 0.98175 meters, computed by using the following formula: $L = \frac{n}{6400} (2\pi r)$ Where: n = number of mils r = radius of the circle

Table 8-1. Determination of Site Without a GST (Continued).

STEP	ACTION
	Since there are 6,400 mils in a circle, when solving for the circumference of a circle with a radius of 1,000 meters, the use of the formula (2πr) will yield a circumference of only 6,283.1853 meters. To yield a more precise solution for the mil relation formula, the multiplication factor of 1.0186 must be applied. Note that in the previous example 0.98175 multiplied by 1.0186 is equal to 1. The GST automatically applies the conversion factor of 1.0186 by reading values opposite the M gauge point.
3	Determine the value for complementary angle of site. **| ∢SI |X CSF = CAS (±) ≈ NEAREST 0.1 MIL**
3a	Determine the value for the CSF from the TFT, Table G, Column 12 or 13. The entry argument for this table is chart range (to the nearest 10 meters). If the angle of site is plus, use Column 12. If the angle of site is minus, use Column 13. Interpolate as necessary.
	Note: Since interpolation is needed for entering Table G, a more accurate CAS is determined by using chart range to the nearest 10 meters. If speed is more important to the FDO, he may decide to use chart range to the **nearest 500 meters** as the entry argument for Table G.
3b	Multiply the CSF by the absolute value of the angle of site (step 2), and express the result to the nearest 0.1 mil. This is the complementary angle of site and will always have the same sign as the CSF (TFT).
4	Determine the value of site. Site is the algebraic sum of the angle of site and the complementary angle of site and is expressed to the nearest mil. **∢SI (±)** **+ CAS (±)** **SI (±) NEAREST 1 MIL**

8-5. Determination of Site Without a GST, Requiring Interpolation

The example in Table 8-2 uses data for the firing unit location and firing chart from Chapter 6. The following data are given:

Weapon System:	**MI09A3**
Charge:	**4GB**
Chart Rg From I/A to the Tgt (Grid 430 290):	**4,340 meters**
I/A Altitude:	**1062**
Target Altitude (Map Spot):	**1040**

Table 8-2. Determining Site Without a GST, Requiring Interpolation.

STEP	ACTION
1	Determine the vertical interval. TGT ALT 1040 - PLT ALT 1062 VI -22
2	Determine the angle of site. $\frac{\text{VERTICAL INTERVAL}}{\text{RG (IN 1,000s OF M)}} \quad \frac{-22}{4.34} \times 1.0186 = -5.2$ (∢SI)
3	Determine the value of complementary angle of site.
3a	Use chart range to the nearest 10 meters to interpolate CSF from Table G.
3b	Determine the value of the CSF. Interpolation is required. RANGE — COMP SITE FACTOR 4000 — -0.049 340 — X 500 4340 — ? -0.019 4500 — -0.068 CROSS MULTIPLY: $\frac{340}{500} = \frac{X}{-0.019}$ $500X = 340(-0.019)$ $X = \frac{340(-0.019)}{500} = -0.01292 \approx -0.013$ CSF FOR RANGE 4000 -0.049 ADD THE VALUE OF X +(-0.013) CSF FOR RANGE 4340 -0.062
3c	| ∢SI | 5.2 X CSF -0.062 CAS -0.3224 ≈ -0.3
4	Determine the value of site. ∢ SI -5.2 + CAS +(-0.3) SI -5.5 ≈ -6 (NEAREST 1 MIL)

8-6. Determination of Vertical Angle

The vertical angle is the smaller angle in a vertical plane from the horizontal to a straight line joining the observer and target. The angle of site and the vertical angle are essentially the same angles viewed from different perspectives. (See Figure 8-2.) The steps for determining VA are in Table 8-3.

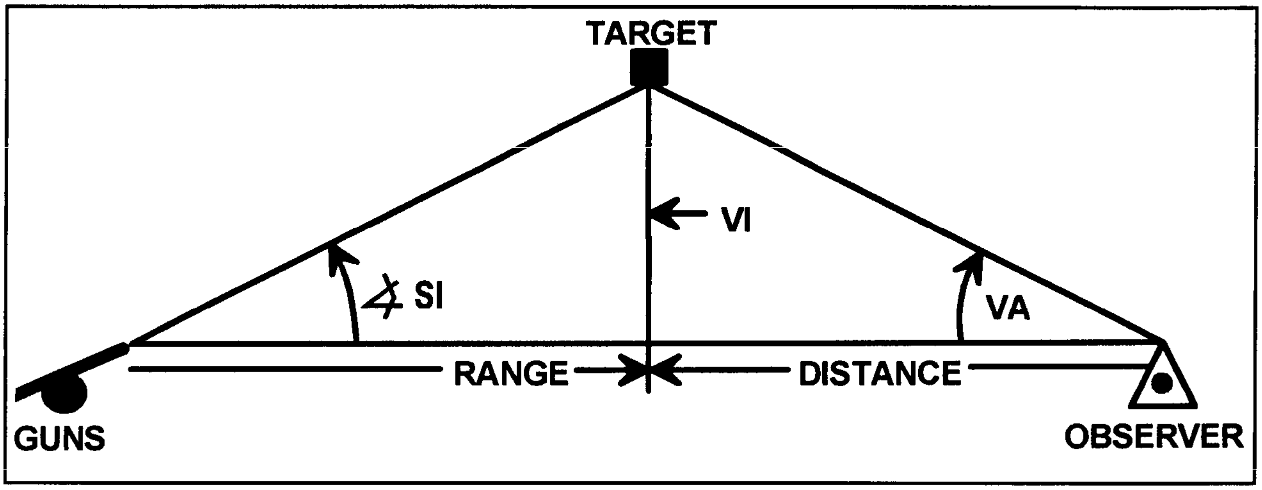


Figure 8-2. Vertical Angle.

Table 8-3. Determination of Vertical Angle.

STEP	ACTION
1	Determine the vertical interval. **TGT ALT** **- OBS ALT** **VI (±), NEAREST 1 METER**
2	Determine the vertical angle. To compute the vertical angle, use the following equation: $\frac{\text{VERTICAL INTERVAL}}{\text{DISTANCE (IN 1,000s OF M)}} \times 1.0186 = \text{VA}$
	NOTE: If VA is greater than ±100 mils, it must be computed by using the following formula: **TANGENT VA = VI/R (IN THOUSANDS)**. (See paragraph 8-4.)

8-7. The Graphical Site Table

a. The computation of site with the TFT is time consuming. The GST was developed to provide a quick and accurate computation of vertical angle, angle of site, and site. The GST can also be used to compute the vertical interval when the site, the charge, and the range are known or when the vertical angle and the distance are known. It can be used to convert yards to meters or meters to yards and to multiply and divide. Each GST is designed for a particular weapon and projectile family, and the computations are valid only for the weapon specified on the GST.

b. The GST consists of three parts: a base, a slide, and a cursor with a manufacturer's hairline. (See Figure 8-3.)

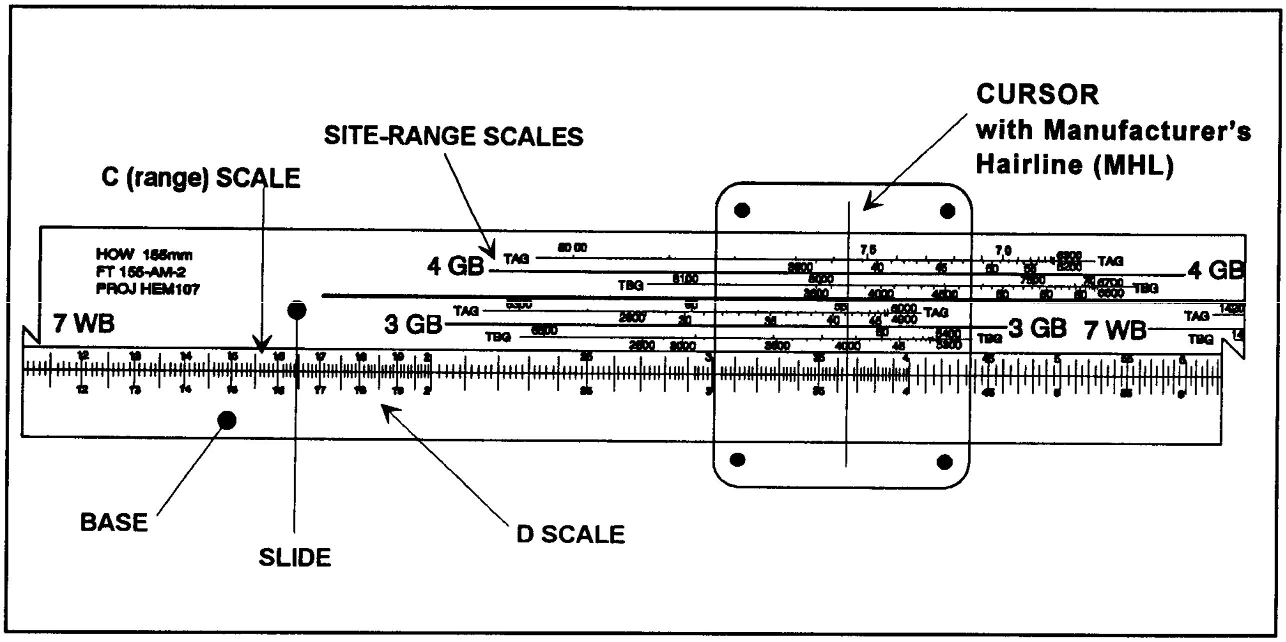


Figure 8-3. Graphical Site Table.

(1) Base. The base is marked by the D scale, which is a logarithmic scale of variable graduations. This scale is used to determine VI, VA, angle of site, and site. The accuracy depends on the values read off the scale. The back of some GSTs have instructions on how to use it.

(2) Slide. The slide is marked with a C scale, gauge points, and site-range scales.

(a) C (range) scale. This scale is identical to the logarithmic D scale, and there are two sides to the slide. The C and D scales, along with the M gauge point, are used for computing vertical interval, vertical angle, and angle of site. Multiplication and division may also be performed by using the C and D scales.

(b) Gauge points. The C scale is marked with two M (meter) and YD (yard) gauge points. The M gauge point multiplies the value opposite the C index by 1.0186, which gives a precise solution to the mil relation formula and is used in all computations **(m =1.0186 W/R).** The YD gauge point multiplies the value opposite the M gauge point by 0.9144, which gives an immediate solution to the formula: **(YARDS x 0.9144 = METERS).**

(c) Site-range scales. These scales are used to compute site when the VI and range are known or to compute the VI when the site and range are known. For each charge indicated, there are two site-range scales. One is black, marked "TAG," and the other is red, marked "TBG." Each side is placed in relation to the M gauge point so that site is read on the D scale opposite the M gauge point when VI on the D scale is divided by range on the site-range scale. The TAG and TBG scales are constructed to include CAS. They differ from each other just as the CSF for a plus angle of site differs from the CSF for a minus angle of site. The TAG scale is used when the VI is plus, and the TBG scale is used when the VI is minus. The value of site is read or placed opposite the M gauge point. When there are no site range scales for a particular charge or the scale does not include the appropriate gun target range, site for that charge must be computed manually.

(d) Range changeover point. On all GSTs for all charges, there is a point on all site-range scales where the scales begin to "double back"; that is, the cursor is moved to the left rather than to the right for an increase in range for a given VI. The range at which each scale reverses direction is called the range changeover point. The location of the changeover point can be shown by plotting site as a function of site in mils and range in meters (Figure 8-4). Recall that site equals the angle of site plus the complementary angle of site. In Figure 8-4, at the lesser ranges (5,000 to 7,000 meters), the angle of site is decreasing at a greater rate than complementary angle of site is increasing; thus, site decreases. At the longer ranges (8,000 to 9,000 meters), the angle of site is decreasing at a lesser rate than the complementary angle of site is increasing; thus, site increases. The site curve shows decreasing values up to a range of about 7,600 meters and then increasing values beyond. The range at which site is at an absolute minimum value is 7,600 meters and is the range changeover point for that charge and projectile.

(e) Cursor. The cursor has a vertical hairline, known as the manufacturer's hairline. It enables the user to place or read a value on the slide opposite another value on the base.

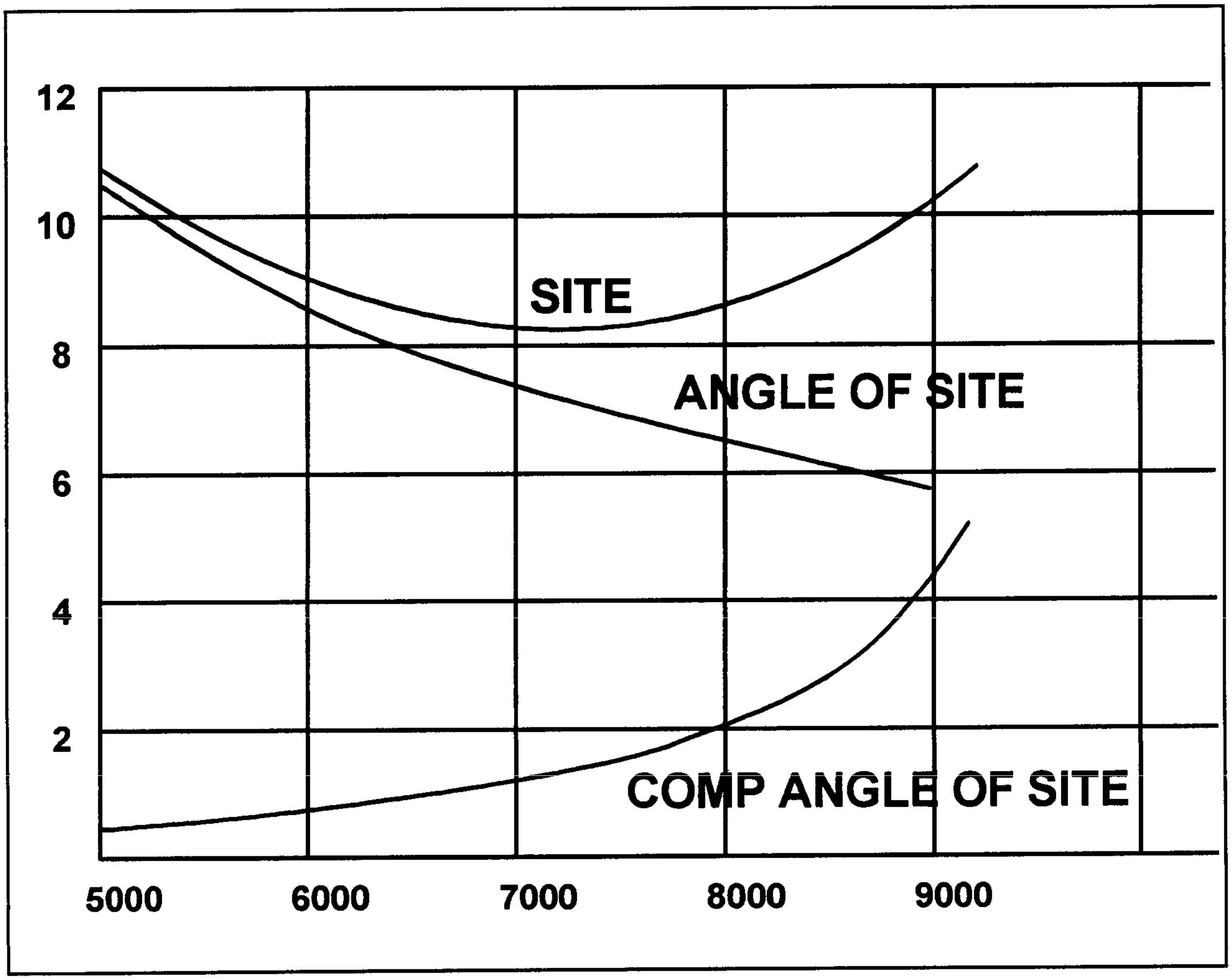


Figure 8-4. Range Changeover Graph.

8-8. Average Site

a. A considerable amount of time can be saved in mission processing if average site can be precomputed for the area of operations. As time permits after occupation, the VCO should develop a color-coded average site map (Figure 8-5). The average sites and altitudes would be listed within each color-coded area. Site is computed for vertical interval segments on the basis of ranges and charges to be used most frequently. The error in site will normally be small and is an acceptable tradeoff of accuracy for speed. When a target is plotted on the average site map, the VCO can read and announce site. This technique may not be practical in certain situations, for example, in mountainous terrain or in fast-moving situations. Here the VCO could use the altitude of the nearest preplotted target to compute site.

b. The VCO creates and improves his average site map by using the following steps.

(1) Plotting of contour intervals. The VCO color-codes his map along with selected contour intervals, creating zones with little variation in altitude. VI is based on the mean altitude in each zone. Compute site for each color-coded zone by using the range to the center of the zone and the appropriate charge. This will result in an average site to use for all targets plotted within a color-coded zone.

(2) Refining average site. As time permits, average site values can be refined by computing additional values for variations in range within a color-coded zone. This will determine if there are significant changes in site caused by changes in range. For example, site would be computed for a zone between the 300 and 320 contour intervals by using ranges throughout the zone (that is, 5,000, 6,000, 7,000). If site changes by more than 1 mil, the VCO would announce the refined site.

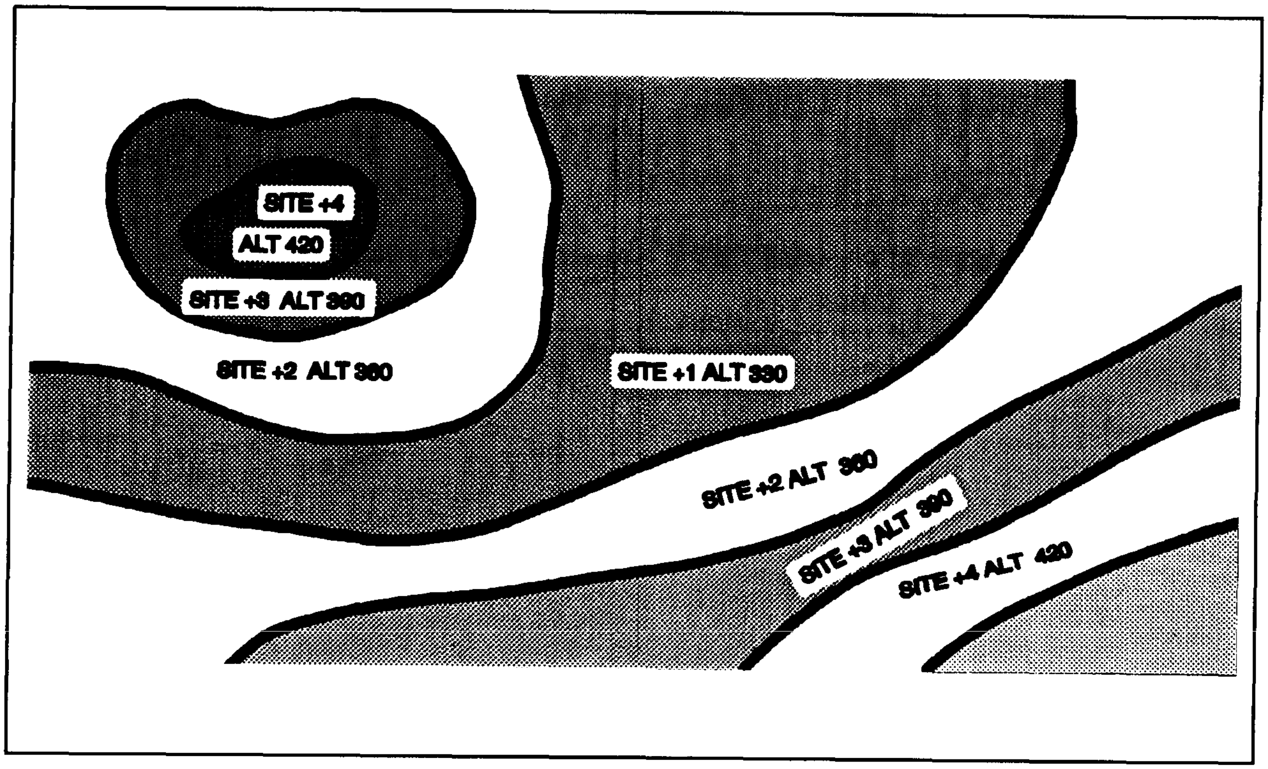
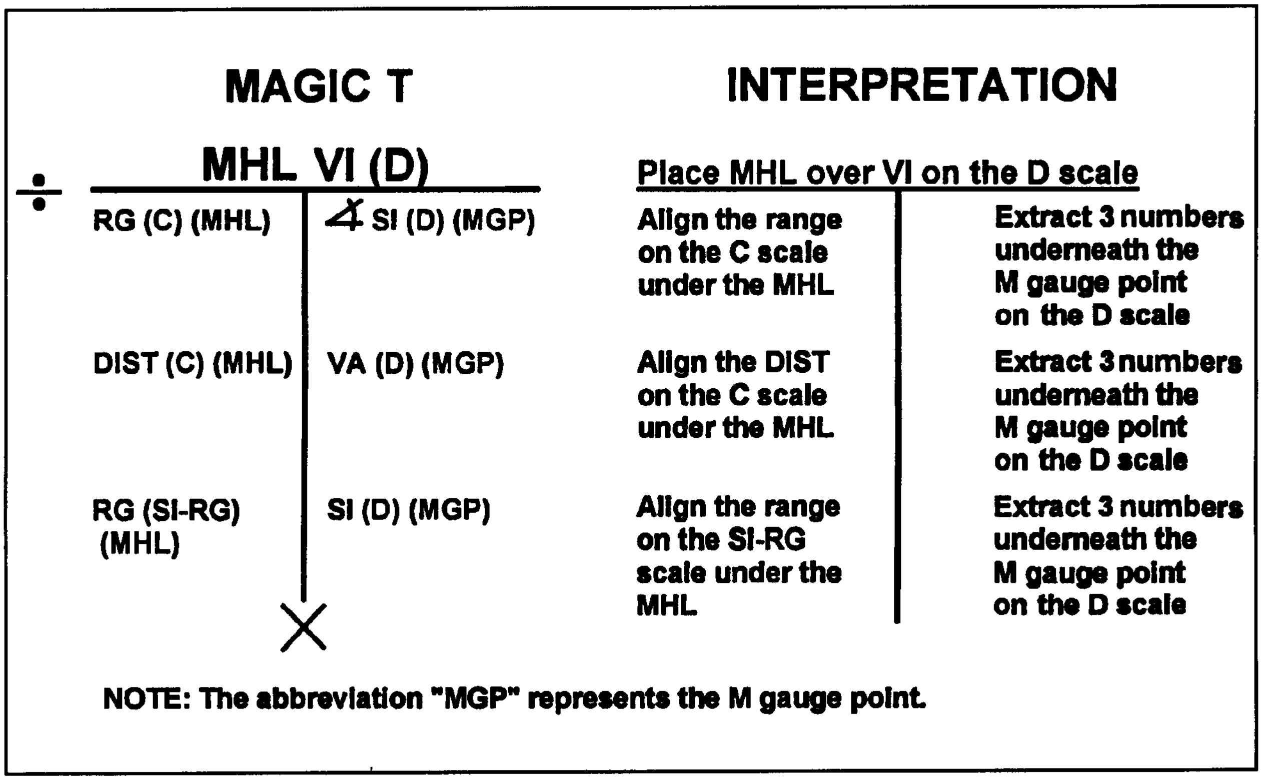


Figure 8-5. VCO Color-Coded Map, Marked With Average Site and Corresponding Altitude.

8-9. Determination of Angle of Site and Vertical Angle With the GST

a. The procedures for computing angle of site and vertical angle are the same. Both are computed by using the C and D scales and are not associated with a particular charge or a particular weapon. In each case, two values are needed: the range (or distance) to the target in meters and the number of meters the target is above or below the howitzer or observer (vertical interval.,

b. The diagram in Figure 8-6 is known as the Magic T. It can be used to help determine angle of site, VA, and site when using the GST. The horizontal line in the Magic T represents division, and the vertical line represents multiplication.



INTERPRETATION

Place MHL over VI on the D scale

Align the range on the C scale under the MHL	Extract 3 numbers underneath the M gauge point on the D scale
Align the DIST on the C scale under the MHL	Extract 3 numbers underneath the M gauge point on the D scale
Align the range on the SI-RG scale under the MHL	Extract 3 numbers underneath the M gauge point on the D scale

NOTE: The abbreviation "MGP" represents the M gauge point.

Figure 8-6. Magic T.

c. The following steps in Table 8-4 show how to determine angle of site and VA by using the GST.

Table 8-4. Determination of Angle of Site and VA by Using the GST.

STEP	ACTION
1	Determine the vertical interval by subtracting the unit (observer) altitude from the target altitude. **TGT ALT** **- UNIT ALT (OBS ALT)** **VI (±), NEAREST 1 METER**
2	Move the MHL until it is over the value of the VI on the D scale.
3	Without moving the cursor, slide the C scale until the range (distance) is directly beneath the MHL.
4	Determine the angle of site (vertical angle) underneath the M gauge point on the D scale.
4a	Extract three numbers.
4b	Determine placement of the decimal point by using "rough math." The angle of site (VA) should be close to the value determined when the VI is divided by the range (distance) in thousands. **VI ÷ RG (DIS) (IN 1,000s) = ∢ SI (VA) (APPROX)**
	NOTE: Rough math is used to approximate the placement of the decimal point. Rough math will give the operator a rough idea of the number of integers for the value of angle of site, vertical angle, or site.
4c	Express the value to the nearest 0.1 mil for angle of site and nearest 1 mil for VA. The angle of site (VA) will have the same sign as the VI.

8-10. Determination of Site With the GST

Site is computed by using the site-range and D scales. The value determined will be valid for a particular charge, weapon, and projectile family. Two values are needed--the range to the target in meters and the vertical interval. Use the steps in Table 8-5 to determine site with a GST.

Table 8-5. Determination of Site With the GST.

STEP	ACTION
1	Determine the vertical interval by subtracting the unit altitude from the target altitude. **TGT ALT** **- UNIT ALT** **VI (±), NEAREST 1 METER**
2	Move the MHL until it is over the value of the VI on the D scale.
3	Without moving the cursor, move the slide until the range is directly beneath the MHL on the appropriate site-range scale for the charge being fired. There are two site-range scales for each charge. If the VI is plus, use the TAG scale. If the VI is minus, use the TBG scale.
4	Determine site underneath the M gauge point on the D scale.
4a	Extract three numbers.
4b	Determine placement of the decimal point by using rough math. The site should be close to the value determined when the VI is divided by the range in thousands. **VI ÷ RANGE (IN 1,000s) = SI (APPROX)**
4c	Express the value to the nearest mil. Site will have the same sign as the VI.

8-11. Sample Problems

The examples in Tables 8-6 through 8-9 use data for the firing unit location, known point, and observer (T03) from Chapter 6. The following data are given:

Weapon System:	**M109A3**
Charge:	**4GB**
Chart Rg From I/A to Known Point 1:	**4,960 meters**
Distance from T03 to Known Point 1:	**1,760 meters**
I/A Altitude:	**1062**
T03 Altitude:	**1127**
Known Point 1 Altitude:	**1024**

a. Determination of Site (Manual Computation). Table 8-6 shows an example of manually determining site.

Table 8-6. Manual Computation of Site.

STEP	ACTION
1	Determine the vertical interval. TGT ALT 1024 - PLT ALT 1062 VI -38
2	Determine the angle of site. $\frac{\text{VERTICAL INTERVAL}}{\text{RG (IN 1,000s)}} \quad \frac{-38}{4.96} \times 1.0186 = -7.8$ (∢SI)
3	Determine the value of complementary angle of site. (See paragraph 8-5.) | ∢SI | 7.8 X CSF -0.091 CAS -0.7093 ≈ -0.7
4	Determine the value of site. ∢SI -7.8 + CAS +(-0.7) SI -8.5 ≈ -8 (NEAREST 1 MIL)
	NOTE: On many occasions, a GST may be needed to manually compute site if the range is not listed on the appropriate site-range scale. In these instances, the angle of site can be determined with a GST (paragraph 8-9) to the nearest 0.1 mil. The CAS is determined by using the TFT (Table 8-1).

b. Determination of Vertical Angle (Manual Computation). Table 8-7 shows an example of manually computing VA.

Table 8-7. Manual Computation of VA.

STEP	ACTION
1	Determine the vertical interval. **TGT ALT 1024** **- OBS ALT 1127** **VI -103**
2	Determine the vertical angle. $\frac{\textbf{VERTICAL INTERVAL}}{\textbf{DIS (IN 1,000s)}}$ $\frac{-103}{1.76}$ **X 1.0186 = VA -59.6 ≈ -60 (NEAREST 1 MIL)**

c. Determination of Angle of Site and Vertical Angle With the GST. Table 8-8 shows an example of determining angle of site and VA with the GST.

> **NOTE:** The values in parentheses pertain to the observer and the determination of VA.

Table 8-8. Determination of Angle of Site and VA With a GST.

STEP	ACTION
1	Determine the vertical interval. **TGT ALT 1024** **- PLT ALT (OBS ALT) 1062 (1127)** **VI -38 (-103)**
2	Move the MHL until it is over the value of the VI on the D scale.
3	Without moving the cursor, slide the C scale until the range (distance) is directly beneath the MHL.
4	Determine the angle of site (VA) underneath the M gauge point on the D scale.
4a	Extract three numbers (digits from GST): **∢SI is 780 and VA is 596.**
4b	Determine placement of the decimal point by using rough math. The angle of site (VA) should be close to the value determined when the VI is divided by the range (distance) in thousands. **VI -38 (-103)** **÷ RG (DIS)(IN 1,000s) 4.96 (1.76)** **∢SI (VA)(APPROX) -7.66 (-58.52)**
4c	Express the value to the accuracy in Table 8-4, step 4c: **∢SI -7.80 ≈ -7.8 (VA -59.6 ≈ -60)**. The angle of site (VA) has the same sign as the VI: **∢SI -7.8 (VA -60).**

d. Determination of Site With a GST. Table 8-9 shows an example of determining site with a GST.

Table 8-9. Determination of Site With a GST.

STEP	ACTION
1	Determine the vertical interval. TGT ALT 1024 - PLT ALT 1062 VI -38
2	Move the MHL until it is over the value of the VI on the D scale.
3	Without moving the cursor, move the slide until the range (4960) is directly beneath the MHL on the appropriate site-range scale for the charge being fired. Use charge 4GB, TBG scale.
4	Determine site underneath the M gauge point on the D scale.
4a	Extract three numbers (digits from GST) (849).
4b	Determine placement of the decimal point by using rough math. The site should be close to the value determined when the VI is divided by the range in thousands. VI -38 ÷RANGE (IN 1,000s) 4.96 SI (APPROX) -7.66
4c	Express the value to the nearest mil: **SI -8.49 ≈ -8.** Site will have the same sign as the VI.

8-12. High-Angle Site

a. Site is always computed for high-angle fire and added to the determined angle of elevation, which yields high-angle QE. However, site may have a relatively small effect in high-angle fire because of the large angle of fall. Therefore, if the angle of site is small **and the FDO directs** to ignore it, then site **may be** ignored.

b. In high-angle fire, an increase in the angle of elevation decreases range. A decrease in the angle of elevation increases range. The complementary site factors, found in Table G of the TFT, are relatively large (greater than 1) and are the opposite sign of the VI and angle of site. Therefore, the site will have the opposite sign of the VI and angle of site.

c. High-angle site is determined by using the CSF (TFT) or the 10-mil site factor from the GFT. Using the GFT is the preferred method. The reading obtained from the 10-mil site factor scale is the actual site for each 10 mils of angle of site. The site is computed by multiplying the angle of site, divided by 10, by the 10-mil site factor. The 10-mil site factor is always negative.

8-13. Determination of High-Angle Site With the TFT

The procedures for computing high-angle site with a TFT (Table 8-10) are the same as low-angle manual computations of site (Table 8-l). A GST can be used to compute the angle of site.

Table 8-10. Determination of High-Angle Site With the TFT.

STEP	ACTION
1	Determine the VI by subtracting the unit altitude from the target altitude. **TGT ALT** **- UNIT ALT** **VI (±), NEAREST 1 METER**
2	Determine the angle of site. To compute angle of site, use the following equation: $\frac{\textbf{VERTICAL INTERVAL}}{\textbf{RG (IN 1,000s OF M)}}$ **X 1.0186 = ∢SI(±)(NEAREST 0.1 MIL)**
3	Determine the value for the CSF from the TFT, Table G, Column 12 or 13. The entry argument for this table is chart range (to the nearest 10 meters). If the angle of site is plus, use Column 12. If the angle of site is minus, use Column 13. Interpolate as necessary.
	NOTE: Since interpolation is necessary, a more accurate CAS is determined by using chart range to the nearest 10 meters. If speed is more important to the FDO, he may decide to use chart range to the **nearest 500 meters** as the entry argument for Table G.
4	Determine the CAS by multiplying the absolute value of angle of site (step 2) by the CSF (step 3), and express the result to the nearest 0.1 mil. CAS will have the same sign as the CSF. **| ∢SI |** **X CSF** **CAS (±) (NEAREST 0.1 MIL)**
5	Determine the site by algebraically adding the angle of site to the CAS, and express the result to the nearest 1 mil. It will be a signed value. **∢SI** **+ CAS** **SI (±) NEAREST 1 MIL**

8-14. Determination of High-Angle Site With a High-Angle GFT

The use of the high-angle GFT to determine site is the preferred method. (See Table 8-11.)

Table 8-11. Determination of High-Angle Site With a High-Angle GFT.

STEP	ACTION
1	Determine the VI by subtracting the unit altitude from the target altitude. **TGT ALT** **- UNIT ALT** **VI (±), NEAREST 1 METER**
2	Determine angle of site with the GST (paragraph 8-9).
3	Determine the 10-mil site factor by placing the MHL over the range on the GFT. The 10-mil site factor is always negative.
4	Determine site by dividing angle of site (step 2) by 10; then multiply this value by the 10-mil site factor (step 3). Express this value to the nearest 1 mil, and determine the appropriate sign. It will have the opposite sign of the VI. **(ANGLE OF SITE ÷ 10) X 10-MIL SITE FACTOR = SITE.**

8-15. Determination of 10-Mil Site Factor Without a High-Angle GFT

The 10-mil site factor is the value of high-angle site for every 10 mils of angle of site. The 10-mil site factor can be determined manually by solving two equal equations for the 10-mil site factor.

$$\text{SI} = \measuredangle\text{SI} + \text{CAS (FOR LOW AND HIGH ANGLE)}$$

$$\text{SI} = \measuredangle\text{SI} + (\left|\measuredangle\text{SI}\right| \times \text{CSF})$$

FOR POSITIVE ∢SI:

$$\measuredangle\text{SI} = \measuredangle\text{SI}\ (1 + \text{CSF})$$

USING HIGH-ANGLE GFT:

$$\text{HI}\measuredangle\text{SI} = \frac{\measuredangle\text{SI}}{10} \times \text{10-MIL SI FACTOR}$$

$$\frac{\measuredangle\text{SI}}{10} \times \text{10-MIL SI FACTOR} = \measuredangle\text{SI}\ (1 + \text{CSF})$$

DIVIDE BOTH SIDES BY $\frac{\measuredangle\text{SI}}{10}$

$$\text{10-MIL SI FACTOR} = 10\ (1 + \text{CSF})$$

NOTE: If the 10-mil site factor is not listed on the high-angle GFT, use the last listed value or change charges.

The FDC can compute high-angle site by manually determining the 10-mil site factor for those situations when a high-angle GFT is not available. The 10-mil site factor from the GFT actually reflects the complementary angle of site for a positive VI. Therefore, this method will introduce a slight inaccuracy when estimating for negative VIs.

Chapter 9

FIRE MISSION PROCESSING

In the battery or platoon FDC, all actions are oriented toward timely and accurate fire mission processing. All actions must provide the best possible flow of information between FDC personnel. The battery or platoon FDC must be trained to determine responsive and accurate firing data. Upon receipt of a call for fire, FDC personnel must work as a team to accomplish many tasks at the same time. (See Figure 9-1.)

Section I

Duties and the Record of Fire

This section implements STANAG 2934 and QSTAG 225.

Understanding the duties within the FDC is imperative. All activity supports the computer. He determines and records firing data on the record of fire. He is also the link to the howitzers, because he transmits the fire commands.

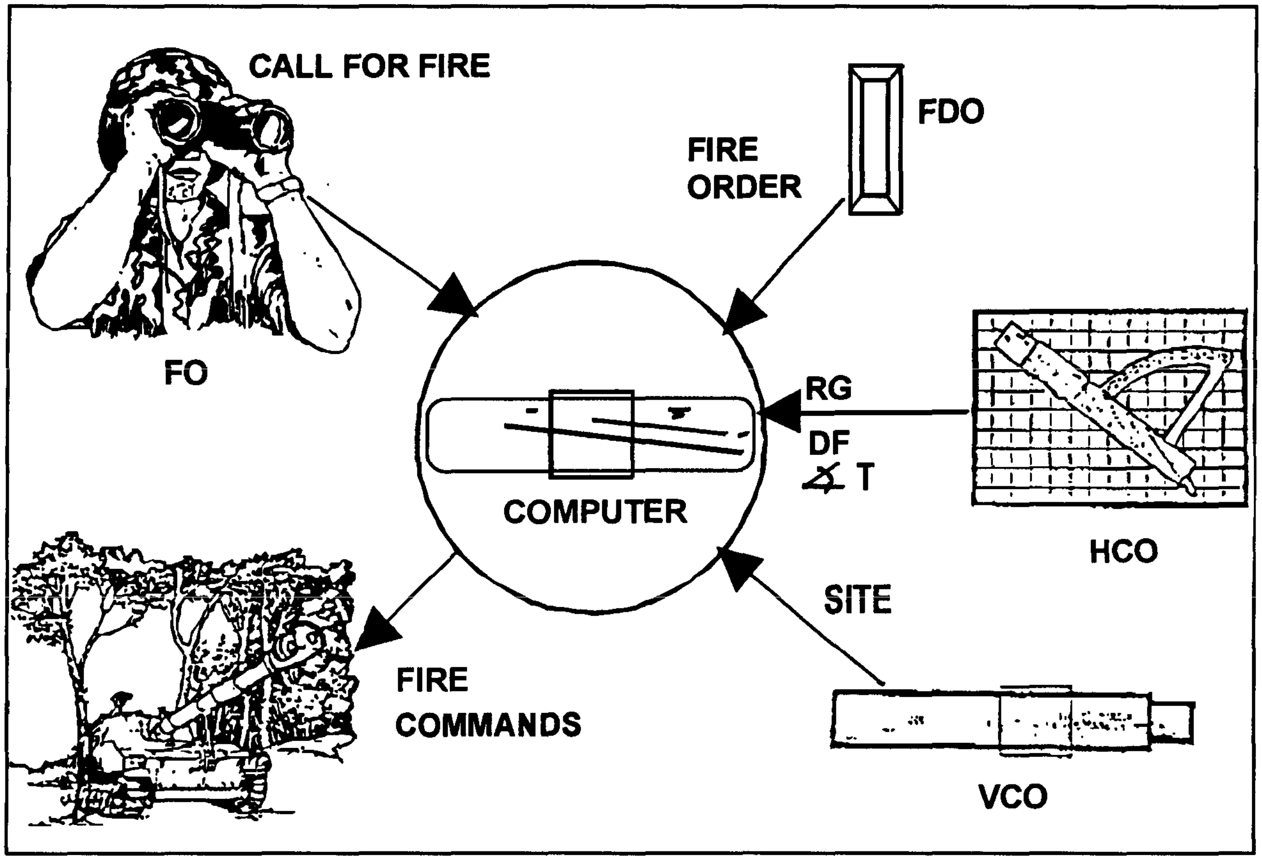


Figure 9-1. Flow of Information Between the Gunnery Team.

9-1. Crew Duties for the FDC

The procedures in Table 9-1 should be used to facilitate mission processing and ensure responsiveness. (For automated FDC crew duties, see Appendix F.)

Table 9-1. Mission Processing.

FDC PERSONNEL	ACTION
	A call for fire is received in the FDC.
	NOTE: The * indicates that actions so marked are accomplished at the same time.
RATELO*	Receives and records the CFF (authenticates if necessary) and announces **FIRE MISSION** to the FDC.
ALL	Announce **FIRE MISSION**.
COMPUTER*	Announces **FIRE MISSION** to the howitzer(s).
RATELO	Announces (or records on mission board) the CFF to the FDC. (Ensures a loud readback to the observer.)
HCO*	Reads back target location and plots target. Determines chart range and deflection.
VCO*	Plots target and determines chart range and deflection and target altitude.
FDO or Chief*	1) Plots the target on the situation map and verifies it is safe and does not violate any fire support coordinating measures (FSCMs).
	2) Decides how to attack the target and issues the fire order (FO) to the FDC.
COMPUTER	Reads back FO and records it on record of fire.
COMPUTER*	Records and announces initial fire commands to the howitzer(s) up to and including fuze. This is based on the CFF and FO (FDO or chief monitors).
RATELO*	Composes and transmits the MTO according to the CFF and FO (FDO or chief monitors).
COMPUTER	Records MTO on record of fire.
HCO	Announces chart range to the computer; for example, **1/A, RANGE 5980**.
VCO	Announces **CHECK** or **HOLD** (±30 meters).
COMPUTER	If **CHECK** is announced, places announced range under the MHL of the appropriate GFT.
	If **HOLD** is announced, FDO or chief verifies charts and determines which range to use.
COMPUTER	Reads back range that is set on the GFT (for example, **RANGE 5980**) and records range on the ROF.
HCO	Announces chart deflection to computer (for example, **DEFLECTION 3286**).
VCO	Announces **CHECK** or **HOLD** (±3 mils).
COMPUTER	If **CHECK** is announced, records the announced chart deflection on the ROF.
	If **HOLD** is announced, FDO or chief verifies charts and determines which deflection to use.
COMPUTER	1) Reads back chart deflection.
	2) Determines and records elevation. (Refer to Appendix F for assistance when determining data with or without a GFT setting.) (Refer to Appendix G for assistance when determining data with or without a GFT setting.)
	3) If firing fuze time, determines, announces, and records fuze setting.
	4) If firing fuze VT, determines, records, and announces FS.
	5) Determines and records deflection correction on ROF.
	6) Determines, records, and announces deflection to fire.

Table 9-1. Mission Processing (Continued).

FDC PERSONNEL	ACTION
VCO	Determines and announces site.
COMPUTER	1) Records site on ROF.
	2) Determines and records quadrant elevation on ROF.
	3) Announces QE to FDO or chief for verification.
FDO or Chief	1) Ensures all data are correct.
	2) Verifies the data are safe by using the safety T.
	a) If data are safe, announces **SAFE**.
	b) If data are unsafe, announces **UNSAFE** and states the reason why; for example, **UNSAFE, QUADRANT ELEVATION THREE MILS BELOW MINIMUM SAFE QE**).
COMPUTER	1) If data are safe, announces QE to howitzer(s).
	2) Records and announces MOF I/E, if applicable.
	3) Polices the ROF.
HCO and VCO	Orient target grid on firing charts, and await any subsequent corrections from the observer.
VCO	Updates ammo board as time permits.
	NOTE: During 24-hour operation, the FDC chief will assume the duties of the FDO. The FDO or chief will supervise all actions of FDC personnel.

9-2. Elements of Firing Data

The data determined from the firing chart must be converted to firing data that can be placed on the weapon and ammunition. These data consist of the charge, fuze setting (when applicable), deflection, and quadrant elevation to be fired.

a. Shell. Shell is the projectile to be fired. The projectile will have a direct impact on determining the remaining elements since firing tables are based on the projectile.

b. Charge. The amount of propellant to be fired with artillery ammunition is varied by the number of propellant increments. The charge selected is based on the range to the target and the tactical situation.

c. Fuze. Fuze is the fuze to be fired. The fuze will have a direct impact on determining the quadrant elevation when firing mechanical time fuzes.

d. Fuze Setting. When a projectile with a mechanical time or proximity fuze is fired, the computer determines a fuze setting to be set on the fuze that should cause it to function at the desired point along the trajectory. Fuze setting is a function of elevation. This fuze setting is determined from the TFT or GFT. Some projectiles may also be fired with a point-detonating fuze, which can be set for delay action.

e. Deflection. The deflection to fire is the deflection announced to the howitzer. To compute deflection to fire, apply the deflection correction to the announced chart deflection by using the LARS rule (left, add; right, subtract). Determine the deflection correction by adding the GFT deflection correction to the drift corresponding to the initial elevation. (GFT deflection correction is discussed in Chapter 10.)

f. Quadrant Elevation. Quadrant elevation is the algebraic sum of site and the angle of elevation. Quadrant elevation is the angle through which the tube of the howitzer must be elevated from the base of the trajectory to cause the trajectory to pass through the target.

(1) Elevation. The angle of elevation is the vertical angle between the base of the trajectory and the axis of the bore required for a projectile to achieve a prescribed range under standard conditions.

(2) Site. If the target and the howitzer are not at the same altitude, site will be determined. Site is combined with elevation to cause the trajectory to pass through the target. If the target and howitzer are at the same altitude, site is announced as zero.

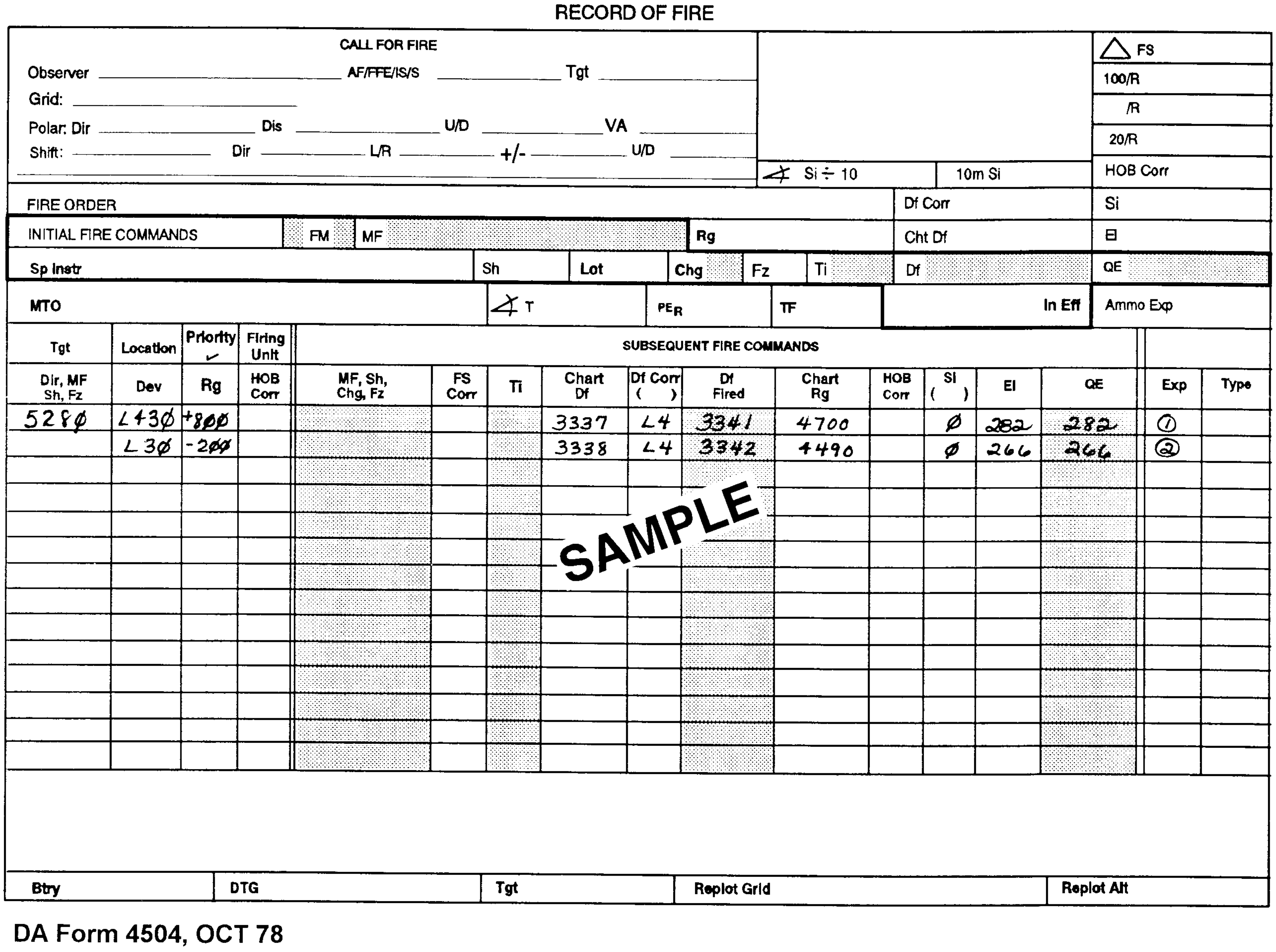
9-3. Recording Firing Data

a. DA Form 4504 (Record of Fire) is a legal document used for determiningg and recording iring data. It is organized to allow a smooth flow in determining and processing afire mission. It is used for the following:

- Recording the call for fire.
- Computing and recording firing data for all types of fire missions.
- Keeping a permanent record of a fire mission, to include the type and amount of ammo expended during the mission.

b. On DA Form 4504 (Figure 9-2), the heavy black lines indicate major sections of the form. Shaded portions denote items that must be announced to the howitzer sections. The use of each block on the record of fire is explained below.

(1) Call for fire block. The CFF announced by the observer is recorded in this block. (See Figure 9-3.) Table 9-2 explains each item and its use.



RECORD OF FIRE

CALL FOR FIRE

Observer ________ AF/FFE/IS/S ________ Tgt ________

Grid: ________

Polar: Dir ________ Dis ________ U/D ________ VA ________

Shift: ________ Dir ________ L/R ________ +/- ________ U/D ________

		△ FS
		100/R
		/R
		20/R
∡ Si ÷ 10	10m Si	HOB Corr

FIRE ORDER		Df Corr	Si
INITIAL FIRE COMMANDS	FM	MF	Rg	Cht Df	El

Sp Instr	Sh	Lot	Chg	Fz	Ti	Df	QE
MTO	∡ T	PE_R	TF	In Eff			Ammo Exp

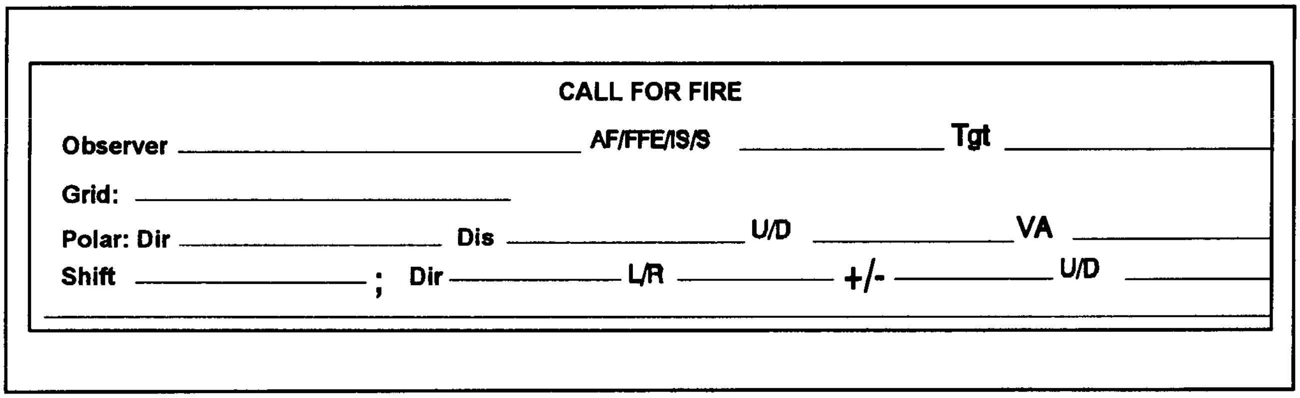
Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS													
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
5280	L430	+800					3337	L4	3341	4700		0	282	282	①	
	L30	-200					3338	L4	3342	4490		0	266	266	②	

SAMPLE

Btry	DTG	Tgt	Replot Grid	Replot Alt

DA Form 4504, OCT 78

Figure 9-2.



CALL FOR FIRE

Observer ________ AF/FFE/IS/S ________ Tgt ________

Grid: ________

Polar: Dir ________ Dis ________ U/D ________ VA ________

Shift ________ ; Dir ________ L/R ________ +/- ________ U/D ________

Figure 9-3. Call for Fire Block.

Table 9-2. Call for Fire Block Items.

ITEM	ACTION
Observer ___	Used to record the **call sign** of the observer.
AF/FFE/IS/S ___	Used to record the **mission type**. Choices are AF (adjust fire), FFE (fire for effect), IS (immediate suppression), and S (suppression). The blank line is used for other types; for example, immediate smoke.
Tgt ___	Used to record the **target number** sent by the observer in suppression missions.
Grid: ___	Used to record the **grid and altitude** for the grid method of target location.
Polar:Dir ___	Used to record the **observer direction** to the target, in mils, for the polar method of target location.
Dis ___	Used to record the **observer distance** to the target, in meters, for the polar method of target location.
U/D ___	Used to record the **vertical shift correction**, in meters, for the polar method of target location. Circle U (up) or D (down).
VA ___	Used to record the **vertical angle**, in mils, for the polar method of target location. VA is a signed (±) value.
Shift ___:	Used to record the **known point or target number** from which the observer is shifting for the shift from a known point method of target location.
Dir ___	Used to record the **direction** to the known point or target, in mils, for the shift from a known point method of target location.
L/R ___	Used to record the **lateral shift** to the target, in meters, for the shift from a known point method of target location. Circle L (left) or R (right).
+/- ___	Used to record the **range correction** to the target, in meters, for the shift from a known point method of target location. Circle + (add) or - (drop).
U/D ___	Used to record the **vertical shift correction** to the target, in meters, for the shift from a known point method of target location. Circle U (up) or D (down).

(2) Computational space and related data blocks. These blocks are used to compute and record data used in determining firing data. (See Figure 9-4.) Table 9-3 explains each item and its use.

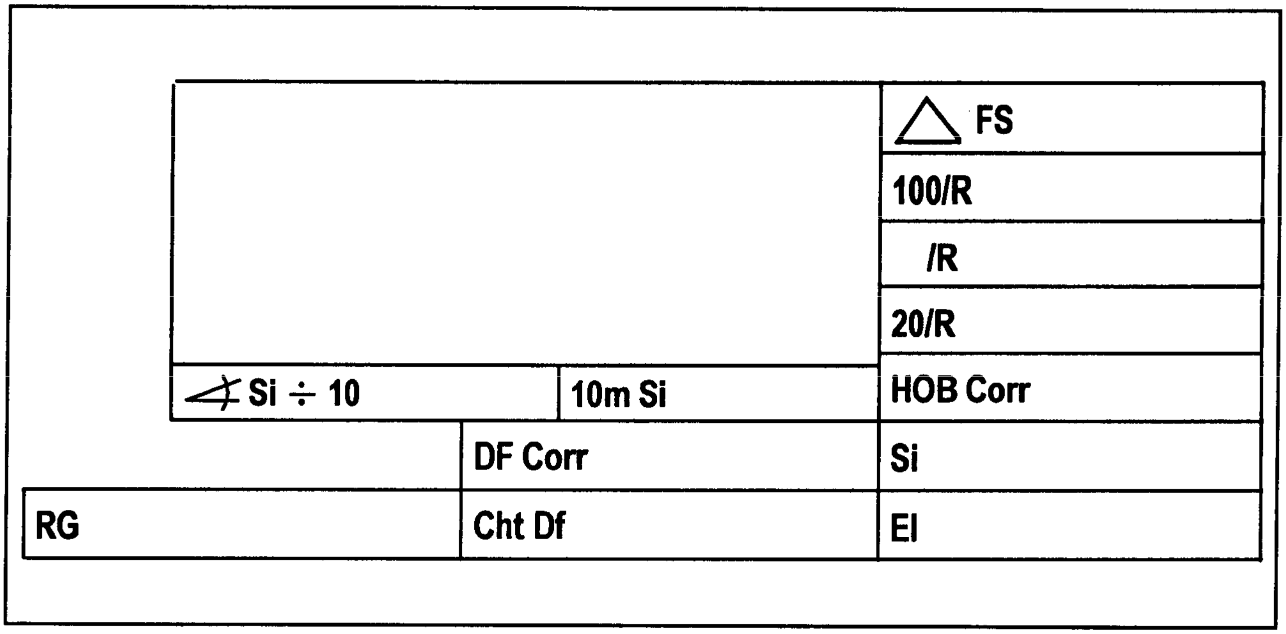


Figure 9-4. Computational Space and Related Data Blocks.

Table 9-3. Computational Space and Related Data Blocks Items.

ITEM	ACTION
Computational Space	Used to record computational data, such as determining VI and deflection correction.
∢Si÷10	Used to record **∢ Si÷10** when computing site for high-angle fire missions.
10m Si	Used to record the **10-mil site factor** when computing site for high-angle fire missions.
Df Corr	Used to record the **deflection correction** to be used for a fire mission.
Rg	Used to record the initial **chart range** for a fire mission.
Chart Df	Used to record the initial **chart deflection** for a fire mission.
▲FS	Used to record **▲FS/▲10MHOB**. This is used to compute a change in FS for a 10-meter change in HOB and is recorded after the first time the fuze is fired.
100/R	Used to record **100/R**. This is used to move the burst 100 meters laterally or vertically.
/R	Used to record the **/R**. This is used to move a burst other than 100 or 20 meters vertically or laterally.
20/R	Used to record **20/R**. This is used to move the burst 20 meters laterally or vertically.
HOB Corr	Used to record the **height of burst correction** if a time fuze is used in the initial volley.
Si	Used to record the **site** for a fire mission. Site is a signed (±) value.
El	Used to record the initial **elevation** for a fire mission.

(3) Fire order and initial fire commands block. The fire order announced by the FDO and the initial fire commands transmitted to the howitzers are recorded in this block. (See Figure 9-5.) Table 9-4 explains each item and its use.

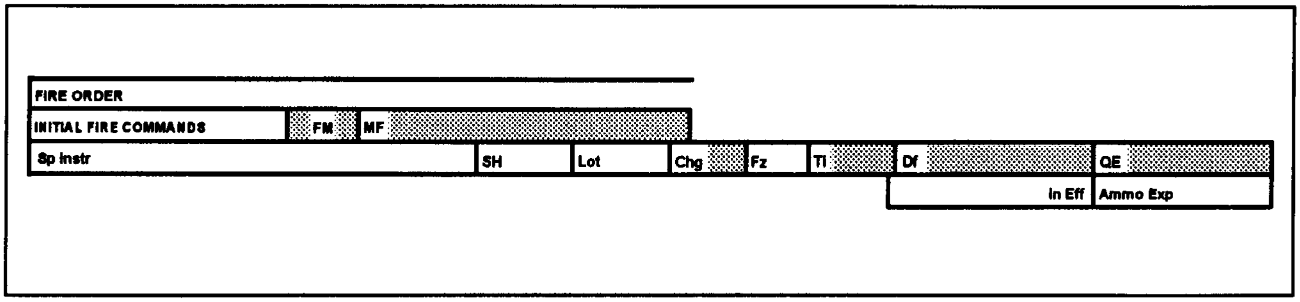

FIRE ORDER
INITIAL FIRE COMMANDS | FM | MF
Sp Instr | SH | Lot | Chg | Fz | Ti | Df | QE
In Eff | Ammo Exp

Figure 9-5. Fire Order and Initial Fire Commands Block.

Table 9-4. Fire Order and Initial Fire Commands Block Items.

ITEM	ACTION
FIRE ORDER	Used to record the fire order.
INITIAL FIRE COMMANDS	
FM	Used to check or circle the warning order **FIRE MISSION** sent to the howitzer(s).
MF	Used to record the **pieces to follow, pieces to fire, and method of fire**.
Sp Instr	Used to record any **special instructions** sent to the howitzer(s).
Sh	Used to record the **shell**, if other than standard, sent to the howitzer(s).
Lot	Used to record the **ammunition lot**, if other than standard, sent to the howitzers. There are two lot designators (projectile and propellant) for separate-loading ammunition and one lot designator for the projectile for semifixed ammunition.
Chg	Used to record the **charge** fired in a fire mission.
Fz	Used to record the **fuze**, if other than standard, sent to the howitzer(s).
Ti	Used to record the **fuze setting** for mechanical time or variable time fuzes sent to the howitzer(s).
Df	Used to record the initial **deflection to fire** sent to the howitzer(s).
QE	Used to record the initial **quadrant elevation** sent to the howitzer(s).
in Eff	Used to record the **method of fire for effect**. This is the number and shell-fuze combination in effect.
Ammo Exp	Used to record the **ammunition expenditure**. This is the number of rounds fired with initial fire commands. The number of rounds is recorded when computed and circled when fired.

(4) Message to observer block. The message to observer, angle T, probable error in range, and time of flight are recorded in this block. (See Figure 9-6.) Data determined but not sent are recorded in parentheses. Table 9-5 explains each item and its use.

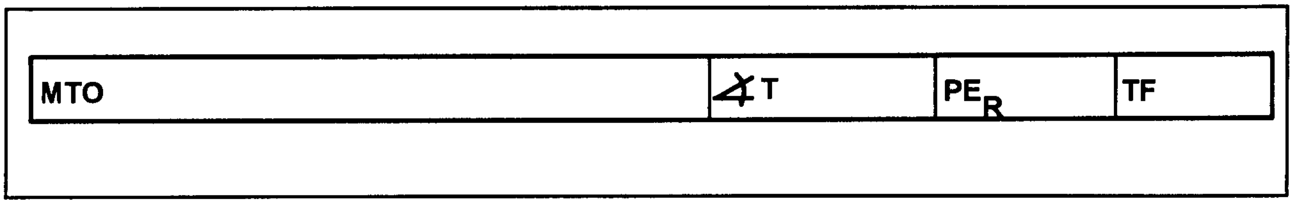

MTO | ∡T | PE_R | TF

Figure 9-6. Message to Observer Block.

Table 9-5. Message to Observer Block Items.

ITEM	ACTION
MTO	Used to record the **message to observer** sent to the observer for a fire mission.
∢T	Used to record the angle T for a fire mission. Angle T is sent to the observer if it is greater than or equal to 500 mils. The actual value is recorded and then expressed to the nearest 100 mils before being sent.
PE$_R$	Used to record the **probable error in range** for a fire mission. Probable error in range is sent to the observer when it is greater than or equal to 38 meters for an area fire mission or 25 meters for a registration, destruct mission, or FPF.
TF	Used to record the **time of flight** of the projectile for a fire mission.

(5) Fire planning and observer subsequent corrections block. Fire plans or subsequent corrections transmitted by the observer are recorded in this block. (See Figure 9-7.) Table 9-6 explains each item and its use.

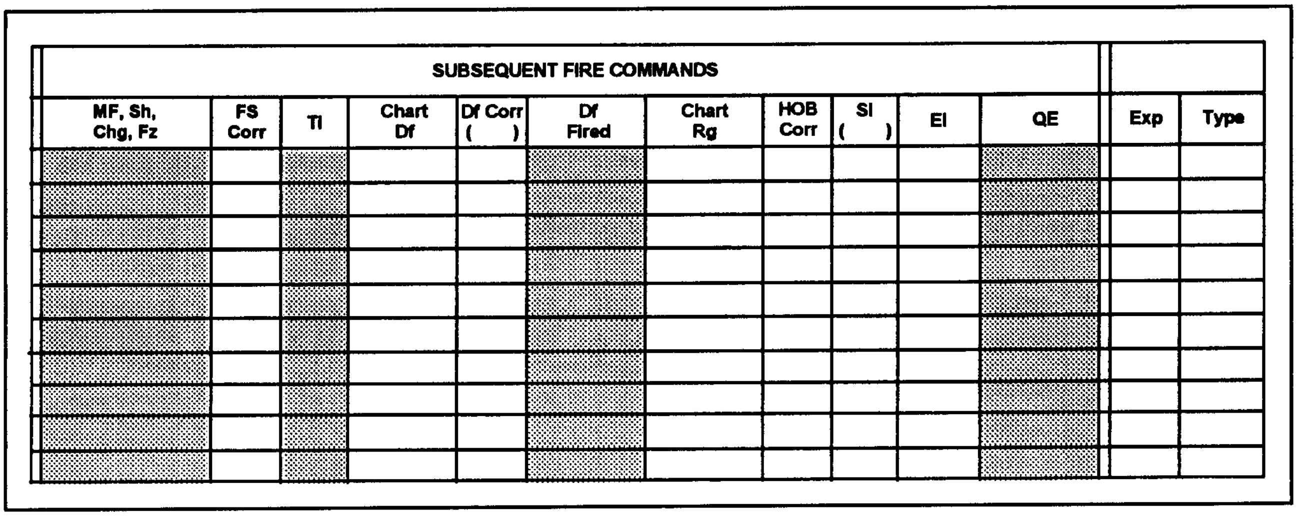
Tgt	Location	Priority ✓	Firing Unit
Dir, MF Sh, Fz	Dev	Rg	HOB Corr

Figure 9-7. Fire Planning and Observer Subsequent Corrections Block.

Table 9-6. Fire Planning and Observer Subsequent Corrections Block Items.

ITEM	ACTION
Tgt	Used to record the **target number** for fire plan targets.
Location	Used to record the **grid location** for a fire plan target.
Priority	Used to record a check mark to indicate a **priority target**.
Firing Unit	Used to record the **unit to fire** for fire plan targets.
Dir, MF, Sh, Fz	Used to record the **direction, method of fire, shell, or fuze** for a fire mission.
Dev	Used to record the **deviation** correction sent by the observer.
Rg	Used to record the **range** correction sent by the observer.
HOB Corr	Used to record the **height of burst correction** sent by the observer. Other items may be recorded in this block, such as FFE, EOM, and so on.

(6) Subsequent fire commands block. Fire commands are recorded in this block. (See Figure 9-8.) Data placed in parentheses indicate data that were determined but not sent because of no change. Table 9-7 explains each item and its use.



SUBSEQUENT FIRE COMMANDS												
MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	SI ( )	El	QE	Exp	Type
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		
▨		▨			▨					▨		

Figure 9-8. Subsequent Fire Commands Block.

Table 9-7. Subsequent Fire Commands Block Items.

ITEM	ACTION
MF, Sh, Chg, Fz	Used to record the **method of fire, shell, charge, or fuze** if changed from the initial fire commands.
FS Corr	Used to record the **fuze setting correction** for mechanical time or VT fuzes.
Ti	Used to record the **fuze setting** for mechanical or VT fuzes.
Chart Df	Used to record the subsequent **chart deflection** as announced by the HCO once the observer's corrections have been applied.
Df Corr	Used to record the **deflection correction** for a fire mission. In low-angle fire, this will normally be the same as the initial deflection correction. In high-angle fire, drift is determined for each round and recorded here.
Df Fired	Used to record the **deflection to fire** sent to the howitzer(s) for subsequent rounds.
Chart Rg	Used to record the subsequent **chart range** as announced by the HCO once the observer's corrections have been applied.
HOB Corr	Used to record the **height of burst** correction determined for a fire mission.
SI ( )	Used to record the **site** for a fire mission. This will normally be the same as the initial site unless it is recomputed.
El	Used to record the **elevation** determined by the computer for subsequent rounds.
QE	Used to record the **quadrant elevation** sent to the howitzer(s) for subsequent rounds.
Exp and Type	Used to record the **ammunition expenditure and shell-fuze type**. This portion of the record of fire is used to indicate a total number of rounds fired of a particular shell and fuze up to that point in the mission. When the shell and/or fuze changes, the count is restarted and the previous shell or fuze is recorded. Upon completion of the mission, the computer uses this total, by type, to subtract from the ammo count. Place a check mark after the type when this number is subtracted from the unit's ammo count. The number of rounds is recorded when computed and circled when fired.

(7) Computational space and administrative blocks. These are the lower computational areas used to record required data or conduct computations. (See Figure 9-9.) Table 9-8 explains each item and its use.

Btry	DTG	Tgt	Replot Grid	Replot Alt

Figure 9-9. Computational Space and Administrative Blocks.

Table 9-8. Computational Space and Administrative Blocks Items.

ITEM	ACTION
Btry	Used to record the **firing unit** who fired the mission.
DTG	Used to record the **date-time group** the unit entered the FFE phase of the mission.
Tgt	Used to record the **target number** assigned to the mission.
Replot Grid	Used to record the **replot grid** when replot is conducted.
Replot Alt	Used to record the **replot altitude** when replot is conducted.

Section II

HIGH EXPLOSIVES

The HE projectile is the base round for the HE family ofprojectiles. The HE projectile is available in all cannon weapon systems (105 mm, 155 mm). The HE ballistic family includes the antipersonnel improved conventional munitions, illumination, chemical, and smoke.

9-4. Overview

a. HE projectiles are hollow steel cases filled with explosives (trinitrotoluene [TNT] or composition B). They can be fuzed for air, surface, or subsurface burst. HE projectiles are used against personnel and material objects because of blast and fragmentation effects.

b. Determination of firing data for a point-detonating (Q), mechanical time super quick, time, or variable time fuze mated to an HE projectile is almost identical. Only minor procedural differences exist. Data are determined from the GFT, GST, and TFT.

c. The HE-quick shell-tie combination is the ammunition used for the basic fire mission. Chart data are determined to the target. The computer determines data with the GFT. The procedures for computing data **without a GFT setting** areas outlined in Table 9-9.

Table 9-9. Computation of Data Without a GFT Setting.

ITEM	ACTION
RANGE	**Range is the base scale.** The MHL is placed over the range, and all elements that are a function of range can be determined.
100/R	**100/R is a function of range.** (To determine 100/R, the MHL is placed directly over the range.) It is determined from the 100/R scale and expressed to the nearest mil. It can be determined manually by dividing 100 by range expressed in thousandths multiplied by 1.0186.
El	**Elevation is a function of range**. (To determine elevation, the MHL is placed directly over the range.) It is determined from the elevation scale and is expressed to the nearest mil.
Drift	**Drift is a function of elevation**. (To determine drift, the MHL is placed directly over the elevation.) It is determined from the drift scale and expressed to nearest mil. Drift is always recorded as a left (L) correction.
M582/M564 FS	**Fuze setting is a function of elevation**. (To determine FS, the MHL is placed directly over the elevation.) It is determined from the appropriate fuze setting scale (TF/M582 or M564) and expressed to the nearest tenth (0.1) of a FS increment.
TOF	**Time of flight is a function of elevation**. (To determine TOF, the MHL is placed directly over the elevation). It is determined from the TF/M582 scale and expressed to the nearest **whole** second.
VT FS	**Variable time fuze setting is a function of elevation**. (To determine VT FS, the MHL is placed directly over the elevation). It is determined from TF/M582 scale and expressed by vanishing the tenths and applying a .0 (express down). If the value extracted from the TF/M582 scale is already determined to the whole second, there is no need to express down.
▲FS/▲10M HOB	**Change in fuze setting for a change of 10 meters in HOB is a function of FS**. (To determine delta FS, the MHL is placed directly over the FS.) It is determined from the ▲FS/▲10m HOB scale and expressed to the nearest hundredth (0.01).

NOTE: Under normal circumstances, FDC personnel will be able to determine a GFT setting. The determination and explanation of a GFT setting is covered in Chapter 10. When a GFT setting is applied, certain elements of data will be determined as described below.

- EI--Elevation is determined by placing the MHL over the range and reading the elevation scale directly under the elevation gauge line (EGL).
- FS--Fuze setting is determined by placing the MHL over the range and reading the appropriate fuze scale directly under the time gauge line (TGL). The TGL is valid only for the registering fuze.

NOTE: The **fire order SOP and fire command standards** in Figure 9-10 are used for all the examples found in this chapter.

FIRE ORDER SOP		
ELEMENT		**SOP**
1	UNIT TO FIRE	PLATOON
2	ADJUSTING ELEMENT AND/OR MOF Projectile in adj Ammo lot & charge in adj Fuze in adj	#3 1 RD FDO or COMPUTER SELECT
3	BASIS FOR CORRECTIONS	USE GFT
4	DISTRIBUTION	PARALLEL
5	SPECIAL INSTRUCTIONS	OBSR SELECT
6	METHOD OF FIRE FOR EFFECT	FDO WILL ANNOUNCE
7	PROJECTILE I/E	OBSR SELECT
8	AMMO LOT & CHARGE I/E	FDO or COMPUTER SELECT
9	FUZE I/E	OBSR SELECT
10	TARGET NUMBER	NEXT AVAILABLE

FIRE COMMAND STANDARDS		
ELEMENT		**STANDARD**
1	WARNING ORDER	
2	PIECES TO FOLLOW/PIECES TO FIRE/METHOD OF FIRE	
3	SPECIAL INSTRUCTIONS	
4	PROJECTILE	HE
5	AMMUNITION LOT	AG
6	CHARGE	
7	FUZE	Q
8	FUZE SETTING	
9	DEFLECTION	
10	QUADRANT	
11	METHOD OF FIRE IN FIRE FOR EFFECT	

Figure 9-10. Fire Order SOP and Fire Command Standards.

9-5. Examples of Completing the Record of Fire for HE Fire Missions

a. HE/Q Adjust-Fire Mission. Use the steps in Table 9-10 to process an HE/Q adjust-fire mission. Figure 9-11 shows an example ROF for this type of mission.

Table 9-10. HE/Q Adjust-Fire Mission.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records as directed by the fire order.
	Sh	Computer announces and records if other than standard.
	Lot	Computer announces and records if other than standard.
4	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If it is not announced in the fire order, the computer will determine the charge.
7	Chart Df	HCO determines and announces chart deflection. Computer records it.
8	El	Computer determines and records elevation.
9	Drift	Computer determines and records drift in the computational space.
10	Df Corr	Computer records deflection correction. Because there is no GFT setting available, this element will be the same as drift.
11	Df	Computer determines, announces, and records the deflection to fire (**DF CORR + CHT DF = DF TO FIRE**).
12	SI	VCO determines and announces site. Computer records it.
13	QE	Computer determines, announces, and records quadrant elevation (**SI + EL = QE**).
14	In Eff	Computer announces and records the method of fire for effect.
15	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) has been fired, the computer circles the number.
16	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.

b. Police of Record of Fire. Use the steps in Table 9-11 to police the record of fire.

Table 9-11. Police of the Record of Fire.

STEP	REFERENCE	ACTION
1	Delta FS (▲FS)	Determine after the first time fuze is fired.
2	100/R	Always determined and expressed to the nearest mil.
3	20/R	Always determined and expressed to the nearest mil.
4	Computational Space	Computer records the VCO's math steps used to determine VI.
5	Ammo Exp	Computer circles the number of rounds when the howitzer(s) have fired.
6	TF	Computer determines and records the TOF. If it is not sent to the observer during the mission, it is placed in parentheses.
7	PE$_R$	Computer determines and records the PE$_R$. If PE$_R$ is less than 38, then <38 is recorded in parentheses. If it is greater than or equal to 38, then the actual value is recorded and transmitted to the observer by the RATELO.
8	∢T	When direction is received, the HCO determines and announces angle T. Computer records it to the nearest 10 mils and places it in parentheses. If it is greater than or equal to 500 mils, it is recorded again to the nearest 100 mils (if not already expressed to 100 mils) and transmitted to the observer by the RATELO.
9	SI( )	Computer records the site in the parentheses at the top of the SI column. During subsequent corrections, record this value on each line used to compute fire commands.
10	Df Corr ( )	Computer records the deflection correction in the parentheses at the top of the Df Corr column. During subsequent corrections, record this value on each line used to compute fire commands.
11	Exp and Type	Computer circles the number of rounds when the howitzer(s) have fired.
12	Surveillance	Computer records end of mission surveillance in the lower computational space if sent by the observer.
13	Tgt	Computer records the target number assigned to this mission at the bottom of the ROF.
14	DTG	Computer records the date and time the unit entered the FFE phase of the mission. If FFE is never entered, then the computer records the DTG of when the unit ended the mission.
		NOTE: If local time is not used, then the time zone designator must be entered in the DTG.
15	Btry	Computer records the battery or platoon designation.

c. HE/Q Fire Mission. Use the steps in Table 9-12 for a subsequent adjustment of an HE/Q fire mission. An example ROF for this entire mission is shown in Figure 9-ll.

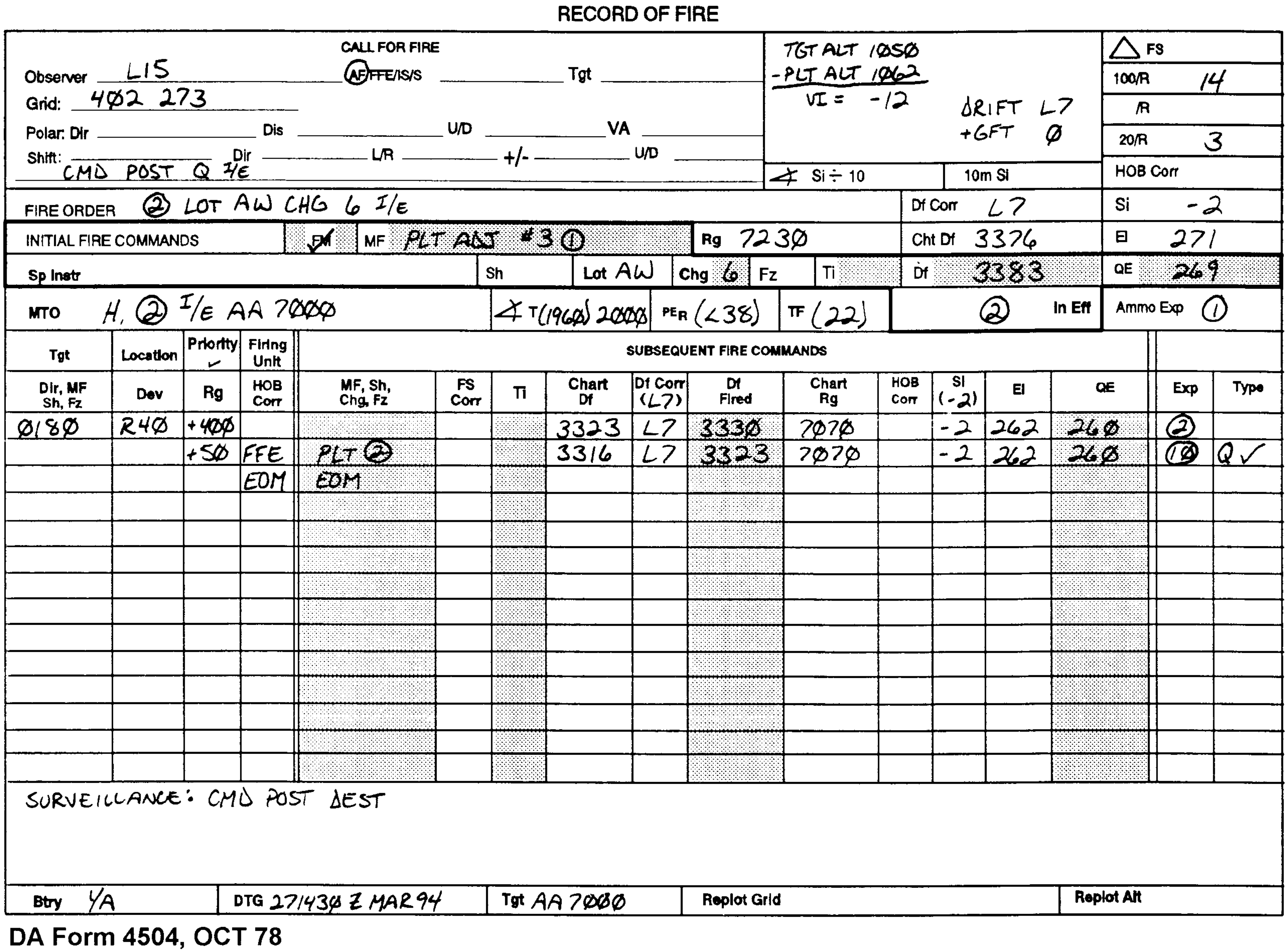
Table 9-12. Subsequent Adjustment of an HE/Q Fire Mission.

STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's direction and subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
3	Chart Rg	HCO determines and announces chart range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
4	Chart Df	HCO determines and announces chart deflection. Computer records it.
5	El	Computer determines and records elevation.
6	Df	Computer determines, records, and announces deflection **(CHT DF + DF CORR = DF)**.
7	QE	Computer determines, records, and announces QE **(EL + (SI)= QE)**.
8	Exp and Type	Computer determines and records the total number of rounds (by type) fired to this point.
9	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Repeat steps 1 through 9 as necessary to complete the observer's corrections. These steps are valid until the observer changes fuze or projectile. Site and deflection correction are not recomputed; the observer will correct for inaccuracies or changes through adjustments. An example ROF for this entire mission is shown in Figure 9-11.	

d. High-explosive With Mechanical Time (M582).

(1) Determining data for an HE/ti round is exactly the same as HE/Q except for the HOB correction and the fuze setting correction.

(2) A time fuze achieves the best effects on the target when it functions at a 20-meter HOB. To achieve the 20-meter HOB, the trajectory of the projectile must be altered to cause the projectile to pass 20 meters above the target. By applying the mil-relation formula in a vertical plane, the amount of mils the trajectory needs to be altered at any range is 20/R. When the value of 20/R is used as the HOB correction, it will always be a positive value. The HOB correction is included in the computation of QE. The HOB correction is added to the site (ground site), and a total site is determined. This total site is applied to elevation to determine QE. The HOB correction is applied only to the initial time QE.



RECORD OF FIRE

CALL FOR FIRE

Observer LIS [✓ AF]/FFE/IS/S Tgt

Grid: 402 273

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

CMD POST Q I/E

TGT ALT 1050
-PLT ALT 1062
VI = -12

DRIFT L7
+GFT 0

∢ Si ÷ 10

10m Si

△ FS

100/R 14

/R

20/R 3

HOB Corr

FIRE ORDER ② LOT AW CHG 6 I/E

Df Corr L7

Si -2

INITIAL FIRE COMMANDS [✓ FM] MF PLT ADJ #3 ①

Rg 7230

Cht Df 3376

El 271

Sp Instr

Sh

Lot AW

Chg 6

Fz

Ti

Df 3383

QE 269

MTO H, ② I/E AA 7000

∢ T(1960) 2000

PE_R (∠38)

TF (22)

② In Eff

Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L7)	Df Fired	Chart Rg	HOB Corr	Si (-2)	El	QE	Exp	Type
0180	R40	+400					3323	L7	3330	7070		-2	262	260	②	
		+50	FFE	PLT ②			3316	L7	3323	7070		-2	262	260	⑩	Q ✓
			EOM	EOM												

SURVEILLANCE: CMD POST DEST

Btry Y/A DTG 271430 Z MAR 94 Tgt AA 7000 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 9-11. Example Record of Fire for an HE/Q Adjust-Fire Mission.

(3) If subsequent adjustments for the HOB are necessary, then the FS is the only element of firing data that is recomputed. Deflection and QE will remain the same. A FS correction will be applied to the previous fuze setting. The FS correction will be a multiple of ▲ FS/ ▲ 10M HOB. The ▲ FS moves the functioning of the fuze along the trajectory by increments of 10 meters. The observer will adjust the HOB by transmitting HOB corrections (up or down) to the nearest 5 meters. The observer's corrections in meters must be converted to corrections in FS. The observer's HOB correction is divided by 10 and then multiplied by ▲ FS/ ▲ l0M HOB. This value is expressed to the nearest tenth (0.1) of a FS increment. Before this can be applied as a FS correction, it must have a sign (±). The sign is based on the direction (up or down) of the observer's correction. If the correction is up, then the fuze functioned late and the FS correction must be subtracted. If the correction is down, then the fuze functioned early and the FS correction must be added. Simply stated, for an up correction, the FS correction is negative; for a down correction, the FS correction is positive. An easy rule to remember is USDA (up, subtract; down, add).

e. HE/Ti (M582) Fire Mission With HE/Q in Adjustment.

(1) Process the HE/Q adjustment as outlined in paragraph 9-5. Once the observer has requested a change in fuze type to a mechanical time fuze, process the request as described in Table 9-13. Figure 9-12 shows an example ROF for this type of mission.

Table 9-13. HE/Ti (M582) Fire Mission With HE/Q in Adjustment.

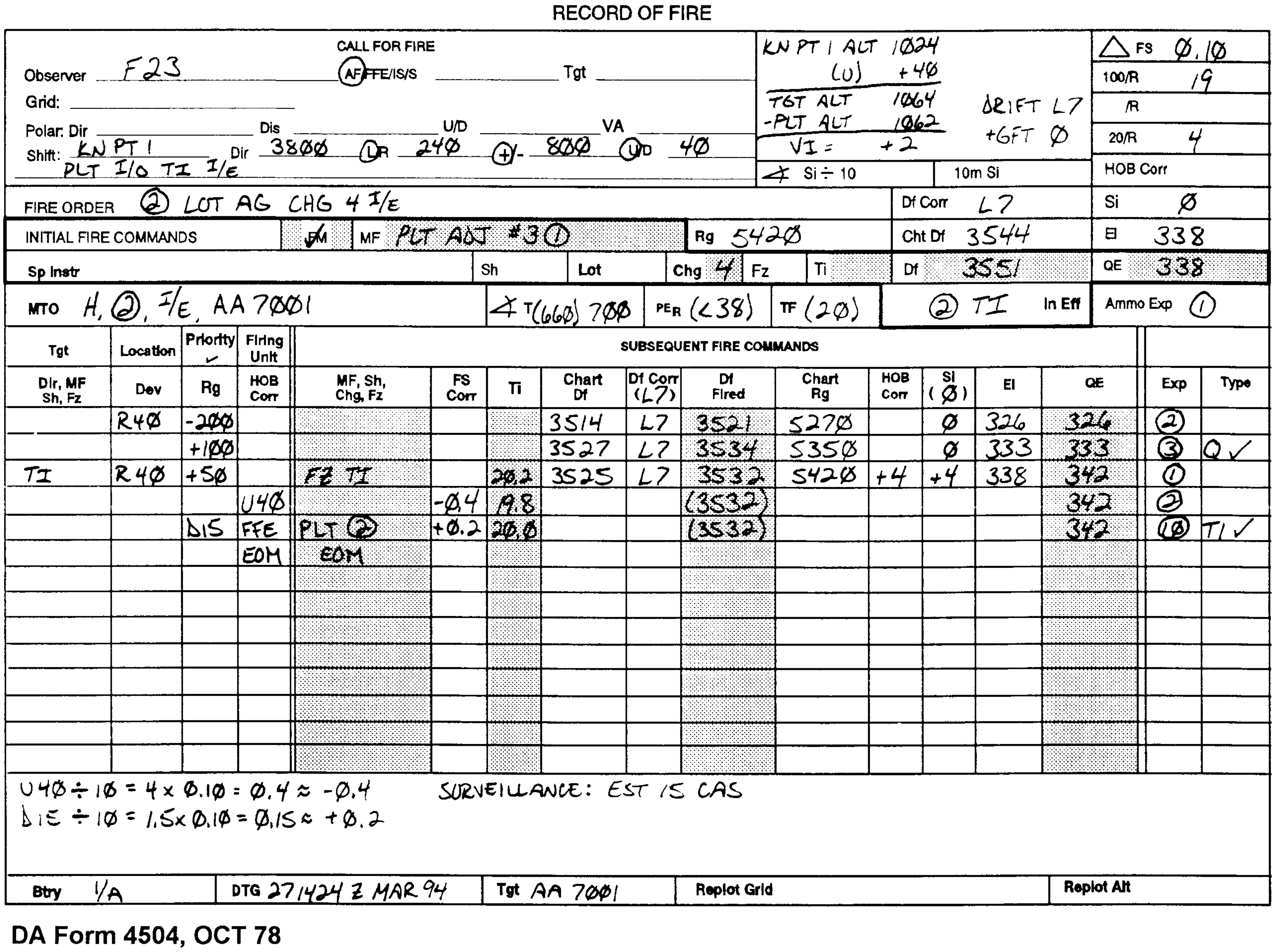
STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze. Computer announces **FUZE TIME**.
3	Chart Rg	HCO determines and announces chart range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
4	Chart Df	HCO determines and announces chart deflection. Computer records it.
5	El	Computer determines and records elevation.
6	Ti	Computer determines, announces, and records the time setting.
7	Df	Computer determines, records, and announces deflection **(CHT DF + DF CORR = DF)**.
8	HOB Corr	Computer determines and records the HOB Corr. 20/R is the HOB correction, and it is a signed value (+).
9	SI	Computer determines site. The HOB correction (step 8) is algebraically added to the previously determined ground site. The result is **total site**. It is recorded in the SI block.
10	QE	Computer determines, records, and announces QE **(EL + TOTAL SITE = QE)**.
11	Exp and Type	Computer determines and records the total number of fuze Q rounds fired. When the shell or fuze type changes, the count starts over and the previous type fired to this point is totaled.
12	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
		NOTE: Ensure ▲FS is determined during policing of the ROF. If the observer adjusts the HOB, it will be needed to recompute the FS. The FS determined in step 6 is used to determine ▲FS.

(2) If a 20-meter HOB was not achieved, the fuze setting must be adjusted. At this point in the mission, the observer does not make any range or deviation corrections. The only corrections are for HOB. Therefore, the only firing data that will change are the fuze setting. Use the steps in Table 9-14 to adjust the fuze setting, Figure 9-12 shows an example ROF for this type of mission.

Table 9-14. Adjustment of Time Fuze.

STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
3	FS Corr	Computer determines and records FS correction. The FS correction is determined by dividing the HOB correction by 10 and multiplying this value by ▲FS. The result is expressed to the nearest tenth and is a signed value (USDA). The computations are placed in the bottom computational space of the ROF **(HOB CORR÷ 10) X ▲FS = FS CORR).**
4	Ti	Computer determines, announces, and records the fuze setting. The fuze setting is determined by applying the FS correction to the previous fuze setting fired.
5	Df	Computer records deflection in parentheses (it does not change).
6	QE	Computer records and announces QE.
7	Exp and Type	Computer determines and records the total number of rounds by type. When the shell or fuze type changes, the count starts over and the previous type fired to this point is totaled.
8	Police of the	Computer ensures that all data pertaining to the ROF mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Repeat steps 1 through 8 as necessary to process the observer's HOB correction. An example of this mission is shown in Figure 9-12.	

f. HE/Ti (M582) FFE Mission. Use Table 9-15 for processing an HE/Ti (M582) FFE fire mission. Figure 9-13 shows an example ROF for this type of mission.



RECORD OF FIRE

CALL FOR FIRE

Observer F23 [✓ AF] FFE/IS/S Tgt

Grid:

Polar: Dir Dis U/D VA

Shift: KN PT 1 Dir 3800 [✓ L] R 240 [✓ +] / - 800 [✓ U] D 40
PLT I/O TI I/E

KN PT 1 ALT 1024
(U) +40
TGT ALT 1064
-PLT ALT 1062
VI = +2
DRIFT L7
+GFT 0
∡ Si ÷ 10
10m Si

△ FS 0.10
100/R 19
/R
20/R 4
HOB Corr
Si 0
El 338
QE 338

FIRE ORDER ② LOT AG CHG 4 I/E

Df Corr L7

INITIAL FIRE COMMANDS ✓FM MF PLT ADJ #3 ①

Rg 5420

Cht Df 3544

Sp Instr Sh Lot Chg 4 Fz Ti

Df 3551

MTO H, ②, I/E, AA 7001

∡T (660) 700

PER (∠38)

TF (20)

② TI In Eff

Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L7)	Df Fired	Chart Rg	HOB Corr	Si (0)	El	QE	Exp	Type
	R40	-200					3514	L7	3521	5270		0	326	326	②	
		+100					3527	L7	3534	5350		0	333	333	③	Q ✓
TI	R40	+50		FZ TI		20.2	3525	L7	3532	5420	+4	+4	338	342	①	
			U40		-0.4	19.8			(3532)					342	②	
		Δ15	FFE	PLT ②	+0.2	20.0			(3532)					342	⑩	TI ✓
			EOM	EOM												

U40 ÷ 10 = 4 × 0.10 = 0.4 ≈ -0.4
Δ15 ÷ 10 = 1.5 × 0.10 = 0.15 ≈ +0.2

SURVEILLANCE: EST 15 CAS

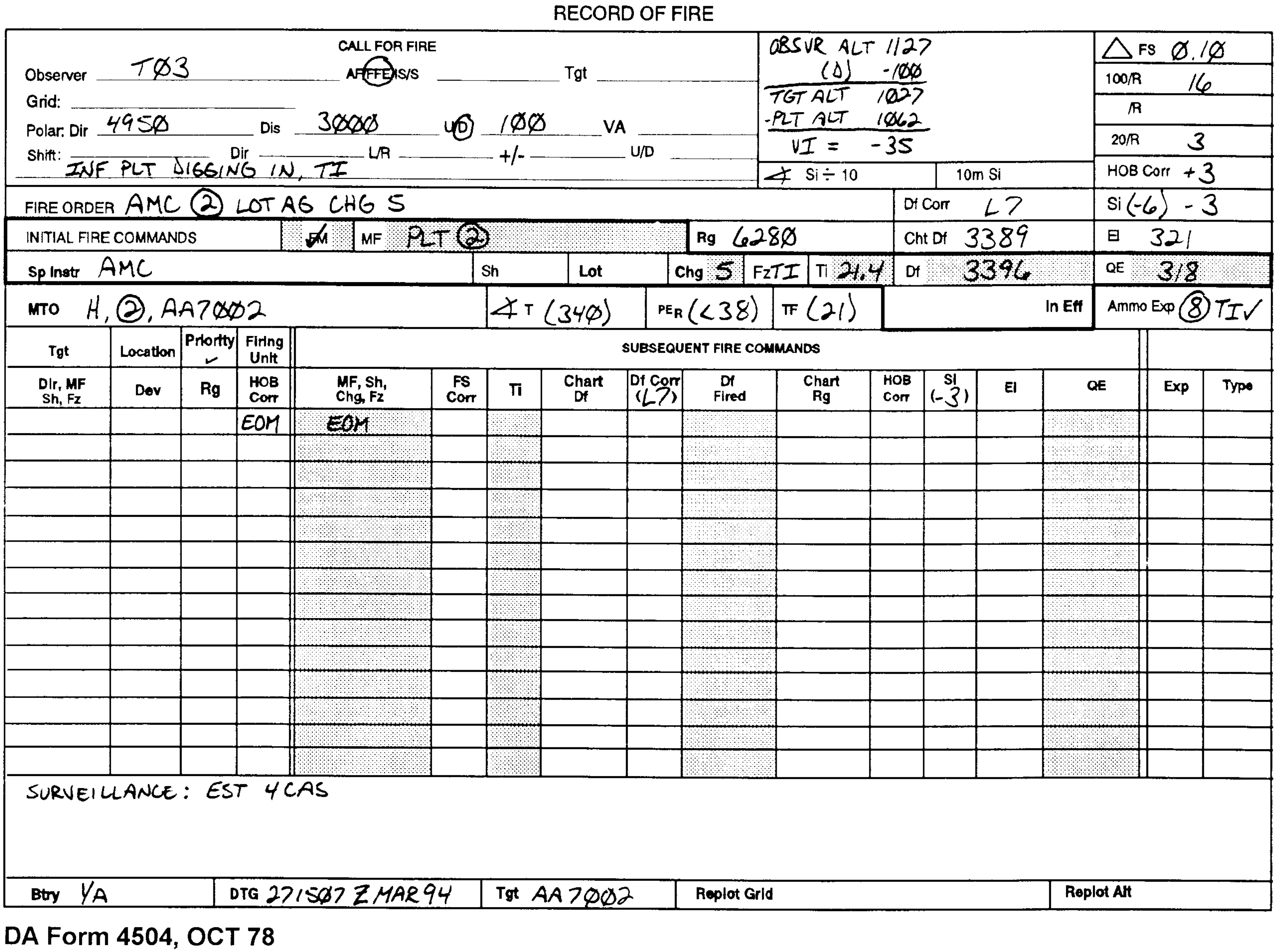
Btry 1/A DTG 271424 Z MAR 94 Tgt AA 7001 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 9-12. Example ROF for an HE/Ti (M582) Adjust-Fire Mission.

Table 9-15. HE/Ti (M582) FFE Fire Mission Process.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records as directed by the fire order.
	Sh	Computer announces and records if other than standard.
	Lot	Computer announces and records if other than standard.
4	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces chart range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If it is not announced in the fire order, the computer will determine the charge.
7	Fz	Computer records and announces fuze time.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	El	Computer determines and records elevation.
10	Ti	Computer determines, announces, and records the time setting.
11	Drift	Computer determines drift and records it in the computational space.
12	Df Corr ( )	Computer records deflection correction. Because there is no GFT setting available, this element will be the same as drift.
13	Df	Computer determines, announces, and records the deflection to fire (**DF CORR + CHT DF = DF TO FIRE**).
14	100/R	Computer determines and records 100/R.
15	20/R	Computer determines 20/R and expresses it to the nearest mil (**100/R 5 = 20/R**).
16	HOB Corr	Computer determines and records the HOB correction. 20/R is the HOB correction, and it is a signed value (+).
17	Ground SI	VCO determines and announces site. Computer records the ground site in parentheses.
18	SI ( )	Computer determines and records total site (**HOB CORR + (GROUND SI) = TOTAL SI**).
19	QE	Computer determines, announces, and records quadrant elevation (**TOT SI + EL = QE**).
20	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) has been fired, the computer circles the number.
21	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations. (See Figure 9-13.)



RECORD OF FIRE

CALL FOR FIRE

Observer T03 AF [✓ FFE] IS/S Tgt

Grid:

Polar: Dir 4950 Dis 3000 U [✓ D] 100 VA

Shift: Dir L/R +/- U/D

INF PLT DIGGING IN, TI

OBSVR ALT 1127
(D) -100
TGT ALT 1027
-PLT ALT 1062
VI = -35

∡ Si ÷ 10 10m Si

△ FS 0.10
100/R 16
/R
20/R 3
HOB Corr +3
Si (-6) -3

FIRE ORDER AMC ② LOT A6 CHG 5

Df Corr L7

INITIAL FIRE COMMANDS ✓ FM MF PLT ②

Rg 6280

Cht Df 3389

El 321

Sp Instr AMC Sh Lot Chg 5 FzTI Ti 21.4 Df 3396 QE 318

MTO H, ②, AA7002 ∡T (340) PE$_R$ (<38) TF (21) In Eff

Ammo Exp ⑧ TI✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L7)	Df Fired	Chart Rg	HOB Corr	Si (-3)	El	QE	Exp	Type
			EOM	EOM												

SURVEILLANCE: EST 4CAS

Btry 1/A DTG 271507 Z MAR94 Tgt AA7002 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 9-13. Example ROF for an HE/Ti (M582) FFE Fire Mission.

g. High-Explosive With Variable Time (M732/M728).

(1) The variable time, or proximity fuze, is designed to function at a predetermined HOB (7 meters for M728/732). No HOB correction is needed because of the low HOB. The VT has a built-in radio transmitter-receiver. The fuze transmits a signal. When the reflected signal reaches a certain strength, the fuze will function.

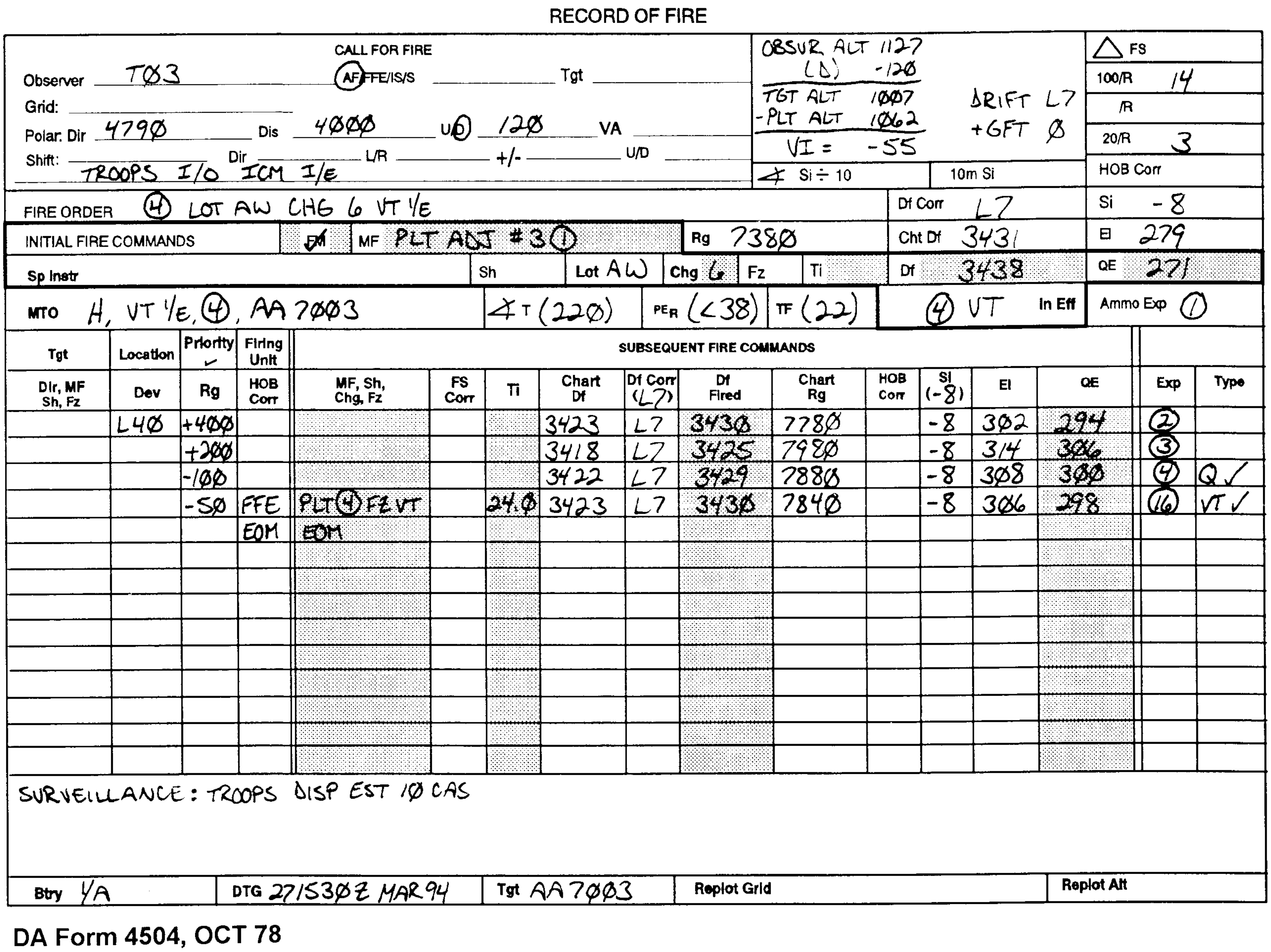
(2) The VT fuze setting is determined from the time of flight of the projectile. The TOF is determined to the nearest tenth of a second (0.1). However, a VT fuze cannot physically be set to the nearest tenth. The scales are graduated in whole seconds; therefore, the TOF must be expressed **down** to the whole second. If the TOF extracted is already determined to the whole second, there is no need to express down. The VT memory aid **"vanish tenths"** will help you understand the determination of the VT FS. Expressing down provides a greater assurance of an airburst. About 3 seconds before the fuze is set, the fuze is armed and the radio transmitter is activated. Whenever a VT FS is determined, recorded, or announced, it will always end in point zero.

NOTE: If the observer transmits a graze repeat, the automatic correction to the VT FS is to subtract 1.0 seconds.

h. HE/VT Fire Mission With HE/Q in Adjustment. Process the HE/Q adjustment as outlined in paragraph 9-5. Once the observer has requested a change in fuze type to a variable time fire, process the request as described in Table 9-16. Figure 9-14 shows an example ROF for this type of mission.

Table 9-16. HE/VT Fire Mission With HE/Q in Adjustment Process.

STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze. Computer announces **FUZE VT**.
3	Chart Rg	HCO determines and announces chart range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
4	Chart Df	HCO determines and announces chart deflection. Computer records it.
5	El	Computer determines and records elevation.
6	Ti	Computer determines, announces, and records the variable time fuze setting. The computer first determines the TOF to the nearest tenth and then vanishes the tenths and applies a point zero.
7	Df	Computer determines, records, and announces deflection (**CHT DF + DF CORR = DF**).
8	QE	Computer determines, records, and announces QE (**EL + (SI) = QE**).
9	Exp and Type	Computer determines and records the total number of fuze Q rounds fired. When the shell or fuze type changes, the count starts over and the previous type fired to this point is totaled.
10	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations. (See Figure 9-14.)



RECORD OF FIRE

CALL FOR FIRE

Observer T03 [✓ AF]/FFE/IS/S Tgt

Grid:

Polar: Dir 4790 Dis 4000 U/[✓ D] 120 VA

Shift: Dir L/R +/- U/D

TROOPS I/O ICM I/E

OBSVR ALT 1127
(Δ) -120
TGT ALT 1007
-PLT ALT 1062
VI = -55
DRIFT L7
+GFT 0

∡ Si ÷ 10

10m Si

△ FS
100/R 14
/R
20/R 3
HOB Corr

FIRE ORDER ④ LOT AW CHG 6 VT I/E

Df Corr L7

Si -8

INITIAL FIRE COMMANDS [✓ FM] MF PLT ADJ #3 ①

Rg 7380

Cht Df 3431

El 279

Sp Instr

Sh

Lot AW

Chg 6

Fz

Ti

Df 3438

QE 271

MTO H, VT I/E, ④, AA 7003

∡T (220)

PER (<38)

TF (22)

④ VT In Eff

Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L7)	Df Fired	Chart Rg	HOB Corr	Si (-8)	El	QE	Exp	Type
	L40	+400					3423	L7	3430	7780		-8	302	294	②	
		+200					3418	L7	3425	7980		-8	314	306	③	
		-100					3422	L7	3429	7880		-8	308	300	④	Q ✓
		-50	FFE	PLT ④ FZ VT		24.0	3423	L7	3430	7840		-8	306	298	⑯	VT ✓
			EOM	EOM												

SURVEILLANCE: TROOPS DISP EST 10 CAS

Btry 1/A DTG 271530Z MAR94 Tgt AA7003 Replot Grid Replot Alt

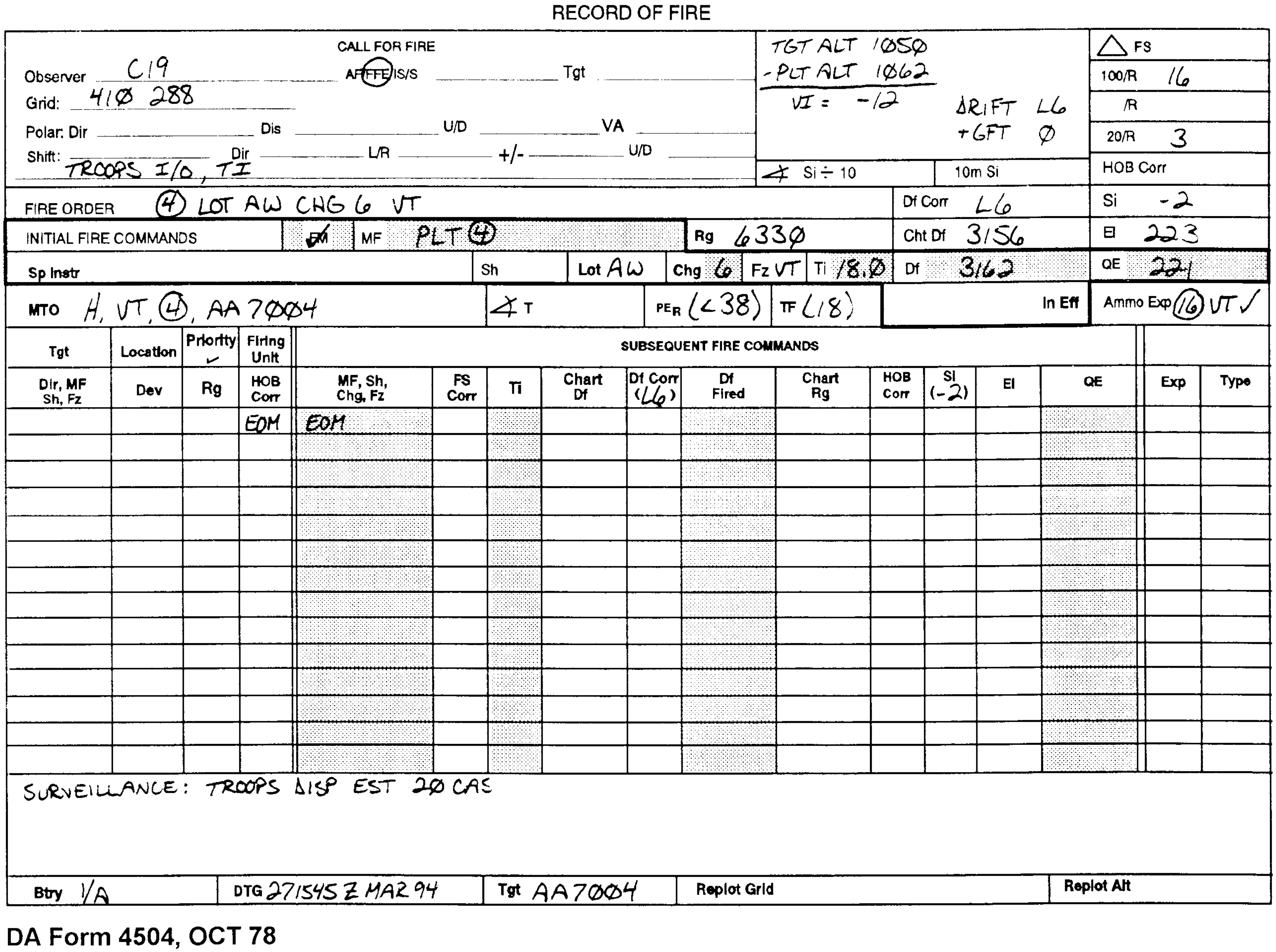
DA Form 4504, OCT 78

Figure 9-14. Example ROF for an HE/VT Adjust-Fire Mission.

i. HE/VT FFE Fire Mission. Use Table 9-17 for processing an HE/VT FFE fire mission. Figure 9-15 shows an example ROF for this type of mission.

Table 9-17. HE/VT FFE Fire Mission Process.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records as directed by the fire order.
	Sh	Computer announces and records if other than standard.
	Lot	Computer announces and records if other than standard.
4	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If it is not announced in the fire order, the computer will determine the charge.
7	Fz	Computer records and announces fuze VT.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	El	Computer determines and records elevation.
10	Ti	Computer determines, announces, and records the time setting for fuze VT.
11	Drift	Computer determines and records drift in the computational space.
12	Df Corr	Computer records deflection correction. Because there is no GFT setting available, this element will be the same as drift.
13	Df	Computer determines, announces, and records the deflection to fire (**DF CORR + CHT DF = DF TO FIRE**).
14	SI	VCO determines and announces site. The computer records site.
15	QE	Computer determines, announces, and records quadrant elevation (**SI + EL = QE**).
16	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) has been fired, the computer circles the number.
17	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations. (See Figure 9-15.)



RECORD OF FIRE

CALL FOR FIRE

Observer C19 AF/[✓ FFE]/IS/S Tgt

Grid: 410 288

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

TROOPS I/O, TI

TGT ALT 1050
-PLT ALT 1062
VI = -12

ΔRIFT L6
+GFT 0

∢ Si ÷ 10

10m Si

△ FS

100/R 16

/R

20/R 3

HOB Corr

FIRE ORDER ④ LOT AW CHG 6 VT

Df Corr L6

Si -2

INITIAL FIRE COMMANDS ☑ FM MF PLT ④

Rg 6330

Cht Df 3156

El 223

Sp Instr

Sh

Lot AW

Chg 6

Fz VT

Ti 18.0

Df 3162

QE 221

MTO H, VT, ④, AA7004

∢T

PE$_R$ (<38)

TF (18)

In Eff

Ammo Exp ⑯ VT ✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L6)	Df Fired	Chart Rg	HOB Corr	Si (-2)	El	QE	Exp	Type
			EOM	EOM												

SURVEILLANCE: TROOPS ΔISP EST 20 CAS

Btry 1/A

DTG 271545Z MAR 94

Tgt AA7004

Replot Grid

Replot Alt

DA Form 4504, OCT 78

Figure 9-15. Example ROF for an HE/VT FFE Fire Mission.

9-6. Example of Completing the Record of Fire for a Nonstandard Square Weight WP or HE Projectile

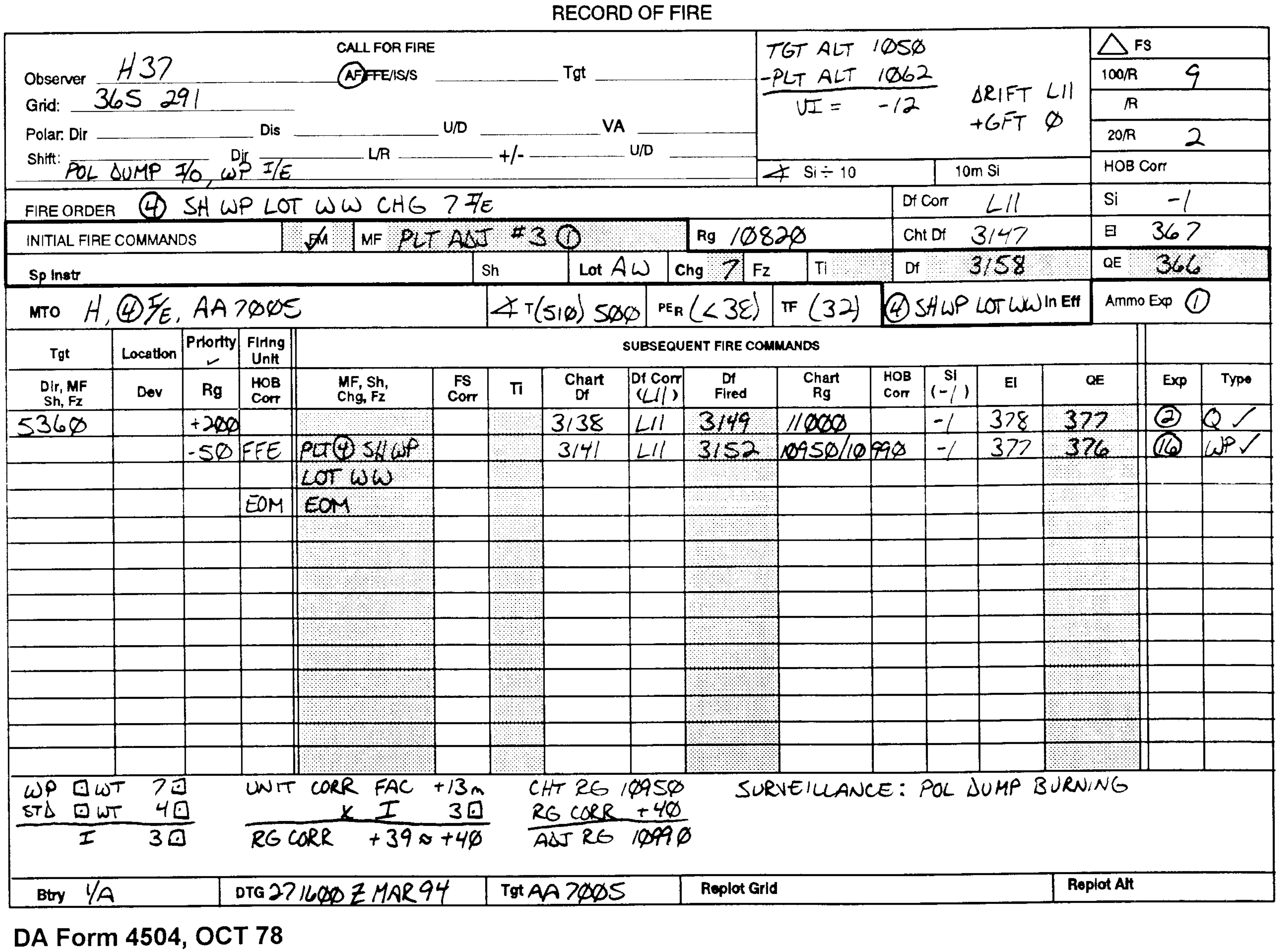
a. Several projectiles require corrections to firing data because of variations in square weight. The determination of firing data incorporates the use of the GFT and the TFT. The basic HE mission procedures must be altered to compensate for a deviation from the standard square weight from which the firing tables were developed. The TFTs have tables that correct for nonstandard conditions, one of which is weight. The computer must enter the appropriate TFT with the chart range to the target and the difference in square weight (increase or decrease). The difference in weight is determined by subtracting the standard square weight (or registration square weight) from the actual square weight of the projectile to be fired. The range correction factor is extracted and multiplied by the change in square weight. The result is expressed to the nearest 10 meters and is a signed value (±). This value is algebraically added to the chart range. This new range is known as the **adjusted range** and is used to compute elevation and all elements that are a function of elevation. The following steps apply to nonstandard square weight WP and HE projectiles.

NOTE: Normal HE procedures are followed until the observer requests the nonstandard square weight projectile.

b. Table 9-18 lists the procedures for processing a WP/Q FFE mission following HE adjustment. Figure 9-16 shows an example ROF for this type of mission.

Table 9-18. WP/Q FFE Mission Following HE Adjustment Process.

STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
3	Rg	HCO determines and announces range. Computer records the range on the left side of the range block and places a slash after it.
4	Fz	Computer records and announces, if applicable.
5	Chart Df	HCO determines and announces chart deflection. Computer records it.
6	Detm Diff in Sq Wt	Computer determines difference in square weight. Subtract the standard square weight from the square weight of the projectile to be fired. The difference is recorded as an increase (inc) or a decrease (dec). Record computations in the lower computational space.
7	Unit Corr Factor	Enter Table F of the appropriate TFT with the chart range to the nearest 100 meters (step 3). Extract the range correction factor for a decrease or increase (Column 18 or 19) for 1 square. Record this **signed value** in the computational space.
8	Rg Corr	Multiply the difference in square weight (step 6) by the unit correction factor (step 7). Express this value to the nearest 10 meters.
9	Adjusted Rg	Add the chart range (step 3) to the range correction (step 8). Record this adjusted range in the right side of the range block. This value is used to determine elevation and all data that are a function of elevation.
10	El	Computer determines and records elevation.
11	Df	Computer determines, announces, and records the deflection to fire (**DF CORR + CHT DF = DF TO FIRE**).
12	QE	Computer determines, announces, and records quadrant elevation (**SI + EL = QE**).
13	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: The range correction is determined for the initial WP or nonstandard HE, and it is applied to subsequent chart ranges as necessary. It is not recomputed for subsequent corrections. To process subsequent adjustments or time fuzes (MTSQ), refer to HE mission processing (paragraph 9-5) and simply apply the range correction as necessary. (See Figure 9-16.)	



RECORD OF FIRE

CALL FOR FIRE

Observer H37 [✓ AF] FFE/IS/S Tgt

Grid: 365 291

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

POL DUMP F/O, WP I/E

TGT ALT 1050
-PLT ALT 1062
VI = -12

DRIFT L11
+GFT 0

∡ Si ÷ 10

10m Si

△ FS	
100/R	9
/R	
20/R	2
HOB Corr	
Si	-1
El	367
QE	366
Ammo Exp	①

FIRE ORDER ④ SH WP LOT WW CHG 7 F/E

Df Corr L11

INITIAL FIRE COMMANDS [✓ FM] MF PLT ADJ #3 ①

Rg 10820

Cht Df 3147

Sp Instr

Sh

Lot AW

Chg 7

Fz

Ti

Df 3158

MTO H, ④ F/E, AA7005

∡ T (510) 500

PE_R (<3E)

TF (32)

④ SH WP LOT WW In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L/)	Df Fired	Chart Rg	HOB Corr	Si (-/)	El	QE	Exp	Type
5360		+200					3138	L11	3149	11000		-1	378	377	②	Q ✓
		-50	FFE	PLT ④ SH WP			3141	L11	3152	10950/10990		-1	377	376	⑯	WP ✓
				LOT WW												
			EOM	EOM												

WP □WT 7□
STD □WT 4□
I 3□

UNIT CORR FAC +13m
× I 3□
RG CORR +39 ≈ +40

CHT RG 10950
RG CORR +40
ADJ RG 10990

SURVEILLANCE: POL DUMP BURNING

Btry 1/A

DTG 271600Z MAR94

Tgt AA7005

Replot Grid

Replot Alt

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Figure 9-16. Example ROF for an HE Adjust-Fire Mission With WP/Q I/E.

Section III

High-Angle Fire

High-angle fire is used for firing into or out of deep defilade such as that found in heavily wooded, mountainous, and urban areas. It is also used to fire over high terrain features near friendly troops (Figure 9-17). The observer may request high-angle fire on the basis of terrain in the target area. The FDO also may order high-angle fire on the basis of a terrain analysis from the firing unit position to the target area. The primary characteristic of high-angle fire is that an increase in elevation causes a decrease in range.

Because high-angle fire involves large quadrant elevations and long times of flight, it will not be as responsive as low-angle fire to the immediate needs of a maneuver force. Trajectories are vulnerable to enemy detection. The long time of flight makes it difficult for the observer to identify his round, and corrections may change drastically from round to round. To help the observer, FDC personnel will announce **SPLASH** *5 seconds before each round impacts. To further help the observer, the FDC announces time of flight in the MTO.*

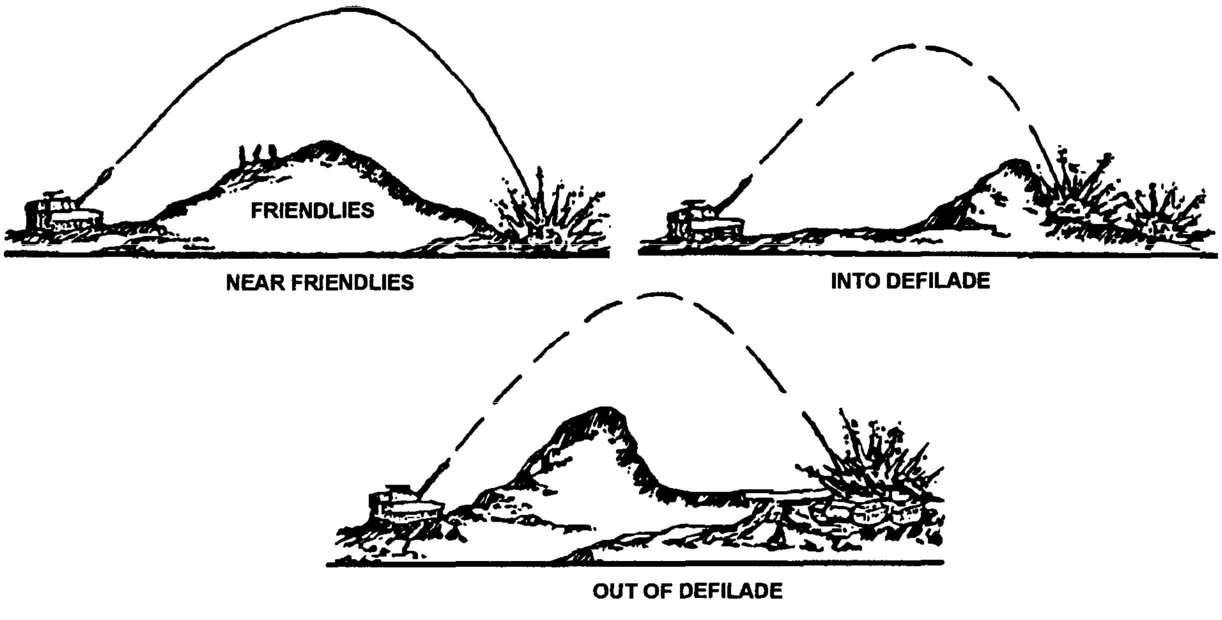


Figure 9-17. High-Angle Fire.

9-8. High-Angle GFT

The high-angle GFT (Figure 9-18, page 9-31) consists of one rule with ballistic data for multiple charges on each side. The scales on the high-angle GFT from top to bottom are as follows:

a. 100/R. This scale shows the number of mils needed to move the burst 100 meters laterally or vertically. The scale increases from right to left and is read to the nearest mil.

b. Range. This scale is expressed logarithmically in meters and applies to all charges appearing on that side of the GFT. Range increases from left to right and is read to the nearest 10 meters.

c. Elevation. This scale is expressed in mils and increases from right to left. It is interpolated to the nearest mil.

d. 10-m Site Factor. The values on this scale denote the site for each 10 mils angle of site. The numbers are printed in red and are negative values. The scale increases from left to right and is visually interpolated to the nearest tenth (0.1) of a mil.

e. Drift. The values on this scale are in mils. The scale increases from right to left and is interpolated to the nearest mil.

f. TF. This scale is graduated in seconds and is used to determine both time of flight (to the nearest whole second) and VT fuze setting. The TF scale increases from right to left.

NOTE: Figure 9-19, page 9-31 shows an aid that can be used when reading the high-angle GFT.

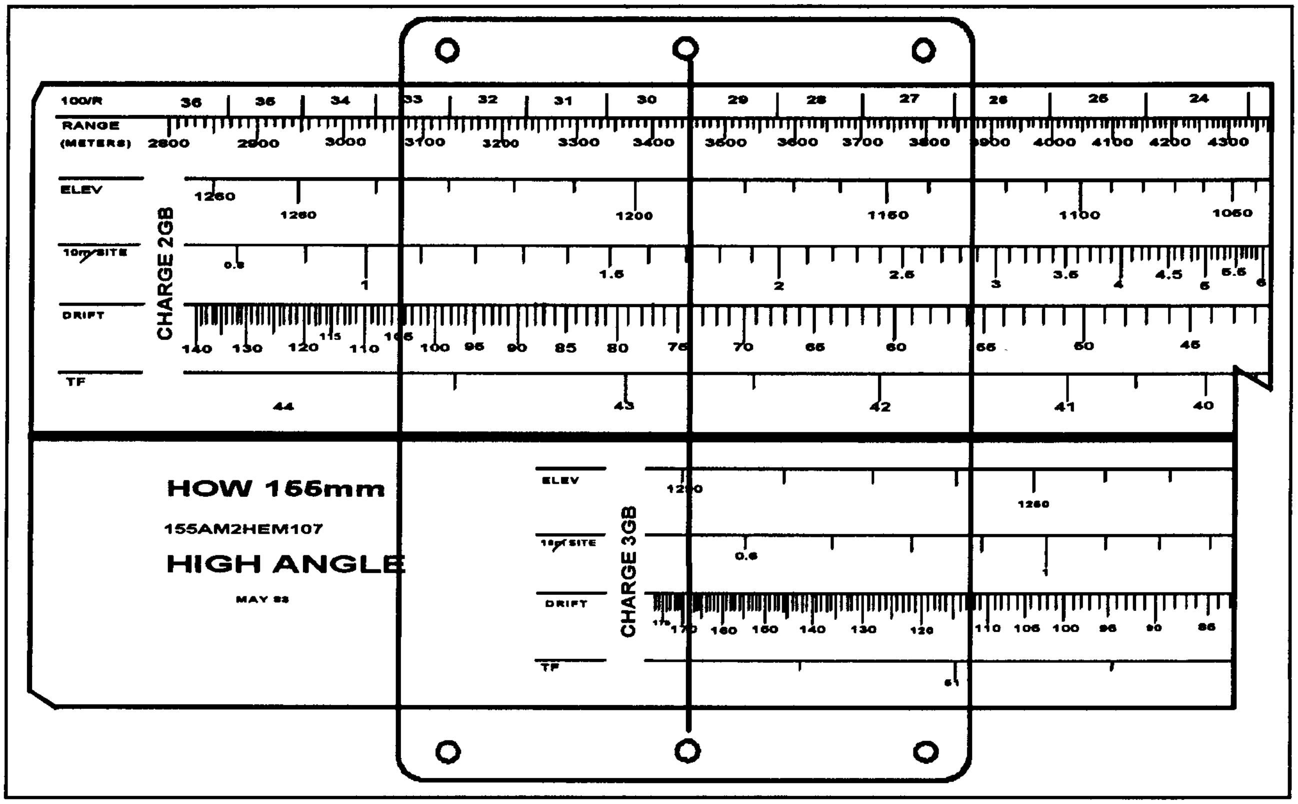


Figure 9-18. High-Angle GFT.

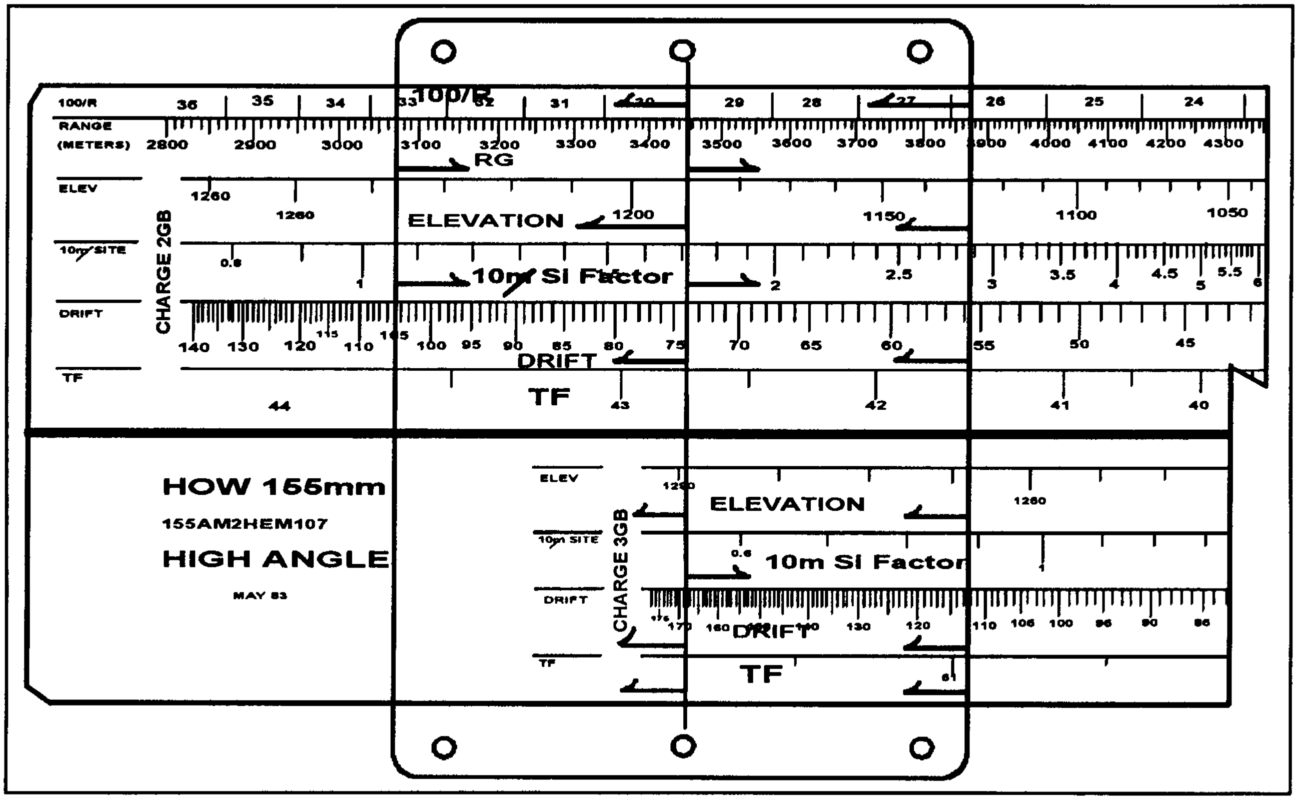


Figure 9-19. Aid for Reading the High-Angle GFT.

9-8. Duties of Personnel in High-Angle Fire

a. Except for differences noted in this section, the procedures for high-angle fire are the same as low-angle fire. Duties of FDC personnel in high-angle fire differ in several ways as described below.

b. The FDO does the following:

(1) Includes the command **HIGH ANGLE** in his fire order.

(2) Considers high-angle fire characteristics in selecting the shell and fuze to fire.

(a) Antipersonnel improved conventional munitions (APICM) and DPICM can be used in high-angle fire for the same types of targets as in low-angle fire.

(b) The high-angle trajectory has two inherent characteristics that affect munitions selection: a steep angle of fall and large probable errors. The steep angle of fall means the projectile is almost vertical as it approaches the ground. When the HE projectile bursts, the side spray contains most of the fragmentation. Since the projectile is nearly vertical, side spray is in all directions and nearly parallel to the ground (Figure 9-20). Thus, shell HE with fuze quick or fuze VT is very effective when fired high angle. The large probable error in height of burst makes the use of MTSQ time fuzes impractical in high-angle fire.

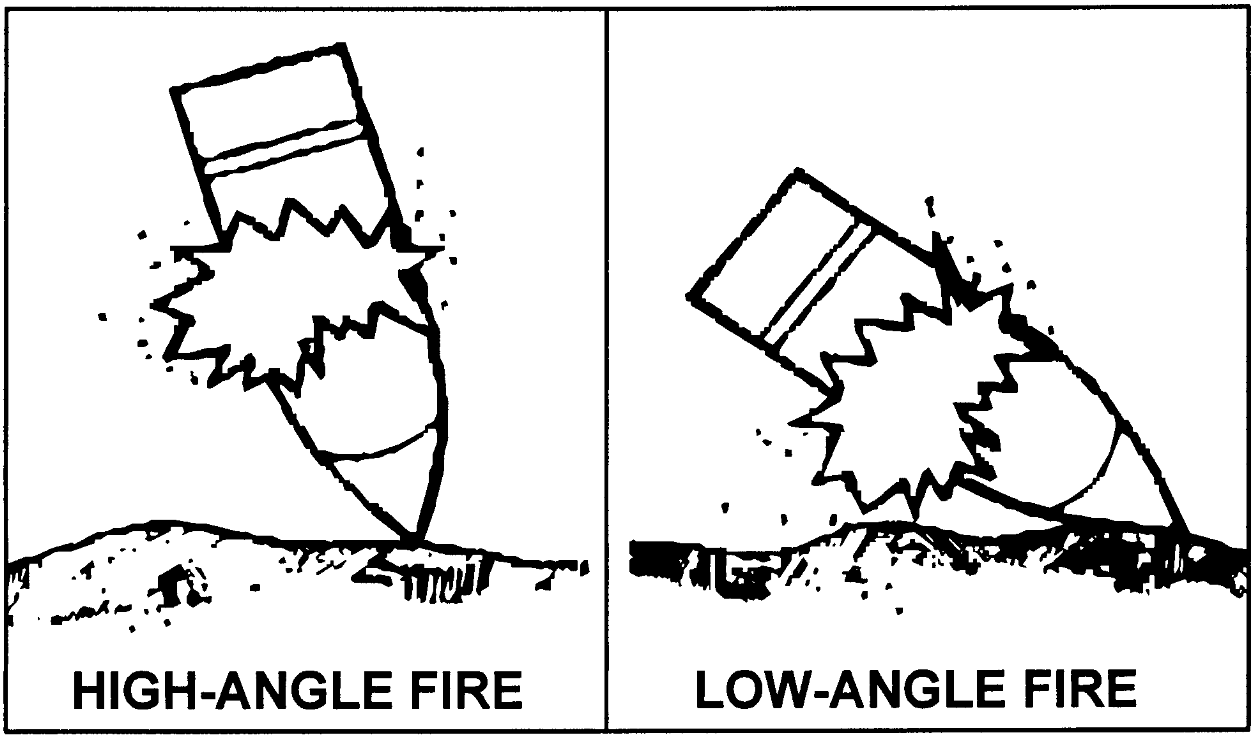


Figure 9-20. High-Angle Side Spray Compared to Low-Angle Side Spray.

c. The VCO computes and announces angle of site rather than site.

d. The computer does the following:

(1) Selects the charge to be fired (if it is not announced in the fire order). High-angle fire has two characteristics that affect the selection of charge: a shorter range span for each charge and a range overlap between charges. The range span within which accurate fire can be delivered by a particular charge is less for high-angle fire than for low-angle fire. This may cause a problem during a high-angle fire mission, because a large observer correction may move the round outside the capabilities of the initial charge fired. This, in turn, will necessitate changing charges. Changing charges in a high-angle fire mission is sometimes unavoidable, although it is not desirable. For this reason, the computer initially selects the charge that is least likely to require changing. As a guideline, he selects the lowest charge that allows for a range shift of at least 500 meters short of and 500 meters beyond the initial chart range.

(2) Includes drift correction. Drift is appreciably greater in high-angle fire than in low-angle fire. Because drift changes a great amount for a relatively small elevation change, the computer determines drift (recorded as the deflection correction) for each elevation. The correction is always applied to the left. If a GFT setting is available for the high-angle GFT, the computer will determine drift and algebraically add it to the GFT deflection correction. The sum is the deflection correction to be applied to the chart deflection.

(3) Includes site in the computation of QE unless the FDO directs otherwise. Site is included when the angle of site is large or when a high-angle registration or a mass mission is being fired. When several firing units are to mass on a target and only one firing unit is to adjust, site is computed at the initial range for each unit. Site for the nonadjusting units may be recomputed before FFE (for example, when the adjusting unit changes charge or when the adjusting unit conducted a target replot). When adjustment is required before massing and only one unit is to adjust, the unit that is most centrally located should be designated as the adjusting unit to minimize large differences in range for the nonadjusting units. If site is to be ignored, the FDO announces **IGNORE SITE** in the fire order. Since one of the criteria for ignoring site is a small angle of site, the FDO may have to wait for the VCO to compute and announce angle of site. In this situation, the FDO issues a fire order and later supplements it with the command **IGNORE SITE.**

(4) Announces **HIGH ANGLE** as a special instruction when sending initial fire commands to the howitzers.

(5) The RATELO announces the time of flight in the message to observer and announces **SPLASH** for each round.

9-9. Example of Completing the ROF for an HE High-Angle Adjust-Fire Mission

a. The steps in Table 9-19 are used to process an HE high-angle adjust-fire mission. Figure 9-21 shows an example ROF for this type of mission.

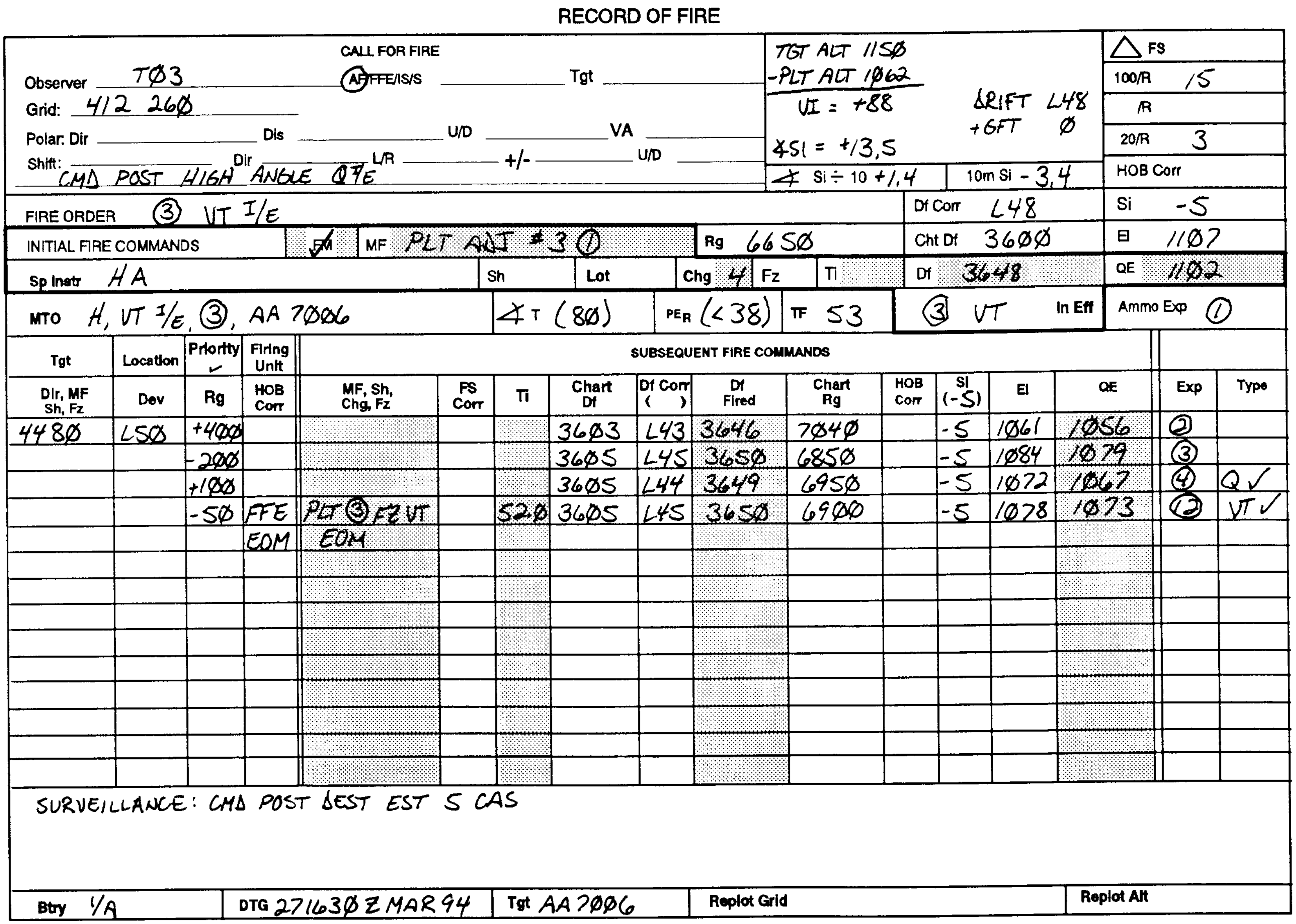
Table 9-19. HE High-Angle Adjust-Fire Mission.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records high-angle as directed by the fire order.
	Sh	Computer announces and records if other than standard.
	Lot	Computer announces and records if other than standard.
4	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces range. Computer places the MHL of the high-angle GFT over the announced range and records it on the record of fire.
6	Chg	Computer determines, announces, and records charge. (If the charge is not announced in the fire order, the computer will determine charge.)
7	Fz	Computer records and announces fuze type if other than standard.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	El	Computer determines and records elevation.
10	TF	Computer determines and records time of flight. The RATELO transmits time of flight to the observer.
11	Drift	Computer determines and records drift in the upper computational space.
12	Df Corr	Computer records deflection correction. Because there is no GFT setting available, this element will be the same as drift.
13	Df	Computer determines, announces, and records the deflection to fire (**DF CORR + CHT DF = DF TO FIRE**).
14	∢Si÷10	VCO determines and announces angle of site. Computer divides the angle of site by 10 and records the result to the nearest 0.1 mil.
15	10m Si	Computer determines and records the 10-mil site factor from the GFT. This value is always negative.
16	SI ( )	Computer determines and records site (**∢ SI ÷ 10 X 10 MIL SI = SITE).**
		NOTE: High-angle site will always have the opposite sign of VI.
17	QE	Computer determines, announces, and records quadrant elevation (**SI + EL = QE**).
18	In Eff	Computer announces and records the method of fire for effect.
19	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) have been fired, the computer circles the number.
20	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations. **The deflection correction is not carried down. Drift is determined for each subsequent adjustment.**

b. The steps in Table 9-20 are used to process a high-angle subsequent adjustment. An example ROF for this entire mission is shown in Figure 9-21.

Table 9-20. High-Angle Subsequent Adjustment.

STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's direction and subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
3	Chart Rg	HCO determines and announces chart range. Computer places the MHL of the high-angle GFT over the announced range and records it on the record of fire.
4	Chart Df	HCO determines and announces chart deflection. Computer records it.
5	El	Computer determines and records elevation.
6	Df Corr	Computer records deflection correction. Because there is no GFT setting available, this element will be the same as drift. Drift is determined with each subsequent round.
7	Df	Computer determines, records, and announces deflection **(CHT DF + DF CORR = DF)**.
8	QE	Computer determines, records, and announces QE **(EL + (SI) = QE)**.
9	Exp and Type	Computer determines and records the total number of rounds (by type) fired to this point.
10	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Repeat steps 1 through 10 as necessary to complete the observer's corrections. These steps are valid until the observer changes fuze or projectile.	



RECORD OF FIRE

CALL FOR FIRE

Observer T03 [✓ AF]/FFE/IS/S Tgt

Grid: 412 260

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

CMD POST HIGH ANGLE Q7E

TGT ALT 1150
-PLT ALT 1062
VI = +88
∡SI = +13,5
DRIFT L48
+6FT 0

∡ Si ÷ 10 +1,4

10m Si -3,4

△ FS

100/R 15

/R

20/R 3

HOB Corr

FIRE ORDER ③ VT I/E

Df Corr L48

Si -5

INITIAL FIRE COMMANDS FM ✓ MF PLT ADJ #3 ①

Rg 6650

Cht Df 3600

El 1107

Sp Instr HA

Sh

Lot

Chg 4

Fz

Ti

Df 3648

QE 1102

MTO H, VT I/E, ③, AA 7006

∡T (80)

PE_R (<38)

TF 53

③ VT In Eff

Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si (-5)	El	QE	Exp	Type
4480	L50	+400					3603	L43	3646	7040		-5	1061	1056	②	
		-200					3605	L45	3650	6850		-5	1084	1079	③	
		+100					3605	L44	3649	6950		-5	1072	1067	④	Q ✓
		-50	FFE	PLT ③ FZ VT		520	3605	L45	3650	6900		-5	1078	1073	⑫	VT ✓
			EOM	EOM												

SURVEILLANCE: CMD POST DEST EST 5 CAS

Btry 1/A

DTG 271630Z MAR 94

Tgt AA 7006

Replot Grid

Replot Alt

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Figure 9-21. Example ROF for an HE High-Angle Adjust-Fire Mission.

Section IV

Illumination

This section implements STANAG 2088 and QSTAG 182.

Illuminating projectiles are available for the 105-mm and the 155-mm howitzers. They are used to illuminate a designated area for observing enemy night operations, for adjusting artillery fires at night, for marking locations, for friendly direction, or in *ground/vehicular laser locator designator (G/VLLD) missions.*

Illuminating projectiles are base-ejection projectiles fired with mechanical time fuzes. The filler consists of an illuminating canister and a parachute assembly. The FDO should select the lowest practical charge to prevent a malfunction caused by the parachute ripping when the flare is ejected from the projectile.

9-10. Overview

Illumination is conducted by using one of the following techniques.

a. The **one-gun illumination pattern** is used when effective illumination can be achieved by firing one round at a time.

b. The **two-gun illumination pattern** is used when an area requires more illumination than one gun can furnish. This is commonly used for aerial observers.

(1) The **two-gun illumination range spread pattern** is fired along the GT line. It is used when the area to be illuminated has greater depth than width.

(2) The **two-gun illumination lateral spread pattern** is fired perpendicular to the GT line. It is used when the area to be illuminated has greater width than depth.

c. The **four-gun illumination pattern** is used to illuminate a large area. Four rounds are fired at the same time by using both the lateral and range spread patterns. This is more commonly referred to as the four-gun illumination range and lateral spread.

NOTE: The decision to use the GT line or observer-target (OT) line for illumination missions should be based on unit SOP and mission, enemy, terrain, troops, and time available (METT-T). When using the OT line, the FDC will use the target grid to plot individual aimpoints. Use of the GT line may be more responsive to the observer's needs, but may not always provide the exact illumination coverage desired. The arguments for using the OT line are:

- The observer may not be able to visualize the GT line, but he can always visualize the OT line.
- The observer may not know which firing unit will fire his mission, especially if the mission is passed to a reinforcing FA unit. Therefore, he may not have the information needed to visualize the GT line.
- The terrain may restrict effective illumination of the target area if the observer desires illumination in respect to his OT direction, but the firing unit computes data by using the GT line.

However, for illustrative purposes with the example fire missions, our unit SOP is to use the GT line for all illum range spreads, lateral spreads, or combination.

9-11. Illuminating Projectile GFT

a. There are two manual computational methods for the illuminating projectile. One method uses a special illuminating projectile GFT, and the other method uses Part 2 of the base HE TFT. Graphical firing tables have been developed for use with all 155-mm M485A1 and A2 illuminating projectiles and with the 105-mm M314A1 and A2 and M314A2E1 projectiles. Figure 9-22 shows a GFT for the illuminating projectile.

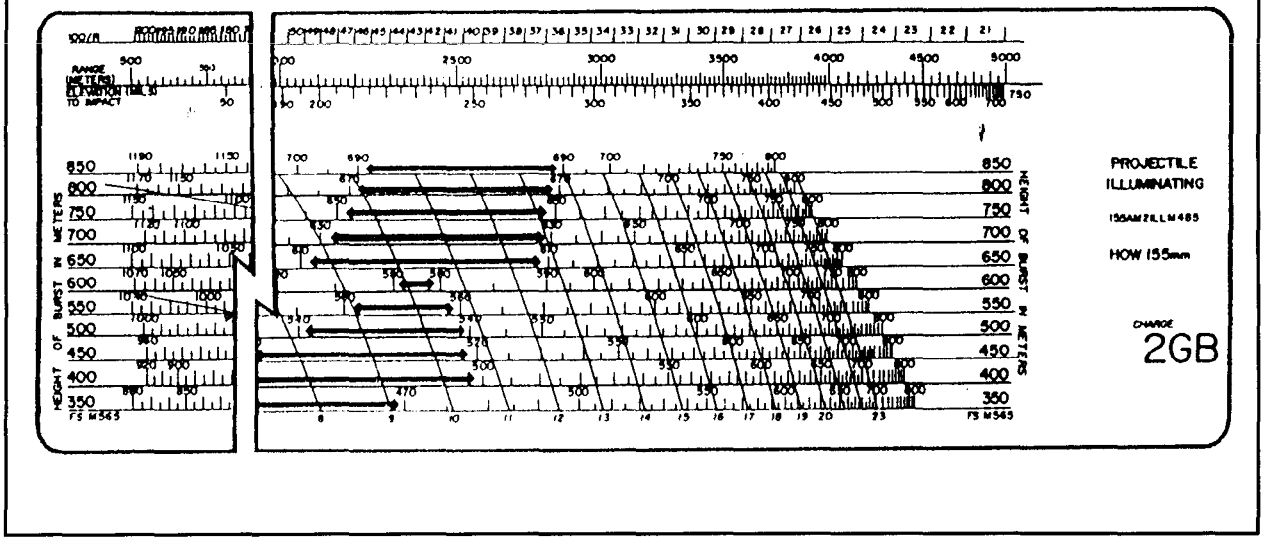


Figure 9-22. 155-mm Illuminating GFT.

b. The scales of the illuminating GFT, from top to bottom, are described below:

(1) The 100/R scale is printed in red along the top edge of the rule. For a given range, the 100/R scale denotes the number of mils needed to shift the burst 100 meters laterally or vertically. 100/R is read to the nearest mil.

(2) The range scale is the base scale of the illuminating GFT. All other scales are plotted with reference to the range scale. Range is read to the nearest 10 meters.

(3) The elevation-to-impact scale is graduated in mils. The elevation-to-impact scale is used to determine the range (on the range scale) to which a nonfunctioning projectile will impact.

(4) The HOB scales, labeled from 350 to 850 meters, are at the left and right edge of the QE scales. The HOB scales are graduated in 50-meter increments.

(5) The QE scale shown for each listed HOB gives the QE needed to achieve that HOB at the desired range. The QE scale is graduated in mils and is visually interpolated to the nearest mil.

(6) The FS scale consists of a series of red arcs. The scale includes a red line for each whole FS increment for the M565 MT fuze. The value of each line is printed in red at the bottom of the scale. The fuze setting is read for the desired range and HOB to an accuracy of 0.1 FS increment by visual interpolation.

NOTE: The heavy black arrows along the QE scale denote when the trajectory is near or at the summit and does not exceed by 50 meters the HOB it represents.

9-12. Illumination Firing Data

a. The illum projectile is not weight-zoned. It is designed to illuminate a large area (Figure 9-23). The minimum corrections from the observer are 200 meters for range and deviation and 50 meters for HOB. All subsequent HOB corrections are always given in multiples of 50 meters. Because of these characteristics, the determination of firing data is significantly different from HE. Drift, site, elevation, and FS are not determined. However, an illum HOB is determined. The HOB is used in conjunction with range to determine QE and FS. Therefore, any HOB correction sent by the observer will cause both the FS and QE to change.

b. The HCO determines chart data in the same manner as in an HE mission. The VCO determines VI in the same manner as in an HE mission. The computer will express the VI determined by the VCO to the nearest 50 meters.

CANNON	PROJECTILE	OPTIMAL HEIGHT OF BURST (METERS) OF ILLUMINANT IGNITION	EFFECTIVE ILLUM DIAMETER (SPREAD)	BURNING TIME (SECONDS)	RATE OF CONTINUOUS ILLUMINATION (ROUNDS PER MINUTE)	RATE OF FALL (METERS PER SECOND)
105 mm	M314A2	750	800	60	2	10
155 mm	M485A2	600	1000	120	1	5

Figure 9-23. Employment Factors for Illuminating Projectiles.

9-13. Determination of Illumination Firing Data With the GFT

a. The appropriate HOB scale is determined by applying the VI determined by the computer to the optimum HOB for the illuminating projectile being fired. During subsequent adjustments, the observer's HOB correction is applied to the previous HOB determined.

b. QE is determined by placing the MHL over the chart range. The QE is determined by visually interpolating the point of intersection of the MHL and the appropriate HOB scale. Determine QE to the nearest mil.

c. Fuze setting is determined in the same manner as QE; that is, by placing the MHL over the chart range. Fuze setting is determined by visually interpolating between the red fuze setting arcs along the selected HOB scale. To determine the value of the arcs, follow the arcs to the bottom of the GFT. This fuze setting is for the M565 MT fuze. To determine a fuze setting for MT M577, enter Table B, Part 2, of the TFT and apply the FS correction to the MT M565 value. Determine FS to the nearest tenth.

9-14. Determination of Illumination Firing Data With the TFT

a. Part 2 of the TFT deals exclusively with illum data. Each charge has two tables, Tables A and B. Table A lists basic data, and Table B lists corrections to fuze setting.

b. FS and QE are determined by entering Table A with the chart range (expressed to the nearest 100 meters). QE is extracted from Column 2 (QUAD ELEV) and M565 FS from Column 3 (FS). These values are for the optimum HOB and must be corrected for VI.

c. HOB corrections are made in 50-meter increments. Columns 4 and 5 of Table A list the corrections to QE and FS for an increase of 50 meters in HOB. The VI is expressed to the nearest 50 meters. Once the VI is expressed, it is divided by 50 to determine the number of 50-meter increments that are needed. The number of 50-meter increments are multiplied by the value in Column 4 (QE) and Column 5 (FS). These values are applied to QE and FS. For a positive VI, the values are added; for a negative VI, the values are subtracted. These corrected values are the FS and QE that should be fired.

d. To process HOB corrections, divide the observer's HOB correction by 50. This will provide the number of 50-meter increments. Multiply the number of 50-meter increments by the values in Columns 4 and 5. Apply this correction value as described above.

e. 100/R can be determined manually by using the mil relation formula by dividing 100 by the range in thousands and multiplying that value by 1.0186. The result is expressed to the nearest mil.

NOTE: The FS determined from the illuminating GFT or from Table A, Part 2, Column 3 of the TFT is for the M565 fuze. A correction value must be applied to determine a fuze setting for the M577 fuze. Table B of the TFT lists the correction values. To determine the correction value, enter Table B with the FS for the M565 fuze. Apply this FS correction to the FS for the M565 fuze. The resulting value is the FS for the M577 fuze.

9-15. Processing a One-Gun Illumination Fire Mission

a. The steps in Table 9-21 are used to process a one-gun illum mission. Figure 9-24 shows an example ROF for this type of mission. The time fuze being fired is M577.

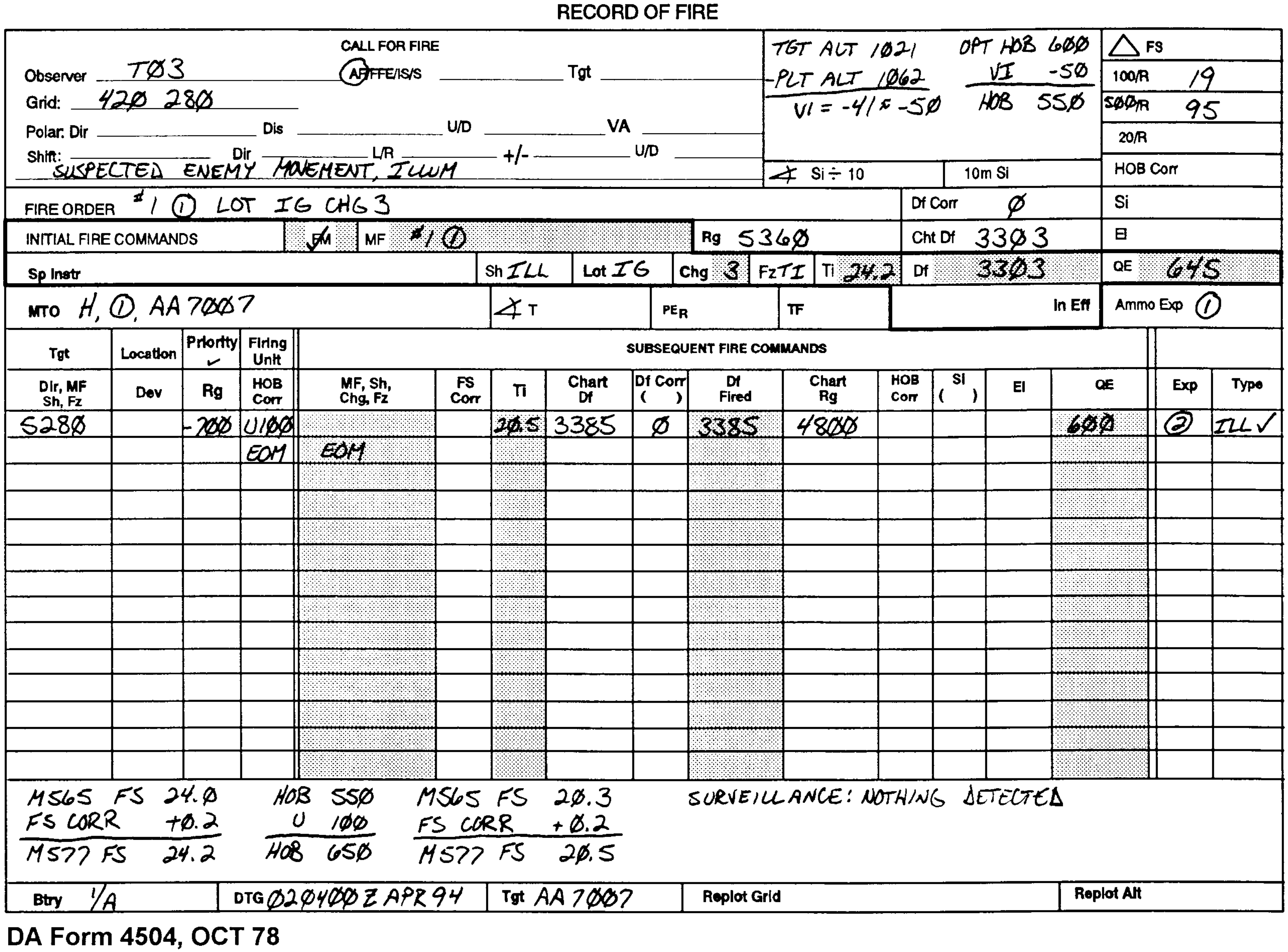
Table 9-21. One-Gun Illumination Fire Mission Process.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records as directed by the fire order.
	Sh	Computer announces and records shell illumination.
	Lot	Computer announces and records the lot for shell illumination.
4	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces range. Computer places the MHL of the illumination GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If not announced in the fire order, the computer will determine the charge.
7	Fz	Computer records and announces fuze time.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	VI	VCO determines and announces the VI. Computer records in upper computational space and expresses VI to the nearest 50 meters.
10	Illumination HOB	Computer determines the HOB by modifying the optimum HOB. The VI is applied to the optimum HOB. This value determines the HOB scale to be used on the GFT.
11	Ti (M565)	Computer determines, announces, and records the FS. If the M577 fuze is to be fired, the M565 FS is recorded in the lower computational space where it will be corrected.
12	FS Corr	Computer determines and records the FS correction from Table B of the TFT and records it in the lower computational space.
13	Ti (M577)	The FS correction determined in step 12 is applied to the M565 FS to determine the M577 FS. This value is recorded in the Ti block and announced to the howitzer(s).
14	Df	Computer records and announces the chart deflection as the deflection to fire.
15	QE	Computer determines and records the QE directly from the GFT and announces it.
16	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) have been fired, the computer circles the number.
17	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
		NOTE: During the police of the ROF for an illum mission, the value for ____/R is determined. This value is a multiple of 100/R. It is either 400/R (for 105-mm howitzers) or 500/R (for 155-mm howitzers) (determined at the initial chart range). It is determined by multiplying 100/R by 4 or 5.

b. The steps in Table 9-22 are used to process an illumination subsequent adjustment. An example ROF for this entire mission is shown in Figure 9-24. The time fuze being fired is the M577.

Table 9-22. Illumination Subsequent Adjustment.

STEP	REFERENCE	ACTION
1	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's direction and subsequent corrections.
2	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
3	Chart Rg	HCO determines and announces chart range. Computer places the MHL of the illumination GFT over the announced range and records it on the record of fire.
4	Chart Df	HCO determines and announces chart deflection. Computer records it.
5	HOB	Computer determines the HOB by applying the observer's up or down (±) correction to the previous HOB. The computations are done in the lower computational space. This value determines the HOB scale to be used on the GFT.
6	Ti (M565)	Computer determines, announces, and records the FS. If the M577 fuze is to be fired, the M565 FS is recorded in the lower computational space where it will be corrected.
7	FS Corr	Computer determines the FS correction from Table B of the TFT and records it in the lower computational space.
8	Ti (M577)	The FS correction determined in step 7 is applied to the M565 FS to determine the M577 FS. This value is recorded in the Ti block and is announced to the howitzer(s).
9	Df	Computer records and announces the chart deflection as the deflection to fire.
10	QE	Computer determines and records the QE directly from the GFT and announces it.
11	Exp and Type	Computer determines and records the total number of rounds (by type) fired to this point.
12	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Repeat steps 1 through 12 as needed to complete the observer's corrections.	



RECORD OF FIRE

CALL FOR FIRE

Observer T03 [✓ AF]FE/IS/S Tgt

Grid: 420 280

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

SUSPECTED ENEMY MOVEMENT, ILLUM

TGT ALT 1021
-PLT ALT 1062
VI = -41 ≈ -50

OPT HOB 600
VI -50
HOB 550

△ FS

100/R 19

500/R 95

20/R

HOB Corr

∢ Si ÷ 10

10m Si

Si

El

FIRE ORDER #1 ① LOT IG CHG 3

Df Corr 0

INITIAL FIRE COMMANDS ✓FM MF #1 ① Rg 5360

Cht Df 3303

Sp Instr Sh ILL Lot IG Chg 3 Fz TI Ti 24.2 Df 3303 QE 645

MTO H, ①, AA 7007 ∢ T PE_R TF In Eff Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
5280		-700	U100			20.5	3385	0	3385	4800				600	②	ILL ✓
			EOM	EOM												

M565 FS 24.0
FS CORR +0.2
M577 FS 24.2

HOB 550
U 100
HOB 650

M565 FS 20.3
FS CORR +0.2
M577 FS 20.5

SURVEILLANCE: NOTHING DETECTED

Btry 1/A DTG 020400Z APR 94 Tgt AA 7007 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 9-24. Example ROF for a One-Gun Illumination Fire Mission.

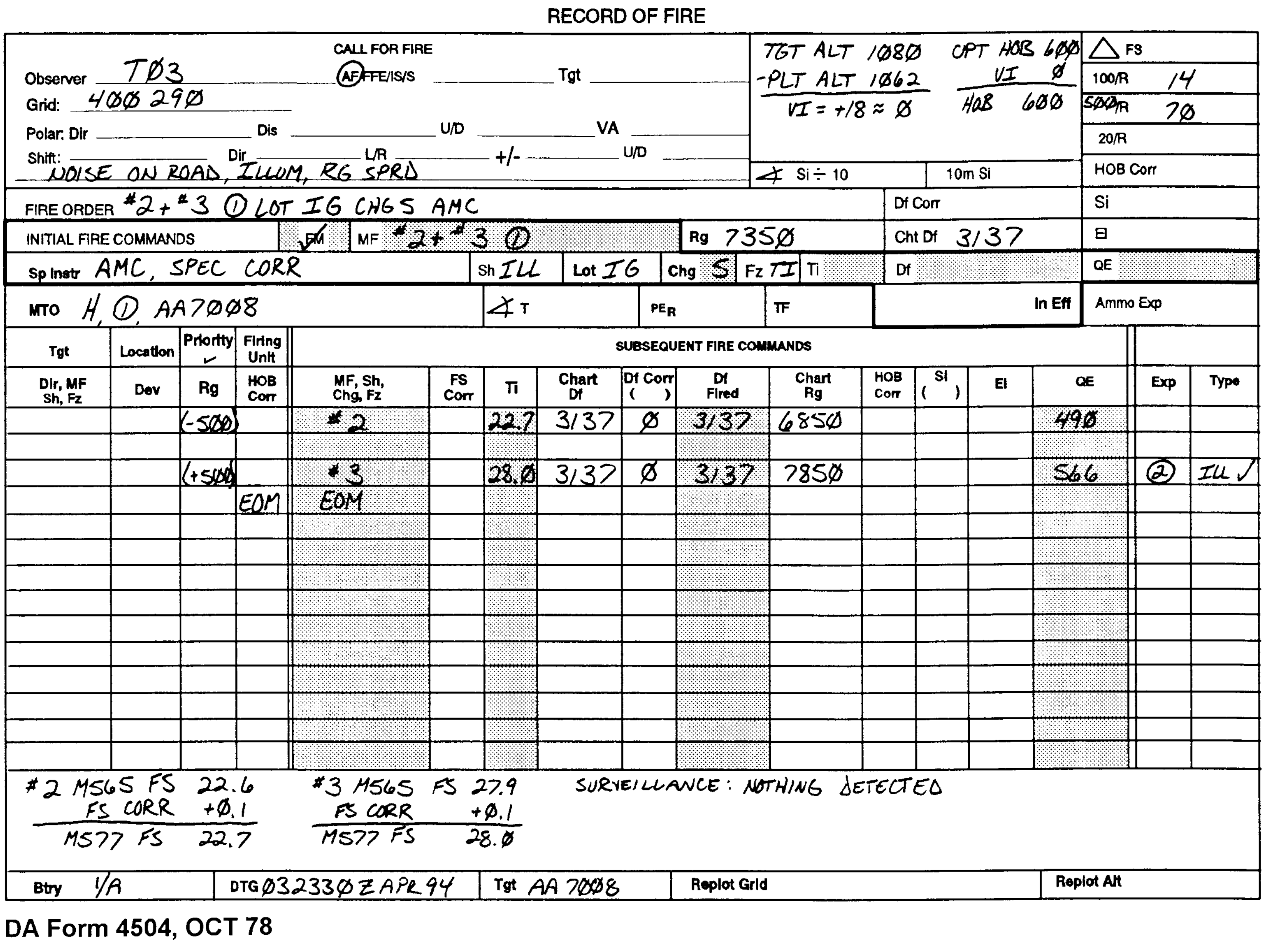
9-16. Two-Gun Illumination Range Spread

a. A two-gun range spread requires two illuminating projectiles to be fired along the GT line to provide the maximum range coverage. The projectiles are fired one effective illum diameter apart (refer to Figure 9-23). To determine the aimpoints, the computer will add and subtract one-half the illum diameter to the chart range of the aimpoint. The computer will then determine firing data at the adjusted ranges. The chart deflection will remain the same and both illumination rounds are fired with the same deflection.

b. Use Table 9-23 to process a two-gun illumination range spread fire mission. An example ROF for this entire mission is shown in Figure 9-25. The time fuze being fired is fuze M577.

Table 9-23. Two-Gun Illumination Range Spread Fire Mission Process.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records as directed by the fire order.
	Sh	Computer announces and records shell illumination.
	Lot	Computer announces and records the lot for shell illumination.
	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces range. Computer places the MHL of the illuminating GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If it is not announced in the fire order, the computer will determine the charge.
7	Fz	Computer records and announces fuze time.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	VI	VCO determines and announces the VI. Computer records in upper computational space and expresses to the nearest 50 meters.
10	Illumination HOB	Computer determines the HOB by modifying the optimum HOB. The VI is applied to the optimum HOB. This value determines the HOB scale to be used on the GFT.
11	Determine Aimpoints	Computer adds and subtracts one-half the illum diameter of the projectile from the chart range. These ranges are recorded on separate lines in the subsequent fire commands block. The deflection remains the same for both howitzers and is also recorded on each line.
	NOTE: Steps 12 through 16 are completed for each range determined in step 11. The data are recorded on the corresponding line for each range.	
12	Ti (M565)	Computer determines, announces, and records the FS. If the M577 fuze is to be fired, the M565 FS is recorded in the lower computational space where it will be corrected.
13	FS Corr	Computer determines the FS correction from Table B of the TFT and records it in the lower computational space.
14	Ti (M577)	The FS correction determined in step 13 is applied to the M565 FS to determine the M577 FS. This value is recorded in the Ti block and is announced to the howitzer(s).
15	Df	Computer records and announces the chart deflection as the deflection to fire.
16	QE	Computer determines and records the QE directly from the GFT and announces it.
17	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) has been fired, the computer circles the number.
18	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: During the police of the ROF for an illum mission, the value for ___/R is determined. It is either 400/R or 500/R depending on the illuminating projectile used. It is determined by multiplying 100/R (determined at the initial chart range) by 4 or 5.	



RECORD OF FIRE

CALL FOR FIRE

Observer T03 [✓ AF]/FFE/IS/S Tgt

Grid: 400 290

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

NOISE ON ROAD, ILLUM, RG SPRD

TGT ALT 1080
-PLT ALT 1062
VI = +18 ≈ 0

OPT HOB 600
VI 0
HOB 600

△ FS
100/R 14
500/R 70
20/R
HOB Corr

∡ Si ÷ 10 | 10m Si

FIRE ORDER #2 + #3 ① LOT IG CHG 5 AMC

Df Corr

Si

INITIAL FIRE COMMANDS FM ✓ MF #2 + #3 ① Rg 7350 Cht Df 3/37 El

Sp Instr AMC, SPEC CORR Sh ILL Lot IG Chg 5 Fz TI Ti Df QE

MTO H, ①, AA7008 ∡ T PER TF In Eff Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
		(-500)		#2		22.7	3/37	0	3/37	6850				490		
		(+500)		#3		28.0	3/37	0	3/37	7850				566	②	ILL ✓
			EOM	EOM												

#2 M565 FS 22.6
FS CORR +0.1
M577 FS 22.7

#3 M565 FS 27.9
FS CORR +0.1
M577 FS 28.0

SURVEILLANCE: NOTHING DETECTED

Btry 1/A | DTG 032330Z APR 94 | Tgt AA 7008 | Replot Grid | Replot Alt

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Figure 9-25. Example ROF for a Two-Gun Illumination Range Spread Fire Mission.

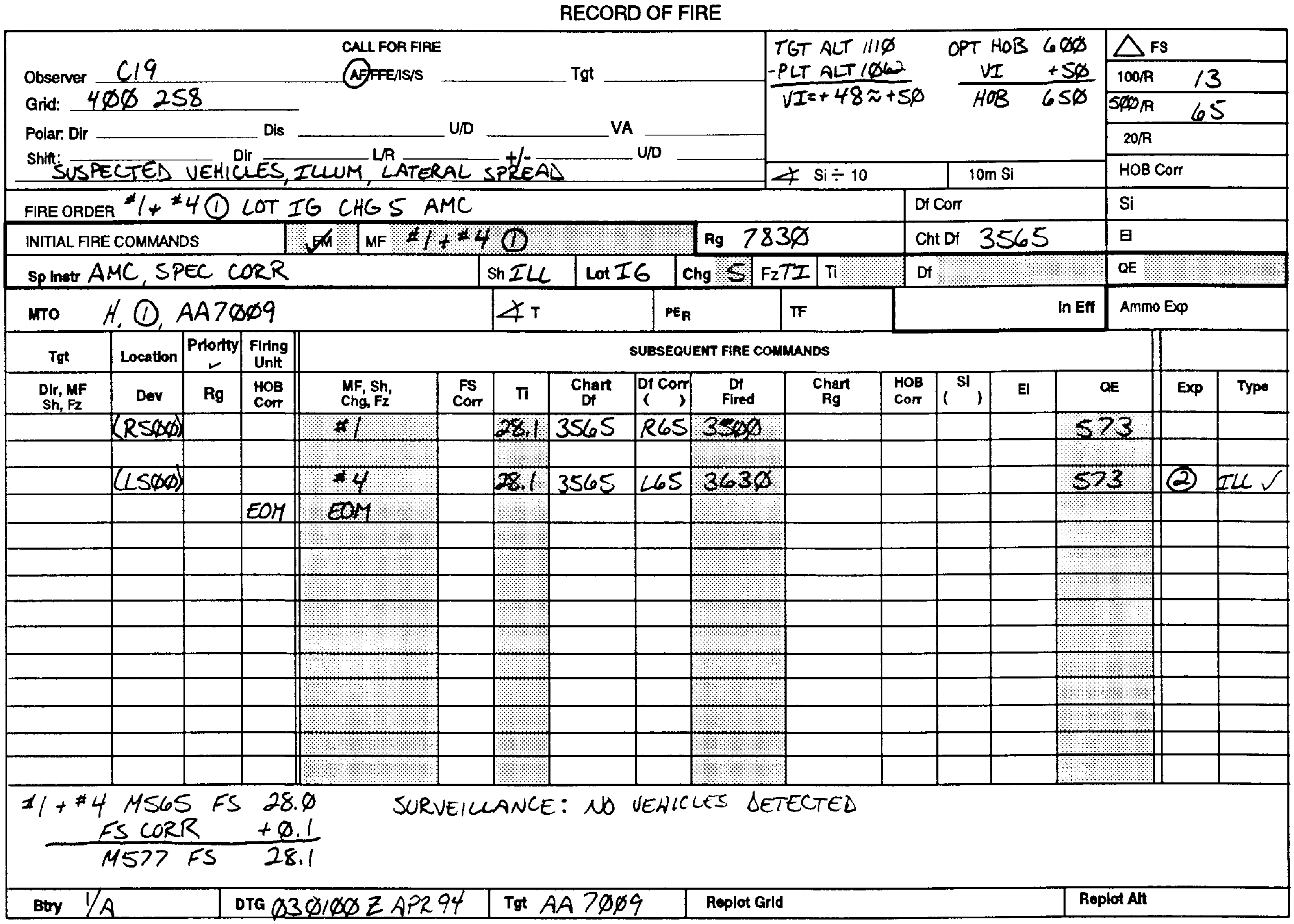
9-17. Two-Gun Illumination Lateral Spread

a. A two-gun lateral spread requires two illuminating projectiles to be fired perpendicular to the GT line to allow for the maximum lateral coverage. The projectiles are fired one effective illum diameter apart (refer to Figure 9-23). To determine the aimpoints, the computer must determine a multiple of 100/R (400/R for 105 mm and 500/R for 155 mm). The computer will add and subtract this value from the chart deflection to the aimpoint. The range will be the same for both projectiles. Therefore, the FS and QE for both projectiles will be the same.

b. Use Table 9-24 to process a two-gun illumination lateral spread fire mission. An example ROF for this entire mission is shown in Figure 9-26. The time fuze being fired is the M577.

Table 9-24. Two-Gun Illumination Lateral Spread Fire Mission Process.

STEP	REFERENCE	ACTION
1	CFF	Computer records the CFF sent by the observer.
2	Fire Order	Computer records the fire order announced by the FDO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the pieces to follow, pieces to fire, and method of fire.
	Sp Instr	Computer announces and records as directed by the fire order.
	Sh	Computer announces and records shell illumination.
	Lot	Computer announces and records the lot for shell illumination.
4	MTO	Computer records the MTO announced by the RATELO.
5	Rg	HCO determines and announces range. Computer places the MHL of the illuminating GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If not announced in the fire order, the computer will determine the charge.
7	Fz	Computer records and announces fuze time.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	VI	VCO determines and announces the VI. Computer records it in the upper computational space and expresses it to the nearest 50 meters.
10	Illumination HOB	Computer determines the HOB by modifying the optimum HOB. The VI is applied to the optimum HOB. This value determines the HOB scale to be used on the GFT.
11	100/R	Computer determines and records 100/R at the initial chart range from the GFT.
12	__/R	Computer determines and records a multiple of 100/R. The multiple is based on the illuminating projectile (400/R for 105 mm and 500/R for 155 mm).
	NOTE: Chart deflection and range are recorded on two separate lines in the subsequent fire commands block. The computer adds and subtracts __/R from the chart deflection. This is accomplished by recording **L__/R** and **R__/R** in the lower Df Corr block. Steps 13 through 17 are completed for the two separate lines.	
13	Ti (M565)	Computer determines, announces, and records the FS. If the M577 fuze is to be fired, the M565 FS is recorded in the lower computational space where it will be corrected.
14	FS Corr	Computer determines and records the FS correction from Table B of the TFT and records it in the lower computational space.
15	Ti (M577)	The FS correction determined in step 14 is applied to the M565 FS to determine the M577 FS. This value is recorded in the Ti block and announced to the howitzer(s).
16	Df	Computer records and announces the chart deflection. Computer determines and announces the deflection to fire by applying _/R to the chart deflection by using LARS.
17	QE	Computer determines and records the QE directly from the GFT and announces it.
18	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) has been fired, the computer circles the number.
19	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.



RECORD OF FIRE

CALL FOR FIRE

Observer C19 [✓ AF] FFE/IS/S Tgt

Grid: 400 258

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

SUSPECTED VEHICLES, ILLUM, LATERAL SPREAD

TGT ALT 1110
-PLT ALT 1062
VI=+48≈+50

OPT HOB 600
VI +50
HOB 650

△ FS

100/R 13

~~500~~/R 65

20/R

HOB Corr

∡ Si ÷ 10

10m Si

FIRE ORDER #1+#4 ① LOT IG CHG 5 AMC

Df Corr

Si

INITIAL FIRE COMMANDS ~~FM~~ ✓ MF #1+#4 ①

Rg 7830

Cht Df 3565

El

Sp Instr AMC, SPEC CORR

Sh ILL Lot IG Chg 5 Fz TI Ti

Df

QE

MTO H, ①, AA7009

∡ T

PE_R

TF

In Eff

Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
	(R500)			#1		28.1	3565	R65	3500					573		
	(L500)			#4		28.1	3565	L65	3630					573	②	ILL ✓
			EOM	EOM												

#1 + #4 M565 FS 28.0
FS CORR +0.1
M577 FS 28.1

SURVEILLANCE: NO VEHICLES DETECTED

Btry	DTG	Tgt	Replot Grid	Replot Alt
1/A	030100Z APR94	AA 7009		

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Figure 9-26. Example ROF for a Two-Gun Illumination Lateral Spread Fire Mission.

9-18. Four-Gun Illumination--Range and Lateral Spread

a. The four-gun illum pattern is used to illuminate a large area in width and depth. Four rounds are fired at the same time by using the range and lateral spread patterns. The observer may request a range and lateral spread in the initial CFF or may request this pattern during a subsequent correction as part of a one-gun or two-gun (range or lateral spread) illum mission.

b. To process a four-gun illum mission, combine the procedures for the two-gun range spread and the two-gun lateral spread illum missions. The flank howitzers will fire the two-gun lateral spread while the interior howitzers will fire the two-gun range spread.

c. If the four-gun illum mission is requested during a subsequent correction, the FDO must initiate a new fire order and the computer will announce new initial fire commands.

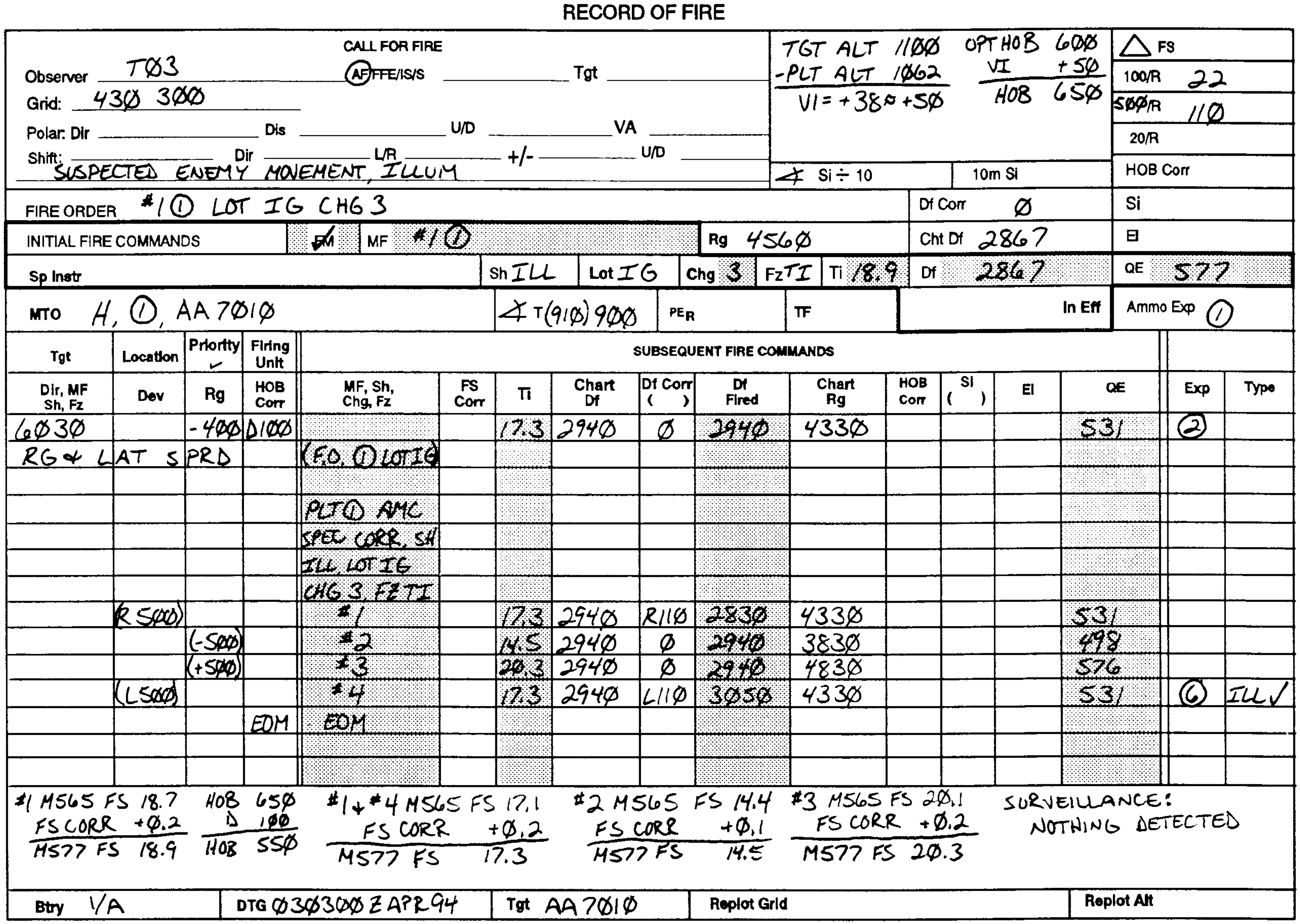
NOTE: An example ROF for this type of mission is shown in Figure 9-27. The time fuze being fired is the M577.

9-19. Coordinated Illumination

a. A coordinated illum mission is a combination of an illum mission (one-gun, two-gun, two-gun range or lateral spread, or four-gun range and lateral spread) and another fire mission (normally HE). The illumination is adjusted by the observer until the target is illuminated. When the best target illumination is achieved, the observer will command the FDC to **MARK** the illumination. Once the observer has marked the illum round, he will request coordinated illumination and transmit another call for fire. The FDC will process both missions following normal procedures. The rounds will be fired at a predetermined interval that will ensure the rounds of the second mission function when the target is best illuminated. This allows the observer to make the needed corrections and observe the effects. The firing interval may be controlled by either the FDC or observer. The preferred method is for the FDC to control the firing interval.

b. Every time an illum round is fired, the FDC will start a stopwatch. When the target receives the best illumination, the observer will announce **ILLUMINATION MARK.** The FDC will stop the stopwatch. This time interval is known as the illumination mark time and this value is recorded. When the second call for fire is received, the FDC must compute the TF for the second mission. This TF plus a five-second reaction time is subtracted from the illum mark time and the difference is the firing interval **(ILLUM MARK TIME - (TF + 5 SECONDS) = FIRING INTERVAL).** At this point, the FDC must ensure both missions are AMC. The FDC commands the howitzer(s) firing the illum mission to fire. The stopwatch is started as the illum mission is fired. When the firing interval is reached, the FDC commands the howitzer(s) firing the second mission to fire.

c. The observer may request by round at my command. In this situation, the observer wishes to control the firing of both missions. The FDC will compute data, ensuring both missions are AMC. The FDC must also transmit the TOF of the second mission to the observer. When the howitzers for both missions report **READY,** the FDC will relay this information to the observer. The observer commands the firing of the ilhum mission. After determining the firing interval, the observer commands the firing of the second mission at the appropriate time.



RECORD OF FIRE

CALL FOR FIRE

Observer T03 — [✓ AF]/FFE/IS/S — Tgt

Grid: 430 300

Polar: Dir — Dis — U/D — VA

Shift: — Dir — L/R — +/- — U/D

SUSPECTED ENEMY MOVEMENT, ILLUM

TGT ALT 1100
-PLT ALT 1062
VI = +38 ≈ +50

OPT HOB 600
VI +50
HOB 650

△ FS	
100/R	22
500/R	110
20/R	
HOB Corr	
Si	
El	
QE	577
Ammo Exp	①

∡ Si ÷ 10 — 10m Si

FIRE ORDER #1 ① LOT IG CHG 3 — Df Corr 0

INITIAL FIRE COMMANDS [✓ FM] MF #1 ① — Rg 4560 — Cht Df 2867

Sp Instr — Sh ILL — Lot IG — Chg 3 — Fz TI — Ti 18.9 — Df 2867

MTO H, ①, AA7010 — ∡ T(910) 900 — PE R — TF — In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
6030		-400	D100			17.3	2940	0	2940	4330				531	②	
RG & LAT SPRD				(F.O. ① LOT IG												
				PLT ① AMC												
				SPEC CORR, SH												
				ILL LOT IG												
				CHG 3, FZ TI												
	(R500)			#1		17.3	2940	R110	2830	4330				531		
		(-500)		#2		14.5	2940	0	2940	3830				498		
		(+500)		#3		20.3	2940	0	2940	4830				576		
	(L500)			#4		17.3	2940	L110	3050	4330				531	⑥	ILL ✓
			EOM	EOM												

#1 M565 FS 18.7
FS CORR +0.2
M577 FS 18.9

HOB 650
Δ 100
HOB 550

#1 & #4 M565 FS 17.1
FS CORR +0.2
M577 FS 17.3

#2 M565 FS 14.4
FS CORR +0.1
M577 FS 14.5

#3 M565 FS 20.1
FS CORR +0.2
M577 FS 20.3

SURVEILLANCE:
NOTHING DETECTED

Btry 1/A — DTG 030300Z APR 94 — Tgt AA7010 — Replot Grid — Replot Alt

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Figure 9-27. Example ROF for a Four-Gun Illumination Range and Lateral Spread Fire Mission.

d. Use the steps in Table 9-25 to determine the firing interval. Example ROFs for this type of mission are shown in Figures 9-28 and 9-29. The illum time fuze being fired is the M577.

e. An example of determining the firing interval is shown below.

f. When coordinated illumination is requested, the FDO must initiate a new fire order for the second mission and the computer will announce new initial fire commands. If the howitzers that are firing the illumination are also included in the second mission, the FDC must ensure those howitzer sections understand they are firing both missions and inform them of the firing interval between missions.

Table 9-25. Determination of the Firing Interval.

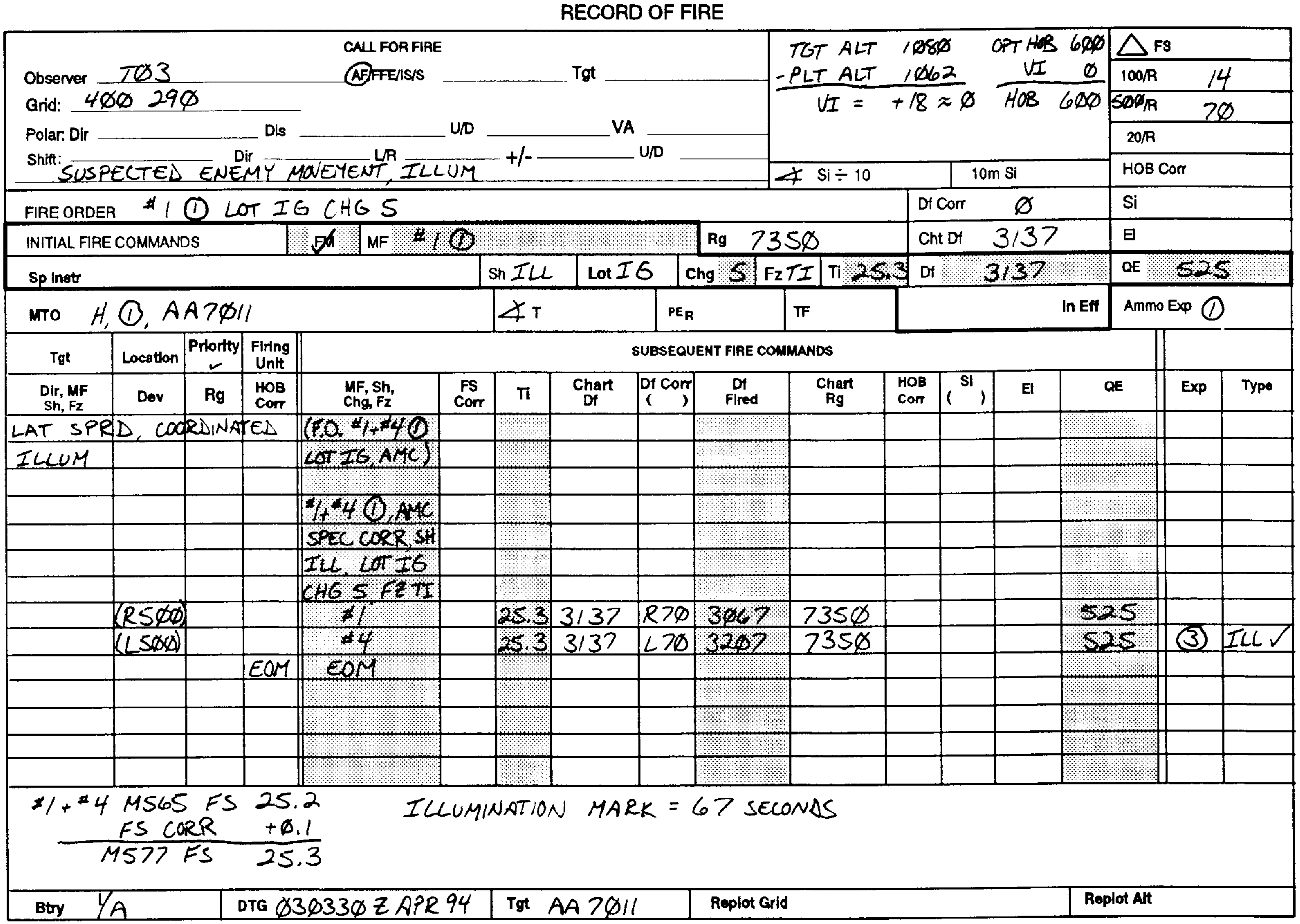
STEP	ACTION
1	Record the number of seconds to the best illumination (mark time), as determined with the stopwatch.
2	Record the time of flight for the second mission.
3	Subtract step 2 from step 1 to determine the difference.
4	Subtract 5 seconds from the difference determined in step 3 for reaction time.
5	The result is the firing interval between the illumination mission and the second mission.

EXAMPLE

ILLUMINATION MARK (STOPWATCH)	64
HE TIME OF FLIGHT (GFT/TFT)	-18
DIFFERENCE	46
REACTION TIME	-5
FIRING INTERVAL	41

The FDC must give the command to fire the HE projectile 41 seconds after the illum round is fired.

	Illum Fired	Command to Fire HE		MARK Best Illum
Time Line	0	41	46	64
		5 Seconds Reaction	18 Seconds HE TOF	HE Impacts



RECORD OF FIRE

CALL FOR FIRE

Observer T03 [✓ AF] FFE/IS/S Tgt

Grid: 400 290

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

SUSPECTED ENEMY MOVEMENT, ILLUM

TGT ALT 1080
-PLT ALT 1062
VI = +18 ≈ 0

OPT HOB 600
VI 0
HOB 600

∡ Si ÷ 10

10m Si

△ FS

100/R 14

500/R 70

20/R

HOB Corr

Si

El

FIRE ORDER #1 ① LOT IG CHG 5

Df Corr 0

INITIAL FIRE COMMANDS [✓ FM] MF #1 ①

Rg 7350

Cht Df 3137

Sp Instr

Sh ILL Lot IG Chg 5 Fz TI Ti 25.3 Df 3137 QE 525

MTO H, ①, AA7011

∡T

PE R

TF

In Eff

Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
LAT SPRD, COORDINATED				(F.O. #1+#4 ①												
ILLUM				LOT IG, AMC)												
				#1+#4 ①, AMC												
				SPEC CORR, SH												
				ILL, LOT IG												
				CHG 5, FZ TI												
	(R500)			#1		25.3	3137	R70	3067	7350				525		
	(L500)			#4		25.3	3137	L70	3207	7350				525	③	ILL ✓
			EOM	EOM												

#1 + #4 M565 FS 25.2
FS CORR +0.1
M577 FS 25.3

ILLUMINATION MARK = 67 SECONDS

Btry 1/A DTG 030330Z APR 94 Tgt AA7011 Replot Grid Replot Alt

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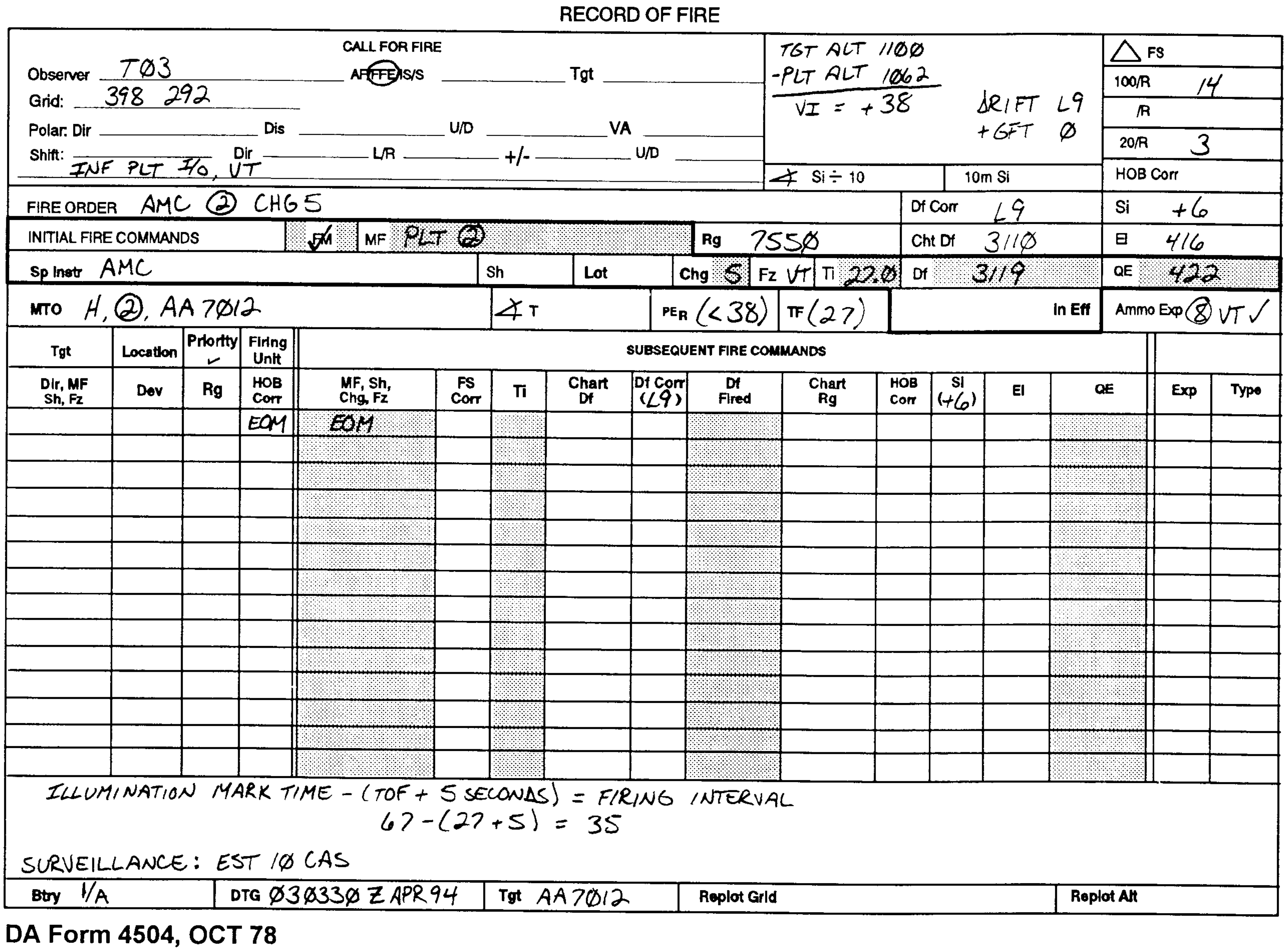
Figure 9-28. Example ROF for the Illumination Portion of a Coordinated Illumination Fire Mission.



RECORD OF FIRE

CALL FOR FIRE

Observer T03 AF [✓ FFE] IS/S Tgt

Grid: 398 292

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

INF PLT I/O, VT

TGT ALT 1100
-PLT ALT 1062
VI = +38

DRIFT L9
+GFT 0

△ FS

100/R 14

/R

20/R 3

∡ Si ÷ 10

10m Si

HOB Corr

FIRE ORDER AMC ② CHG 5

Df Corr L9

Si +6

INITIAL FIRE COMMANDS [✓ FM] MF PLT ②

Rg 7550

Cht Df 3110

El 416

Sp Instr AMC

Sh

Lot

Chg 5 Fz VT Ti 22.0

Df 3119

QE 422

MTO H, ②, AA 7012

∡ T

PE_R (<38) TF (27)

In Eff

Ammo Exp ⑧ VT ✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L9)	Df Fired	Chart Rg	HOB Corr	Si (+6)	El	QE	Exp	Type
			EOM	EOM												

ILLUMINATION MARK TIME - (TOF + 5 SECONDS) = FIRING INTERVAL
67 - (27 + 5) = 35

SURVEILLANCE: EST 10 CAS

Btry I/A DTG 030330Z APR 94 Tgt AA7012 Replot Grid Replot Alt

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Figure 9-29. Example ROF for the HE Portion of a Coordinated Illumination Fire Mission.

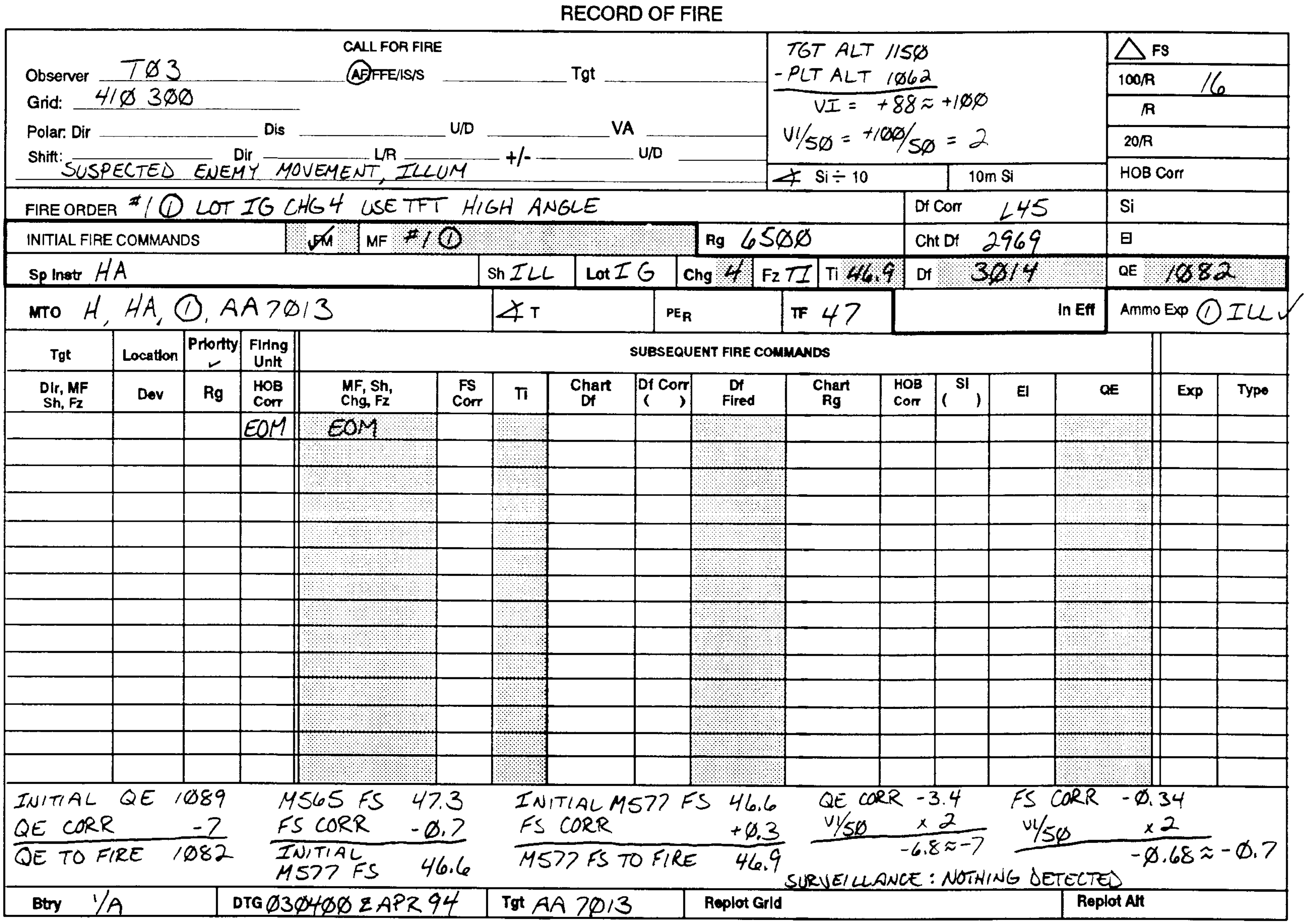
9-20. High-Angle Illumination

a. Some impact areas are so small that firing low-angle illumination severely restricts or prohibits the firing of the round because of range-to-impact concerns with the projectile body. To compensate for this, fire high-angle illumination and use the TFT (Part 2, Illumination). **This is not the preferred method of firing illumination.**

b. Use Table 9-26 to process a high-angle illumination mission. An example ROF for this type of mission is shown in Figure 9-30. The time fuze being fired is M577.

Table 9-26. High-Angle Illumination Process.

STEP	ACTION
1	Determine and record the chart range and deflection.
2	Determine VI, and express it to the nearest 50 meters, if applicable.
3	Determine the change in 50-meter increments from the value determined in step 2.
4	Determine the QE at the chart range from Table A, Column 2.
5	Determine the M565 FS corresponding to the QE determined in step 4 from Column 3.
6	Determine the correction factor to QE from Column 4, the correction factor to FS from Column 5, and the FS correction from Table B, if applicable.
7	Determine the FS to fire. Multiply the value from step 3 by the FS correction from step 6. This value is expressed to the nearest 0.1 and is then applied to the FS from step 5. If firing the M577 fuze, apply the FS correction from Table B determined in step 6.
8	Determine the QE to fire. Multiply the value from step 3 by the QE correction from step 6. This value is expressed to the nearest 1 mil and is then applied to the QE from step 4.
9	Determine the deflection to fire on the basis of the fire order (one-gun, two-gun, two-gun range or lateral spread, or four-gun range and lateral spread).
	NOTE: Deflection equals the drift correction corresponding to the QE (nearest listed value) plus the chart deflection. See Table F, High-Angle, Column 8. Drift should be expressed to the nearest mil.



RECORD OF FIRE

Observer T03
CALL FOR FIRE [✓ AF] FFE/IS/S Tgt
Grid: 410 300
Polar: Dir Dis U/D VA
Shift: Dir L/R +/- U/D
SUSPECTED ENEMY MOVEMENT, ILLUM

TGT ALT 1150
- PLT ALT 1062
VI = +88 ≈ +100
VI/50 = +100/50 = 2

∠ Si ÷ 10
10m Si

△ FS
100/R 16
/R
20/R
HOB Corr
Si
El

FIRE ORDER #1 ① LOT IG CHG 4 USE TFT HIGH ANGLE
Df Corr L45

INITIAL FIRE COMMANDS ~~FM~~ ✓ MF #1 ①
Rg 6500
Cht Df 2969

Sp Instr HA
Sh ILL
Lot IG
Chg 4
Fz TI
Ti 46.9
Df 3014
QE 1082

MTO H, HA, ①, AA7013
∠ T
PE R
TF 47
In Eff
Ammo Exp ① ILL ✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
			EOM	EOM												

INITIAL QE 1089
QE CORR -7
QE TO FIRE 1082

M565 FS 47.3
FS CORR -0.7
INITIAL M577 FS 46.6

INITIAL M577 FS 46.6
FS CORR +0.3
M577 FS TO FIRE 46.9

QE CORR -3.4
VI/50 x 2
-6.8 ≈ -7

FS CORR -0.34
VI/50 x 2
-0.68 ≈ -0.7

SURVEILLANCE: NOTHING DETECTED

Btry 1/A
DTG 030400 Z APR 94
Tgt AA 7013
Replot Grid
Replot Alt

DA Form 4504, OCT 78

Figure 9-30. Example ROF for a High-Angle Illumination Fire Mission.

Chapter 10

Registrations

Registration is a means of determining cumulative errors and the corrections for those errors. The purpose of this chapter is to explain registrations and their application to the gunnery problem.

Section I

Reasons for Registrations

Registrations should not be needed if the firing unit can meet their portion of the five requirements for accurate predicted fire (minus target location). If the observer cannot provide an accurate target location, the battalion S3 needs to consider providing a survey team to extend survey into the target area and providing common survey to the observers.

If all conditions of weather, position, and material were standard, a cannon firing at a particular elevation and deflection would cause the projectile to travel the range shown in the firing table corresponding to that elevation and charge. Since all standard conditions will never exist at the same time, firing table data must be corrected.

The purpose of a registration is to determine firing data corrections that will correct for the cumulative effects of all nonstandard conditions. With these corrections applied to firing data, a unit can rapidly and successfully engage any accurately located target within the range of their cannons and have a first round FFE capability.

10-1. Accurate Firing Unit Location

Accurate range and deflection from the firing unit to the target also require that the weapons be located accurately and that the FDC knows this location. The battalion survey section uses PADS to provide accurate survey information on the unit location. Survey techniques available to the firing unit can also help in determining the location of each weapon. The FDC can determine the grid location of each piece by using the reported direction and distance from the aiming circle used to lay the battery or platoon.

10-2. Accurate Weapon and Ammunition Information

The actual performance of the weapon is measured by the weapon muzzle velocity for a projectile family-propellant combination. The firing unit can measure the muzzle velocity of a weapon and correct for nonstandard projectile weight and propellant temperature. This is done by using the M90 velocimeter and MVCT M90-2 for each charge, propellant type, and projectile family. Calibration should be conducted continuously by using the M90. Firing tables and technical gunnery procedures allow the unit to consider specific ammunition information (weight, fuze type, and propellant temperature); thus, accurate firing data are possible.

10-3. Accurate Meteorological Information

The effects of weather on the projectile in flight must be considered, and firing data must compensate for those effects. Firing tables and technical gunnery procedures allow the unit to take into account specific met information (air temperature, air density, wind direction, and wind speed) in the determination of accurate firing data.

10-4. Accurate Computational Procedures

The computation of firing data must be accurate. If the five requirements for accurate predicted fire (minus target location) cannot be met, **registrations** can be conducted to compute data that will compensate for nonstandard conditions. Applying these corrections to other fire missions will allow the unit to determine accurate firing data.

NOTE: If the unit is able to meet the five requirements for accurate predicted fire, it will still be necessary to improve the firing data derived from the GFT. The unit will not be able to fire accurately (first round fire for effect capability) by firing "cold stick" data. Therefore, the use of a met + VE technique will allow the unit to take all measurable nonstandard conditions into account, and derive a GFT setting. Met + VE techniques are discussed in Chapter 11.

10-5. When to Conduct Registrations

a. The FDO must consider the following:

- Mission.
- Equipment.
- Troops.
- Time.
- Terrain and weather.
- Commander's guidance.
- Tactical situation.
- Enemy target acquisition assets.
- Availability and location of observers.
- Availability, location, and survey accuracy of known points.
- Type of registration.
- Assurance of registration validity.

b. A mission conducted only for the purpose of registering does not cause any damage to the enemy. It does, however, expose the firing unit to enemy TA devices. Also, missions conducted solely for the purpose of registering require additional ammunition and time. Therefore, when possible, registration missions should be integrated into other missions, especially when the observer is equipped with a laser.

c. Met + VE GFT settings should be used when accurate MVVS, met data, and survey are available. The amount of corrections needed to adjust onto a target will be minimal. Firing two check rounds from an inferred GFT setting can be an abbreviated registration. Any refinement sent by the observer should be used to adjust the GFT setting.

d. The flow chart shown in Figure 10-1 can be used to help you decide whether or not to conduct a registration.

10-6. Types of Registrations

a. There are two types of registrations: precision registration and high-burst and/or mean-point-of-impact (HB/MPI) registration. Within the two categories are alternate methods of registering that may be more suitable for use in a particular tactical situation.

(1) Precision registration. The precision registration is a technique for determining, by adjustment, firing data that will place the MPI of a group of rounds on a point of known location. The point of known location is called a known point.

(2) High-burst and/or mean point-of-impact registration. The HB/MPI registration determines the mean burst location of a group of rounds fired with a single set of firing data. When the mean burst location (or MPI) has been determined, the chart data (should hit data) are determined and compared to the data that were fired (adjusted-data [did hit data]).

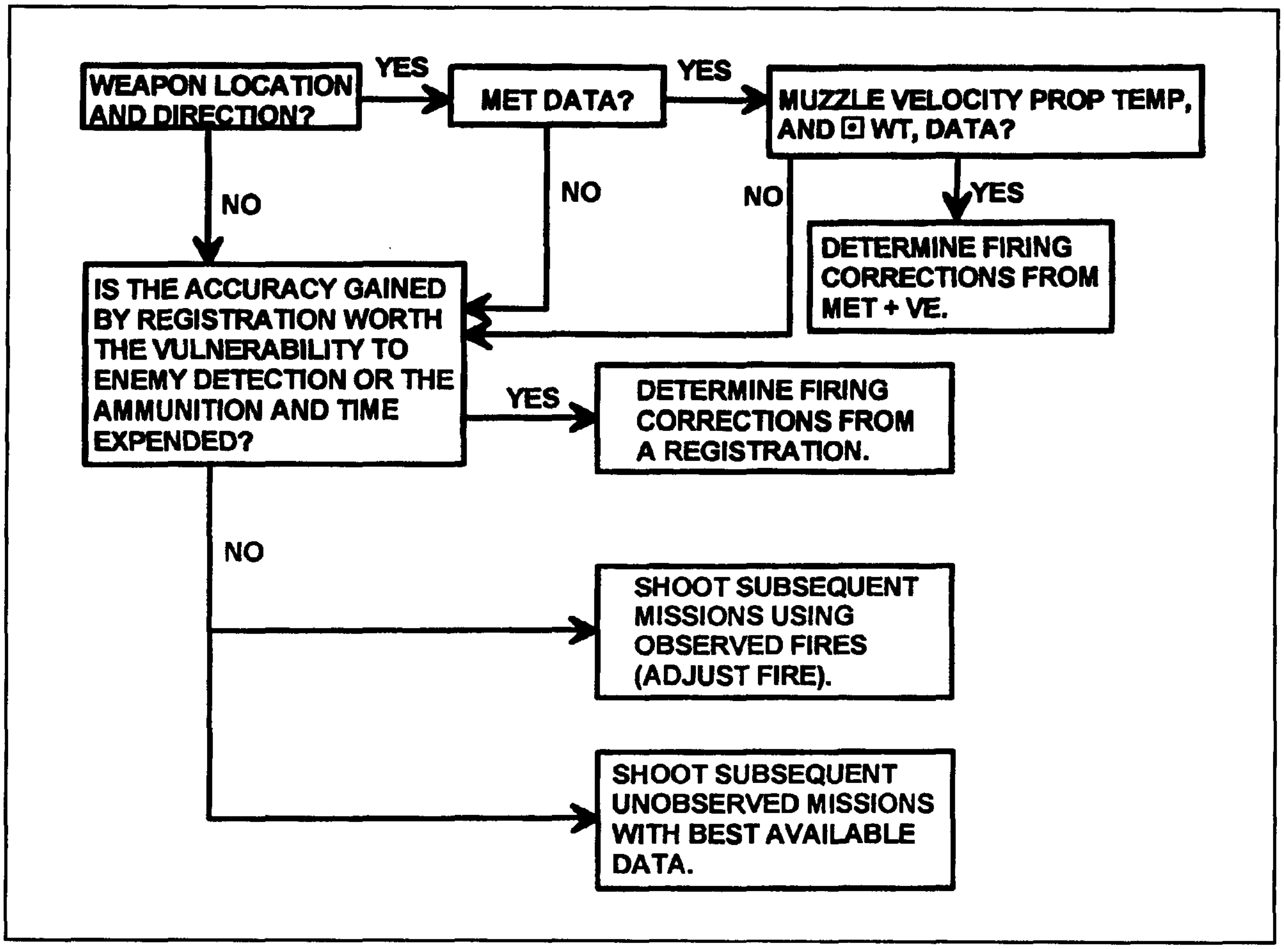


Figure 10-1. Registration Decision Diagram.

b. Alternate registration types are discussed below.

(1) Radar-observed registration. The radar-observed registration is a form of the HB/MPI registration and is thoroughly discussed later in this chapter.

(2) Abbreviated registration. Any registration that is conducted by using fewer usable rounds than recommended for the precision or HB/MPI techniques is an abbreviated registration. The use of fewer rounds degrades the results of total corrections. However, the use of fewer rounds to determine the mean burst location (MBL) or the use of a larger "acceptance box" (for example, 2 PEs rather than 1 PE from the MPI) is acceptable if the decreased assurance is acceptable to the commander.

(a) Abbreviated HB/MPI registration. An abbreviated HB/MPI registration is conducted exactly like an HB/MPI registration, except fewer rounds are fired.

(b) Met + VE and check round(s). This form of abbreviated registration requires the solution of a subsequent met to an accurately located target and determines adjusted data by adjusting a round(s) fired by use of the met + VE firing data. Final corrections are determined on the basis of observer refinement.

(c) Abbreviated laser registration. The abbreviated laser registration determines total corrections by comparing the data fired to the chart data determined to the burst location.

(d) Adjust-fire missions. Any adjust-fire mission conducted on an accurately located target can be used to improve firing data by determining total corrections on the basis of the observer adjustments. In this case, refinement data must be sent by the observer. The validity of the GFT setting is directly proportional to the accuracy of the target location.

NOTE: Use of the laser with common directional control enables an observer to accurately locate a target to registration-required accuracy.

(3) Offset registration. A platoon or offset position as much as 1,000 to 2,000 meters away from the firing unit center can be used to conduct a registration. The GFT setting determined from the offset position is assumed to be valid for the primary position if common survey and common direction exist between the two positions. A registration from a flank platoon may reduce the vulnerability of the firing unit.

(4) Registration to the rear.

(a) Registering to the rear (or at some azimuth significantly different from the primary azimuth of fire) results in a GFT setting that does not include the primary azimuth of fire within its deflection transfer limits.

(b) To derive a GFT setting for the primary azimuth of lay, apply eight-direction met techniques as follows:

- Determine position constants by working a concurrent met for the registration azimuth.
- Using subsequent met techniques, determine the total corrections (in the direction of the azimuth of lay) by reworking the met.

NOTE: The eight-direction met technique is discussed later in this chapter and in detail in Chapter 11.

10-7. Assurance Tables

A registration conducted with fewer rounds than recommended will degrade the accuracy of the determined corrections. Table 10-1 lists the percentage of probability that the mean location of a particular number of rounds is within 1 or 2 probable errors of the actual mean point of impact achieved by firing an infinite number of rounds. As more rounds are fired, the assurance of validity of the MPI is increased. If the tactical situation dictates, the lesser assurance from an abbreviated registration may have to be accepted.

Table 10-1. Assurance of Registration Validity.

NUMBER OF ROUNDS FIRED	1	2	3	4	5	6
WITHIN 1 PROBABLE ERROR	50%	66%	76%	82%	87%	90%
WITHIN 2 PROBABLE ERRORS	82%	94%	98%	99%	99%	99%

10-8. Registration Corrections and GFT Settings

a. The final step in every registration is the determination and application of registration corrections. Registration corrections consist of total range, total fuze, and total deflection corrections. The total corrections are determined by comparing the chart data (should hit data) to the adjusted data (did hit data) resulting from a registration. When it is impractical to conduct a registration, corrections can be obtained mathematically by use of a met technique. (See Chapter 11.)

b. The total corrections are then used as the basis for a GFT setting. This allows the FDC personnel to apply total corrections to the GFT. With the GFT setting properly applied, it is possible to fire for effect without an adjustment phase on accurately located targets within transfer limits. Total corrections, GFT settings, and transfer limits will be discussed in greater detail later in this chapter. It is important to remember that no registration is complete until registration corrections-are determined and a GFT setting is applied.

NOTE: Should hit data (SHD) are data fired under standard conditions that will cause the round to impact at a point of known location. Did hit data (DHD) are data fired under nonstandard conditions that will cause the round to impact at a point of known location.

Section II

Precision Registrations

Precision registration is a technique that requires an observer to adjust a group of rounds fired from the same howitzer so that their mean point of impact occurs at a point of known location (that is, a known point). The point of registration is accurately located (8-digit grid, 10-meter accuracy or 10-digit grid 1-meter accuracy). It can be determined from survey, can be an easily recognized map spotted terrain feature, or it can be any identifiable point located by a laser and should be on common survey with the firing unit, Corrections are determined by comparing the data that actually did hit the target (adjusted data) to the data that should have hit the target (chart data) if standard conditions had existed at the time of firing.

10-9. Objective

The observer's objective in the impact phase of a precision registration is to obtain spottings of two **OVERS** and two **SHORTS** along the OT line from rounds fired with the same data or from rounds fired with data 25 meters apart (50 meters apart when PER is greater than or equal to 25 meters). This normally requires the spottings of four separate rounds. Four spottings achieved by firing projectiles with the same data or data 25 meters apart is critical. This critical bracket must be formed by the observer making only range corrections since a deviation correction will introduce a difference in firing data greater than the 25-meter requirement. The observer should not make any deviation corrections after establishing the 200-meter bracket. If he does, then any previous rounds cannot be used as part of the 25-meter bracket. However, a **TARGET HIT** or **RANGE CORRECT** will be spotted by the observer as an **OVER** and a **SHORT.** The objective of the time portion of the registration is to correct the mean height of burst of four rounds fired with the same data to 20 meters above the target point. The FDC's objective in a precision registration is to determine corrections to firing data on the basis of the observer's corrections and to determine whether or not the objectives were achieved.

10-10. Initiation of a Precision Registration

a. The decision to register is based on the considerations in Section I. After the decision to register has been made, the FDO announces a fire order.

(1) Fire order. When the FDO announces his fire order, he addresses four questions:

(a) What are we going to do? (for example, precision registration)

(b) Where are we going to do it? (for example, known point 1)

(c) With whom? (for example, with T03)

(d) With what fire order considerations? (The FDO does not address fire order SOP items unless he feels that it is necessary to avoid confusion.)

(2) Registering piece. Use only one weapon to fire the registration. It is best to select the piece that is plotted on the firing chart and for which we have accurate MVV information for the registering charge (for example, the **BASE PIECE).**

(3) Lot. Register the largest calibrated lot of propellant. This lot is used for first-round FFE missions.

(4) Charge selection. Listed below are a few of the factors an FDO should consider when selecting the charge to register.

(a) At what range will most targets be engaged?

(b) If the enemy has a sophisticated sound ranging capability, a lower charge is preferred.

(c) If the enemy has a sophisticated counterbattery radar capability, a higher charge is preferred.

(d) Which charge has the smallest PER for a given range (see the charge selection table in the TFT).

(e) Lower charges produce less tube wear, residue, and noise. They also have better terminal effects with shell HE.

b. When the RATELO hears the fire order, he will announce a message to observer to alert the observer.

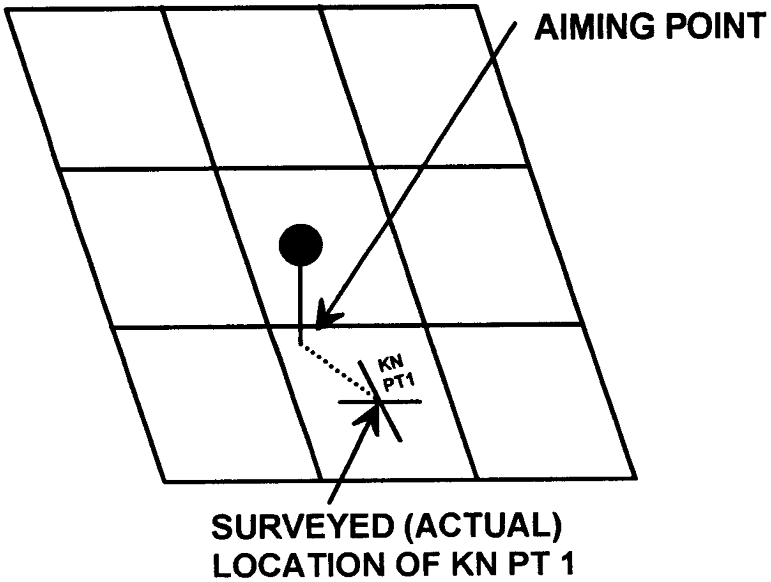
(1) MTO. The MTO includes the information from the fire order that pertains to the observer; for example, type of registration, the known point, and fuzes to be registered. If there is no **known point,** the FDO will direct the observer to select one in a specified area, and the observer will send the location to that point. The FDO will then designate the number of the known point. Because of the possibility of introducing a target location error, this option is least preferred.

(2) Observer's response. After the observer has received the MTO, he will report direction. If the observer is directed to select a known point, he will report the eight-digit grid location and direction. In either case, the report of direction indicates the observer is ready to conduct the registration.

10-11. Conduct of the Impact Phase of a Precision Registration

a. Fire direction procedures for an impact phase of a registration are identical to those used in the conduct of any adjust-fire mission. All observer corrections are plotted on the firing chart and chart data are announced. The computer sends fire commands to the registering piece. Although care should be taken during all computational steps, extraordinary measures should not be used for the conduct of a registration.

b. The final location of the plotting pin on the chart represents the point where the howitzer had to be aimed to have rounds impact on the known point (Figure 10-2). It is not the actual location of the known point. The difference between these locations depicts the effects that all nonstandard conditions had during firing.



Fiaure 10-2. Difference Between Aiming Point and Surveyed Location.

c. The data announced after the observer's final impact refinement shows the range and deflection to the point where the howitzers must aim to have rounds impact on the known point. At this point, no projectile is fired and the time phase of the registration begins. The deflection and elevation corresponding to the data measured to the final pin location is called the adjusted data--the data that **did hit** the known point. Adjusted data will be circled on the record of fire.

10-12. Conduct of the Time Phase of a Precision Registration

a. When the impact phase of the registration is complete, the time phase can be started. The observer's refinement data moved the mean point of impact of the rounds to the known point. At this point, an adjusted deflection and elevation are determined. The adjusted deflection and elevation are did hit data for the known point and the most accurate data with which to begin the time portion.

b. The first fuze setting fired corresponds to the adjusted elevation. The initial fuze setting to fire is determined by placing the MHL over the adjusted elevation and reading a fuze setting corresponding to that adjusted elevation. At the same time, the computer determines ▲ FS corresponding to the first fuze setting fired.

c. As with other fuze time missions, an HOB correction (20/R) is added to the ground site to determine a total site. The total site is added to the adjusted elevation to determine the quadrant to fire for the rest of the mission. The adjusted deflection is fired for the rest of the mission.

d. Normal procedures for application of ▲ FS for up or down corrections are followed to meet the objective of the time phase of the mission, which is to correct the mean height of burst of four rounds fired with the same data to 20 meters above the known point.

e. The adjusted time is determined after the observer's HOB refinement is applied. The adjusted time is circled. With the observer's correction applied, the adjusted time will produce an airburst 20 meters above the known point. The adjusted time is not fired.

10-13. Second Lot Registrations

a. The use of the second lot registration technique has become obsolete with the use of the M90 chronograph and the ability to account for muzzle velocity differences in propellant lots. The GFT settings for subsequent lots can be determined by using the subsequent met techniques if muzzle velocity information is available.

b. Conduct second lot registrations in the same manner as single lot registrations with the following exceptions:

(1) Fire order. The fire order informs the FDC that corrections are needed for two different lots (of the same charge and propellant type).

(2) MTO. The radio operator transmits the MTO notifying the FO to observe two lots by announcing **TWO LOTS** after the fuze or fuzes to be fired.

10-14. Initiation of the Second Lot Registration

a. After completing the first lot time registration, begin firing the first round of the second lot registration with the adjusted deflection and the adjusted quadrant elevation (adjusted elevation plus ground site) determined for the first lot. **Fire fuze quick only.** To notify the observer that a second lot registration is going to be conducted, the FDC announces: **OBSERVE SECOND LOT, OVER.**

b. In the appropriate columns on the ROF, enter the firing data determined from the first lot registration. These data include the following:

- Adjusted deflection.
- Adjusted chart range.
- Value of ground site.
- Adjusted elevation.

c. The adjusting piece must be given commands to change the method of fire, lot and fuze. The objective of the second lot registration is the same as that of the first lot. Once the observer has met the objective, he will announce **(any refinement)** and **RECORD AS SECOND LOT REGISTRATION POINT, END OF MISSION.**

d. To determine the adjusted fuze setting, add the fuze correction from the first lot to the fuze setting corresponding to the subsequent lot adjusted elevation. To determine the adjusted fuze setting for the second lot registration, follow the steps in Table 10-2.

Table 10-2. Determine Adjusted Fuze Setting (Second Lot).

STEP	ACTION
1	Align the MHL of the GFT over the adjusted elevation from the second lot registration.
2	Determine the fuze setting under the MHL.
3	Add the total fuze correction from the first lot precision registration to the fuze setting determined in step 2.

e. The second lot GFT setting will be constructed in the same manner as the first lot GFT setting.

NOTE: To minimize confusion, the second lot GFT setting should be placed on a different cursor and labeled with the appropriate lot.

f. Determine the total deflection correction by using the following formula:

2D LOT ADJ DF - CHART DF = TOT DF CORR

g. Determine the GFT deflection correction by placing the MHL over the second lot adjusted elevation and reading the value under the MHL on the drift scale. This value is subtracted from the total deflection correction, and the LARS rule is used to determine whether the GFT deflection correction is a L or an R.

TOT DF CORR - DRIFT ~ 2D LOT ADJ EL = GFT DF CORR

10-15. Example of a Completed Precision Registration

a. Use Table 10-3 to process a precision registration with fuzes quick and time.

Table 10-3. Precision Registration Example.

STEP	REFERENCE	ACTION
1	Fire Order	Computer records the fire order announced by the FDO.
2	MTO	Computer records the MTO announced by the RATELO.
3	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Announced and circled or checked.
	MF	Computer determines, announces, and records the piece to fire and method of fire.
	Sp Instr	Computer announces and records these as directed by the fire order.
	Sh	Computer announces and records if other than standard.
	Lot	Computer announces and records if other than standard.
4	Rg	HCO determines and announces range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire (should hit range).
5	Chg	Computer announces and records charge. If it is not announced in the fire order, the computer will determine the charge.
6	Chart Df	HCO determines and announces chart deflection (should hit deflection). Computer records it.
7	El	Computer determines and records elevation.
8	Drift	Computer determines drift and records it in the computational space.
9	Df Corr	Computer records deflection correction. This element will be the same as drift.
10	Df	Computer determines, announces, and records the deflection to fire **(DF CORR + CHT DF = DF TO FIRE).**
11	SI	VCO determines and announces site. Computer records it.
12	QE	Computer determines, announces, and records quadrant elevation **(SI + EL = QE).**
13	In Eff	Computer announces and records fuze time.
14	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) have been fired, the computer circles the number.

Table 10-3. Precision Registration Example (Continued).

STEP	REFERENCE	ACTION
15	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Normal police procedures are followed as discussed in Chapter 9 with the exception of PE_R. PE_R for a registration is announced when it is ≥25 meters.	
16	Dir, MF, Sh, Fz, Rg, HOB Corr	Computer records the observer's direction and subsequent corrections.
17	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
18	Chart Rg	HCO determines and announces chart range. Computer places the MHL GFT over the announced range and records it on the record of fire.
19	Chart Df	HCO determines and announces chart deflection. Computer records it.
20	El	Computer determines and records elevation.
21	Df	Computer determines, records, and announces deflection **(CHT DF + (DF CORR)) = DF**.
22	QE	Computer determines, records, and announces QE **(EL + (SI))= QE**.
23	Exp and Type	Computer determines and records the total number of rounds (by type) fired to this point.
24	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Repeat steps 16 through 24 as needed to complete the observer's corrections. These steps are valid until the observer ends the impact phase.	

b. The observer ends the impact phase of the registration by providing refinement data and requesting **RECORD AS REGISTRATION POINT (announces the number of the registration point), TIME REPEAT.** Record this transmission on two lines of the ROF. The first line is used to determine the adjusted elevation and adjusted deflection. The adjusted data are determined by processing the refinement data. These adjusted data are referred to as **DHD** and are recorded and circled on the record of fire for quick reference. The adjusted data are not sent to the howitzer(s).

c. Once the refinement data have been processed, the time phase is initiated. The chart data, deflection to fire (adjusted deflection), and elevation (adjusted elevation) have already been determined. The only data that needs to be computed are the time fuze setting (should hit) and the quadrant elevation. Use the steps in Table 10-4 to process the time phase of the registration.

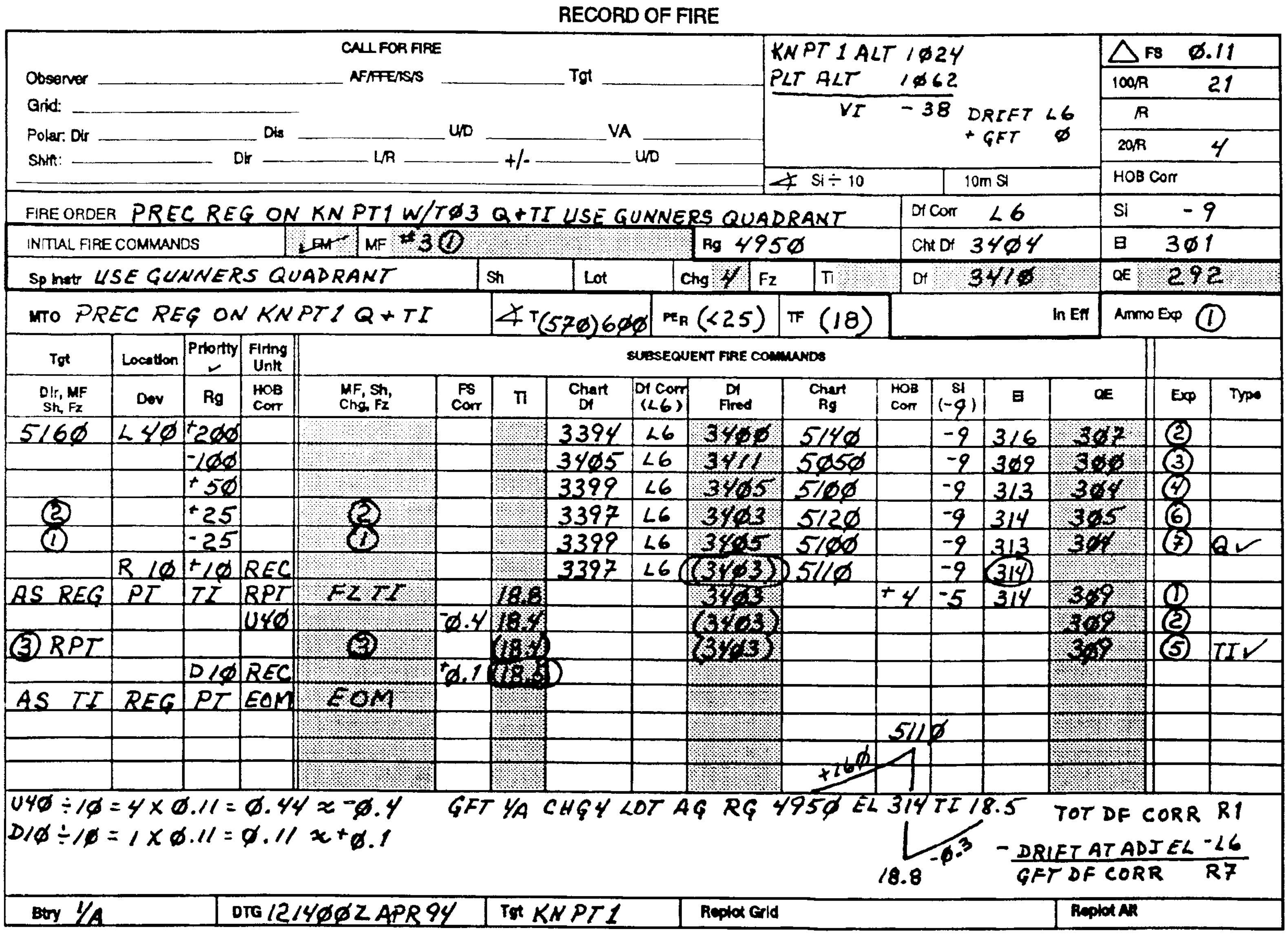
Table 10-4. Time Phase of Precision Registration.

STEP	REFERENCE	ACTION
1	MF, Sh, Chg, Fz	Computer announces and records fuze time.
2	Ti	Computer determines, announces, and records the fuze setting (should hit).
3	Df	Computer records and announces deflection to fire (adjusted deflection).
4	HOB Corr	Computer determines and records the HOB correction. 20/R is the HOB correction.

Table 10-4. Time Phase of Precision Registration (Continued).

STEP	REFERENCE	ACTION
5	SI	Computer determines the total site by algebraically adding the HOB correction to the previously determined ground site. The result is recorded in the site block.
6	El	Computer records the elevation (adjusted elevation).
7	QE	Computer determines, records, and announces QE **(EL + TOTAL SI) = QE**.
8	Exp and Type	Computer determines and records the total number of rounds for the impact phase. The ammo count starts over for the number of rounds being fired with the time fuze. Once the time phase is complete, the count is totaled by fuze type.
9	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Ensure σ FS is determined during police of the ROF, it is a function of fuze setting and is determined by using the fuze setting in step 26.	
10	Dir, MF, Sh, Fz, Dev, Rg, HOB Corr	Computer records the observer's subsequent corrections.
11	MF, Sh, Chg, Fz	Computer announces and records any changes to method of fire, shell, charge, or fuze.
12	FS Corr	Computer determines and records FS correction. The FS correction is determined by dividing the HOB correction by 10 and multiplying this value by σ FS. The result is expressed to the nearest tenth and is a signed value (USDA). The computations are placed in the bottom computational space of the ROF **(HOB CORR ÷ 10) x σ FS = FS CORR.**
13	Ti	Computer determines, announces, and records the fuze setting. The fuze setting is determined by applying the FS correction to the previous fuze setting fired.
14	Df	Computer records deflection in parentheses (it does not change).
15	QE	Computer records and announces QE.
16	Exp and Type	Computer determines and records the total number of rounds by type fired to this point.
17	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	NOTE: Repeat steps 10 through 17 for each subsequent time adjustment. The observer will request HOB corrections until an airburst is observed. The observer will then request **THREE ROUNDS REPEAT**.	

d. After spotting the last round, the observer will provide final refinement data to adjust the mean height of burst to **20 meters.** The observer will also direct **RECORD AS TIME REGISTRATION POINT, END OF MISSION.** Record this transmission on two lines of the ROF. The first line is used to process the final HOB correction and determine the adjusted time (did hit). The adjusted time is recorded and circled on the record of fire for quick reference. These data are not sent to the howitzer(s). The second line is used to record end of mission, which is sent to the howitzer(s). Once EOM is sent to the howitzer(s), a final police of the ROF is conducted. A completed ROF for a precision registration using the M582 time fuze is shown in Figure 10-3.



RECORD OF FIRE

CALL FOR FIRE
Observer ______ AF/FFE/S/S ______ Tgt ______
Grid: ______
Polar: Dir ______ Dis ______ U/D ______ VA ______
Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______

KN PT 1 ALT 1024
PLT ALT 1062
VI -38
DRIFT L6
+ GFT 0
∡ Si ÷ 10
10m Si

△ FS 0.11
100/R 21
/R
20/R 4
HOB Corr

FIRE ORDER PREC REG ON KN PT1 W/T03 Q+TI USE GUNNERS QUADRANT
Df Corr L6
Si -9

INITIAL FIRE COMMANDS ~~FM~~ MF #3 ①
Rg 4950
Cht Df 3404
El 301

Sp Instr USE GUNNERS QUADRANT
Sh
Lot
Chg 4
Fz
Ti
Df 3410
QE 292

MTO PREC REG ON KNPT1 Q + TI
∡T (570) 600
PER (<25)
TF (18)
In Eff
Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L6)	Df Fired	Chart Rg	HOB Corr	Si (-9)	El	QE	Exp	Type
5160	L40	+200					3394	L6	3400	5140		-9	316	307	②	
		-100					3405	L6	3411	5050		-9	309	300	③	
		+50					3399	L6	3405	5100		-9	313	304	④	
②		+25		②			3397	L6	3403	5120		-9	314	305	⑥	
①		-25		①			3399	L6	3405	5100		-9	313	304	⑦	Q ✓
	R 10	+10	REC				3397	L6	(3403)	5110		-9	(314)			
AS REG	PT	TI	RPT	FZ TI		18.8			3403		+4	-5	314	309	①	
			U40		-0.4	18.4			(3403)					309	②	
③ RPT				③		(18.4)			(3403)					309	⑤	TI ✓
		D10	REC		+0.1	(18.5)										
AS TI	REG	PT	EOM	EOM												

5110
+10

U40 ÷ 10 = 4 × 0.11 = 0.44 ≈ -0.4
D10 ÷ 10 = 1 × 0.11 = 0.11 ≈ +0.1

GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5
18.8
-0.3

TOT DF CORR R1
- DRIFT AT ADJ EL - L6
GFT DF CORR R7

Btry 1/A
DTG 121400Z APR 94
Tgt KN PT1
Replot Grid
Replot Alt

DA Form 4504, OCT 78

Figure 10-3. ROF for a Precision Registration.

10-16. Abbreviated Precision Registration

a. The tactical situation or ammo restraints may prohibit conducting a full-scale registration. In such cases, the FDO may conduct an abbreviated precision registration. Although having a lower assurance of validity, an abbreviated precision registration often provides adequate compensation for the effects of nonstandard conditions. The observer ends the registration when he believes that his next correction will put the next round on the registration point. The advantages of this type of registration are fewer rounds are fired so less ammunition is consumed and the registration takes less time so the unit is exposed to enemy TA devices for a shorter period of time.

b. After making the decision to register, the FDO announces a fire order. Once the RATELO hears the fire order, he transmits an MTO to alert the forward observer. After the observer has received the MTO, he sends a direction, which signifies he is ready to observe, to the FDC.

c. The observer procedures for an abbreviated precision registration are different than those used for a normal precision registration.

(1) The observer will use normal adjust-fire procedures until the 100-meter bracket is split.

(2) The correction then sent is an add (or drop) 50 meters FFE or time repeat or time add or drop 50 meters.

(3) The burst which is a result of an add (or drop) 50 meters is spotted. Minor corrections for both deviation and range are sent to the FDC in the following format:

(a) For both a quick and time registration: **L10, -40, RECORD AS REGISTRATION POINT, TIME REPEAT.**

(b) For an impact only registration: **R30, -10, RECORD AS REGISTRATION POINT, END OF MISSION.**

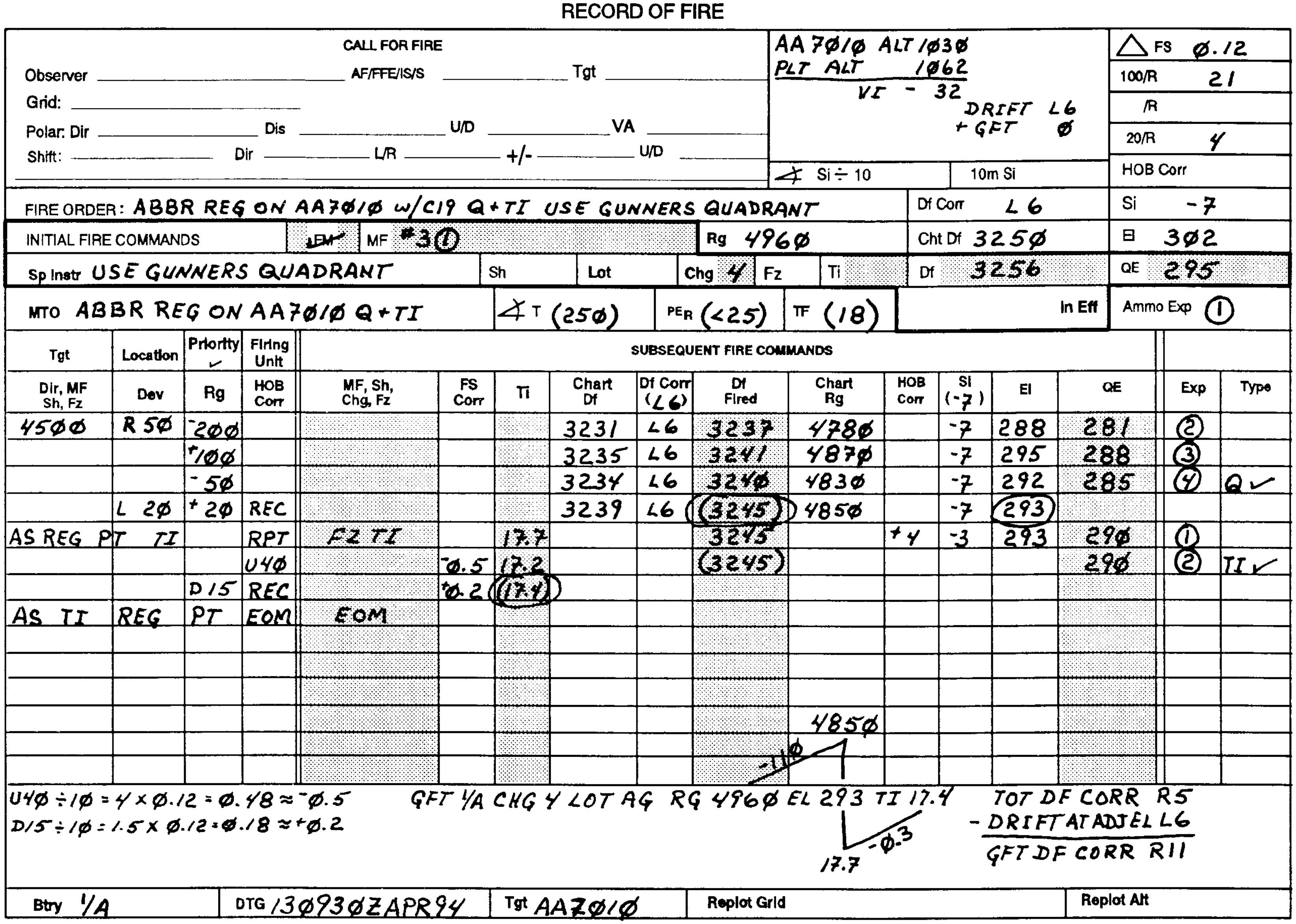
(c) Normal time adjustment procedures are followed in the time portion.

(d) Once an airburst is obtained, a correction for a 20-meter HOB is determined.

(e) Instead of firing for effect, refinement is sent to the FDC in the following format: **U5, RECORD AS TIME REGISTRATION POINT, END OF MISSION.**

NOTE: If the abbreviated registration is conducted as part of a normal adjust-fire mission, steps c(2) and c(3)(e) are modified to allow the observer to request FFE.

d. The GFT setting and total corrections are determined in the same manner as in a normal precision registration. A completed ROF for an abbreviated registration using the M582 time fuze is shown in Figure 10-4.



RECORD OF FIRE

CALL FOR FIRE

Observer ______ AF/FFE/IS/S ______ Tgt ______

Grid: ______

Polar: Dir ______ Dis ______ U/D ______ VA ______

Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______

AA 7010 ALT 1030
PLT ALT 1062
VI - 32
DRIFT L6
+ GFT 0

∡ Si ÷ 10 ______ 10m Si ______

△ FS	0.12
100/R	21
/R	
20/R	4
HOB Corr	
Si	-7
⊟	302
QE	295
Ammo Exp	①

FIRE ORDER: ABBR REG ON AA7010 w/C19 Q+TI USE GUNNERS QUADRANT

Df Corr L6

INITIAL FIRE COMMANDS ~~FM~~ MF #3①

Rg 4960

Cht Df 3250

Sp Instr USE GUNNERS QUADRANT

Sh ______ Lot ______ Chg 4 Fz ______ Ti ______ Df 3256

MTO ABBR REG ON AA7010 Q+TI

∡ T (250) PER (<25) TF (18) In Eff ______

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L6)	Df Fired	Chart Rg	HOB Corr	Si (-7)	El	QE	Exp	Type
4500	R 50	-200					3231	L6	3237	4780		-7	288	281	②	
		+100					3235	L6	3241	4870		-7	295	288	③	
		-50					3234	L6	3240	4830		-7	292	285	④	Q ✓
	L 20	+20	REC				3239	L6	(3245)	4850		-7	(293)			
AS REG PT TI			RPT	FZ TI		17.7			3245		+4	-3	293	290	①	
			U40		-0.5	17.2			(3245)					290	②	TI ✓
		D15	REC		+0.2	(17.4)										
AS TI	REG	PT	EOM	EOM												

4850
-110

U40 ÷ 10 = 4 × 0.12 = 0.48 ≈ -0.5
D15 ÷ 10 = 1.5 × 0.12 = 0.18 ≈ +0.2

GFT 1/A CHG 4 LOT AG RG 4960 EL 293 TI 17.4
17.7 -0.3

TOT DF CORR R5
- DRIFT AT ADJ EL L6
GFT DF CORR R11

Btry 1/A	DTG 130930ZAPR94	Tgt AA7010	Replot Grid	Replot Alt

DA Form 4504, OCT 78

Figure 10-4. ROF for an Abbreviated Precision Registration.

Section III

High-Burst/Mean Point of Impact Registrations

When registration is necessary, clearly defined and accurately located registration points may be limited or not available. Dense vegetation or ground fog may prevent the observers from seeing the ground. At night, adjustment of fire on a registration point is impossible without some type of illumination. The tactical situation may not allow the firing of numerous rounds required for a precision registration. The HB/MPI registration can overcome these problems. This section describes HB and MPI registrations.

10-17. Description

a. In HB and MPI registrations, the unit fires a number of rounds (ideally six) with the same set of firing data. These rounds are observed by two observers in surveyed positions, usually designated 01 and 02, who can measure the direction to each bursting round. One observer measures the VA to each round. On the basis of the observers' average directions and the average VA from one observer, determine and plot the MBL or the mean point of impact. Lastly, determine chart data and compare them to the adjusted data that were fired.

b. An MPI registration is fired with fuze quick. The HB registration is freed with time-tied rounds. The HB offers an advantage over the MPI registration by allowing the FDC to determine a fuze correction. The HB registration is also easier to observe, especially at night, and registration corrections can be determined in areas where the observers cannot see the ground.

c. The requirement for surveyed observer locations with directional control is the primary limitation of HB and MPI registrations.

d. The six basic steps to an HB or MPI registration are as follows:

- Select an orienting point.
- Orient the observers.
- Determine firing data to the orienting point.
- Fire the HB or MPI registrations.
- Determine the mean burst location.
- Determine chart data and registration corrections.

10-18. Selecting an Orienting Point

a. The S3 or FDO selects an orienting point at which all of the rounds will be fried. This point may be located at a grid intersection for convenience. The orienting point is only a temporary point on the firing chart. After computing firing data, the orienting point is no longer needed.

b. The orienting point for either an HB or MPI registration point should meet the following criteria.

(1) It must be visible to both observers.

(2) It should be close to the center of the area of responsibility (unless an eight-directional met technique is to be used to determine a valid GFT setting).

(3) It should ensure an acceptable apex angle (Figure 10-5). (The apex angle is the angle formed by the lines from each observer to the orienting point.) Since two of the methods used to determine the MBL involve the use of trigonometry (polar plot and grid coordinate), a strong apex angle is needed to minimize the effects of small measurement errors. More information can be found in FM 6-2.

(4) For an MPI registration, the orienting point should be in a relatively flat (level) area to eliminate the need to replot the MBL.

Minimum - 150 mils
Acceptable - 150 to 3,050 mils
Preferred - 300 to 2,900 mils
Optimum - 1,067 mils (equilateral triangle)

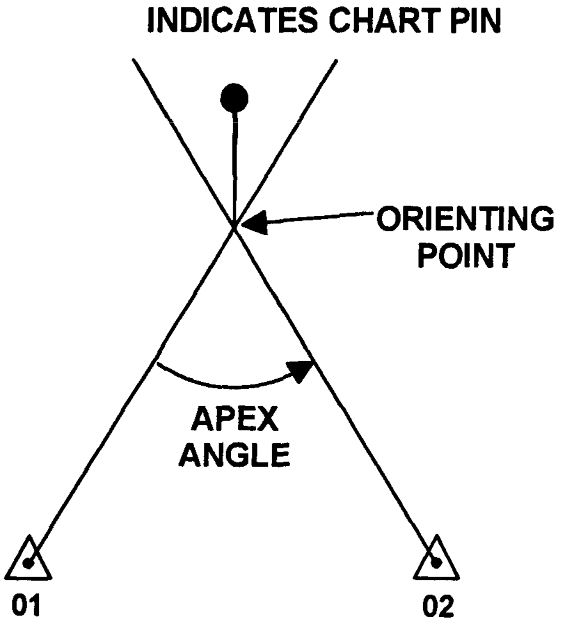


Figure 10-5. Apex Angle.

(5) For an HB registration, the orienting point must be high enough to ensure an airburst. The selected height of burst must be at least 2 FE in height of burst above the ground expressed up to the next 10 meters. The FDO can increase the HOB as long as it exceeds the minimum selected HOB. An example of this is below.

EXAMPLE

FDO of an M198 unit is selecting an orienting point for an HB registration and is firing charge 4GB.

Range to Orienting Point: 5,440 meters (Enter TFT, Table G, Column 5 with 4GB and the range expressed up to the next 500 meters.)

PE$_{HOB}$: 12 meters (extracted from TFT) (2 PE x 12 = 24 ≈ 30 meters. Thus, 30 meters is the lowest HOB that should be selected).

c. The FDO initiates the HB/MPI registration with a fire order; for example, **HIGH-BURST REGISTRATION AT GRID 4128, HEIGHT OF BURST PLUS 30, WITH T03 AND C19, 6 ROUNDS, FUZE TIME, BY ROUND AT MY COMMAND.** As with any registration fire order, this one specifies what will be done, where it is to be done, with whom, and with what fire order considerations (see paragraph 10-10). The FDO has specified BRAMC to be sure that the observers have enough time to spot each round fired and transmit spottings before the next round is fired.

10-19. Orienting the Observers

a. After selecting the orienting point and issuing the fire order, the two observers must be told whereto look to observe the rounds. Plot the observers' locations on the firing chart (if not already done), and measure the direction and distance from each observer to the orienting point. The VCO uses the distances and the VI between each observer location and the orienting point to determine the VA for each observer. Determine the VA by use of the C and D scales of the GST.

b. Send a message to each observer. The MTO contains the information the observers need to orient their instruments. Record the MTO on DA Form 4201. (See Figure 10-6, page 10-19.) The message contains the following elements:

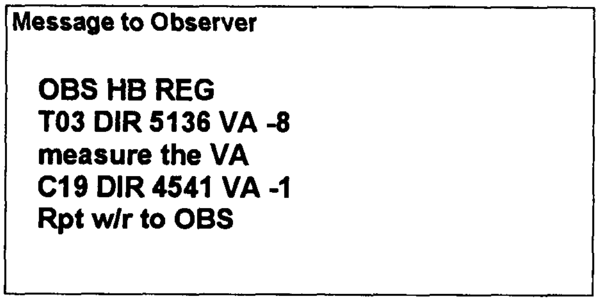
(1) A warning order (for example, OBSERVE HIGH-BURST REGISTRATION). The warning order informs the observers for what type of registration they are preparing.

(2) Orienting data for 01 (T03). The HCO measures the chart data from 01 to the orienting point. The direction reported to the observer is the direction determined on the firing chart. The VCO determines the ground altitude of the orienting point and then adds the HOB to determine the altitude of the orienting point. The VCO subtracts the altitude of the observer from the altitude of the orienting point to determine the vertical interval. The VCO uses the C and D scales of the GST, the vertical interval, and the distance measured by the HCO to determine 01's vertical angle. The vertical angle and direction reported to 01 will enable him to orient on the orienting point.

(3) A directive to 01 to measure the vertical angle. Normally, 01 is the more experienced observer and will measure the VA. Observer 01 measures the vertical angles that will be used to compute the altitude of the mean burst location. Only one observer reports the vertical angle.

(4) Orienting data for 02 (C19). The HCO measures the chart data from 02 to the orienting point. The VCO subtracts the altitude of the observer from the altitude of the orienting point to determine the vertical interval. The VCO uses the C and D scales of the GST, the vertical interval, and the distance measured by the HCO to determine 02's vertical angle. The vertical angle and direction reported to 02 will enable him to orient on the orienting point.

(5) A directive to the observers to report when they are ready to observe. When the observers report that they are ready to observe, the FDC can begin the registration.



Message to Observer

OBS HB REG
T03 DIR 5136 VA -8
measure the VA
C19 DIR 4541 VA -1
Rpt w/r to OBS

Figure 10-6. Example Message to Observer on DA Form 4201.

c. Each observer orients his instrument on the direction and vertical angle announced to him and announces when he is ready to observe the registration.

10-20. Determining Firing Data

a. The HCO determines the range and deflection from the firing unit to the orienting point and announces the data to the computer.

b. The VCO subtracts the altitude of the firing unit from the orienting point altitude to determine the vertical interval. He then uses the D scale and the site-range scale of the GST, the vertical interval, and the range announced by the HCO to determine site. The VCO announces site to the computer.

c. The computer records the site on the ROF and determines and announces the fire commands to the howitzer(s). The HOB correction (20/R) is not used for the HB registration since the HOB was already accounted for in the orienting point altitude. The data fired are the adjusted (did hit) data.

10-21. Firing the HB or MPI Registration

a. After both observers and the registering piece have reported ready, the FDO directs **FIRE THE REGISTRATION.** The first round that is fired may not be observed by either of the observers. There may be cases in which the nonstandard conditions cause the round to impact behind a hill or in a ravine, out of sight of one or both of the observers. Sometimes graze bursts occur at the start of an HB registration. The observers' data for these rounds cannot be used to determine the mean burst location. If this happens, change the firing data to the orienting point by increasing the HOB by at least 2 additional probable errors in HOB (Table G of the TFT) until both observers can see the bursting rounds (see paragraph 10-18). Remember, if the orienting point is changed, new orienting data must be sent to the observers (that is, a new MTO) so that they can orient on the new location.

b. Once both observers have spotted the round, the firing data are not changed. All rounds used to determine the MBL and/or MPI must be fired with the same set of firing data. These firing data are adjusted (did hit) data.

c. When both observers have reported that they have observed the bursting round, the computer transfers the firing data from the ROF to DA Form 4201 and writes "SEE ATTACHED DA FORM 4201" on the ROF. Record all information for the rest of the registration on DA Form 4201.

d. After observing each round, each observer reports the direction to the round and 01 reports the vertical angle. The computer records the data on DA Form 421 as it is sent by the observers. The FDO must determine if any rounds fired were erratic and their spotting discarded. There are no exact rules for determining which rounds are erratic. The following are methods in which erratic rounds may be determined.

(1) Determine the MBL by using graphic intersection (see paragraph 10-22). Using the range to the MBL (expressed to the nearest 100 meters and interpolated), determine the PER and PE$_D$ and construct a rectangle (8 PER x 8 PE$_D$) centered over the MBL and along the GT line. Reject any rounds that plot outside this rectangle. (See Figure 10-7.)

NOTE: All rounds should have functioned within the 100 percent rectangle defined by ±4 PE$_R$ and ±4 PE$_D$. Any rounds outside of the rectangle are considered erratic.

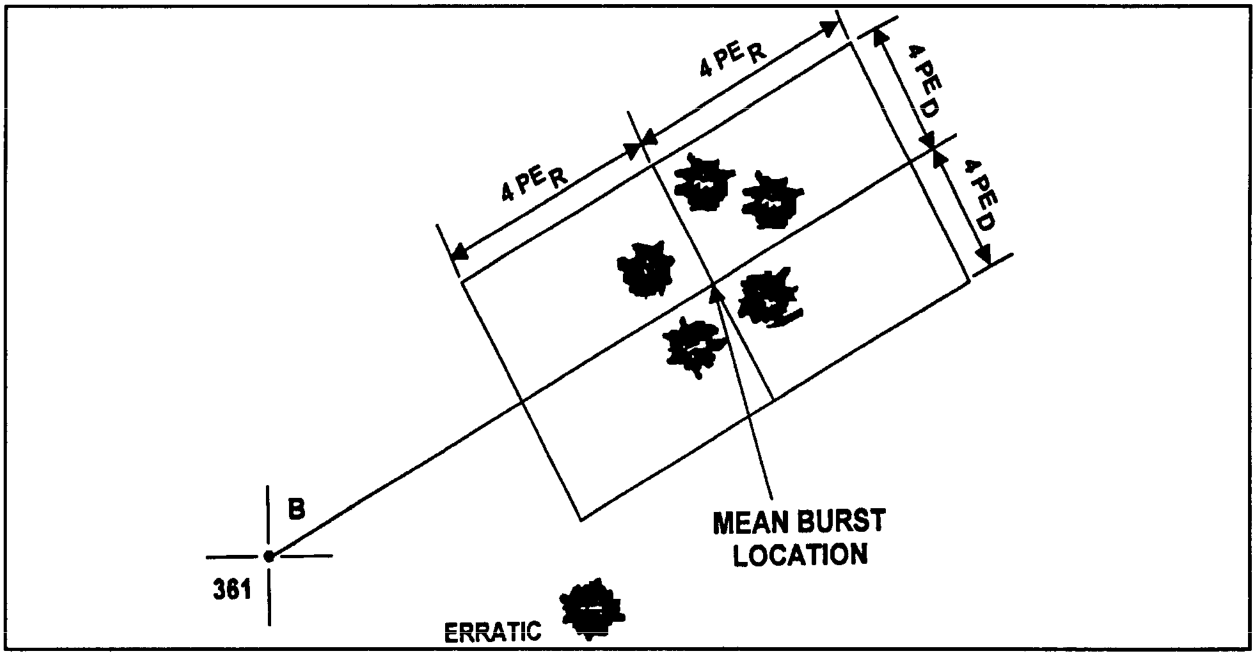


Figure 10-7. 8 PE$_R$ x 8 PE$_D$ Rectangle for HB Registration.

(2) At the range to the MBL, expressed to the nearest 500 meters, determine the PE_{HB}. Using 01's reported vertical angles, the measured distance from 01 to the MBL, and the ground altitude, determine the MBL altitude. Determine the altitude of each round, and compare this altitude with the average altitude. Reject any round that falls outside the average altitude $\pm 4\ PE_{HB}$.

(3) The FDO may use his judgement and experience in determining if a round should be rejected. Care must be taken to ensure that erratic rounds are not used or that usable rounds are not rejected. If a round is considered erratic because of the reported direction from 01 or 02 or because of an incorrect vertical angle, the data from the other observer must also be discarded.

10-22. Determine the Mean Burst Location

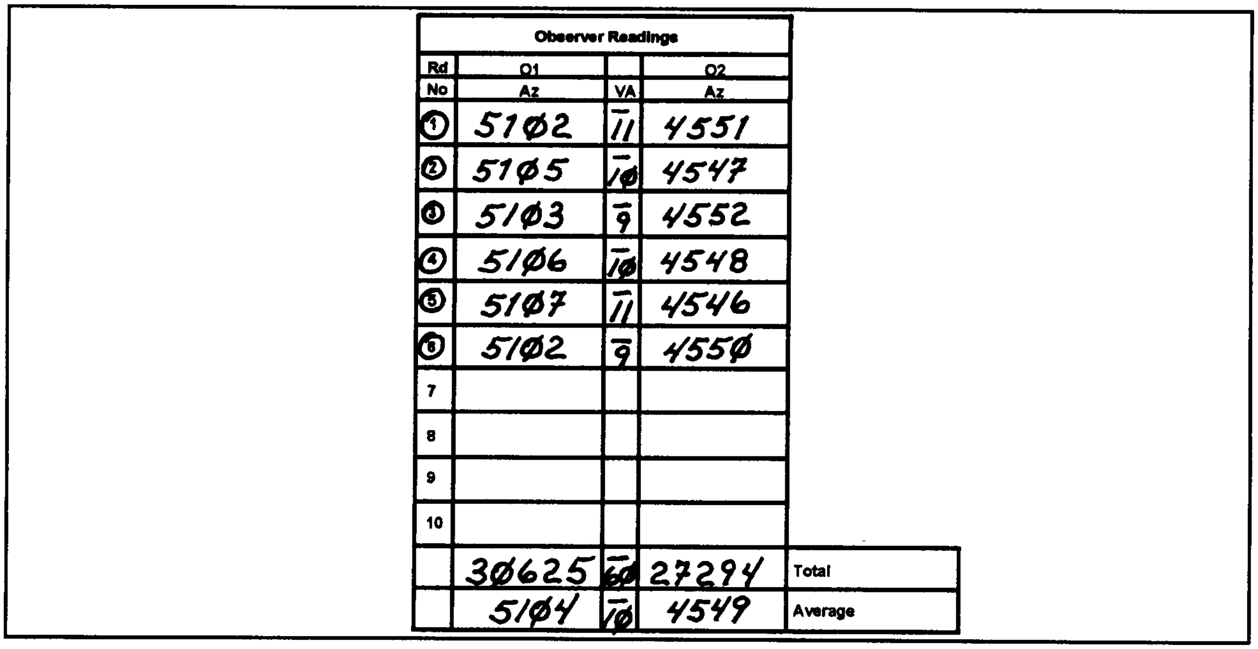
a. List the observers' measured azimuths (spottings) on DA Form 4201 (Figure 10-8) as they are sent by the observers. As the rounds are fired, circle the round number to record the expenditure of rounds during the registration. Some rounds may be considered erratic. Erratic rounds are crossed out, and additional rounds may be fired to replace them.

b. Once the data from the usable rounds are recorded, the FDC determines the MBL. Determine the location by one of three methods. The methods are listed below in increasing order of accuracy and time of computation. The method used by the FDC will depend on the tactical situation. Usually, the graphic intersection method is acceptable. However, when increased accuracy is needed, use one of the other methods if time permits. See paragraph 10-24 for specific steps.

(1) Graphic intersection. Draw the observers' average directions on the firing chart. The point at which the lines intersect is the mean burst location.

(2) Polar plot. Determine the direction and distance from 01 to the mean burst location, and polar plot the MBL on the firing chart.

(3) Grid coordinates. Compute the actual grid coordinates of the MBL, and plot the coordinates on the firing chart.



Observer Readings

Rd No	O1 Az	VA	O2 Az	
①	5102	$\overline{11}$	4551	
②	5105	$\overline{10}$	4547	
③	5103	$\overline{9}$	4552	
④	5106	$\overline{10}$	4548	
⑤	5107	$\overline{11}$	4546	
⑥	5102	$\overline{9}$	4550	
7				
8				
9				
10				
	30625	$\overline{60}$	27294	Total
	5104	$\overline{10}$	4549	Average

Figure 10-8. Observers' Measured Azimuths.

10-23. Example of an HB/MPI Registration

a. The steps in Table 10-5 are used to process an HB/MPI registration.

Table 10-5. HB/MPI Registration.

STEP	REFERENCE	ACTION
1	Fire Order	Computer records the fire order announced by the FDO.
2	Initial Fire Commands	Computer determines, records, and announces the fire commands.
	FM	Anounced and circled or checked.
	MF	Computer determines, announces, and records the piece to fire and method of fire.
	Sp Instr	Computer announces and records these as directed by the fire order. **BRAMC** is announced and recorded.
	Sh	Computer announces and records if other than standard.
	Lot	Computer announces and records if other than standard.
3	Orienting Point Data	The FDC determines the orienting point altitude and data to orient both observers. These data are announced to the computer, who records it on two separate lines in the subsequent fire commands portion of the ROF.
	Ground Altitude of the Orienting Point	The VCO determines and announces the ground altitude of the orienting point. The computer records it.
	Orienting Point Alt	**ORIENTING POINT ALT = HOB + GROUND ALT**
	NOTE: The remaining steps are completed for O2 as well.	
	Direction	The HCO determines and announces the direction from O1 to the orienting point. The computer records this value on the corresponding line in the subsequent fire commands portion of the ROF.
	Distance	The HCO determines and announces the distance from O1 to the orienting point. The computer records this value on the corresponding line in the subsequent fire commands portion of the ROF.
	VI	The VCO determines and announces the VI between the observer and the orienting point. The computer records this value on the corresponding line in the subsequent fire commands portion of the ROF.
	VA	The VCO determines and announces the VA from O1 to the orienting point. The computer records this value on the corresponding line in the subsequent fire commands portion of the ROF.
4	MTO	The RATELO transmits the MTO. Computer records the MTO on DA Form 4201.
5	Rg	HCO determines and announces range. Computer places the MHL of the appropriate GFT over the announced range and records it on the record of fire.
6	Chg	Computer announces and records charge. If it is not announced in the fire order, the computer will determine the charge.
7	Fz	Computer announces and records if other than standard. Fuze time will be fired for an HB; fuze quick for an MPI.
8	Chart Df	HCO determines and announces chart deflection. Computer records it.
9	El	Computer determines and records elevation.

Table 10-5. HB/MPI Registration (Continued).

STEP	REFERENCE	ACTION
10	Ti	Computer determines, announces, and records the fuze setting if firing an HB registration.
11	Drift	Computer determines and records drift in the computational space.
12	Df Corr	Computer records deflection correction. This element will be the same as drift.
13	Df	Computer determines, announces, and records the deflection to fire **DF CORR + CHT DF = DF TO FIRE**.
14	SI	VCO determines site to the orienting point altitude and announces it. Computer records it.
		NOTE: Although a time fuze is used when firing an HB registration, 20/R will not be applied to the site because the HOB correction was applied when the orienting point altitude was determined.
15	QE	Computer determines, announces, and records quadrant elevation.
16	Ammo Exp	Computer records the number of rounds to be fired with the announced firing data. Once the round(s) has been fired and spottings have been received, the computer circles the number.
17	Police of the ROF	Computer ensures that all data pertaining to the mission are recorded. Computer also determines and records data that could be used in subsequent computations.
	Computational Space	Computer records the VCO's math steps used to determine the orienting point altitude and VI.
	Ammo Exp	Computer circles number of rounds when the registration is complete.
	EOM	Computer announces and records EOM when directed by the FDO. The Computer also records "SEE ATTACHED DA FORM 4201" in the subsequent fire commands block.
	Observers' VIs	Computer records on the corresponding line in the observer's subsequent correction block the VCO's math steps used to compute the observers' VIs.
	DTG	Computer records the DTG of when the mission ends.
	Btry	Computer records the battery or platoon firing the registration.
	Data Fired	Computer transfers from the ROF to DA Form 4201 the charge, deflection, fuze setting, and QE fired.

NOTE: A completed ROF for an HB registration using fuze M582 is shown in Figure 10-9.

RECORD OF FIRE

CALL FOR FIRE		
Observer ______ AF/FFE/IS/S ______ Tgt ______ Grid: ______ Polar: Dir ______ Dis ______ U/D ______ VA ______ Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______	GRND ALT 1060 HOB + 40 O.P. ALT 1100 DRIFT L9 PLT ALT 1062 + GFT 0 VI + 38	△ FS 100/R /R 20/R
	∡ Si ÷ 10 | 10m Si	HOB Corr

FIRE ORDER HB REG AT GRID 4128, HOB +40, w/T09 + C19, ⑥, FZTI, BRAMC

FIRE ORDER HB REG AT GRID 4128, HOB +40, w/T09 + C19, ⑥, FZTI, BRAMC			Df Corr L9	Si +8	
INITIAL FIRE COMMANDS	~~EM~~	MF #3⑥	Rg 6340	Cht Df 3287	El 422
Sp Instr BRAMC	Sh	Lot	Chg 4 | Fz TI | Ti 24.8	Df 3296	QE 430
MTO	∡ T	PE_R	TF	In Eff	Ammo Exp ⑥ TI ✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
				EOM (See ATTACHED DA FORM 4201)												
ORIENTING	POINT	ALT	1100	(T03)	01		DIR	5136		DIST	3280				VA	-8
	01	ALT	1127													
	01	VI	-27													
ORIENITING	POINT	ALT	1100	(C19)	02		DIR	4541		DIST	3670				VA	-1
	02	ALT	1103													
	02	VI	-3													

$PE_{HOB} = 17m \times 2 = 34 \approx 40m$

Btry 1/A	DTG 130850APR94	Tgt	Replot Grid	Replot Alt

DA Form 4504, OCT 78

Figure 10-9. Completed ROF for an HB Registration.

10-24. Determination of the MBL

a. After all rounds have been fired and the observer spottings recorded, the FDO will determine if any rounds fired were erratic and should be discarded. If any round(s) are discarded, the FDO may decide to fire more rounds. If more rounds are to be fired, the method of fire and QE will be recorded on the ROF and announced to the registering piece. Use the procedures in Table 10-6 to determine the average observer readings.

Table 10-6. Average Observer Readings.

STEP	REFERENCE	ACTION
1	DIS O1 → O2	Record the distance and azimuth from O1 to O2 if provided by the survey section. If they are not provided by the survey section, determine them from the firing chart.
2	Observer Readings	Determine and record on DA Form 4201 the totals of O1's and O2's reported azimuths and O1's reported VAs.
3	Observer Readings	Determine the average azimuths and VA by dividing the totals determined in step 2 by the number of usable rounds, and record them. Express each result to the nearest mil.

b. The MBL is determined by using one of the methods below.

(1) Graphic intersection. The HCO orients the RDP by using the average direction of 01. Once the RDP is oriented, a line is drawn along the arm of the RDP by using a 6-H pencil. He repeats the same procedure from 02 by using 02's average direction. The point at which the two lines intersect is the mean burst location. The HCO places a plotting pin at the MBL and determines and announces the distance from 01 to the MBL. The VCO uses the average vertical angle of 01, the 01 distance to the MBL, and the GST to determine and announce the vertical interval between 01 and the MBL. The computer adds the vertical interval to 01's altitude to determine the altitude of the MBL **(01 ALT + VI = MBL ALT).** Figure 10-10 can be used to aid in the determination of the MBL altitude. If this aid is used, it is recorded in the margin of DA Form 4201. A completed DA Form 4201 is shown in Figure 10-11 for the graphic intersection technique.

(2) Polar plot. Use the procedures in Table 10-6 and DA Form 4201 (Figure 10-12) to determine the MBL.

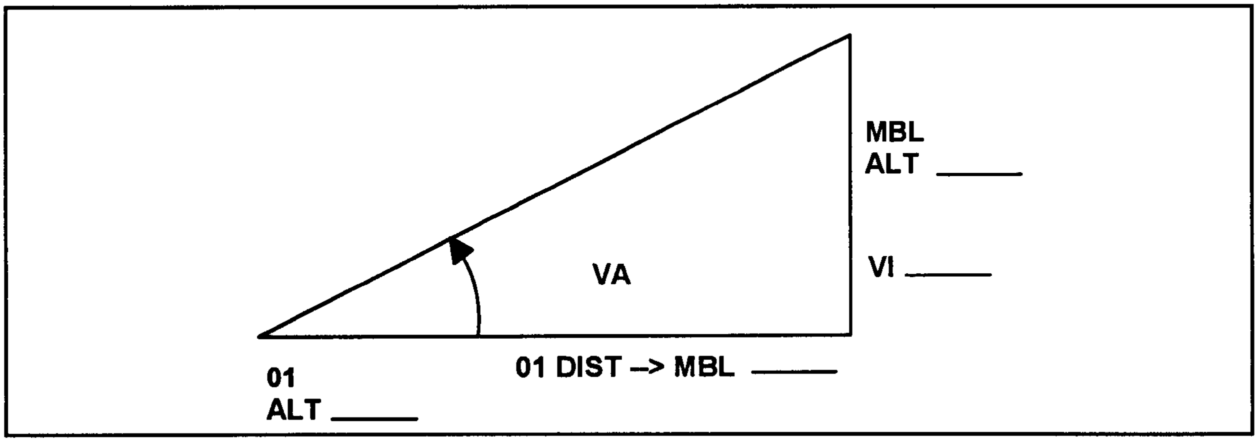
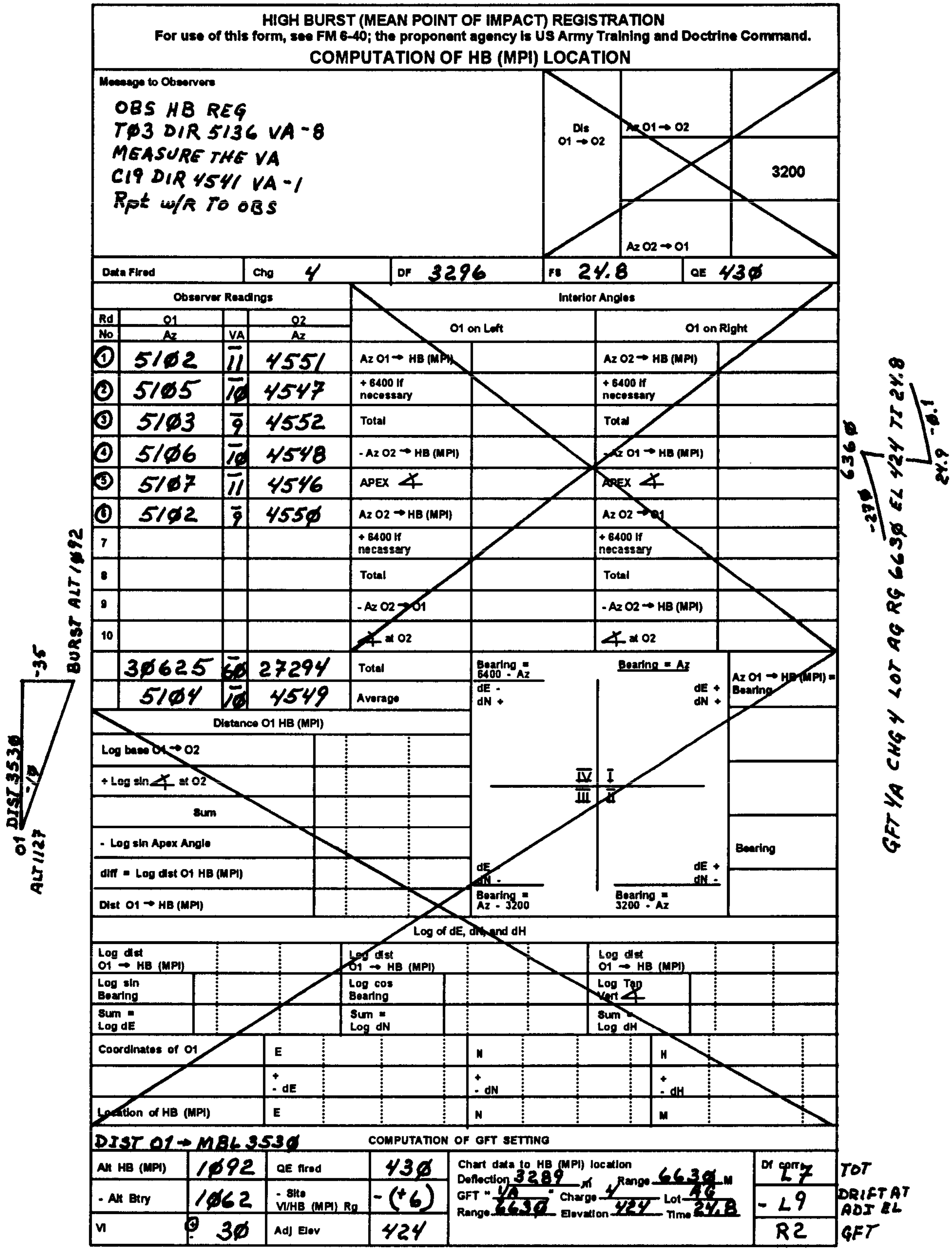


Figure 10-10. Aid for Determining the MBL Altitude.

Table 10-6. Determining the MBL.

STEP	REFERENCE	ACTION
1	Interior Angles O1 on Left	Select the appropriate column based on whether O1 is on the left or right of O2 as the observers face the orienting point. Cross out the section not used.
2	Az O1 (O2) → HB (MPI)	Record the average azimuth from O1 (O2) to the HB (MPI).
3	+6,400 if necessary	Record 6400 in the block if O1 average azimuth (O2 average azimuth) is less than O2 AVG AZ (O1 AVG AZ). If not, leave blank.
4	Total	Record the sum of steps 2 and 3.
5	- Az O2 (O1) → HB (MPI)	Record the average azimuth from O2 to the HB (MPI).
6	APEX ∢	Subtract O2 AZ (O1) from O1 AZ (O2).
7	Az O2 → HB (MPI)	Record the average azimuth from O2 to the HB (MPI).
8	+6400 if necessary	Record 6400 in the block if the AZ O2 → HB (MPI) is less than the AZ O2 → O1. If it is not, leave the block blank.
9	Total	Record the sum of steps 7 and 8.
10	- Az O2 →O1	Record the azimuth from O2 to O1 as reported by the survey section.
11	∢ at O2	Subtract the AZ O2 → O1 recorded in step 10 from the total in step 9.
	NOTE: The section of DA Form 4201 labeled "Distance O1 HB (MPI)" is used to determine the O1 distance to the MBL by using logarithms.	
12	Log base O1→ O2	Use the logarithm (log) tables (TM 6-230) to determine the log base O1 → O2 distance as reported by the survey section.
13	+ Log sin ∢ at O2	Use the logarithm tables to determine the log sine (sin) ∢ at O2 determined in step 11.
14	Sum	Record the sum of steps 12 and 13.
15	- Log sin Apex Angle	Use the logarithm tables to determine the log sine of the apex angle as recorded in step 6.
16	diff = Log dist O1 HB (MPI)	Record the difference between the values determined in steps 14 and 15.
17	Dist O1 → HB (MPI)	Determine and record the antilog of the value recorded in step 16.
18	Computation of a GFT Setting	Express the value determined in step 17 to the nearest 10 meters, and record it on the left of the heading "COMPUTATION OF GFT SETTING." Precede the value with the statement "DIST O1 → MBL."
18a		The HCO places the vertex of the RDP on O1's location and orients it to the average direction determined for O1 to the MBL. He then places a pin at the distance determined for O1 to the MBL. This is the MBL.
18b		The VCO uses the average vertical angle of O1, the O1 distance to the MBL, and the GST to determine and announce the vertical interval between O1 and the MBL. The computer adds the vertical interval to O1's altitude to determine the altitude of the MBL **(O1 ALT + VI = MBL ALT).**
	NOTE: A slide rule or a calculator may also be used to compute the distance with the formula shown in Figure 10-13. If a calculator is used, first convert the angles in mils to degrees by dividing them by 17.7778 (6400 divided by 360 equals 17.7778).	



HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION

For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.

COMPUTATION OF HB (MPI) LOCATION

Message to Observers

OBS HB REG
T03 DIR 5136 VA -8
MEASURE THE VA
C19 DIR 4541 VA -1
Rpt w/R To OBS

Dis O1 → O2	Az O1 → O2	
		3200
	Az O2 → O1	

Data Fired	Chg 4	DF 3296	FS 24.8	QE 430

Observer Readings

Rd No	O1 Az	VA	O2 Az
①	5102	$\overline{11}$	4551
②	5105	$\overline{10}$	4547
③	5103	$\overline{9}$	4552
④	5106	$\overline{10}$	4548
⑤	5107	$\overline{11}$	4546
⑥	5102	$\overline{9}$	4550
7			
8			
9			
10			
	30625	$\overline{60}$	27294
	5104	$\overline{10}$	4549

Interior Angles

O1 on Left		O1 on Right	
Az O1 → HB (MPI)		Az O2 → HB (MPI)	
+ 6400 if necessary		+ 6400 if necessary	
Total		Total	
- Az O2 → HB (MPI)		- Az O1 → HB (MPI)	
APEX ∡		APEX ∡	
Az O2 → HB (MPI)		Az O2 → O1	
+ 6400 if necessary		+ 6400 if necessary	
Total		Total	
- Az O2 → O1		- Az O2 → HB (MPI)	
∡ at O2		∡ at O2	
Total			
Average			

Bearing = 6400 - Az / dE - / dN +

Bearing = Az / dE + / dN +

IV I / III II

dE - / dN - / Bearing = Az - 3200

dE + / dN - / Bearing = 3200 - Az

Az O1 → HB (MPI) = Bearing

Bearing

Distance O1 HB (MPI)

Log base O1 → O2	
+ Log sin ∡ at O2	
Sum	
- Log sin Apex Angle	
diff = Log dist O1 HB (MPI)	
Dist O1 → HB (MPI)	

Log of dE, dN, and dH

Log dist O1 → HB (MPI)		Log dist O1 → HB (MPI)		Log dist O1 → HB (MPI)	
Log sin Bearing		Log cos Bearing		Log Tan Vert ∡	
Sum = Log dE		Sum = Log dN		Sum = Log dH	

Coordinates of O1	E	N	H
	+ - dE	+ - dN	+ - dH
Location of HB (MPI)	E	N	M

DIST O1 → MBL 3530

COMPUTATION OF GFT SETTING

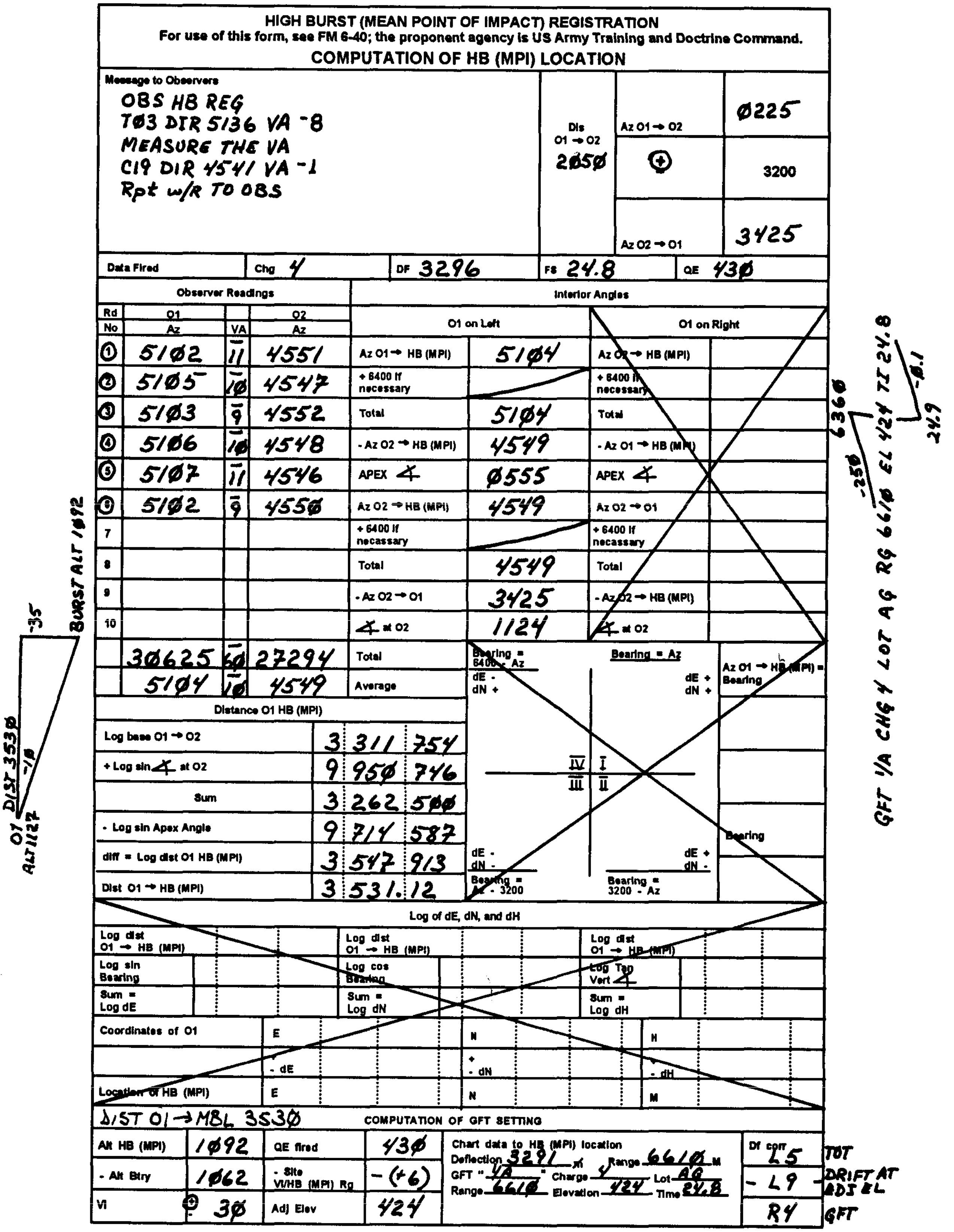
Alt HB (MPI)	1092	QE fired	430	Chart data to HB (MPI) location Deflection 3289 m Range 6630 M GFT " 1/A " Charge 4 Lot AG Range 6630 Elevation 424 Time 24.8	Df corr L7
- Alt Btry	1062	- Site VI/HB (MPI) Rg	- (+6)		- L9
VI	⊕ 30	Adj Elev	424		R2

TOT
DRIFT AT ADJ EL
GFT

BURST ALT 1092
-35
O1 ALT 1127
DIST 3530
-10

GFT 4/A CHG 4 LOT AG RG 6630 EL 424 TI 24.8
6360
-270
24.9
-0.1

Figure 10-11. Completed DA Form 4201 for the Graphic Intersection Technique.



HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION

For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.

COMPUTATION OF HB (MPI) LOCATION

Message to Observers

OBS HB REG
T03 DIR 5136 VA -8
MEASURE THE VA
C19 DIR 4541 VA -1
Rpt w/R TO OBS

Dis O1 → O2 2050	Az O1 → O2	0225
	⊕	3200
	Az O2 → O1	3425

Data Fired | Chg 4 | DF 3296 | FS 24.8 | QE 430

Observer Readings

Rd No	O1 Az	VA	O2 Az
①	5102	$\overline{11}$	4551
②	5105	$\overline{10}$	4547
③	5103	$\overline{9}$	4552
④	5106	$\overline{10}$	4548
⑤	5107	$\overline{11}$	4546
⑥	5102	$\overline{9}$	4550
7			
8			
9			
10			
Total	30625	$\overline{60}$	27294
Average	5104	$\overline{10}$	4549

Interior Angles

O1 on Left		O1 on Right	
Az O1 → HB (MPI)	5104	Az O2 → HB (MPI)	
+ 6400 if necessary		+ 6400 if necessary	
Total	5104	Total	
- Az O2 → HB (MPI)	4549	- Az O1 → HB (MPI)	
APEX ∠	0555	APEX ∠	
Az O2 → HB (MPI)	4549	Az O2 → O1	
+ 6400 if necessary		+ 6400 if necessary	
Total	4549	Total	
- Az O2 → O1	3425	- Az O2 → HB (MPI)	
∠ at O2	1124	∠ at O2	

Distance O1 HB (MPI)

Log base O1 → O2	3	311	754
+ Log sin ∠ at O2	9	950	746
Sum	3	262	500
- Log sin Apex Angle	9	714	587
diff = Log dist O1 HB (MPI)	3	547	913
Dist O1 → HB (MPI)	3	531.	12

Bearing = 6400 - Az; dE -, dN +
Bearing = Az; dE +, dN +
Bearing = Az - 3200; dE -, dN -
Bearing = 3200 - Az; dE +, dN -
IV I
III II

Az O1 → HB (MPI) = Bearing

Bearing

Log of dE, dN, and dH

Log dist O1 → HB (MPI)		Log dist O1 → HB (MPI)		Log dist O1 → HB (MPI)	
Log sin Bearing		Log cos Bearing		Log Tan Vert ∠	
Sum = Log dE		Sum = Log dN		Sum = Log dH	

Coordinates of O1	E	N	H
	+ - dE	+ - dN	+ - dH
Location of HB (MPI)	E	N	M

DIST O1 → MBL 3530

COMPUTATION OF GFT SETTING

Alt HB (MPI)	1092	QE fired	430
- Alt Btry	1062	- Site VI/HB (MPI) Rg	-(+6)
VI	⊕ 30	Adj Elev	424

Chart data to HB (MPI) location
Deflection 3291 mil Range 6610 M
GFT "1/A" Charge 4 Lot AG
Range 6610 Elevation 424 Time 24.8

Df corr L5	TOT
- L9	- DRIFT AT ADJ EL
R4	GFT

GFT 1/A CHG 4 LOT AG RG 6610 EL 424 TI 24.8
-250
6360
-0.1
24.9

BURST ALT 1092
-35
DIST 3530
-10
O1 ALT 1127

Figure 10-12. Completed DA Form 4201 for the Polar Plot Technique.

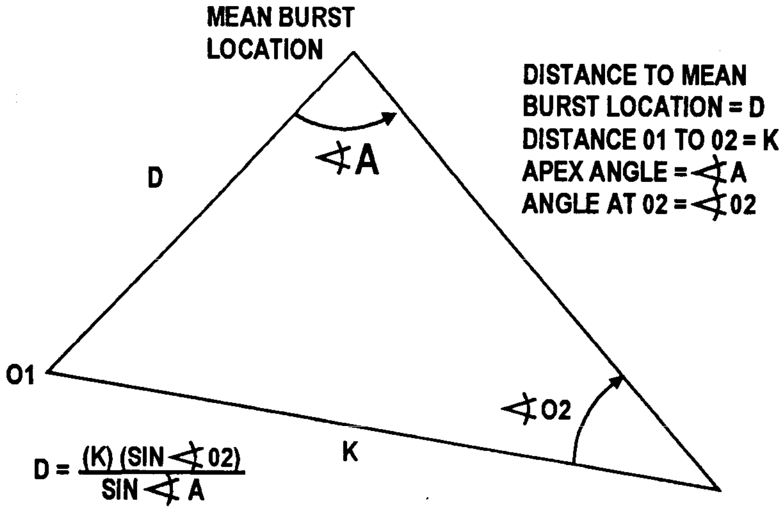


Figure 10-13. Formula for Computing Distance to the MBL.

(3) Grid coordinate. The steps in Table 10-7 and a DA Form 4201 (see Figure 10-14) are used to determine the MBL.

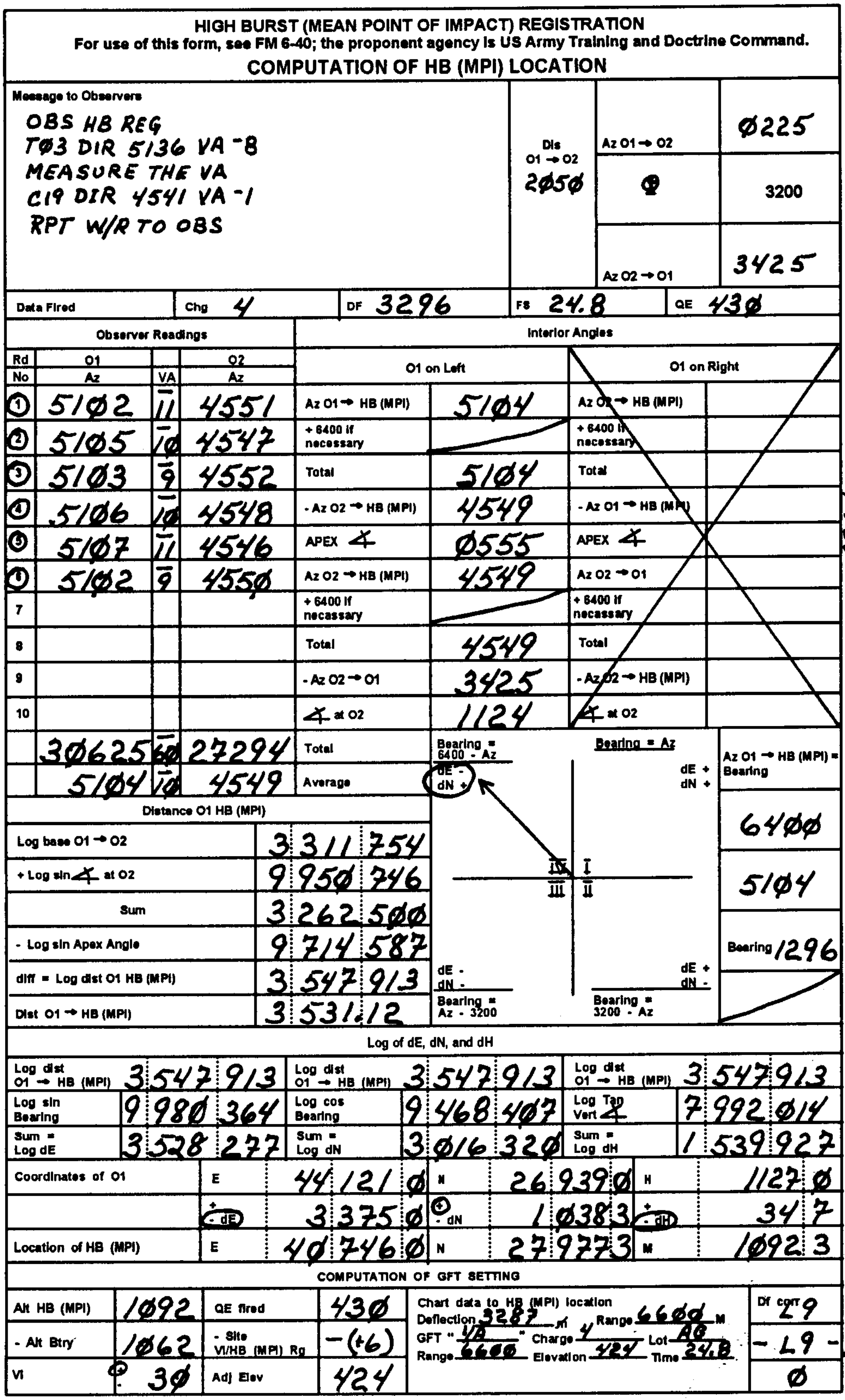
Table 10-7. Determination of the MBL.

STEP	REFERENCE	ACTION
1	Dist O1 → HB (MPI)	Compute O1 distance to the MBL in the same manner as the polar plot technique.
2	Bearing	Determine the bearing angle from O1 to the MBL. Use the diagram (with the top of the form representing north, or 0 mils) and draw a line along the average azimuth from O1 to the MBL. The instructions for each quadrant are listed below. **QUADRANT I BEARING ANGLE = O1 AZ → MBL.** **QUADRANT II BEARING ANGLE = 3200 - (O1 AZ → MBL).** **QUADRANT III BEARING ANGLE = (O1 AZ → MBL) - 3200.** **QUADRANT IV BEARING ANGLE = 6400 - (O1 AZ → MBL).**
3	Az O1 → HB (MPI) → Bearing	On the basis of the quadrant chosen in step 2, record the values used to determine the bearing angle.
		NOTE: The Log of dE, dN, and dH section on DA Form 4201 is used to determine the coordinates of the MBL.
4	Log dist O1→ HB (MPI)	Record the Log dist O1 → HB (MPI) determined in step 16 of the polar plot technique.
5	Log Sin Bearing	Use the logarithm tables to determine the log sine bearing angle.
6	Sum = Log dE	Determine and record the log of the change in easting between O1 and the MBL by adding the values from steps 4 and 5.
7	Coordinates of O1 (Easting)	Record O1's five-digit easting.

Table 10-7. Determine the MBL (Continued).

STEP	REFERENCE	ACTION
8	Space Below Coordinates of O1	Record the antilog of the value determined in step 6. This is the change in easting between O1 and the MBL.
9	Location of HB (MPI) (Easting)	Determine and record the MBL easting by applying the change in easting (step 8) to O1's easting (step 7). Add or subtract the change in easting on the basis of the quadrant used in step 3 **(Quadrant I or II, add; Quadrant III or IV, subtract.)**
10	Log cos Bearing	Use the logarithm tables to determine the log cosine (cos) of the bearing angle.
11	Sum = Log dN	Determine and record the log of the change in northing between O1 and the MBL by adding the values from steps 4 and 10.
12	Coordinates of O1 (Northing)	Record O1's five-digit northing.
13	Space Below Coordinates of O1	Record the antilog of the value determined in step 11. This is the change in northing between O1 and the MBL.
14	Location of HB (MPI) (Northing)	Determine and record the MBL northing by applying the change in northing (step 13) to O1's northing (step 12). Add or subtract the change in northing on the basis of the quadrant used in step 3 **(Quadrant I or II, add; Quadrant III or IV, subtract.)**
15	Log Tan Vert ∢	Use the logarithm tables to determine the log tangent (tan) of the average vertical angle.
16	Sum = Log dH	Determine and record the log of the change in altitude between O1 and the MBL by adding the values from steps 4 and 15.
17	Coordinates of O1 (Height)	Record O1's altitude.
18	Space Below Coordinates of O1	Record the antilog of the value determined in step 16. This is the change in altitude between O1 and the MBL.
19	Location of HB (MPI) (Height)	Determine and record the MBL altitude by applying the change in altitude (step 18) to O1's altitude (step 17). Add or subtract the change in altitude on the basis of the sign of the average vertical angle.
20	Coordinates of the MBL	Announce the determined coordinates and altitude to the HCO. The HCO plots the MBL on the firing chart in the same manner as any surveyed location.

NOTE: A completed DA Form 4201 for the grid coordinates technique is shown in Figure 10-14.



HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION
For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.
COMPUTATION OF HB (MPI) LOCATION

Message to Observers

OBS HB REG
T03 DIR 5136 VA -8
MEASURE THE VA
C19 DIR 4541 VA -1
RPT W/R TO OBS

Dis O1 → O2 2050	Az O1 → O2	0225
	0	3200
	Az O2 → O1	3425

Data Fired | Chg 4 | DF 3296 | FS 24.8 | QE 430

Observer Readings

Rd No	O1 Az	VA	O2 Az
①	5102	-11	4551
②	5105	-10	4547
③	5103	-9	4552
④	5106	-10	4548
⑤	5107	-11	4546
⑥	5102	-9	4550
7			
8			
9			
10			
Total	30625	-60	27294
Average	5104	-10	4549

Interior Angles

O1 on Left		O1 on Right	
Az O1 → HB (MPI)	5104	Az O2 → HB (MPI)	
+ 6400 if necessary		+ 6400 if necessary	
Total	5104	Total	
- Az O2 → HB (MPI)	4549	- Az O1 → HB (MPI)	
APEX ∡	0555	APEX ∡	
Az O2 → HB (MPI)	4549	Az O2 → O1	
+ 6400 if necassary		+ 6400 if necassary	
Total	4549	Total	
- Az O2 → O1	3425	- Az O2 → HB (MPI)	
∡ at O2	1124	∡ at O2	

Distance O1 HB (MPI)

Log base O1 → O2	3.311 754
+ Log sin ∡ at O2	9.950 746
Sum	3.262 500
- Log sin Apex Angle	9.714 587
diff = Log dist O1 HB (MPI)	3.547 913
Dist O1 → HB (MPI)	3 531.12

Bearing = 6400 - Az
dE -
dN +

Bearing = Az
dE +
dN +

IV | I
III | II

dE -
dN -
Bearing = Az - 3200

dE +
dN -
Bearing = 3200 - Az

Az O1 → HB (MPI) = Bearing
6400
5104
Bearing 1296

Log of dE, dN, and dH

Log dist O1 → HB (MPI)	3 547 913	Log dist O1 → HB (MPI)	3 547 913	Log dist O1 → HB (MPI)	3 547 913
Log sin Bearing	9 980 364	Log cos Bearing	9 468 407	Log Tan Vert ∡	7 992 014
Sum = Log dE	3 528 277	Sum = Log dN	3 016 320	Sum = Log dH	1 539 927

Coordinates of O1	E 44 121 0	N 26 939 0	H 1127 0
	± dE 3 375 0	± dN 1 038 3	± dH 34 7
Location of HB (MPI)	E 40 746 0	N 27 977 3	M 1092 3

COMPUTATION OF GFT SETTING

Alt HB (MPI)	1092	QE fired	430
- Alt Btry	1062	- Site VI/HB (MPI) Rg	-(+6)
VI	+ 30	Adj Elev	424

Chart data to HB (MPI) location
Deflection 3287 ℳ Range 6600 M
GFT "1/A" Charge 4 Lot AG
Range 6600 Elevation 424 Time 24.8

Df corr L9 TOT
- L9 - DRIFT AT ADJ EL
0 GFT

GFT 1/A CHG 4 LOT AG RG 6600 EL 424 TI 24.8
6360
-240
24.9
-0.1

Figure 10-14. Completed DA Form 4201 for the Grid Coordinates Technique.

10-25. Determine Chart Data and Registration Corrections

After plotting the MBL on the firing chart, the HCO determines and announces the chart range and deflection from the firing unit to the MBL. Use Table 10-8 to determine the GFT setting.

Table 10-8. Determination of the GFT Setting.

STEP	REFERENCE	ACTION
1	Deflection	Computer records the chart deflection to the MBL as announced by the HCO.
2	Range	Computer records the chart range to the MBL as announced by the HCO.
3	Alt HB(MPI)	Computer records the altitude (to the nearest meter) of the MBL as determined by the technique being used.
4	- Alt Btry	Computer records the registering piece altitude.
5	VI	Computer determines and records the VI by subtracting the altitude of the battery from the altitude of the HB (MPI).
6	QE fired	Computer records the quadrant elevation fired during the registration.
7	- Site VI/HB (MPI) Rg	Computer determines and records site on the basis of the VI from step 5 and the range announced chart range to the MBL from step 2.
8	Adj Elev	Computer determines the adjusted elevation by **subtracting the site** from step 7 from the QE in step 6.
9	GFT___	Computer records the firing unit designation.
10	Charge___	Computer records the charge fired during the registration.
11	Lot___	Computer records the lot fired in the registration.
12	Range___	Computer records the chart range to the MBL as announced by the HCO (from step 2).
13	Elevation___	Computer records the adjusted elevation, from step 8.
14	Time___	Computer records adjusted time.
	NOTE: If the vertical interval between the firing unit and the MBL is less than or equal to 100 meters, the fuze setting used to fire the usable rounds is the adjusted fuze setting. If the vertical interval is greater than 100 meters, see the steps in paragraph 10-26.	
15	Df corr	Computer determines and records the total deflection correction in the first space. The total deflection correction is determined by using the LARS rule and subtracting the chart deflection from the adjusted deflection. Write "TOT" to the right of the determined value.
16	Drift	Computer determines drift (using the appropriate GFT) corresponding to the adjusted elevation and records it in the middle space. Write "DRIFT" to the right of the determined value.
17	GFT Df Corr	Computer determines the GFT deflection correction by subtracting the drift from the total deflection correction and records it in the last space. Write "GFT" to the right of the determined value.

10-26. Effect of Complementary Angle of Site on Adjusted Fuze Setting

a. Fuze setting is determined as a function of elevation and complementary angle of site. When the vertical interval is equal to or less than 100 meters, the CAS is generally so small that it has little effect on the quadrant and fuze setting fired and is disregarded. If the vertical interval is greater than 100 meters, the value of the CAS becomes increasingly large and begins to affect the fuze setting. In this case, the CAS must be added to the elevation to determine the proper fuze setting.

b. As the CAS increases, the the setting also must be increased to reach the desired burst location. If the effect of CAS is not included in the fuze setting, the fuze will function before it reaches the desired location.

c. If the vertical interval is greater than 100 meters, modify the adjusted the setting to correct for the inaccuracy introduced by the large complementary angle of site. The 100-meter VI is only a rule of thumb; CAS may affect the adjusted fuze setting at vertical intervals of less than 100 meters. The FDO should check the effects of CAS anytime he feels it will affect the adjusted fuze setting. Use Table 10-9 to correct the effect of complementary angle of site on adjusted fuze setting when VI is greater than 100 meters.

Table 10-9. Effect of Complementary Angle of Site.

STEP	ACTION
1	Computer determines the angle of site to the MBL by using the VI to the MBL, chart range to the MBL, and GST.
2	Computer determines the CAS by subtracting the angle of site to the MBL from the site to the MBL. **SITE** **- ANGLE OF SITE** **CAS**
3	Computer determines the elevation plus CAS by adding the CAS to the adjusted elevation. **CAS** **+ ADJ EL** **EL PLUS CAS**
4	Computer determines the fuze setting corresponding to the elevation plus CAS by placing the MHL (of the appropriate GFT) over that value and reading the fuze setting under the MHL on the appropriate fuze setting scale.
5	Computer determines the total fuze correction by subtracting the fuze setting corresponding to the elevation plus CAS from the fuze setting fired. **FUZE SETTING FIRED** **- FUZE SETTING ≈ ELEVATION PLUS CAS** **TOTAL FUZE CORRECTION**
6	Computer determines the fuze setting corresponding to the adjusted elevation by placing the MHL (of the appropriate GFT) over the adjusted elevation and reading the fuze setting under the MHL on the appropriate fuze setting scale.
7	Computer determines the adjusted fuze setting by adding the total fuze correction from step 5 to the fuze setting corresponding the adjusted elevation in step 6. The value is then recorded as the adjusted fuze setting for the GFT setting on DA Form 4201.

Section IV

Process an AN/TPQ-36 or AN/TPQ-37 Radar Registration

Field artillery radars can be used to observe registrations. The conduct of a radar-observed registration (commonly known as a radar registration) is similar to that of other HB or MPI registrations. This section outlines the unique procedures and requirements for the AN/TPQ-36 (Q-36) and AN/TPQ-37 (Q-37) radar systems.

10-27. Characteristics

a. The Firefinder radar has two separate modes of operation. The first mode of operation is the friendly fire mode, which is used by friendly artillery and mortar units for adjust-fire missions and registrations. The second is the hostile mode, which tracks incoming projectiles and is used to locate enemy indirect-fire systems.

b. A peculiarity of the two separate modes of operation is how the radar operator inputs data into his computer to orient the radar. Data can only be input while the radar is in the hostile fire mode. Once the operator has input all the data into the computer, he switches from hostile to friendly mode, and a delay is experienced while the radar orients itself. If a problem is encountered during the registration, such as around being unobserved, the first thing the operator does is verify his data. This requires him to switch back to the hostile mode, verify his data, then return to the friendly fire mode. Each time he changes modes, the radar physically reorients itself, taking from 20 to 30 seconds.

c. The radar has three different mission buffers, and they are used to store all the data needed to conduct a friendly fire mission. The radar also has the capability to store the spottings for six rounds. When the friendly fire storage cues are full and another round is tracked, it will replace the oldest spotting with the new one. Unless an observed round is recorded by the radar operator or transmitted to the FDC, these old data are lost when they are automatically replaced by the radar computer. Therefore, the operator needs to monitor the mission and either transmit each individual spotting to the FDC or clear the buffer by deleting erroneously captured information.

d. A danger area exists to the front of the radar. Theoretically, VT fuzes can function prematurely within the danger area or as a result of passing through the danger area. For the Q-36, the danger area is 107 meters out from the radar; for the Q-37, it is 141 meters.

(1) The radar takes 9 seconds to warm up before operation.

(2) Minimum observing distance for the Q-36 is 750 meters; for the Q-37, 3,000 meters.

(3) The friendly fire mode has five different mission types that the radar can conduct. They are as follows:

- Mortar datum plane (MD).
- Mortar impact prediction (MI).
- Artillery airburst (AA).
- Artillery datum plane (AD).
- Artillery impact prediction (AI).

e. The two types most commonly used by artillery are the artillery airburst (HB registration) and the artillery impact prediction (adjust-fire missions and MPI registrations). One of the problems occasionally encountered between the FDC and the radar section is the use of different technical language. For example, in the message to observer, you might announce **OBSERVE HIGH BURST REGISTRATION** to orient the radar. An inexperienced radar operator unfamiliar with artillery terminology may have selected an incorrect mission type, which will result in rounds unobserved or unsuitable data. By understanding the different mission type requirements for radar, mistakes are prevented.

f. The advantages of a radar registration include the following:

- Requires only one observation post--the radar.
- Requires less survey, fewer communications facilities, and less coordination than other HB or MPI registrations.
- Can be conducted quickly.
- Can be conducted in periods of poor visibility.
- Produces the MBL/MPI grid and altitude or the grid and altitude of each round.

g. The disadvantages of a radar registration include the following:

- Exposes radar to detection from the enemy.
- Keeps radar sections from performing their primary mission.
- May need to reposition radar to conduct the registration.

10-28. Conduct of a Radar Registration

The six steps in conducting a radar registration areas follows:

- Select an orienting point.
- Orient the radar.
- Determine firing data to the orienting point.
- Fire the HB or MPI registration.
- Determine the mean burst location.
- Determine chart data and registration corrections.

10-29. Selection of an Orienting Point

a. The radar must be properly sighted in relation to friendly units to fully use its capabilities. There are three areas that significantly impact the ability of the radar to track friendly fire. They are as follows:

- Electrical line of sight.
- Range from the radar to the target.
- Aspect angle (∢ T).

(1) A radar must have electrical line of sight to the point along the descending branch of the trajectory of the round where the burst will occur (HB), or it must be able to track the projectile for enough time to predict its point of impact (MPI). Doctrine calls for radar to be sited in defilade to increase its survivability. This means that there are intervening crests (screening crests) between the radar and the area where the rounds are being fired.

(2) If these crests interfere with the radar's electrical line of sight, then the radar search fence must be oriented high enough so that these crests will not mask the emissions. However, if the radar is oriented above the altitude that the time fuzes are set to function, then **ROUND UNOBSERVED** will very likely be received from the radar. The easiest way to counteract this problem is to modify the procedures normally used to select a height of burst for HB registrations so that the radar is sure to "see" the burst.

(3) Aspect angle is the angle that is formed by the intersection of the gun-target line and the radar-target line, with the vertex of the angle at the target (∢T). The aspect angle should be less than 1,200 mils, with 800 mils being the optimum. A less than optimum aspect angle is going to decrease the probability of tracking each round. (From 1,300 to 1,600 mils, the tracking picture becomes fuzzy with the probability of track decreasing significantly.) These factors must be considered when determining whereto site your radars to optimize their performance.

b. A high-burst registration conducted with the Q-36 or Q-37 radar requires only an electrical line of sight to the selected point. The on-board computer controls the radar to enable it to intersect the trajectory above the screening crest. The radar tracks the round until the airburst is detected. The Q-36 and Q-37 radar systems set up a "window" through which the projectile will pass. The window is referred to as the friendly fire search fence (Figure 10-15). The search fence allows for the best probability of detection. Because of the size of the radar memory queue, no more than six rounds should be fired without coordination with the radar section. Rounds should be fired at 30-second intervals with an angle T of less than 1,000 mils.

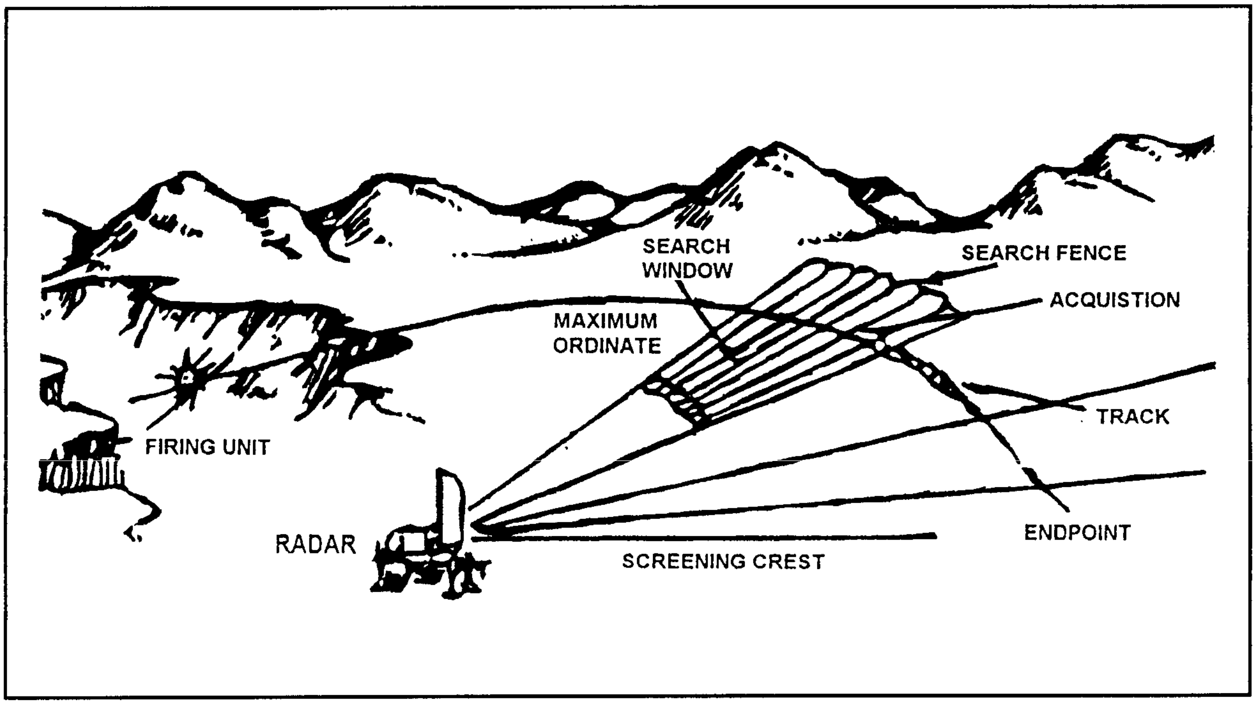


Figure 10-15. Projectile Tracking--AN/TPQ-36 or AN/TPQ-37 Radar.

c. MPI Registration. A characteristic of the radar MPI registration is that the rounds usually cannot be observed at impact because the radar usually is positioned behind masking terrain with a screening crest. The projectile is tracked until it reaches the datum plane height. The radar section reports the grid and altitude of the impact location as predicted by the radar.

10-30. Orienting the Radar

a. After selecting the orienting point, the FDO issues his fire order and the FDC computes orienting data. The registration is initiated by transmitting an MTO. The purpose of this message is to inform the radar section of the mission and to provide the information required to prepare the radar.

b. The message to observer must always include the warning order. It is **OBSERVE HIGH-BURST (or MPI) REGISTRATION FOR (unit call sign).** This informs the radar section of the type of registration to be fired and for whom the registration is conducted. Observe communications security procedures in transmitting information.

c. To orient the AN/TPQ-36 or -37 radar, send the radar the following:

- Grid and altitude of the orienting point.
- Grid and altitude of the firing unit.
- Quadrant elevation.
- Maximum ordinate (to the nearest meter) from the appropriate TFT. Entry argument is quadrant elevation (interpolate). Special if it is meters or feet and above sea level or above gun.
- Time of flight.
- Target number.
- Angle of fall. (Determined by interpolation from Table G by using quadrant elevation as the entry argument.) This is optional.

d. Regardless of the radar system used, the message to observer must include the report order. It is **REPORT WHEN READY TO OBSERVE.**

10-31. Determination of Firing Data to the Orienting Point

The determination of firing data for a radar registration is the same as that for a regular HB or MPI registration.

10-32. Firing the HB or MPI Registration

The radar on-board computer uses the orienting data to check the trajectory and determine whether it fits the capabilities of the radar. Before firing, the radar operator determines whether the data are acceptable, marginal, or unacceptable. The radar section reports when it is ready to observe (for example, **AT MY COMMAND, REQUEST SPLASH, READY TO OBSERVE, OVER).** Since the radar operator checks the acceptability of the orienting data before firing begins, all rounds fired should be acquired by radar. If the first round is not visible, an error has occurred. The radar operator informs the FDC that the round was unobserved. The FDC should verify firing data, If no errors are found and the next round is unobserved, the FDC should compute new orienting data and send the new data to the radar operator.

10-33. Determination of the Mean Burst Location

The radar operator normally reports the grid location and altitude of each burst. The grids may be recorded in the observer reading columns of DA Form 4201. The FDO determines which rounds are usable. Once the FDO determines the usable rounds, he averages the grids and altitudes of the usable rounds to compute the mean burst location. The grid and altitude are then recorded in the Location of HB (MPI) block near the bottom of DA Form 4201.

10-34. Determination of Chart Data and Registration Corrections

After determining the MBL and altitude, the procedures for computing chart data and registration corrections are the same as those for regular HB/MPI registrations. Figure 10-16 shows an example of a completed ROF for an HB radar registration. Figure 10-17 shows an example of a completed DA Form 4201 for an HB radar registration.

10-35. DPICM Registrations (M483A1/M509E1)

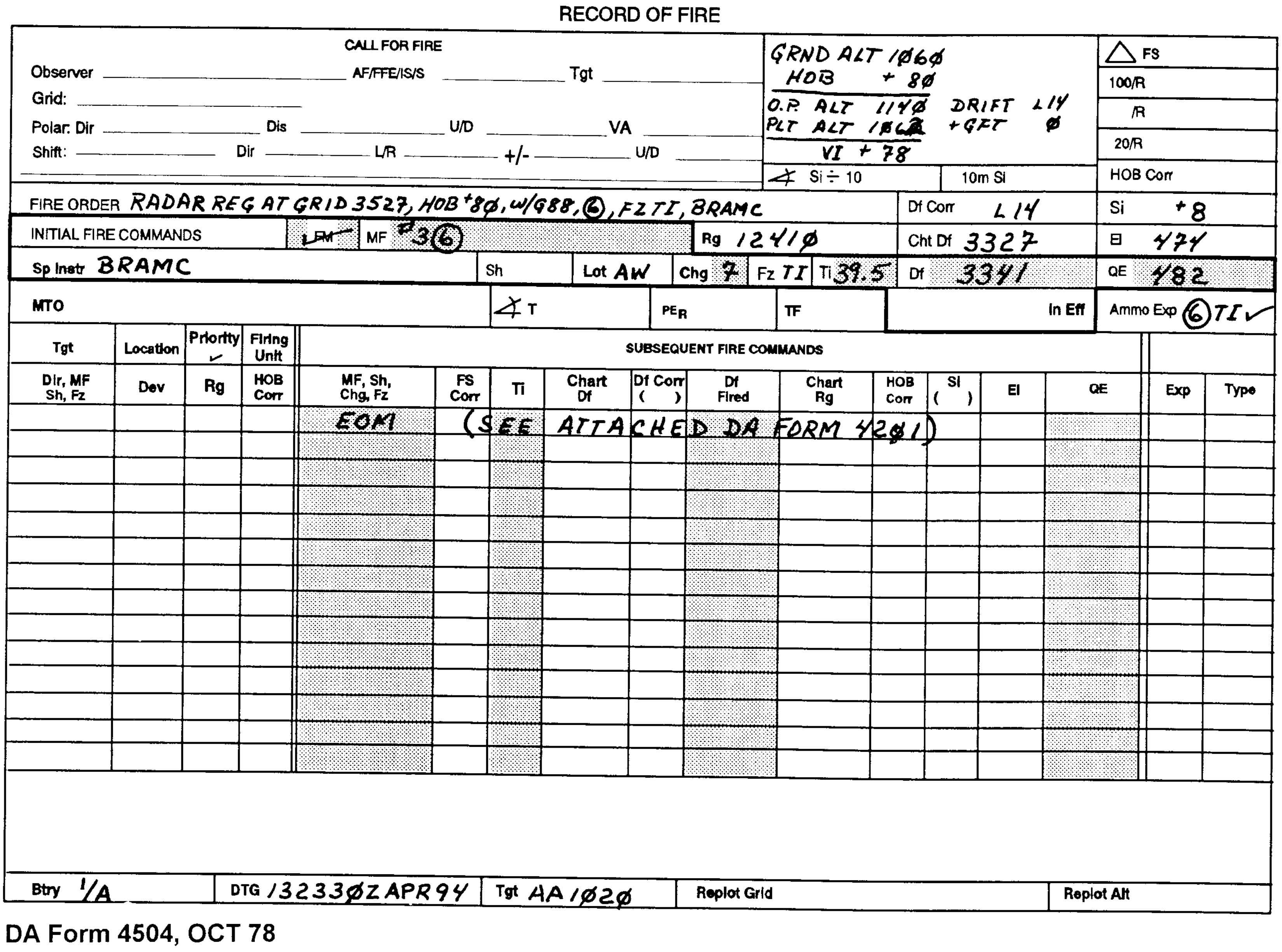
a. The DPICM projectile may be fired in the self-registration mode to provide corrections for other munitions like the area denial artillery munitions (ADAM) or remote antiarmor mine system (RAAMS). The round can be registered by using either the precision or the HB/MPI method. Normally, the HB/MPI method would be selected to conserve ammunition.

b. Firing data should be computed by using the most current firing table.

c. If point-detonating action is desired for an impact registration, the M577 fuze must be set for PD action. An impact registration is not recommended, since no fuze setting correction is determined.

d. In all cases when the round is used in registrations, it must be prepared for the SR mode (expelling charge removed and booster attached to fuze). In the SR mode, the entire round will detonate and destroy the submunitions.

e. The GFT setting is constructed and total corrections are determined as per precision and HB/MPI instructions. An example ROF for a completed precision registration for shell DPICM is shown in Figure 10-18. The **HOW 155mm 155AN1M483A1 GFT** was used for the registration.



RECORD OF FIRE

CALL FOR FIRE

Observer ______ AF/FFE/IS/S ______ Tgt ______
Grid: ______
Polar: Dir ______ Dis ______ U/D ______ VA ______
Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______

GRND ALT 1060
HOB + 80
O.P. ALT 1140 DRIFT L14
PLT ALT 1062 +GFT 0
VI + 78

⦣ Si ÷ 10 | 10m Si

△ FS
100/R
/R
20/R
HOB Corr

FIRE ORDER RADAR REG AT GRID 3527, HOB +80, w/G88, ⑥, FZ TI, BRAMC
Df Corr L14
Si +8

INITIAL FIRE COMMANDS ~~LFM~~ MF #3⑥
Rg 12410
Cht Df 3327
⊟ 474

Sp Instr BRAMC
Sh
Lot AW
Chg 7
Fz TI
Ti 39.5
Df 3341
QE 482

MTO
⦣ T
PE_R
TF
In Eff
Ammo Exp ⑥TI ✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
				EOM	(SEE ATTACHED DA FORM 4201)											

Btry 1/A
DTG 132330ZAPR94
Tgt AA1020
Replot Grid
Replot Alt

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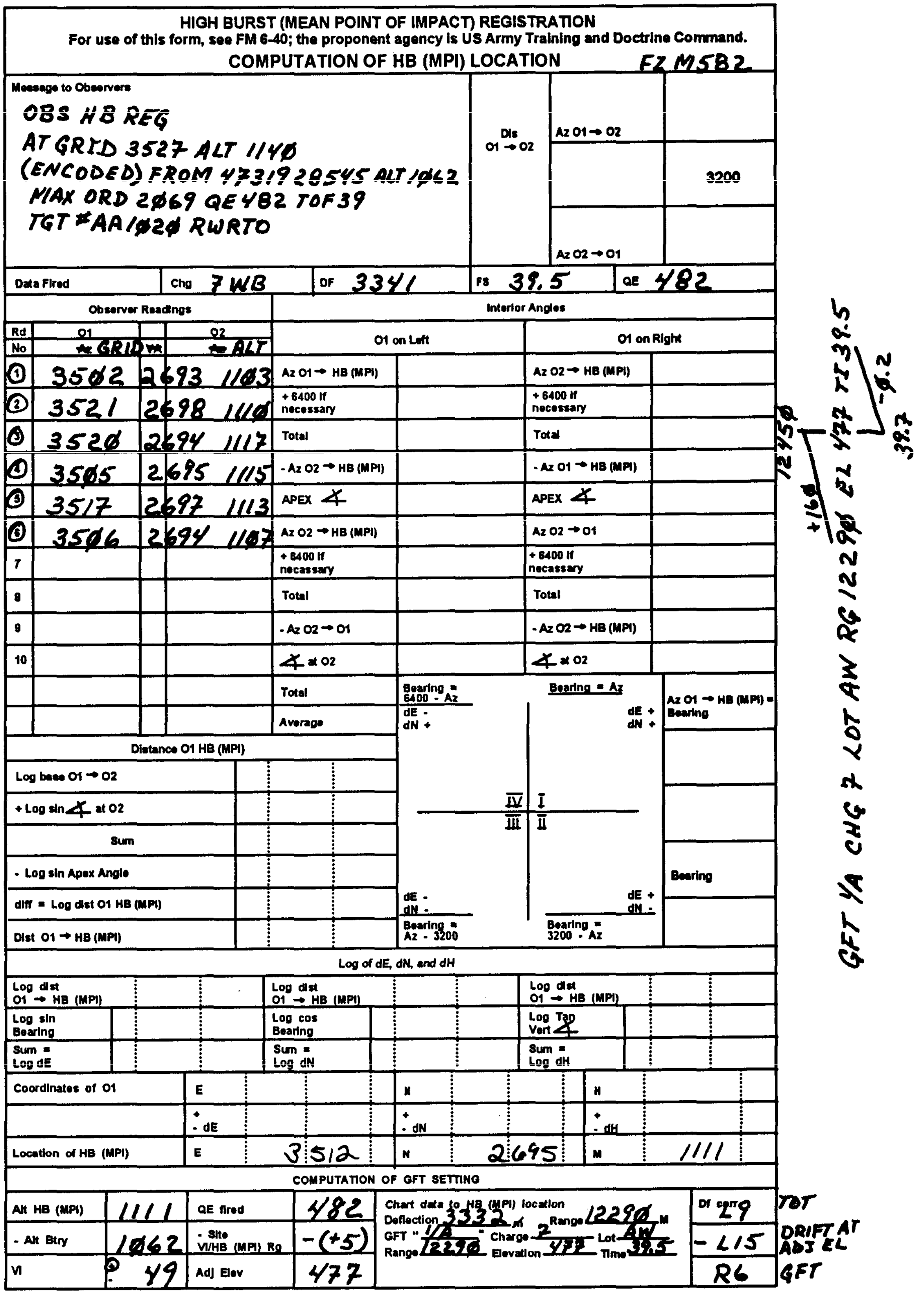
Figure 10-16. Completed ROF for an HB Radar Registration.



HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION
For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.
COMPUTATION OF HB (MPI) LOCATION FZ M5B2

Message to Observers

OBS HB REG
AT GRID 3527 ALT 1140
(ENCODED) FROM 47319 28545 ALT 1062
MAX ORD 2069 QE 482 TOF 39
TGT #AA1020 RWRTO

Dis O1 → O2	Az O1 → O2		
			3200
	Az O2 → O1		

Data Fired	Chg 7 WB	DF 3341	FS 39.5	QE 482

Observer Readings

Rd No	O1 ~~Az~~ GRID	~~VA~~	O2 ~~Az~~ ALT
①	3502	2693	1103
②	3521	2698	1110
③	3520	2694	1117
④	3505	2695	1115
⑤	3517	2697	1113
⑥	3506	2694	1107
7			
8			
9			
10			

Interior Angles

O1 on Left		O1 on Right	
Az O1 → HB (MPI)		Az O2 → HB (MPI)	
+ 6400 if necessary		+ 6400 if necessary	
Total		Total	
- Az O2 → HB (MPI)		- Az O1 → HB (MPI)	
APEX ∡		APEX ∡	
Az O2 → HB (MPI)		Az O2 → O1	
+ 6400 if necessary		+ 6400 if necessary	
Total		Total	
- Az O2 → O1		- Az O2 → HB (MPI)	
∡ at O2		∡ at O2	
Total			
Average			

Bearing = 6400 - Az
dE -
dN +

Bearing = Az
dE +
dN +

IV I
III II

dE -
dN -
Bearing = Az - 3200

dE +
dN -
Bearing = 3200 - Az

Az O1 → HB (MPI) = Bearing
Bearing

Distance O1 HB (MPI)

Log base O1 → O2	
+ Log sin ∡ at O2	
Sum	
- Log sin Apex Angle	
diff = Log dist O1 HB (MPI)	
Dist O1 → HB (MPI)	

Log of dE, dN, and dH

Log dist O1 → HB (MPI)		Log dist O1 → HB (MPI)		Log dist O1 → HB (MPI)	
Log sin Bearing		Log cos Bearing		Log Tan Vert ∡	
Sum = Log dE		Sum = Log dN		Sum = Log dH	

Coordinates of O1	E	N	H
	+ - dE	+ - dN	+ - dH
Location of HB (MPI)	E 3512	N 2695	M 1111

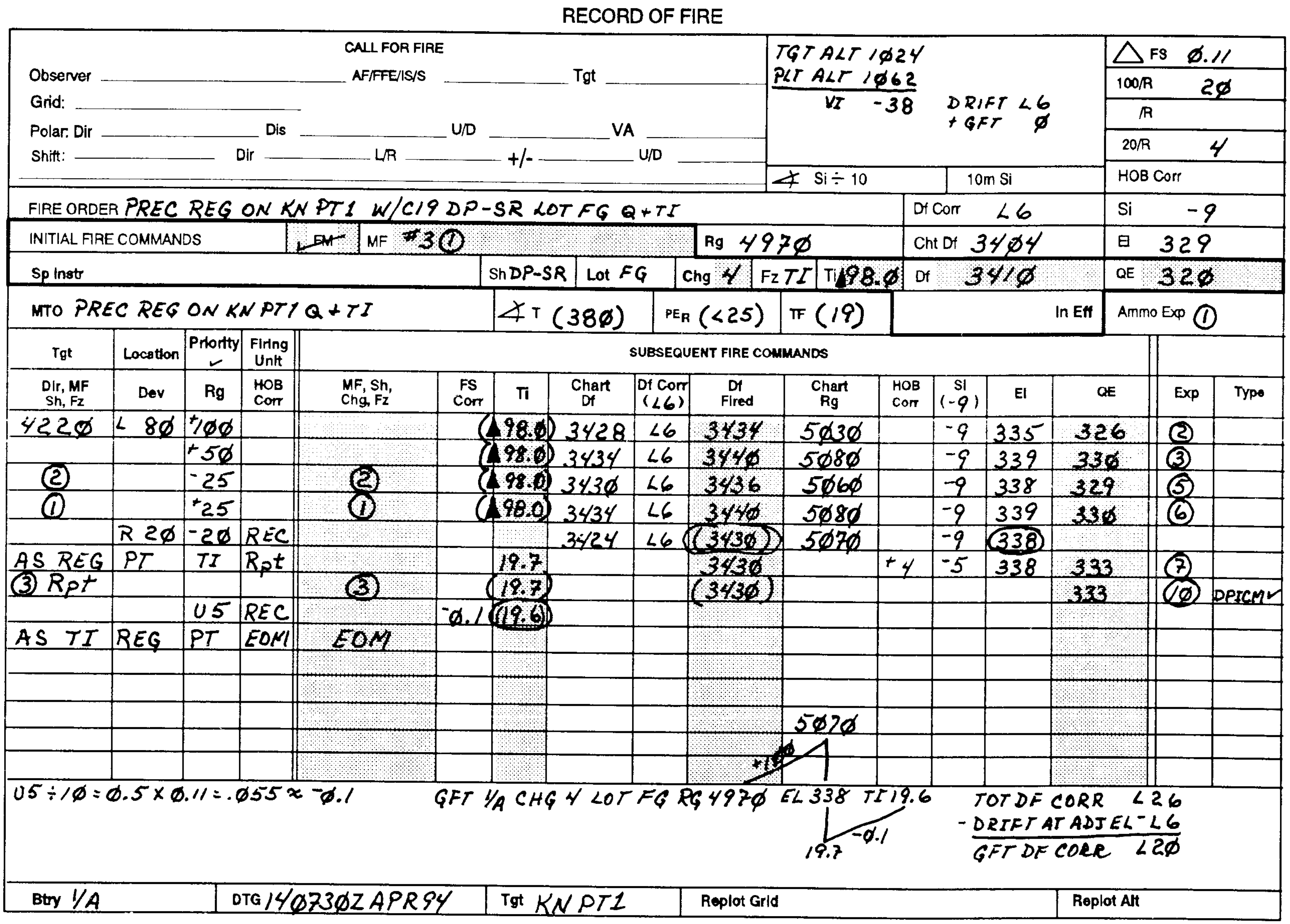
COMPUTATION OF GFT SETTING

Alt HB (MPI)	1111	QE fired	482	Chart data to HB (MPI) location Deflection 3332 m Range 12290 M GFT "1/A" Charge 7 Lot AW Range 12290 Elevation 477 Time 39.5	Df corr L9
- Alt Btry	1062	- Site VI/HB (MPI) Rg	-(+5)		- L15
VI	⊕ 49	Adj Elev	477		R6

TOT
DRIFT AT ADJ EL
GFT

GFT 1/A CHG 7 LOT AW RG 12290 EL 477 TI 39.5
+160
12450
-0.2
39.7

Figure 10-17. Completed DA Form 4201 for an HB Radar Registration.



RECORD OF FIRE

CALL FOR FIRE Observer AF/FFE/IS/S Tgt Grid: Polar: Dir Dis U/D VA Shift: Dir L/R +/- U/D	TGT ALT 1024 PLT ALT 1062 VI -38 DRIFT L6 +GFT 0	△ FS 0.11 100/R 20 /R 20/R 4
	∡ Si ÷ 10 / 10m Si	HOB Corr
FIRE ORDER PREC REG ON KN PT1 W/C19 DP-SR LOT FG Q+TI	Df Corr L6	Si -9
INITIAL FIRE COMMANDS ~~FM~~ MF #3 ①	Rg 4970 / Cht Df 3404	⊟ 329
Sp Instr / Sh DP-SR / Lot FG / Chg 4 / Fz TI / Ti ▲98.0	Df 3410	QE 320
MTO PREC REG ON KN PT1 Q+TI / ∡T (380) / PER (<25) / TF (19)	In Eff	Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L6)	Df Fired	Chart Rg	HOB Corr	Si (-9)	El	QE	Exp	Type
4220	L 80	+100				(▲98.0)	3428	L6	3434	5030		-9	335	326	②	
		+50				(▲98.0)	3434	L6	3440	5080		-9	339	330	③	
②		-25		②		(▲98.0)	3430	L6	3436	5060		-9	338	329	⑤	
①		+25		①		(▲98.0)	3434	L6	3440	5080		-9	339	330	⑥	
	R 20	-20	REC				3424	L6	((3430))	5070		-9	(338)			
AS REG	PT	TI	Rpt			19.7			3430		+4	-5	338	333	⑦	
③ Rpt				③		(19.7)			(3430)					333	⑩	DPICM✓
		U5	REC		-0.1	((19.6))										
AS TI	REG	PT	EOM	EOM												

5070
+10

U5 ÷ 10 = 0.5 × 0.11 = .055 ≈ -0.1

GFT 1/A CHG 4 LOT FG RG 4970 EL 338 TI 19.6

19.7 -0.1

TOT DF CORR L26
- DRIFT AT ADJ EL -L6
GFT DF CORR L20

Btry 1/A	DTG 140730Z APR94	Tgt KN PT1	Replot Grid	Replot Alt

DA Form 4504, OCT 78

Figure 10-18. Completed ROF of a Precision Registration for Shell DPICM.

Section V

High-Angle Registration

On the basis of the tactical considerations, it may become necessary to use high-angle fire instead of low-angle fire. In this situation, a high-angle impact registration can be conducted to improve the accuracy of initial rounds. The use of time fuzes to conduct a time registration is impractical because the height of burst probable error is so large.

10-36. High-Angle GFT

When conducting a high-angle impact registration, it is common for the range probable error to be equal to or greater than 25 meters. Since current high-angle GFTs do not have a probable error in range gauge point, the computer must check Table G of the TFT to determine if the probable error in range is equal to or greater than 25 meters. A probable error in range gauge point may be constructed on the high-angle GFT for each charge. The gauge point is constructed on the TF scale.

10-37. Procedures for High-Angle Impact Registration

Procedures for high-angle impact registrations are the same as low-angle impact registrations with the following three exceptions:

a. Because of the large CAS in high-angle fire, special procedures must be used to determine the adjusted elevation.

b. The high-angle GFT setting is applied differently to the high-angle GFT.

c. High-angle transfer limits are different from low-angle transfer limits because ranges of various charges are smaller.

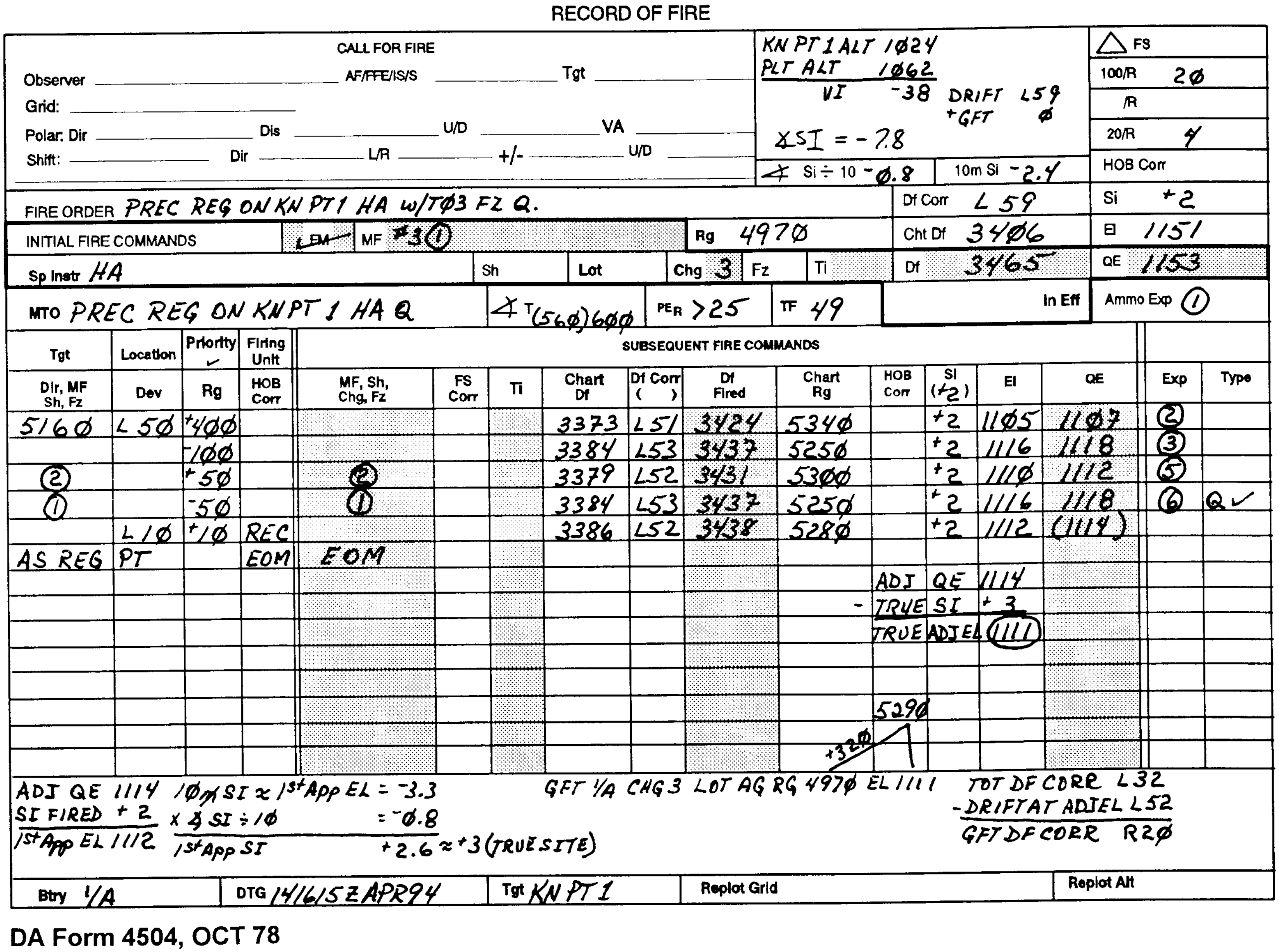
10-38. Computation of the Adjusted Elevation

a. The adjusted elevation, determined from an HA impact registration, often includes a false site. This false site is caused by the relationship of the CAS to total site. The CAS is a fiction of elevation. In low-angle fire, small changes in elevation will cause small changes in CAS. On the other hand, in high-angle fire, small changes in elevation will cause large changes in CAS. In a high-angle registration, the CAS determined at the initial elevation and applied throughout the mission will often differ substantially from the CAS corresponding to the adjusted elevation. This false CAS, when added to the angle of site, will produce a false site. To provide accurate data, the FDC must determine the true site and subtract it from the adjusted QE to compute the true adjusted elevation. To determine the true site, successive approximation is used.

b. The steps in Table 10-10 are used to determine the true site and true adjusted elevation.

Table 10-10. Determination of True Site and True Adjusted Elevation.

STEP	ACTION
1	Determine the first apparent elevation by subtracting the site fired from the adjusted QE. **ADJUSTED QE** **- SITE FIRED** **FIRST APPARENT ELEVATION**
2	Determine the 10-mil site factor corresponding to the first apparent elevation by placing the MHL over the first apparent elevation and reading the value from the 10-mil site factor scale under the MHL.
3	Determine the first apparent site by multiplying the 10-mil site factor corresponding to the first apparent elevation (step 2) by the angle of site divided by 10. Express the result to the nearest 1 mil.
4	If the first apparent site is within 1 mil of the site fired, the first apparent site is the true site. If the first apparent site is not within 1 mil of the site fired, continue the process to determine a second apparent elevation.
5	Determine the second apparent elevation by subtracting the first apparent site from the adjusted QE. **ADJUSTED QE** **- FIRST APPARENT SITE** **SECOND APPARENT ELEVATION**
6	Determine the 10-mil site factor corresponding to the second apparent elevation by placing the MHL over the second apparent elevation and reading the value from the 10-mil site factor scale under the MHL.
7	Determine the second apparent site by multiplying the 10-mil site factor corresponding to the second apparent elevation (step 6) by the angle of site divided by 10. Express the result to the nearest 1 mil.
8	If the second apparent site is within 1 mil of the last site, the second apparent site is the true site. If the second apparent site is not within 1 mil of the previous apparent site, continue steps 5 through 8 until the last computed site is within 1 mil of the previously computed site. The final site computed is the true site.
9	Compute the true adjusted elevation by subtracting the true site from the adjusted QE. **ADJUSTED QE** **- TRUE SITE** **TRUE ADJUSTED ELEVATION**
10	Record the GFT setting on the ROF. Record the high-angle fire GFT setting in the same manner as for the low-angle fire GFT setting. Figure 10-19 shows a completed ROF for a high-angle impact registration.



RECORD OF FIRE

CALL FOR FIRE

Observer ______ AF/FFE/IS/S ______ Tgt ______

Grid: ______

Polar: Dir ______ Dis ______ U/D ______ VA ______

Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______

KN PT 1 ALT 1024
PLT ALT 1062
VI -38 DRIFT L59
+GFT 0
∡SI = -7.8

∡ Si ÷ 10 -0.8 | 10m Si -2.4

△ FS
100/R 20
/R
20/R 4
HOB Corr
Si +2
El 1151
QE 1153

FIRE ORDER PREC REG ON KN PT1 HA w/T03 FZ Q.

Df Corr L 59

INITIAL FIRE COMMANDS ~~EM~~ MF #3 ①

Rg 4970

Cht Df 3406

Sp Instr HA | Sh | Lot | Chg 3 | Fz | Ti | Df 3465

MTO PREC REG ON KNPT 1 HA Q | ∡T (560) 600 | PER >25 | TF 49 | In Eff | Ammo Exp ①

Tgt Dir, MF Sh, Fz	Location Dev	Priority ✓ Rg	Firing Unit HOB Corr	SUBSEQUENT FIRE COMMANDS MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	SI (+2)	El	QE	Exp	Type
5160	L 50	+400					3373	L51	3424	5340		+2	1105	1107	②	
		-100					3384	L53	3437	5250		+2	1116	1118	③	
②		+50		②			3379	L52	3431	5300		+2	1110	1112	⑤	
①		-50		①			3384	L53	3437	5250		+2	1116	1118	⑥	Q ✓
	L 10	+10	REC				3386	L52	3438	5280		+2	1112	(1114)		
AS REG	PT		EOM	EOM												
											ADJ	QE	1114			
										-	TRUE	SI	+3			
											TRUE	ADJ EL	1111			
											5290					
										+320						

ADJ QE 1114
SI FIRED +2
1st App EL 1112

10m SI ≈ 1st App EL = -3.3
x ∡ SI ÷ 10 = -0.8
1st App SI +2.6 ≈ +3 (TRUE SITE)

GFT 1/A CHG 3 LOT AG RG 4970 EL 1111

TOT DF CORR L32
-DRIFT AT ADJ EL L52
GFT DF CORR R20

Btry 1/A | DTG 141615Z APR94 | Tgt KN PT 1 | Replot Grid | Replot Alt

DA Form 4504, OCT 78

Figure 10-19. Completed ROF for a High-Angle Impact Registration.

10-39. DPICM High-Angle Registration

a. Conduct a registration with DPICM (M483A1) in the self-registration mode. This destroys the submunitions and causes the round to detonate like an HE round.

b. If terrain in the target and/or firing unit area requires using high-angle fire, a high-angle **high-burst** registration using the M577 time fuze can be conducted. (The M577 has a small probable error in height of burst in relation to the M564/M565 time fuze family. This type of registration is conducted with the DPICM projectile in the SR mode. The procedures are the same as for those in low-angle HB registration with the following exceptions:

(1) Add a minimum of 4 PE_{HB} (DPICM TFT, Table G, Column 5) to the altitude of the orienting point.

(2) The fuze setting to fire in an HB high-angle registration is the fuze setting corresponding to elevation plus CAS. The CAS in high-angle fire is usually a relatively large negative number. To determine CAS, enter Table G of the TFT with the range to the nearest 500 meters and extract from Column 12 or 13 the CSF for a 1-mil angle of site. Multiply the angle of site by the CSF to determine CAS. Apply the CAS to the elevation determined from the high-angle GFT. Move the MHL over the value of elevation plus CAS, and read from the TF scale to the nearest 0.1 fuze setting increment.

(3) Determine drift and elevation from the high-angle GFT.

(4) Determine site by multiplying the 10-mil site factor corresponding to the adjusted elevation by the angle of site divided by 10.

c. Determine the adjusted elevation for a high-angle HB registration in the same manner as for a low-angle HB registration. Site is based on the altitude of the mean burst location.

d. Determine the adjusted time in the same manner as in a low-angle HB registration. To determine the total fuze correction, subtract the time corresponding to elevation plus CAS from the adjusted time. When firing with a GFT setting, apply the total fuze correction to the fuze setting corresponding to the adjusted elevation to determine the fuze setting to fire.

Section VI

Offset Registrations or Registrations to the Rear

The tactical situation may make registering from the unit location or along the primary azimuth of fire impractical. The offset registration or registration to the rear should reduce the vulnerability of the firing unit to detection by enemy counterbattery assets. Both of these registrations may require coordination for firingpositions or known points. The registrations are conducted by using normal precision or HB/MPI registration procedures.

10-40. Offset Registration

a. An offset registration is conducted by one howitzer from a position away from the rest of the unit. The offset position must be coordinated to ensure there are no other friendly units in the area as the registration may draw enemy counterbattery fire. The offset position must be on common survey with the firing unit to ensure that any corrections for survey errors in the offset position are valid in the firing unit position.

b. Adjusted data and resulting corrections determined from the offset position are valid for that position within normal range and deflection transfer limits.

c. The registration corrections are based on the azimuth and range from the offset position to the known point. It is assumed that if a registration were conducted from the firing unit area by using the same range and azimuth (as from the offset position), the adjusted data and resulting corrections would be the same as those obtained in the offset position. (See Figure 10-20).

10-41. Registrations to the Rear

A registration to the rear (or along some other azimuth significantly different from the primary azimuth of fire) may be either a precision or an HB/MPI registration. The registration will result in corrections, but these corrections must be modified for the primary zone of fire by using the eight-direction met technique (Chapter 11). The actual area where the rounds will be bursting must be coordinated to ensure there are no friendly units in the area.

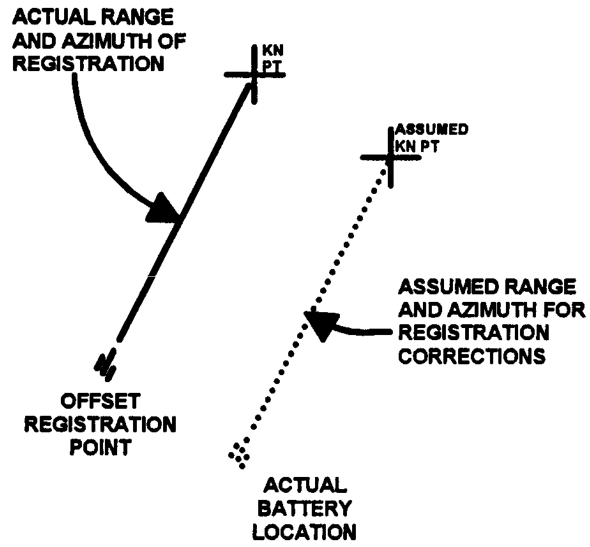


Figure 10-20. Offset Registration Data.

Section VII

Determination and Application of Registration Corrections

Registration corrections consist of a total range, total fuze, and total deflection correction. FDC personnel compute these corrections by comparing the chart or ***should hit*** *data (the data that when fired under standard conditions will cause the round to burst at a point of known location) with the adjusted or* ***did hit*** *data (the data that when fired under nonstandard conditions will cause the round to burst at a point of known location).*

10-42. Computation of Total Range Correction

a. If standard conditions existed, the elevation fired to achieve the chart range would be the elevation listed in the firing tables for that chart range, When nonstandard conditions exist the range that is achieved by firing a certain elevation is greater or less than the range listed in the firing tables by an amount equal to all of the effects caused by the nonstandard conditions. The difference is the total range correction.

b. The total range correction is the difference in meters between the initial chart range and the firing table range corresponding to the adjusted elevation. Determine the total range correction as follows:

(1) From the TFT or GFT, determine the range (to the nearest 10 meters) corresponding to the adjusted elevation.

(2) Subtract the initial chart range (or achieved range) from the range corresponding to the adjusted elevation. The result is the total range correction. The total range correction is

EXAMPLE
GIVEN: An M109A3 howitzer platoon registered with charge 4GB. The base piece was over platoon center (the location plotted on the firing chart was the base piece). The initial chart range was 4,950 meters, and the adjusted elevation was 314. To determine total range corrections, use the procedures in Table 10-11.

Table 10-11. Total Range Correction.

STEP	ACTION
1	From the precision registration example in Figure 10-3, the range corresponding to the adjusted elevation of 314 is 5,110 meters.
2	Subtract the initial chart range from the range corresponding to the adjusted elevation. The result is the total range correction of +160 meters (5110 - 4950 = +160 meters)(**DHD - SHD = TOT**).
3	The difference between the initial chart range and the range corresponding to the adjusted elevation is +160. This procedure can be portrayed by using part of the "lazy Z" as shown in Figure 10-21, page 10-48.

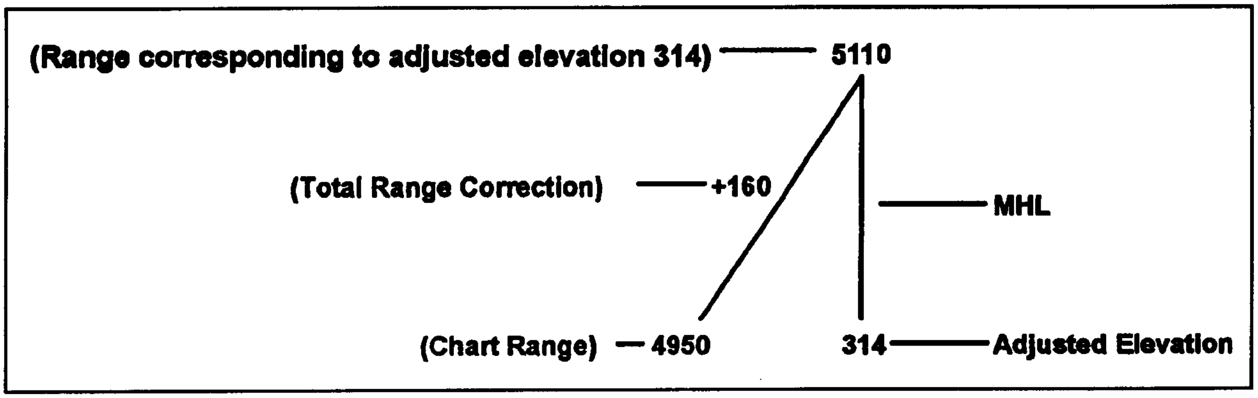


Figure 10-21. Range and Elevation Depicted on the Lazy Z.

10-43. Computation of Total Fuze Correction

a. The time portion of a precision or high-burst registration will result in an adjusted or did hit time (fuze setting). The time corresponding to the adjusted elevation is the should hit time that must be compared to the actual adjusted time determined by firing. The difference between the time corresponding to the adjusted elevation and the adjusted time is the total fuze correction **(DHD - SHD = TOT).**

b. To determine the total fuze correction, subtract the time corresponding to the adjusted elevation (or elevation plus CAS if the VI is greater than 100) from the adjusted time. The total fuze correction is always a signed value and is used in solving a concurrent met. See the following example.

EXAMPLE
Continuing the example above, the firing unit obtained an adjusted time of 18.5. The time corresponding to the adjusted elevation is 18.8. Subtract the time corresponding to the adjusted elevation from the adjusted time to determine the total fuze correction of (18.5 - 18.8 = -0.3). This procedure can be portrayed by using part of the lazy Z as shown in Figure 10-22.

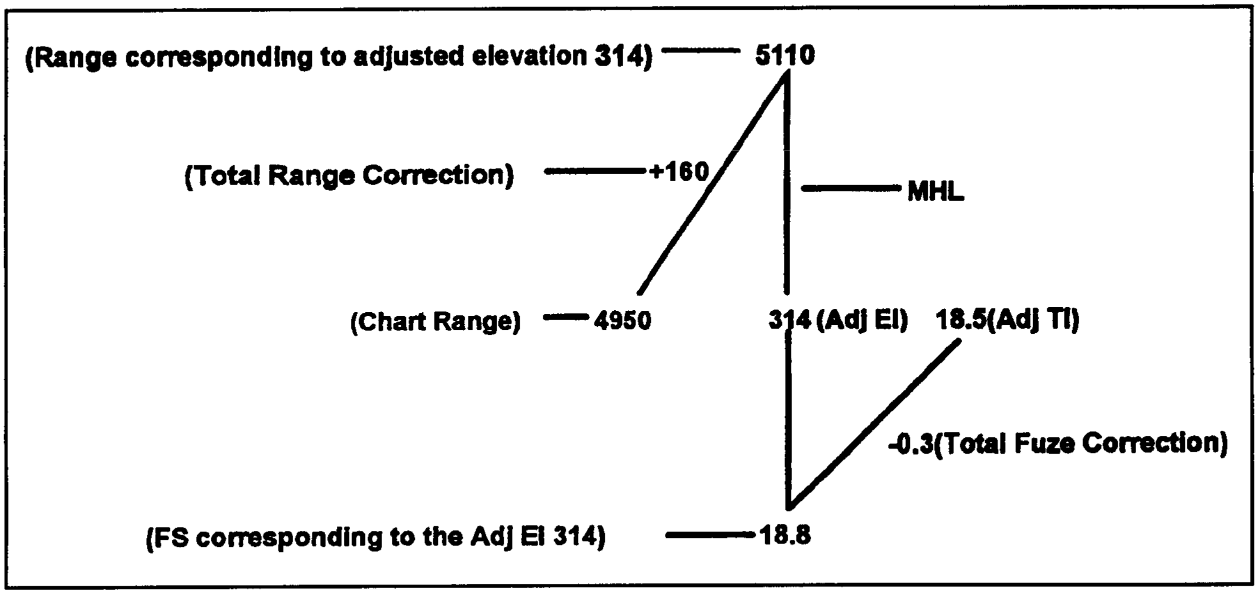


Figure 10-22. A Completed Lazy Z.

10-44. Computation of Total Deflection Correction

a. The total deflection correction is the correction, in mils, that must be added to the chart deflection to correct for all nonstandard conditions.

b. To determine the total deflection correction, subtract the chart deflection from the adjusted deflection. The total deflection correction is used in solving the concurrent met technique, in processing immediate type fire missions, and for updating manual safety computations after a registration. For all other missions, the GFT DF correction plus drift is used.

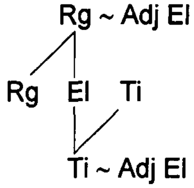
c. A GFT deflection correction is determined by subtracting the drift corresponding to the adjusted elevation from the total deflection correction. The GFT deflection correction remains the same for all elevations fired with the registered charge. The drift is applied to the GFT deflection correction to determine the deflection correction to be used for that mission. Using the precision registration example in Figure 10-3, determine the total deflection correction as follows:

ADJUSTED DEFLECTION	**3403**
- CHART DEFLECTION	**3404**
TOTAL DEFLECTION CORRECTION	**R1**
- DRIFT CORRESPONDING TO ADJ EL	**L6**
GFT DEFLECTION CORRECTION	**R7**

10-45. Determination of Total Registration Corrections

The computational space on DA Form 4757-R (Registration / Special Corrections Work Sheet) will be used to determine the total corrections. Use Table 10-12 to determine total registration corrections,

Table 10-12. Total Registration Corrections.

STEP	ACTION
1	Record the chart range, adjusted elevation, and adjusted time from the registration.
2	Determine and record the range corresponding to the adjusted elevation by placing the MHL over the adjusted elevation and reading the value from the range scale under the MHL. This value is recorded at the top of the lazy Z. 
3	Without moving the cursor, determine and record the fuze setting (M564/M582) corresponding to the adjusted elevation by reading the value from the fuze scale (for the registered fuze) under the MHL.
4	Determine and record the total range correction. If the value of range decreased from chart to adjusted, the sign of the total range correction is negative. If the range increased, the sign is positive. Record the difference in range with the appropriate sign on the lazy Z. **(RG ~ ADJ EL) - (CHT RG) = TOT RG CORR (±)**
5	Determine and record the total fuze correction. If the value of fuze setting decreased from chart to adjusted, the sign of the total fuze correction is negative. If the fuze setting increased, the sign is positive. Record the difference in fuze setting with the appropriate sign on the lazy Z. **(ADJ FS) - (FS ~ ADJ EL) = TOT FS CORR (±)**
6	Determine and record the total deflection correction. If the value of the chart deflection decreased from chart to adjusted, the sign of the total deflection correction is right (R). If the deflection increased, the sign is a left (L). **(ADJ DF) - (CHT DF) = TOT DF CORR (L/R)**

10-46. Low-Angle GFT Settings

a. The data determined from a registration must be applied to FDC graphical equipment. This will enable the unit to attack accurately located targets without adjustment (first round fire for effect) within transfer limits.

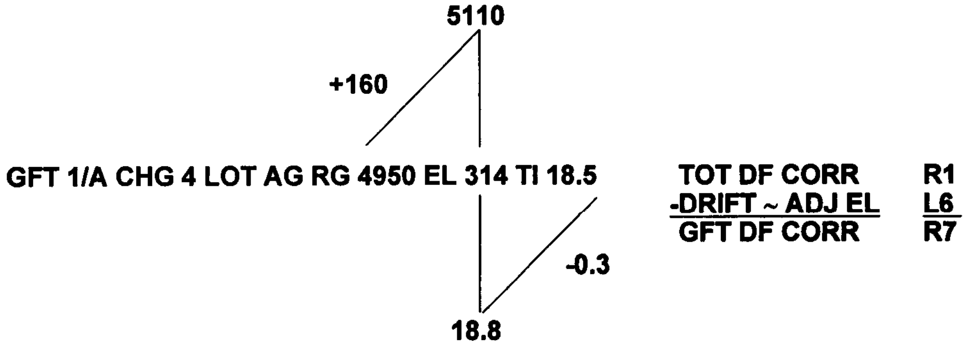
b. Listed below are the elements of a GFT setting. These elements are recorded in the lower computational space of the record of fire used to process the registration. Additionally, they may also be recorded on DA Form 4757-R and on the record of fire of a mission in which they are being used. For the HB/MPI registration, the GFT setting is recorded on DA Form 4201. The acronym UCARET is used as an aid in recording the GFT setting. It is used to keep the GFT setting preceding the total and GFT deflection corrections in order.

- Unit that fired the registration.
- Charge fired during the registration and the charge for which the GFT setting applies.
- Ammunition lot used in the registration. With separate-loading ammunition, the first letter designates the projectile lot used during the registration. The second letter designates the propellant lot used during the registration.
- Range (chart or achieved) from the howitzer to the point of known location.
- Elevation (adjusted or did hit).
- Time (adjusted or did hit fuze setting).
- Total deflection correction (the difference between the adjusted deflection and the chart deflection).
- GFT deflection correction (the difference between the total deflection correction and the drift corresponding to the adjusted elevation).

c. The following is an example of a completed GFT setting as it is written.

GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5
TOT DF CORR R1 GFT DF CORR R7

d. The following is an example of a completed GFT setting as it is written with total corrections.



10-47. Determination of a GFT Setting When the Registering Piece is not the Base Piece

It may not always be possible to register with the base piece. When a howitzer other than the base piece is used to register, corrections must be made to compensate for the displacement of the registering piece from the base piece. Use a DA Form 4757-R and the steps in Table 10-13 to determine the necessary corrections.

Table 10-13. GFT Setting--Registering Piece is not BP.

STEP	REFERENCE	ACTION
1	Chart Rg	Record the **chart range** determined at the start of the registration.
2	Registering Piece Displ (F-/B+)	Enter the displacement of the registering piece from the base piece either forward or back. For forward displacement, use minus; for back displacement, use plus.
3	Achieved Rg (1 + 2)	Determine and record the achieved range from the registering piece to the registration point by adding the piece displacement (step 2) to the chart range (step 1).
4	Lateral Displ (L/R)	Enter the left or right lateral displacement of the registering piece from the base piece.
5	Achieved Rg (3)	Enter the achieved range determined in step 3.
6	Registering Piece Displ Corr (4 ÷ 5)(L+/R-)	Determine and record the base piece displacement correction by dividing the lateral displacement (step 4) by the achieved range, in thousands (step 5). Use a GST for the division, and express the result to the nearest mil. Circle L for left or R for right.
7	Corr Df (Reg)	Record the **correct deflection**. When the piece is displaced laterally, the deflection that hit the registration point is no longer called the adjusted deflection. It is now called the correct deflection.
8	Registering Piece Displ Corr (6) (L+/R-)	Record the base piece displacement correction determined in step 6.
9	Adj Df (7 + 8)	Determine and record the adjusted deflection by adding the base piece displacement correction (step 8) to the correct deflection (step 7).
10	Chart Df	Record the chart deflection from the registration.
11	Total Df Corr (9 - 10) (L+/R-)	Determine and record the total deflection correction by subtracting the chart deflection (step 10) from the adjusted deflection (step 9). Use the LARS rule to determine whether the total deflection correction is left or right (+ = L and - = R).
12	Drift Corr ≈ Adj El (L)	Determine and record the drift corresponding to the adjusted elevation by placing the MHL (of the appropriate GFT) over the adjusted elevation and reading the drift under the MHL.
13	GFT Df Corr (11 - 12)	Determine and record the GFT deflection correction by subtracting the drift corresponding to adjusted elevation (step 12) from the total deflection correction (step 11). Use the LARS rule to determine whether the GFT deflection correction is left or right.
	NOTE: The GFT setting can now be recorded. Use the acronym UCARET.	
14	GFT ___	Unit: Record the battery or platoon designation.
15	Chg ___	Charge: Record the charge fired in the registration.
16	Lot ___	Ammo lot: Record the lot fired in the registration.
17	Rg ___	Range: Record the chart (achieved) range.
18	El ___	Elevation: Record the adjusted elevation.
19	Ti ___	Time: Record the adjusted time.
20	Total Df Corr	Record the total deflection correction.
21	GFT Df Corr	Record the GFT deflection correction.

10-48. Construction of a GFT Setting

Once the information for the GFT setting has been determined and recorded on DA Form 4757-R, the GFT setting can be constructed on the GFT. Use the steps in Table 10-14 to construct a GFT setting on the GFT.

Table 10-14. Construction of a GFT Setting.

STEP	ACTION
1	Move the cursor of the GFT until the MHL is over the GFT setting range (chart or achieved range to the point of known location) on the range scale.
2	Using a blue soft-lead pencil or water-based fine-tip marker, place a dot over the GFT setting elevation (adjusted elevation).
3	Using a red soft-lead pencil or water-based fine-tip marker, place a dot over the GFT setting time (adjusted fuze setting).
4	Move the cursor until the elevation (blue) dot is over the range K line. Using the blue pencil or marker and a straightedge, trace the range K line on the cursor through the dot. The line should be as fine as possible to enhance the accuracy of data determined. This is the elevation gauge line (EGL). Label the top of this line "EL."
5	Move the cursor until the time (red) dot is over the fuze K line. Using the red pencil or marker and a straightedge, trace the fuze K line on the cursor through the dot. The line should be as fine as possible to enhance the accuracy of data determined. This is the time gauge line (TGL). Label the top of this line "TI."
6	Move the cursor until the MHL is over the GFT setting range (chart or achieved range to the point of known location). Under the EGL, determine elevation from the elevation scale. It should check with 0 tolerance with the adjusted elevation. If not, erase and reconstruct the EGL.
7	Move the cursor until the MHL is over the GFT setting range. Under the TGL, determine FS from the FS scale. It should check with 0.0 tolerance with the adjusted fuze setting. If not, erase and reconstruct the TGL.
8	In the upper left corner of the cursor, record the total deflection correction and circle the value.
9	In the upper right corner of the cursor, record the GFT deflection correction.

NOTE: An example of a one-plot GFT setting applied to a GFT is shown in Figure 10-23.

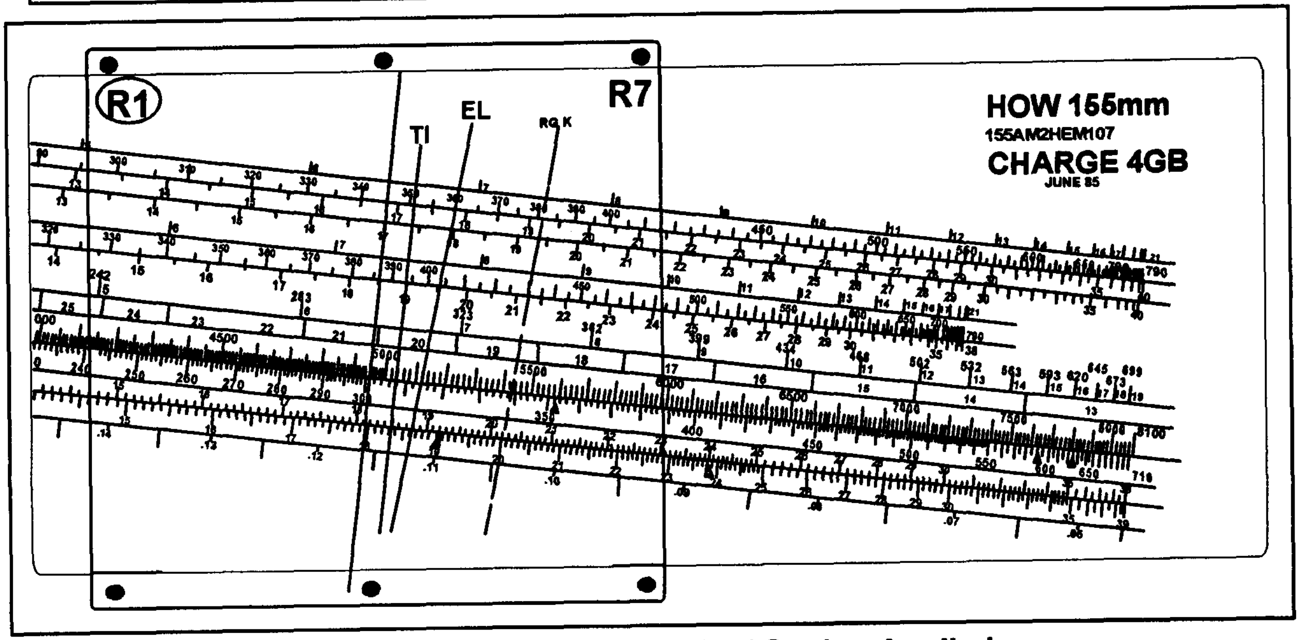


Figure 10-23. GFT With a GFT Setting Applied.

10-49. Construction of a Two-Plot or Multiplot GFT Setting

The steps in Table 10-15 are used to construct a two-plot or multiplot GFT setting.

Table 10-15. Construction of a Two-Plot or Multiplot GFT Setting.

STEP	ACTION
1	Move the cursor of the GFT until the MHL is over the GFT setting range on the range scale.
2	Using a blue soft-lead pencil or water-based fine-tip marker, place a dot over the GFT setting elevation.
3	Using a red soft-lead pencil or water-based fine-tip marker, place a dot over the GFT setting time.
4	Repeat steps 1 through 3 for each set of data for the GFT setting.
5	Using the blue and red pencils or markers, connect the elevation dots with a blue line and connect the time dots with a red line. Use as fine a line as possible to enhance the accuracy of data determined. On that portion of the cursor above and below the elevation and time dots, extend the EGL and TGL to the edge of the cursor at an angle appropriate to the last two points used at the top and bottom of the constructed line. This extension is a more accurate portrayal of range K and fuze K. It represents conditions presently existing, determined by firing, rather than those from the computer-generated averages depicted by range K and fuze K lines on the GFT.
6	Move the cursor until the MHL is over each range. Under the EGL, determine elevation from the elevation scale. It should check with 0 tolerance with the adjusted elevation. If not, erase and reconstruct the EGL.
7	Move the cursor until the MHL is over each range. Under the TGL, determine time from the time scale. It should check with 0.0 tolerance with the adjusted fuze setting. If not, erase and reconstruct the TGL.
8	In the upper left corner of the cursor, record the average total deflection correction and circle the value.
9	In the upper right corner of the cursor, record the average GFT deflection correction.

10-50. Update of a GFT Setting When Transferring From a Map Spot or Observed Firing Chart

a. Field artillery units must be able to deliver responsive, accurate fires immediately upon occupation of a new position. Firing must not be delayed because of lack of survey or suitable maps. An initial firing chart may be based on a map spot or an observed firing chart. Once the actual survey is brought into the unit's area, the firing charts must be reconstructed on the basis of the firing unit's true location and true azimuth. GFT settings based on map spot or observed fire charts are accurate but must be updated.

b. When a registration is conducted on the basis of the map spot data for the registration point and/or firing unit location, the corrections determined will include corrections for map spot errors and possible human errors in plotting the locations. Once survey data are available, the GFT setting(s) determined must be updated to account for the initial inaccuracies.

c. Once survey data become available, the HCO will construct and plot the locations on a surveyed firing chart. He will determine a new chart range and deflection to the known point. The new chart range will be the range for the GFT setting. The VCO will use the new chart range and an updated VI to recompute site. The computer will recompute the adjusted elevation and new total and GFT deflection corrections. The adjusted fuze setting was determined by firing and will not change. Use Table 10-16 to update a GFT setting when transferring from a map spot or observed firing chart to a surveyed firing chart.

Table 10-16. Update of a GFT When Transferring From Map Spot or Observed Firing Chart.

STEP	ACTION
1	The HCO plots the updated location of the base piece and/or registration point on the basis of the information provided by the survey section.
2	The HCO determines and announces a new chart range and deflection to the known point. The announced range is the range for the GFT setting.
3	The VCO computes a new VI. Subtract the updated base piece (firing unit) altitude from the known point altitude. (One or both of the altitudes may be different.) **TGT ALT** **- PLT ALT** **VI**
4	The VCO uses the new chart range (step 2) and the new VI (step 3) to recompute and announce a new site. The charge will be the charge fired during the registration.
5	The computer determines a new adjusted elevation by subtracting the new site from the adjusted quadrant of the registration. **ADJ QE** **- NEW SITE** **NEW ADJ EL**
6	The computer records the adjusted fuze setting from the registration.
7	The computer determines a new total deflection correction by comparing the new chart deflection to the adjusted deflection from the registration. **ADJ DF** **- NEW CHT DF** **TOT DF CORR**
8	The computer determines the new GFT deflection correction by subtracting the drift corresponding to the new adjusted elevation from the total deflection correction. The drift corresponding to the new adjusted elevation is determined by placing the MHL over the new adjusted elevation and reading the value on the drift scale under the MHL. **TOT DF CORR** **- DRIFT ~ NEW ADJ EL** **GFT DF CORR**
9	The computer will apply the new GFT setting to the appropriate GFT.
	NOTE: A VI greater than 100 meters will cause the complementary angle of site to increasingly affect the fuze setting. If the new VI is greater than 100 meters, recompute the adjusted fuze setting.

10-51. Registration Transfer Limits

a. In manual gunnery techniques, the total corrections determined from a registration are valid only within certain range and deflection transfer limits. Transfer limits define the ranges and deflections within which the GFT setting is expected to produce accurate firing data. The total corrections for nonstandard conditions are valid only when the weapons are firing toward the known point. For example, when weapons are firing on a different azimuth than that of the known point, the wind will not affect the round in the same manner as it did along the azimuth to the known point.

b. Range Transfer Limits.

(1) The range transfer limits for a one-plot GFT setting are shown on the GFT corresponding to the red numbered elevations.

(2) The range transfer limits for a two-plot GFT setting are between the two ranges used to apply the GFT setting(s). This type of GFT setting becomes less accurate outside these two ranges.

(3) The range transfer limits for a multiplot GFT setting are eliminated when three or more sets of corrections are available for the same charge. The optimum multiplot GFT setting reflects a plot for each met line number that the charge may cause the projectile to pass through (met check gauge points).

c. Deflection Transfer Limits.

(1) The total registration corrections are valid only within certain deflection transfer limits.

(2) When the chart range to a target is 10,000 meters or less, the total corrections are valid within an area 400 mils left and 400 mils right of a line between the unit and the known point (mean burst location) (Figure 10-24).

(3) When the chart range to a target is less than 10,000 meters, the total corrections are valid within an area 400 mils left and 400 mils right of a line between the unit and the known point (mean burst location) out to 10,000 meters, and 4,000 meters left and 4,000 meters right of the line for ranges beyond 10,000 meters. (See Figure 10-25.)

(4) Total registration corrections may be determined throughout the entire 6,400 mils around the firing unit by using the eight-direction met technique (Chapter 11).

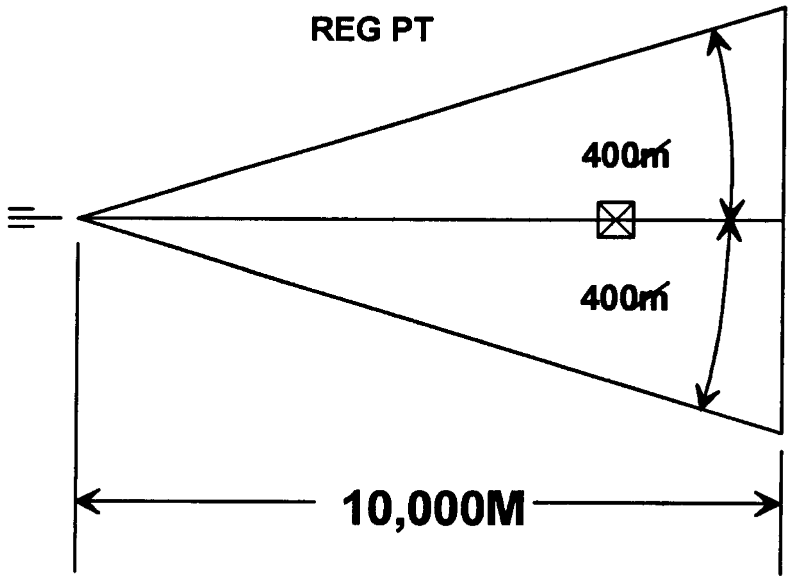


Figure 10-24. Deflection Transfer Limits--10,000 Meters or Less.

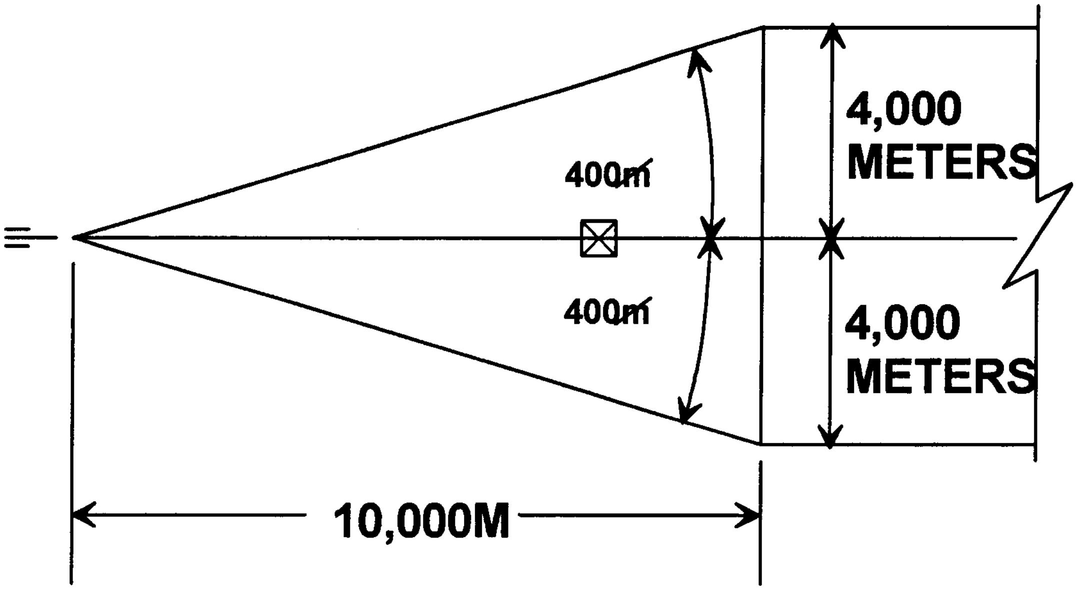


Figure 10-25. Deflection Transfer Limits--Ranges Greater Than 10,000 Meters.

10-52. High-Angie GFT Settings

a. GFT settings for high-angle fire are written in the same manner as those for low-angle fire. An example is shown below.

GFT 1/A, Chg 3, Lot AG, Rg 4970, EI 1111

Tot Df Corr L32 GFT Df Corr R20

b. The high-angle GFT setting is constructed on the GFT by placing the MHL over the adjusted elevation for the charge fired and drawing a range gauge line through the GFT setting range on the range scale parallel to the MHL. The MHL becomes the elevation gauge line, and all data except for range and 100/R are read under the MHL. The GFT deflection correction and charge are recorded on the cursor.

10-53. High-Angle Transfer Limits

Standard range transfer limits are not applicable to high-angle fire because the **range span of each charge is so short.** Corrections in the form of GFT settings and GFT deflection corrections are considered valid for the charge used in determining the corrections and are also considered valid for other charges as shown in Table 10-17.

Table 10-17. High-Angle Transfer Limits.

WEAPON	CHARGE REGISTERED WITH	TRANSFER LIMITS
105-mm Howitzer	1, 2, 3, 4, 5	All ranges charges 1 through 5
	6	Charge 6 only ± 1, 500 meters
	7	Charge 7 only ± 1, 500 meters*
155-mm and 103-mm Howitzers	1, 2, 3 ,4	All ranges charges 1 through 5
	5	Charge 5 only ± 1, 500 meters
	6	Charge 6 only ± 1, 500 meters*
	7	Charge 7 only ± 1, 500 meters*
	8	Charge 8 only ± 1, 500 meters*

*** ± 2,000 meters for registration point ranges greater than 10,000 meters.**

10-54. Transfer of GFT Settings

a. When only one unit of a battalion equipped with weapons for which the same firing tables are used is allowed to register, the GFT setting determined by the registering unit maybe transferred to the nonregistering units in the absence of better information.

b. Transferring of GFT settings should only occur if a concurrent met technique cannot be performed and position constants cannot be isolated (Chapter 11). To transfer a GFT setting, certain conditions must exist as follows:

- Common survey between positions.
- Azimuth of fire (octant) are the same.
- Ability to correct for MVVs for the registered lot.

c. The distance over which the GFT settings are transferred should be monitored closely. The further from the registration point the GFT setting is transferred, the less accurate the GFT setting will be. This is due to the different effects of the met (weather) conditions. The guidance given in chapter 11 on the validity of met messages should be used when transferring GFT settings.

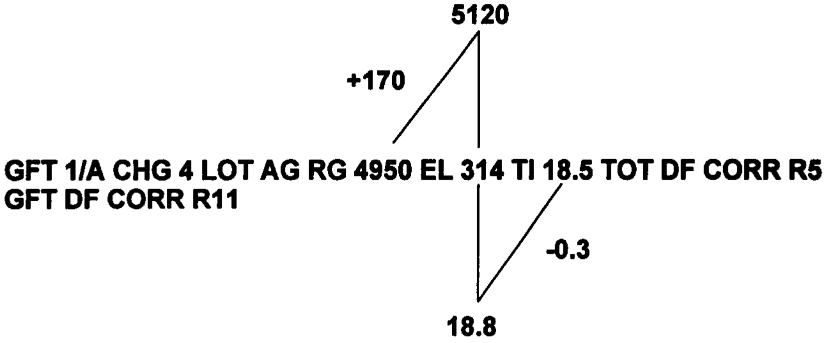
d. The procedures for determining a GFT setting for a nonregistering unit is listed in Table 10-18 below. The registering unit must send the GFT setting and registering piece MVV to the nonregistering unit.

Table 10-18. GFT Setting for Nonregistering Unit.

STEP	ACTION
1	Record the GFT setting and MVV of the registering piece.
2	Determine and record the total corrections from the registration.
3	Determine and record the difference in MVV between the registering howitzer and the base piece.
	BASE PIECE MVV
	- REGISTERING PIECE MVV
	DIFFERENCE IN MVV
4	Determine and record the MV correction factor from the TFT, Table F, Column 10 or 11 (decrease or increase). Enter with the registration range (to the nearest 100 meters) and record as a signed value.
5	Determine the range correction by multiplying the MV correction factor by the difference in MVV (step 4 x step 3). Express the result to the nearest 10 meters. **This value will have the same sign as the correction factor extracted from the TFT**. (See the note below.)
6	Apply the range correction to the total registration range correction (step 5 + step 2). Ensure that all values are signed during this step. Record the new total range correction (±).
7	Apply the new total range correction to the registration range. This is the new range corresponding to the adjusted elevation. Determine the new adjusted elevation by placing the MHL over the new range corresponding to the adjusted elevation.
8	Determine a new fuze setting corresponding to the adjusted elevation by placing the MHL over the elevation determined in step 7.
9	Determine the fuze setting correction for the difference in MVV. Enter the TFT, Table J, Column 2 or 3 with the fuze setting determined in step 8 expressed to the nearest whole increment, and determine the MV correction factor.
10	Determine the fuze setting correction by multiplying the MV unit correction by the difference in MVV (step 9 x step 3). Express the result to the nearest tenth (0.1). **This value will have the same sign as the correction factor extracted from the TFT**. (See the note below.)
11	Apply the fuze setting correction to the total registration FS correction (step 10 + step 2). Ensure that all values are signed during this step. Record the new total fuze setting correction (±).
12	Apply the new total fuze setting correction (step 11) to the fuze setting corresponding to the adjusted elevation (step 8). This value is the new adjusted fuze setting.
13	Determine a new total deflection correction by applying drift corresponding to the adjusted elevation (step 7) to the GFT deflection correction (step 1).
14	The corrected GFT setting is recorded as follows:
	Unit: (designation of nonregistered unit)
	Charge: (registered charge)
	Ammo lot: (registered lot)
	Range: (step 1)
	El: (step 7)
	Ti: (step 12)
	Tot Df Corr: (step 13) GFT Df Corr: (step 1)
	NOTE: The reason for the range correction (step 5) and the fuze setting correction (step 10) having the same sign as the TFT correction value is the actual unit of measurement. The unit correction factor indicates the correction needed for each 1-meter-per-second change. Solving the mathematical formula would lead to the same sign as simply using the sign listed in the TFT. This procedure is only applied in certain situations and is the exception and not the rule.

10-55. Example of Transferring a GFT Setting

Battery A, 1st Platoon registered, and Battery C, 1st Platoon wants the GFT setting transferred to their unit. Battery A, 1st Platoon registered with their base piece which has an MVV of -1.6 M/s. The base piece for Battery C, 1st Platoon has an MVV of -7.7 m/s.



GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5 TOT DF CORR R5
GFT DF CORR R11

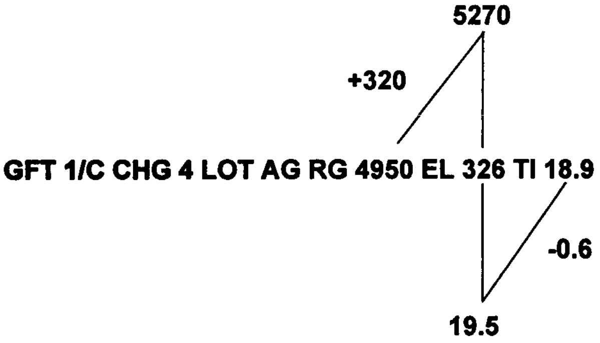
BASE PIECE MVV	-7.7
- REGISTERING PIECE MVV	-1.6
DIFFERENCE IN MVV	-6.1

DIFFERENCE IN MVV	D 6.1
x MV UNIT CORRECTION	+24.4
MV RG CORRECTION	148.8 ≈ +150 METERS

MV RG CORRECTION	+150 METERS
+ TOT RG CORRECTION	+170 METERS
NEW TOT RG CORRECTION	+320 METERS

DIFFERENCE IN MVV	D 6.1
x MV UNIT CORRECTION	-0.052
MV FS CORRECTION	0.3172 ≈ -0.3

MV FS CORRECTION	-0.3
+ TOT FS CORRECTION	-0.3
NEW TOT FS CORRECTION	-0.6



GFT 1/C CHG 4 LOT AG RG 4950 EL 326 TI 18.9

GFT DF CORR	R11
+ DRIFT	L7
TOT DF CORR	R4

Chapter 11

Meteorological Techniques

Met techniques described in this chapter allow a unit to account for the effects of nonstandard conditions and achieve first round fire for effect.

Section I

Principles

Understanding the applications of met techniques requires basic knowledge of registration and met principles.

11-1. Purpose and Use of Met Techniques

a. Nonstandard Conditions

(1) Accurate fires can be placed on targets of known location without adjustments. Under standard conditions, the firing table data would achieve the desired results. However, it is valid to assume that standard conditions will not exist. Corrections need to be applied to firing table data to compensate for the nonstandard conditions of weather, position, and material. The most accurate means of determining these corrections is by registering. Registration corrections are only valid within transfer limits and for a specified period of time. However, conducting a registration may not be an option. Therefore, techniques are needed to mathematically determine corrections and compensate for changing nonstandard conditions. The **met techniques** are used to measure deviations from standard conditions and to compute corrections for them.

(2) The firing tables used to determine firing data for artillery weapons are based on an **arbitrary set of standard conditions** of weather, position, and material. The standards for weather are established by the ICAO (International Civil Aviation organization). (See Figure 11-1.)

WEATHER	STANDARD CONDITIONS
1	AIR TEMPERATURE 100 PERCENT (59°F)
2	AIR DENSITY 100 PERCENT (1,225 gm/m^3)
3	NO WIND
POSITION	**STANDARD CONDITIONS**
1	GUN, TARGET, AND MDP AT SAME ALTITUDE
2	ACCURATE RANGE
3	NO ROTATION OF THE EARTH
MATERIAL	**STANDARD CONDITIONS**
1	STANDARD WEAPON, PROJECTILE, AND FUZE
2	PROPELLANT TEMPERATURE (70°F)
3	LEVEL TRUNNIONS AND PRECISION SETTINGS
4	FIRING TABLE MUZZLE VELOCITY
5	NO DRIFT
LEGEND: gm/m^3 = grams per cubic meter	

Figure 11-1. Standard Conditions.

(3) The first seven columns of Table F of the TFT are based on one of two conditions occurring:

- Standard conditions are in effect.
- The sum of the corrections for all nonstandard conditions in effect equals zero.

It is obvious that the first will never occur and the second has a minimal chance of occurring. Therefore, if a unit wants to provide surprise and massed fires, it must consider the effects of nonstandard conditions in some way. The best solution to correct for all nonstandard conditions in effect is to register. This allows a unit to achieve first round FFE on an accurately located target. To correctly determine registration corrections and the effects of nonstandard conditions as they change over time, a unit must follow the five steps to improve firing data. (See Table 11-1.)

Table 11-1. Five Steps to Improve Firing Data.

STEP	ACTION
1	Round bursts at a point of known location. (Known point for precision registration and mean burst location for HB/MPI registration.)
2	Determine should hit and did hit data.
	Should hit data are data that when fired under standard conditions cause the round to burst at the point of known location.
	Did hit data are data that when fired under nonstandard conditions cause the round to burst at the point of known location.
3	Determine total corrections (**TOTAL CORR = DHD - SHD**). Determine the GFT setting (this always represents total corrections). Apply the total corrections to the subsequent missions to achieve first round FFE. Total corrections equal the sum of met corrections and position (pos) constants (**TOTAL CORR = MET CORR + POS CONSTANTS**). TOTAL CORR MET? POS? Met corrections are all measurable nonstandard conditions for which you can account. These are the effects of weather, propellant temperature, projectile weight, MVV, VI, and rotation of the earth (that is, any corrections for nonstandard conditions in the TFT). Position constants are all nonstandard conditions that are difficult to identify, relatively small in magnitude, and remain relatively constant. These include, but are not limited to, met not up to date, unknown errors in measuring met, errors in measuring MV, unknown errors in survey, firing chart construction, inherent error captured during the registration, and any human error that occurred during the registration procedures (in other words, anything that caused a correction during the registration that cannot be classified as a met correction). There are three position constants: position deflection correction, position velocity error, and position fuze correction. For more detail, refer to paragraph 11-2.

Table 11-1. Five Steps to Improve Firing Data (Continued).

STEP	ACTION
	NOTE: These first three steps are a registration. Met corrections and position constants are unknown. Total corrections are the only known quantity. The procedures a unit follows at this time will determine its ability to accurately apply the corrections from the registration to future missions as the effects of nonstandard conditions change. Presently, the unit can achieve first round FFE on accurately located targets. However, this accuracy degrades as the effects of nonstandard conditions change. Then the unit is faced with two options: register again or adjust fire. Neither is acceptable. Registering repeatedly needlessly exposes the unit to the counterfire threat and wastes ammo and time. Adjusting fire prevents a unit from achieving surprise and massed fires. **Therefore, it is imperative that a unit account for all measurable nonstandard conditions in effect (met corrections) DURING the registration.** Step 4 outlines this procedure, and step 5 outlines the procedure for application of registration corrections over time so that accuracy is maintained.
4	Isolate position constants (concurrent met technique) (**TOTAL CORR - MET CORR = POS CONSTANTS**). 
	NOTE: To successfully complete step 4, a unit must account for the following measurable nonstandard conditions that are in effect during the registration: ● **Weather.** A met balloon that is flown concurrently with the registration measures the effects of nonstandard air temperature, air density, and wind. ● **Muzzle velocity variation.** The unit should calibrate during the registration so that a current MVV is determined. ● **Propellant temperature.** A nonstandard propellant temperature affects the achieved muzzle velocity, which affects the achieved range. ● **Projectile square weight.** A nonstandard projectile square weight affects the drag on the projectile throughout the trajectory, which affects the achieved range. ● **Rotation of the earth.** Rotation affects achieved range and azimuth. ● **Vertical interval.** A difference in altitude between the target (point of known location) and the battery causes a range correction. This is called complementary range and is caused by CAS. ● **Drift.** Since howitzer tubes are rifled, projectiles drift to the right. A left deflection correction is determined.
	By quantifying all met corrections, the position constants are isolated. Once this is completed, the unit can maintain first round fire for effect over time without adjusting (assuming accurate target location) or repeatedly registering by completing **step 5**. Also, these position constants are used to improve the fires of other units. There are two requirements to transfer position constants: ● Common survey is established between transferring units. ● Registering FDC must account for all measurable nonstandard conditions in effect during the registration that affected the howitzer and the projectile.
	Updating survey is still a concurrent met technique and allows a unit to correct for any errors in survey that were in effect during the registration. There are two types of survey error we are concerned with: ● **Position survey.** This is survey of the firing unit location and establishes accurate howitzer locations and directional control. This updated survey affects chart range, direction of fire, battery altitude, and total corrections.

Table 11-1. Five Steps to Improve Firing Data (Continued).

STEP	ACTION
	● **Target survey.** This is survey of the known point used in the registration and establishes accurate location of the known point. This updated survey affects chart range, direction of fire, target (known point) altitude, and total corrections. Over time, the effects of nonstandard conditions change. As this happens, new met corrections are determined to maintain accuracy of fires.
5	Determine new total corrections (subsequent met technique) (**NEW TOTAL CORR = NEW MET CORR + POS CONSTANTS**). 
	This bar diagram implies that total corrections get larger. It could get smaller. The key point is that total corrections change because met corrections change. Position constants remained the same because they were completely isolated in step 4. Once the unit determines the new met corrections, they are added to the position constants to derive new total corrections. The new total corrections are graphically portrayed as a GFT setting. The unit is once again achieving first round FFE on accurately located targets. As time passes and nonstandard conditions change (mainly weather and propellant temperature), total corrections are updated. New met corrections are determined and added to the position constants, and new total corrections are derived (GFT setting). Once step 5 is completed, a unit then returns to step 3 and enters a step 3 to step 5 loop. To enter this loop, step 4 must be completed. If a unit registered and never quantified the met corrections that were valid during the registration, it would have no position constants with which to start step 5. All the effort expended during the first three steps becomes worthless.
	NOTE: Other applications of the subsequent met technique are as follows: ● Eight-direction met. ● Met to a target. ● Met to a met check gauge point. ● Met + VE.

11-2. Position Constants

a. When a unit displaces to a new position and cannot register, the position constants from the last position may be used as a basis for determining a GFT setting by solving a subsequent met. The use of this technique may cause slight inaccuracies, but it will produce the most accurate data possible until the unit can conduct another registration or met + VE with a check round. Once new position constants are determined, the old position constants are not used.

b. The position deflection correction generally accounts for errors in survey and chart construction. The position deflection correction should only be transferred if common survey exists between positions.

c. The position fuze correction should be considered a fuze characteristic and not a correction for existing weather conditions. The position fuze correction should only be applied to the same lot of fuzes.

d. The position velocity error is expressed in meters per second. It is the position constant which accounts for all range errors not accounted for by met data, muzzle velocity variation, and propellant temperature. Therefore, it will include any errors in survey and should only be transferred if common survey exists. However, the position VE is a constant for projectiles within the registering projectile family.

e. Part of the position VE and position deflection correction are charge independent, specifically errors in the firing chart and survey. The position fuze correction is charge independent because it is a fuze characteristic. Since position constants are relatively small and a portion of the position constants are charge independent, it is possible to compute a GFT setting for other charges and lots. The GFT setting will not be as accurate as a GFT setting derived from a registration, but it will be more accurate than firing with no GFT setting.

11-3. Met Messages

a. Among the nonstandard conditions that affect the projectile after it leaves the tube is the atmosphere (weather conditions) through which the projectile passes. The three properties of the atmosphere that the artillery considers in its gunnery computations are wind (both direction and speed), air temperature, and air density.

(1) Wind. The effects of wind on a projectile are easy to understand. A tail wind causes an increase in range and a head wind causes a decrease in range. A crosswind blows the projectile to the right or left, which causes a deflection error. The FDC converts ballistic wind measurements into range and deflection components and applies corrections to the deflection and elevation of the howitzer.

(2) Temperature. Variations in air temperature cause two separate effects on a projectile. One effect is caused by the inverse relationship between density and temperature. This effect is compensated for when density effects are considered. The second effect is regarded as the true temperature. It is the result of the relationship between the speed of the projectile and the speed of the air compression waves that form in front of or behind the projectile. These air compression waves move with the speed of sound, which is directly proportional to the air temperature. The relationship between the variation in air temperature and the drag on the projectile is difficult to determine. This is particularly true for supersonic projectiles, since they break through the air compression waves after they are formed. As firing tables indicate, an increase in air temperature may increase, decrease, or have no effect on achieved range, depending on the initial elevation and muzzle velocity of the weapon.

(3) Air density. Density of the air through which a projectile passes creates fiction, which affects the forward movement of the projectile. This affects the distance a projectile travels. The density effect is inversely proportional to the projectile ranges; that is, an increase in density causes a decrease in range.

b. The met section is responsible for sampling the weather conditions at various altitudes. Data determined by these samples are converted, manually or by computer, to provide specific weather information at specific altitudes. These weather data are transmitted to artillery units in fixed formats called **met messages.** The field artillery uses the following four types of met messages:

(1) Ballistic met message. This message is used by cannon units, rocket units, mortar units, and air defense artillery.

(2) Computer met message. This message is used by artillery computer systems.

(3) Fallout met message. This message is used in nuclear and chemical fallout predictions.

(4) Target acquisition met message. This message is used by radar platoons of the target acquisition battery (TAB).

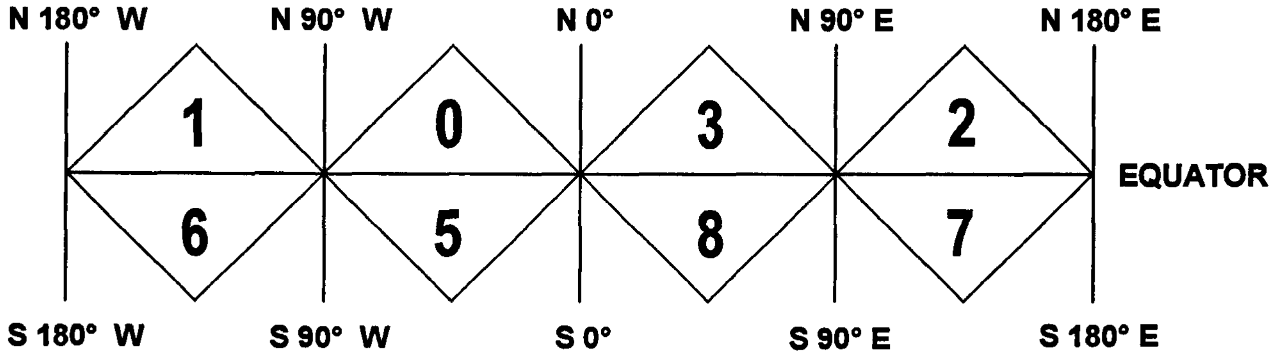
> **NOTE:** Only the ballistic and computer met messages will be described in the following paragraphs.

11-4. Ballistic Met Message

The ballistic met message is a coded message containing information about current atmospheric conditions. There are two types of ballistic met messages provided for artillery. Type 2 messages (surface to air) are used in air defense artillery and type 3 messages (surface to surface) are used by FA cannon and rocket units. Type 3 messages are used in solving DA Form 4200 (Met Data Correction Sheet). Type 3 messages are used for all elevations, for all charges, and for all howitzers in manual FDC operations. The ballistic met message is recorded on DA Form 3675 (Ballistic Met Message) and is divided into an introduction and a body.

a. The introduction of the ballistic met message consists of **four six-character groups.**

(1) Group 1. The first three letters (MET) in group 1 identify the transmission as a met message. The next letter (B) indicates that it is a ballistic met message. The next digit (3) indicates the type of met message (surface to surface). The last digit (1) designates the octant of the earth in which the met station is located. (See Figures 11-2 and 11-3.) In Figure 11-3, octant 1 indicates that the met station is located between 90°W and 180°W longitude and is north of the equator.



CODE NUMBER	OCTANT
0	North latitude, 0° to 90°west longitude
1	North latitude, 90° to 180° west longitude
2	North latitude, 180° to 90° east longitude
3	North latitude, 90° to 0° east longitude
4	Not used
5	South latitude, 0° to 90° west longitude
6	South latitude, 90° to 180° west longitude
7	South latitude, 180° to 90° east longitude
8	South latitude, 90° to 0° east longitude
9	Used for coded identification

Figure 11-2. Octants.

(2) Group 2. This group designates the center of the area in which the met message is valid. This is expressed in tens, units, and tenths of degrees of latitude and longitude (347= 34.7 and 985 = 98.5°). When the longitude is 100 or greater, the initial digit (1) is omitted. If the number 9 is used to designate the octant, the six digits or letters represent the coded location (in latitude and longitude) of the met station that produced the message. (See Figure 11-3.)

(3) Group 3. The first two digits (27) in group 3 represent the day of the month that the met message is valid. The next three digits (125) indicate the hour in tens, units, and tenths of hours (125 = 12.5 hours = time 1230) the met message is valid. The hours refer to Greenwich Mean Time (GMT). The last digit (0) in group 3 indicates the number of hours the message will remain valid. The US does not try to predict the length of time a met message will remain valid. Therefore, the last digit in group 3 of a ballistic met message will always be 0. Some allied nations predict the length of time a met message will remain valid. These predictions vary from 1 to 8 hours. Code 9 indicates 12 hours. (See Figure 11-3.)

(4) Group 4. The first three digits (055) in group 4 indicate the altitude of the met station (MDP) above mean sea level in multiples of 10 meters (055 = 550 meters). The next three digits (972) indicate the atmospheric pressure at the MDP (972 = 97.2 percent). When a value is equal to or greater than 100 percent the initial digit (1) is omitted (012= 101.2 percent). (See Figure 11-3.)

b. The body of the met message can consist of 16 met message lines (00-15). Each line consists of **two six-number groups.** Each line contains the ballistic data for a particular altitude zone. Ballistic data are the weighted average of the conditions that exist from the surface up through the altitude zone, indicated by the line number, and back to the surface. (See Figure 11-4.)

BALLISTIC MET MESSAGE
For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or xxx	$L_oL_oL_o$ or xxx	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	347	985	27	125	0	055	972

Figure 11-3. Introduction of the Ballistic Met Message.

ZONE HEIGHT (METERS)	LINE NUMBER ZZ
SURFACE	00
200	01
500	02
1000	03
1500	04
2000	05
3000	06
4000	07
5000	08
6000	09
8000	10
10000	11
12000	12
14000	13
16000	14
18000	15

Figure 11-4. Altitude Zones and Line Numbers.

(1) The first two digits in the first group on each line identifies the altitude zone (00 [surface] through 15 [18,000 meters]). (See Figure 11-4.) Line 02 is used as an example. (See Figure 11-5.)

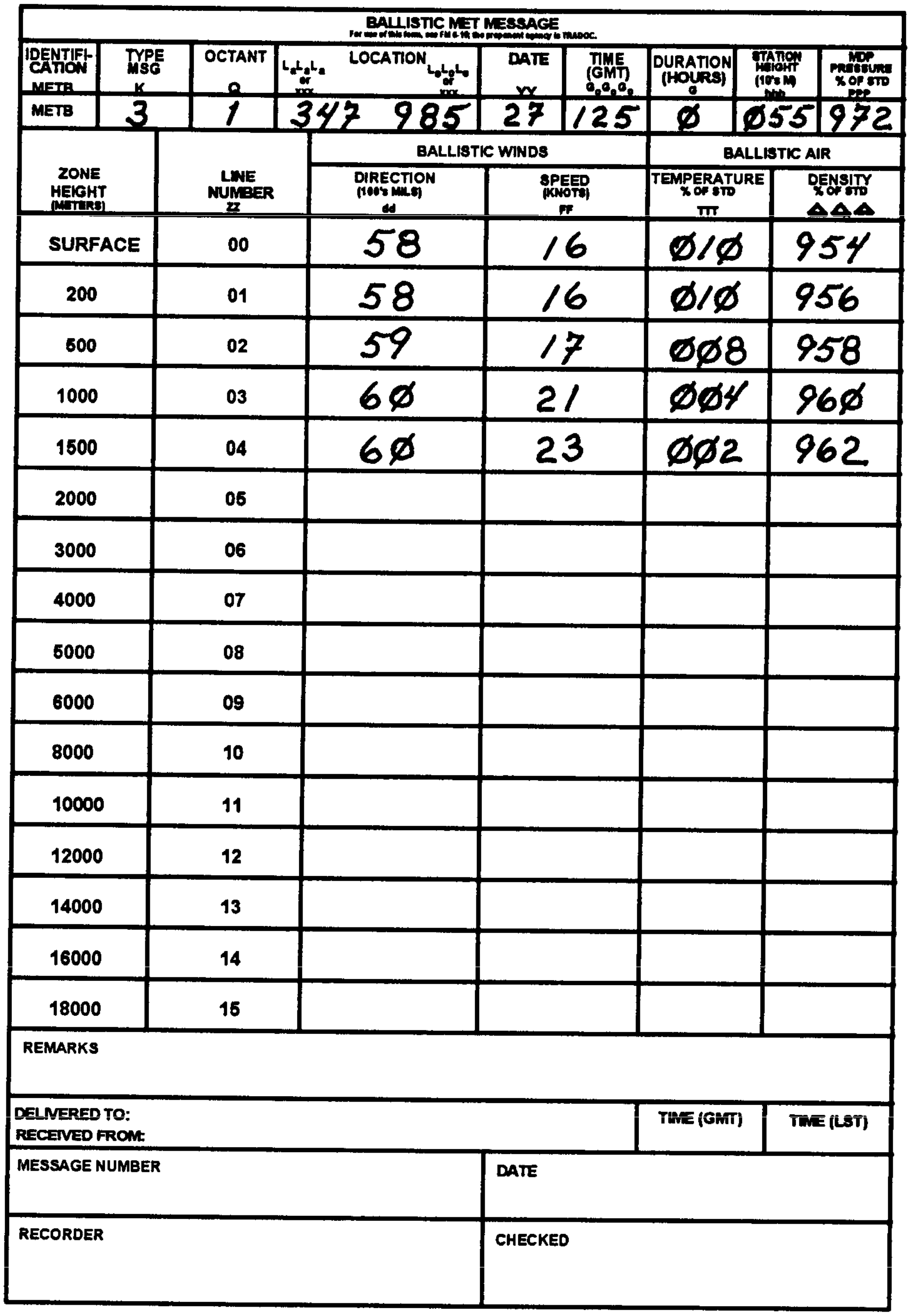
(2) The next two digits in the first group (59) indicate the direction from which the ballistic wind is blowing. It is expressed in hundreds of mils true azimuth (59 = 5900). (See Figure 11-5.)

(3) The last two digits of the first group (17) indicate the wind speed of the ballistic wind in knots (17= 17 knots). (See Figure 11-5.)

(4) The first three digits of the second group (008) indicate the ballistic air temperature expressed as a percentage (to the nearest 0.1 percent) of the ICAO standard (008 = 100.8). (See Figure 11-5.)

(5) The last three digits of the second group (958) indicate the ballistic air density expressed as a percentage (to the nearest 0.1 percent) of the ICAO standard density (958 = 95.8). (See Figure 11-5.)

NOTE: When the air temperature or air density is equal to or greater than 100 percent, the initial digit (1) is omitted. A completed ballistic met message recorded on DA Form 3675 is shown in Figure 11-5.



BALLISTIC MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or XXX	LOCATION $L_oL_oL_o$ or XXX	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	347	985	27	125	0	055	972

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	BALLISTIC WINDS		BALLISTIC AIR	
		DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE % OF STD TTT	DENSITY % OF STD △△△
SURFACE	00	58	16	010	954
200	01	58	16	010	956
500	02	59	17	008	958
1000	03	60	21	004	960
1500	04	60	23	002	962
2000	05				
3000	06				
4000	07				
5000	08				
6000	09				
8000	10				
10000	11				
12000	12				
14000	13				
16000	14				
18000	15				

REMARKS

DELIVERED TO: RECEIVED FROM:	TIME (GMT)	TIME (LST)
MESSAGE NUMBER	DATE	
RECORDER	CHECKED	

Figure 11-5. Completed DA Form 3675.

11-5. Computer Met Message

Like the ballistic met message, the computer met message is a coded message that reports the atmospheric conditions in selected layers starting at the surface and extending to an altitude that will normally include the maximum ordinate of field artillery weapons that use these data. Unlike the ballistic met message used in manual computations (in which the weather conditions existing in one layer or zone are weighted against the conditions in lower layers and reported as percentages of standard), the computer met message reports actual average wind direction, wind speed, air temperature, and pressure in each layer. The computer met message is used by the battery computer system (BCS) in the computation of the equations of motion used in the computer program. The computer met message is recorded on DA Form 3677 (Computer Met Message) and is divided into two parts--an introduction and a body.

a. The introduction of the computer met message consists of **four six-character groups.**

(1) Group 1. The first five letters (METCM) identify the transmission as a computer met. The last digit (1) designates the octant of the earth in which the met station is located. The octant code key is the same as that for the ballistic met message. (See Figure 11-6.)

(2) Group 2. This is the same as group 2 of the ballistic met message. (See Figure 11-6.)

(3) Group 3. This is the same as group 3 of the ballistic met message. (See Figure 11-6.)

(4) Group 4. The first three digits (049) of group 4 indicate the altitude of the met station MDP above sea level in tens of meters (049 = 490). The last three digits (987) indicate the atmospheric pressure, in millibars, at the met station. When the pressure value is greater than 999, the first digit (1) is omitted. (For example, 009= 1009). (See Figure 11-6.)

b. The body of the met message can consist of 27 met message lines (00-26). Each line consists of **two eight-number groups.** Each line contains the actual average weather data for a particular zone. (See Figure 11-6.)

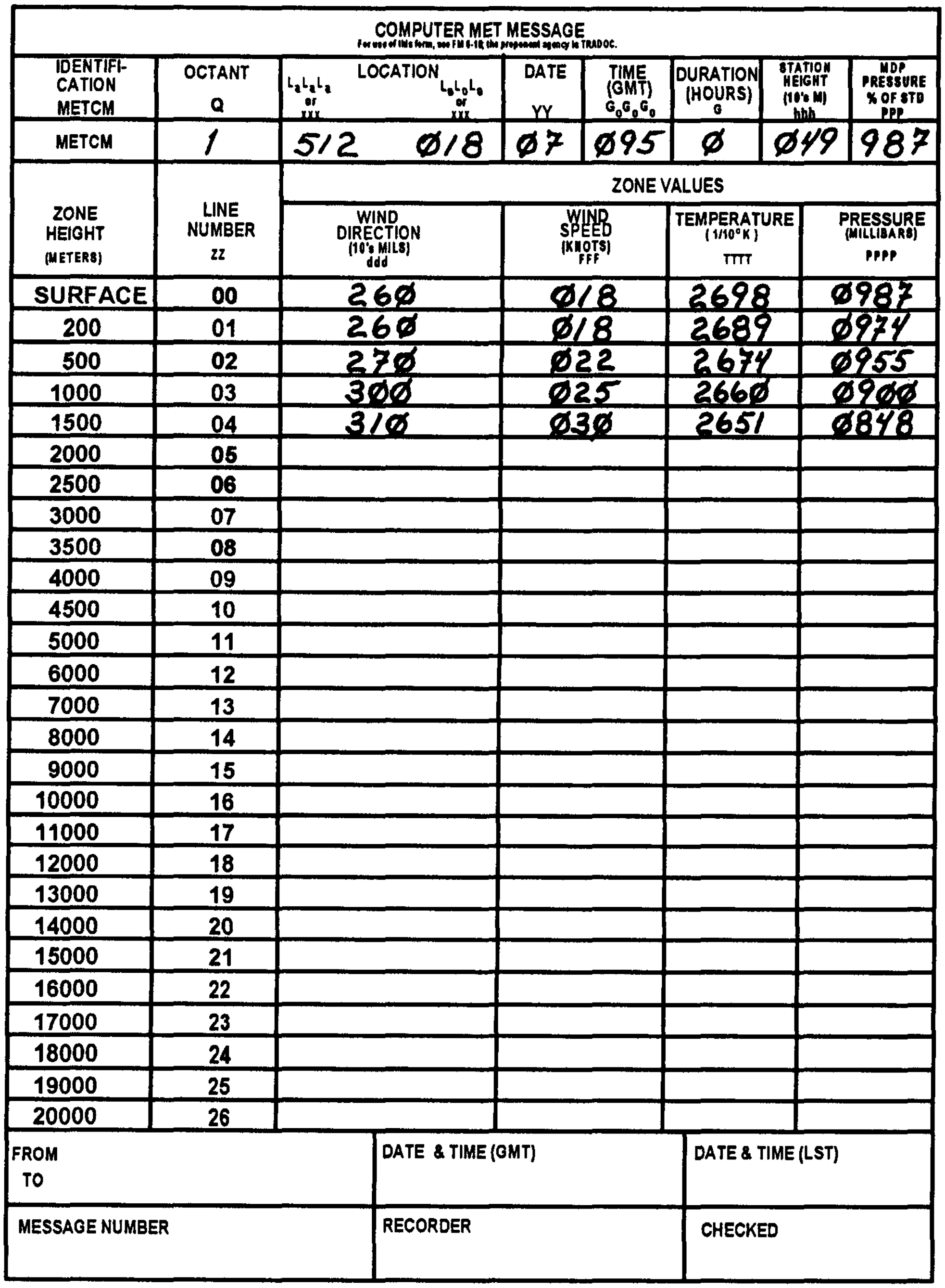
(1) The first two digits in the first group on each line identifies the altitude zone (00 [surface] through 26 [20,000 meters]). Line 00 is used as an example. (See Figure 11-6.)

(2) The next three digits in the first group (260) indicates the direction from which the wind is blowing. It is expressed in tens of mils true azimuth (260= 2600). (See Figure 11-6.)

(3) The last three digits of the first group (018) indicate the wind speed expressed in knots (01 8 =18 knots). (See Figure 11-6.)

(4) The first four digits of the second group (2698) indicate the actual air temperature expressed in degrees Kelvin (K) to the nearest tenth of a degree (269.8°K). (See Figure 11-6.)

(5) The last four digits of the second group (0987), indicate the actual air pressure, in millibars, to the nearest millibar (987 millibars). (See Figure 11-6.)



COMPUTER MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METCM	OCTANT Q	LOCATION $L_aL_aL_a$ or XXX	$L_oL_oL_o$ or XXX	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METCM	1	512	018	07	095	0	049	987

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	ZONE VALUES			
		WIND DIRECTION (10's MILS) ddd	WIND SPEED (KNOTS) FFF	TEMPERATURE (1/10°K) TTTT	PRESSURE (MILLIBARS) PPPP
SURFACE	00	260	018	2698	0987
200	01	260	018	2689	0974
500	02	270	022	2674	0955
1000	03	300	025	2660	0900
1500	04	310	030	2651	0848
2000	05				
2500	06				
3000	07				
3500	08				
4000	09				
4500	10				
5000	11				
6000	12				
7000	13				
8000	14				
9000	15				
10000	16				
11000	17				
12000	18				
13000	19				
14000	20				
15000	21				
16000	22				
17000	23				
18000	24				
19000	25				
20000	26				

FROM TO	DATE & TIME (GMT)	DATE & TIME (LST)
MESSAGE NUMBER	RECORDER	CHECKED

Figure 11-6. Completed DA Form 3677.

11-6. Met Message Checking Procedures

a. When the FDC receives a met message, it should be checked to ensure that it is valid. Any peculiarities noted in the message should be questioned. If the timeliness or validity of a met message is doubted, that also should be questioned and referred to the artillery met section, whose personnel are qualified to explain message variations or to correct message transmission errors. Verbal transmission of met messages may cause copying errors, particularly if the message is copied down on something other than the standard (ballistic or computer) met form. FDC personnel should use the guidelines in subparagraphs b through e below when checking met messages.

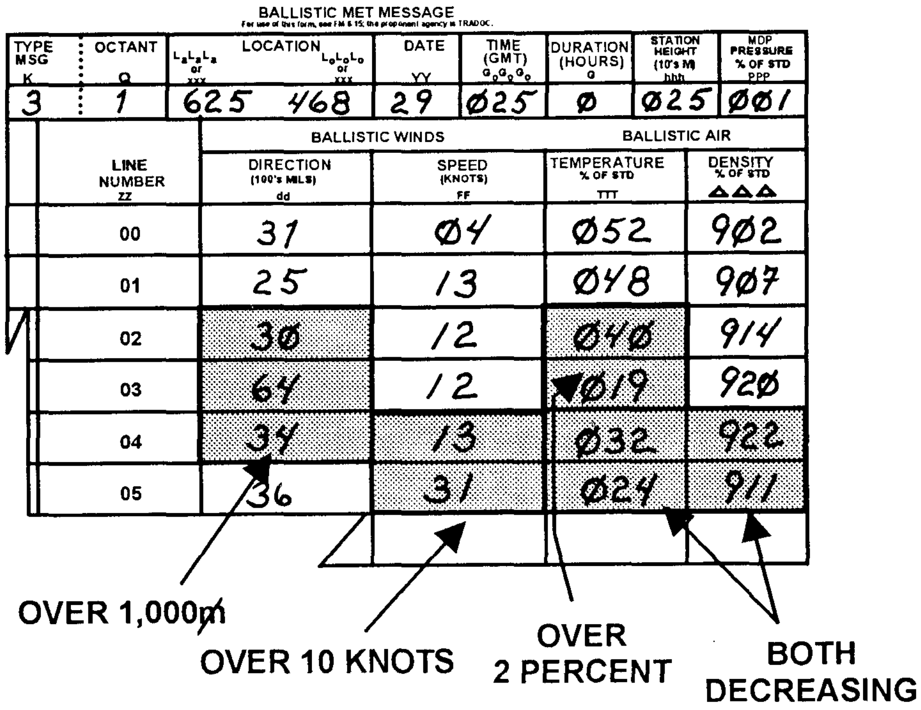
b. Check the ballistic or computer met message heading as follows: (See Figure 11-7 or 11-8.)

(1) Check message type, octant, and location entries for correctness.

(2) Check date-time entries to ensure data are current. If the met message is more than 4 hours old, consult with the met section to determine message validity (date-time entries are expressed in Greenwich mean time).

(3) Map-spot the altitude of the MDP by using the latitude and longitude from the location block in the header of the met message. (See FM 21-26 for additional information on how to plot a latitude and longitude. An error of 50 meters or more will affect air temperature and density and/or pressure corrections applied to firing data.)

c. Check the ballistic met message body as follows: (See Figure 11-7.)



BALLISTIC MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or XXX	LOCATION $L_oL_oL_o$ or XXX	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
3	1	625	468	29	025	0	025	001

LINE NUMBER ZZ	BALLISTIC WINDS DIRECTION (100's MILS) dd	BALLISTIC WINDS SPEED (KNOTS) FF	BALLISTIC AIR TEMPERATURE % OF STD TTT	BALLISTIC AIR DENSITY % OF STD △△△
00	31	04	052	902
01	25	13	048	907
02	30	12	040	914
03	64	12	019	920
04	34	13	032	922
05	36	31	024	911

Figure 11-7. Ballistic Met Message Errors.

(1) Ballistic wind direction should trend in a fairly uniform manner. Question drastic changes (1,000 mils or greater) or sudden reverses of wind direction from line to line, particularly if wind speeds are more than 10 knots. Direction changes greater than 1,000 mils are common when wind speeds are 10 knots or less.

(2) Question severe increases or decreases (10 knots or greater) in wind speed from line to line.

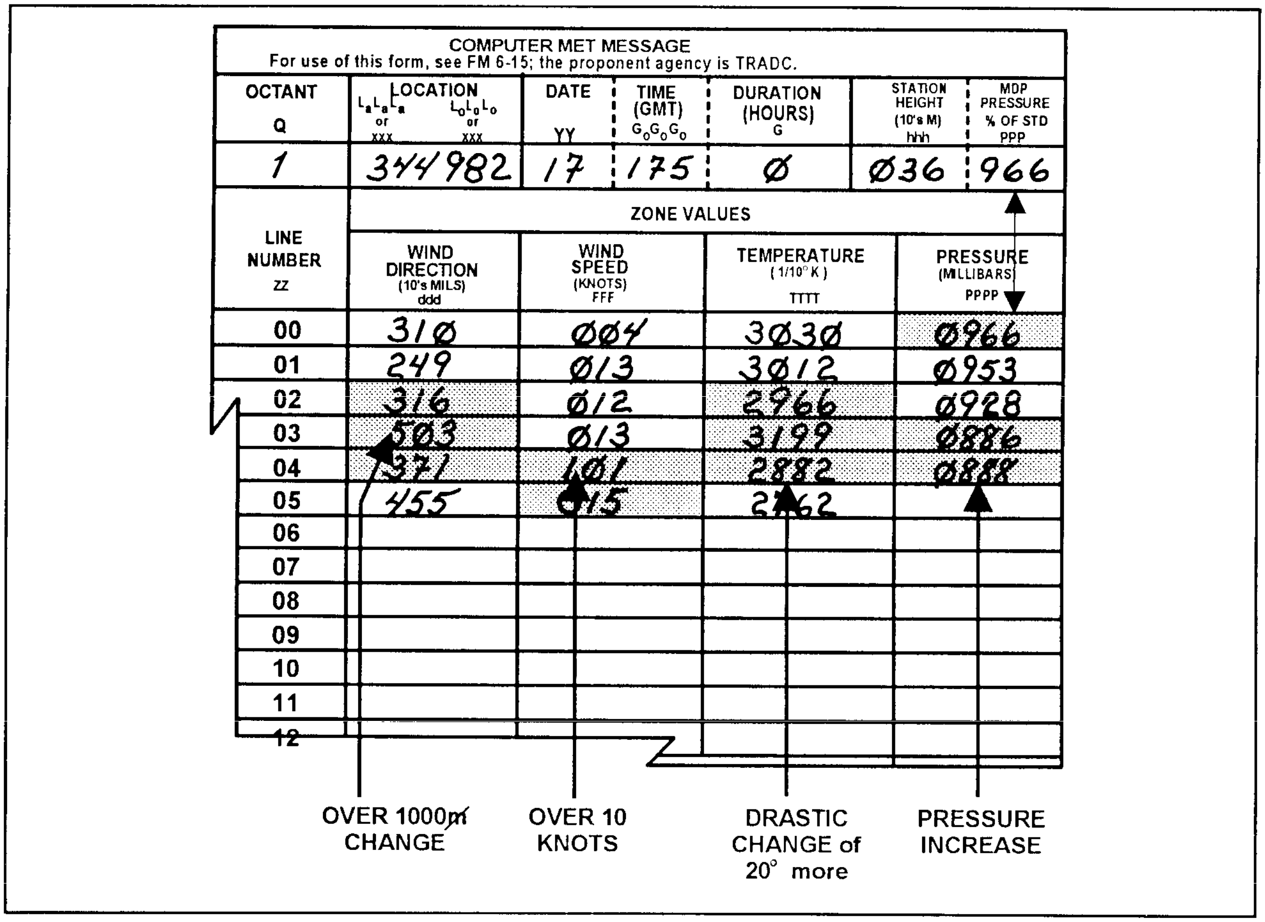
(3) Ballistic temperatures and densities normally show an inverse relationship; that is, as temperature increases, density should decrease.

(4) Check for drastic changes (2 percent or more) in density or temperature. Ballistic temperature and density should change smoothly between zones.

d. Consecutive messages should show a trend that relates to the actual weather conditions unless weather conditions have changed during sunrise or sunset transition periods or because of a frontal passage, rain, snow, or a rapid increase or decrease in cloud cover.

e. Check for errors in the computer met message as follows: (See Figure 11-8.)

(1) Question drastic wind direction changes (1,000 mils or greater) or sudden reverses of wind direction from line to line, particularly if wind speeds are more than 10 knots. Direction changes greater than 1,000 mils are-common when wind speeds are 10 knots or less.



COMPUTER MET MESSAGE
For use of this form, see FM 6-15; the proponent agency is TRADC.

OCTANT Q	LOCATION $L_aL_aL_a$ or XXX $L_oL_oL_o$ or XXX	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
1	344982	17	175	0	036	966

LINE NUMBER ZZ	ZONE VALUES			
	WIND DIRECTION (10's MILS) ddd	WIND SPEED (KNOTS) FFF	TEMPERATURE (1/10° K) TTTT	PRESSURE (MILLIBARS) PPPP
00	310	004	3030	0966
01	249	013	3012	0953
02	316	012	2966	0928
03	503	013	3199	0886
04	371	101	2882	0888
05	455	015	2[illegible]62	
06				
07				
08				
09				
10				
11				
12				

OVER 1000~~m~~ CHANGE

OVER 10 KNOTS

DRASTIC CHANGE of 20° more

PRESSURE INCREASE

Figure 11-8. Computer Met Message Errors.

(2) Question severe increases or decreases (10 knots or greater) in wind speed from line to line.

(3) Question a severe increase or decrease (over 20°K) in temperature from line to line.

(4) Check for differences in identification line pressure and surface pressure; both should match.

(5) Check for increases in pressure. Pressure should decrease smoothly from line to line. Pressure will never increase with height.

11-7. Met Message Space and Time Validity

a. Space Considerations. The accuracy of a met message may decrease as the distance from the met sounding site to balloon and sensors increases. Local topography has a pronounced effect on the distance that met data can reasonably be extended. In mountainous terrain, distinct wind variations occur over short distances. This effect extends to much greater heights than the mountain tops. Large bodies of water affect both time and space considerations of the met message because of the land and sea breezes and the effect of humidity on density. It would be impossible to compute an exact distance for every combination of weather and terrain. Met messages for artillery are considered valid up to 20 kilometers (km) from the balloon release point (met section). The validity distance decreases proportionately with the roughness of the terrain and the proximity of large bodies of water.

b. Time Consideration. The passage of time may decrease the accuracy of a message because of the changing nature of weather. With existent equipment, the artillery met section has difficulty in providing met messages more often than every 2 hours over an extended period of time. There are no specific rules for determining the usable time, since that determination depends on the following:

- Characteristics of the atmosphere.
- Periods of transition.
- Met section movement.
- Personnel.
- Supplies and equipment.
- Altitude of the met message (line number) required by the artillery firing units.

When the weather pattern is variable, the usable time is variable. If a frontal passage is forecast for the area, the met section will take a new sounding after passage of the front. When the weather pattern is stable and is forecast to remain so, time between messages may be extended to several hours or longer, depending on the time of day and existing weather conditions. (See Figure 11-9.)

c. Criteria for Use of Met Data. Results of many studies that are based on artillery firing and met data show that the order of preference of various sources of met data is as shown in paragraphs (1) through (3) below. A current met message is one that is less than 2 hours old unless an exchange of air mass has occurred since the met message was produced or unless periods of transition are involved.

(1) Current met message from a station within 20 kilometers of the midpoint of the trajectory (upwind is best).

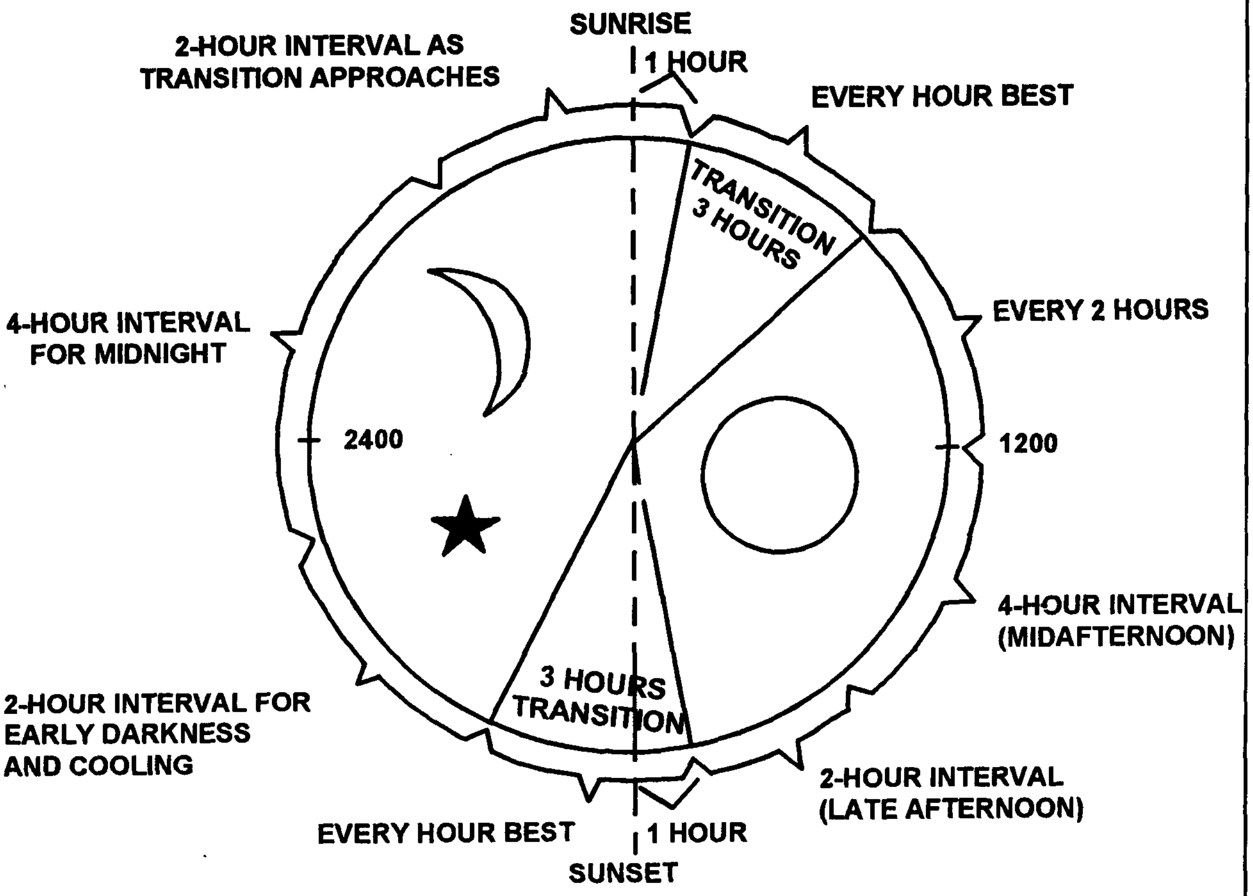


Figure 11-9. Met Message Time Validity.

(2) Current met message from the nearest station up to 80 kilometers from the midpoint of the trajectory. A 4-hour old met message may be used except when day-to-night transitions or frontal passages are occurring.

(3) Met messages over 2 hours old but from a station within 20 kilometers of the midpoint of the trajectory. A 4-hour-old met message may be used except when day-to-night transitions or frontal passages are occurring.

Section II

Concurrent Met Technique

A concurrent met is solved to isolate position constants. To perform a concurrent met technique, the firing unit must have total corrections determined from a registration and the met conditions that were valid at the time of the registration. Met corrections are determined and then subtracted from the total corrections to isolate position constants. Any errors in the met corrections and total corrections will be contained in the position constants. Every effort must be made to obtain the most accurate met corrections available.

11-8. DA Form 4200

The concurrent met technique is solved on DA Form 4200. There are two methods to solve a concurrent met technique. The first is the vowel rule. This follows the sequence of the tables in the TFT, and computations are completed after extracting data from a vowel table. Table 11-2 provides the abbreviated steps for this method. The second is the RATT rule. RATT is an acronym for *record, apply, transfer, tables.* This also follows the sequence of the tables in the TFT, but computations are completed after extracting data from **each** table. Table 11-3 provides the abbreviated steps for this method.

Table 11-2. Concurrent Met Technique (Vowel Rule).

STEP	ACTION
1	Determine and enter total corrections from the GFT setting.
2	Enter the known data. For a concurrent met, these include the following: ● Charge. ● Adjusted quadrant. ● Chart range. ● Latitude. ● Battery altitude. ● Altitude of target and burst. ● Direction of fire. ● Equations for position deflection correction, position velocity error, and position fuze correction. ● Muzzle velocity variation. ● Propellant temperature. ● Total range correction. ● Fuze setting corresponding to (~) adjusted elevation. ● GFT setting with lazy Z. ● Total fuze correction. ● Target number. ● Date-time group.
3	Determine the met line number from Table A of the TFT.
4	Enter the met message data.
5	Compute ▲h, height of target above gun, and the chart direction of wind.
6	Enter the TFT, and determine and extract the following: ● Complementary (comp) range from Table B. ● Wind components from Table C. ● Corrections to temperature and density from Table D. ● Correction to muzzle velocity for propellant temperature from Table E.
7	Compute corrected values for temperature, density, entry range, crosswind, range wind, and variations from standard.
8	Enter the TFT, and determine and extract the following: ● Unit corrections from Table F (Columns 8 through 19). ● Rotation corrections for range from Table H. ● Rotation corrections for azimuth from Table I.
9	Compute met deflection correction and position deflection correction.
10	Compute met range correction and position velocity error (VE).
11	Enter the TFT, and determine and extract the unit corrections from Table J by using the variations from standard determined in step 7 and the ▲V determined in step 10.
12	Compute the met fuze correction and position fuze correction.

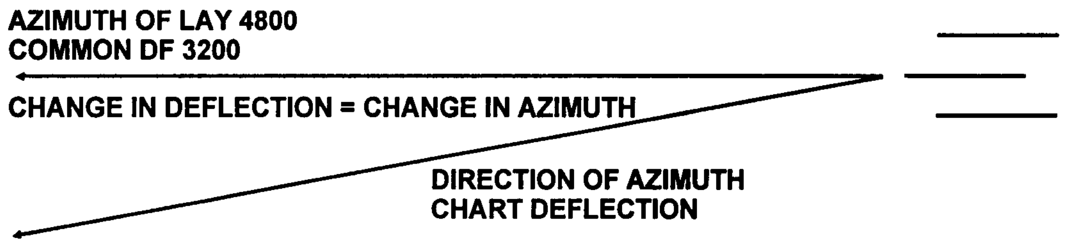
Table 11-3. Concurrent Met Technique (RATT Rule).

STEP	ACTION
1	Determine and record total corrections from the GFT setting.
2	Record the known data. (Refer to Table 11-2, step 2.)
3	Apply the known data.
4	Record the met line number from Table A of the TFT.
5	Record the met message data.
6	Apply ▲h and the chart direction of the wind.
7	Record complementary range from Table B.
8	Apply complementary range to chart range, and determine entry range.
9	Record wind components from Table C.
10	Apply wind components, and determine crosswind and range wind.
11	Transfer range wind to MET RANGE CORRECTION section.
12	Record corrections to temperature and density from Table D.
13	Apply corrections to temperature and density, and determine corrected values.
14	Transfer corrections to temperature and density to the MET RANGE CORRECTION section.
15	Record the correction to muzzle velocity for propellant temperature from Table E.
16	Record unit correction factors from Table F (Columns 8 through 19).
17	Apply unit correction factors to variations from standard.
18	Record rotation correction for range from Table H.
19	Apply rotation correction, and determine the met range correction.
20	Transfer the met range correction.
21	Apply the met range correction, and complete COMPUTATION of VE block.
22	Record rotation corrections from azimuth from Table I.
23	Apply rotation correction, drift correction, and crosswind correction, and determine met deflection correction and position deflection correction.
24	Record unit correction factors from Table J.
25	Apply unit correction factors to variations from standard, and determine met fuze correction and position fuze correction.

11-9. Solution of a Concurrent Met

Table 11-4 shows a detailed solution of a concurrent met using the RATT rule. The example uses the data shown in Figure 11-10.

Table 11-4. Solution of a Concurrent Met.

STEP	ACTION
1	Record the known data from the registration on DA Form 4200. Use the ROF shown in Figure 11-10, page 11-19.
1a	Record the charge (**4GB**).
1b	Record the adjusted QE. **ADJ EL 314** **+ GROUND SI +(-9)** **ADJ QE 305**
1c	Record the chart range in both blocks (**4950**).
1d	Record the latitude (nearest 10°)(**35.5°N ≈ 40°N**).
1e	Record the battery altitude (to the nearest 1 meter in parentheses and to the nearest 10 meters) in the block (**1062 ≈ 1060**). Enter to the nearest 1 meter in the lower block (**1062**).
1f	Record target altitude and altitude of the burst (nearest meter)(**1024**).
1g	Record the direction of fire (to the nearest mil in parentheses and to the nearest 100 mils in the block) (**4596 ≈ 4600**). The following diagram shows how to determine the direction of fire.  **COMMON DEFLECTION 3200** **CHART DEFLECTION -3404** **CHANGE IN DEFLECTION -204** **AZIMUTH OF FIRE 4800** **+ CHANGE IN AZIMUTH +(-204)** **DIRECTION OF FIRE 4596**
	NOTE: The direction of fire can also be determined by using the LARS rule to compare the chart deflection to the common deflection and by using the RALS rule to apply the angular difference to the azimuth of fire. Keeping the algebraic sign will simplify the math step.
1h	Record the total deflection correction (**R1**) in the wind components and deflection computational space. Use the equation **TOT DF CORR - MET DF CORR = POS DF CORR** to determine the position deflection correction. Record it as follows: **TOTAL DF CORR R1** **- MET DF CORR** **POS DF CORR**
1i	Record in the MET RANGE CORRECTION section the ◙ weight of the projectile fired during the registration (**4◙**). Also, record the standard projectile weight, which can be determined from the introduction of the appropriate TFT (**4◙**).
1j	Record the MVV (**-1.6**) of the howitzer that fired the registration. Use the equation **VE - MVV = POS VE** in the MET RANGE CORRECTION computational block. Record it as follows: **VE - MVV = POS VE** **- (-1.6) =**
1k	Record the propellant temperature at the time of the registration (**+56**).
1l	Divide the MV UNIT CORRECTION block in half with a diagonal line.

RECORD OF FIRE

CALL FOR FIRE

Observer ______ AF/FFE/IS/S ______ Tgt ______
Grid: ______
Polar: Dir ______ Dis ______ U/D ______ VA ______
Shift: ______ Dir ______ L/R ______ +/- ______ U/D ______

KN PT 1 ALT 1024
PLT ALT 1062
VI -38
DRIFT L6
+GFT 0

∡ Si ÷ 10 ______ 10m Si ______

△ FS	0.11
100/R	21
/R	
20/R	4
HOB Corr	
Si	-9
⊟	301
QE	292
Ammo Exp	①

FIRE ORDER PREC REG ON KN PT 1 w/T03 Q+TI USE GUNNERS QUADRANT

Df Corr L6

INITIAL FIRE COMMANDS ~~FM~~ MF #3① Rg 4950

Cht Df 3404

Sp Instr Use Gunners Quadrant Sh ______ Lot ______ Chg 4 Fz ______ Ti ______

Df 3410

MTO PREC REG on KN PT1 Q+TI ∡T (570) 600 PE_R (<25) TF (18) In Eff ______

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L6)	Df Fired	Chart Rg	HOB Corr	Si (-9)	El	QE	Exp	Type
5160	L 40	+200					3394	L6	3400	5140		-9	316	307	②	
		-100					3405	L6	3411	5050		-9	309	300	③	
		+50					3399	L6	3405	5100		-9	313	304	④	
②		+25		②			3397	L6	3403	5120		-9	314	305	⑥	
①		-25		①			3399	L6	3405	5100		-9	313	304	⑦	Q ✓
	R 10	+10	REC				3397	L6	(3403)	5110		-9	314			
AS REG	PT	TI	Rpt	FZ TI		18.8			3403		+4	-5	314	309	①	
			U40		-0.4	18.4			(3403)					309	②	
③ Rpt				③		(18.4)			(3403)					309	⑤	TI ✓
		D 10	REC		+0.1	18.5										
AS TI	REG	PT	EOM	EOM												

5110
+160

U40 ÷ 10 = 4 × 0.11 = 0.44 ≈ -0.4
D10 ÷ 10 = 1 × 0.11 = 0.11 ≈ +0.1

GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5
18.8
-0.3

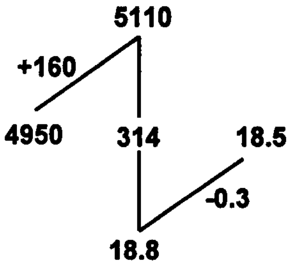
TOT DF CORR R1
- DRIFT AT ADJ EL L6
GFT DF CORR R7

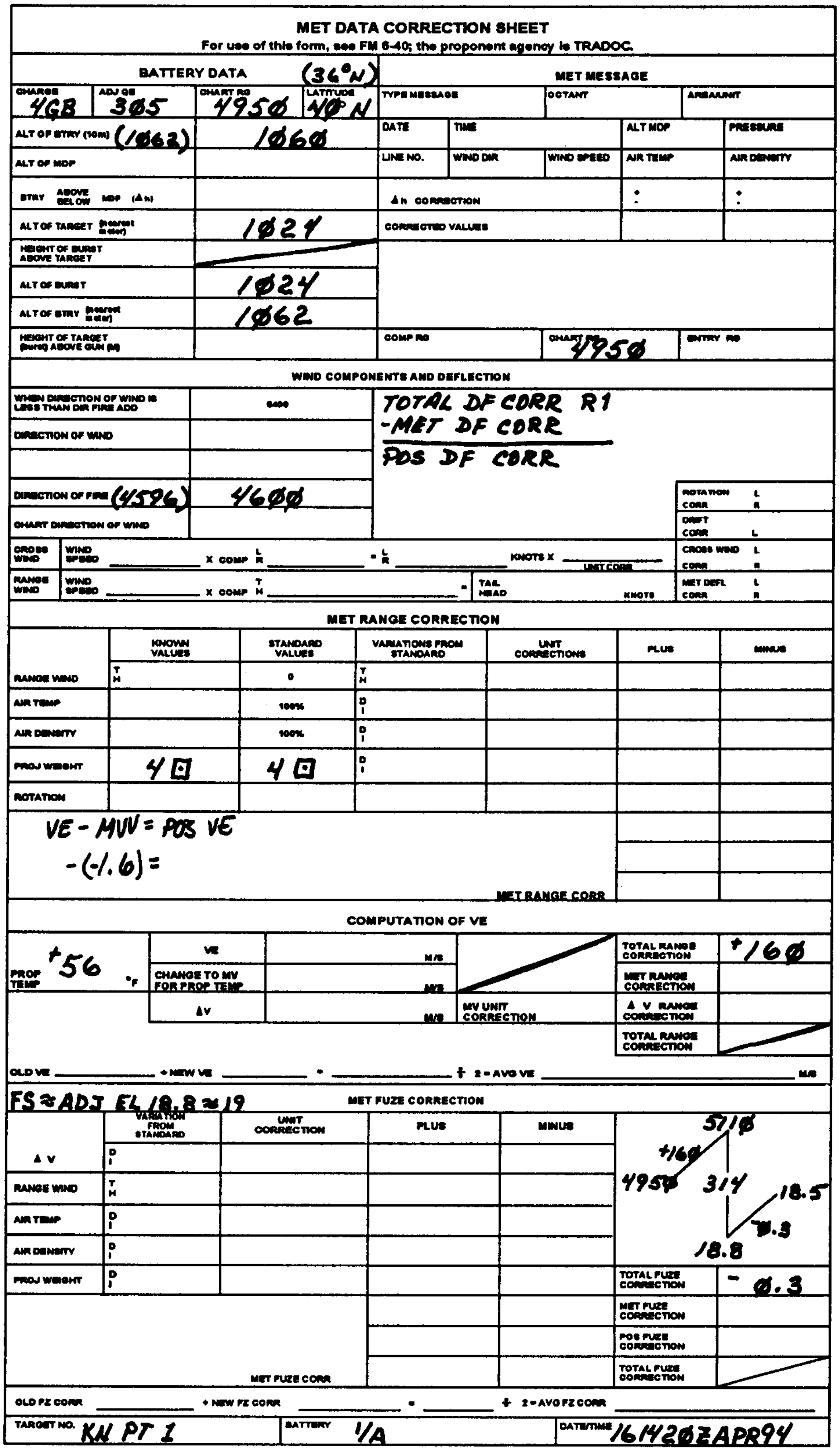
Btry 1/A DTG 161400ZAPR94 Tgt KN PT1 Replot Grid ______ Replot Alt ______

DA Form 4504, OCT 78

Figure 11-10. Completed ROF for a Precision Registration.

Table 11-4. Solution of a Concurrent Met (Continued).

STEP	ACTION
1m	Record the lazy Z in the bottom computational block (range, adjusted elevation, adjusted fuze setting, and total corrections [values only, no letters]). 
1n	Record the total range correction in the top block, and line out the bottom block (**+160**).
1o	Record the total fuze correction in the top block, and line out the bottom block (**-0.3**).
1p	Record the fuze setting corresponding to the adjusted elevation to the nearest 0.1, and then express it to the nearest whole fuze setting increment. Record it in the space to the left of the words "MET FUZE CORRECTION" as follows: **FS ~ ADJ EL = 18.8 ≈ 19**
1q	Record the known point number (**KN PT 1**).
1r	Record the unit designation (**1/A**).
1s	Record the date-time group.
	NOTE: A DA Form 4200 with the above known data is shown in Figure 11-11.
2	Determine the met line number of the met message from Table A.
2a	Enter Table A for the appropriate charge with the adjusted QE (Figure 11-12, page 11-22).
2b	Extract the met line number corresponding to the adjusted quadrant. This indicates which line of data from the met message will be used in solving the met. Record the value in the **LINE NO.** block (**02**).
3	Record the met message data on DA Form 4200. The ballistic met message is shown in Figure 11-13, page 11-22.
3a	Record data from the identification line (**METB3, 1, 355 163, 16, 2000, 1200, 97.2**) and the line number (**02**) determined in step 2b from the met message in the met message block. (See Figure 11-14, page 11-23.)
3b	Record the altitude of the MDP (**1200**), wind direction (**5900**), wind speed (**34**), air temperature (**100.5**), and air density (**100.9**) from the met message in the appropriate blocks. (See Figure 11-14.)
	NOTE: Data from the met message must be decoded before being recorded on DA Form 4200 (Figure 11-14).
4	Compute ▲h, height of target above gun, and chart direction of wind.
4a	Determine the difference in altitude between the battery and the MDP to correct the values for air temperature and density. Circle the word "above" or "below" as appropriate. **ALT OF BTRY 1060** **- ALT OF MDP - (1200)** **BTRY (BELOW) MDP -140**
4b	Determine the height of target above gun (VI) to the nearest 1 meter, and express it to the nearest 100 meters. (See Figure 11-14.) **ALT OF BURST 1024** **-ALT OF BTRY (NEAREST METER) -1062** **HEIGHT OF TARGET ABOVE GUN -38 ≈ 0**



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE 305	CHART RG 4950	LATITUDE 40 N
ALT OF BTRY (10m) (1062)	1060		
ALT OF MDP			
BTRY ABOVE BELOW MDP (▲h)			
ALT OF TARGET (nearest meter)	1024		
HEIGHT OF BURST ABOVE TARGET			
ALT OF BURST	1024		
ALT OF BTRY (nearest meter)	1062		
HEIGHT OF TARGET (burst) ABOVE GUN (M)			

MET MESSAGE

TYPE MESSAGE		OCTANT		AREA/UNIT
DATE	TIME		ALT MDP	PRESSURE
LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY
▲h CORRECTION			+ −	+ −
CORRECTED VALUES				
COMP RG		CHART RG 4950		ENTRY RG

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	

TOTAL DF CORR R1
-MET DF CORR
POS DF CORR

ROTATION CORR	L R
DRIFT CORR	L
CROSS WIND CORR	L R
MET DEFL CORR	L R

CROSS WIND: WIND SPEED ______ X COMP L R ______ = L R ______ KNOTS X ______ UNIT CORR

RANGE WIND: WIND SPEED ______ X COMP T H ______ = TAIL HEAD KNOTS

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T H	0	T H			
AIR TEMP		100%	D I			
AIR DENSITY		100%	D I			
PROJ WEIGHT	4 ⊡	4 ⊡	D I			
ROTATION						

VE - MVV = POS VE
-(-1.6) =

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +56 °F	VE	M/S		TOTAL RANGE CORRECTION	+160
	CHANGE TO MV FOR PROP TEMP	M/S		MET RANGE CORRECTION	
	▲V	M/S	MV UNIT CORRECTION	▲ V RANGE CORRECTION	
				TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS ≈ ADJ EL 18.8 ≈ 19

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
▲ V	D I			
RANGE WIND	T H			
AIR TEMP	D I			
AIR DENSITY	D I			
PROJ WEIGHT	D I			

5710
+160
4950
314
18.5
0.3
18.8

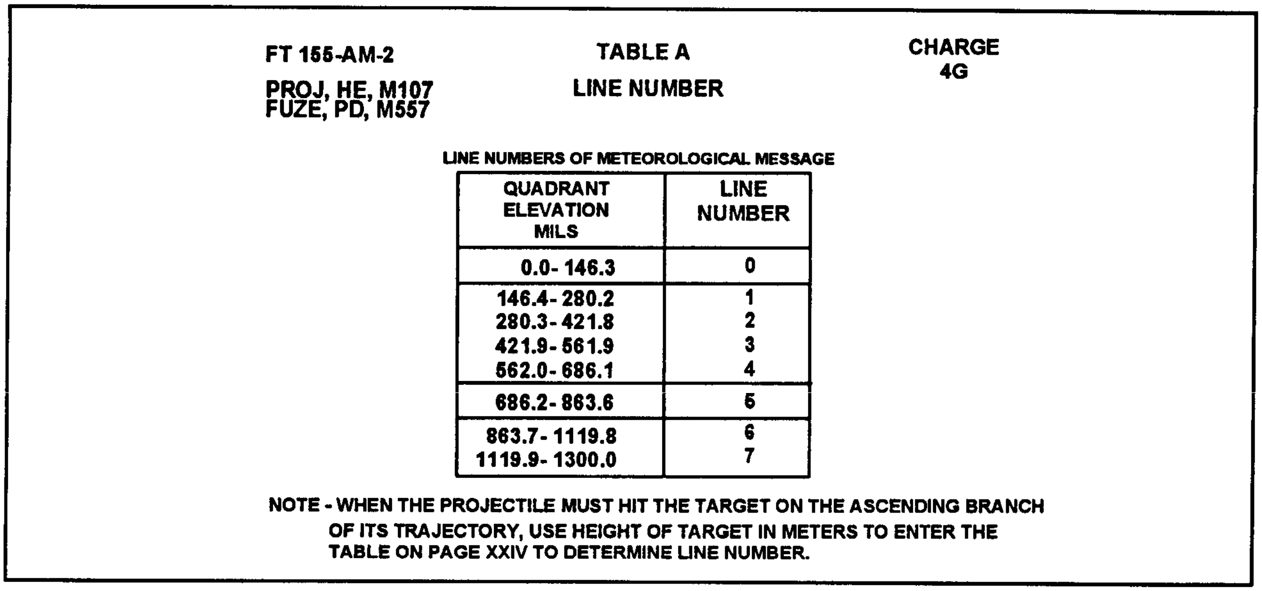
TOTAL FUZE CORRECTION	− 0.3
MET FUZE CORRECTION	
POS FUZE CORRECTION	
TOTAL FUZE CORRECTION	

MET FUZE CORR

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1 | BATTERY 1/A | DATE/TIME 161420ZAPR94

Figure 11-11. DA Form 4200 Containing Known Data.



FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

TABLE A

LINE NUMBER

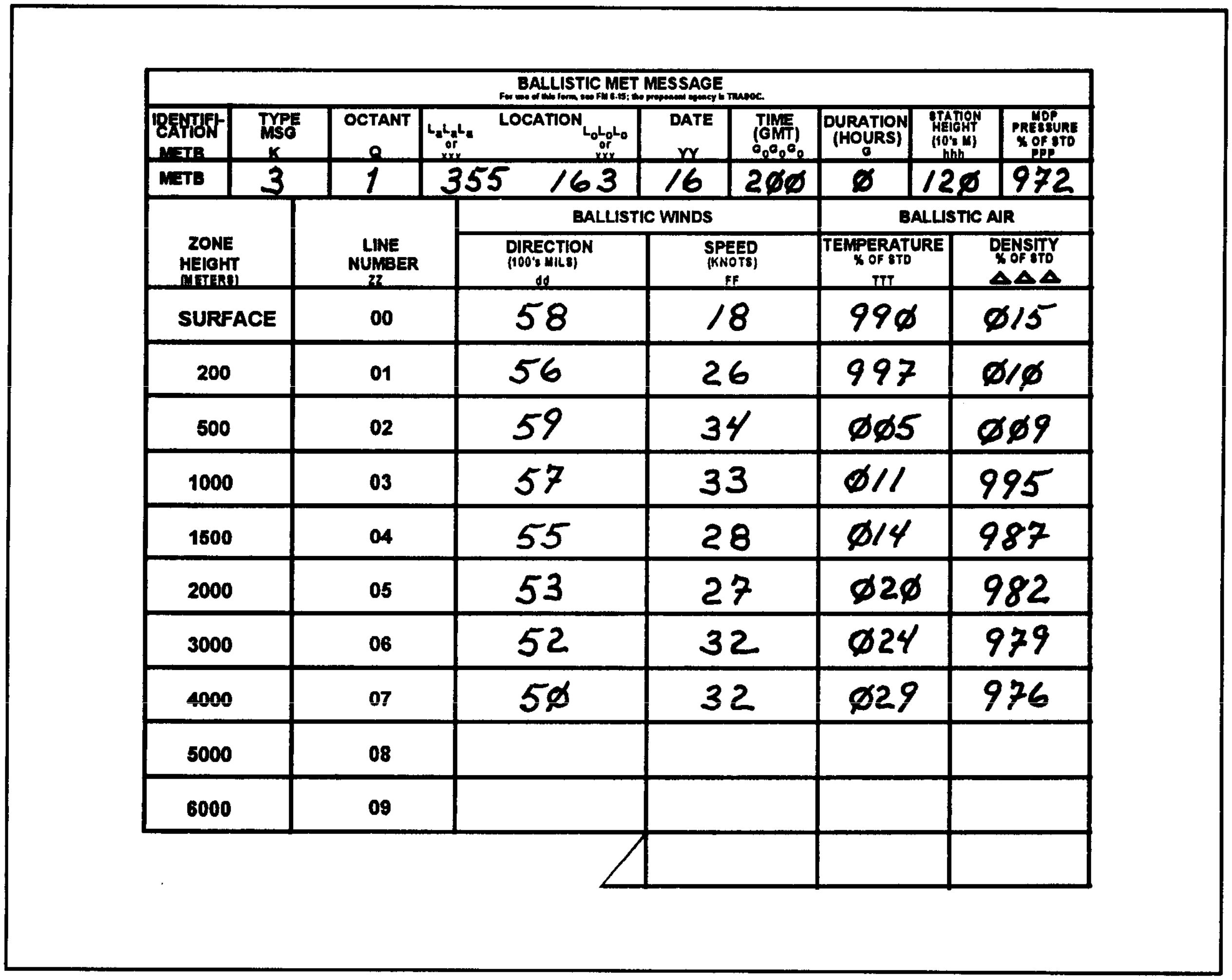
CHARGE
4G

LINE NUMBERS OF METEOROLOGICAL MESSAGE

QUADRANT ELEVATION MILS	LINE NUMBER
0.0- 146.3	0
146.4- 280.2	1
280.3- 421.8	2
421.9- 561.9	3
562.0- 686.1	4
686.2- 863.6	5
863.7- 1119.8	6
1119.9- 1300.0	7

NOTE - WHEN THE PROJECTILE MUST HIT THE TARGET ON THE ASCENDING BRANCH OF ITS TRAJECTORY, USE HEIGHT OF TARGET IN METERS TO ENTER THE TABLE ON PAGE XXIV TO DETERMINE LINE NUMBER.

Figure 11-12. Table A.

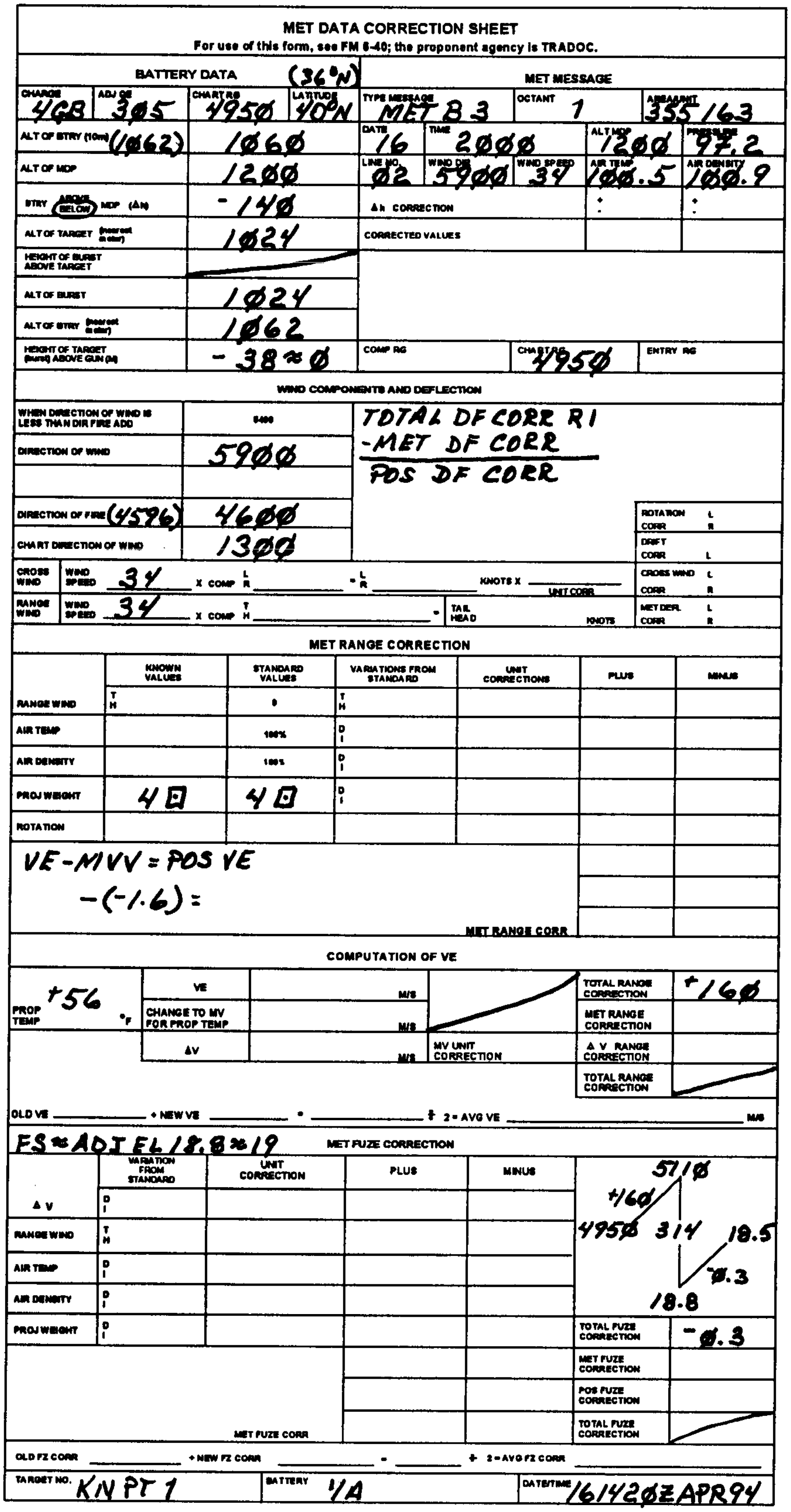


BALLISTIC MET MESSAGE
For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or XXX	$L_oL_oL_o$ or XXX	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	355	163	16	200	0	120	972

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	BALLISTIC WINDS		BALLISTIC AIR	
		DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE % OF STD TTT	DENSITY % OF STD △△△
SURFACE	00	58	18	990	015
200	01	56	26	997	010
500	02	59	34	005	009
1000	03	57	33	011	995
1500	04	55	28	014	987
2000	05	53	27	020	982
3000	06	52	32	024	979
4000	07	50	32	029	976
5000	08				
6000	09				

Figure 11-13. Ballistic Met Message Valid at the Time of the Registration.



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE 305	CHART RG 4950	LATITUDE 40°N

ALT OF BTRY (10m) (1062)	1060
ALT OF MDP	1200
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140
ALT OF TARGET (nearest m eter)	1024
HEIGHT OF BURST ABOVE TARGET	
ALT OF BURST	1024
ALT OF BTRY (nearest m eter)	1062
HEIGHT OF TARGET (burst) ABOVE GUN (M)	- 38 ≈ 0

MET MESSAGE

TYPE MESSAGE MET B 3		OCTANT 1		AREA/UNIT 355/163
DATE 16	TIME 2000		ALT MDP 1200	PRESSURE 97.2
LINE NO. 02	WIND DIR 5900	WIND SPEED 34	AIR TEMP 100.5	AIR DENSITY 100.9
Δh CORRECTION			+ -	+ -
CORRECTED VALUES				

COMP RG	CHART RG 4950	ENTRY RG

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5900
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	1300

TOTAL DF CORR R I
-MET DF CORR
POS DF CORR

CROSS WIND — WIND SPEED 34 X COMP L R ______ = L R ______ KNOTS X ______ UNIT CORR

RANGE WIND — WIND SPEED 34 X COMP T H ______ = TAIL HEAD ______ KNOTS

ROTATION CORR	L R
DRIFT CORR	L
CROSS WIND CORR	L R
MET DEFL CORR	L R

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T H	0	T H			
AIR TEMP		100%	D I			
AIR DENSITY		100%	D I			
PROJ WEIGHT	4□	4□	D I			
ROTATION						

VE - MVV = POS VE
-(-1.6) =

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +56 °F	VE	M/S		TOTAL RANGE CORRECTION	+160
	CHANGE TO MV FOR PROP TEMP	M/S		MET RANGE CORRECTION	
	ΔV	M/S	MV UNIT CORRECTION	Δ V RANGE CORRECTION	
				TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS ≈ ADJ EL 18.8 ≈ 19

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	D I			
RANGE WIND	T H			
AIR TEMP	D I			
AIR DENSITY	D I			
PROJ WEIGHT	D I			

5110
+160
4950 314 18.5
0.3
18.8

TOTAL FUZE CORRECTION	-0.3
MET FUZE CORRECTION	
POS FUZE CORRECTION	
TOTAL FUZE CORRECTION	

MET FUZE CORR

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1	BATTERY 1/A	DATE/TIME 161420Z APR94

Figure 11-14. DA form 4200 With Met Message Data Recorded.

Table 11-4. Solution of a Concurrent Met (Continued).

STEP	ACTION
4c	Subtract the direction of fire from the direction of wind to determine the chart direction of wind. Add 6400 to the direction of wind if it is less than the direction of fire. (See Figure 11-14.) **DIRECTION OF WIND 5900** **DIRECTION OF FIRE 4600** **CHART DIRECTION OF WIND 1300**
	NOTE: The chart direction of wind is used to divide the wind direction into crosswind and range wind components.
4d	Record the wind speed (**34**) in the CROSS WIND and RANGE WIND blocks.
5	Extract the complementary range from Table B.
5a	Enter Table B with the chart range expressed to the nearest 100 meters (**4950** ≈ **5000**) and the height of target above gun (VI) to the nearest 100 meters (**0**). (See Figure 11-15.)
5b	Extract the chart range. Record the value in the COMP RG block in the MET MESSAGE section, and apply it to the chart range. The result is the entry range to the nearest meter. Express this value to the nearest 100 meters, and record it out to the side of the ENTRY RG block. (See Figure 11-16, page 11-26.) **COMP RG 0** **+ CHART RG 4950** **= ENTRY RG 4950 ≈** $\boxed{5000}$
6	Extract the wind components from Table C.
6a	Enter Table C with the chart direction of wind (**1300**). Extract and record the crosswind (**R0.96**) component and range wind (**H0.29**) component. (See Figure 11-17, page 11-27.)
6b	Multiply the wind components by the wind speed, and express the result to the nearest 1 knot. Circle the appropriate symbol (L or R for cross wind and T or H for range wind). (See Figure 11-16, page 11-26.)
6c	The range wind and crosswind are now known values. The range wind is recorded in the KNOWN VALUES block under the MET RANGE CORRECTION section. (See Figure 11-16.)
7	Determine the temperature and density corrections from Table D.
7a	Enter Table D with the ▲ h (**-140**). (See Figure 11-18, page 11-27.)
7b	Extract the corrections that will be applied to the temperature and density to compensate for the difference in altitude between the battery and the MDP (**DT Correction +0.3; DD Correction +1.4**). Record them in the ▲ h CORRECTION block.
7c	Apply the corrections to the temperature and density, and record the result in the CORRECTED VALUES block and in the KNOWN VALUES column of the MET RANGE CORRECTION section. (See Figure 11-16.) **AIR TEMP 100.5 AIR DENSITY 100.9** **▲h CORRECTION +0.3 ▲h CORRECTION +1.4** **CORRECTED VALUE 100.8 CORRECTED VALUE 102.3**
8	Determine the correction to muzzle velocity for propellant temperature from Table E.
8a	Enter Table E with the propellant temperature to the nearest degree Fahrenheit (**+56°**).
8b	Interpolate the effect on muzzle velocity as required. (See Figures 11-19 and 11-20, page 11-28.)
8c	Record the value in the CHANGE TO MV FOR PROP TEMP block (**-0.6**).
9	Determine the variations from standard.

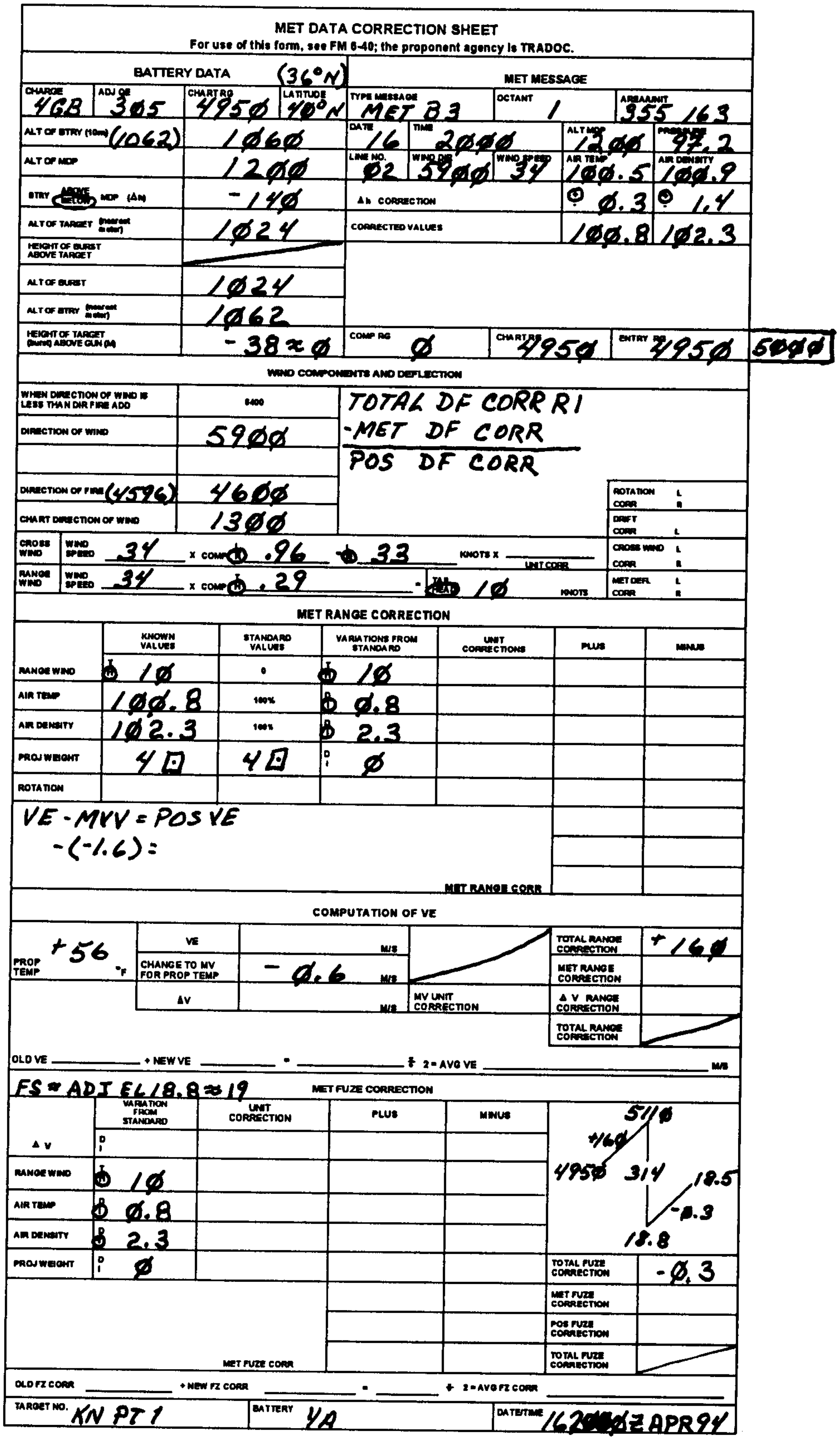
LINE NUMBERS OF METEOROLOGICAL MESSAGE

LINE NO.	RANGE METERS	HEIGHT OF TARGET ABOVE GUN - METERS -400	-300	-200	-100	0	100	200	300
	3500	-59	-46	-31	-16	0	17	34	52
0	3600	-61	-47	-32	-16	0	17	35	54
	3700	-64	-49	-33	-17	0	18	36	56
	3800	-66	-50	-34	-18	0	18	38	57
	3900	-68	-52	-35	-18	0	19	39	59
	4000	-70	-54	-37	-19	0	20	40	61
	4100	-72	-55	-38	-19	0	20	41	63
	4200	-75	-57	-39	-20	0	21	42	65
	4300	-77	-59	-40	-21	0	21	44	67
	4400	-79	-61	-41	-21	0	22	45	69
	4500	-82	-63	-43	-22	0	23	46	71
	4600	-84	-65	-44	-22	0	23	48	73
	4700	-87	-66	-45	-23	0	24	49	75
	4800	-89	-68	-47	-24	0	25	50	77
	4900	-92	-70	-48	-24	0	25	52	79
1	5000	-95	-72	-49	-25	0	26	53	82
	5100	-97	-74	-51	-26	0	27	55	84
	5200	-100	-76	-52	-26	0	28	56	86
	5300	-103	-79	-53	-27	0	28	58	89
	5400	-105	-81	-55	-28	0	29	59	91
	5500	-108	-83	-56	-29	0	30	61	94
	5600	-111	-85	-58	-30	0	31	63	96
	5700	-114	-87	-59	-30	0	32	65	99
	5800	-117	-90	-61	-31	0	32	66	102
	5900	-121	-92	-63	-32	0	33	68	105
	6000	-124	-95	-64	-33	0	34	70	108
	6100	-127	-97	-66	-34	0	35	72	111
	6200	-131	-100	-68	-35	0	36	74	114
2	6300	-134	-103	-70	-36	0	37	77	118
	6400	-138	-106	-72	-37	0	39	79	121
	6500	-142	-109	-74	-38	0	40	81	125
	6600	-146	-112	-76	-39	0	41	84	129
	6700	-150	-115	-78	-40	0	42	86	133
	6800	-154	-118	-81	-41	0	43	89	137
	6900	-159	-122	-83	-43	0	45	92	142
	7000	-164	-126	-86	-44	0	46	95	147
		2	3						

LINE NUMBERS OF METEOROLOGICAL MESSAGE

HEIGHT OF TARGET ABOVE GUN - METERS 400	500	600	700	800	900	1000	RANGE METERS	LINE NO.
71	91	112	133	156	179	203	3500	
73	94	115	137	161	185	210	3600	
76	97	119	142	166	191	217	3700	
78	100	123	146	171	197	223	3800	
81	103	126	151	176	203	230	3900	
83	106	130	155	182	209	237	4000	
86	110	134	160	187	215	245	4100	
88	113	138	165	193	222	252	4200	3
91	116	142	170	198	228	259	4300	
94	120	147	175	204	235	267	4400	
96	123	151	180	210	242	275	4500	
99	127	155	185	216	249	283	4600	
102	130	160	190	223	256	291	4700	
105	134	164	196	229	264	300	4800	
108	138	169	202	236	271	309	4900	
111	142	174	207	242	279	318	5000	
114	146	179	213	249	287	327	5100	
117	150	184	219	257	296	337	5200	
121	154	189	226	264	305	347	5300	
124	159	195	232	272	314	357	5400	
128	163	200	239	280	323	368	5500	
131	168	206	246	288	333	379	5600	
135	173	212	253	297	343	391	5700	
139	178	218	261	306	354	404	5800	
143	183	225	269	316	365	417	5900	
147	188	232	277	325	376	430	6000	
151	194	239	286	336	389	445	6100	4
156	200	246	295	347	401	460	6200	
161	206	254	305	358	415	476	6300	
166	213	262	315	370	430	494	6400	
171	220	271	325	383	446	513	6500	
177	227	280	337	397	463	533	6600	
182	235	290	349	413	481	556	6700	
189	243	300	362	429	502	582	6800	
195	252	312	377	447	525	612	6900	5
202	261	324	393	468	552	648	7000	
4					5			

Figure 11-15. Table B.



MET DATA CORRECTION SHEET
For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE	ADJ QE	CHART RG	LATITUDE
4GB	305	4950	40°N

ALT OF BTRY (10m) (1062): 1060
ALT OF MDP: 1200
BTRY ABOVE [✓ BELOW] MDP (Δh): -140
ALT OF TARGET (nearest meter): 1024
HEIGHT OF BURST ABOVE TARGET:
ALT OF BURST: 1024
ALT OF BTRY (nearest meter): 1062
HEIGHT OF TARGET (burst) ABOVE GUN (M): -38 ≈ 0

MET MESSAGE

TYPE MESSAGE	OCTANT	AREA/UNIT		
MET B3	1	355 163		
DATE	TIME		ALT MDP	PRESSURE
16	2000		1200	97.2
LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY
02	5900	34	100.5	100.9
Δh CORRECTION			+ 0.3	+ 1.4
CORRECTED VALUES			100.8	102.3

COMP RG: 0
CHART RG: 4950
ENTRY RG: 4950 | 5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD: 6400
DIRECTION OF WIND: 5900
DIRECTION OF FIRE (4596): 4600
CHART DIRECTION OF WIND: 1300

TOTAL DF CORR R1
-MET DF CORR
POS DF CORR

ROTATION CORR L R
DRIFT CORR L
CROSS WIND CORR L R
MET DEFL CORR L R

CROSS WIND: WIND SPEED 34 x COMP (R) .96 = (R) 33 KNOTS x ______ UNIT CORR
RANGE WIND: WIND SPEED 34 x COMP (H) .29 = TAIL [✓ HEAD] 10 KNOTS

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T [✓ H] 10	0	T [✓ H] 10			
AIR TEMP	100.8	100%	D [✓ I] 0.8			
AIR DENSITY	102.3	100%	D [✓ I] 2.3			
PROJ WEIGHT	4 ▣	4 ▣	D I 0			
ROTATION						

VE - MVV = POS VE
-(-1.6) =

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +56 °F
VE ______ M/S
CHANGE TO MV FOR PROP TEMP - 0.6 M/S
ΔV ______ M/S
MV UNIT CORRECTION

TOTAL RANGE CORRECTION	+160
MET RANGE CORRECTION	
Δ V RANGE CORRECTION	
TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS ≈ ADJ EL 18.8 ≈ 19

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	D I			
RANGE WIND	T [✓ H] 10			
AIR TEMP	D [✓ I] 0.8			
AIR DENSITY	D [✓ I] 2.3			
PROJ WEIGHT	D I 0			

MET FUZE CORR

5110
+160
4950 314 18.5
-0.3
18.8

TOTAL FUZE CORRECTION	-0.3
MET FUZE CORRECTION	
POS FUZE CORRECTION	
TOTAL FUZE CORRECTION	

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1
BATTERY YA
DATE/TIME 162000Z APR94

Figure 11-16. DA Form 4200 With Tables A Through E Completed.

CHARGE
4G

TABLE C

WIND COMPONENTS

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

COMPONENTS OF A ONE KNOT WIND

CHART DIRECTION OF WIND MIL	CROSS WIND KNOT	RANGE WIND KNOT	CHART DIRECTION OF WIND MIL	CROSS WIND KNOT	RANGE WIND KNOT
0	0	H1.00	3200	0	T1.00
100	R.10	H.99	3300	L.10	T.99
200	R.20	H.98	3400	L.20	T.98
300	R.29	H.96	3500	L.29	T.96
400	R.38	H.92	3600	L.38	T.92
500	R.47	H.88	3700	L.47	T.88
600	R.56	H.83	3800	L.56	T.83
700	R.63	H.77	3900	L.63	T.77
800	R.71	H.71	4000	L.71	T.71
900	R.77	H.63	4100	L.77	T.63
1000	R.83	H.56	4200	L.83	T.56
1100	R.88	H.47	4300	L.88	T.47
1200	R.92	H.38	4400	L.92	T.38
1300	R.96	H.29	4500	L.96	T.29
1400	R.98	H.20	4600	L.98	T.20
1500	R.99	H.10	4700	L.99	T.10
1600	R1.00	0	4800	L1.00	0
1700	R.99	T.10	4900	L.99	H.10
1800	R.98	T.20	5000	L.98	H.20
1900	R.96	T.29	5100	L.96	H.29
2000	R.92	T.38	5200	L.92	H.38
2100	R.88	T.47	5300	L.88	H.47
2200	R.83	T.56	5400	L.83	H.56
2300	R.77	T.63	5500	L.77	H.63
2400	R.71	T.71	5600	L.71	H.71
2500	R.63	T.77	5700	L.63	H.77
2600	R.56	T.83	5800	L.56	H.83
2700	R.47	T.88	5900	L.47	H.88
2800	R.38	T.92	6000	L.38	H.92
2900	R.29	T.96	6100	L.29	H.96
3000	R.20	T.98	6200	L.20	H.98
3100	R.10	T.99	6300	L.10	H.99
3200	0	T1.00	6400	0	H1.00

Figure 11-17. Table C.

FT 155-AM-2

TABLE D

CHARGE
4G

PROJ, HE, M107
FUZE, PD, M557

TEMPERATURE
AND DENSITY CORRECTIONS

CORRECTIONS TO TEMPERATURE (DT) AND DENSITY (DD), IN PERCENT,
TO COMPENSATE FOR THE DIFFERENCE IN ALTITUDE,
IN METERS, BETWEEN THE BATTERY AND THE MDP

DH		0	+10-	+20-	+30-	+40-	+50-	+60-	+70-	+80-	+90-
0	DT	0.0	0.0	0.0	-0.1+	-0.1+	-0.1+	-0.1+	-0.2+	-0.2+	-0.2+
	DD	0.0	-0.1+	-0.2+	-0.3+	-0.4+	-0.5+	-0.6+	-0.7+	-0.8+	-0.8+
+100-	DT	-0.2+	-0.2+	-0.2+	-0.3+	-0.3+	-0.3+	-0.3+	-0.4+	-0.4+	-0.4+
	DD	-1.0+	-1.1+	-1.2+	-1.3+	-1.4+	-1.5+	-1.6+	-1.7+	-1.8+	-1.8+
+200-	DT	-0.5+	-0.5+	-0.5+	-0.6+	-0.6+	-0.6+	-0.6+	-0.7+	-0.7+	-0.7+
	DD	-2.0+	-2.1+	-2.2+	-2.3+	-2.4+	-2.5+	-2.6+	-2.7+	-2.8+	-2.8+
+300-	DT	-0.7+	-0.7+	-0.7+	-0.8+	-0.8+	-0.8+	-0.8+	-0.9+	-0.9+	-0.9+
	DD	-3.0+	-3.1+	-3.2+	-3.3+	-3.4+	-3.5+	-3.6+	-3.7+	-3.8+	-3.8+

NOTES - 1. DH IS BATTERY HEIGHT ABOVE OR BELOW THE MDP.
2. IF ABOVE THE MDP, USE THE SIGN BEFORE THE NUMBER.
3. IF BELOW THE MDP, USE THE SIGN AFTER THE NUMBER.

Figure 11-18. Table D.

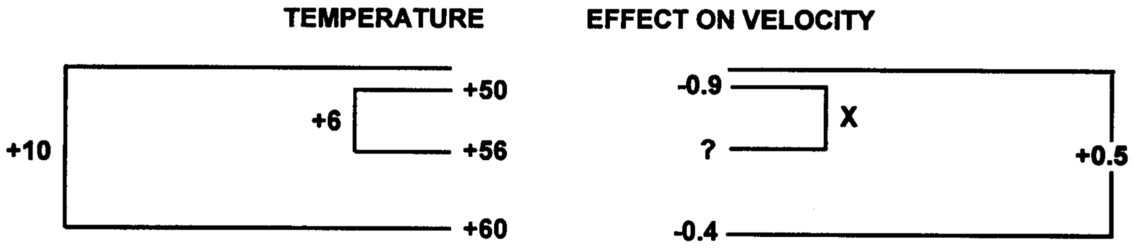
TABLE E

PROPELLANT TEMPERATURE

EFFECTS ON MUZZLE VELOCITY DUE TO PROPELLANT TEMPERATURE

TEMPERATURE OF PROPELLANT DEGREES F	EFFECT ON VELOCITY M/S	TEMPERATURE OF PROPELLANT DEGREES C
-40	*-6.4*	*-40.0*
-30	*-5.6*	*-34.4*
-20	*-4.8*	*-28.9*
-10	*-4.2*	*-23.3*
0	*-3.5*	*-17.8*
10	*-2.9*	*-12.2*
20	*-2.4*	*-6.7*
30	*-1.8*	*-1.1*
40	*-1.3*	4.4
50	*-0.9*	10.0
60	*-0.4*	15.6
70	0.0	21.1
80	0.4	26.7
90	0.8	32.2
100	1.2	37.8
110	1.7	43.3
120	2.1	48.9
130	2.5	54.4

Figure 11-19. Table E.



CROSS MULTIPLY $\frac{+6}{+10} = \frac{X}{+0.5}$

10 X = 6(0.5) $X = \frac{+6(+0.5)}{+10} = +0.3$

EFFECT ON VELOCITY AT 50°	-0.9
ALGEBRAICALLY ADD THE VALUE OF X	+ (+0.3)
CHANGE TO MV FOR PROP TEMP	-0.6

Figure 11-20. Interpolation.

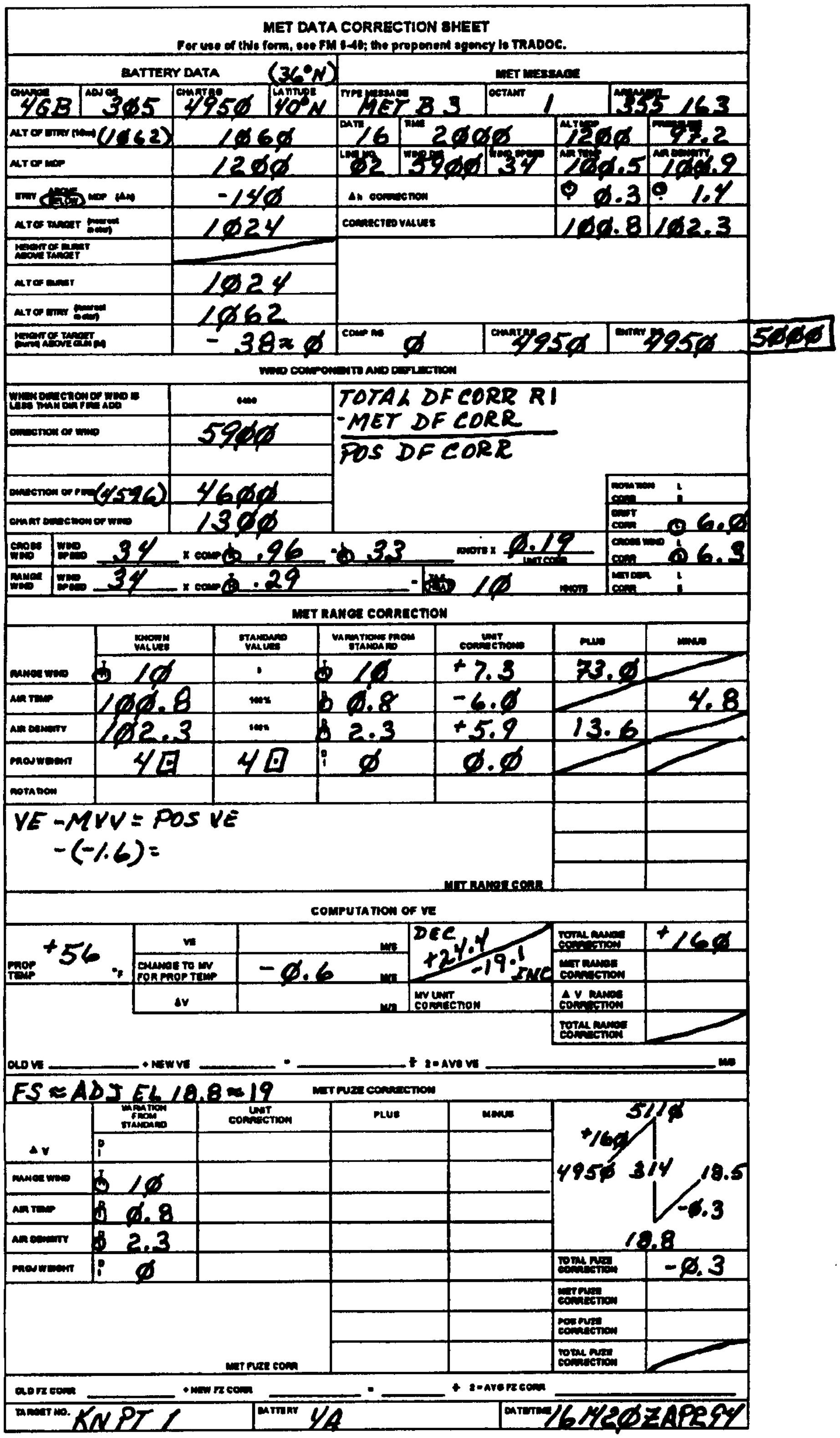
Table 11-4. Solution of a Concurrent Met (Continued).

STEP	ACTION
	The known values for range wind (**H10**), air temperature (**100.8**), air density (**102.3**), and projectile weight (**4◙**) have been recorded in the KNOWN VALUES column under the MET RANGE CORRECTION section. Compare the known value to the standard value. Circle the (I) for an increase or the (D) for a decrease (whichever is appropriate), and record the difference in the VARIATIONS FROM STANDARD column. Transfer the values to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section. (See Figure 11-16.)
10	Determine unit corrections for drift, crosswind, muzzle velocity, range wind, air density, air temperature, and projectile weight from Table F.
10a	Enter Table F with the entry range (**5000**). (See Figure 11-21, page 11-30.)
10b	Extract the azimuth correction for drift from Column 8 (**L6.0**). (Record all unit corrections as shown in Figure 11-22, page 11-31.)
10c	Extract the crosswind unit correction from Column 9 (**0.19**).
10d	Extract the range correction for muzzle velocity from Columns 10 and 11 (**DEC +24.4/INC -19.1**). Extract both corrections, because it is unknown at this time if the muzzle velocity effect will be an increase or a decrease.
10e	Extract the correction for range wind from Column 12 for a head wind or Column 13 for a tail wind (**+7.3**).
10f	Extract the correction for air temperature from Column 14 for a decrease or Column 15 for an increase (**-6.0**).
10g	Extract the correction for air density from Column 16 for a decrease or Column 17 for an increase (**+5.9**).
10h	Extract the correction for projectile weight from Column 18 for a decrease or Column 19 for an increase (**0.0**). This correction will be recorded with an ending of **.0**.
10i	Next to the UNIT CORRECTIONS column there are two columns: PLUS and MINUS. If the unit correction is a plus, cross out the MINUS block; if the unit correction is a minus, cross out the PLUS block. (See Figure 11-22.)
10j	Multiply the crosswind unit correction (**0.19**) by the crosswind value (**R 33**), and record the result to the nearest 0.1 in the CROSS WIND CORR block (**R6.3**).
10k	Multiply the variations from standard by the unit corrections, and record the results to the nearest tenth (0.1) in the boxes that are not crossed out. (See Figure 11-22.)
11	Determine the correction to range to compensate for the earth's rotation from Table H.
11a	Enter Table H with the entry range (**5000**) expressed to the nearest listed value (**nearest 500 meters**) and the exact direction of fire (**4596**) expressed to the nearest listed value (nearest 200 mils). The value extracted is for 0 degrees latitude and must be multiplied by a correction factor for latitudes other than 0. At the bottom of Table H are the correction factors for latitudes other than 0. (See Figure 11-23, page 11-32.)
11b	Record the correction for range (**+18**) and the correction factor for the change in latitude (**0.77**) on the line titled **"ROTATION"** in the MET RANGE CORRECTION section. Record it as follows: **+18 x 0.77**. (See Figure 11-24, page 11-33.)
	NOTE: Azimuth to target equals direction of fire. If the direction of fire, when expressed to the nearest mil, falls exactly between two listed values, use the correction for the higher listed value. This applies to Tables H and Table I.
11c	Cross out the appropriate column (PLUS or MINUS), and multiply the correction to range by the correction factor for the change in latitude. Record the result to the nearest tenth.
12	Determine the met range correction.
12a	Once all the multiplication is complete, total the PLUS column and total the MINUS column. (See Figure 11-24.)

1	2	3	4	5	6	7	8	9
RANGE	ELEV	FS FOR GRAZE BURST FUZE M564	DFS PER 10 M DEC HOB	DR PER 1 MIL D ELEV	FORK	TIME OF FLIGHT	AZIMUTH CORRECTIONS	
							DRIFT (CORR TO L)	CW OF 1 KNOT
M	MIL			M	MIL	SEC	MIL	MIL
3500	198.4	12.0	0.17	15	3	12.2	3.5	0.13
3600	204.9	12.4	0.17	15	3	12.5	3.7	0.14
3700	211.5	12.8	0.16	15	3	12.9	3.8	0.14
3800	218.2	13.2	0.16	15	4	13.3	4.0	0.14
3900	224.9	13.6	0.15	15	4	13.7	4.1	0.15
4000	231.7	14.0	0.15	15	4	14.1	4.3	0.15
4100	238.6	14.4	0.14	14	4	14.5	4.4	0.15
4200	245.6	14.8	0.14	14	4	14.9	4.6	0.16
4300	252.6	15.2	0.14	14	4	15.3	4.8	0.16
4400	259.7	15.6	0.13	14	5	15.7	4.9	0.16
4500	267.0	16.0	0.13	14	5	16.2	5.1	0.17
4600	274.3	16.4	0.13	14	5	16.6	5.3	0.17
4700	281.7	16.9	0.12	13	5	17.0	5.5	0.17
4800	289.2	17.3	0.12	13	5	17.4	5.6	0.18
4900	296.8	17.7	0.12	13	5	17.9	5.8	0.18
5000	304.5	18.2	0.11	13	6	18.3	6.0	0.19
5100	312.3	18.6	0.11	13	6	18.8	6.2	0.19
5200	320.3	19.1	0.11	12	6	19.2	6.4	0.19
5300	328.3	19.5	0.11	12	6	19.7	6.6	0.20
5400	336.5	20.0	0.10	12	7	20.1	6.8	0.20
5500	344.9	20.4	0.10	12	7	20.6	7.1	0.20
5600	353.4	20.9	0.10	12	7	21.1	7.3	0.21
5700	362.0	21.4	0.10	11	7	21.5	7.5	0.21
5800	370.9	21.9	0.10	11	8	22.0	7.7	0.22
5900	379.8	22.3	0.09	11	8	22.5	8.0	0.22
6000	389.0	22.8	0.09	11	8	23.0	8.2	0.22
6100	398.4	23.4	0.09	11	9	23.5	8.5	0.23
6200	408.0	23.9	0.09	10	9	24.0	8.8	0.23
6300	417.8	24.4	0.09	10	10	24.6	9.0	0.24
6400	427.9	24.9	0.08	10	10	25.1	9.3	0.24
6500	438.3	25.5	0.08	9	11	25.7	9.6	0.25
6600	449.0	26.0	0.08	9	11	26.2	9.9	0.25
6700	460.0	26.6	0.08	9	12	26.8	10.3	0.26
6800	471.4	27.2	0.08	9	13	27.4	10.6	0.26
6900	483.2	27.8	0.08	8	13	28.0	11.0	0.27
7000	495.5	28.5	0.07	8	14	28.7	11.3	0.27

1	10	11	12	13	14	15	16	17	18	19
RANGE	RANGE CORRECTIONS FOR									
	MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KNOT		AIR TEMP 1 PCT		AIR DENSITY 1 PCT		PROJ WT OF 1 SQ (4 SQ STD)	
	DEC	INC	HEAD	TAIL	DEC	INC	DEC	INC	DEC	INC
M	M	M	M	M	M	M	M	M	M	M
3500	17.7	-14.0	4.8	-1.9	10.4	-4.3	-3.1	3.1	-24	25
3600	18.2	-14.4	4.9	-2.0	10.8	-4.4	-3.2	3.2	-24	26
3700	18.6	-14.7	5.1	-2.1	11.1	-4.5	-3.4	3.4	-24	26
3800	19.1	-15.0	5.3	-2.2	11.4	-4.7	-3.5	3.6	-25	27
3900	19.5	-15.4	5.5	-2.3	11.7	-4.8	-3.7	3.7	-25	28
4000	20.0	-15.7	5.6	-2.4	12.0	-4.9	-3.9	3.9	-26	28
4100	20.4	-16.0	5.8	-2.4	12.3	-5.0	-4.1	4.1	-26	29
4200	20.9	-16.4	6.0	-2.5	12.6	-5.2	-4.3	4.3	-27	29
4300	21.3	-16.7	6.2	-2.6	12.9	-5.3	-4.5	4.5	-27	30
4400	21.8	-17.1	6.3	-2.7	13.2	-5.4	-4.7	4.7	-28	30
4500	22.2	-17.4	6.5	-2.8	13.5	-5.5	-4.9	4.9	-28	31
4600	22.6	-17.7	6.7	-2.9	13.7	-5.6	-5.1	5.1	-29	31
4700	23.1	-18.1	6.8	-3.0	14.0	-5.7	-5.3	5.3	-29	32
4800	23.5	-18.4	7.0	-3.1	14.3	-5.8	-5.5	5.5	-30	32
4900	24.0	-18.8	7.2	-3.2	14.6	-5.9	-5.7	5.7	-30	33
5000	24.4	-19.1	7.3	-3.2	14.8	-6.0	-5.9	5.9	-30	33
5100	24.9	-19.5	7.5	-3.3	15.1	-6.1	-6.1	6.2	-31	34
5200	25.3	-19.8	7.7	-3.4	15.3	-6.2	-6.3	6.4	-31	34
5300	25.8	-20.2	7.8	-3.5	15.6	-6.3	-6.6	6.6	-32	35
5400	26.2	-20.5	8.0	-3.6	15.8	-6.4	-6.8	6.9	-32	35
5500	26.7	-20.9	8.1	-3.7	16.0	-6.5	-7.0	7.1	-32	36
5600	27.2	-21.2	8.3	-3.8	16.2	-6.6	-7.3	7.3	-33	36
5700	27.6	-21.6	8.4	-3.9	16.4	-6.6	-7.5	7.6	-33	37
5800	28.1	-21.9	8.6	-4.0	16.7	-6.7	-7.7	7.8	-33	37
5900	28.5	-22.3	8.7	-4.1	16.8	-6.8	-8.0	8.1	-34	38
6000	29.0	-22.6	8.9	-4.2	17.0	-6.8	-8.2	8.4	-34	38
6100	29.5	-23.0	9.0	-4.3	17.2	-6.9	-8.5	8.6	-35	39
6200	29.9	-23.3	9.2	-4.4	17.4	-7.0	-8.8	8.9	-35	39
6300	30.4	-23.7	9.3	-4.5	17.6	-7.0	-9.0	9.2	-35	40
6400	30.9	-24.1	9.4	-4.5	17.7	-7.0	-9.3	9.5	-36	41
6500	31.3	-24.4	9.6	-4.6	17.8	-7.1	-9.6	9.7	-36	41
6600	31.8	-24.8	9.7	-4.7	18.0	-7.1	-9.9	10.0	-37	42
6700	32.3	-25.2	9.8	-4.8	18.1	-7.2	-10.1	10.3	-37	42
6800	32.8	-25.5	9.9	-4.9	18.2	-7.2	-10.4	10.6	-37	43
6900	33.2	-25.9	10.0	-5.0	18.3	-7.2	-10.7	11.0	-38	43
7000	33.7	-26.3	10.1	-5.1	18.4	-7.2	-11.0	11.3	-38	44

Figure 11-21. Table F.



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N) | MET MESSAGE

CHARGE 4GB	ADJ QE 305	CHART QE 4950	LATITUDE 40°N	TYPE MESSAGE MET B3	OCTANT 1	AREA/ALT 355 163

ALT OF BTRY (10m) (1062)	1060	DATE 16	TIME 2000		ALT MDP 1200	PRESSURE 97.2
ALT OF MDP	1200	LINE NO. 02	WIND DIR 5900	WIND SPEED 34	AIR TEMP 100.5	AIR DENSITY 100.9
BTRY ABOVE/BELOW MDP (Δh)	-140	Δh CORRECTION			+ 0.3	+ 1.4
ALT OF TARGET (nearest 10m)	1024	CORRECTED VALUES			100.8	102.3
HEIGHT OF BURST ABOVE TARGET						
ALT OF BURST	1024					
ALT OF BTRY (nearest 10m)	1062					
HEIGHT OF TARGET (burst) ABOVE GUN (m)	- 38 ≈ 0	COMP QE 0	CHART QE 4950		ENTRY QE 4950	5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400	TOTAL DF CORR R1 -MET DF CORR POS DF CORR
DIRECTION OF WIND	5900	
DIRECTION OF FIRE (4596)	4600	ROTATION CORR L R
CHART DIRECTION OF WIND	1300	DRIFT CORR L 6.0

CROSS WIND — WIND SPEED 34 × COMP L .96 = L 33 KNOTS × 0.19 UNIT CORR — CROSS WIND CORR L 6.3

RANGE WIND — WIND SPEED 34 × COMP T .29 = TAIL/HEAD T 10 KNOTS — MET DEFL CORR L R

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T 10	0	T 10	+7.3	73.0	
AIR TEMP	100.8	100%	D 0.8	-6.0		4.8
AIR DENSITY	102.3	100%	I 2.3	+5.9	13.6	
PROJ WEIGHT	4□	4□	D I 0	0.0		
ROTATION						

VE - MVV = POS VE
-(-1.6) =

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +56 °F	VE	M/S	DEC +24.4 -19.1 INC	TOTAL RANGE CORRECTION	+160
	CHANGE TO MV FOR PROP TEMP	-0.6 M/S		MET RANGE CORRECTION	
	ΔV	M/S	MV UNIT CORRECTION	ΔV RANGE CORRECTION	
				TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS ≈ ADJ EL 18.8 ≈ 19

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
ΔV	D I			
RANGE WIND	T 10			
AIR TEMP	D 0.8			
AIR DENSITY	I 2.3			
PROJ WEIGHT	D I 0			

5110
+160
4950 314 18.5
-0.3
18.8

TOTAL FUZE CORRECTION	-0.3
MET FUZE CORRECTION	
POS FUZE CORRECTION	
TOTAL FUZE CORRECTION	

MET FUZE CORR

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1 | BATTERY 4A | DATE/TIME 161420ZAPR94

Figure 11-22. DA Form 4200 With Data From Table F Complete.

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M577

TABLE H

ROTATION - RANGE

CHARGE
4G

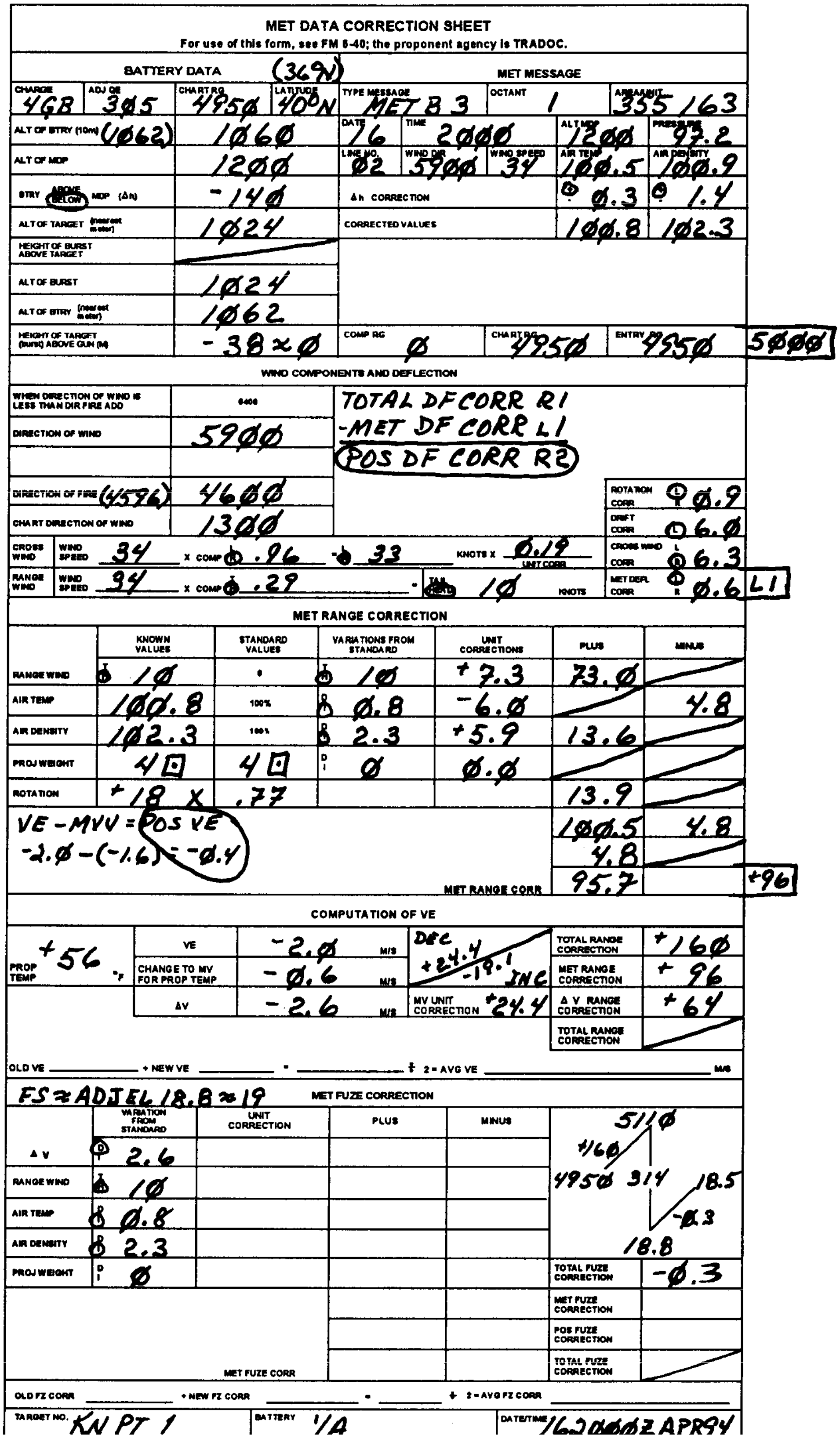
CORRECTIONS TO RANGE, IN METERS, TO COMPENSATE FOR THE ROTATION OF THE EARTH

RANGE METERS	AZIMUTH OF TARGET - MILS								
	0 3200	200 3000	400 2800	600 2600	800 2400	1000 2200	1200 2000	1400 1800	1600 1600
500	0	0	-1+	-1+	-2+	-2+	-2+	-2+	-2+
1000	0	-1+	-2+	-2+	-3+	-4+	-4+	-4+	-4+
1500	0	-1+	-3+	-4+	-5+	-5+	-6+	-6+	-7+
2000	0	-2+	-3+	-5+	-6+	-7+	-8+	-8+	-9+
2500	0	-2+	-4+	-6+	-7+	-9+	-10+	-10+	-10+
3000	0	-2+	-5+	-7+	-9+	-10+	-11+	-12+	-12+
3500	0	-3+	-5+	-8+	-10+	-12+	-13+	-14+	-14+
4000	0	-3+	-6+	-9+	-11+	-13+	-14+	-15+	-15+
4500	0	-3+	-6+	-9+	-12+	-14+	-16+	-16+	-17+
5000	0	-4+	-7+	-10+	-13+	-15+	-17+	-18+	-18+
5500	0	-4+	-7+	-11+	-14+	-16+	-18+	-19+	-19+
6000	0	-4+	-8+	-11+	-14+	-17+	-18+	-20+	-20+
6500	0	-4+	-8+	-11+	-14+	-17+	-19+	-20+	-20+
7000	0	-4+	-8+	-11+	-15+	-17+	-19+	-20+	-21+
7500	0	-4+	-8+	-11+	-14+	-17+	-18+	-20+	-20+
8000	0	-3+	-7+	-10+	-13+	-15+	-16+	-17+	-18+
********	********	********	********	********	********	********	********	********	********
8000	0	-2+	-3+	-5+	-6+	-7+	-8+	-9+	-9+
7500	0	-1+	-1+	-1+	-2+	-2+	-2+	-3+	-3+
7000	0	0	+1-	+1-	+1-	+1-	+2-	+2-	+2-
6500	0	+1-	+2-	+3-	+4-	+5-	+5-	+5-	+5-
6000	0	+2-	+3-	+5-	+6-	+7-	+8-	+9-	+9-
5500	0	+2-	+5-	+7-	+9-	+10-	+11-	+12-	+12-
5000	0	+3-	+6-	+9-	+12-	+14-	+15-	+16-	+16-
4500	0	+4-	+8-	+12-	+15-	+18-	+20-	+21-	+22-
	3200 6400	3400 6200	3600 6000	3800 5800	4000 5600	4200 5400	4400 5200	4600 5000	4800 4800
	AZIMUTH OF TARGET - MILS								

NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.
2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.
3. AZIMUTH IS MEASURED CLOCKWISE FROM NORTH.
4. CORRECTIONS ARE FOR 0 DEGRESS LATITUDE. FOR OTHER LATITUDES MULTIPLY CORRECTIONS BY THE FACTOR GIVEN BELOW.

LATITUDE (DEG)	10	20	30	40	50	60	70
MULTIPLY BY	.98	.94	.87	.77	.64	.50	.34

Figure 11-23. Table H.



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (369N)

CHARGE	ADJ QE	CHART RG	LATITUDE
4GB	305	4950	40°N

ALT OF BTRY (10m) (1062)	1060
ALT OF MDP	1200
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140
ALT OF TARGET (nearest meter)	1024
HEIGHT OF BURST ABOVE TARGET	
ALT OF BURST	1024
ALT OF BTRY (nearest meter)	1062
HEIGHT OF TARGET (burst) ABOVE GUN (M)	-38 ≈ 0

MET MESSAGE

TYPE MESSAGE	OCTANT	AREA/UNIT		
MET B 3	1	355 163		
DATE 16	TIME 2000		ALT MDP 1200	PRESSURE 97.2
LINE NO. 02	WIND DIR 5900	WIND SPEED 34	AIR TEMP 100.5	AIR DENSITY 100.9
Δh CORRECTION			+ 0.3	+ 1.4
CORRECTED VALUES			100.8	102.3

COMP RG	CHART RG	ENTRY RG	
0	4950	4950	5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5900
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	1300

TOTAL DF CORR R1
-MET DF CORR L1
POS DF CORR R2

CROSS WIND: WIND SPEED 34 x COMP R .96 = R 33 KNOTS x 0.19 UNIT CORR

RANGE WIND: WIND SPEED 34 x COMP T .29 = TAIL 10 KNOTS

ROTATION CORR	L 0.9
DRIFT CORR	L 6.0
CROSS WIND CORR	R 6.3
MET DEFL CORR	L 0.6 L1

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T 10	0	T 10	+ 7.3	73.0	
AIR TEMP	100.8	100%	D 0.8	-6.0		4.8
AIR DENSITY	102.3	100%	D 2.3	+ 5.9	13.6	
PROJ WEIGHT	4 ▣	4 ▣	0	0.0		
ROTATION	+ 18 x	.77			13.9	
					100.5	4.8
					4.8	
				MET RANGE CORR	95.7	+96

VE - MVV = POS VE
-2.0 - (-1.6) = -0.4

COMPUTATION OF VE

PROP TEMP +56 °F	VE	-2.0 M/S	DEC +24.4 -19.1 INC	TOTAL RANGE CORRECTION	+160
	CHANGE TO MV FOR PROP TEMP	-0.6 M/S		MET RANGE CORRECTION	+ 96
	ΔV	-2.6 M/S	MV UNIT CORRECTION +24.4	Δ V RANGE CORRECTION	+ 64
				TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS ≈ ADJ EL 18.8 ≈ 19

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	D 2.6			
RANGE WIND	T 10			
AIR TEMP	D 0.8			
AIR DENSITY	D 2.3			
PROJ WEIGHT	0			
MET FUZE CORR				

5110
+160
4950 314 18.5
-0.3
18.8

TOTAL FUZE CORRECTION	-0.3
MET FUZE CORRECTION	
POS FUZE CORRECTION	
TOTAL FUZE CORRECTION	

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO.	BATTERY	DATE/TIME
KN PT 1	1/A	162000Z APR94

Figure 11-24. DA Form 4200 With Position VE and Position Deflection Determined.

Table 11-4. Solution of a Concurrent Met (Continued).

STEP	ACTION
12b	Subtract the smaller column from the larger column. Express the sum to the nearest 1 meter, and record it out to the side of the MET RANGE CORRECTION block with the appropriate sign. (See Figure 11-24.)
13	Determine the ▲V range correction.
13a	Record the met range correction in the MET RANGE CORRECTION block in the COMPUTATION OF VE section. (See Figure 11-24.)
13b	Algebraically subtract the met range correction from the total range correction to determine the ▲V range correction. (See Figure 11-24.) **TOTAL RANGE CORRECTION +160** **- MET RANGE CORRECTION - (+96)** **▲V RANGE CORRECTION +64**
	NOTE: The following is an explanation of step 14.
	The total range correction from the registration represents the correction for all nonstandard conditions effecting range. The met range correction represents the correction due to measurable nonstandard conditions that occur after the projectile leaves the tube. The ▲V range correction represents what is left and is determined by algebraically subtracting the met range correction from the total range correction. The symbol ▲V represents the total variation from the standard muzzle velocity. The ▲V range correction represents the magnitude of the correction, in meters, required to offset the variation in muzzle velocity. Because MV is measured in meters per second, the ▲V range correction must be converted from meters to meters per second.
	To accomplish the conversion, divide the ▲V range correction by the appropriate muzzle velocity unit correction factor extracted from Table F. Determining which factor to use requires a complete understanding of the ▲V range correction.
	A positive ▲V range correction shows that an increase in range is needed. It follows that the velocity developed was not enough to achieve the range desired. Therefore, the MV was less than standard, or a decrease. Because the velocity was a decrease value, the decrease unit factor is used. The unit correction factor indicates the correction in meters necessary for each 1 meter-per-second **decrease** from the standard. When the MV decreases from standard, a plus range correction is needed. When the MV increases from standard, a minus range correction is needed.
14	Determine the ▲V.
14a	Divide the ▲V range correction (**+64**) by the MV unit correction (**+24.4**). If the ▲V range correction is a minus, use the increase factor. If the ▲V range correction is a plus, use the decrease factor. (See Figure 11-24.) **▲V RANGE CORRECTION +64** **÷MV UNIT CORRECTION ÷(+24.4)** **▲V -2.6 (expressed to the nearest 0.1)**
14b	The ▲V will be expressed to the nearest 0.1 and **will have the sign opposite the MV unit correction**. Record the result in the ▲V block and the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section.
	NOTE: The following is an explanation of step 15.
	▲V is made up of propellant temperature effect, which can be measured; muzzle velocity variation, which can be measured; and the position VE, which is due to elements that cannot be easily measured (chart, material, survey errors, and so on). Since the total (▲V) is known and a part due to propellant temperature is known, the remaining part (VE) can be determined by algebraically subtracting the change to MV for propellant temperature from the ▲V. (See Figure 11-24.) For further discussion, see TFT 155 AM-2 or any TFT (not addendums) Part 1, Introduction, Sample Met Problem.

CHARGE
4G

TABLE I

ROTATION - AZIMUTH

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

CORRECTIONS TO AZIMUTH, IN MILS, TO COMPENSATE FOR THE ROTATION OF THE EARTH

40 DEGREES NORTH LATITUDE

	AZIMUTH OF TARGET - MILS								
RANGE METERS	0 6400	400 6000	800 5600	1200 5200	1600 4800	2000 4400	2400 4000	2800 3600	3200 3200
500	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R
1000	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R
1500	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R
2000	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R
2500	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R
3000	L0.4R	L0.5R	L0.5R	L0.5R	L0.5R	L0.5R	L0.5R	L0.5R	L0.5R
3500	L0.5R	L0.5R	L0.5R	L0.5R	L0.6R	L0.6R	L0.6R	L0.6R	L0.6R
4000	L0.6R	L0.6R	L0.6R	L0.6R	L0.7R	L0.7R	L0.7R	L0.7R	L0.7R
4500	L0.7R	L0.7R	L0.7R	L0.7R	L0.7R	L0.8R	L0.8R	L0.8R	L0.8R
5000	L0.7R	L0.7R	L0.8R	L0.8R	L0.8R	L0.9R	L0.9R	L0.9R	L0.9R
5500	L0.8R	L0.8R	L0.9R	L0.9R	L0.9R	L1.0R	L1.0R	L1.1R	L1.1R
6000	L0.9R	L0.9R	L0.9R	L1.0R	L1.1R	L1.1R	L1.2R	L1.2R	L1.2R
6500	L1.0R	L1.0R	L1.0R	L1.1R	L1.2R	L1.3R	L1.3R	L1.4R	L1.4R
7000	L1.0R	L1.1R	L1.1R	L1.2R	L1.3R	L1.4R	L1.5R	L1.6R	L1.6R
7500	L1.1R	L1.1R	L1.2R	L1.3R	L1.5R	L1.6R	L1.7R	L1.8R	L1.8R
8000	L1.2R	L1.2R	L1.3R	L1.5R	L1.7R	L1.9R	L2.1R	L2.2R	L2.2R
******	******	******	******	******	******	******	******	******	******
8000	L1.1R	L1.2R	L1.4R	L1.7R	L2.1R	L2.5R	L2.8R	L3.0R	L3.1R
7500	L0.9R	L1.0R	L1.3R	L1.8R	L2.3R	L2.8R	L3.2R	L3.5R	L3.6R
7000	L0.7R	L0.9R	L1.2R	L1.7R	L2.4R	L3.0R	L3.5R	L3.9R	L4.0R
6500	L0.5R	L0.7R	L1.1R	L1.7R	L2.4R	L3.2R	L3.8R	L4.2R	L4.3R
6000	L0.3R	L0.5R	L0.9R	L1.6R	L2.5R	L3.3R	L4.0R	L4.5R	L4.7R
5500	0.0	L0.2R	L0.7R	L1.6R	L2.5R	L3.4R	L4.3R	L4.8R	L5.0R
5000	R0.3L	R0.1L	L0.5R	L1.5R	L2.5R	L3.6R	L4.5R	L5.1R	L5.3R
4500	R0.6L	R0.3L	L0.3R	L1.3R	L2.5R	L3.7R	L4.7R	L5.4R	L5.6R
	3200 3200	2800 3600	2400 4000	2000 4400	1600 4800	1200 5200	800 5600	400 6000	0 6400
	AZIMUTH OF TARGET - MILS								

40 DEGREES SOUTH LATITUDE

NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.
2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.
3. R DENOTES CORRECTION TO THE RIGHT, L TO THE LEFT.
4. AZIMUTH IS MEASURED CLOCKWISE FROM THE NORTH.

Figure 11-25. Table I.

Table 11-4. Solution of a Concurrent Met (Continued).

STEP	ACTION
15	Determine the velocity error.
	Algebraically subtract the change to MV for propellant temperature (**-0.6**) from the ▲V (**-2.6**). (See Figure 11-24.) **▲V -2.6** **- CHANGE TO MV FOR PROP TEMP - (-0.6)** **VE -2.0**
16	Determine the position VE.
	The position VE is determined by algebraically subtracting the value of the MVV (**-1.6**) from the VE (**-2.0**). Once the position VE is determined, circle it. (See Figure 11-24.) **VE -2.0** **- MVV - (-1.6)** **POS VE -0.4**
	NOTE: The position VE is what is left after stripping the MVV from the VE. It is an error that remains constant. The position VE is a constant for the projectile family.
17	Determine corrections for azimuth to compensate for rotation of the earth from Table I.
17a	Select the appropriate Table I on the basis of latitude (**40°N**).
17b	Enter with the entry range (**5000**) to the nearest listed value (**nearest 500 meters**) and the exact direction of fire (**4596**) expressed to the nearest listed value (nearest 400 mils [**4400**]). For northern latitudes, enter the table from the top. For southern latitudes, enter the table from the bottom. (See Figure 11-25.)
17c	Extract the proper correction (**L0.9**), and record it in the ROTATION CORR block in the WIND COMPONENTS AND DEFLECTION section. (See Figure 11-24.)
18	Determine the met deflection correction.
	Algebraically add the values for rotation, drift, and crosswind. Express the result to the nearest 1 mil, and record it to the right of the MET DEFL CORR block as a left (L) or a right (R). (See Figure 11-24.) **ROTATION CORRECTION L0.9** **+ DRIFT CORRECTION L6.0** **+ CROSSWIND CORRECTION R6.3** **MET DEFLECTION CORRECTION L0.6 ≈** $\boxed{\text{L1}}$
	NOTE: This value represents that part of the total deflection correction caused by measurable nonstandard conditions.
19	Determine position deflection correction.
	Record the met deflection correction in the equation for deflection, and algebraically subtract the met deflection correction from the total deflection correction, applying the correct sign. Once the position deflection correction is determined, circle it. (See Figure 11-24.) **TOTAL DF CORR R1** **- MET DF CORR L1** **POS DF CORR R2**
	NOTE: This value represents the position deflection correction, the part of the total deflection correction due to unmeasurable nonstandard conditions.
20	Determine from Table J the unit corrections for fuze.
20a	Enter Table J with the fuze setting corresponding to the adjusted elevation (**18.8**) expressed to the nearest whole fuze setting increment (**19**). (See Figure 11-26.)
20b	Extract the correction for ▲V from Column 2 for a decrease or from Column 3 for an increase (**-0.049**). (Record all unit corrections to the nearest thousandths as shown in Figure 11-27, page 11-38.)
20c	Extract the correction for range wind from Column 4 for a head wind or Column 5 for a tail wind (**-0.010**).

CHARGE
4G

TABLE J

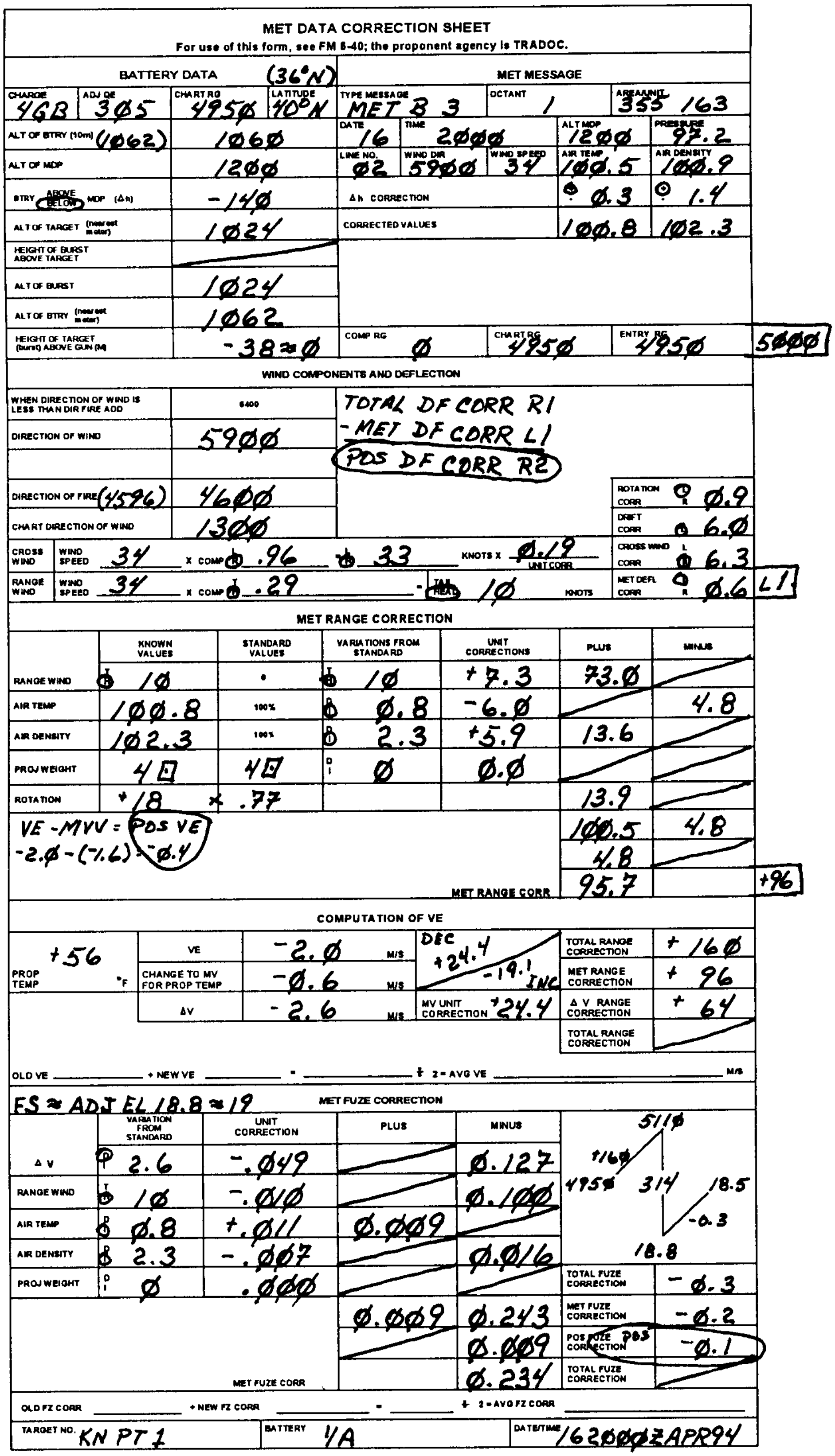
FUZE CORRECTION FACTORS

FT 155-AM-2

PROJ, HE, M557
FUZE, MTSQ, M564

1	2	3	4	5	6	7	8	9	10	11
FS	FUZE CORRECTIONS FOR									
	MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KNOT		AIR TEMP 1 PCT		AIR DENSITY 1 PCT		PROJ WT OF 1 SQ (4 SQ STD)	
	DEC	INC	HEAD	TAIL	DEC	INC	DEC	INC	DEC	INC
0										
1										
2	-.006	.006	.000	.000	-.001	.000	.000	.000	.011	-.011
3	-.009	.009	-.001	.000	-.001	.001	.000	.000	.015	-.015
4	-.012	.011	-.001	.000	-.003	.001	.000	.000	.020	-.020
5	-.014	.013	-.001	.001	-.004	.002	.001	-.001	.024	-.024
6	-.017	.016	-.002	.001	-.005	.003	.001	-.001	.028	-.028
7	-.020	.018	-.002	.001	-.007	.003	.001	-.001	.031	-.032
8	-.022	.020	-.003	.001	-.009	.004	.002	-.001	.035	-.036
9	-.025	.022	-.004	.002	-.010	.004	.002	-.002	.039	-.040
10	-.027	.024	-.004	.002	-.012	.005	.002	-.002	.042	-.044
11	-.030	.026	-.005	.002	-.014	.006	.003	-.003	.045	-.047
12	-.032	.028	-.006	.002	-.015	.007	.003	-.003	.049	-.051
13	-.035	.030	-.006	.003	-.017	.007	.004	-.004	.052	-.055
14	-.037	.032	-.007	.003	-.018	.008	.004	-.004	.055	-.059
15	-.039	.034	-.007	.003	-.020	.008	.005	-.004	.059	-.062
16	-.042	.036	-.008	.003	-.022	.009	.005	-.005	.062	-.066
17	-.044	.038	-.009	.004	-.023	.010	.006	-.006	.065	-.070
18	-.047	.040	-.009	.004	-.025	.010	.006	-.006	.068	-.073
19	-.049	.042	-.010	.004	-.026	.011	.007	-.007	.071	-.077
20	-.052	.044	-.010	.004	-.027	.011	.008	-.007	.074	-.081
21	-.054	.046	-.011	.005	-.029	.012	.008	-.008	.078	-.084
22	-.057	.048	-.011	.005	-.030	.012	.009	-.009	.081	-.088
23	-.059	.050	-.012	.005	-.031	.013	.010	-.009	.084	-.091
24	-.062	.052	-.012	.005	-.032	.013	.010	-.010	.087	-.095
25	-.064	.054	-.013	.006	-.034	.014	.011	-.011	.090	-.099
26	-.067	.056	-.013	.006	-.035	.014	.012	-.012	.093	-.103
27	-.069	.059	-.013	.006	-.036	.014	.013	-.012	.096	-.107
28	-.072	.061	-.014	.006	-.037	.015	.013	-.013	.100	-.110
29	-.074	.063	-.014	.006	-.038	.015	.014	-.014	.103	-.114
30	-.077	.065	-.015	.007	-.039	.015	.015	-.015	.107	-.118
31	-.079	.067	-.015	.007	-.040	.016	.016	-.016	.110	-.121
32	-.082	.070	-.015	.007	-.041	.016	.017	-.016	.114	-.125
33	-.084	.072	-.015	.007	-.041	.016	.018	-.017	.118	-.128
34	-.087	.074	-.016	.007	-.042	.017	.019	-.018	.122	-.132
35	-.089	.077	-.016	.008	-.043	.017	.019	-.019	.127	-.135

Figure 11-26. Table J.



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE	ADJ QE	CHART RG	LATITUDE
4GB	305	4950	40°N

ALT OF BTRY (10m) (1062)	1060
ALT OF MDP	1200
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140
ALT OF TARGET (nearest meter)	1024
HEIGHT OF BURST ABOVE TARGET	
ALT OF BURST	1024
ALT OF BTRY (nearest meter)	1062
HEIGHT OF TARGET (burst) ABOVE GUN (M)	-38 ≈ 0

MET MESSAGE

TYPE MESSAGE	OCTANT	AREA/UNIT
MET B 3	1	355 163

DATE	TIME	ALT MDP	PRESSURE
16	2000	1200	97.2

LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY
02	5900	34	100.5	100.9
Δh CORRECTION			0.3	1.4
CORRECTED VALUES			100.8	102.3

COMP RG	CHART RG	ENTRY RG	
0	4950	4950	5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5900
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	1300

TOTAL DF CORR R1
-MET DF CORR L1
POS DF CORR R2

CROSS WIND — WIND SPEED 34 x COMP R .96 R 33 KNOTS x 0.19 UNIT CORR

RANGE WIND — WIND SPEED 34 x COMP .29 = TAIL [✓ HEAD] 10 KNOTS

ROTATION CORR L R	L 0.9
DRIFT CORR	L 6.0
CROSS WIND CORR L R	R 6.3
MET DEFL CORR L R	L 0.6 — L1

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	H 10	•	H 10	+7.3	73.0	
AIR TEMP	100.8	100%	I 0.8	-6.0		4.8
AIR DENSITY	102.3	100%	I 2.3	+5.9	13.6	
PROJ WEIGHT	4□	4□	0	0.0		
ROTATION	+18 × .77				13.9	
					100.5	4.8
					4.8	
				MET RANGE CORR	95.7	+96

VE - MVV = POS VE
-2.0 - (-1.6) = -0.4

COMPUTATION OF VE

PROP TEMP °F	+56
VE	-2.0 M/S
CHANGE TO MV FOR PROP TEMP	-0.6 M/S
ΔV	-2.6 M/S
DEC / INC	+24.4 / -19.1
MV UNIT CORRECTION	+24.4
TOTAL RANGE CORRECTION	+160
MET RANGE CORRECTION	+96
Δ V RANGE CORRECTION	+64
TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS ≈ ADJ EL 18.8 ≈ 19

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	D 2.6	-.049		0.127
RANGE WIND	H 10	-.010		0.100
AIR TEMP	I 0.8	+.011	0.009	
AIR DENSITY	I 2.3	-.007		0.016
PROJ WEIGHT	0	.000		
			0.009	0.243
				0.009
		MET FUZE CORR		0.234

5110
+160
4950 314 18.5
-0.3
18.8

TOTAL FUZE CORRECTION	-0.3
MET FUZE CORRECTION	-0.2
POS FUZE CORRECTION POS	-0.1
TOTAL FUZE CORRECTION	

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO.	BATTERY	DATE/TIME
KN PT 1	1/A	162000ZAPR94

Figure 11-27. Completed DA Form 4200 Containing the Concurrent Met.

Table 11-4. Solution of a Concurrent Met (Continued).

STEP	ACTION
20d	Extract the correction for air temperature from Column 6 for a decrease or Column 7 for an increase (**+0.011**).
20e	Extract a correction for air density from Column 8 for a decrease or Column 9 for an increase (**-0.007**).
20f	Extract a correction for projectile weight from Column 10 for a decrease or Column 11 for an increase (**0.000**).
20g	Next to the UNIT CORRECTIONS column there are two columns--a PLUS column and a MINUS column. If the correction is a plus, cross out the minus block. If the correction is a minus, cross out the plus block. (See Figure 11-27.)
21	Determine the met fuze correction.
21a	Multiply the variations from standard by the unit corrections, and record the results to the nearest thousandths (0.001) in the boxes that are not crossed out. (See Figure 11-27.)
21b	Total the PLUS column, and total the MINUS column. Subtract the smaller column from the larger column. Express the sum to the nearest 0.1, and record it in the MET FUZE CORRECTION block with the appropriate sign. (See Figure 11-27.)
22	Determine the position fuze correction.
	Algebraically subtract the met fuze correction (**-0.2**) from the total fuze correction (**-0.3**). The result is the position fuze correction (**-0.1**). Circle the position fuze correction. (See Figure 11-27.) **TOTAL FUZE CORRECTION -0.3** **- MET FUZE CORRECTION - (-0.2)** **POSITION FUZE CORRECTION -0.1**
	NOTE: The completed DA Form 4200 containing the concurrent met is shown in Figure 11-27.

Section III

Subsequent Met Technique

A subsequent met is computed to determine new total corrections. Total corrections determined from a registration will remain valid only as long as the met corrections do not change.

11-10. Overview

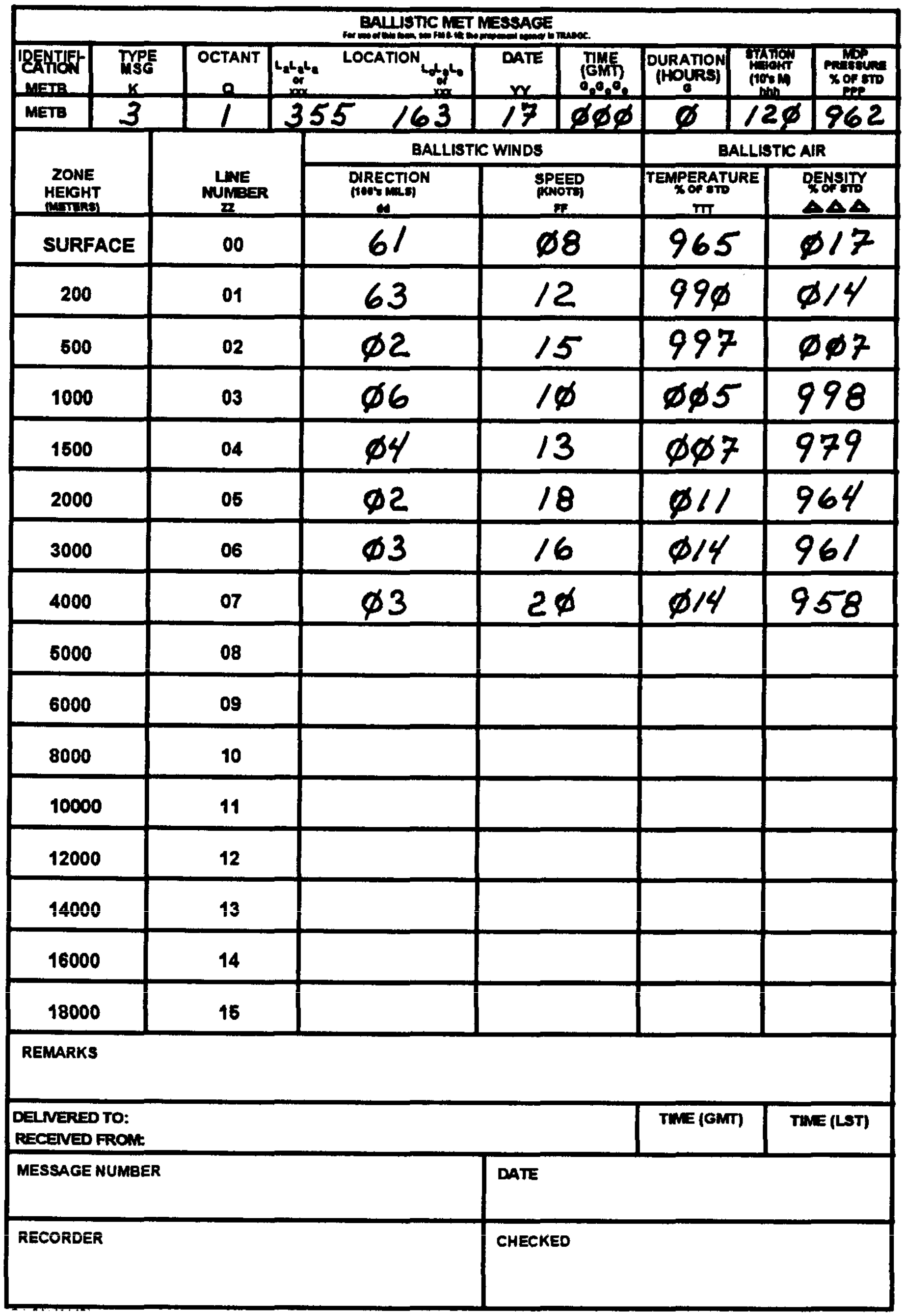
Whenever a met condition (weather, propellant temperature, projectile weight, or propellant lot) changes, the GFT setting derived from the registration is no longer valid. Registering every time one of the conditions changes is not feasible. To update registration corrections, a subsequent met can be solved to quantify new met corrections, which are added to the position constants determined from the concurrent met. The result is new total corrections that are used to determine a new GFT setting.

11-11. Solution of a Subsequent Met

Table 11-5 shows a detailed example of the solution of a subsequent met technique. It uses the previously completed concurrent met (Figure 11-27) and assumes the battery and MDP have not moved.

Table 11-5. Solution of a Subsequent Met.

STEP	ACTION
1	Record the position constants determined from the concurrent met.
1a	Record the position deflection correction (**R2**) in the WIND COMPONENTS AND DEFLECTION computational space. Use the equation below to compute the GFT deflection correction. Record it in the WIND COMPONENTS AND DEFLECTION computational space as follows: **POS DF CORR R2** **+ MET DF CORR** **TOTAL DF CORR** **- DRIFT ~ ADJ EL** **GFT DF CORR**
1b	Record the position VE determined from the registration (**-0.4**) in the MET RANGE CORRECTION computational block. Use the equation **POS VE + MVV = VE**. Once the equation is written and the VE determined, record the VE in the COMPUTATION OF VE section VE block. **POS VE + MVV = VE** **- 0.4 + (-1.6) = -2.0**
1c	Record the position fuze correction (**-0.1**).
2	Record the known data.
	NOTE: The following elements listed in steps 2a through 2dd, **except for the met message data**, are always known data in a subsequent met **if the unit and met station have not moved**. If the unit has moved, new known data must be determined from the new position. If the MDP has moved, the MDP altitude and ▲h must be determined.
2a	Record the charge (**4GB**).
	NOTE: Since an adjusted quadrant is unknown, use the met line number from the concurrent met and record the met message.
2b	Record the line number of the met message in the **LINE NO**. block (**02**).
2c	Record the met message data on DA Form 4200. The ballistic met message is shown in Figure 11-28.
2d	Record data from the identification line (**METB3, 1, 355 163, 17, 0000, 1200, 96.2**) in the met message block.
2e	Record the altitude of the MDP (**1200**), wind direction (**0200**), wind speed (**15**), air temperature (**99.7**), and air density (**100.7**) from the met message in the appropriate blocks. (See Figure 11-29, page 11-43.)
2f	Record the chart range in both blocks (**4950**).
2g	Record the latitude (nearest 10°)(**35.5°N ≈ 40°N**).
2h	Record the battery altitude (to the nearest 1 meter in parentheses and to the nearest 10 meters in the block) (**1062 ≈ 1060**). Enter the battery altitude to the nearest 1 meter in the lower block (**1062**).
2i	Determine the difference in altitude between the battery and the MDP. **ALT OF BTRY 1060** **- ALT OF MDP -(1200)** **BTRY (BELOW) MDP -140**
2j	Record the corrections from the concurrent met determined from Table D that are applied to the temperature and density to compensate for the difference in altitude between the battery and the MDP. **DT CORRECTION +0.3 DD CORRECTION +1.4**.
2k	Apply the corrections to the temperature and density, and record the result in the CORRECTED VALUES block and in the KNOWN VALUES column of the MET RANGE CORRECTION section. **AIR TEMP 99.7 AIR DENSITY 100.7** **▲h CORRECTION +0.3 ▲h CORRECTION +1.4** **CORRECTED VALUE 100.0 CORRECTED VALUE 102.1**



BALLISTIC MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or XXX $L_oL_oL_o$ or XXX	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	355 163	17	000	0	120	962

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	BALLISTIC WINDS DIRECTION (100's MILS) dd	BALLISTIC WINDS SPEED (KNOTS) FF	BALLISTIC AIR TEMPERATURE % OF STD TTT	BALLISTIC AIR DENSITY % OF STD ΔΔΔ
SURFACE	00	61	08	965	017
200	01	63	12	990	014
500	02	02	15	997	007
1000	03	06	10	005	998
1500	04	04	13	007	979
2000	05	02	18	011	964
3000	06	03	16	014	961
4000	07	03	20	014	958
5000	08				
6000	09				
8000	10				
10000	11				
12000	12				
14000	13				
16000	14				
18000	15				

REMARKS

DELIVERED TO:
RECEIVED FROM:
TIME (GMT)
TIME (LST)

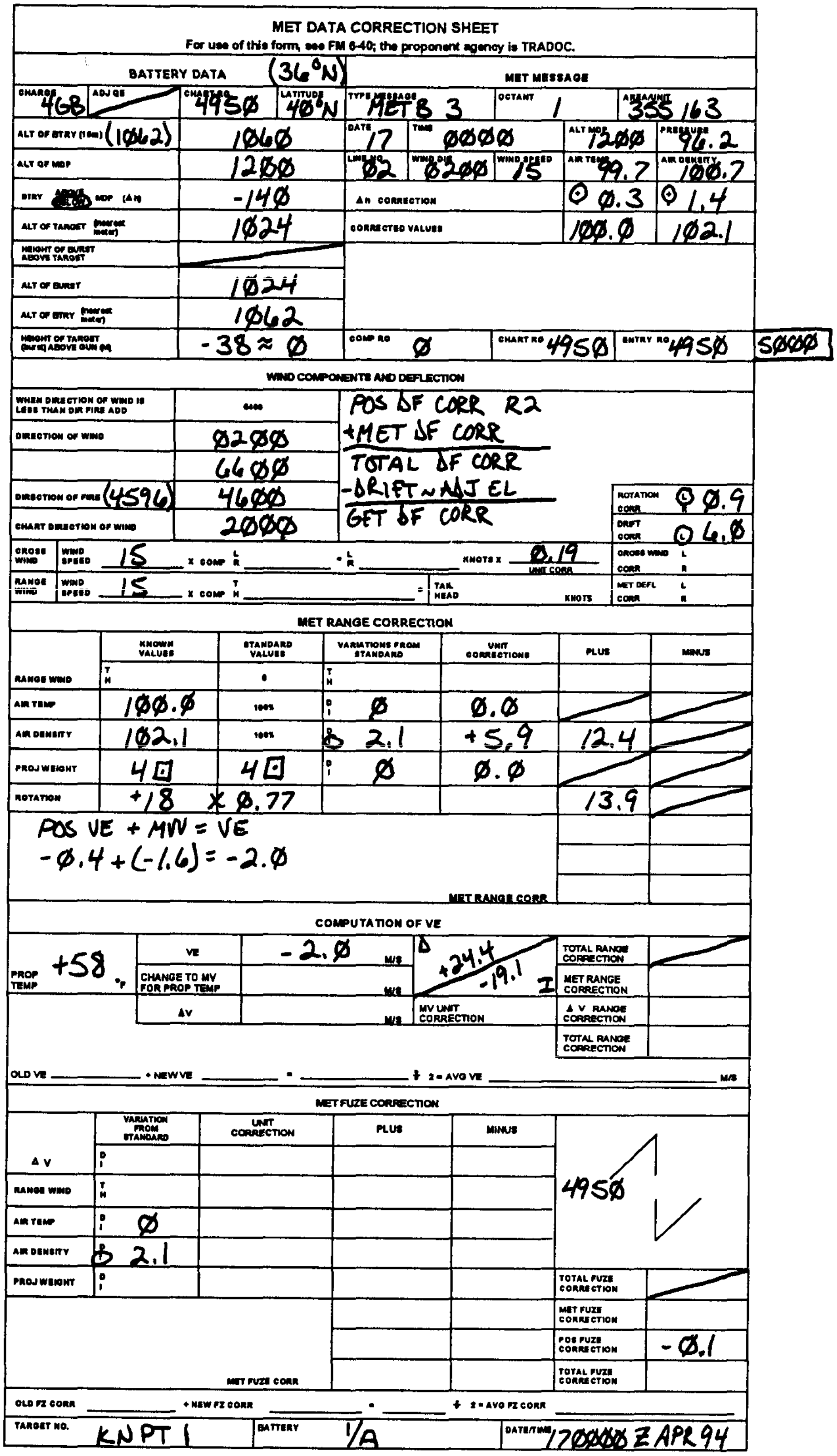
MESSAGE NUMBER
DATE

RECORDER
CHECKED

Figure 11-28. Valid Ballistic Met Message.

Table 11-5. Solution of a Subsequent Met (Continued).

STEP	ACTION
2l	Determine the variation from standard for air temperature and air density. Circle the (I) for an increase or the (D) for a decrease, and record the difference in the VARIATIONS FROM STANDARD column. Record the unit corrections from the concurrent met determined from Table F. Line out the appropriate block (PLUS or MINUS) and record the sum of the variation from standard multiplied by the unit correction. Transfer the values of the variation from standard to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section.
2m	Record the target altitude and altitude of the burst (nearest meter)(**1024**).
2n	Determine the height of target above gun (VI) to the nearest 1 meter, and express it to the nearest 100 meters.
	ALT OF BURST 1024 **ALT OF BTRY (nearest meter) 1062** **HEIGHT OF TARGET ABOVE GUN -38 ≈ 0**
2o	Record the complementary range (**0**) from the concurrent met determined from Table B.
	NOTE: If the height of target above the gun has changed from the concurrent met, determine the complementary range value by using Table B of the TFT. Enter the table with the chart range expressed to the nearest 100 meters and height of target above gun (VI) to the nearest 100 meters. Enter the value determined in the COMP RG block.
2p	Apply the complementary range to the chart range. The result is the entry range to the nearest meter. Express this value to the nearest 100 meters, and record it out to the side of the ENTRY RG block. **COMP RG 0** **CHART RG + 4950** **ENTRY RG 4950 ≈ 5000**
2q	Record the direction of fire (to the nearest mil in parentheses and to the nearest 100 mils in the block) (**4596 ≈ 4600**).
2r	Add 6400 to the direction of wind, since it is less than the direction of fire. Record the result in the blank space provided. Subtract the direction of fire from the direction of wind to determine the chart direction of wind. **DIRECTION OF WIND 0200** **+ 6400 6400** **DIRECTION OF WIND 6600** **- DIRECTION OF FIRE 4600** **CHART DIRECTION OF WIND 2000**
2s	Record the crosswind unit correction from the concurrent met determined from Table F (**0.19**).
2t	Record the azimuth correction for rotation from the concurrent met determined from Table I (**L0.9**).
2u	Record the azimuth correction for drift from the concurrent met determined from Table F (**L6.0**).
2v	Record the ◙ weight of the projectile fired during the registration from the concurrent met (**4◙**). Record the standard projectile weight determined from the introduction of the appropriate TFT (**4◙**). Record the difference in the VARIATIONS FROM STANDARD column (**0**). Transfer the result to the VARIATION FROM STANDARD column under the MET FUZE CORRECTION section.
2w	Record the range correction for rotation and the correction factor for the change in latitude from the concurrent met determined from Table H (**+18 x .77**). Line out the appropriate block (PLUS or MINUS), and record the product.
2x	Record the current propellant temperature (**+58**).



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE
CHART RG 4950	LATITUDE 40°N
ALT OF BTRY (10m) (1062)	1060
ALT OF MDP	1200
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140
ALT OF TARGET (nearest meter)	1024
HEIGHT OF BURST ABOVE TARGET	
ALT OF BURST	1024
ALT OF BTRY (nearest meter)	1062
HEIGHT OF TARGET (burst) ABOVE GUN (M)	-38 ≈ 0

MET MESSAGE

TYPE MESSAGE MET B 3		OCTANT 1		AREA/UNIT 355 163
DATE 17	TIME 0000		ALT MDP 1200	PRESSURE 96.2
LINE NO 02	WIND DIR 0200	WIND SPEED 15	AIR TEMP 99.7	AIR DENSITY 100.7
Δh CORRECTION			⊕ 0.3	⊕ 1.4
CORRECTED VALUES			100.0	102.1

COMP RG 0 CHART RG 4950 ENTRY RG 4950 5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	0200
	6600
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	2000

POS DF CORR R2
+MET DF CORR
TOTAL DF CORR
-DRIFT ~ ADJ EL
GFT DF CORR

ROTATION CORR Ⓛ 0.9
DRIFT CORR Ⓛ 6.0

CROSS WIND: WIND SPEED 15 X COMP L/R ______ = L/R ______ KNOTS X 0.19 UNIT CORR — CROSS WIND CORR L/R

RANGE WIND: WIND SPEED 15 X COMP T/H ______ = TAIL/HEAD ______ KNOTS — MET DEFL CORR L/R

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T/H	0	T/H			
AIR TEMP	100.0	100%	D/I 0	0.0		
AIR DENSITY	102.1	100%	Ⓓ 2.1	+5.9	12.4	
PROJ WEIGHT	4⊡	4⊡	D/I 0	0.0		
ROTATION	+18	X 0.77			13.9	

POS VE + MVV = VE
-0.4 + (-1.6) = -2.0

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +58 °F	VE	-2.0 M/S	Δ +24.4 / -19.1 I	TOTAL RANGE CORRECTION	
	CHANGE TO MV FOR PROP TEMP	M/S		MET RANGE CORRECTION	
	ΔV	M/S	MV UNIT CORRECTION	Δ V RANGE CORRECTION	
				TOTAL RANGE CORRECTION	

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	D/I			
RANGE WIND	T/H			
AIR TEMP	D/I 0			
AIR DENSITY	Ⓓ 2.1			
PROJ WEIGHT	D/I			

4950

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	

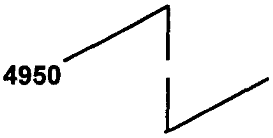
MET FUZE CORR

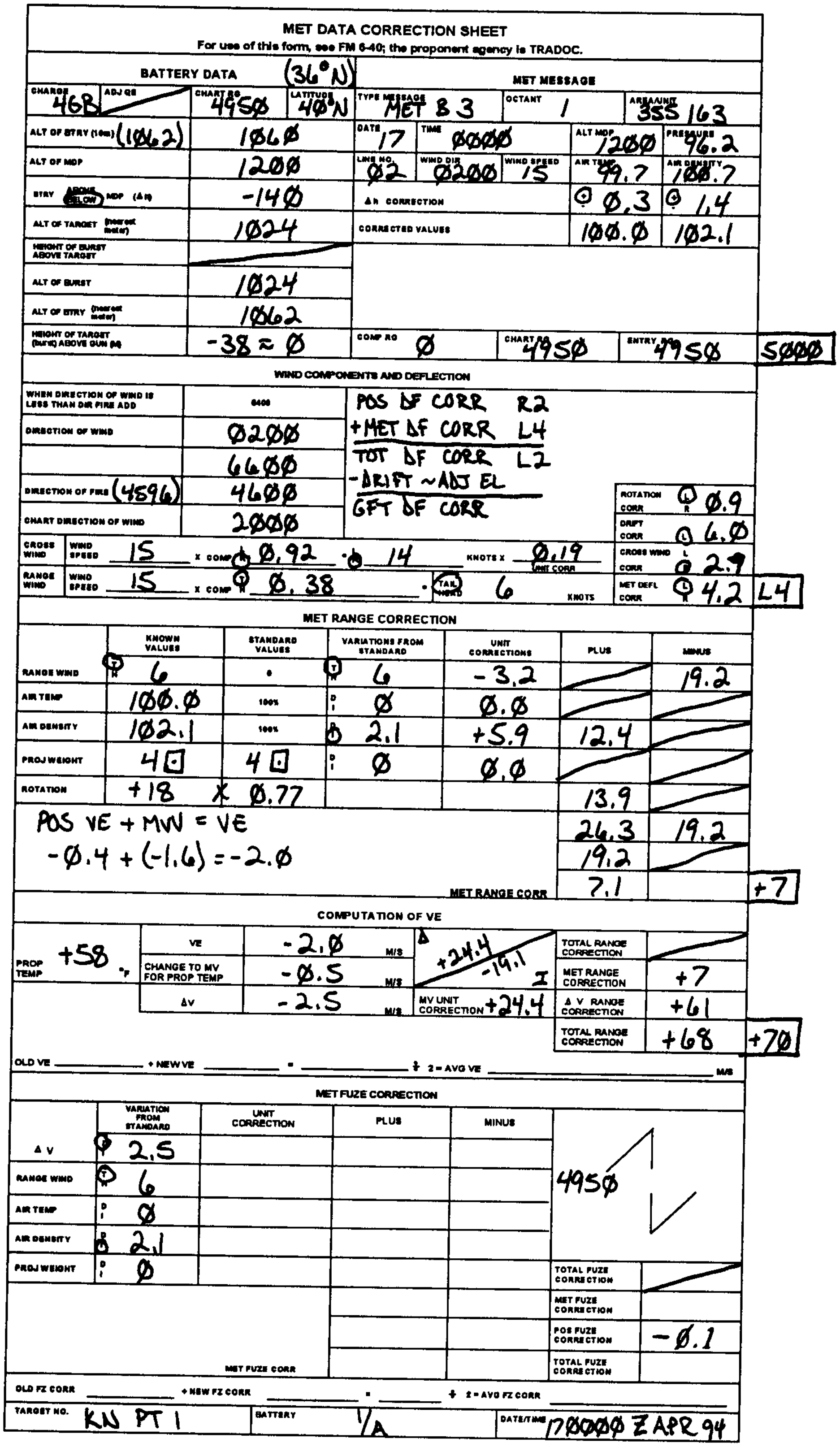
OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KNPT 1 BATTERY 1/A DATE/TIME 170000 Z APR 94

Figure 11-29. DA Form 4200 With Known Data for a Subsequent Met Technique.

Table 11-5. Solution of a Subsequent Met (Continued).

STEP	ACTION
2y	Divide the MV UNIT CORRECTION block in half with a diagonal line, and record both range correction values for muzzle velocity from the concurrent met determined from Table F (**DEC +24.4/INC -19.1**).
2z	Record the lazy Z in the bottom computational block. Show only the chart range. 
2aa	Line out the top TOTAL RANGE CORRECTION block and the top TOTAL FUZE CORRECTION block.
2bb	Record the known point number (**KN PT 1**).
2cc	Record the unit designation (**1/A**).
2dd	Record date-time group.
	NOTE: A DA Form 4200 with the above known data is shown in Figure 11-29.
3	Determine crosswind and range components from Table C. (See Figure 11-30.)
3a	Enter Table C with the chart direction of wind (**2000**). Extract and record the crosswind (**R0.92**) component and range wind (**T0.38**) component.
3b	Multiply the wind components by the wind speed, and express the result to the nearest 1 knot. Circle the appropriate symbol (L or R for crosswind and T or H for range wind).
3c	Multiply the crosswind determined in step 3b (**R14**) by the unit correction for crosswind (**0.19**) from Table F that was already recorded. Record the sum (**R2.7**) in the CROSS WIND CORR block.
4	Determine the met deflection correction. (See Figure 11-30.)
	Algebraically add the values for rotation, drift, and cross wind. Express the result to the nearest 1 mil, and record the result to the right of the MET DEFL CORR block as a left (L) or a right (R). **ROTATION CORRECTION L0.9** **+ DRIFT CORRECTION L6.0** **+ CROSSWIND CORRECTION R2.7** **MET DEFLECTION CORRECTION L4.2 ≈ L4**
5	Determine total deflection correction. (See Figure 11-30.) Record the met deflection correction in the equation for deflection, and algebraically add the met deflection correction and the position deflection correction, applying the correct sign. **POS DF CORR R2** **+ MET DF CORR L4** **TOTAL DF CORR L2**
6	Record the value determined for range wind (**T6**) in the KNOWN VALUES column of the MET RANGE CORRECTION section. Determine and record the variation from standard, and transfer it down to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section. (See Figure 11-30.)
7	Determine from Table E the correction to muzzle velocity for propellant temperature.
7a	Enter Table E with the propellant temperature to the nearest degree Fahrenheit (**+58°**). (See Figure 11-30.)
7b	Interpolate the change to muzzle velocity as required.
7c	Record the correction (**-0.5**) in the CHANGE TO MV FOR PROP TEMP block.
8	Determine the ▲V range correction. (See Figure 11-30.)
8a	Algebraically add the VE (**-2.0**) and the change to MV for propellant temperature (**-0.5**) to determine the ▲V (**-2.5**).



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE	CHART RQ 4950	LATITUDE 40°N
ALT OF BTRY (10m) (1062)	1060		
ALT OF MDP	1200		
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140		
ALT OF TARGET (nearest meter)	1024		
HEIGHT OF BURST ABOVE TARGET			
ALT OF BURST	1024		
ALT OF BTRY (nearest meter)	1062		
HEIGHT OF TARGET (burst) ABOVE GUN (m)	-38 ≈ 0		

MET MESSAGE

TYPE MESSAGE MET B3	OCTANT 1	AREA/UNIT 355 163		
DATE 17	TIME 0000		ALT MDP 1200	PRESSURE 96.2
LINE NO. 02	WIND DIR 0200	WIND SPEED 15	AIR TEMP 99.7	AIR DENSITY 100.7
Δh CORRECTION			+ 0.3	+ 1.4
CORRECTED VALUES			100.0	102.1

COMP RQ 0	CHART RQ 4950	ENTRY RQ 4950	5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	0200
	6600
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	2000

POS DF CORR R2
+MET DF CORR L4
TOT DF CORR L2
-DRIFT ~ADJ EL
GFT DF CORR

CROSS WIND WIND SPEED 15 x COMP [✓ L] R 0.92 = [✓ L] R 14 KNOTS x 0.19 UNIT CORR

RANGE WIND WIND SPEED 15 x COMP [✓ T] H 0.38 = [✓ TAIL] HEAD 6 KNOTS

ROTATION CORR	[✓ L] R 0.9
DRIFT CORR	[✓ L] R 6.0
CROSS WIND CORR	L [✓ R] 2.9
MET DEFL CORR	[✓ L] R 4.2

L4

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	[✓ T] H 6	0	[✓ T] H 6	-3.2		19.2
AIR TEMP	100.0	100%	D I 0	0.0		
AIR DENSITY	102.1	100%	D [✓ I] 2.1	+5.9	12.4	
PROJ WEIGHT	4□	4□	D I 0	0.0		
ROTATION	+18 × 0.77				13.9	
					26.3	19.2
					19.2	
MET RANGE CORR					7.1	

POS VE + MVV = VE
-0.4 + (-1.6) = -2.0

+7

COMPUTATION OF VE

PROP TEMP +58 °F	VE	-2.0 M/S	Δ +24.4 / -19.1 I	TOTAL RANGE CORRECTION	
	CHANGE TO MV FOR PROP TEMP	-0.5 M/S		MET RANGE CORRECTION	+7
	ΔV	-2.5 M/S	MV UNIT CORRECTION +24.4	Δ V RANGE CORRECTION	+61
				TOTAL RANGE CORRECTION	+68

+70

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
ΔV	[✓ +] 2.5			
RANGE WIND	[✓ T] H 6			
AIR TEMP	D I 0			
AIR DENSITY	D [✓ I] 2.1			
PROJ WEIGHT	D I 0			
MET FUZE CORR				

4950

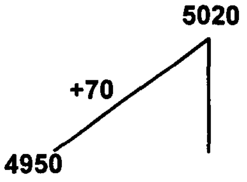
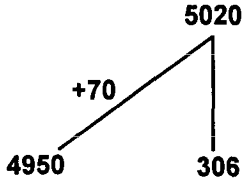
TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	

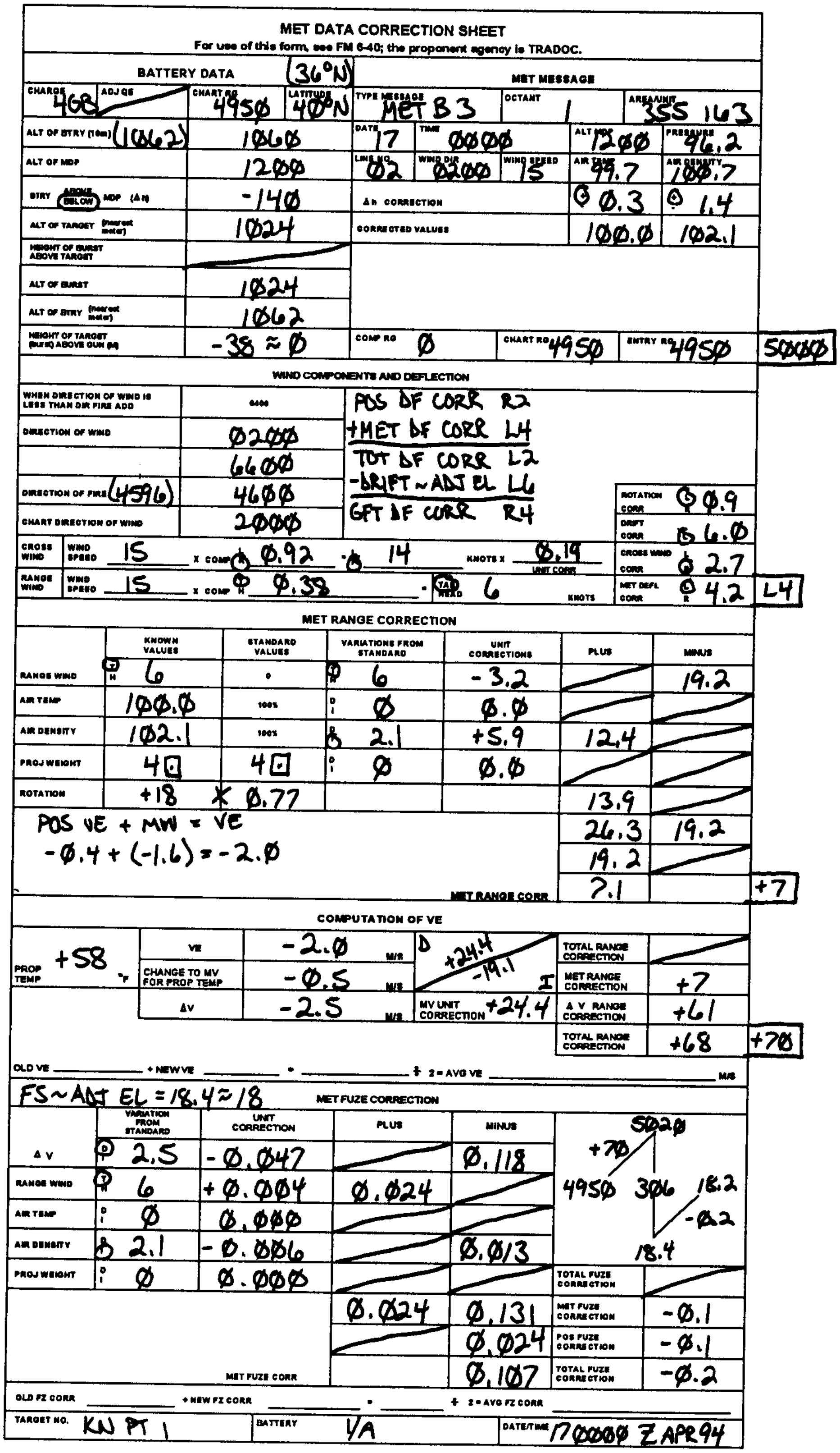
OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1	BATTERY 1/A	DATE/TIME 170000 Z APR 94

Figure 11-30. DA Form 4200 With Total Deflection and Total Range Corrections

Table 11-5. Solution of a Subsequent Met (Continued).

STEP	ACTION
8b	Multiply the ▲V (**-2.5**) by the appropriate MV unit correction (**DEC +24.4**).
8c	Express the result to the nearest 1 meter, and record it in the ▲V RANGE CORRECTION block. The ▲V range correction will have the opposite sign of the ▲V (**+61**).
8d	Once the ▲V has been determined, it can be recorded in the VARIATION FROM STANDARD column under the MET FUZE CORRECTION section.
9	Determine from Table F the unit correction factors. (See Figure 11-30.)
9a	Enter Table F with entry range (**5000**). Extract and record the unit correction for range wind (**-3.2**), air temperature (**0.0**), and air density (**+5.9**).
9b	Multiply the variation from standard for range wind (**T6**) by the unit correction (**-3.2**), line out the appropriate block (PLUS or MINUS), and record the result (**19.2**).
9c	Multiply the variation from standard for air temperature (**0**) by the unit correction (**0.0**), line out the appropriate block (PLUS or MINUS), and record the result (**0.0**).
10	Determine the met range correction. (See Figure 11-30.)
10a	Total the PLUS column, and total the MINUS column. Subtract the smaller from the larger. Express the result to the nearest 1 meter, and record it out to the side of the MET RANGE CORR block with the appropriate sign.
10b	Record the met range correction (**+7**) in the MET RANGE CORRECTION block under the COMPUTATION OF VE section.
11	Determine the total range correction. (See Figure 11-30.)
	Algebraically add the met range correction (**+7**) and the ▲V range correction (**+61**) to determine the total range correction (**+68**). Express the result to the nearest 10 meters (**+70**), and record it out to the side of the TOTAL RANGE CORRECTION block. **MET RANGE CORRECTION** **+7** **+ ▲V RANGE CORRECTION** **+ (+61)** **TOTAL RANGE CORRECTION** **+68 ≈ +70**
12	Determine the adjusted elevation. (See Figure 11-31.)
12a	Apply the total range correction to the chart range on the lazy Z. 
12b	Place the MHL of the GFT over the range corresponding to the adjusted elevation (**5020**), and read the adjusted elevation under the MHL (**306**). 



MET DATA CORRECTION SHEET
For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE	CHART RG 4950	LATITUDE 40°N
ALT OF BTRY (10m) (1062)	1060		
ALT OF MDP	1200		
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140		
ALT OF TARGET (nearest meter)	1024		
HEIGHT OF BURST ABOVE TARGET			
ALT OF BURST	1024		
ALT OF BTRY (nearest meter)	1062		
HEIGHT OF TARGET (burst) ABOVE GUN (M)	-38 ≈ 0		

MET MESSAGE

TYPE MESSAGE MET B3		OCTANT 1		AREA/UNIT 355 163
DATE 17	TIME 0000		ALT MDP 1200	PRESSURE 96.2
LINE NO 02	WIND DIR 0200	WIND SPEED 15	AIR TEMP 99.7	AIR DENSITY 100.7
Δh CORRECTION			Ⓘ 0.3	Ⓘ 1.4
CORRECTED VALUES			100.0	102.1

COMP RG 0	CHART RG 4950	ENTRY RG 4950	5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	0200
	6600
DIRECTION OF FIRE (4596)	4600
CHART DIRECTION OF WIND	2000

POS DF CORR R2
+MET DF CORR L4
TOT DF CORR L2
-DRIFT ~ ADJ EL L6
GFT DF CORR R4

CROSS WIND: WIND SPEED 15 x COMP Ⓛ 0.92 = Ⓛ 14 KNOTS x 0.19 UNIT CORR
RANGE WIND: WIND SPEED 15 x COMP Ⓣ 0.38 = ⓉAIL/HEAD 6 KNOTS

ROTATION CORR	Ⓛ 0.9
DRIFT CORR	Ⓛ 6.0
CROSS WIND CORR	Ⓛ 2.7
MET DEFL CORR	Ⓛ 4.2

L4

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	Ⓣ 6	0	Ⓣ 6	-3.2		19.2
AIR TEMP	100.0	100%	0	0.0		
AIR DENSITY	102.1	100%	Ⓘ 2.1	+5.9	12.4	
PROJ WEIGHT	4□	4□	0	0.0		
ROTATION	+18	✱ 0.77			13.9	
					26.3	19.2
					19.2	
				MET RANGE CORR	7.1	

POS VE + MW = VE
-0.4 + (-1.6) = -2.0

+7

COMPUTATION OF VE

PROP TEMP +58 °F	VE	-2.0 M/S	D +24.4 / -19.1 I	TOTAL RANGE CORRECTION	
	CHANGE TO MV FOR PROP TEMP	-0.5 M/S		MET RANGE CORRECTION	+7
	ΔV	-2.5 M/S	MV UNIT CORRECTION +24.4	ΔV RANGE CORRECTION	+61
				TOTAL RANGE CORRECTION	+68

+70

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS~ADJ EL = 18.4 ≈ 18

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
ΔV	Ⓓ 2.5	-0.047		0.118
RANGE WIND	Ⓣ 6	+0.004	0.024	
AIR TEMP	0	0.000		
AIR DENSITY	Ⓘ 2.1	-0.006		0.013
PROJ WEIGHT	0	0.000		
			0.024	0.131
				0.024
		MET FUZE CORR		0.107

5020
+70
4950 306 18.2
-0.2
18.4

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	-0.1
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	-0.2

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1	BATTERY 1/A	DATE/TIME 170000 Z APR94

Figure 11-31. Completed DA Form 4200 Containing the Subsequent Met.

Table 11-5. Solution of a Subsequent Met (Continued).

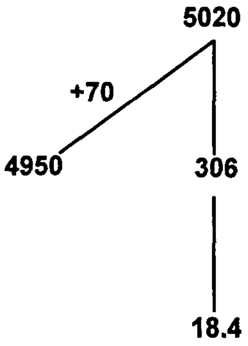
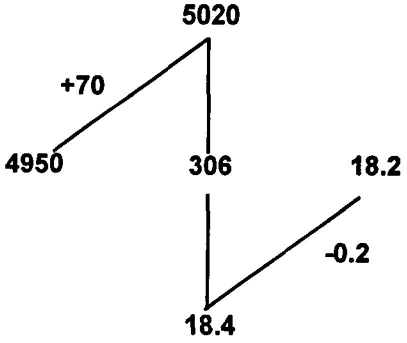
STEP	ACTION
12c	With the MHL on the adjusted elevation, determine the fuze setting corresponding to the adjusted elevation from the M582 scale (**18.4**) and record it on the lazy Z. (If firing the M564 fuze, use the M564 scale.) 
13	Determine the GFT deflection correction. (See Figure 11-31.)
13a	Determine the drift corresponding to the adjusted elevation, and record it in the equation for deflection **(DRIFT ~ ADJ EL = L6)**.
13b	Algebraically subtract the drift corresponding to the adjusted elevation (**L6**) from the total deflection correction (**L2**) to determine the GFT deflection correction (**R4**). Record the result. **POS DF CORR R2** **+ MET DF CORR L4** **TOTAL DF CORR L2** **- DRIFT ~ ADJ EL L6** **GFT DF CORR R4**
14	Determine the met fuze correction. (See Figure 11-31.)
14a	All variations from standard should be entered in the MET FUZE CORRECTION section.
14b	Record the fuze setting corresponding to the adjusted elevation to the nearest 0.1, and then express it to the nearest whole fuze setting increment. Record it in the space to the left of the words "MET FUZE CORRECTION" as follows: **FS ~ ADJ EL = 18.4 ≈ 18**.
14c	Enter Table J with the fuze setting corresponding to the adjusted elevation expressed to the nearest whole increment.
14d	Extract and record the unit corrections for ▲V (**-0.047**), range wind (**+0.004**), air temperature (**0.000**), air density (**-0.006**), and projectile weight (**0.000**).
14e	Line out the appropriate block (PLUS or MINUS). Multiply the unit correction by the variation from standard, and record the result.
14f	Total the PLUS column, and total the MINUS column. Subtract the smaller from the larger, and express the result to the nearest 0.1.
14g	Record the met fuze correction (**-0.1**) in the MET FUZE CORRECTION block.
15	Determine total fuze correction. (See Figure 11-31.)
	Algebraically add the position fuze correction (**0.1**) and the met fuze correction (**-0.1**) to determine the total fuze correction (**-0.2**). Record the result.

Table 11-5. Solution of a Subsequent Met (Continued).

<table>
<tr><th>STEP</th><th>ACTION</th></tr>
<tr><td>16</td><td>Determine adjusted time. (See Figure 11-31.)</td></tr>
<tr><td></td><td>Apply the total fuze correction (-0.2) to the fuze setting corresponding to the adjusted elevation (18.4) to determine the new adjusted fuze setting (18.2) to complete the lazy Z.



</td></tr>
<tr><td>17</td><td>Use the acronym UCARET, and determine the GFT setting. Record it on the side of DA Form 4200 as follows:
GFT 1/A CHG 4 LOT AG RG 4950 EL 306 TI 18.2 (M582)
TOTAL DF CORR L2 GFT DF CORR R4</td></tr>
<tr><td></td><td>NOTE: Figure 11-31 shows the completed subsequent met technique.</td></tr>
</table>

Section IV

Subsequent Met Applications

Subsequent met applications include eight-direction met, met to a met check gauge point, met to a target, and met + VE. These are called subsequent met techniques but they do not necessarily require met conditions that were subsequent to a registration nor are position constants required. They are listed under subsequent met techniques because they are used to determine new GFT settings or new total corrections. These techniques would also be used if the jive requirements for accurate predicted fire were being met or registration corrections were not available. The procedures would be identical to solving a subsequent met technique, with the exception that all position constants would be zero.

11-12. Eight-Direction Met

a. Certain combat conditions may require a firing unit to provide accurate artillery support throughout a 6,400-mil zone. Transfer limits define an area within which total corrections are-assumed to be valid. These transfer limits place a severe limitation on a 6,400-mil firing capability. Total corrections could be obtained by conducting a registration in each 800-mil sector of the unit's area of responsibility. Such registrations, however, would be costly and would endanger unit survivability. An alternative to registering in each 800-mil sector is the use of the eight-direction met technique.

b. The eight-direction met technique provides corrections to range, deflection, and fuze setting to compensate for the effects of ballistic wind direction and speed and for rotation of the earth throughout the firing unit's area of responsibility. These corrections are combined with the position constants determined in the concurrent met by solving a subsequent met in each 800-mil sector or selected 800-mil sectors. (See Figure 11-32.)

c. Lateral transfer limits can be eliminated for ranges of 10,000 meters or less by solving an eight-direction met. For ranges greater than 10,000 meters, because the lateral transfer limits are valid 4,000 meters left and right of the battery registration point, there will be areas between the 800-mil segments that are not covered by valid corrections. When needed, corrections to cover these areas must be computed by using the met-to-target technique.

d. The eight-direction met technique consists of two steps:

- Solution of a concurrent met technique to determine the position VE correction, position deflection correction, and position fuze correction.
- Solving for met corrections for other 800-mil segments by use of the met + VE technique and the position constants to determine GFT settings for those octants.

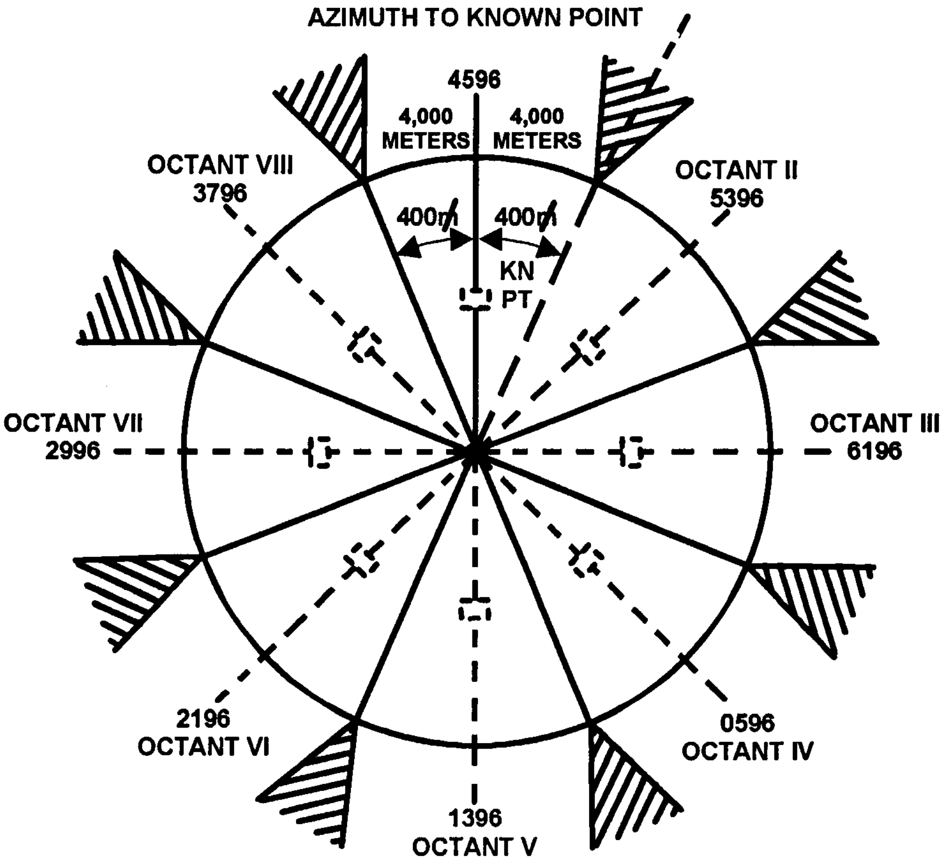


Figure 11-32. Met Octants.

NOTE: The direction of fire will be different for each octant. The value used for altitude of target is the altitude of the registration point. The **FS ~ ADJ EL** will be determined on the basis of the computed adjusted elevation. The eight-direction met technique could be solved without registering. The procedures would be identical to solving a subsequent met technique, with the exception that all position constants would be zero.

11-13. Solution of an Eight-Direction Met Technique

NOTE: This example illustrates how to solve the eight-direction met following the solution of the **concurrent met.**

a. All known data remain the same as the concurrent met except for the direction of fire. The direction of fire must be determined for the new octant by applying 800 roils to the original direction of fire.

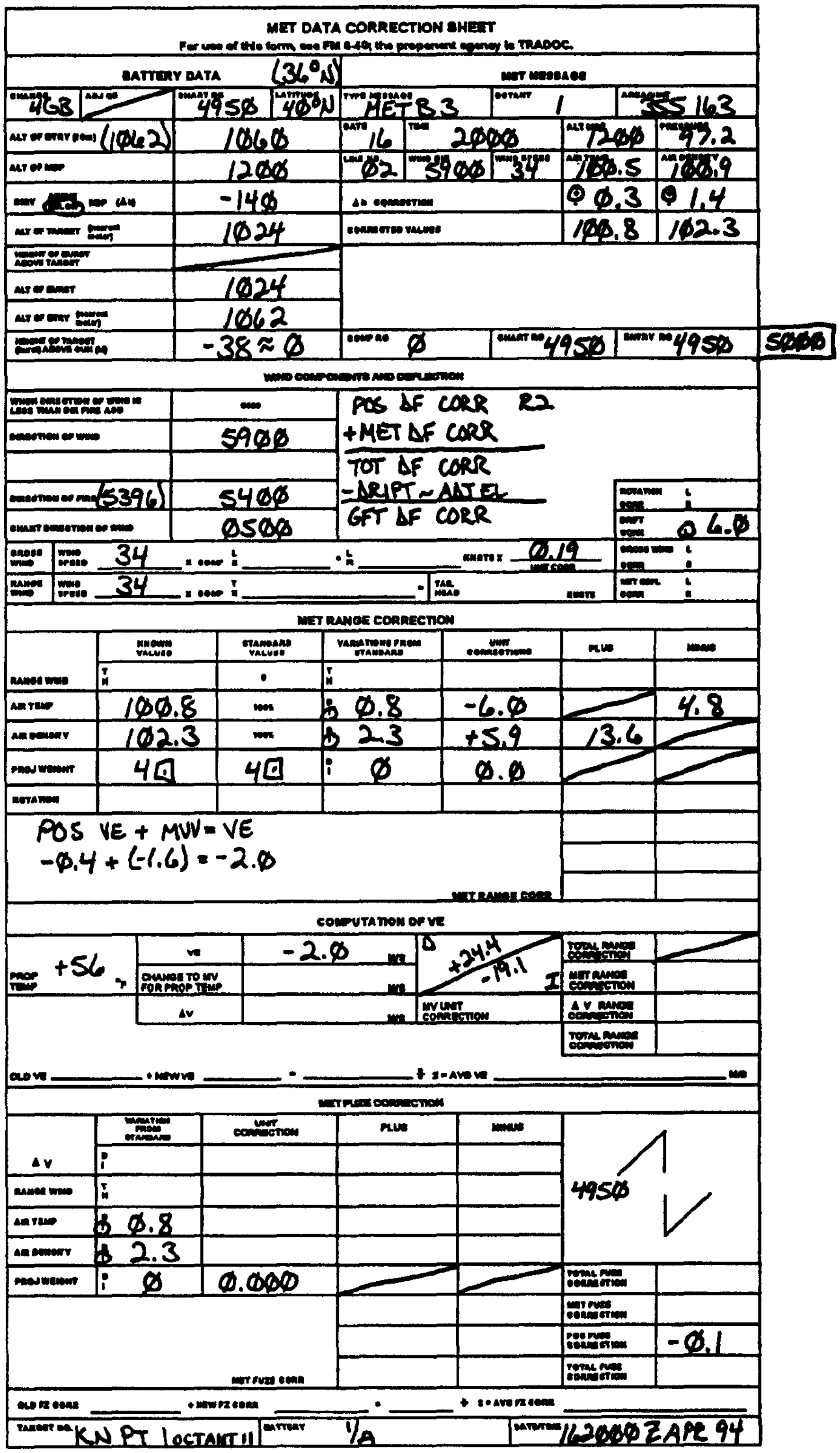
b. The steps shown in Table 11-6 give a detailed example of the solution of an eight-direction met technique.

Table 11-6. Eight-Direction Met.

STEP	ACTION
1	Record the position constants. (See Figure 11-33.)
1a	Record the position deflection correction (**R2**) in the WIND COMPONENTS AND DEFLECTION computational space. Use the equation **POS DF CORR + MET DF CORR = TOTAL DF CORR - DRIFT ~ ADJ EL = GFT DF CORR** in the wind components and deflection computational space. Record it as follows:
	POS DF CORR R2 **+ MET DF CORR** **TOTAL DF CORR** **- DRIFT ~ ADJ EL** **GFT DF CORR**
1b	Record the position VE determined from the registration (**-0.4**) in the MET RANGE CORRECTION computational block. Use the equation **POS VE + MVV = VE**. Once the equation is written and the VE determined, record the VE in the COMPUTATION OF VE section VE block. **POS VE + MVV = VE** **-0.4 + (-1.6) = -2.0**
1c	Record the position fuze correction (**-0.1**).
2	Record the known data. (See Figure 11-33, page 11-53.)
2a	Record the charge (**4GB**).
	NOTE: Use the met line number from the concurrent met, and record the met message.
2b	Record the line number of the met message in the **LINE NO**. block (**02**).
2c	Record the met message data on DA Form 4200. The ballistic met message is shown in Figure 11-34, page 11-55.
2d	Record data from the identification line (**METB3, 1, 355163, 16, 2000, 1200, 97.2**) in the MET MESSAGE section, and record the altitude of the MDP (**1200**) in the BATTERY DATA section.

Table 11-6. Eight-Direction Met (Continued).

STEP	ACTION
2e	Record the met data from line 02. Record the wind direction (**5900**), wind speed (**34**), air temperature (**100.5**), and air density (**100.9**) in all appropriate blocks. (See Figure 11-33.)
2f	Record the chart range in both blocks (**4950**).
2g	Record the latitude (nearest 10°)(**35.5°N ≈ 40°N**).
2h	Record the battery altitude (to the nearest 1 meter in parentheses and to the nearest 10 meters in the block) (**1062 ≈ 1060**). Record the battery altitude to the nearest 1 meter in the lower block (**1062**).
2i	Determine the difference in altitude between the battery and the MDP. **ALT OF BTRY 1060** **- ALT OF MDP -(1200)** **BTRY (BELOW) MDP -140**
2j	Record the corrections from the concurrent met determined from Table D that are applied to the temperature and density to compensate for the difference in altitude between the battery and the MDP. **DT CORRECTION +0.3 DD CORRECTION +1.4**
2k	Apply the corrections to the temperature and density, and record the result in the CORRECTED VALUES block in the MET MESSAGE section and in the KNOWN VALUES column of the MET RANGE CORRECTION section. **AIR TEMP 100.5 AIR DENSITY 100.9** **▲h CORRECTION +0.3 ▲h CORRECTION +1.4** **CORRECTED VALUE 100.8 CORRECTED VALUE 102.3**
2l	Determine the variation from standard for air temperature and air density. Circle the (I) for an increase or the (D) for a decrease, and record the difference in the VARIATIONS FROM STANDARD column. Record the unit corrections from the concurrent met determined from Table F. Line out the appropriate block (PLUS or MINUS), and record the sum of the variation from standard multiplied by the unit correction. Transfer the values of the variation from standard to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section.
2m	Record target altitude and altitude of the burst (to the nearest meter)(**1024**).
2n	Determine the height of target above gun (VI) to the nearest 1 meter, and express it to the nearest 100 meters. **ALT OF BURST 1024** **ALT OF BTRY (nearest meter) 1062** **HEIGHT OF TARGET ABOVE GUN -38 ≈ 0**
2o	Record the complementary range (**0**) from the concurrent met determined from Table B.
2p	Apply the complementary range to the chart range. The result is the entry range to the nearest meter. Express this value to the nearest 100 meters, and record it out to the side of the ENTRY RG block. **COMP RG 0** **CHART RG 4950** **ENTRY RG 4950 ≈ 5000**
2q	Determine the new direction of fire by applying 800 mils to the original direction of fire. Record the result (to the nearest mil in parentheses and to the nearest 100 mils in the block)(**4596 + 800 mils = 5396 ≈ 5400**).
2r	Determine and record the chart direction of wind. Subtract the direction of fire from the direction of wind to determine the chart direction of wind. **DIRECTION OF WIND 5900** **- DIRECTION OF FIRE 5400** **CHART DIRECTION OF WIND 0500**
2s	Record the crosswind unit correction from the concurrent met determined from Table F (**0.19**).



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE	CHART QE 4950	LATITUDE 40°N
ALT OF BTRY (10m) (1062)	1060		
ALT OF MDP	1200		
BTRY [illegible] MDP (Δh)	-140		
ALT OF TARGET (nearest meter)	1024		
HEIGHT OF BURST ABOVE TARGET			
ALT OF BURST	1024		
ALT OF BTRY (nearest meter)	1062		
HEIGHT OF TARGET (burst) ABOVE GUN (m)	-38 ≈ 0		

MET MESSAGE

TYPE MESSAGE METB3		OCTANT 1		AREA/MET 355163
DATE 16	TIME 2000		ALT MDP 1200	PRESSURE 97.2
LINE NO 02	WIND DIR 5900	WIND SPEED 34	AIR TEMP 100.5	AIR DENSITY 100.9
Δh CORRECTION			⊕ 0.3	⊕ 1.4
CORRECTED VALUES			100.8	102.3

COMP RG 0 | CHART RG 4950 | ENTRY RG 4950 | 5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5900
DIRECTION OF FIRE (5396)	5400
CHART DIRECTION OF WIND	0500

POS DF CORR R2
+MET DF CORR
TOT DF CORR
-DRIFT ~ ADJ EL
GFT DF CORR

ROTATION CORR L R
DRIFT CORR ⊘ 6.0
CROSS WIND CORR L R
MET DEFL CORR L R

CROSS WIND: WIND SPEED 34 × COMP L/R ____ = L/R ____ KNOTS × 0.19 UNIT CORR

RANGE WIND: WIND SPEED 34 × COMP T/H ____ = TAIL/HEAD ____ KNOTS

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T H	0	T H			
AIR TEMP	100.8	100%	I 0.8	-6.0		4.8
AIR DENSITY	102.3	100%	I 2.3	+5.9	13.6	
PROJ WEIGHT	4□	4□	D I 0	0.0		
ROTATION						

POS VE + MUV = VE
-0.4 + (-1.6) = -2.0

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +56 °F	VE	-2.0 m/s	D +24.4 / I -19.1	TOTAL RANGE CORRECTION	
	CHANGE TO MV FOR PROP TEMP	m/s		MET RANGE CORRECTION	
	ΔV	m/s	MV UNIT CORRECTION	ΔV RANGE CORRECTION	
				TOTAL RANGE CORRECTION	

OLD VE ____ + NEW VE ____ = ____ ÷ 2 = AVG VE ____ M/S

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
ΔV	D I			
RANGE WIND	T H			
AIR TEMP	I 0.8			
AIR DENSITY	I 2.3			
PROJ WEIGHT	D I 0	0.000		

4950

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	

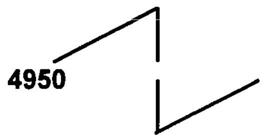
MET FUZE CORR

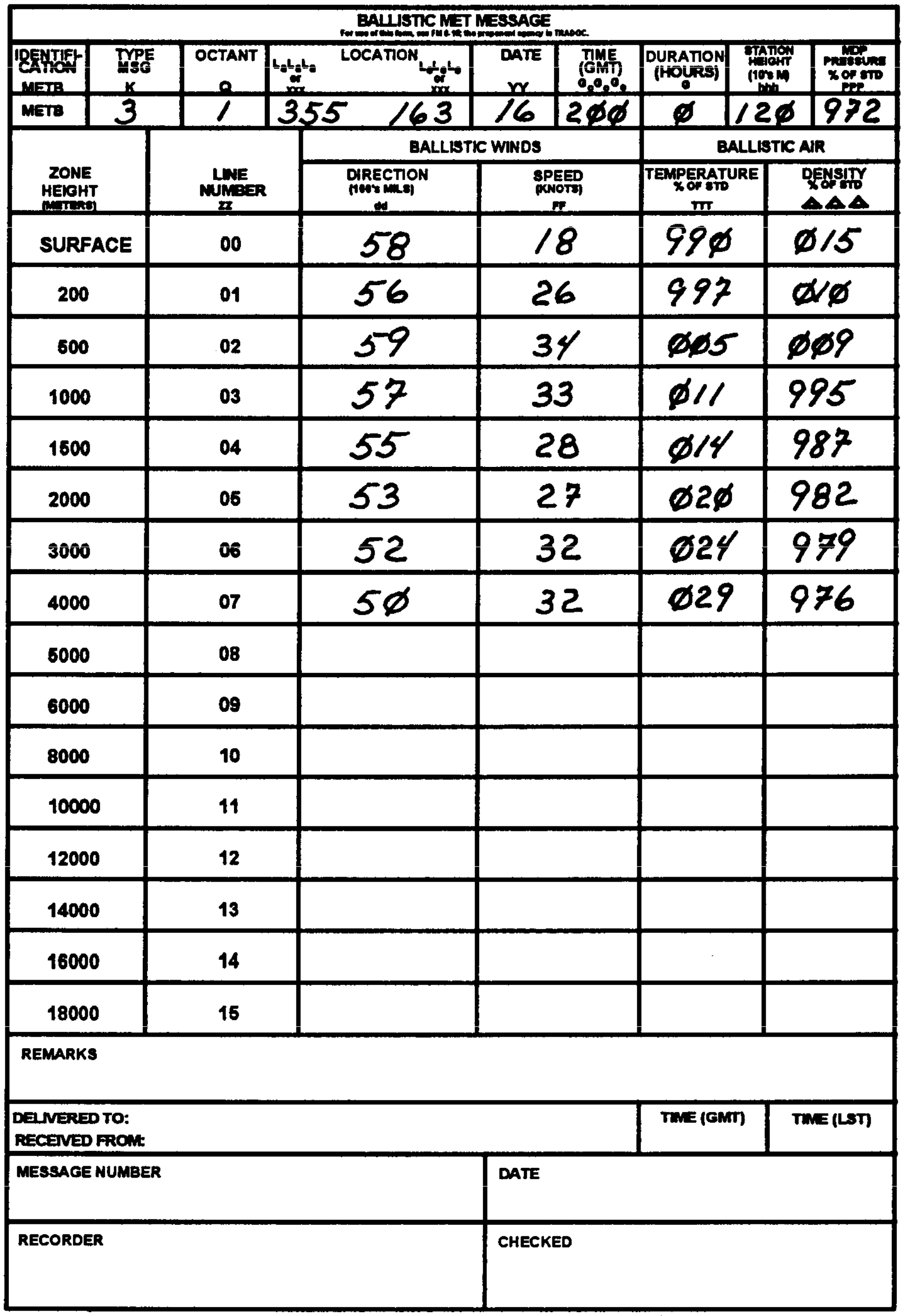
OLD FZ CORR ____ + NEW FZ CORR ____ = ____ ÷ 2 = AVG FZ CORR ____

TARGET NO. KN PT OCTANT 1 | BATTERY 1/A | DATE/TIME 162000Z APR 94

Figure 11-33. DA Form 4200 With Known Data for an Eight-Direction Met Technique.

Table 11-6. Eight-Direction Met (Continued).

STEP	ACTION
2t	Record the azimuth correction for drift from the concurrent met determined from Table F (**L6.0**).
2u	Record the ▣ weight of the projectile fired during the registration from the concurrent met (**4** ▣). Record the standard projectile weight determined from the introduction of the appropriate TFT (**4** ▣). Record the difference in the VARIATION FROM STANDARD column (**0**) in the MET RANGE CORRECTION section. Record (**0.0**) in the UNIT CORRECTION block in the MET RANGE CORRECTION section, and line out the PLUS and MINUS columns. Transfer the projectile weight from the VARIATIONS FROM STANDARD column (**0**) in the MET RANGE CORRECTION section to the VARIATIONS FROM STANDARD column under the MET FUZE CORRECTION section. Record the projectile weight (**0.000**) in the UNIT CORRECTIONS block in the MET FUZE CORRECTION section, and line out the PLUS and MINUS columns.
2v	Record the current propellant temperature (**+56**).
2w	Divide the MV UNIT CORRECTION block in half with a diagonal line, and record both range correction values for muzzle velocity from the subsequent met determined from Table F (**DEC +24.4/INC -19.1**).
2x	Line out the top TOTAL RANGE CORRECTION block and the top TOTAL FUZE CORRECTION block.
2y	Record the lazy Z in the bottom computational block. Show only the chart range. 
2z	Record the known point number (**KN PT 1**) and the octant for which the met is being solved (**Octant II**).
2aa	Record the unit designation (**1/A**).
2bb	Record the date-time group.
	NOTE: A DA Form 4200 with the above known data is shown in Figure 11-33.
3	Determine crosswind and range components from Table C. (See Figure 11-35, page 11-57.)
3a	Enter Table C with the chart direction of wind (**0500**). Extract and record the crosswind (**R0.47**) component and range wind (**H0.88**) component.
3b	Multiply the wind components by the wind speed, and express the result to the nearest 1 knot. Circle the appropriate symbol (L or R for crosswind and T or H for range wind).
3c	Multiply the crosswind determined in step 3b (**R16**) by the unit correction for crosswind (**0.19**) from Table F that was already recorded. Record the sum (**R3.0**) in the CROSS WIND CORR block.
3d	Record the value determined for range wind (**H30**) in the KNOWN VALUES column of the MET RANGE CORRECTION section. Determine the variation from standard. Record it in the VARIATIONS FROM STANDARD column of the MET RANGE CORRECTION section. Transfer it down to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section.
4	Determine from Table E the correction to muzzle velocity for propellant temperature. (See Figure 11-35.)
4a	Enter Table E with the propellant temperature to the nearest degree Fahrenheit (**+56°**).
4b	Interpolate the change to muzzle velocity as required.
4c	Record the correction (**-0.6**) in the CHANGE TO MV FOR PROP TEMP block.
5	Determine the ▲V range correction. (See Figure 11-35.)



BALLISTIC MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or xxx	LOCATION $L_oL_oL_o$ or xxx	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	355	163	16	200	0	120	972

		BALLISTIC WINDS		BALLISTIC AIR	
ZONE HEIGHT (METERS)	LINE NUMBER ZZ	DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE % OF STD TTT	DENSITY % OF STD ▲▲▲
SURFACE	00	58	18	990	015
200	01	56	26	997	010
500	02	59	34	005	009
1000	03	57	33	011	995
1500	04	55	28	014	987
2000	05	53	27	020	982
3000	06	52	32	024	979
4000	07	50	32	029	976
5000	08				
6000	09				
8000	10				
10000	11				
12000	12				
14000	13				
16000	14				
18000	15				

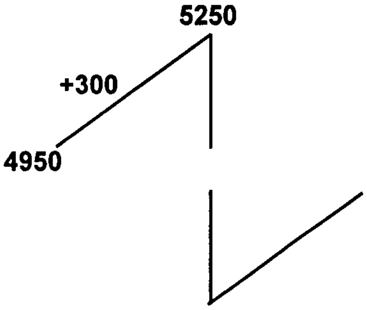
REMARKS

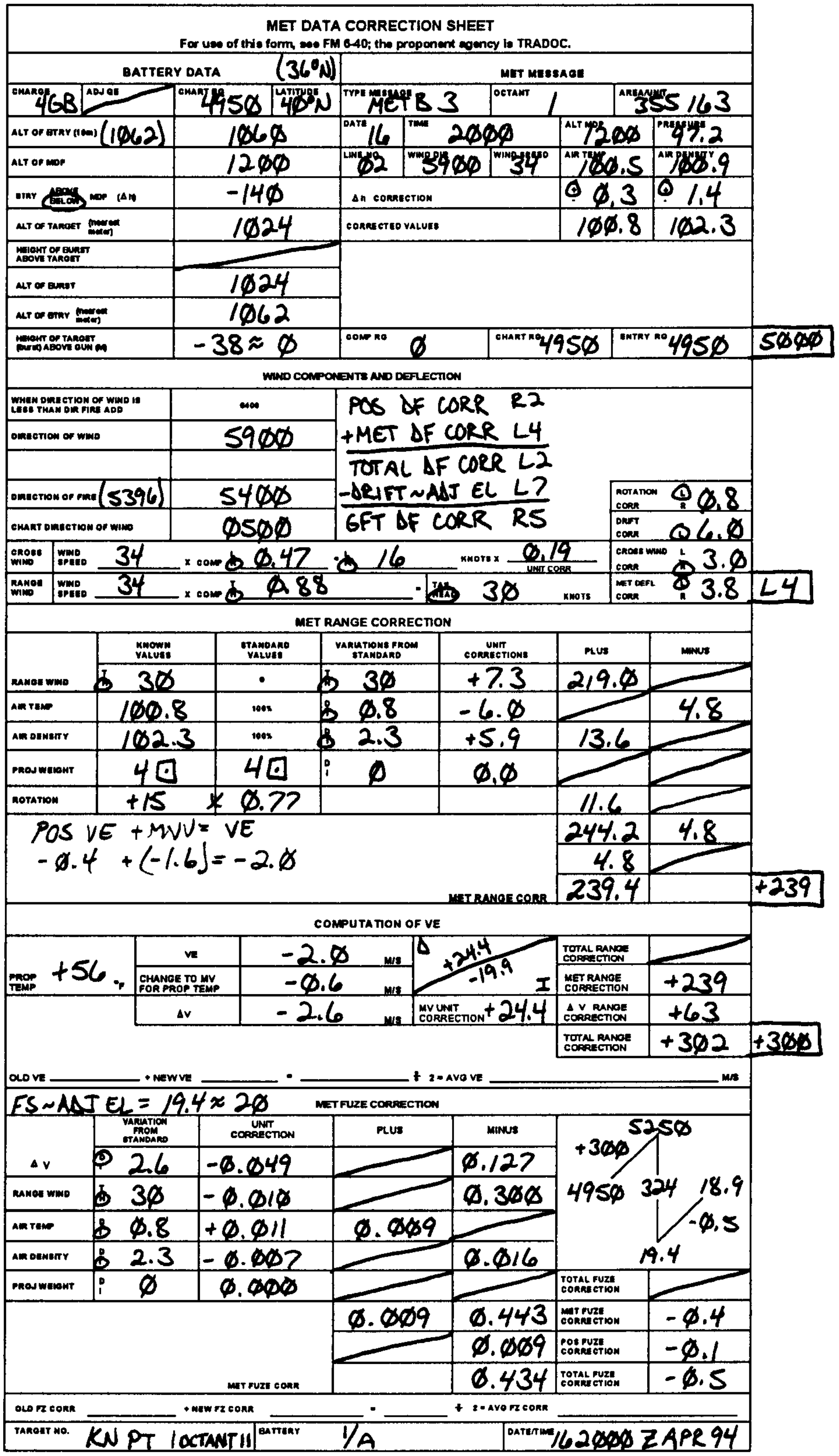
DELIVERED TO: RECEIVED FROM:	TIME (GMT)	TIME (LST)
MESSAGE NUMBER	DATE	
RECORDER	CHECKED	

DA FORM 3675, MAY 92

Figure 11-34. Valid Ballistic Met Message.

Table 11-6. Eight-Direction Met (Continued).

STEP	ACTION
5a	Algebraically add the VE (**-2.0**) and the change to MV for propellant temperature (**-0.6**) to determine the ▲V (**-2.6**).
5b	Multiply the ▲V (**-2.6**) by the appropriate MV unit correction (**DEC +24.4**).
5c	Express the result to the nearest 1 meter, and record it in the ▲V RANGE CORRECTION block. The ▲V range correction will have the opposite sign of the ▲V (**+63**).
5d	Once the ▲V has been determined, it can be recorded in the VARIATION FROM STANDARD column under the MET FUZE CORRECTION section.
6	Determine from Table F the unit correction for range wind. (See Figure 11-35.)
6a	Enter Table F with entry range (**5000**). Extract and record the unit correction for range wind (**+7.3**).
6b	Multiply the variation from standard (**H30**) by the unit correction (**+7.3**). Line out the appropriate block (PLUS or MINUS), and record the result (**219.0**).
7	Determine the correction to range to compensate for the earth's rotation from Table H. (See Figure 11-35.)
7a	Enter Table H with the entry range (**5000**) expressed to the nearest listed value (**nearest 500 meters**) and the exact direction of fire (**5396**) expressed to the nearest listed value (nearest 200 mils). The value extracted is for 0 degrees latitude and must be multiplied by a correction factor for latitudes other than 0. At the bottom of Table H are the correction factors for latitudes other than 0.
7b	Record the correction for range (**+15**) and the correction factor for the change in latitude (**0.77**) on the line titled "ROTATION" in the MET RANGE CORRECTION section. Record it as follows: **+15 x 0.77**.
7c	Cross out the appropriate column (PLUS or MINUS), and multiply the correction to range by the correction factor for the change in latitude. Record the result (**11.6**) to the nearest tenth.
8	Determine the met range correction. (See Figure 11-35.)
8a	Total the PLUS column, and total the MINUS column. Subtract the smaller total of the two columns from the larger total. Express the result to the nearest 1 meter, and record it out to the side of the MET RANGE CORR block with the appropriate sign.
8b	Record the met range correction (**+239**) in the MET RANGE CORRECTION block under the COMPUTATION OF VE section.
9	Determine the total range correction. (See Figure 11-35.)
	Algebraically add the met range correction (**+239**) and the ▲V range correction (**+63**) to determine the total range correction (**+302**). Express the result to the nearest 10 meters (**+300**), and record it out to the side of the TOTAL RANGE CORRECTION block. **MET RANGE CORRECTION +239** **+ ▲V RANGE CORRECTION + (+63)** **TOTAL RANGE CORRECTION +302 ≈ +300**
10	Determine the adjusted elevation. (See Figure 11-35.)
10a	Apply the total range correction to the chart range on the lazy Z. 



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE	CHART RG 4950	LATITUDE 40°N

ALT OF BTRY (10m) (1062)	1060
ALT OF MDP	1200
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140
ALT OF TARGET (nearest meter)	1024
HEIGHT OF BURST ABOVE TARGET	
ALT OF BURST	1024
ALT OF BTRY (nearest meter)	1062
HEIGHT OF TARGET (burst) ABOVE GUN (M)	-38 ≈ 0

MET MESSAGE

TYPE MESSAGE METB3		OCTANT 1	AREA/UNIT 355163	
DATE 16	TIME 2000		ALT MDP 1200	PRESSURE 97.2
LINE NO 02	WIND DIR 5900	WIND SPEED 34	AIR TEMP 100.5	AIR DENSITY 100.9
Δh CORRECTION			+ 0.3	+ 1.4
CORRECTED VALUES			100.8	102.3

COMP RG 0 | CHART RG 4950 | ENTRY RG 4950 | 5000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5900
DIRECTION OF FIRE (5396)	5400
CHART DIRECTION OF WIND	0500

POS DF CORR R2
+MET DF CORR L4
TOTAL DF CORR L2
-DRIFT~ADJ EL L7
GFT DF CORR R5

CROSS WIND: WIND SPEED 34 x COMP R 0.47 = R 16 KNOTS x 0.19 UNIT CORR

RANGE WIND: WIND SPEED 34 x COMP H 0.88 = TAIL [✓ HEAD] 30 KNOTS

ROTATION CORR	[✓ L] R 0.8
DRIFT CORR	[✓ L] 6.0
CROSS WIND CORR	L [✓ R] 3.0
MET DEFL CORR	[✓ L] R 3.8

L4

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	H 30	•	H 30	+7.3	219.0	
AIR TEMP	100.8	100%	D 0.8	-6.0		4.8
AIR DENSITY	102.3	100%	D 2.3	+5.9	13.6	
PROJ WEIGHT	4□	4□	D I 0	0.0		
ROTATION	+15	x 0.77			11.6	
					244.2	4.8
					4.8	
				MET RANGE CORR	239.4	

POS VE + MVV = VE
-0.4 + (-1.6) = -2.0

+239

COMPUTATION OF VE

PROP TEMP +56 °F	VE	-2.0 M/S	Δ +24.4 -19.9 I	TOTAL RANGE CORRECTION	
	CHANGE TO MV FOR PROP TEMP	-0.6 M/S		MET RANGE CORRECTION	+239
	ΔV	-2.6 M/S	MV UNIT CORRECTION +24.4	Δ V RANGE CORRECTION	+63
				TOTAL RANGE CORRECTION	+302

+300

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS~ADJ EL = 19.4 ≈ 20

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	2.6	-0.049		0.127
RANGE WIND	H 30	-0.010		0.300
AIR TEMP	D 0.8	+0.011	0.009	
AIR DENSITY	D 2.3	-0.007		0.016
PROJ WEIGHT	D I 0	0.000		
			0.009	0.443
				0.009
		MET FUZE CORR		0.434

5250
+300
4950 324 18.9
-0.5
19.4

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	-0.4
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	-0.5

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. KN PT 1 OCTANT II | BATTERY 1/A | DATE/TIME 162000 Z APR 94

GFT 1/A CHG4 LOT AG RG 4950 EL 324 TI 18.9
TOT ΔF CORR L2 GFT ΔF CORR R5

Figure 11-35. Completed DA Form 4200 Containing the Eight-Direction Met.

Table 11-6. Eight-Direction Met (Continued).

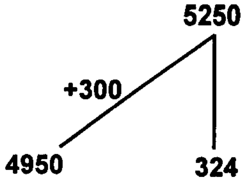
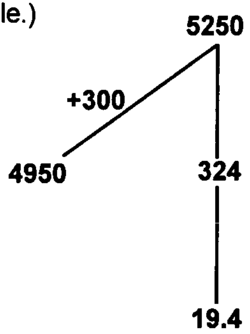
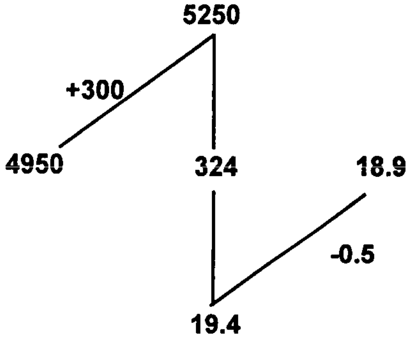
<table>
<tr><th>STEP</th><th>ACTION</th></tr>
<tr><td>10b</td><td>Place the MHL of the GFT over the range corresponding to the adjusted elevation (5250), and read the adjusted elevation under the MHL (324).
 </td></tr>
<tr><td>10c</td><td>With the MHL over the adjusted elevation, determine the fuze setting corresponding to the adjusted elevation from the M582 scale (19.4), and record it on the lazy Z. (If firing the M564 fuze, use the M564 scale.)
 </td></tr>
<tr><td>11</td><td>Determine from Table I corrections for azimuth to compensate for rotation of the earth. (See Figure 11-35.)</td></tr>
<tr><td>11a</td><td>Select the appropriate Table I on the basis of latitude (40°N).</td></tr>
<tr><td>11b</td><td>Enter with the entry range (5000) to the nearest listed value (nearest 500 meters) and the exact direction of fire (5396) expressed to the nearest listed value (nearest 400 mils). For northern latitudes, enter from the top. For southern latitudes, enter from the bottom.</td></tr>
<tr><td>11c</td><td>Extract the proper correction (L0.8), and record it in the ROTATION CORR block in the WIND COMPONENTS AND DEFLECTION section.</td></tr>
<tr><td>12</td><td>Determine the met deflection correction. (See Figure 11-35.)</td></tr>
<tr><td></td><td>Algebraically add the values for rotation, drift, and crosswind. Express the result to the nearest 1 mil, and record it to the right of the MET DEFL CORR block as a left (L) or a right (R).
ROTATION CORRECTION L0.8
+ DRIFT CORRECTION L6.0
<u>+ CROSSWIND CORRECTION</u> <u>R3.0</u>
MET DEFLECTION CORRECTION L3.8 ≈ L4</td></tr>
<tr><td>13</td><td>Determine total deflection correction. (See Figure 11-35.)</td></tr>
<tr><td></td><td>Record the met deflection correction in the equation for deflection, and algebraically add the met deflection correction and the position deflection correction, applying the correct sign.
POS DF CORR R2
<u>+ MET DF CORR</u> <u>L4</u>
TOTAL DF CORR L2</td></tr>
<tr><td>14</td><td>Determine the GFT deflection correction. (See Figure 11-35.)</td></tr>
<tr><td>14a</td><td>Determine the drift corresponding to the adjusted elevation, and record it in the equation for deflection (DRIFT ~ ADJ EL = L7).</td></tr>
</table>

Table 11-6. Eight-Direction Met (Continued).

STEP	ACTION
14b	Algebraically subtract the drift corresponding to the adjusted elevation (**L7**) from the total deflection correction (**L2**) to determine the GFT deflection correction (**R5**). Record the result. **POS DF CORR R2** **+ MET DF CORR L4** **TOTAL DF CORR L2** **- DRIFT ~ ADJ EL L7** **GFT DF CORR R5**
15	Determine the met fuze correction. (See Figure 11-35.)
15a	All variations from standard should be entered in the MET FUZE CORRECTION section.
15b	Record the fuze setting corresponding to the adjusted elevation to the nearest 0.1, and then express it to the nearest whole fuze setting increment. Record it in the space to the left of the words "MET FUZE CORRECTION" as follows: (**FS ~ ADJ EL = 19.4 ≈ 19**).
15c	Enter Table J with the fuze setting corresponding to the adjusted elevation expressed to the nearest whole increment.
15d	Extract and record the unit corrections for ▲V (**-0.049**), range wind (**+0.010**), air temperature (**+0.011**), air density (**-0.007**), and projectile weight (**0.000**).
15e	Line out the appropriate block (PLUS or MINUS). Multiply the unit correction by the variation from standard, and record the result in either the PLUS or MINUS block, as appropriate.
15f	Total the PLUS column, and total the MINUS column. Subtract the smaller total of the two columns from the larger. Express the result to the nearest 0.1.
15g	Record the met fuze correction (**-0.4**) in the MET FUZE CORRECTION block.
16	Determine total fuze correction. (See Figure 11-35.)
	Algebraically add the position fuze correction (**-0.1**) and the met fuze correction (**-0.4**) to determine the total fuze correction (**-0.5**). Record the result.
17	Determine adjusted time. (See Figure 11-35.)
	Apply the total fuze correction (**-0.5**) to the fuze setting corresponding to the adjusted elevation (**19.4**) to determine the new adjusted fuze setting (**18.9**), and complete the lazy Z. 
18	Use the acronym UCARET to determine the GFT setting. Record the GFT setting on the side of DA Form 4200. **GFT 1/A CHG 4 LOT AG RG 4950 EL 324 TI 18.9 (M582)** **TOTAL DF CORR L2 GFT DF CORR R5**
	NOTE: Figure 11-35 shows the completed eight-direction met technique.

11-14. Met to a Target

a. Because of the restrictions of transfer limits for the total corrections represented by a GFT setting, there are areas beyond 10,000 meters that are not covered by normal eight-direction met techniques. If a target that requires accurate surprise fires appears in one of the areas, a met to the target is solved. A met to target may also be solved for situations when the unit needs to fire a projectile that they did not register with (for example, M549A1 RAP). Because of the time needed to solve a met to a target, this technique is usually reserved for those situations requiring FFE fires against a "high-payoff" target.

b. The met-to-target technique consists of the two steps below.

(1) Solution of a concurrent met to determine the position VE, position deflection correction, and position fuze correction. If position constants are not available, use zero for these values.

(2) Solving for met corrections by using the chart range and direction to the target and the position constants to determine a GFT setting. The chart range used is the range to the target. The direction of fire is determined on the basis of the chart direction to the target. The met line number and complementary range are determined from Table B on the basis of the chart range to the target and the height of target above gun.

11-15. Solution of a Met-to-Target Technique

a. Target AB7450 is located outside the octants for which the GFT settings have been determined.

b. All known data remain the same as those for the concurrent met except for the following:

- Target AB7450 is located at grid 440240, altitude 1120.
- Chart deflection to the target is df 4155.
- Chart range to the target is rg 5630.

c. Table 11-7 shows a detailed example of the solution of a met-to-target technique.

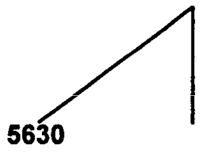
Table 11-7. Met-to-Target Technique.

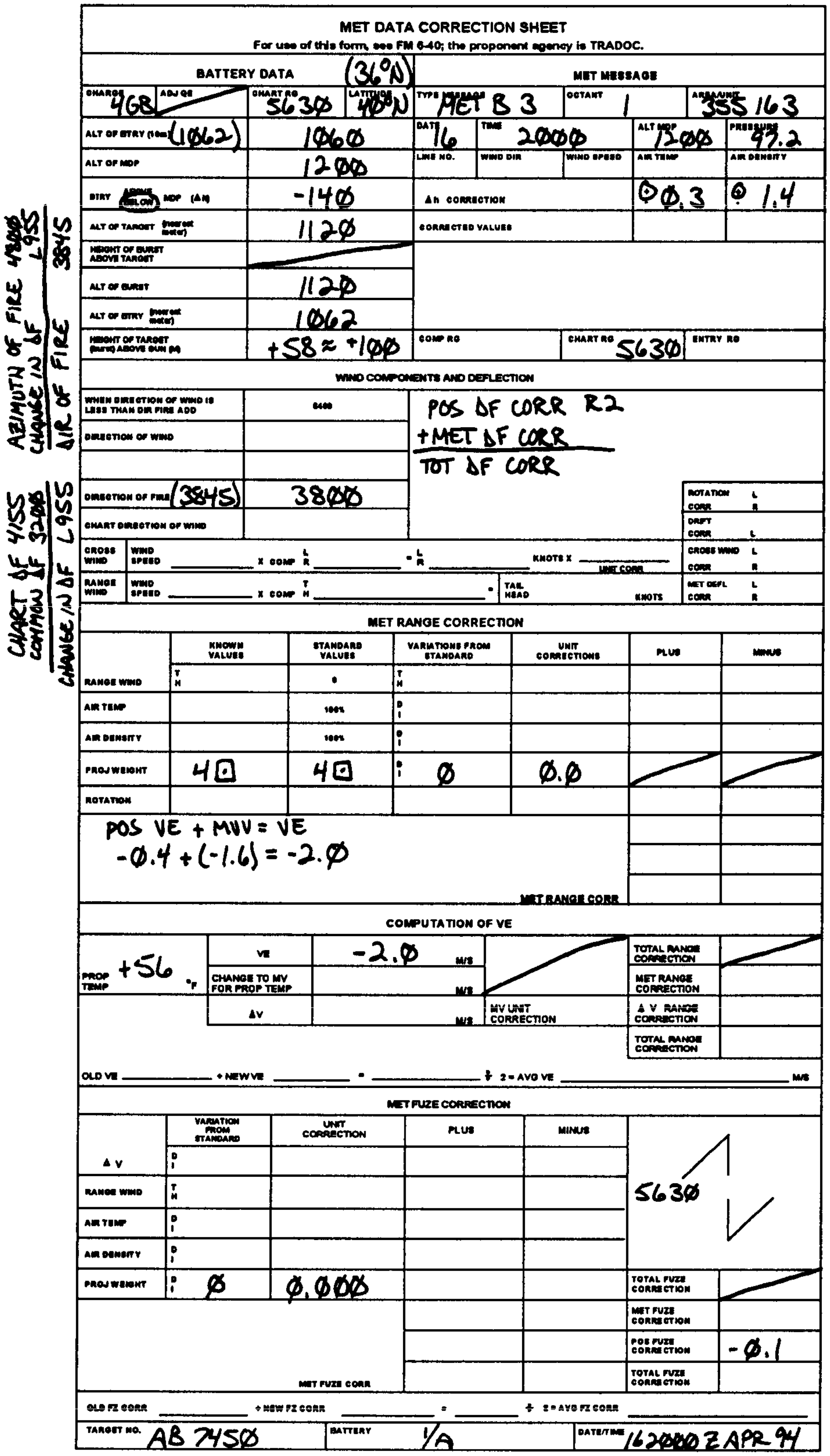
STEP	ACTION
1	Record the position constants. (See Figure 11-36.)
1a	Record the position deflection correction (**R2**) in the WIND COMPONENTS AND DEFLECTION computational space. Use the equation **POS DF CORR + MET DF CORR = TOTAL DF CORR** in the WIND COMPONENTS AND DEFLECTION computational space. **POS DF CORR R2** **+ MET DF CORR** **TOTAL DF CORR**
1b	Record the position VE determined from the registration (**-0.4**) in the MET RANGE CORRECTION computational block. Use the equation **POS VE + MVV = VE**. Once the equation is written and the VE determined, record the VE in the COMPUTATION OF VE section VE block. **POS VE + MVV = VE** **-0.4 + (-1.6) = -2.0**
1c	Record the position fuze correction (**-0.1**).

Table 11-7. Met-to-Target Technique (Continued).

STEP	ACTION
2	Record the known data. (See Figure 11-36.)
2a	Record the charge (**4GB**).
2b	Record the chart range (**5630**) in the CHART RANGE block in the BATTERY DATA and MET MESSAGE sections.
2c	Record the latitude (to the nearest 10°)(**35.5°N ≈ 40°N**).
2d	Record data from the identification line (**METB3, 1, 355163, 16, 2000, 1200, 97.2**) in the MET MESSAGE section blocks, and record the altitude of the MDP (**1200**) in the BATTERY DATA section.
2e	Record the battery altitude (to the nearest 1 meter in parentheses and to the nearest 10 meters in the block) (**1062 ≈ 1060**). Record it to the nearest 1 meter in the lower block (**1062**).
2f	Determine the difference in altitude between the battery and the MDP. **ALT OF BTRY 1060** **- ALT OF MDP -(1200)** **BTRY (BELOW) MDP -140**
2g	Record the corrections from the concurrent met determined from Table D that are applied to the temperature and density to compensate for the difference in altitude between the battery and the MDP. **DT CORRECTION +0.3 DD CORRECTION +1.4**
2h	Record target altitude and altitude of the burst (nearest meter)(**1120**).
2i	Determine the height of target above gun (VI) to the nearest 1 meter, and express it to the nearest 100 meters. **ALT OF BURST 1120** **ALT OF BTRY (nearest meter) 1062** **HEIGHT OF TARGET ABOVE GUN +58 ≈ +100**
2j	Determine and record the direction of fire (to the nearest mil in parentheses and to the nearest 100 mils in the block)(**3845 ≈ 3800**). **CHART DF 4155 AZ OF FIRE 4800** **- COMMON DF 3200 + CHANGE IN DF (RALS) L955** **CHANGE IN DF (LARS) L955 DIR OF FIRE 3845 ≈ 3800**
	NOTE: Use the LARS rule when determining the change in deflection and use the RALS rule when determining the direction of fire.
2k	Record the ◙ weight of the projectile fired during the registration from the concurrent met (**4 ◙**). Record the standard projectile weight determined from the introduction of the appropriate TFT (**4 ◙**). Record the difference in the VARIATION FROM STANDARD column (**0**) in the MET RANGE CORRECTION section. Record (**0.0**) in the UNIT CORRECTIONS block in the MET RANGE CORRECTION section, and line out the PLUS and MINUS columns. Transfer the projectile weight from the VARIATION FROM STANDARD column (**0**) to the VARIATION FROM STANDARD column under the MET FUZE CORRECTION section. Record (**0.000**) in the UNIT CORRECTION block in the MET FUZE CORRECTION section, and line out the PLUS and MINUS columns.
2l	Record the current propellant temperature (**+56**).
2m	Divide the MV UNIT CORRECTION block in half with a diagonal line.
2n	Line out the top TOTAL RANGE CORRECTION block and the top TOTAL FUZE CORRECTION block.

Table 11-7. Met-to-Target Technique (Continued).

STEP	ACTION
2o	Record the lazy Z in the bottom computational block. Show only the chart range. 
2p	Record the target number (**AB7450**).
2q	Record the unit designation (**1/A**).
2r	Record the date-time group.
	NOTE: A DA Form 4200 with the above known data is shown in Figure 11-36.
3	Extract from Table B the complementary range and the line number for the met message. (See Figure 11-37, page 11-65.)
3a	Enter Table B with the chart range (**5630**) expressed to the nearest 100 meters (**5600**) and the height of target above gun (VI) to the nearest 100 meters (**+58 ≈ +100**).
3b	Extract and record the value in the COMP RG block, and apply it to the chart range. The result is the entry range to the nearest meter. Express this value to the nearest 100 meters, and record it out to the side of the ENTRY RG block. **COMP RG +31** **CHART RG +5630** **ENTRY RG 5661 ≈ 5700**
3c	Use the same entry arguments as in step 3a to extract the met line number, and record it. The line numbers are listed below and to the right of the chart ranges in bold print with the heavy dividing lines representing a particular line number.
3d	Record the line number of the met message in the **LINE NO.** block (**02**).
3e	Record the met message data from line 02 on DA Form 4200. The ballistic met message is shown in Figure 11-34. Record the wind direction (**5900**), wind speed (**34**), air temperature (**100.5**), and air density (**100.9**) in the appropriate blocks.
3f	Apply the corrections to the temperature and density, and record the result in the CORRECTED VALUES block in the MET MESSAGE section and in the KNOWN VALUES column of the MET RANGE CORRECTION section. **AIR TEMP 100.5 AIR DENSITY 100.9** **▲h CORRECTION +0.3 ▲h CORRECTION +1.4** **CORRECTED VALUE 100.8 CORRECTED VALUE 102.3**
3g	Determine the variation from standard for air temperature and air density. Circle the (I) for an increase or the (D) for a decrease (whichever is appropriate), and record the difference in the VARIATIONS FROM STANDARD column in the MET RANGE CORRECTION section. Transfer the values of the variation from standard to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section.
4	Determine and record the chart direction of wind. Subtract the direction of fire from the direction of wind to determine the chart direction of wind. (See Figure 11-37.) **DIRECTION OF WIND 5900** **- DIRECTION OF FIRE 3800** **CHART DIRECTION OF WIND 2100**
5	Determine from Table C the crosswind and range components. (See Figure 11-37.)
5a	Enter Table C with the chart direction of wind (**2100**). Extract and record the crosswind (**R 0.88**) component and range wind (**T 0.47**) component.
5b	Multiply the wind components by the wind speed, and express the result to the nearest 1 knot. Circle the appropriate symbol (L or R for crosswind and T or H for range wind).



AZIMUTH OF FIRE 4800
CHANGE IN DF L955
DIR OF FIRE 3845

CHART DF 4155
COMMON DF 3200
CHANGE IN DF L955

MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (36°N)		MET MESSAGE	
CHARGE 4GB	ADJ QE	TYPE MESSAGE MET B 3	OCTANT 1
CHART RG 5630	LATITUDE 40°N	AREA/UNIT 355 163	
ALT OF BTRY (10m) (1062)	1060	DATE 16	TIME 2000
ALT OF MDP	1200	ALT MDP 1200	PRESSURE 97.2
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140	LINE NO.	WIND DIR
ALT OF TARGET (nearest meter)	1120	WIND SPEED	AIR TEMP
HEIGHT OF BURST ABOVE TARGET		AIR DENSITY	
ALT OF BURST	1120	Δh CORRECTION	AIR TEMP ⊕0.3; AIR DENSITY ⊕1.4
ALT OF BTRY (nearest meter)	1062	CORRECTED VALUES	
HEIGHT OF TARGET (burst) ABOVE GUN (M)	+58 ≈ +100	COMP RG	CHART RG 5630
		ENTRY RG	

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	
DIRECTION OF FIRE (3845)	3800
CHART DIRECTION OF WIND	

POS DF CORR R2
+MET DF CORR
TOT DF CORR

CROSS WIND: WIND SPEED ________ X COMP L R ________ = L R ________ KNOTS X ________ UNIT CORR

RANGE WIND: WIND SPEED ________ X COMP T H ________ = TAIL HEAD ________ KNOTS

ROTATION CORR	L R
DRIFT CORR	L
CROSS WIND CORR	L R
MET DEFL CORR	L R

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T H	0	T H			
AIR TEMP		100%	D I			
AIR DENSITY		100%	D I			
PROJ WEIGHT	4 ▣	4 ▣	D I 0	0.0		
ROTATION						

POS VE + MVV = VE
-0.4 + (-1.6) = -2.0

MET RANGE CORR

COMPUTATION OF VE

PROP TEMP +56 °F	VE	-2.0 M/S		TOTAL RANGE CORRECTION
	CHANGE TO MV FOR PROP TEMP	M/S		MET RANGE CORRECTION
	ΔV	M/S	MV UNIT CORRECTION	ΔV RANGE CORRECTION
				TOTAL RANGE CORRECTION

OLD VE ________ + NEW VE ________ = ________ ÷ 2 = AVG VE ________ M/S

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
ΔV	D I			
RANGE WIND	T H			
AIR TEMP	D I			
AIR DENSITY	D I			
PROJ WEIGHT	D I 0	0.000		

5630

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	

MET FUZE CORR

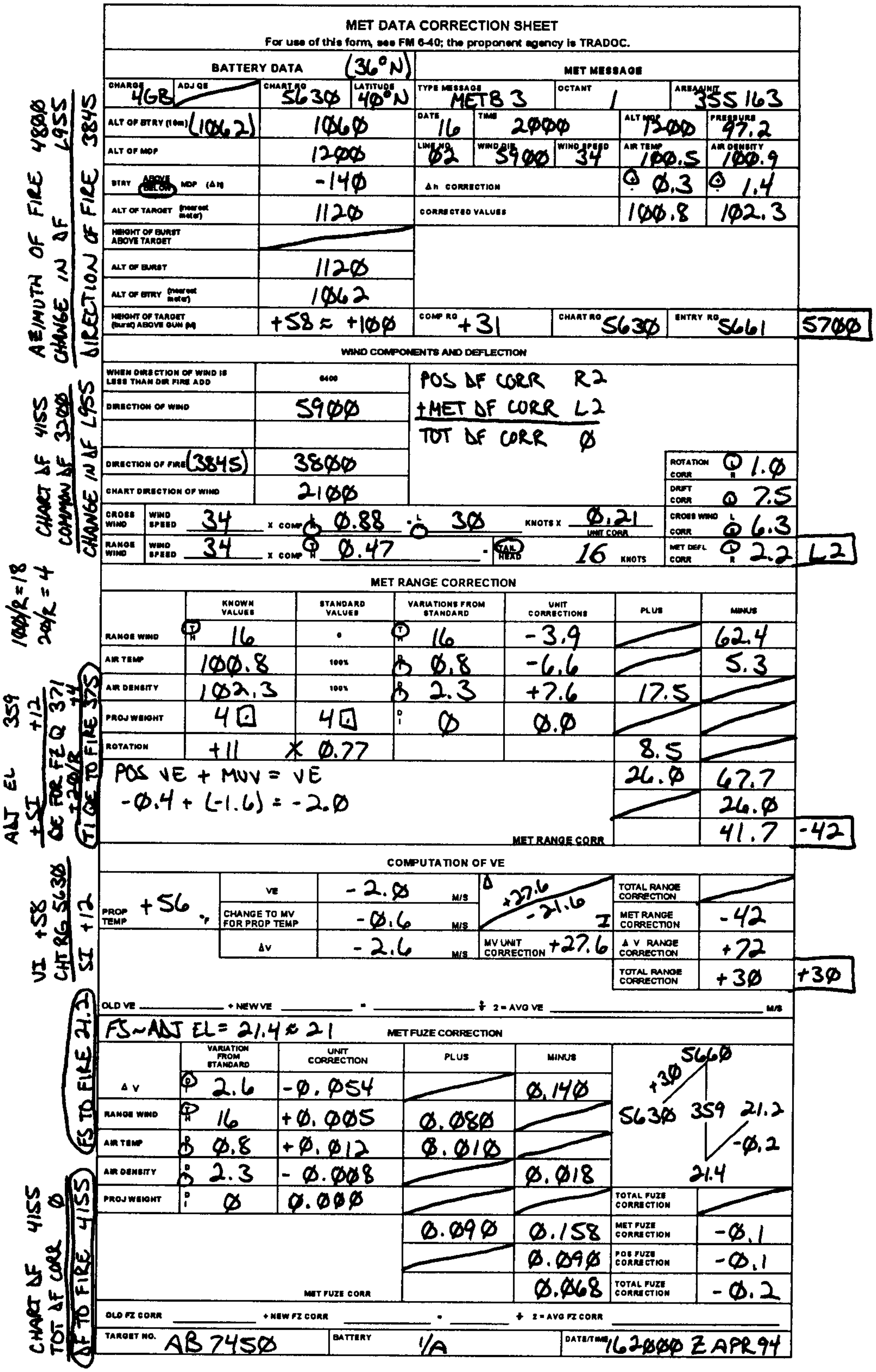
OLD FZ CORR ________ + NEW FZ CORR ________ = ________ ÷ 2 = AVG FZ CORR ________

TARGET NO. AB 7450 | BATTERY 1/A | DATE/TIME 162000Z APR 94

Figure 11-36. DA Form 4200 With Known Data for a Met-to-Target Technique.

Table 11-7. Met-to-Target Technique (Continued).

STEP	ACTION
5c	Record the value determined for range wind (**T16**) in the KNOWN VALUES column of the MET RANGE CORRECTION section. Determine the variation from standard, and record it in the VARIATIONS FROM STANDARD block in the MET RANGE CORRECTION section. Transfer it down to the VARIATION FROM STANDARD column in the MET FUZE CORRECTION section.
6	Determine from Table E the correction to muzzle velocity for propellant temperature. (See Figure 11-37.)
6a	Enter Table E with the propellant temperature to the nearest degree Fahrenheit (**+56°**).
6b	Interpolate the change to muzzle velocity as required.
6c	Record the correction (**-0.6**) in the CHANGE TO MV FOR PROP TEMP block.
7	Determine the ▲V. (See Figure 11-37.)
7a	Algebraically add the VE (**-2.0**) and the change to MV for propellant temperature (**-0.6**) to determine the ▲V (**-2.6**).
7b	Once the ▲V has been determined, it can be recorded in the VARIATION FROM STANDARD column under the MET FUZE CORRECTION section.
8	Determine from Table F the unit corrections for drift, crosswind, muzzle velocity, range wind, air density, air temperature, and projectile weight.
8a	Enter Table F with the entry range (**5700**). (See Figure 11-37.)
8b	Extract from Column 8 the azimuth correction for drift (**L 7.5**).
8c	Extract from Column 9 the crosswind unit correction (**0.21**).
8d	Extract from Columns 10 and 11 the range correction for muzzle velocity (**DEC +27.6/INC -21.6**). Record both corrections.
8e	Extract from Column 12 the correction for range wind for a head wind. Extract from Column 13 the correction for range wind for a tail wind (**-3.9**).
8f	Extract from Column 14 the correction for air temperature for a decrease (**-6.6**). Extract from Column 15 the air temperature for an increase.
8g	Extract from Column 16 the correction for air density for a decrease. Extract from Column 17 the correction for air density for an increase (**+7.6**).
8h	Extract from Column 18 the correction for projectile weight for a decrease. Extract from Column 19 the correction for projectile weight for an increase (**0.0**). This correction will be recorded with an ending of **.0**.
8i	If the unit correction is a plus, cross out the MINUS block; if the unit correction is a minus, cross out the PLUS block.
8j	Multiply the crosswind unit correction (**0.21**) by the crosswind value (**R30**), and record the result to the nearest 0.1 in the CROSS WIND CORR block (**R6.3**).
8k	Multiply the variations from standard by the unit corrections, and record the results to the nearest tenth (0.1).
9	Determine the ▲V range correction. (See Figure 11-37.)
9a	Multiply the ▲V (**-2.6**) by the appropriate MV unit correction (**DEC +27.6**).
9b	Express the result to the nearest 1 meter, and record it in the ▲V RANGE CORRECTION block. The ▲V range correction will have the opposite sign of the ▲V (**+72**).
10	Determine from Table H the correction to range to compensate for the earth's rotation. (See Figure 11-37.)
10a	Enter Table H with the entry range (**5700**) expressed to the nearest listed value (**nearest 500 meters**) and the exact direction of fire (**3845**) expressed to the nearest listed value (**nearest 200 mils**). The value extracted is for 0 degrees latitude and must be multiplied by a correction factor for latitudes other than 0. At the bottom of Table H are the correction factors for latitudes other than 0.



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

AZIMUTH OF FIRE 4800
CHANGE IN DF L955
DIRECTION OF FIRE 3845

CHART DF 4155
COMMON DF 3200
CHANGE IN DF L955

100/R = 18
20/R = 4

ALT EL 359
+SI +12
QE FOR FZ Q 371
+20/R +4
TI QE TO FIRE 375

VI +58
CHT RG 5630
SI +12

FS TO FIRE 21.2

CHART DF 4155
TOT DF CORR 0
DF TO FIRE 4155

BATTERY DATA (36°N)

CHARGE 4GB	ADJ QE	CHART RG 5630	LATITUDE 40°N
ALT OF BTRY (10m) (1062)	1060		
ALT OF MDP	1200		
BTRY [ABOVE ✓ BELOW] MDP (Δh)	-140		
ALT OF TARGET (nearest meter)	1120		
HEIGHT OF BURST ABOVE TARGET			
ALT OF BURST	1120		
ALT OF BTRY (nearest meter)	1062		
HEIGHT OF TARGET (burst) ABOVE GUN (M)	+58 ≈ +100		

MET MESSAGE

TYPE MESSAGE METB 3		OCTANT 1		AREA/UNIT 355163
DATE 16	TIME 2000		ALT MDP 1200	PRESSURE 97.2
LINE NO. 02	WIND DIR 5900	WIND SPEED 34	AIR TEMP 100.5	AIR DENSITY 100.9
Δh CORRECTION			+ 0.3	+ 1.4
CORRECTED VALUES			100.8	102.3

COMP RG +31 | CHART RG 5630 | ENTRY RG 5661 | 5700

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5900
DIRECTION OF FIRE (3845)	3800
CHART DIRECTION OF WIND	2100

POS DF CORR R2
+MET DF CORR L2
TOT DF CORR 0

CROSS WIND: WIND SPEED 34 x COMP L 0.88 = L 30 KNOTS x 0.21 UNIT CORR

RANGE WIND: WIND SPEED 34 x COMP T/H T 0.47 = [✓ TAIL] HEAD 16 KNOTS

ROTATION CORR L/R	L 1.0
DRIFT CORR	L 7.5
CROSS WIND CORR L/R	L 6.3
MET DEFL CORR L/R	L 2.2

L2

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	T 16	0	T 16	-3.9		62.4
AIR TEMP	100.8	100%	I 0.8	-6.6		5.3
AIR DENSITY	102.3	100%	I 2.3	+7.6	17.5	
PROJ WEIGHT	4□	4□	0	0.0		
ROTATION	+11	X 0.77			8.5	
					26.0	67.7
						26.0
MET RANGE CORR						41.7

POS VE + MUV = VE
-0.4 + (-1.6) = -2.0

-42

COMPUTATION OF VE

PROP TEMP +56 °F	VE	-2.0 M/S	Δ +27.6 / -21.6 I	TOTAL RANGE CORRECTION	
	CHANGE TO MV FOR PROP TEMP	-0.6 M/S		MET RANGE CORRECTION	-42
	ΔV	-2.6 M/S	MV UNIT CORRECTION +27.6	Δ V RANGE CORRECTION	+72
				TOTAL RANGE CORRECTION	+30

+30

OLD VE ______ + NEW VE ______ = ______ ÷ 2 = AVG VE ______ M/S

FS~ADJ EL = 21.4 ≈ 21

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
ΔV	I 2.6	-0.054		0.140
RANGE WIND	T 16	+0.005	0.080	
AIR TEMP	I 0.8	+0.012	0.010	
AIR DENSITY	I 2.3	-0.008		0.018
PROJ WEIGHT	0	0.000		
			0.090	0.158
				0.090
MET FUZE CORR				0.068

5660
+30
5630 359 21.2
-0.2
21.4

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	-0.1
POS FUZE CORRECTION	-0.1
TOTAL FUZE CORRECTION	-0.2

OLD FZ CORR ______ + NEW FZ CORR ______ = ______ ÷ 2 = AVG FZ CORR ______

TARGET NO. AB7450 | BATTERY 1/A | DATE/TIME 162000 Z APR 94

Figure 11-37. Completed DA Form 4200 (Met to Target).

Table 11-7. Met-to-Target Technique (Continued).

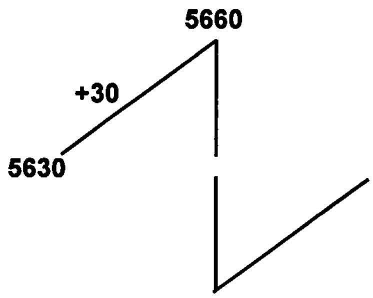
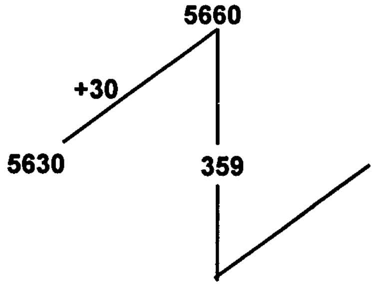
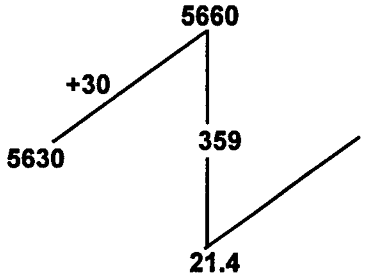
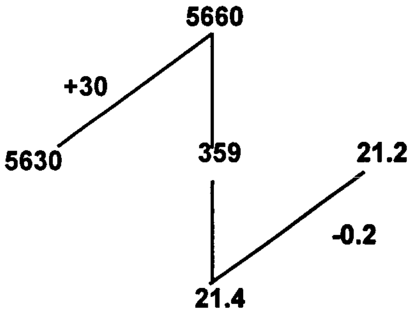
STEP	ACTION
10b	Record the correction for range (**+11**) and the correction factor for the change in latitude (**0.77**) in the MET RANGE CORRECTION section **(+11 X 0.77)**.
10c	Cross out the appropriate column (PLUS or MINUS), and multiply the correction to range by the correction factor for the change in latitude. Record the result (**8.5**) to the nearest tenth.
11	Determine the met range correction. (See Figure 11-37.)
11a	Total the PLUS column, and total the MINUS column. Subtract the smaller total from the larger, and express the result to the nearest 1 meter. Record the result out to the side of the MET RANGE CORR block with the appropriate sign.
11b	Record the met range correction (**-42**) in the MET RANGE CORRECTION block under the COMPUTATION OF VE section.
12	Determine the total range correction. (See Figure 11-37.)
12a	Algebraically add the met range correction (**-42**) and the V range correction (**+72**) to determine the total range correction (**+30**). Express the result to the nearest 10 meters (**+30**) and record it out to the side of the TOTAL RANGE CORRECTION block. **MET RANGE CORRECTION -42** **+ ▲V RANGE CORRECTION + (+72)** **TOTAL RANGE CORRECTION +30 ≈ +30**
13	Determine the adjusted elevation. (See Figure 11-37.)
13a	Apply the total range correction to the chart range on the lazy Z. 
13b	Place the MHL of the GFT over this new range (**5660**), and read the elevation under the MHL (**359**). 
13c	With the MHL on the elevation, determine the fuze setting from the M582 scale (**21.4**), and record it on the lazy Z. (If firing the M564 fuze, use the M564 scale.) 

Table 11-7. Met-to-Target Technique (Continued).

STEP	ACTION
14	Determine from Table I the correction for azimuth to compensate for rotation of the earth. (See Figure 11-37.)
14a	Select the appropriate Table I on the basis of latitude (**40°N**).
14b	Enter with the entry range (**5700**) to the nearest listed value (**nearest 500 meters**) and the exact direction of fire (**3845**) expressed to the nearest listed value (**nearest 400 mils**). For northern latitudes, enter the table from the top. For southern latitudes, enter the table from the bottom.
14c	Extract the proper correction (**L1.0**), and record it in the ROTATION CORR block in the WIND COMPONENTS AND DEFLECTION section.
15	Determine the met deflection correction. (See Figure 11-37.)
	Algebraically add the values for rotation, drift, and crosswind. Express the result to the nearest 1 mil, and record it to the right of the MET DEFL CORR block as a left (L) or a right (R). **ROTATION CORRECTION L1.0** **+ DRIFT CORRECTION L7.5** **+ CROSSWIND CORRECTION R6.3** **MET DEFLECTION CORRECTION L2.2 ≈ L2**
16	Determine total deflection correction. (See Figure 11-37.) Record the met deflection correction in the equation for deflection, and algebraically add the met deflection correction and the position deflection correction, applying the correct sign. **POS DF CORR R2** **+ MET DF CORR L2** **TOTAL DF CORR 0**
17	Determine the met fuze correction. (See Figure 11-37.)
17a	All variations from standard should be entered in the MET FUZE CORRECTION section.
17b	Record the fuze setting corresponding to the adjusted elevation to the nearest 0.1, and then express it to the nearest whole fuze setting increment. Record it in the space to the left of the words "MET FUZE CORRECTION" as follows: **FS ~ ADJ EL = 21.4 ≈ 21**.
17c	Enter Table J with the fuze setting corresponding to the adjusted elevation expressed to the nearest whole increment.
17d	Extract and record the unit corrections for ▲V (**-0.054**), range wind (**+0.005**), air temperature (**+0.012**), air density (**-0.008**), and projectile weight (**0.000**).
17e	Line out the appropriate block (PLUS or MINUS). Multiply the unit correction by the variation from standard, and record the result in the PLUS or MINUS column of the MET FUZE CORRECTION section.
17f	Total the PLUS column, and total the MINUS column. Subtract the smaller total from the larger, and express the result to the nearest 0.1.
17g	Record the met fuze correction (**-0.1**) in the MET FUZE CORRECTION block.
18	Determine total fuze correction. (See Figure 11-37.)
	Algebraically add the position fuze correction (**-0.1**) and the met fuze correction (**-0.1**) to determine the total fuze correction (**-0.2**). Record the result in the TOTAL FUZE CORRECTION block.

Table 11-7. Met-to-Target Technique (Continued).

STEP	ACTION
19	Determine adjusted time. (See Figure 11-37.)
	Apply the total fuze correction (**-0.2**) to the fuze setting corresponding to the adjusted elevation (**21.4**) to determine the new adjusted fuze setting (**21.2**), and complete the lazy Z. 
20	Determine the firing data computations, and record them on the side of DA Form 4200. CHART DF 4155 + TOTAL DF CORR 0 DF TO FIRE 4155 FUZE SETTING TO FIRE 21.2 VI = +58, CHART RANGE 5630, SITE = +12 ADJUSTED ELEVATION 359 + SITE +12 QE FOR FUZE Q 371 100/R = 18, 20/R = 4 QE TO FIRE FOR FUZE Q 371 + 20/R +4 QE TO FIRE FOR FUZE TIME (M582) 375
	NOTE: Figure 11-37 shows the completed DA Form 4200 for the met-to-target technique.

11-16. Computing a GFT Setting for an Unregistered Charge

a. When data from a registration and concurrent met are known, the FDC can derive a GFT setting for an unregistered charge.

b. Total corrections for the unregistered charge are determined by applying the position constants determined for the registered charge to the met corrections for the unregistered charge. This is done by using the following steps:

(1) Determine the range to a met check gauge point on the GFT for the unregistered charge. This will be used as the chart range on the met data correction sheet. The entry range will be the met check gauge point range expressed to the nearest 100 meters. The altitude of the target is the same as the battery altitude.

NOTE: All corrections from the TFT are based on the unregistered charge.

(2) Compute the total deflection correction as follows:

(a) Compute the met deflection correction by use of the met data correction sheet.

(b) Add the position deflection correction determined from the registered charge to the newly computed met deflection correction for the unregistered charge. The sum is the total deflection-correction for the unregistered charge.

NOTE: The position deflection correction generally accounts for errors in survey and chart construction. These errors are independent of charge in that they remain constant regardless of the charge fired. Therefore, it is valid to apply a position deflection correction determined for one charge to other charges.

(3) Compute total range correction and adjusted elevation as follows:

(a) Add the position velocity error for the registered charge to the MVV to determine the VE.

(b) Add the MVV correction for propellant temperature to the VE to determine the ▲ V for the unregistered charge.

(c) Multiply the ▲ V by the appropriate MV unit correction to determine the ▲ V range correction.

(d) Add the ▲ V range correction to the met range correction for the unregistered charge to determine the total range correction.

(e) Add the total range correction to the chart range (range to the met check gauge point) to determine the range corresponding to adjusted elevations.

(f) Set the adjusted range under the MHL of the GFT, and read the adjusted elevation for the unregistered charge.

NOTE: Position velocity errors caused by survey and chart errors are charge independent and, therefore, can be transferred to other charges. Muzzle velocity variations can be transferred to all preferred charges within the same charge group and lot.

(4) Compute the total fuze correction as follows:

(a) Determine the fuze setting corresponding to the adjusted elevation.

(b) Compute the met fuze correction.

(c) Add the met fuze correction to the position fuze correction determined for the registered charge. The sum is the total fuze correction. Apply this correction to the fuze setting corresponding the adjusted elevation to determine the adjusted fuze setting for the unregistered charge.

NOTE: The position fuze correction is a constant fuze characteristic. Fuze characteristics are independent of the charge fired. The position fuze correction is similar to a known fuze setting correction, which is determined historically by observing the performance of a particular lot of fuzes.

(5) Compute the GFT deflection correction by subtracting the drift correction corresponding to the adjusted elevation for the unregistered charge from the total deflection correction. The remainder is the GFT deflection correction for the unregistered charge.

11-17. Met to Met Check Gauge Point

a. The one-plot GFT setting determined by registering has limited range transfer limits. A more accurate GFT setting can be determined by using the data from a registration and one or more met + VE computations to met check gauge points. Solution of a met to met check gauge point using subsequent met techniques will yield total corrections at each met check gauge point range. The met check gauge points selected should be the ones farthest away, in range, from the registration chart range.

b. The met to met check gauge point technique consists of the following steps:

- Solution of a concurrent met to determine the position VE, position deflection correction, and position fuze correction.
- Solving for met corrections to the selected met check gauge points and adding the position constants to determine GFT settings for these ranges. The chart ranges will be the ranges to the selected met check gauge points and the line number of the met message will be determined on the basis of that range and a height of target above gun of O. The altitude of target used will be the same as the battery altitude.

c. Combine the data from the registration and the met(s) to met check gauge points to determine a two-plot or multiplot GFT setting.

11-18. Met + VE

a. Registrations may not always be practical or necessary on the basis of the current situation and the factors of METT-T. If a battery is meeting the five requirements for accurate predicted fire (less accurate target location), there is still a need to improve the data read from the GFT. A GFT setting can be determined by solving a subsequent met by using the met + VE technique. The steps for working a met+ VE are similar to the subsequent met technique. Since no registration has been conducted and position constants were not isolated, position constants are not considered (use zero for these values).

b. For accuracy, the chart ranges used for the met+ VE technique should correspond to met check gauge points, unless the met-to-target technique is being used. The altitude of target will be the same as the battery altitude unless the met-to-target technique is used.

c. The direction of fire will correspond to the chart direction to the center of the zone of responsibility or the target.

d. The values for position deflection correction, position velocity error, and position fuze setting will be recorded as zeros (0).

Chapter 12

TERRAIN GUN POSITION CORRECTIONS AND SPECIAL CORRECTIONS

To enhance survivability on the battlefield a unit must take maximum advantage of the natural cover and concealment offered by the terrain and vegetation (Figure 12-1). When pieces are so positioned corrections may be required to obtain an acceptable burst pattern (sheaf) in the target area. These corrections compensate for the differences in muzzle velocity between pieces and terrain positioning of the weapons. When FFE rounds impact in the target area. the results, to a large extent, depend on how well the sheaf fits the size and shape of the target.

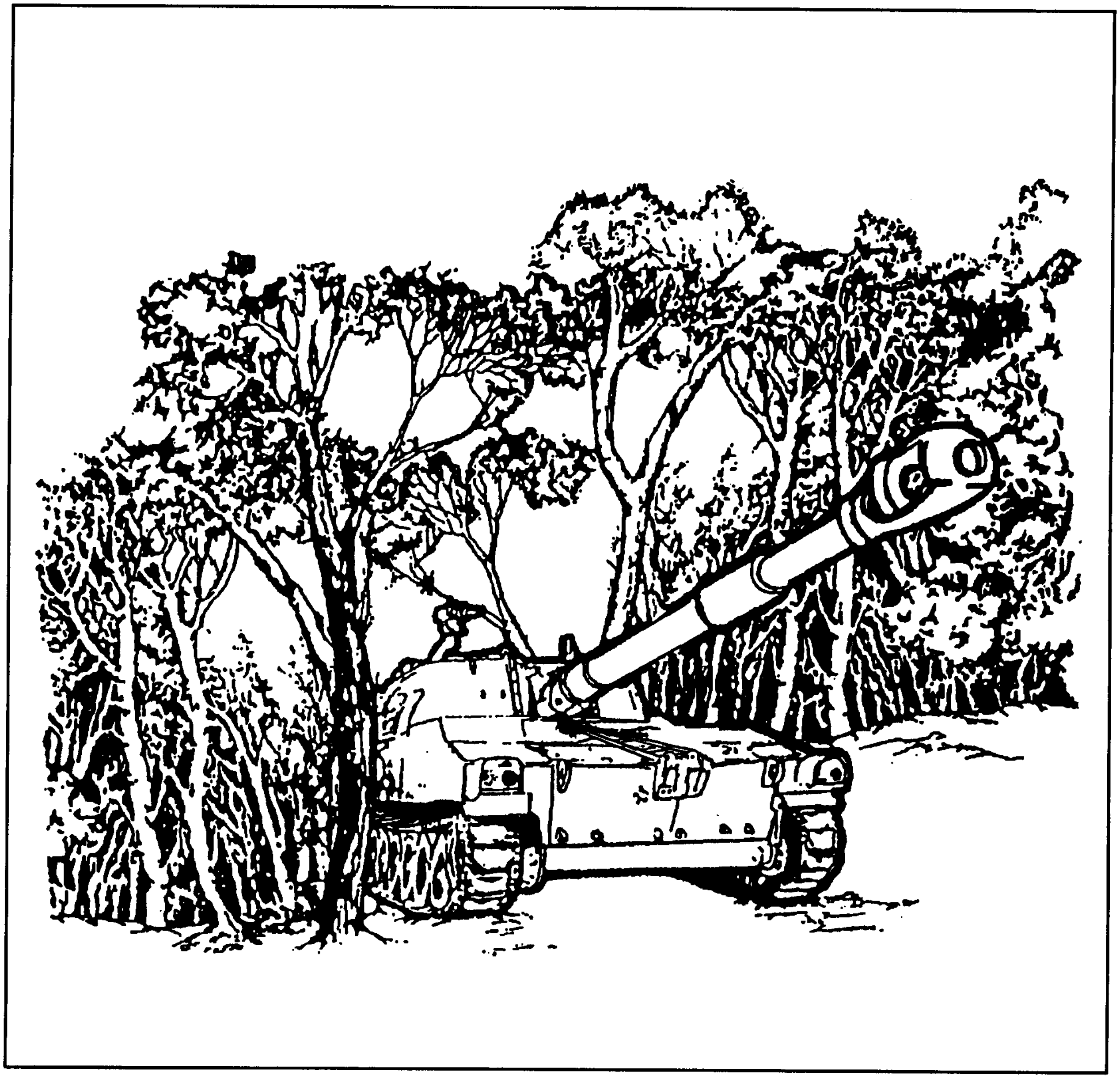


Figure 12-1. Maximum Advantage of Cover and Concealment.

Section I
Types of Corrections

Artillery fires can be computed to fit the size and shape of the target by computing corrections for the following:

- *Individual piece displacements (position corrections).*
- *Shooting strength of each piece (muzzle velocity corrections).*
- *Target size, shape, and attitude (irregularly shaped targets).*

12-1. Overview

a. Terrain gun position corrections (TGPCs) are individual piece corrections applied to the gunner's aid on the panoramic telescope (pantel), the correction counter on the range quadrant, and the fuze setting of each piece.

b. Special corrections are individual piece corrections applied to fuze settings, deflection, and quadrant elevation to place the FFE bursts in a **precise** pattern on the target.

c. Special corrections and TGPCs include corrections for the location of each weapon in the firing unit area (position corrections) and for the shooting strength of each weapon (muzzle velocity corrections).

(1) The goal of TGPCs is to compute corrections to obtain an acceptable sheaf in the target area.

(2) The goal of special corrections is to compute aimpoints tailored to fit the target size, shape, and attitude.

12-2. Piece Displacement

a. To determine position corrections, the relative position of pieces in the firing unit area must be known (piece displacement). Piece displacement is the number of meters the piece is forward or behind and right or left of the base piece. It is measured on lines parallel (forward or behind) and perpendicular to (right or left) the azimuth of fire. (See Figure 12-2.)

b. Piece displacement (Figure 12-2) can be determined by estimation and/or pacing, by hasty traverse, or by survey. Usually, estimation and pacing are not accurate enough for the large displacement distances involved in firing unit positions. The hasty traverse technique is a quick, accurate means of determining piece displacement by using the M10 or M17 plotting board. The survey technique provides grid coordinates for each weapon location.

(1) Estimation is the least desirable method to determine piece displacement. Using this technique, the XO or platoon leader estimates the displacement of the pieces from the base piece both parallel and perpendicular to the azimuth of lay. The pacing technique is fairly accurate in small open areas, but it is time consuming. The XO or platoon leader uses this technique to determine displacement by pacing from the base piece both parallel and perpendicular to the azimuth of lay.

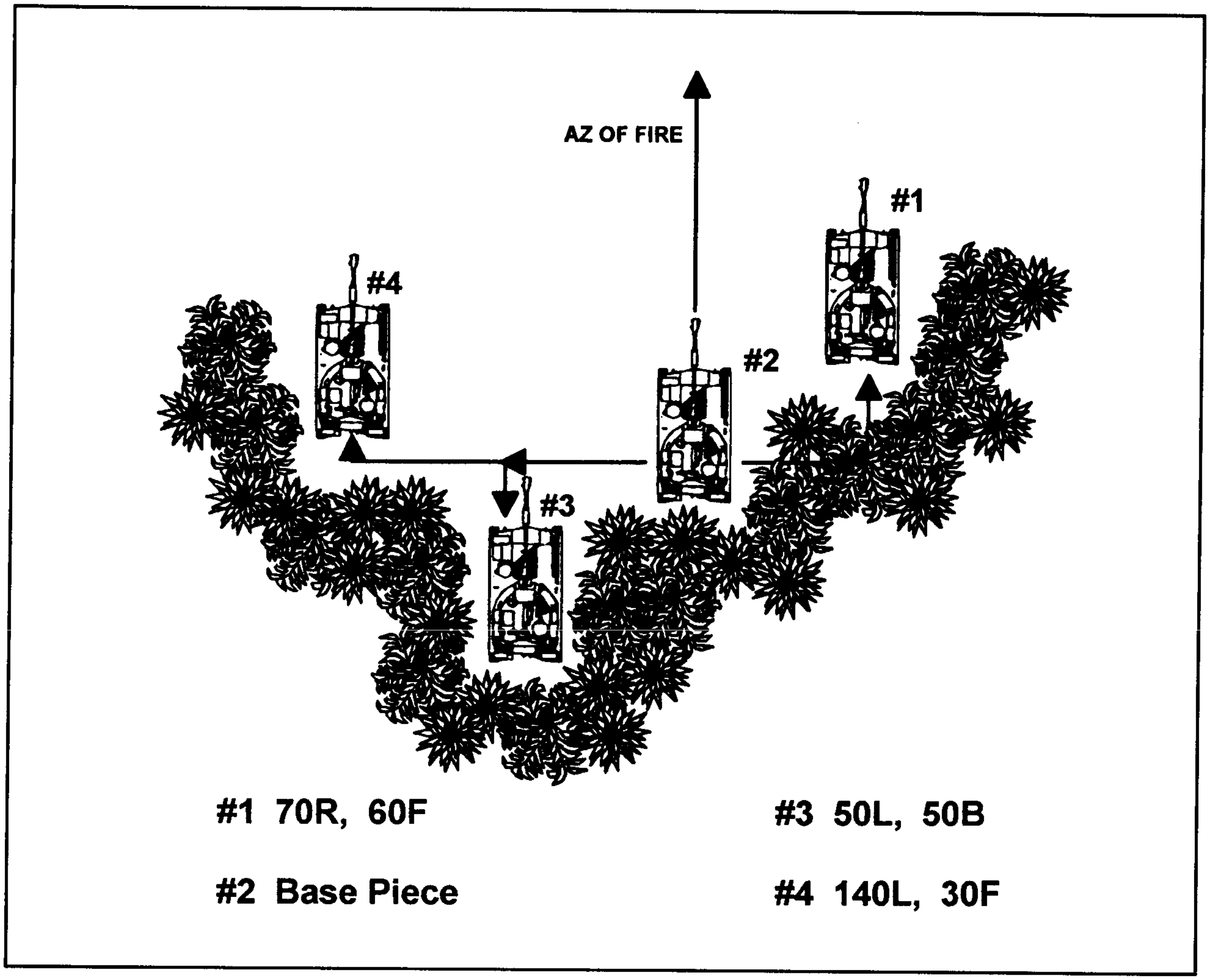


Figure 12-2. Piece Displacement.

(2) The hasty traverse technique is a graphic solution of piece displacement that uses the M10 or M17 plotting board. The advance party provides the FDC with the initial lay deflection, distance and vertical angle to each howitzer position from the aiming circle (AC).

(3) The survey method is the most accurate method. Field artillery survey crews provide a surveyed grid and altitude to each weapon position. Piece displacement is computed by determining the difference between the grid coordinates from the base piece to each weapon position.

12-3. Sheafs

a. A target is covered by fire through controlling the pattern of bursts (sheaf) on the target.

b. When firing a parallel sheaf, the rounds impact at the target in generally the same pattern formed by the howitzers in the firing unit area. The width and depth of the unit's sheaf are always measured on a line perpendicular to the line of fire. As the line of fire changes, so does the width and depth of the unit's sheaf. (See Figure 12-3.)

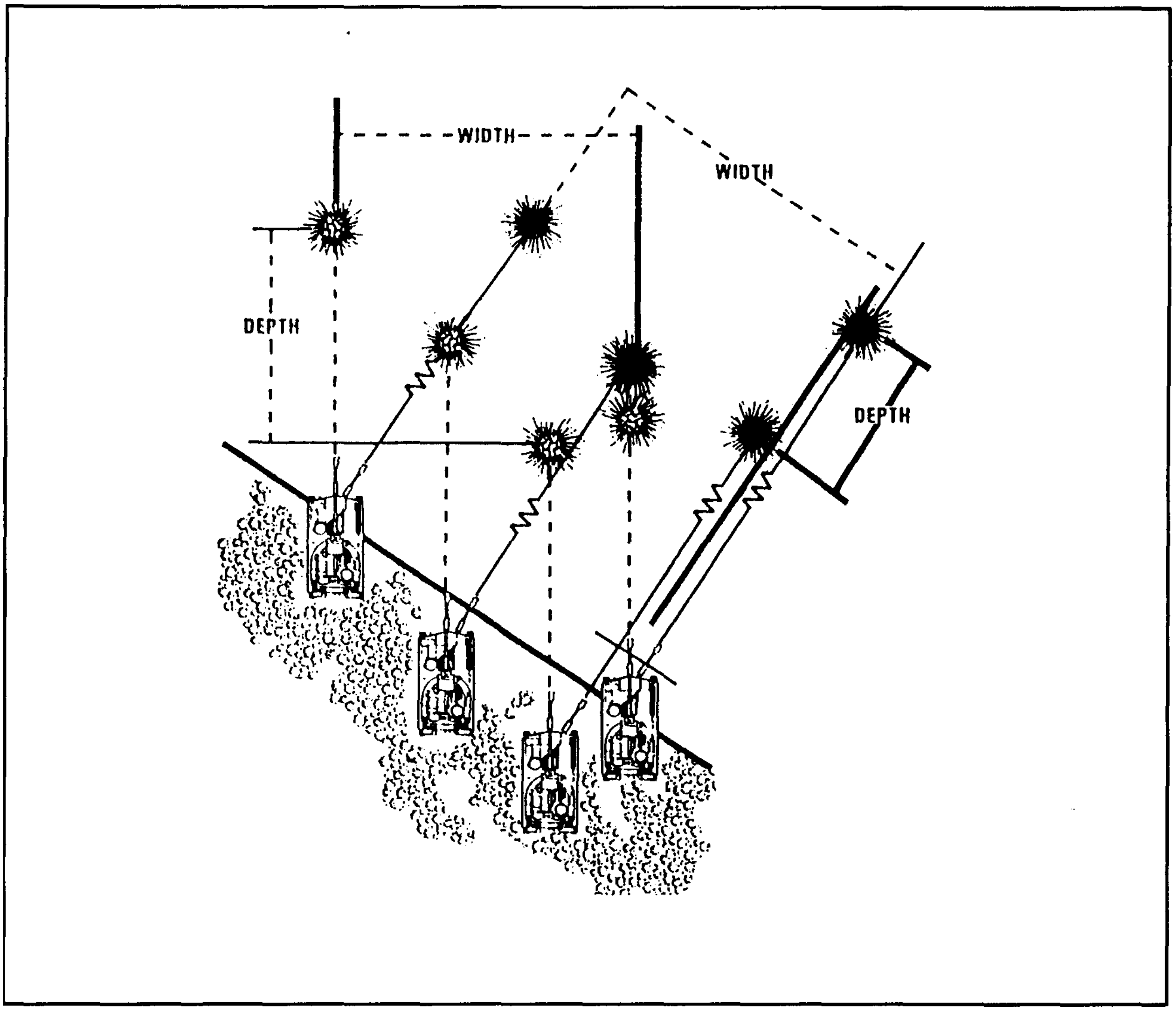


Figure 12-3. Changes in the Sheaf caused by a Change in the Line of Fire.

c. A parallel sheaf does not require TGPCs or special corrections. All weapons fire the same deflection and quadrant.

d. There are three basic types of sheafs that may be obtained with TGPCs and special corrections.

(1) Converged sheaf. All weapons have the same aimpoint.

(2) Open sheaf. Aimpoints are separated by one effective burst width. Figure 12-4 shows sheaf widths for an open sheaf. The open sheaf width equals the number of howitzers multiplied by the projectile effective burst width. See Figure 12-5 for burst widths.

NOTE: For manual computations of TGPCs and special corrections with an M17 plotting board, a width of 30 meters is used for the 105-mm howitzer for ease of computation.

CALIBER	WIDTHS (FOUR HOWITZERs)
105 mm	120 M
155 mm	200 M
203 mm	320 M

Figure 12-4. Open Sheaf Widths.

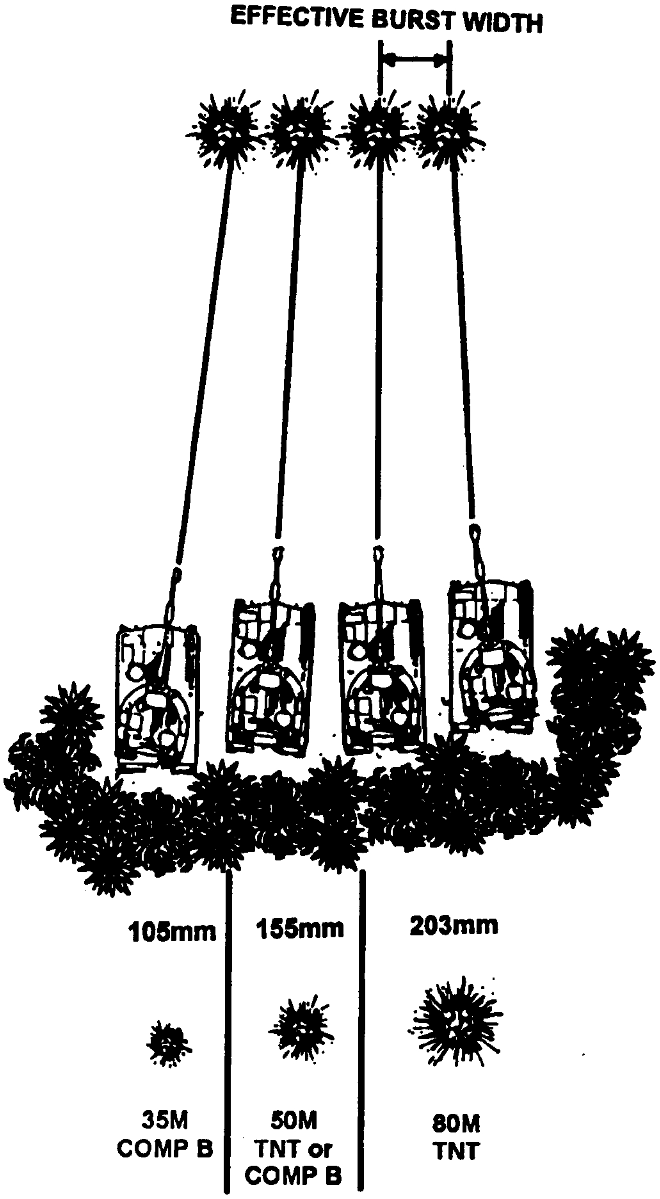


Figure 12-5. Projectile Burst Widths.

(3) Special sheafs. Special sheafs are sheafs other than parallel, converged, or open.

(a) Linear. The sheaf is described by a length, and attitude or by two grids. Aimpoints are evenly distributed along the length of the sheaf along the attitude specified.

(b) Rectangular. The sheaf is described by a length, width, and attitude. Aimpoints are evenly distributed along two lines equal to the length and parallel to the attitude specified.

(c) Circular. The sheaf is described by a grid and a radius. Aimpoints are evenly distributed on a concentric circle half the radius specified.

(d) Irregular. The sheaf is described by a series of grids. Aimpoints are evenly distributed along the length of the sheaf.

Section II

The M17/M10 Plotting Board

The M17 and M10 plotting boards are versatile pieces of the fire direction set. The M17 and M10 plotting boards are similar and used to determine TGPCs and special corrections. The differences are as follows:

- *The M17 has a snap-type pivot in the center; the M10 uses a small screw.*
- *The M17 has a map scale graduated in metric measure; the M10 scale is graduated in both meters and yards.*

NOTE: In further discussions, the term "M17" will refer to the M17 and M10 plotting boards.

12-4. Description

The M17 plotting board consists of two parts--the gridded base and the clear disk.

a. The gridded base is a white plastic board. The center area of the board is a circular gridded area called the target area. The grid pattern divides the target area into squares. The scale assigned to the grid pattern is at the discretion of the user, but most common scales for various operations are as follows:

OPERATION	SCALE
Terrain Gun Position Correction	1 Square = 10 meters
Special Corrections	1 Square = 10 meters
Laser Adjustment of Fire	1 Square = 100 meters
Target Location	1 Square = 100 meters

b. A red arrow is printed from the bottom to the top of the target area. This arrow represents the direction of fire. The arrow points to a vernier scale. The center graduation forms the vernier index, which is used to determine direction from the scales on the clear disk. The vernier scale may be used to determine directions to an accuracy of 1 mil. Along the top edge of the plotting board is a measuring scale graduated in millimeters. On the bottom is a scale in meters. On the right side there is a scale in inches.

c. The clear disk is a transparent circular plastic board that snaps or screws into a center pivot on the gridded base. A single black line is engraved in the clear disk, This line represents the 0-3200 line when weapons are plotted.

d. The edge of the disk is engraved with scales that are graduated every 10 mils. The outermost scale is a black numbered scale (the outer black scale). The scale is numbered every 100 mils starting at 0 and ending at 63. The outer black scale is used to represent azimuth and lay deflection. Immediately inside the outer black scale is a red numbered scale (the red scale). This scale is numbered every 100 mils from 0 to 32. Past the 32 graduation the numbering continues from 1 to 5. This scale is used to orient the disk on chart deflection. The innermost scale is a black numbered scale (the inner black scale). This scale is numbered every 100 mils from 0 to 3200 and is used to orient the disk for lay deflection for the M12-series pantel when lay deflection is measured from the line of fire.

e. The screw or rivet secures the disk to the base and maybe used to represent one of the following:

- Base piece.
- Target.
- Observer location.
- Location of the last burst.

NOTE: In the following sample problems, the Ml 7 plotting board is viewed with the curved edge to the operator's left and the description "top of the plotting board" refers to the side of the plotting board with the vernier scale.

12-5. Plotting Piece Locations for Weapons Equipped With the M100-Series Sight

a. The following is an example of the platoon leader's report for the M100-series sight:

HOWITZER	LAID FROM	LAY DEFLECTION	DISTANCE	VA
1	AC	2595	105	+3
2	AC	2910	55	+1
3 (BP)	AC	3405	90	-2
4	AC	3950	100	-5

NOTE: Howitzer Number 3 is the base piece. The azimuth of lay is 4,800 mils.

b. Table 12-1 shows the steps required to plot piece locations for weapons equipped with the M100-series sight.

Table 12-1. Plot Piece Locations for Weapons Equipped With the M100-Series Sight.

STEP	ACTION
1	Plot the location of the aiming circle.
1a	Receive the XO's report with the lay deflections, distances, and vertical angles from the aiming circle to the howitzers.
1b	Using the outer black scale, rotate the disk of the plotting board until the lay deflection of base piece is opposite the vernier index.
1c	Count the distance from base piece (rivet) to the aiming circle from the center of the plotting board toward the **top** of the plotting board. Each square on the gridded base will represent 10 meters. Plot the aiming circle as a dot drawn with a soft-lead pencil at the appropriate distance. Circle the dot, and label it "AC." (See Figure 12-6.)
1d	The center of the plotting board represents the location of base piece. Label the rivet with the base piece number.
2	Plot the location of the pieces laid from the aiming circle.
2a	Rotate the disk of the plotting board until the lay deflection of the next piece on the outer black scale is opposite the vernier index.
2b	Count the distance between the piece to the aiming circle **from the aiming circle location** toward the **bottom** of the plotting board. Each square on the gridded base will represent 10 meters. Plot the piece as a dot drawn with a soft-lead pencil at the appropriate distance. Circle the dot, and label it with the appropriate howitzer number.
2c	Plot the remainder of the pieces that were laid from the aiming circle by using the same procedures listed in steps 2 through 2b.
3	Plot the location of the pieces laid from other howitzers.
3a	Rotate the disk of the plotting board until the lay deflection of the next piece on the outer black scale is opposite the vernier index.
3b	Count the distance between the piece and the laying howitzer **from the laying howitzer location** toward the **bottom** of the plotting board. Each square on the gridded base will represent 10 meters. Plot the piece as a dot drawn with a soft-lead pencil at the appropriate distance. Circle the dot, and label it with the appropriate howitzer number.
3c	Plot the remainder of the pieces that were laid from another howitzer by using the same procedures listed in steps 3 through 3b.
4	Establish an azimuth index on the plotting board.
4a	Rotate the clear disk until **32** on the outer black scale is opposite the vernier index.
4b	With a soft-lead pencil, draw an arrow on the outer edge of the gridded base so that it points to the azimuth of lay on the outer black scale. This arrow will be the azimuth scale.
5	Beginning at the red **32** graduation, continue the deflection scale by numbering the 100-mil graduations of the scale. Number the graduation in increasing order beginning to the left of the 32.
	NOTE: You must first line out the numbers 1 through 5 and then relabel them 33 through 37. (See Figure 12-7.)
6	Measure piece displacement.
6a	Rotate the disk of the plotting board until **32** of the outer black scale is opposite the vernier index.
6b	Count the number of meters, left or right, from the base piece to the howitzer. (Each square on the gridded base represents 10 meters). This distance, measured to the nearest 5 meters, is the lateral displacement. The sign of the lateral displacement is left (L) or right (R).
6c	Count the number of meters forward (toward the top of the plotting board) or back (toward the bottom of the plotting board) from the base piece to the howitzer. (Each square on the gridded base represents 10 meters.) This distance, measured to the nearest 5 meters, is the range displacement. The sign of the range displacement is + (forward) or - (back).

NOTE: The following data are an example of piece displacement as shown in step 6.

HOWITZER	LATERAL DISPLACEMENT	RANGE DISPLACEMENT
1	R75	0
2	R35	+35
3	0	0
4	L50	+15

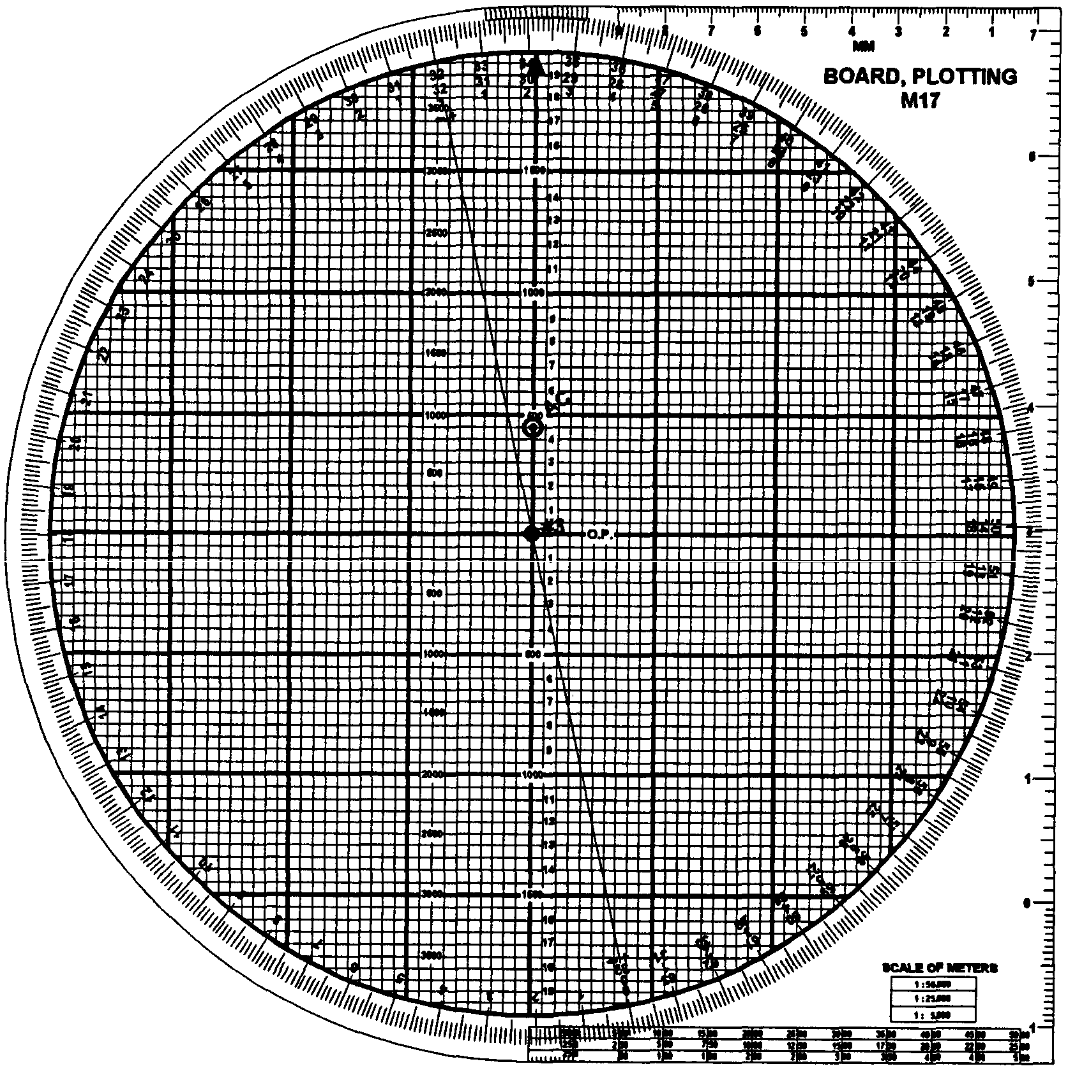


Figure 12-6. M17 Plotting Board With the Aiming Circle and Base Piece Plotted.

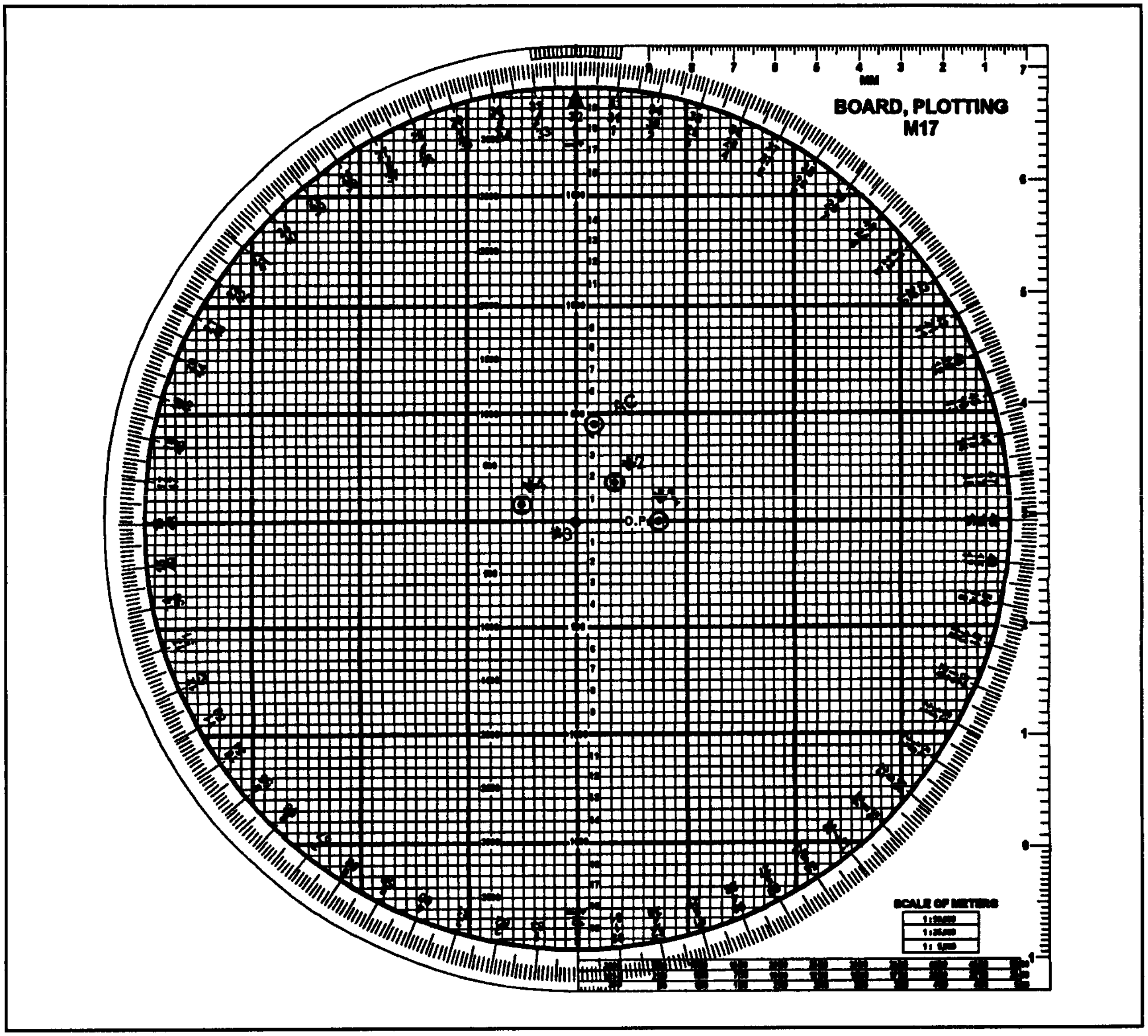


Figure 12-7. M17 Plotting Board With all Pieces Plotted, Azimuth Index Established, and Deflection Scale Continued for the M100-Series Sight.

12-6. Plotting Piece Locations for Weapons Equipped With the M12-Series Sight

a. The M12-series sight is capable of determining deflection to a maximum value of 3,200 mils. The sight is graduated from 1 to 3200 twice to form a full circle. Consequently, every deflection has a "back deflection" of equal value in the opposite direction. This arrangement is indicated on the plotting board by the inner black scale. This scale is a lay deflection scale graduated from 0 to 3200. Care must be taken when setting up the plotting board to prevent the use of the wrong scale and thereby creating a **"mirror image"** of the battery. The use of the scales is dictated by the location of the howitzers in relationship to the position of the aiming circle. In the XO's report, the XO must indicate whether each piece is to the **left or right** of the aiming circle in respect to the azimuth of lay. If the lay deflection for a howitzer is exactly 3200, the XO's report must indicate whether that piece is forward (down range) or behind (the aiming circle is down range) in comparison to the aiming circle. The rules for the use of the scales areas follows:

(1) If the piece is left of the 0-3200 line as viewed from the aiming circle, **use the inner black scale.**

(2) If the piece is right of the 0-3200 line as viewed from the aiming circle, **use the outer black scale.**

(3) If the piece is on the 0-3200 line (lay deflection 3200) and behind as viewed from the aiming circle, **use the inner black scale,**

(4) If the piece is on the 0-3200 line (lay deflection 3200) and forward as viewed from the aiming circle, **use the outer black scale.**

b. For ease in determining whether a piece is left or right and forward or back, the XO need only realize that **if the piece is laid using the red graduations on the aiming circle it is to the left or forward of the aiming circle as you face the azimuth of fire.**

c. A simple alternative to the use of these rules is to have the XO report all lay deflections as they would be determined by using values read from the black numbered graduations of the aiming circle. **It is recommended that this method be unit SOP in an attempt to avoid confusion with the plotting board.**

d. The plotting of the pieces and establishment of an azimuth index are done by using the same procedures as described for the M100-series sight.

e. Piece displacement is determined by using the same procedures as described for the M100-series sight.

f. The following is an example of the platoon leader's report for the M12-series sight:

HOWITZER	LAID FROM	LAY DEFLECTION	DISTANCE	VA
1	AC	2595	105	+3
2	AC	2910	55	+1
3 (BP)	AC	0205	90	-2
4	AC	0750	100	-5

NOTE: Howitzers 3 and 4 are left of the aiming circle. Azimuth of lay (AOL) equals 4800.

g. Use the steps in Table 12-2 to plot piece locations for weapons equipped with the M12-series sight.

Table 12-2. Plot Piece Locations for Weapons Equipped With the M12-Series Sight.

STEP	ACTION
1	Plot the location of the aiming circle.
1a	Receive the XO's report with the lay deflections, distances, and vertical angles from the aiming circle to the howitzers.
1b	Rotate the disk of the plotting board until the lay deflection of base piece on the outer (inner) black scale is opposite the vernier index.
	NOTE: In this example, the aiming circle and number 4 were plotted using the **inner black** scale. Number 1 and number 2 were plotted using the **outer black** scale.
1c	Count the distance from base piece to the aiming circle from the center of the plotting board toward the **top** of the plotting board. Each square on the gridded base will represent 10 meters. Plot the aiming circle as a dot drawn with a soft-lead pencil at the appropriate distance. Circle the dot, and label it "AC."
1d	The center of the plotting board represents the location of the base piece.
2	Plot the location of the pieces laid from the aiming circle.
2a	Rotate the disk of the plotting board until the lay deflection of the next piece on the outer (inner) black scale is opposite the vernier index.
2b	Count the distance between the piece to the aiming circle from the aiming circle location toward the bottom of the plotting board. Each square on the gridded base will represent 10 meters. Plot the piece as a dot drawn with a soft-lead pencil at the appropriate distance. Circle the dot, and label it with the appropriate howitzer number.
2c	Plot the remainder of the pieces that were laid from the aiming circle.
3	Plot the location of the pieces laid from other howitzers.
3a	Rotate the disk of the plotting board until the lay deflection of the next piece on the outer (inner) black scale is opposite the vernier index.
3b	Plot the remainder of the pieces that were laid from another howitzer.
4	Establish an azimuth index on the plotting board.
4a	Rotate the clear disk until **32** on the outer black scale is opposite the vernier index.
4b	With a soft-lead pencil, draw an arrow on the outer edge of the gridded base that points to the azimuth of lay on the outer black scale and label it "AZ." **This arrow is the azimuth index**. (See Figure 12-8.)
5	Establish a deflection index on the plotting board (M12-series sight).
5a	Rotate the clear disk until **32** on the outer black scale is opposite the vernier index.
5b	With a soft-lead pencil, draw an arrow on the outer edge of the gridded base that points to the common deflection on the inner red scale and label it "DF." **This arrow is the deflection index**. (See Figure 12-8.)
6	Beginning at the red 5 graduation, continued the deflection scale by numbering the 100-mil graduation of the scale. Number the graduations in increasing order beginning to the left of the 5. (See Figure 12-8.)

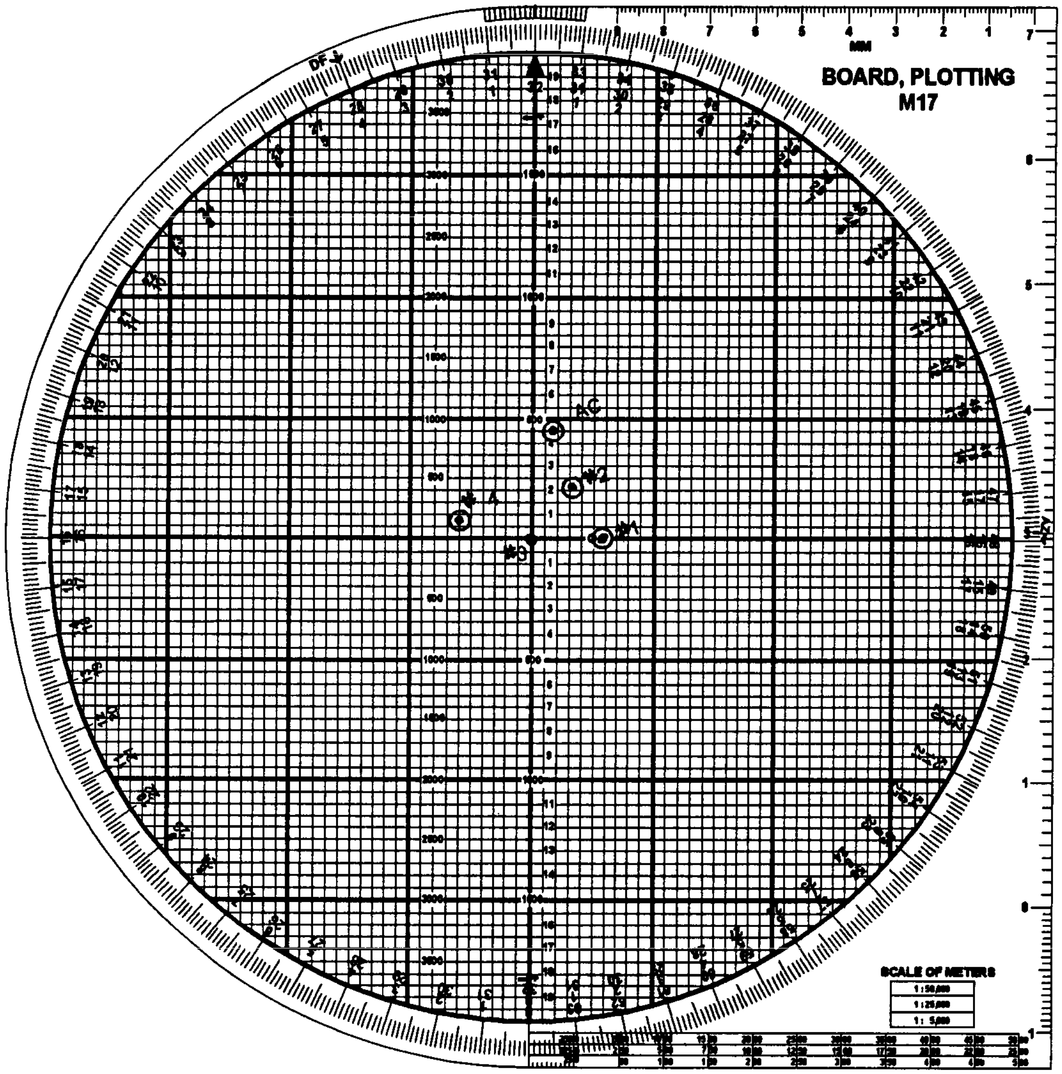


Figure 12-8. M17 Plotting Board With all Pieces Plotted, Azimuth Index Established, and Deflection Scale Continued for the M12-Series Sight.

12-7. Determination of Base Piece Grid Coordinates

After the pieces have been plotted on the M17, the **base piece grid** can be determined by using the steps in Table 12-3.

> **NOTE:** The grid determined can be used to plot the base piece on the firing chart.

Table 12-3. Determination of Base Piece Grid.

STEP	ACTION
1	Rotate the clear disk until the **0** on the outer black scale is opposite the **azimuth index**.
2	From the aiming circle location, determine base piece displacement.
3	Apply base piece displacement (displ) to the aiming circle coordinates to determine the base piece grid. **LEFT DISPLACEMENT = DECREASE IN EASTING** **RIGHT DISPLACEMENT = INCREASE IN EASTING** **FORWARD DISPLACEMENT = INCREASE IN NORTHING** **BEHIND DISPLACEMENT = DECREASE IN NORTHING**
	NOTE: Using the example from paragraph 12-5, determine the base piece grid. The advance party reported the grid to the aiming circle as E:37783 N:40821.
4	Rotate the clear disk until the **0** on the outer black scale is opposite the **azimuth index**.
5	From the aiming circle location, determine base piece displacement **(R90, B20)**.
6	Apply base piece displacement to the aiming circle coordinates to determine the base piece grid. **RIGHT DISPLACEMENT (R90) = INCREASE IN EASTING (+90)** **BEHIND DISPLACEMENT (B20) = DECREASE IN NORTHING (-20)** **AIMING CIRCLE GRID 37783 40821** **BASE PIECE DISPL +90 -20** **BASE PIECE GRID 37873 40801**

Section III

Terrain Gun Position Corrections

Terrain gun position corrections are the precomputed corrections carried on the howitzers to compensate for terrain positioning and muzzle velocity differences to achieve acceptable results in the target area. TGPCs should be computed each time the firing unit occupies a position. The use of TGPCs will allow the unit to effectively engage targets whose size and orientation requires a sheaf other than a parallel sheaf.

12-8. Transfer Limits and Sectors of Fire

a. Terrain gun position corrections are most accurate at the range and direction for which they are computed. They are considered valid 2,000 meters over and short of the center range and 400 mils right and left of the center azimuth of the sector. (See Figure 12-9.)

b. Terrain gun position corrections will provide an acceptable effect on the target provided the firing unit's position is within a box 400 meters wide and 200 meters deep. This box is centered over the firing unit center and oriented perpendicular to the azimuth of lay. If the firing unit is spread out more than 400 meters by 200 meters, a degradation in effectiveness of sheafs can be expected as fires are shifted throughout the sector for which they were computed.

c. If a firing unit's area of responsibility covers an area larger than the TGPC transfer limits, the unit should compute TGPCs for other sectors. Ranges to the centers of the other sectors may be different. Overlapping sectors for different charges may be necessary. (See Figure 12-10.)

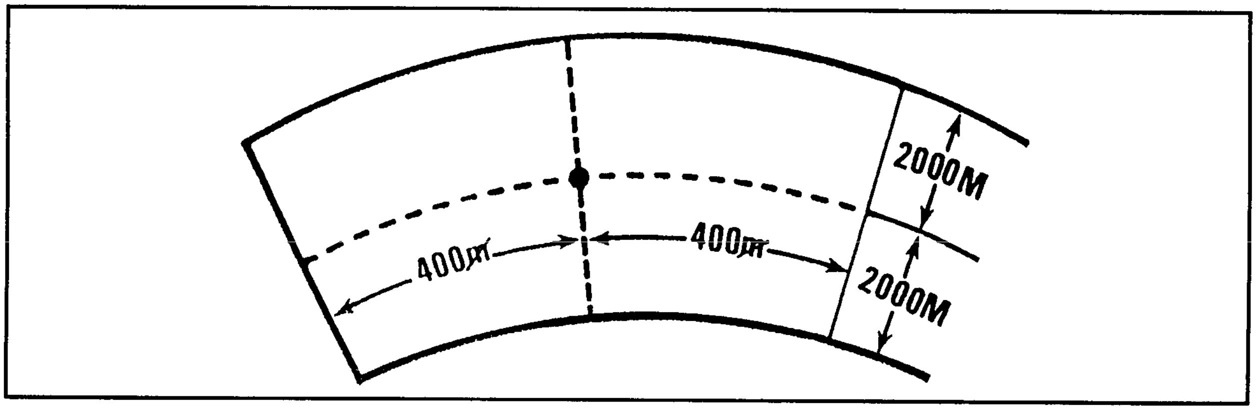


Figure 12-9. TGPC Transfer Limits.

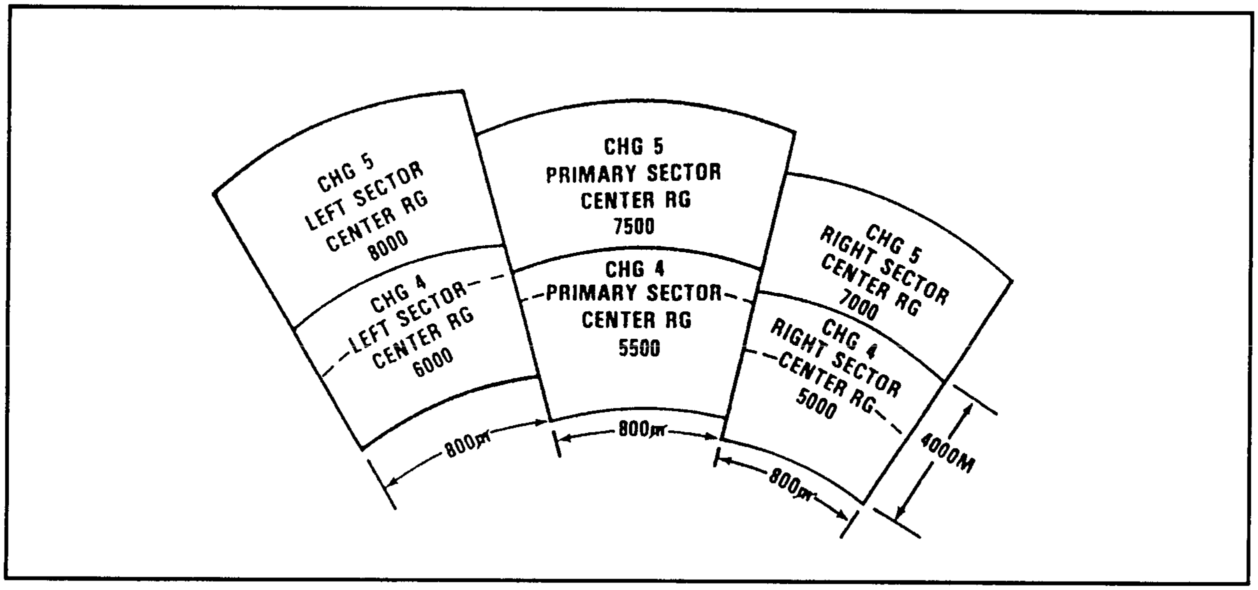


Figure 12-10. Three Sectors With Different Ranges and Overlapping Sectors for Different Charges.

12-9. Fire Order and Fire Commands

a. The FDO must establish a fire order SOP that indicates the corrections for the primary sector are standard. This is done in the special instructions section of the fire order SOP.

b. Fire command standards should direct that the primary TGPCs sector is used unless otherwise specified. The **special instructions** block of the fire commands will indicate which TGPC sector will be used for a mission if other than the primary sector. The absence of any instructions in the initial fire commands indicates that corrections for the primary sector will be fired. The command **LEFT (RIGHT) SECTOR** in the special instructions block of the initial fire commands indicates that the corrections for the left (right) sector are to be set on the howitzers. The command **CANCEL TERRAIN GUN POSITION CORRECTIONS** indicates that all TGPCs are to be zeroed for the mission. After end of mission is announced, the primary sector TGPCs are reapplied to the howitzers.

12-10. Determination of Terrain Gun Position Corrections

a. It is recommended that TGPCs be computed for a converged sheaf. This will generally provide an acceptable sheaf within the transfer limits. TGPCs can be computed by using other sheafs, but the dispersion of bursts can be expected to increase as the target range varies from the range to the center of the sector. It is preferred that base piece carry no corrections. To do otherwise causes the base piece to "zero" the corrections on adjustment and reapply them during fire for effect, which may lead to error. Therefore, the aimpoint of the base piece should be the center pivot when computing TGPCs.

> **NOTE:** DA Form 4757 (Registration/Special Corrections Work Sheet) is completed regardless of the sheaf used. Before computing any TGPCs, plot the howitzers on the M17.

b. Table 12-4 lists the steps for determining TGPCs and completing DA Form 4757.

Table 12-4. Determination of TGPCs.

<table>
<tr><th>STEP</th><th>REFERENCE</th><th>ACTION</th></tr>
<tr><td>1</td><td>(Transfer Limits Block) L/P/R</td><td>Circle the sector for which the corrections are to be computed.</td></tr>
<tr><td>2</td><td>Chg ______</td><td>Record the charge used for the corrections.</td></tr>
<tr><td>3</td><td colspan="2">Record deflection to the left and right limits of the sector.
<table>
<tr><td colspan="2"></td><td>LEFT</td><td>CENTER</td><td>RIGHT</td><td colspan="2"></td></tr>
<tr><td>CEN DF+4000</td><td>DF</td><td></td><td></td><td></td><td>DF</td><td>CEN DF-4000</td></tr>
</table></td></tr>
<tr><td>4</td><td colspan="2">Record the minimum and maximum range for the sector.
<table>
<tr><td colspan="2"></td><td>LEFT</td><td>CENTER</td><td>RIGHT</td><td colspan="2"></td></tr>
<tr><td>CEN RG-2000M</td><td>RG</td><td>(min)</td><td></td><td>(max)</td><td>RG</td><td>CEN RG+2000M</td></tr>
</table></td></tr>
<tr><td>5</td><td>1
Pos
Lateralor
Corr
(L/R)</td><td>Record the position lateral correction required to move each weapon to its selected burst line (open) or aimpoint to the nearest 5 meters.</td></tr>
<tr><td>6</td><td>2
100/R
GFT *
(______)
CEN RG</td><td>Using a GFT, determine and record 100/R for the center range.</td></tr>
<tr><td>7</td><td>3
Pos Df
Corr
(L/R)
$\frac{1 x 2}{100}$</td><td>The position deflection correction is determined by multiplying the position lateral correction (Col 1) by 100/R (Col 2) and dividiing the result by 100 and expressing the result to the nearest mil. Assign the direction (L/R) of the lateral correction.</td></tr>
<tr><td>8</td><td>4
Btry
Comp
VE
(I/D)</td><td>Record battery comparative VEs. Record plus VEs as increases (I) and minus VEs as decreases (D). Comparative VEs (comp VEs) are determined by subtracting the base piece MVV from the other howitzer(s) MVV. Use the formula **GUN # MVV - BP MVV = COMP VE (I/D)**.</td></tr>
</table>

Table 12-4. Determination of TGPCs (Continued).

STEP	REFERENCE	ACTION
9	5 MV Unit Corr Fac (Tbl F) D+____ I-____	Determine and record the muzzle velocity unit correction factors (fac) from Table F in the TFT on the basis of the center range. Record the appropriate correction factor for each howitzer on the basis of comparative VE.
10	6 MV Rg Corr 4 x 5	Determine and record the muzzle velocity range correction by multiplying the comparative (Col 4) by the muzzle velocity unit correction factor. Express the result to the nearest meter (±).
11	7 Pos Rg Corr (F = -) (B = +)	Record the required position range corrections (the number of meters forward or behind the base piece) to the nearest 5 meters. If the weapon is forward (F) of base piece, the correction is minus; if it is behind (B), the correction is plus.
12	8 Total Rg Corr 6 + 7	Determine and record the change in total range correction by adding the muzzle velocity range correction to the position range correction (±). Express the result to the nearest 1 meter.
13	9 Pos El Corr 8 ÷ DR Per 1₥ D El (Tble F) (______)	Determine and record the change in range for 1 mil change in elevation from Table F (Column 5) of the TFT. Determine and record the position elevation correction by dividing the total range correction by the change in range for 1 mil change in elevation. Express the result to the nearest mil (±).
14	10 8 ≈ 10M Plus CEN Rg * (______)	Determine and record the corrected range by expressing the total range correction to the nearest 10 meters and adding it to the center range.
15	11 FS ~ 10	Determine and record the fuze setting. Place the MHL (using the appropriate GFT) over the corrected range, and read the FS under the MHL.
16	12 Pos Ti Corr 11 Minus FS ~ CEN Rg (______)	Determine and record the position time correction by subtracting the fuze setting corresponding to the center range from the fuze setting corresponding to the corrected range.

c. The note on the bottom of DA Form 4757 lets you know to use the chart range to target wherever there is an * displayed.

d. The steps in Table 12-5 are used to determine TGPCs for all sheafs.

NOTE: Step 1 will be different for each type of sheaf. **Steps 2 through 17** are common to all sheafs.

Table 12-5. Determination of TGPCs for all Sheafs.

STEP	ACTION
CONVERGED SHEAF	
1	The single aimpoint for the converged sheaf will be the center of the plotting board.
CIRCULAR SHEAF	
1	Plot the piece locations, and determine piece displacement.
	NOTE: Base piece aimpoint will be the pivot in the center of the plotting board. This is done so that the base piece has no corrections.
1a	To plot the remaining aimpoints in the sheaf, the angle between aimpoints must be determined. Use the formula: $\frac{\textbf{6400}}{\textbf{NUMBER OF WEAPONS - 1}}$ **= ANGLE BETWEEN AIMPOINTS**
1b	Rotate the clear disk until the 0 graduation of the outer black scale is opposite the **azimuth index**.
1c	Count the effective burst width from the center toward the top of the board, and mark a small **X** on the disk with a soft-lead pencil. This is the first aimpoint.
1d	Plot the next aimpoint by rotating the clear disk until the value of the angle in step 1a is opposite the azimuth index. Count the burst width from the center toward the top of the board, and mark a small **X** on the disk with a soft-lead pencil. This is the second aimpoint.
1e	Plot the remaining aimpoints by rotating the clear disk to increase the value opposite the azimuth index by the angle in step 1a. Count the burst width from the center toward the top of the board, and mark a small **X** on the disk with a soft-lead pencil.
OPEN SHEAF	
1	Draw burst lines one burst width apart on the base of the plotting board. The burst lines are parallel to the center red arrow and are drawn from the top to the bottom of the plotting board in pencil. The first burst line will be the center line (red arrow). This line represents the burst line of the base piece. Additional burst lines are drawn for the remaining pieces, left and right of the center. Aimpoints will be the intersection of the burst line and the center horizontal red line on the base of the plotting board.
ALL SHEAFS	
2	The TGPCs must be computed for the center of the sector. Since the transfer limit for deflection is 800 mils, use the common deflection as the center of sector deflection and a range at the center of the area in which the FDO expects to engage the majority of targets. On the basis of this range, the FDO selects a charge.
3	Using the GFT, determine 100/R corresponding to the center range. Determine the change in range for a 1-mil change in elevation from the TFT, Table F, Column 5, for the appropriate charge.
4	Rotate the clear disk until the **32** graduation on the outer black scale is opposite the vernier scale.
5	Determine, by counting, the lateral correction (to the nearest 5 meters) from the leftmost piece to the leftmost aimpoint and the direction (left or right) from the howitzer to the aimpoint.
6	To determine the deflection correction for this howitzer, multiply the lateral correction determined in step 5 by the center range 100/R determined in step 3. Divide the product (answer) by 100, and express this answer to the nearest mil. Assign the sign (L/R) for the lateral correction. This is the deflection correction.
7	Determine the comparative VE for the howitzer.
8	Enter Table F of the TFT with the center of sector range, and extract from Columns 10 and 11 the unit correction for a 1 m/s change in muzzle velocity.

Table 12-5. Determination of TGPCs for all Sheafs (Continued).

STEP	ACTION
9	Determine the MV range correction by multiplying the comparative VE by the appropriate unit correction. (If the sign of the comparative VE is negative, use the decrease unit correction; if the sign of the comparative VE is positive, use the increase unit correction.) Express the answer to the nearest meter, and assign the sign of the unit correction. This is the MV range correction. **NOTE**: If the comparative VE is within ±1.5 m/s, steps 7 through 9 may be disregarded for speed, since ±1.5 m/s generally equates to ±2 probable errors in range.
10	Determine the position range correction by counting the distance from the howitzer to the assigned aimpoint toward the top or bottom of the plotting board. If the aimpoint is closer to the top of the board, the sign of the correction is plus (+). If the howitzer is closer to the top of the board, the sign of the correction is minus (-).
11	Algebraically add the MV range correction to the position range correction. The sum is the total range correction.
12	Divide the total range correction by the change in range for a 1-mil change in elevation from step 3. Express this answer to the nearest mil, and assign the sign of the total range correction. This is the position quadrant correction.
13	Determine the fuze setting corresponding to the center range from the GFT by using the manufacturer's hairline.
14	Determine the fuze setting corresponding to the corrected range (center range plus the total range correction) from the GFT.
15	Determine the position time correction by using the formula **FS AT CORR RG (STEP 15) - FS AT THE CEN RG (STEP 14) = POS TIME CORR**.
16	Determine corrections for the remainder of the pieces as described above.
17	Determine the transfer limits. The transfer limits define the area in which the TGPCs may be expected to provide accurate corrections for the sheaf.
17a	Determine the transfer limits for deflection as follows: **LEFT LIMIT = CENTER DF + 400 MILS** **RIGHT LIMIT = CENTER DF - 400 MILS**
17b	Determine the range transfer limits as follows: **MAX RANGE LIMIT = CENTER RANGE + 2,000 METERS** **MIN RANGE LIMIT = CENTER RANGE - 2,000 METERS**
17c	The HCO draws in blue pencil on the firing chart the range and deflection limits from the battery center. The HCO informs the FDO if any target plots outside the transfer limits.

12-11. Hasty Terrain Gun Position Corrections

a. Even with well-trained FDC personnel, computing TGPCs is time-consuming. Corrections are required for firing shortly after occupation of a position. If the advance party has determined displacement and computed TGPCs, corrections will be available immediately. If the advance party has not been able to do this, hasty TGPCs must be determined and used until accurate TGPCs are computed. For the hasty solution, piece displacement is estimated and fuze corrections are ignored.

b. Hasty TGPCs computations are designed to provide a converged sheaf at the center range of the TGPCs sector.

c. Tables 12-8 through 12-13 show data for hasty TGPCs and special corrections. The data presented in these tables are:

- Range in 1,000-meter increments.
- Charge most likely to be fired at the listed range.
- Deflection correction, in mils, to compensate for lateral piece displacement. These values have been determined to the nearest mil with the GST for each 20 meters of lateral displacement (20 to 200 meters).

$$\frac{\text{LATERAL DISPLACEMENT (D SCALE)}}{\text{RANGE IN 1,000s (C SCALE)}} = \text{HASTY TGPC DF CORR}$$

- Position range correction, in mils, to compensate for piece displacement in range. QE corrections to the nearest mil for each 20 meters of front or rear displacement (20 to 100 meters) were computed by using the range change per mil for the listed ranges.

$$\frac{\text{DISPLACEMENT}}{\text{RANGE CHANGE PER MIL}} = \text{HASTY TGPC POSITION RG CORR}$$

- MV correction in mils to compensate for the difference in shooting strengths (battery comparative VEs). MV corrections were determined by using the following formula.

$$\frac{\text{MVUCF X BTRY COMP VE}}{\text{RANGE CHANGE PER MIL}} = \text{HASTY TGPC MV CORR}$$

NOTE: MVUCF is the muzzle velocity unit correction factor from the TFT, Table F, Columns 10 and 11.

12-12. Determination of Hasty TGPCs

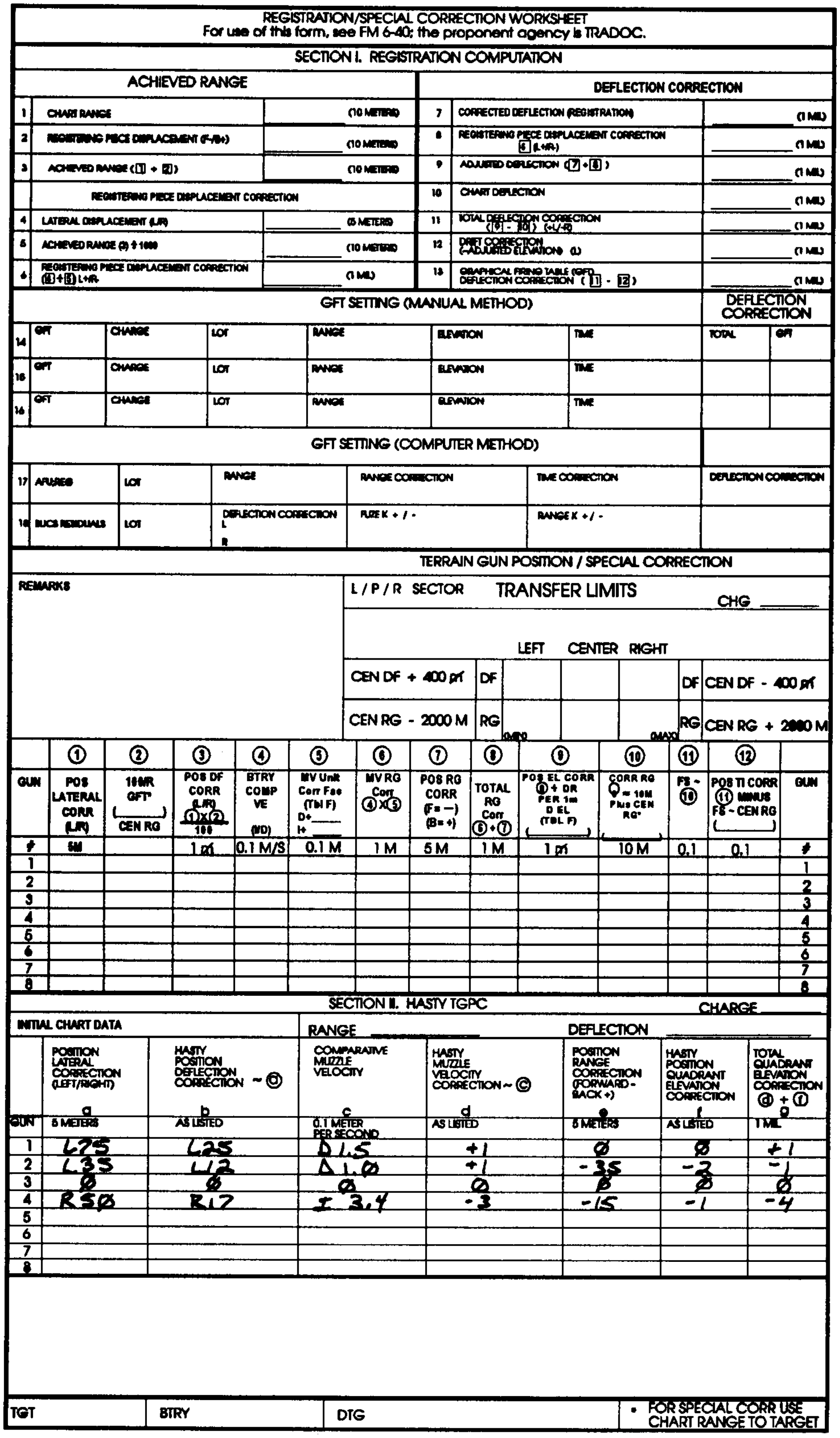
Table 12-6 gives the procedures for determining hasty TGPCs, and Table 12-7 gives the procedures for completing DA Form 4757. Figure 12-11 shows recorded hasty TGPCs.

Table 12-6. Determination of Hasty TGPCs.

STEP	ACTION
1	Enter the table at the nearest listed range to the center of the TGPC sector.
2	Extract the deflection correction by visually interpolating (if necessary) between the lateral displacements listed that bracket the estimated lateral displacement of the piece. If the piece is left of base piece (BP), the correction is to the right; if the piece is right of BP, the correction is to the left. This correction is placed on the gunner's aid of the pantel.
3	Extract the position range correction, in mils, by visually interpolating between the range displacements listed that bracket the estimated lateral displacement of the piece. If the piece is behind BP, the correction is plus; if the piece is forward of BP, the correction is minus.
4	Extract the MV correction, in mils, for the battery comparative VE by visually interpolating between the VEs listed that bracket the VE of the piece. A positive VE will have a negative correction; a negative VE will have a positive correction.
5	Add the position range correction, in mils, to the MV correction, in mils. The sum is the elevation correction to be carried on the correction counter on the range quadrant.

Table 12-7. Completion of DA Form 4757.

STEP	REFERENCE	ACTION
1	Charge ______ Deflection ____ Range _______	Record the charge, deflection, and range to the center of the sector.
2	Position Lateral Correction (L/R) a 5 Meters	Record the position lateral correction required to move each weapon to its selected burst line or aimpoint to the nearest 5 meters.
3	Hasty Position Deflection Correction ~ⓐ b As Listed	Determine and record the hasty position deflection correction corresponding to the lateral correction (Col a) from the hasty TGPC tables.
4	Platoon Comparative Muzzle Velocity Variation c 0.1 Meter Per Second	Record the comparative VE for each howitzer.
5	Hasty Muzzle Velocity Correction ~ⓒ d As Listed	Determine and record the hasty muzzle velocity correction corresponding to the comparative VEs (Col c) from the hasty TGPC tables.
6	Position Range Correction (Forward - Back +) e 5 Meters	Record the required position range corrections to the nearest 5 meters. If the weapon is forward of the base piece, the correction is minus; if it is behind, the correction is plus.
7	Hasty Position Quadrant Elevation Correction f As Listed	Determine and record the hasty quadrant elevation correction corresponding to the position range correction.
8	Total Quadrant Elevation Correction ⓓ+ⓕ g 1 Mil	Determine and record the total quadrant correction by adding the hasty MV correction (Col d) to the hasty QE correction (Col f).



REGISTRATION/SPECIAL CORRECTION WORKSHEET
For use of this form, see FM 6-40; the proponent agency is TRADOC.

SECTION I. REGISTRATION COMPUTATION

	ACHIEVED RANGE			DEFLECTION CORRECTION	
1	CHART RANGE	(10 METERS)	7	CORRECTED DEFLECTION (REGISTRATION)	(1 MIL)
2	REGISTERING PIECE DISPLACEMENT (F-/B+)	(10 METERS)	8	REGISTERING PIECE DISPLACEMENT CORRECTION 6 (L+/R-)	(1 MIL)
3	ACHIEVED RANGE (1 + 2)	(10 METERS)	9	ADJUSTED DEFLECTION (7 + 8)	(1 MIL)
	REGISTERING PIECE DISPLACEMENT CORRECTION		10	CHART DEFLECTION	(1 MIL)
4	LATERAL DISPLACEMENT (L/R)	(5 METERS)	11	TOTAL DEFLECTION CORRECTION (9 - 10) (+L/-R)	(1 MIL)
5	ACHIEVED RANGE (3) ÷ 1000	(10 METERS)	12	DRIFT CORRECTION (-ADJUSTED ELEVATION) (L)	(1 MIL)
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4 ÷ 5) L+/R-	(1 MIL)	13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11 - 12)	(1 MIL)

GFT SETTING (MANUAL METHOD) — DEFLECTION CORRECTION

14 GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	TOTAL	GFT
15 GFT	CHARGE	LOT	RANGE	ELEVATION	TIME		
16 GFT	CHARGE	LOT	RANGE	ELEVATION	TIME		

GFT SETTING (COMPUTER METHOD)

17 AFU/REG	LOT	RANGE	RANGE CORRECTION	TIME CORRECTION	DEFLECTION CORRECTION
18 BUCS RESIDUALS	LOT	DEFLECTION CORRECTION L R	FUZE K + / -	RANGE K + / -	

TERRAIN GUN POSITION / SPECIAL CORRECTION

REMARKS

L / P / R SECTOR TRANSFER LIMITS CHG ______

		LEFT	CENTER	RIGHT		
CEN DF + 400 m̸	DF				DF	CEN DF - 400 m̸
CEN RG - 2000 M	RG (MIN)			(MAX)	RG	CEN RG + 2000 M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (____) CEN RG	POS DF CORR (L/R) ①X② / 100	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+____ I+____	MV RG Corr ④X⑤	POS RG CORR (F= —) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ + DR PER 1m D EL (TBL F) (____)	CORR RG ⑨ ≈ 10M Plus CEN RG* (____)	FS ~ ⑩	POS TI CORR ⑪ MINUS FS ~ CEN RG (____)	GUN
#	5M		1 m̸	0.1 M/S	0.1 M	1 M	5 M	1 M	1 m̸	10 M	0.1	0.1	#
1													1
2													2
3													3
4													4
5													5
6													6
7													7
8													8

SECTION II. HASTY TGPC CHARGE ______

INITIAL CHART DATA RANGE ______ DEFLECTION ______

GUN	POSITION LATERAL CORRECTION (LEFT/RIGHT) a	HASTY POSITION DEFLECTION CORRECTION ~ ⓐ b	COMPARATIVE MUZZLE VELOCITY c	HASTY MUZZLE VELOCITY CORRECTION ~ ⓒ d	POSITION RANGE CORRECTION (FORWARD - BACK +) e	HASTY POSITION QUADRANT ELEVATION CORRECTION f	TOTAL QUADRANT ELEVATION CORRECTION ⓓ + ⓕ g
	5 METERS	AS LISTED	0.1 METER PER SECOND	AS LISTED	5 METERS	AS LISTED	1 MIL
1	L75	L25	D1.5	+1	0	0	+1
2	L35	L12	Δ1.0	+1	-35	-2	-1
3	0	0	0	0	0	0	0
4	R50	R17	I 3.4	-3	-15	-1	-4
5							
6							
7							
8							

TGT	BTRY	DTG	* FOR SPECIAL CORR USE CHART RANGE TO TARGET

Figure 12-11. Completed DA Form 4757 for Hasty TGPCs (M109A3).

NOTE: The following tables are to be used for hasty TGPCs and special corrections. They are separated by weapon system.

Table 12-8. Hasty TGPCs and Special Corrections, 105-mm M101A1.

Mid Range	Charge	Deflection Corrections										Position Correction					MV Correction (m)							
		20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	+1.5 -1.5	+2.0 -2.0	+2.5 -2.5	+3.0 -3.0	+3.5 -3.5	+4.0 -4.0	+4.5 -4.5	+5.0 -5.0
2000	3	10	20	31	41	51	61	71	81	92	102	2	4	6	8	10	-2 +2	-3 +3	-4 +4	-4 +5	-5 +6	-6 +6	-6 +7	-7 +13
3000	4	7	14	20	27	34	41	47	54	61	68	2	3	5	7	8	-2 +3	-3 +3	-4 +4	-5 +5	-5 +6	-6 +7	-7 +7	-8 +9
4000	4	5	10	15	20	25	31	36	41	46	51	2	4	6	8	10	-3 +4	-5 +5	-6 +7	-7 +8	-8 +9	-10 +11	-11 +12	-12 +8
5000	5	4	8	12	16	20	24	29	33	37	41	2	3	5	6	8	-2 +2	-2 +3	-3 +4	-4 +5	-4 +6	-5 +7	-5 +7	-6 +8
6000	5	3	7	10	14	17	20	24	27	31	34	2	4	6	7	9	-2 +3	-3 +5	-4 +6	-5 +7	-6 +8	-7 +9	-8 +10	-8 +11
7000	6	3	6	9	12	15	17	20	23	26	29	2	3	5	7	8	-2 +2	-2 +3	-3 +3	-4 +4	-4 +4	-5 +5	-6 +6	-6 +6
8000	7	3	5	8	10	13	15	18	20	23	25	1	3	4	5	7	-2 +2	-2 +2	-3 +3	-3 +3	-4 +4	-4 +4	-5 +5	-5 +5
9000	7	2	5	7	9	11	14	16	18	20	23	2	3	5	6	8	-2 +2	-3 +3	-3 +3	-4 +4	-4 +4	-5 +5	-6 +6	-6 +6
10000	7	2	4	6	8	10	12	14	16	18	20	2	4	6	8	10	-3 +3	-4 +4	-4 +4	-5 +5	-6 +6	-7 +7	-8 +8	-9 +9

Table 12-9. Hasty TGPCs and Special Corrections, 203-mm M110A2 (M106).

M110A2 203-MM (8-INCH) FT 8-Q-1 M106		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	+5 -5	+10 -10	+15 -15	+20 -20	+25 -25	+30 -30	+35 -35	+40 -40	+45 -45	+50 -50
		MILS										MILS										MILS									
1000	3GB	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2	+1 -2
1500	3GB	13	26	40	53	66	80	93	106	120	133	1	1	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+2 -2	+2 -2	+2 -3	+2 -3
2000	4GB	10	20	30	40	50	60	70	80	90	100	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3
3000	4GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4
3500	4GB	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+3 -2	+3 -3
4000	4GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4
4500	4GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+3 -4
5000	5GB	4	8	12	16	20	24	28	32	36	40	0	1	2	3	4	4	5	6	7	8	+0 -0	+0 -0	+0 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+2 -2	+3 -3
5500	5GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+3 -3	+4 -4	+4 -4	+5 -5
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+3 -3	+4 -4	+5 -5	+5 -5
7500	5GB	2	5	8	10	13	16	18	21	24	26	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+4 -4	+4 -4	+5 -5	+5 -5
8000	5GB	2	5	7	10	12	15	17	20	22	25	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
8500	5GB	2	4	7	9	11	14	16	18	21	23	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
9000	5GB	2	4	6	8	11	13	15	17	20	22	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -6	+6 -7	+7 -8	+8 -9
9500	5GB	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -2	+3 -3	+4 -3	+5 -4	+6 -4	+7 -5	+8 -5	+8 -6
10000	5GB	2	4	6	8	10	12	14	16	18	20	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
10500	5GB	1	3	5	7	9	11	13	15	17	19	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+4 -5	+6 -6	+7 -8	+8 -9	+9 -10	+10 -11	+12 -12

Table 12-9. Hasty TGPCs and Special Corrections, 203-mm M110A2 (M106)(Continued).

M110A2 203-MM (8-INCH) FT 8-Q-1 M106		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS M/S									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	+5 -5	+10 -10	+15 -15	+20 -20	+25 -25	+30 -30	+35 -35	+40 -40	+45 -45	+50 -50
		MILS										MILS										MILS									
11000	7WB	1	3	5	7	9	10	12	14	16	18	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
11500	7WB	1	3	5	6	8	10	12	13	15	17	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
12000	7WB	1	3	5	6	8	10	11	13	15	16	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
12500	7WB	1	3	4	6	8	9	11	12	14	16	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
13000	7WB	1	3	4	6	7	9	10	12	13	15	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -3	+3 -4	+4 -5	+5 -6	+6 -6	+6 -7	+7 -8
13500	7WB	1	2	4	5	7	8	10	11	13	14	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+6 -7	+7 -8
14000	7WB	1	2	4	5	7	8	10	11	12	14	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+6 -8	+7 -8
14500	7WB	1	2	4	5	6	8	9	11	12	13	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+7 -8
15000	7WB	1	2	4	5	6	8	9	10	12	13	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
15500	7WB	1	2	3	5	6	7	9	10	11	12	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
16000	7WB	1	2	3	5	6	7	8	10	11	12	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+4 -5	+5 -6	+7 -7	+8 -9	+9 -10	+11 -11	+12 -13	+14 -14
16500	8WB	1	2	3	4	6	7	8	9	10	12	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9
17000	8WB	1	2	3	4	5	7	8	9	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+4 -6	+5 -6	+6 -7	+7 -8	+8 -9
17500	8WB	1	2	3	4	5	6	8	9	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8	+8 -9
18000	8WB	1	2	3	4	5	6	7	8	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -6	+6 -7	+7 -8	+8 -9
18500	8WB	1	2	3	4	5	6	7	8	9	10	1	3	4	6	8	9	11	12	14	16	+1 -1	+2 -2	+3 -3	+4 -4	+5 -5	+6 -6	+8 -8	+9 -9	+10 -10	+11 -11
19000	8WB	1	2	3	4	5	6	7	8	9	10	1	3	4	6	8	9	11	12	14	16	+1 -1	+2 -2	+3 -3	+4 -4	+5 -5	+6 -6	+8 -8	+9 -9	+10 -10	+11 -11
19500	8WB	1	2	3	4	5	6	7	8	9	10	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+11 -12	+13 -14	+14 -15
20000	9	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
20500	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
21000	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
21500	9	0	1	2	3	4	5	6	7	8	9	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+5 -6	+6 -7	+7 -8	+8 -9	+10 -11	+11 + 12	+12 + 13
22000	9	0	1	2	3	4	5	6	7	8	9	2	4	6	8	10	12	14	16	18	20	+1 -2	+3 -4	+4 -5	+6 -7	+8 -9	+9 -10	+11 + 12	+13 + 13	+14 + 15	+16 + 17

Table 12-10. Hasty TGPCs and Special Corrections, 203-mm M110A2 (M650).

M110A2 FT 8-S-1 M650		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	-5 +5	-10 +10	-15 +15	-20 +20	-25 +25	-30 +30	-35 +35	-40 +40	-45 +45	-50 +50
		MILS										MILS										MILS									
2000	4GB	10	20	30	40	50	60	70	80	90	100	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2	+1 -3	+2 -3
3000	4GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -2	+1 -2	+1 -2	+1 -2	+1 -3	+2 -3	+2 -3
3500	4GB	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -3	+2 -3	+2 -3	+2 -3
4000	4GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -3	+2 -3	+2 -3	+2 -4
4500	4GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -2	+1 -2	+1 -2	+1 -3	+2 -3	+2 -3	+2 -3	+3 -4
5000	4GB	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4
5500	4GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+3 -4
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -6	+5 -6
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -5	+4 -5	+5 -6	+5 -6
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6
7500	5GB	2	5	8	10	13	16	18	21	24	26	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -1	+1 -1	+2 -2	+3 -3	+3 -3	+4 -4	+4 -4	+5 -5	+6 -6
8000	5GB	2	5	7	10	12	15	17	20	22	25	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7
8500	5GB	2	4	7	9	11	14	16	18	21	23	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7
9000	5GB	2	4	6	8	11	13	15	17	20	22	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -9
9500	5GB	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
10000	5GB	2	4	6	8	10	12	14	16	18	20	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
10500	5GB	1	3	5	7	9	11	13	15	17	19	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+5 -5	+6 -7	+7 -8	+8 -9	+10 -10	+11 -12	+12 -13
11000	6WB	1	3	5	7	9	10	12	14	16	18	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+7 -8
11500	6WB	1	3	5	6	8	10	12	13	15	17	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+7 -8
12000	6WB	1	3	5	6	8	10	11	13	15	16	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9
12500	6WB	1	3	4	6	8	9	11	12	14	16	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+10 -10	+11 -12
13000	6WB	1	3	4	6	7	9	10	12	13	15	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+11 -12
13500	6WB	1	2	4	5	7	8	10	11	13	14	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+11 -12	+13 -13	+14 -15
14000	8	1	2	4	5	7	8	10	11	12	14	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+5 -5	+5 -6
14500	8	1	2	4	5	6	8	9	11	12	13	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6
15000	8	1	2	4	5	6	8	9	10	12	13	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6
15500	8	1	2	3	5	6	7	9	10	11	12	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6
16000	8	1	2	3	5	6	7	8	10	11	12	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+3 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -6
16500	8	1	2	3	4	6	7	8	9	10	12	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
17000	8	1	2	3	4	5	7	8	9	10	11	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7

Table 12-10. Hasty TGPCs and Special Corrections, 203-mm M110A2 (M650) (Continued).

M110A2 FT 8-S-1 M650		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	-5 +5	-10 +10	-15 +15	-20 +20	-25 +25	-30 +30	-35 +35	-40 +40	-45 +45	-50 +50
		MILS										MILS										MILS									
17500	8	1	2	3	4	5	6	8	9	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
18000	8	1	2	3	4	5	6	7	8	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
18500	8	1	2	3	4	5	5	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -2	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
19000	8	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+2 -2	+3 -3	+4 -4	+5 -5	+6 -6	+7 -7	+8 -8	+9 -9
19500	8	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -2	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
20000	8	1	2	3	4	5	6	7	8	9	10	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+4 -4	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+12 -12	+13 -14
20500	8	0	1	2	3	4	5	6	7	8	9	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+4 -5	+5 -6	+6 -7	+8 -9	+9 -10	+10 -11	+12 -13	+13 -14
21000	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
21500	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
22000	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
22500	9	0	1	2	3	4	5	6	7	8	8	1	3	4	6	8	9	11	12	14	16	+1 -1	+2 -2	+4 -4	+5 -5	+7 -7	+8 -8	+10 -10	+11 -11	+12 -12	+14 -14
23000	9	0	1	2	3	4	5	6	6	7	8	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+11 -12	+12 -14	+14 -15
23500	9	0	1	2	3	4	5	5	6	7	8	2	4	6	8	10	12	14	16	18	20	+1 -1	+3 -3	+5 -5	+7 -7	+9 -9	+10 -11	+12 -12	+14 -14	+16 -16	+18 -18
24000	8R	0	1	2	3	4	5	5	6	7	8	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+6 -7	+7 -8	+8 -9	+9 -10	+11 -11	+12 -13
24500	8R	0	1	2	3	4	4	5	6	7	8	1	3	4	6	8	9	11	12	14	16	+1 -1	+3 -3	+4 -4	+6 -6	+8 -8	+9 -9	+11 -11	+13 -13	+14 -14	+16 -16
25000	8R	0	1	2	3	4	4	5	6	7	8	1	3	4	6	8	9	11	12	14	16	+1 -2	+3 -4	+5 -6	+6 -7	+8 -9	+10 -11	+11 -12	+13 -14	+15 -16	+16 -17
25500	8R	0	1	2	3	3	4	5	6	7	7	2	4	6	8	10	12	14	16	18	20	+2 -3	+4 -5	+6 -7	+8 -9	+10 -11	+12 -13	+14 -15	+16 -17	+19 -20	+21 -22
26000	9R	0	1	2	3	3	4	5	6	6	7	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -6	+7 -7	+7 -8	+8 -9
26500	9R	0	1	2	3	3	4	5	6	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+4 -4	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+12 -12	+13 -14
27000	9R	0	1	2	2	3	4	5	5	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+4 -5	+5 -6	+7 -7	+8 -9	+9 -10	+11 -11	+12 -13	+14 -14
27500	9R	0	1	2	2	3	4	5	5	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -10	+11 -12	+13 -13	+14 -14
28000	9R	0	1	2	2	3	4	5	5	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+3 -3	+4 -5	+6 -6	+7 -8	+9 -9	+11 -11	+12 -12	+14 -14	+15 -15
28500	9R	0	1	2	2	3	4	4	5	6	7	1	3	4	6	8	9	11	12	14	16	+2 -3	+4 -5	+6 -7	+9 -9	+11 -11	+13 -13	+16 -15	+18 -17	+20 -19	+23 -21
29000	9R	0	1	2	2	3	4	4	5	6	6	2	4	6	8	10	12	14	16	18	20	+3 -3	+6 -6	+9 -9	+12 -12	+15 -14	+18 -17	+21 -20	+24 -23	+27 -26	+30 -28

Table 12-11. Hasty TGPCs and Special Corrections, M109A2/A3 (M198).

M109A2/A3 M198 155-AN-1 483A1		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	+5 -5	+10 -10	+15 -15	+20 -20	+25 -25	+30 -30	+35 -35	+40 -40	+45 -45	+50 -50
		MILS										MILS										MILS									
1000	4GB	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2	+1 -2
1500	4GB	13	26	40	53	66	80	93	106	120	133	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -2	+0 -2	+1 -2	+1 -2	+1 -3	+1 -3	+1 -3
2000	4GB	10	20	30	40	50	60	70	80	90	100	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -2	+2 -3	+2 -3	+3 -3	+3 -3
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -2	+2 -3	+3 -3	+3 -4	+4 -4	+4 -4
3000	5GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -3	+3 -4
3500	5GB	5	11	17	2	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -3	+3 -4	+3 -4
4000	5GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4	+3 -4
4500	5GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -3	+3 -4	+4 -4	+4 -5
5000	5GB	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
5500	5GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -2	+2 -3	+3 -3	+3 -4	+4 -4	+4 -5	+5 -5
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -3	+3 -4	+4 -5	+5 -5	+6 -6	+6 -7	+7 -8
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -4	+4 -5	+5 -6	+6 -6	+7 -7	+8 -8
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -4	+5 -5	+6 -6	+6 -7	+7 -8	+8 -8
7500	7WB	2	5	8	10	13	16	18	21	24	26	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+3 -4
8000	7WB	2	5	7	19	12	15	17	20	22	25	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -4
8500	7WB	2	4	7	9	11	14	16	18	21	23	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5
9000	7WB	2	4	6	8	11	13	15	17	20	22	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5
9500	7WB	2	4	6	8	10	12	14	16	18	21	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7
10000	7WB	2	4	6	8	10	12	14	16	18	20	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+4 -4	+4 -5	+5 -6	+6 -6	+6 -7
10500	7WB	1	3	5	7	9	11	13	15	17	19	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+6 -7
11000	7WB	1	3	5	7	9	10	12	14	16	18	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+6 -7
11500	7WB	1	3	5	6	8	10	12	13	15	17	1	2	3	4	6	7	8	9	10	12	+1 -1	+1 -1	+2 -2	+3 -3	+4 -4	+4 -4	+5 -5	+6 -6	+6 -6	+7 -7
12000	7WB	1	3	5	6	8	10	11	13	15	16	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
12500	7WB	1	3	4	6	8	9	11	12	14	16	1	3	4	6	8	9	11	12	14	16	+0 -2	+2 -2	+2 -3	+4 -4	+4 -5	+6 -6	+6 -7	+8 -8	+8 -9	+10 -10
13000	7WB	1	3	4	6	7	9	10	12	13	15	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+5 -6	+6 -7	+7 -8	+9 -9	+10 -11	+11 -12	+12 -13
13500	7WB	1	2	4	5	7	8	10	11	13	14	2	5	7	10	12	14	17	19	22	24	+1 -2	+3 -4	+4 -5	+6 -7	+7 -8	+9 -10	+11 -11	+12 -13	+14 -15	+15 -16
14000	7WB	1	2	4	5	7	8	10	11	12	14	4	7	11	14	18	22	25	29	32	36	+2 -2	+5 -5	+7 -7	+10 -10	+12 -12	+15 -14	+17 -17	+20 -19	+22 -21	+25 -26
14500	8WB	1	2	4	5	6	8	9	11	12	13	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -3	+3 -4	+4 -5	+5 -6	+6 -6	+6 -7	+7 -8
15000	8WB	1	2	4	5	6	8	9	10	12	13	1	3	4	6	8	9	11	12	14	16	+0 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
15500	8WB	1	2	3	5	6	7	9	10	11	12	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
16000	8WB	1	2	3	5	6	7	8	10	11	12	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
16500	8WB	1	2	3	4	6	7	8	9	10	12	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+4 -5	+5 -6	+6 -7	+8 -9	+9 -10	+11 -11	+12 -13	+13 -14
17000	8WB	1	2	3	4	5	7	8	9	10	11	3	6	10	13	16	19	22	26	29	32	+2 -2	+5 -4	+7 -7	+9 -9	+12 -11	+14 -13	+16 -15	+18 -18	+20 -20	+23 -22

Table 12-11. Hasty TGPCs and Special Corrections, M109A2/A3 (M198) (Continued).

M109A2/A3 M198 155-AM-2 M107		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	-5 +5	-10 +10	-15 +15	-20 +20	-25 +25	-30 +30	-35 +35	-40 +40	-45 +45	-50 +50
		MILS										MILS										MILS									
1000	4GB	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -0	+1 -1	+1 -1	+1 -1	+1 -1	+1 -1	+2 -1	+2 -2
1500	4GB	13	26	40	53	66	80	93	106	120	133	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+1 -2	+2 -2	+2 -2	+2 -3
2000	4GB	10	20	30	40	50	60	70	80	90	100	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+2 -2	+2 -2	+3 -3	+3 -3	+3 -3
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -2	+2 -3	+3 -3	+3 -3	+3 -4	+4 -4
3000	4GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -1	+1 -2	+2 -2	+2 -2	+3 -3	+3 -3	+4 -4	+4 -4	+5 -4
3500	4GB	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -1	+1 -2	+2 -2	+2 -3	+3 -3	+4 -4	+4 -4	+5 -5	+5 -5
4000	5GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4
4500	5GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+3 -4
5000	5GB	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+2 -2	+3 -3	+3 -3	+4 -4
5500	5GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+3 -3	+3 -3	+4 -4
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	3	4	6	8	9	11	12	14	16	+0 -1	+0 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+6 -7
7500	5GB	2	5	8	10	13	16	18	21	24	26	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
8000	5GB	2	5	7	10	12	15	17	20	22	25	2	4	6	8	10	12	14	16	18	20	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
8500	6WB	2	4	7	9	11	14	16	18	21	23	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6
9000	6WB	2	4	5	8	11	13	15	17	20	22	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
9500	6WB	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8	+8 -9
10000	6WB	2	4	6	8	10	12	14	16	18	20	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -6	+6 -7	+7 -8	+8 -9
10500	6WB	1	3	5	7	9	11	13	15	17	19	1	3	4	6	9	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -8	+8 -9
11000	6WB	1	3	5	7	9	10	12	14	16	18	2	4	5	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+8 -8	+9 -9	+10 -11	+11 -12
11500	7WB	1	3	5	6	8	10	12	13	15	17	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+6 -7
12000	7WB	1	3	5	6	8	10	11	13	15	16	1	2	3	4	5	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+6 -7
12500	7WB	1	3	4	6	8	9	11	12	14	16	1	3	4	5	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
13000	7WB	1	3	4	6	7	9	10	12	13	15	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
13500	7WB	1	2	4	5	7	8	10	11	13	14	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+4 -5	+6 -7	+7 -8	+8 -9	+9 -10	+11 -11	+12 -13
14000	7WB	1	2	4	5	7	8	10	11	12	14	2	5	7	10	12	14	17	19	22	24	+2 -1	+3 -3	+5 -5	+6 -6	+8 -7	+9 -9	+11 -10	+12 -12	+14 -13	+15 -15
14500	8	1	2	4	5	6	8	9	11	12	13	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+7 -8
15000	8	1	2	4	5	6	8	9	10	12	13	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
15500	8	1	2	3	5	6	7	9	10	11	12	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
16000	8	1	2	3	5	6	7	8	10	11	12	1	3	4	6	8	9	11	12	14	16	+0 -2	+2 -2	+2 -4	+4 -4	+5 -5	+6 -6	+7 -7	+8 -8	+9 -9	+10 -10
16500	8	1	2	3	4	6	7	8	9	10	12	1	3	4	6	8	9	11	12	14	16	+0 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
17000	8	1	2	3	4	5	7	8	9	10	11	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+5 -6	+6 -7	+7 -8	+9 -10	+10 -11	+11 -12	+12 -13
17500	8	1	2	3	4	5	6	8	9	10	11	3	6	8	11	14	17	20	22	25	28	+1 -2	+3 -4	+5 -6	+7 -8	+9 -10	+11 -12	+13 -14	+15 -15	+17 -17	+19 -19

Table 12-12. Hasty TGPCs and Special Corrections, M102.

M102 105-AS-2		HASTY POSITION DEFLECTION CORRECTIONS (LATERAL) (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	-.5 +.5	-1.0 +1.0	-1.5 +1.5	-2.0 +2.0	-2.5 +2.5	-3.0 +3.0	-3.5 +3.5	-4.0 +4.0	-4.5 +4.5	-5.0 +5.0
		MILS										MILS										MILS									
1000	5	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+1 -2
1500	5	13	26	40	53	66	80	93	106	120	133	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+1 -2	+2 -2	+2 -2
2000	5	10	20	30	40	50	60	70	80	90	100	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+1 -2	+2 -2	+2 -3	+2 -3
2500	5	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+2 -2	+2 -2	+2 -3	+3 -3	+3 -3
3000	5	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -1	+1 -2	+2 -2	+2 -2	+2 -3	+3 -3	+3 -3	+3 -4
3500	5	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -2	+2 -3	+3 -3	+3 -3	+4 -4	+4 -4
4000	6	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+2 -2	+3 -3	+3 -3
4500	6	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4
5000	6	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+3 -3	+3 -3
5500	6	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -3	+2 -3	+2 -3	+3 -4	+3 -4	+3 -5
6000	6	3	6	10	13	16	20	23	26	27	33	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5
6500	6	3	6	9	12	15	18	21	24	25	30	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6
7000	6	2	5	8	11	14	17	20	22	24	28	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
7500	6	2	5	8	10	13	16	18	21	22	26	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7
8000	6	2	5	7	10	12	15	17	20	21	25	2	4	6	8	10	12	14	16	18	20	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -5	+5 -6	+6 -7	+7 -8	+8 -9
8500	6	2	4	7	9	11	14	16	18	20	23	2	5	7	10	12	14	17	19	22	24	+0 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
9000	7	2	4	6	8	11	13	15	17	18	22	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -2	+2 -3	+3 -4	+4 -4	+4 -5	+5 -6	+6 -6	+6 -7
9500	7	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7	+6 -7
10000	7	2	4	5	8	10	12	14	16	17	20	2	4	6	8	10	12	14	16	18	20	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -7	+7 -8	+8 -9
10500	7	1	3	5	7	9	11	13	15	16	19	2	5	7	10	12	14	17	19	22	24	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
11000	7	1	3	5	7	9	10	12	14	15	18	3	5	10	13	16	19	22	26	29	32	+1 -2	+2 -4	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+12 -12	+13 -14	+14 -15

Section IV

Special Corrections

The corrections determined by using TGPCs are valid only within the specified transfer limits and produce the sheaf for which they were computed. If a target falls outside the transfer limits or is irregularly shaped, it is necessary to compute special corrections.

12-13. Definitions and Use

Special corrections are individual piece corrections applied to time, deflection, and quadrant elevation to place FFE bursts in precise location on a target. Special corrections are used for:

- Individual piece locations (position correction).
- Shooting strength of each piece (calculated correction).
- Target shape and size.

a. Knowing when to compute special corrections is as important as knowing how to compute them. Some factors that influence the use of special corrections are:

- Time available for computation.
- Target size, shape, and proximity to friendly troops.
- Accuracy of target location.

b. Special corrections should be applied when and where they will increase the effectiveness of fires on the target. Because of the time required for computation, they are used only for FFE missions.

c. The special corrections are computed in a similar manner to TGPCs, the major difference being the plotting of the target. The following types of sheafs may be computed:

- Converged sheaf.
- A target described by grid, length, and attitude.
- A target described by two grids.
- A target described by three or more grids.
- A circular target.

12-14. Computation of Special Corrections

Table 12-13 provides the steps and procedures for the computation of special corrections.

Table 12-13. Computation of Special Corrections.

STEP	ACTION
	CONVERGED SHEAF
1	The single aimpoint will be the center of the plotting board. To determine corrections, go to step 6.
	TARGET DESCRIBED BY GRID, ATTITUDE, AND LENGTH
2	The center of the plotting board will represent the center grid reported in the call for fire.
2a	Rotate the clear disk until the attitude reported in the call for fire is opposite the **azimuth index** on the outer black scale.
2b	Divide the length of the target by 2.
2c	Along the vertical red line, count the distance determined in step 2b from the center of the plotting board to the top. (Each square equals 10 meters.) Mark this distance with a small **X**. This marks the outer end of the target.
2d	Along the center vertical red line, count the distance determined in step 2c from the center of the plotting board toward the bottom. (Each square equals 10 meters.) Mark this distance with a small **X**. This marks the other end of the target.
2e	Divide the length of the target by one less than the number of howitzers to fire.
2f	Starting at either end of the target, count the distance computed in step 2e. Each square represents 10 meters. At the end of the distance, mark a small **X** on the target. Repeat this process until the other end of the target is reached. The small Xs represent the aimpoints.
2g	Rotate the clear disk until the deflection to the center of the target (measured from the firing chart) is opposite the vernier index on the inner red scale.
	NOTE: The sheaf width using this method will be one effective burst width greater than the target length. To make the sheaf width equal to the target length, subtract one effective burst width from the target length before dividing by 2 in step 2b.
2h	To compute corrections, go to step 6.
	TARGET DESCRIBED BY TWO GRIDS
3	Determine the center of the target.
3a	Subtract the eastings and northings of the grids. Use the following: **FIRST EASTING COORDINATE** / **FIRST NORTHING COORDINATE** **- SECOND EASTING COORDINATE** / **- SECOND NORTHING COORDINATE** **DIFFERENCE IN EASTING (±)** / **DIFFERENCE IN NORTHING (±)**
3b	Divide the difference in easting and the difference in northing by two.
3c	Algebraically subtract the values from step 3b above from the first grid easting and northing. This is the center grid.
3d	The HCO plots the center grid and determines chart range and deflection to the center of the target.
3e	Rotate the clear disk until 0 is opposite the **azimuth index** on the outer black scale. The top of the plotting board now represents grid north.
3f	Plot the end of the target by counting the difference in easting divided by 2 and the difference in northing divided by 2 as determined in step 3b. If the easting sign is negative, count the distance to the west (left); if the sign is positive, count the distance to the east (right). Then, if the northing sign is negative, count south (bottom); if it is positive, count north (top). At the end of this distance, mark a small **X**.
3g	To plot the other end of the target, reverse the signs and plot the distances in the opposite direction from the center.
3h	Rotate the clear disk until the long axis of the target is aligned with the center red line on the base of the plotting board.
3i	Divide the length of the target by one less than the number of howitzers to fire.

Table 12-13. Computation of Special Corrections (Continued).

STEP	ACTION
3j	Starting at either end of the target, count the distance computed in step 3i. Each square represents 10 meters. At the end of the distance, mark a small **X** on the target. Repeat this process until the other end of the target is reached. The small Xs represent the aimpoints.
3k	Rotate the clear disk until the deflection (red scale) to the center of the target (measured from the firing chart) is opposite the vernier index.
3l	To compute corrections, go to step 6.
	TARGET DESCRIBED BY THREE OR MORE GRIDS
4	Select one of the inner grids as the center. This grid does not need to be the actual center. It will be represented by the center of the plotting board and will provide a starting point from which the remainder of the grids can be plotted.
4a	To plot the remaining grids, subtract the easting and northing of the center grid from the first grid. Use the following: **FIRST EASTING COORDINATE** **FIRST NORTHING COORDINATE** **- CENTER EASTING COORDINATE** **- CENTER NORTHING COORDINATE** **DIFFERENCE IN EASTING (±)** **DIFFERENCE IN NORTHING (±)**
4b	Rotate the clear disk until 0 is opposite the **azimuth index** on the outer black scale. The top of the plotting board now represents grid north.
4c	Plot the first grid by counting the difference in easting and the difference in northing as determined in step 4a. If the easting sign is negative, count the distance to the west (left); if the sign is positive, count the distance to the east (right). Then, if the northing sign is negative, count south (bottom); if it is positive, count north (top). At the end of this distance, mark a small **X**.
4d	To plot the remaining grids, repeat the procedure described in steps 4a through 4c above for each grid.
4e	Using a soft-lead pencil, connect all the grids. This is the target.
4f	Rotate the clear disk until each segment of the target is aligned with a vertical red line of the gridded base. Count the length of each segment, and add the lengths to determine a total length of the target.
4g	Divide the length of the target by one less than the number of howitzers to fire.
4h	Starting at either end of the target, count the distance computed in step 4g. Each square represents 10 meters. At the end of the distance, mark a small **X** on the target. Repeat this process until the other end of the target is reached. The small Xs represent the aimpoints.
4i	Rotate the clear disk until the deflection to the center of the target on the inner red scale (measured from the firing chart) is opposite the vernier index.
4j	To compute corrections, go to step 6.
	CIRCULAR TARGET
5	The grid given in the call for fire is represented by the center of the plotting board.
5a	To plot the aimpoints in the sheaf, the angle between aimpoints must be determined. Use the formula **ANGLE = 6400 ÷ THE NUMBER OF WEAPONS**. This allows even distribution of aimpoints on a circle, regardless of the number of howitzers.
5b	Rotate the clear disk until the 0 graduation of the outer black scale is opposite the **azimuth index**.
5c	Count half the radius from the center toward the top of the board, and mark a small **X** on the disk with a soft-lead pencil. This is the first aimpoint.
5d	Plot the next aimpoint by rotating the clear disk until the value of the angle determined in step 5a is opposite the azimuth index. Count half the radius from the center toward the top of the board, and mark a small **X** on the disk with a soft-lead pencil. This is the second aimpoint.
5e	Plot the remaining aimpoints by rotating the clear disk to increase the value opposite the azimuth index by the angle determined in step 5a. Count half the radius from the center toward the top of the board, and mark a small **X** on the disk with a soft-lead pencil.

Table 12-13. Computation of Special Corrections (Continued).

STEP	ACTION
5f	The HCO determines the chart range and deflection to the center of the target.
5g	Rotate the clear disk until the chart deflection is opposite the vernier index on the inner red scale.
5h	To compute corrections, go to step 6.
	COMPUTATION OF SPECIAL CORRECTIONS
6	Using the GFT, determine 100/R corresponding to the chart range. Determine the change in range for a 1-mil change in elevation from Column 5 of Table F for the appropriate charge. Enter the TFT with the chart range expressed to the nearest 100 meters.
6a	Rotate the clear disk until the chart deflection on the inner red scale is opposite the vernier scale.
6b	Determine, by counting, the lateral correction (to the nearest 5 meters) from the leftmost piece to the leftmost aimpoint and the direction (left or right) from the howitzer to the aimpoint.
6c	To determine the deflection correction for a howitzer, multiply the lateral correction determined in step 6b by the center range 100/R determined in step 6. Divide the product (answer) by 100, and express the result to the nearest mil. Assign the sign (L/R) of the lateral correction. This is the deflection correction.
6d	Determine the comparative VE for the howitzer. **HOWITZER MVV** **- BASE PIECE MVV** **COMPARATIVE VE**
6e	Enter Table F of the TFT with the center of sector range, and extract from Columns 10 and 11 the unit correction for a 1 m/s change in muzzle velocity. Enter the TFT with the chart range expressed to the nearest 100 meters.
6f	Determine the MV range correction by multiplying the comparative VE by the appropriate unit correction. (If the sign of the comparative VE is negative, use the decrease unit correction; if the sign of the comparative VE is positive, use the increase unit correction.) Express the answer to the nearest meter, and assign the sign of the unit correction. This is the MV range correction.
	NOTE: If the comparative VE is within 1.5 m/s, steps 6d through 6f may be disregarded.
6g	Determine the position range correction by counting the distance from the howitzer to the assigned aimpoint toward the top or bottom of the plotting board. If the aimpoint is closer to the top of the board, the sign of the correction is plus (+). If the howitzer is closer to the top of the board, the sign of the correction is minus (-).
6h	Algebraically add the muzzle velocity range correction to the position range. The sum is the total range correction.
6i	Divide the total range correction by the change in range for a 1-mil change in elevation from step 6. Express this answer to the nearest mil, and assign the sign of the total range correction. This is the position quadrant correction.
6j	Determine the fuze setting corresponding to the chart range from the GFT by using the manufacturer's hairline.
6k	Determine the fuze setting corresponding to the corrected range (chart range plus the total range correction) from the GFT using the manufacturer's hairline.
6l	Determine the position time correction using the formula: **FS AT CORRECTED RANGE (STEP 6K) - FS AT THE CENTER RANGE (STEP 6J) = POSITION TIME CORRECTION.**
6m	Determine corrections for the remainder of the pieces as described above.
	NOTE: DA Form 4757 will be used when computing and recording special corrections. Unlike TGPCs, the FDC will apply the special corrections computed to the chart range and deflection data. The special instruction **SPECIAL CORRECTIONS** is included in the fire commands. This special instruction will automatically cancel any TGPCs that are being carried on the howitzers for that mission.

Section IV

Use of Plotting Board for Fire Mission Processing

When the use of a firing chart is not possible, the M10 or M17 plotting board and GFT or TFT may be used to compute firing data. The observer transmits the call for fire to the firing unit and describes the target location by using any of the methods of target location.

12-15. M17 Plotting Board

The steps in Table 12-14 are used to process fire missions with the Ml 7 plotting board. See Figure 12-12 for the Ml 7 format for processing fire missions.

Table 12-14. Processing Fire Missions With the M17.

STEP	ACTION
1	Plot the target location on a map.
2	Plot the firing unit location on a map.
3	Determine the range to the target by using an RDP or similar type of scale.
4	Determine the gun-target azimuth by using the RDP or protractor.
5	Determine the charge to fire.
6	Issue the initial fire commands.
6a	Determine the initial deflection by comparing the azimuth to the initial target location with the azimuth of lay. Use the LARS rule, and apply the difference to the common deflection. (If this is an emergency mission, while moving or marking center of sector, establish the azimuth to the target as azimuth of fire so that the initial deflection will be the common deflection.)
6b	Add drift to the initial deflection to determine the deflection to fire unless speed is essential. Announce the deflection to fire to the howitzer(s).
6c	Determine site unless speed is essential.
6d	Determine elevation from the appropriate TFT or GFT by using the gun-target range determined in step 3.
6e	Add site to the elevation to determine quadrant elevation. Announce QE to the howitzer(s).
7	Determine and record 100/R at the initial range.
8	Place a mark **on** the clear plastic disk opposite the number on the outer black scale that corresponds to the OT direction. Label the mark "O."
9	Place a second mark **on** the clear plastic disk opposite the number that corresponds to the GT direction. Label the mark "G."
	NOTE: The observer follows normal procedures during the adjustment so that subsequent corrections can be plotted on the M17 and converted into corrections with respect to the GT line. For this procedure, the rivet (center) of the plotting board always represents the location of the last burst.
10	Select an appropriate scale (assign a convenient value to the squares on the plotting board). Most shifts can be plotted when a value of 10 to 20 meters is assigned to each square.
11	Rotate the clear disk so that the mark "O" representing the OT direction is over the red zero on the vernier scale. The M17 is oriented to the OT direction. The center red arrow represents the OT line.
12	Plot the observer's corrections on the disk.
13	Rotate the clear disk until the mark "G" is over the red zero on the vernier scale. The M17 is oriented to the GT direction. The center red arrow represents the GT line.

Table 12-14. Processing Fire Missions With the M17 (Continued).

STEP	ACTION
14	Starting from the rivet, measure the observer's corrections in relation to the GT line. Determine the right or left deviation in meters.
15	Multiply the value for 100/R by the left or right deviation correction. Divide this product by 100, which is the lateral correction in mils. $\frac{\textbf{100/R x GT DEVIATION CORR}}{\textbf{100}}$ **= L/R CORR IN MILS**
16	Using LARS, add the correction, in mils, to the last deflection fired to determine the new deflection to fire. Announce the new deflection to fire to the howitzers.
17	Starting from the rivet, measure the observer's corrections in relation to the GT line and determine the correction in range, add or drop, in meters.
	NOTE: Either the GFT or TFT can be used to determine the elevation. Steps 18 and 19 describe the procedures for using the GFT, and steps 20 through 24 describe the procedures for using the TFT.
18	Determine the adjusted range by adding or subtracting the observer's range correction along the GT line to the last range fired.
19	Move the MHL over the new range, and determine the elevation from under the MHL. If there is a current GFT setting, determine the elevation from the elevation gauge line. Go to step 25.
	USING THE TFT
20	Add the range correction to the last range fired.
21	Enter the TFT with the appropriate charge in Table F. Use the new range as the entry argument. Determine elevation from Column 2 (interpolation may be necessary). **OR**
22	Determine the C-factor (change in elevation for a 100-meter change in range) at the initial range by entering Table F, Column 5, with the initial range and extracting the value for the change in range for a 1-mil change in elevation. Divide 100 by the value extracted from Column 5. This is your C-factor.
23	Compute the change in elevation required for the range correction along the GT line by multiplying the C-factor by the change in range in hundreds. $\frac{\textbf{C-FACTOR X RANGE CORRECTION}}{\textbf{100}}$ **= CHANGE IN ELEVATION**
24	Add the change in elevation to the last fired elevation to determine the new elevation.
25	Add the new elevation to the old site, and determine quadrant elevation.
	NOTE: The mission will continue to be processed by following steps 16 through 25 until the mission is ended.

12-16. Determination of Subsequent Corrections for a Laser Adjust-Fire Mission

Table 12-15 shows the steps and procedures to determine subsequent corrections for a laser adjust-fire mission.

Table 12-15. Determination of Subsequent Corrections for a Laser Adjust-Fire Mission.

STEP	ACTION
1	The first round is fired as a polar plot target location on the firing chart by using normal adjust-fire procedures.
	NOTE: The M10 or M17 plotting board may be used in the processing of a laser fire mission.
2	The chart operator orients his target grid over the target on the OT direction announced in the call for fire.
3	The computer rotates the clear disk on the plotting board until the OT direction on the outer black scale is opposite the vernier index.
4	The computer, using a scale of 1 square equals 100 meters, counts toward the top of the M17 the distance announced in the call for fire. At the end of this distance, the computer marks a dot with a soft-lead pencil to represent the target.
	NOTE: The rivet represents the observer's location.
5	On receiving the subsequent correction, the computer must convert the polar plot location of the first rounds burst into a correction to bring the impact from the lased burst location to the target location.
5a	The computer records the laser polar plot data to the burst on the record of fire.
5b	The computer rotates the clear disk of the M17 until the direction (outer black scale) given in the subsequent correction is opposite the vernier index.
5c	The computer counts the distance given in the correction from the center to the top of the M17 and at the appropriate distance marks a dot to represent the location of the burst.
5d	The computer rotates the clear disk until the original polar plot direction is opposite the vernier index.
5e	The computer counts the number of meters (to the nearest 10) needed to move the burst (lateral correction) to the target. He announces the lateral correction to the HCO as **LEFT** or **RIGHT** (the direction to move **from burst to target**) (**so many meters**).
5f	The computer next counts the number of meters (to the nearest 10) to move the burst (range correction) to the target. The correction is announced to the HCO as **ADD** or **DROP** (**so many meters**).
6	The HCO then plots the correction by using the target grid and determines chart data. (The target grid is oriented by using the initial observer target direction.)

GRID ____________ GT RG ____________ = ELEVATION

+SITE ____________

GT DIR ____________ GT DIR = QE ____________

CHG ____________ MTO

(100/R = 100 ÷ RG [IN THOUSANDS] or FROM GFT) 100/R = ____________

FIRE MISSION PLT ADJ # ______1___ SH ____ LOT ___ CHG FZ

TI ____________ DF ____________ QE

OT CORR: L/R ____________ +/- ________

GT CORR: L/R ________ =/- ADJ RG = EL

100/R ____________ X GT DEVIATION CORR / 100 = ____________ =__________ m L/R

+_______+ LAST DF

=____________DF

ELEVATION AT NEW RANGE ____________ + SITE__________ = NEW QE_______

OT CORR: L/R ____________ +/- ________

GT CORR: L/R ________ =/- ADJ RG = EL

100/R ____________ X GT DEVIATION CORR / 100 = ____________ =__________ m L/R

+_______+ LAST DF

=____________DF

ELEVATION AT NEW RANGE ____________ + SITE__________ = NEW QE_______

PLT ________ SH ________ FZ ________ DF ________ QE ________

Figure 12-12. Format for Processing Fire Missions With the M17.

12-17. Examples of TGPCs

a. The following is an example of the platoon leader's report for the Ml00-series sight:

HOWITZER	LAID FROM	LAY DEFLECTION	DISTANCE	VA
1	AC	2595	105	+3
2	AC	2910	55	+1
3 (BP)	AC	3405	90	-2
4	AC	3950	100	-5

NOTE: Howitzer Number 3 is the base piece.

b. The following is an example of piece displacement.

HOWITZER	LATERAL DISPLACEMENT	RANGE DISPLACEMENT
1	R75	0
2	R35	+35
3	0	0
4	L50	+15

c. A completed DA Form 4757 for each sheaf (converged, open, and circular) containing TGPCs using the data listed above are shown in Figures 12-13 through 12-15.

TERRAIN GUN POSITION/SPECIAL CORRECTION

REMARKS

L/P/R SECTOR TRANSFER LIMITS CHG 4GB

		LEFT	CENTER	RIGHT		
CEN DF + 400m̸	DF	3600	3200	2800	DF	CEN DF - 400m̸
CEN RG - 2000M	RG	3000 (MIN)	5000	7000 (MAX)	RG	CEN RG + 2000M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (5000) CEN RG	POS DF CORR (L/R) ①X②/100	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+24.4 I-19.1	MV RG Corr ④X⑤	POS RG CORR (F= –) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ + DR PER 1m D EL (TBL F) (13)	CORR RG ⑧ ≈ 10M Plus CEN RG* (5000)	FS ~ ⑩	POS TI CORR ⑪ MINUS FS ~ CEN RG (18.4)	GUN
#	5M		1m̸	0.1M/S	0.1M	1M	5M	1M	1m̸	10M	0.1	0.1	#
1	L75	20	L15	D1.5	+24.4	+37	0	+37	+3	5040	18.5	+0.1	1
2	L35	20	L7	D1.0	+24.4	+24	-35	-11	-1	4990	18.3	-0.1	2
3	0	20	0	0	0	0	0	0	0	5000	18.4	0.0	3
4	R50	20	R10	I3.4	-19.1	-65	-15	-80	-6	4920	18.0	-0.4	4
5													5
6													6
7													7
8													8

Figure 12-13. Completed DA form 4757 Containing TGPCs for a Converged Sheaf.

TERRAIN GUN POSITION/SPECIAL CORRECTION

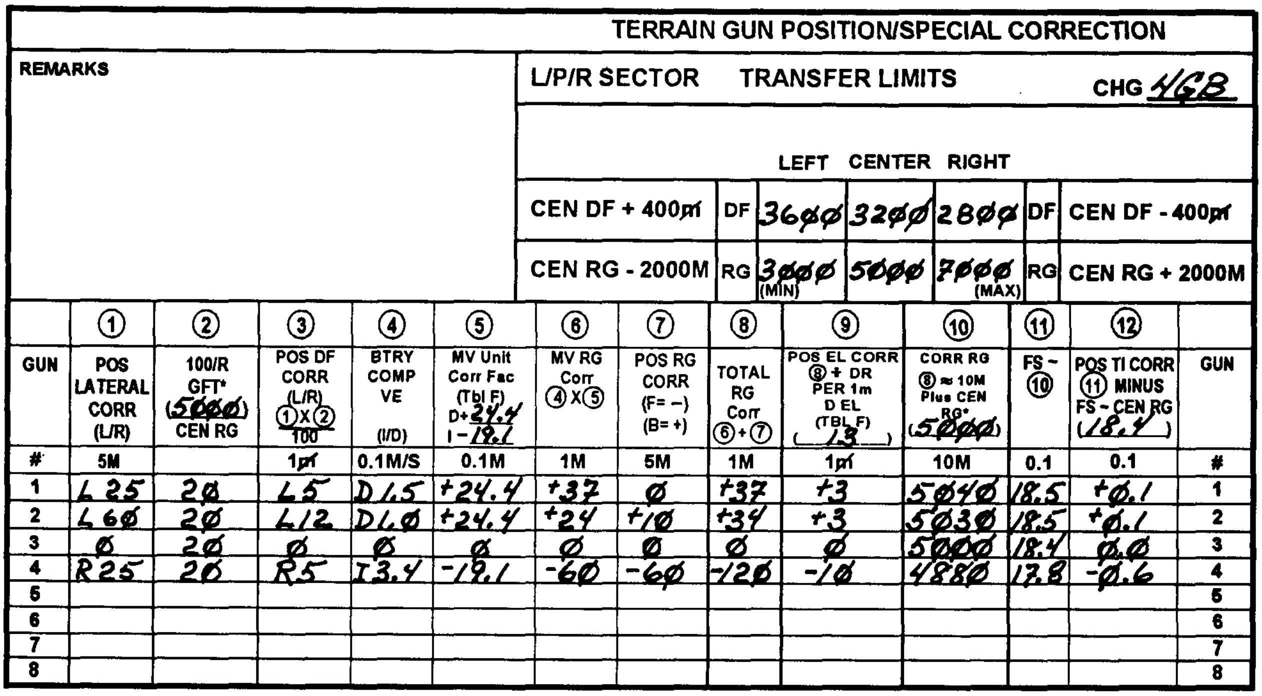
REMARKS

L/P/R SECTOR TRANSFER LIMITS CHG 4GB

		LEFT	CENTER	RIGHT		
CEN DF + 400m̸	DF	3600	3200	2800	DF	CEN DF - 400m̸
CEN RG - 2000M	RG	3000 (MIN)	5000	7000 (MAX)	RG	CEN RG + 2000M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (5000) CEN RG	POS DF CORR (L/R) ①X②/100	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+24.4 I-19.1	MV RG Corr ④X⑤	POS RG CORR (F= –) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ + DR PER 1m D EL (TBL F) (13)	CORR RG ⑧ ≈ 10M Plus CEN RG* (5000)	FS ~ ⑩	POS TI CORR ⑪ MINUS FS ~ CEN RG (18.4)	GUN
#	5M		1m̸	0.1M/S	0.1M	1M	5M	1M	1m̸	10M	0.1	0.1	#
1	R25	20	R5	D1.5	+24.4	+37	0	+37	+3	5040	18.5	+0.1	1
2	R15	20	R3	D1.0	+24.4	+24	-35	-11	-1	4990	18.3	-0.1	2
3	0	20	0	0	0	0	0	0	0	5000	18.4	0.0	3
4	0	20	0	I3.4	-19.1	-6.5	-15	-80	-6	4920	18.0	-0.4	4
5													5
6													6
7													7
8													8

Figure 12-14. Completed DA Form 4757 Containing TGPCs for an Open Sheaf.



TERRAIN GUN POSITION/SPECIAL CORRECTION

REMARKS

L/P/R SECTOR TRANSFER LIMITS CHG 4GB

		LEFT	CENTER	RIGHT		
CEN DF + 400m̸	DF	3600	3200	2800	DF	CEN DF - 400m̸
CEN RG - 2000M	RG	3000 (MIN)	5000	7000 (MAX)	RG	CEN RG + 2000M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (5000) CEN RG	POS DF CORR (L/R) ①X②/100	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+24.4 I-19.1	MV RG Corr ④X⑤	POS RG CORR (F= –) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ + DR PER 1m D EL (TBL F) (13)	CORR RG ⑧ ≈ 10M Plus CEN RG* (5000)	FS - ⑩	POS TI CORR ⑪ MINUS FS - CEN RG (18.4)	GUN
#	5M		1m̸	0.1M/S	0.1M	1M	5M	1M	1m̸	10M	0.1	0.1	#
1	L25	20	L5	D1.5	+24.4	+37	0	+37	+3	5040	18.5	+0.1	1
2	L60	20	L12	D1.0	+24.4	+24	+10	+34	+3	5030	18.5	+0.1	2
3	0	20	0	0	0	0	0	0	0	5000	18.4	0.0	3
4	R25	20	R5	I3.4	-19.1	-60	-60	-120	-10	4880	17.8	-0.6	4
5													5
6													6
7													7
8													8

Figure 12-15. Completed DA form 4757 Containing TGPCs for a Circular Sheaf.

12-18. Examples of Special Corrections

a. Using the data listed below, determine special corrections for a linear target described by a grid, length, and attitude.

GIVEN:

(1) Example of the platoon leader's report for the M1OO-series sight:

HOWITZER	LAID FROM	LAY DEFLECTION	DISTANCE	VA
1	AC	2595	105	+3
2	AC	2910	55	+1
3 (BP)	AC	3405	90	-2
4	AC	3950	100	-5

NOTE: Howitzer Number 3 is the base piece.

(2) Example of piece displacement.

HOWITZER	LATERAL DISPLACEMENT	RANGE DISPLACEMENT
1	R75	0
2	R35	+35
3	0	0
4	L50	+15

(3) Target Grid: 432275

(4) Length: 300 M

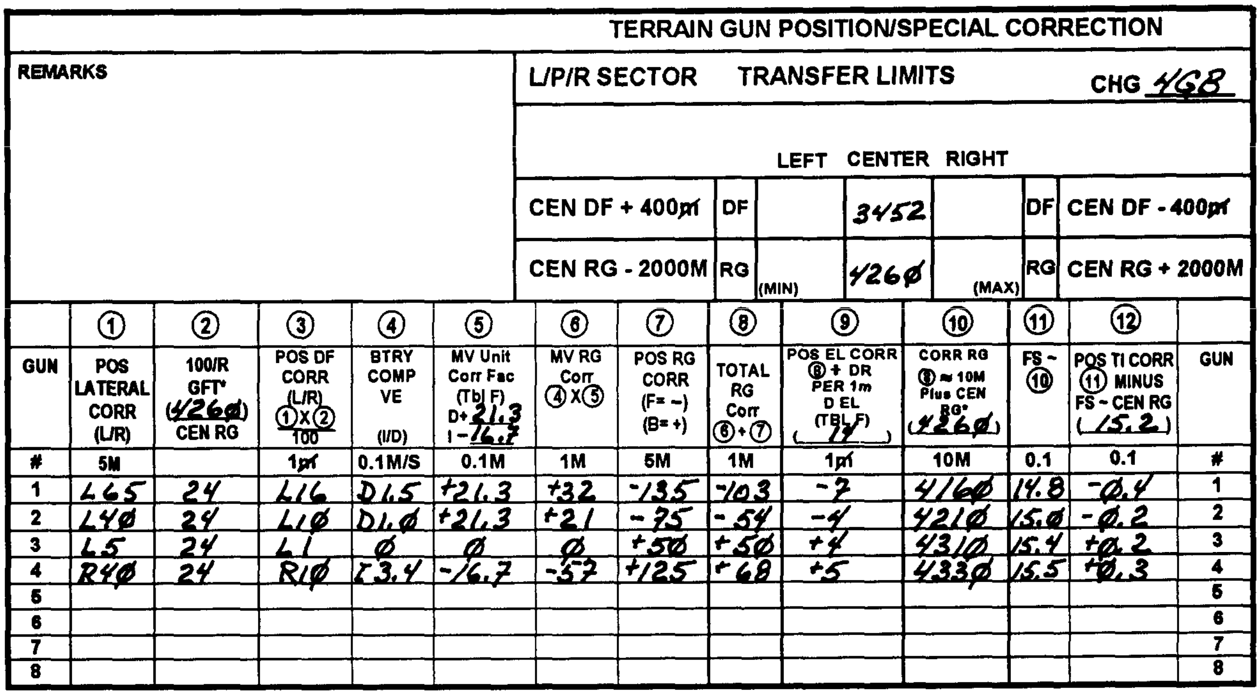
(5) Attitude: 1,300

(6) $\frac{\text{Target Length}}{2} = \frac{300\text{ M}}{2} = 150$

(7) $\text{Distance between aimpoints} = \frac{\text{Target Length}}{\text{No howitzers} - 1} = \frac{300}{4 - 1} = \frac{300}{3} = 100$

(8) Chart data to the center grid: Chart range 4260 Chart deflection 3452

b. A completed DA Form 4757 for the special corrections and the Ml7 plotting board are shown in Figures 12-16 through 12-18.



TERRAIN GUN POSITION/SPECIAL CORRECTION

REMARKS

L/P/R SECTOR TRANSFER LIMITS CHG 468

		LEFT	CENTER	RIGHT		
CEN DF + 400₥	DF		3452		DF	CEN DF - 400₥
CEN RG - 2000M	RG	(MIN)	4260	(MAX)	RG	CEN RG + 2000M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (4260) CEN RG	POS DF CORR (L/R) ①X② / 100	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+21.3 I-16.7	MV RG Corr ④X⑤	POS RG CORR (F= -) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ + DR PER 1m D EL (TBL F) (14)	CORR RG ⑧ ≈ 10M Plus CEN RG* (4260)	FS ~ ⑩	POS TI CORR ⑪ MINUS FS ~ CEN RG (15.2)	GUN
#	5M		1₥	0.1M/S	0.1M	1M	5M	1M	1₥	10M	0.1	0.1	#
1	L65	24	L16	D1.5	+21.3	+32	-135	-103	-7	4160	14.8	-0.4	1
2	L40	24	L10	D1.0	+21.3	+21	-75	-54	-4	4210	15.0	-0.2	2
3	L5	24	L1	0	0	0	+50	+50	+4	4310	15.4	+0.2	3
4	R40	24	R10	I3.4	-16.7	-57	+125	+68	+5	4330	15.5	+0.3	4
5													5
6													6
7													7
8													8

Figure 12-16. Completed DA form 4757 Containing Special Corrections.

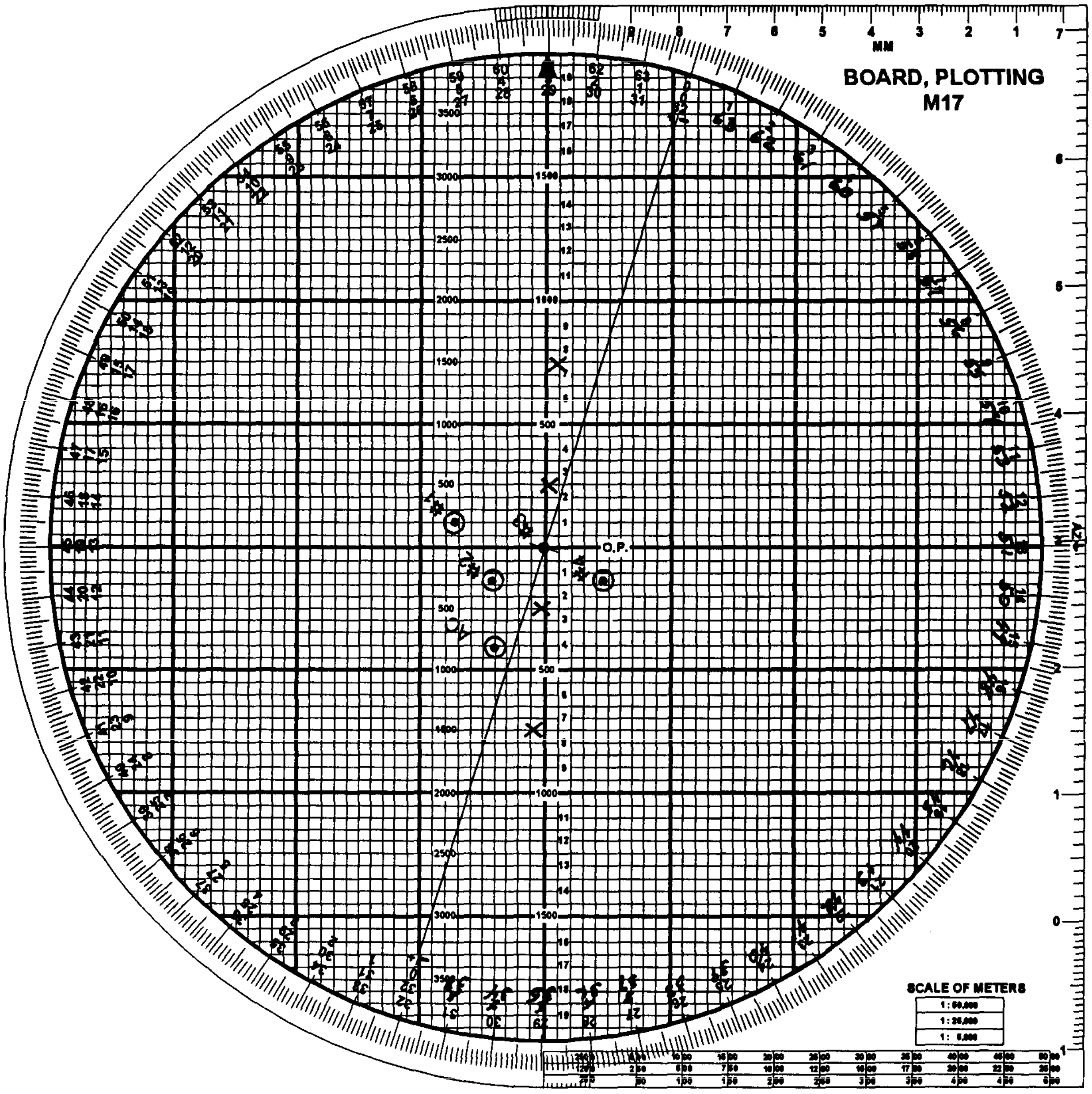


Figure 12-17. M17 Plotting Board Oriented on Attitude 1300, With Target and Burst Points Plotted.

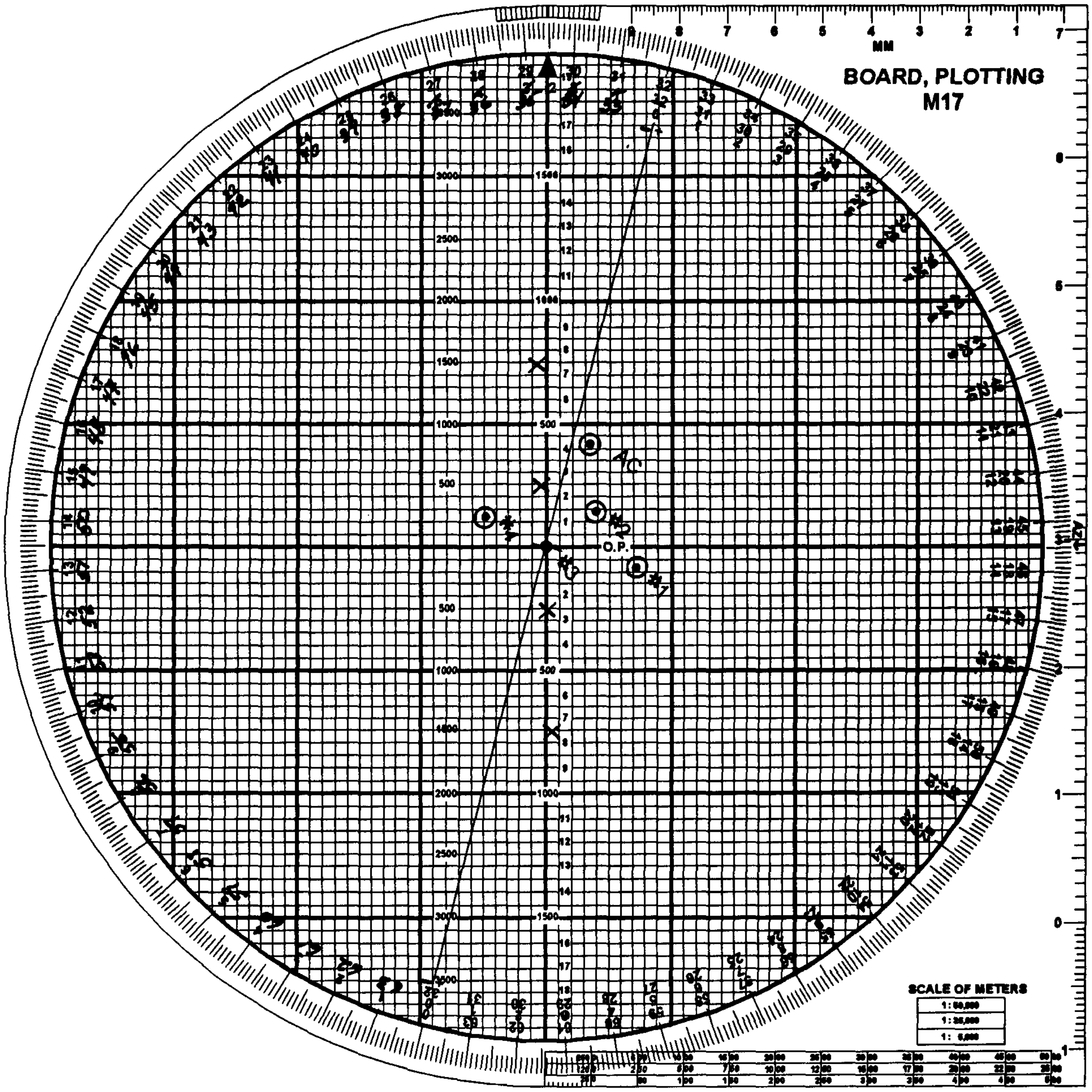


Figure 12-18. M17 Plotting Board Oriented on the Chart Deflection.

c. Using the data listed below, determine special corrections for a linear target described by two grids.

GIVEN:

(1) Example of the platoon leader's report for the M1OO-series sight:

HOWITZER	LAID FROM	LAY DEFLECTION	DISTANCE	VA
1	AC	2595	105	+3
2	AC	2910	55	+1
3 (BP)	AC	3405	90	-2
4	AC	3950	100	-5

NOTE: Howitzer Number 3 is the base piece.

(2) Example of piece displacement.

HOWITZER	LATERAL DISPLACEMENT	RANGE DISPLACEMENT
1	R75	0
2	R35	+35
3	0	0
4	L50	+15

(3) Target Grids: 424275 and 427273

(4)

$$\begin{array}{rr} \text{(Easting)} & \text{(Northing)} \\ 42400 & 27500 \\ \underline{-\ 42700} & \underline{-\ 27300} \\ -300 & +200 \end{array}$$

(5)

$$\frac{\Delta\text{Easting}}{2} = \frac{-300}{2} = 150 \qquad \frac{\Delta\text{Northing}}{2} = \frac{+200}{2} = 100$$

(6) Center Grid:

$$\begin{array}{rr} \text{(Easting)} & \text{(Northing)} \\ 42400 & 27500 \\ \underline{-(-150)} & \underline{-(+100)} \\ 42550 & 27400 \end{array}$$

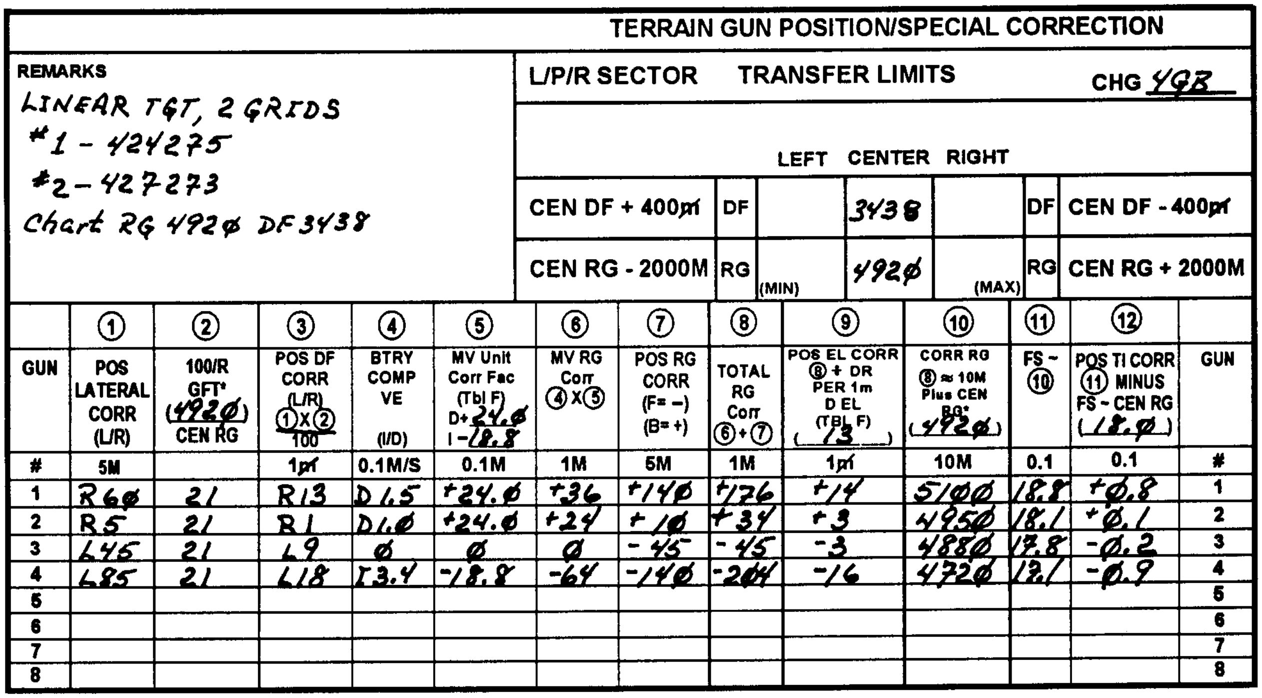
(7) Target Length: 360

(8)

$$\text{Distance between aimpoints} = \frac{\text{Target Length}}{\text{No Howitzers} - 1} = \frac{360}{4 - 1} = \frac{360}{3} = 120$$

(9) Chart data to the center grid: Chart range 4920 Chart deflection 3438

d. A completed DA Form 4757 for the special corrections and the Ml 7 plotting board are shown in Figures 12-19 through 12-22.



TERRAIN GUN POSITION/SPECIAL CORRECTION

REMARKS

LINEAR TGT, 2 GRIDS
#1 - 424275
#2 - 427273
Chart RG 4920 DF 3438

L/P/R SECTOR TRANSFER LIMITS CHG 4GB

		LEFT	CENTER	RIGHT		
CEN DF + 400mil	DF		3438		DF	CEN DF - 400mil
CEN RG - 2000M	RG	(MIN)	4920	(MAX)	RG	CEN RG + 2000M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (4920) CEN RG	POS DF CORR (L/R) ①X② / 100	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+24.0 I-18.8	MV RG Corr ④X⑤	POS RG CORR (F= –) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ + DR PER 1m D EL (TBL F) (13)	CORR RG ⑧ ≈ 10M Plus CEN RG* (4920)	FS ~ ⑩	POS TI CORR ⑪ MINUS FS ~ CEN RG (18.0)	GUN
#	5M		1mil	0.1M/S	0.1M	1M	5M	1M	1mil	10M	0.1	0.1	#
1	R60	21	R13	D1.5	+24.0	+36	+140	+176	+14	5100	18.8	+0.8	1
2	R5	21	R1	D1.0	+24.0	+24	+10	+34	+3	4950	18.1	+0.1	2
3	L45	21	L9	0	0	0	-45	-45	-3	4880	17.8	-0.2	3
4	L85	21	L18	I3.4	-18.8	-64	-140	-204	-16	4720	17.1	-0.9	4
5													5
6													6
7													7
8													8

Figure 12-19. Completed DA form 4757 Containing Special Corrections.

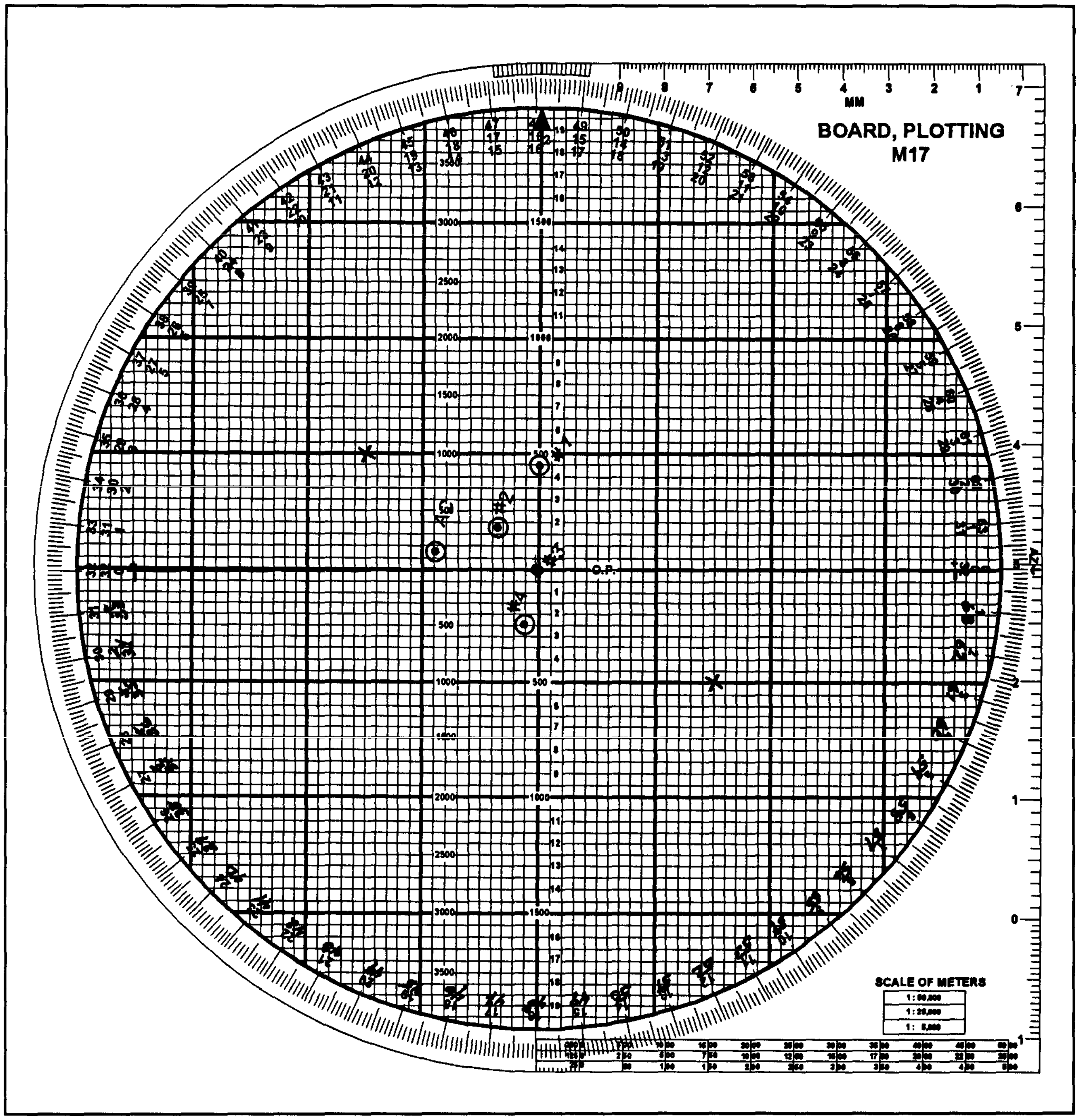


Figure 12-20. M17 Plotting Board With Both Grids Plotted.

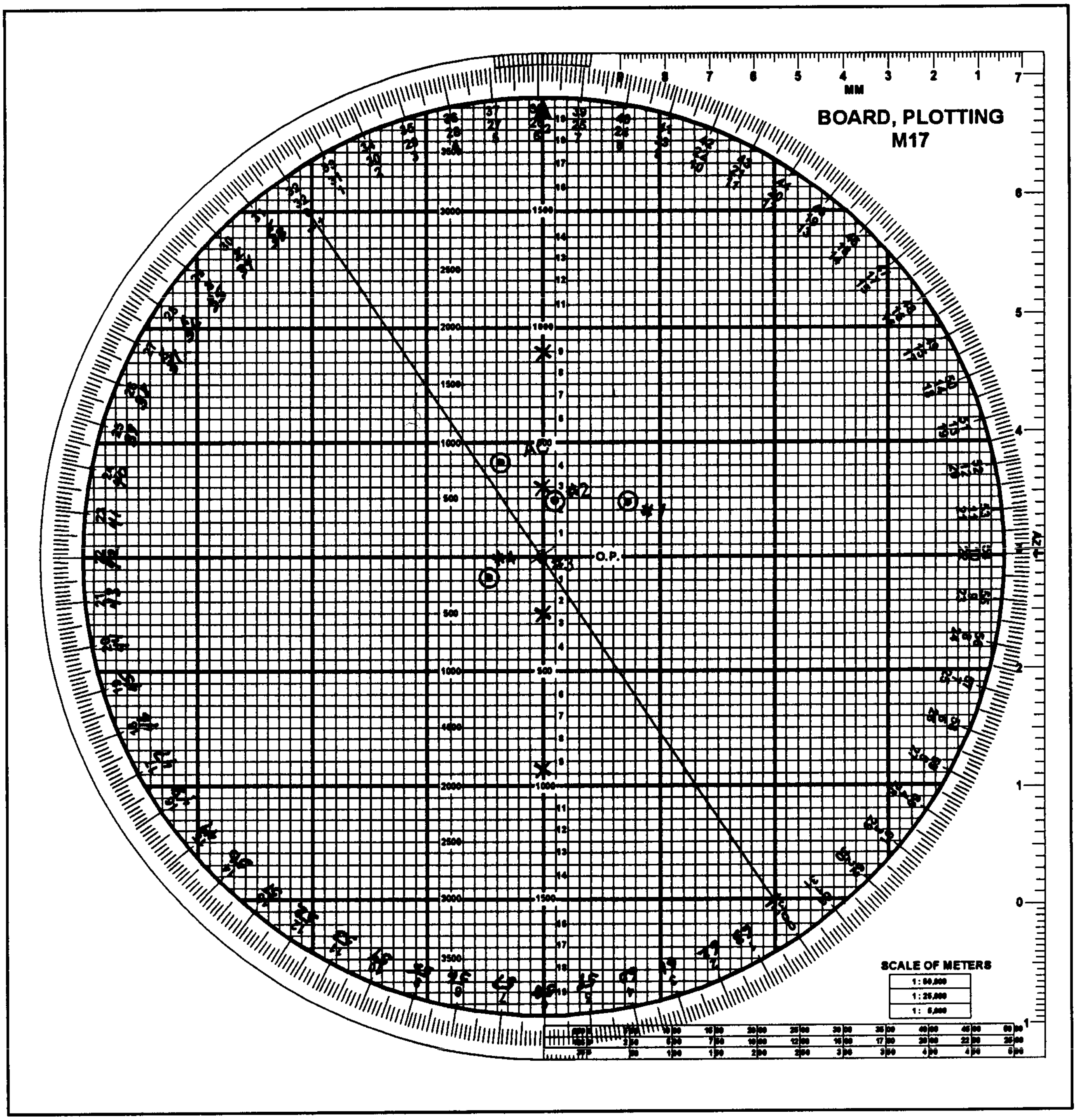


Figure 12-21. M17 Plotting Board With Burst Points Plotted.

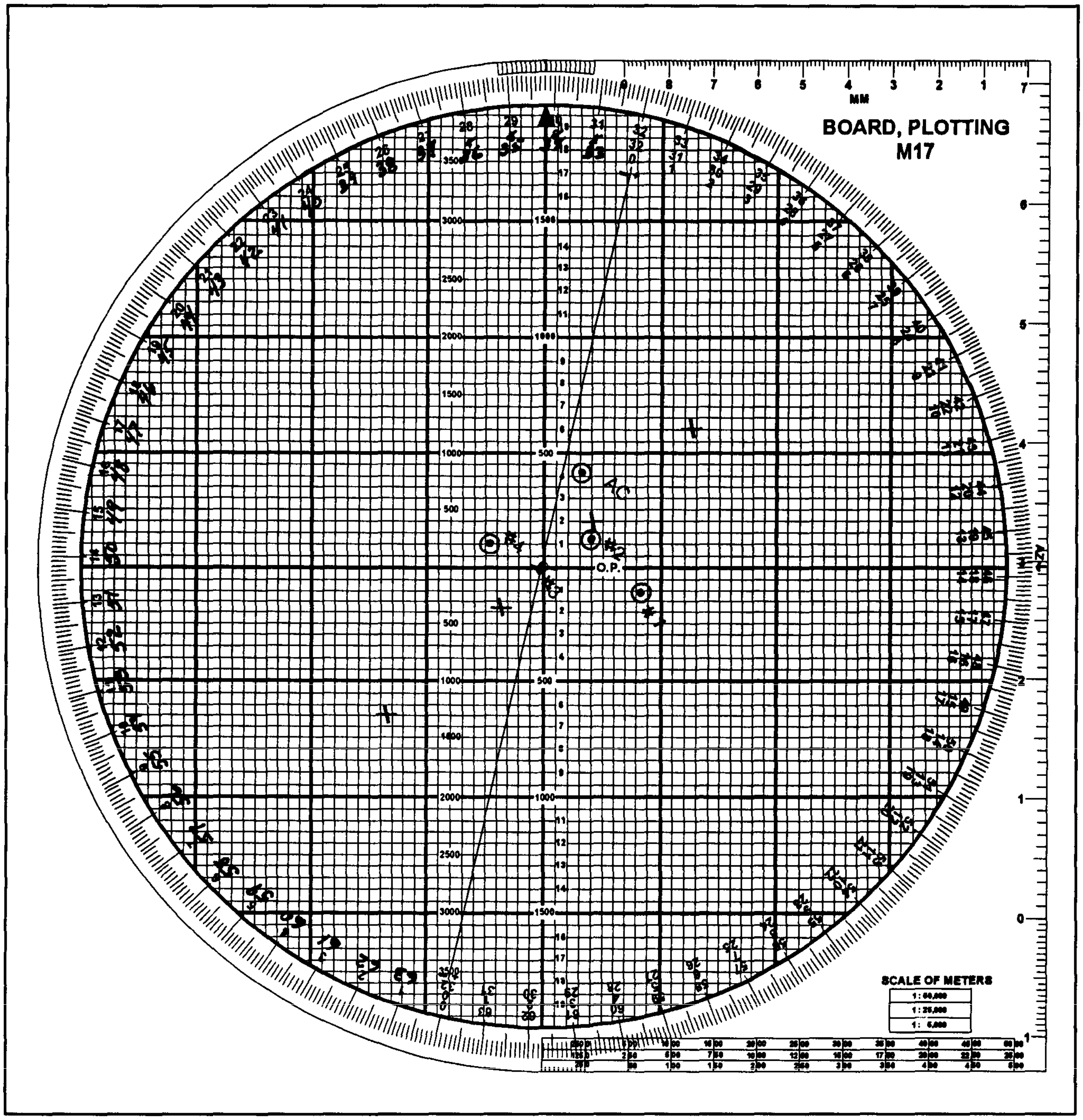


Figure 12-22. M17 Plotting Board Oriented on the Chart Deflection.

Chapter 13

SPECIAL MUNITIONS

This chapter describes procedures for special munition employment. Appendix H provides further information on special mission processing.

Section I

Copperhead

The cannon-launched guided projectile (CLGP) M712 (Copperhead) is a 155-mm, separate-loading, laser-guided HE projectile. It is heavier (137.6 pounds) and longer (54 inches) than the standard 155-mm projectile. The A4712 projectile consists of three main sections: a guidance section (forward), warhead section (center), and control section (rear). The guidance section contains the seeker head assembly and the electronics assembly. The nose of the projectile houses a laser seeker in a plastic cone. The warhead section contains an HE antitank warhead consisting of 14.75 pounds of composition B. The control section includes the fins and wings that deploy in flight and allow the round limited maneuverability.

13-1. Description

a. The Copperhead projectile is shipped and stored in a sealed container. The projectile requires no assembly or testing at the firing site.

b. The FDC can compute firing data for shell Copperhead by using either a shaped trajectory or a ballistic trajectory.

NOTE: The shaped trajectory is based on a revised targeting logic that was first introduced with FT 155-AS-0 (Rev 1) and continued with FT 155-AS-1. The change essentially results in firing higher charges at lower quadrant elevations, resulting in flatter trajectories. This was done to maximize the employment of Copperhead projectiles under low cloud ceilings. Many of the tables in FT 155-AS-1 refer to ballistic or “glide” mode (for example, Table F). In this current FT, the terms *glide* and *shaped* are used synonymously, even though they are different trajectories. A true glide mode is only achieved when computing data by using FT 155-AS-0. However, this method is **not recommended** because it will produce poor results under low cloud ceilings.

(1) The trajectory of the Copperhead projectile is similar to that of a conventional round. Only when the projectile reaches a point on the descending branch of the trajectory does it differ. At that point, on the basis of the two-digit timer setting included in the fire commands, the guidance and control systems are activated. This enables the projectile to alter the remainder of its trajectory.

(2) At 20 seconds from impact, the FDC cues the laser designator operator, who begins designating the target. The ground laser operator may use a G/VLLD, a laser target designator (LTD), or modular universal laser equipment (MULE). Airborne systems include the AH-64, OH-58D, and unmanned aerial vehicles. The Copperhead projectile acquires the reflected laser energy and initiates internal guidance and control, allowing it to maneuver to the target. If the time of flight of the projectile is less than 20 seconds, the FDC will inform the observer to designate the target concurrent with the shot message (that is, **LASER ON, SHOT, OVER).**

c. The ground surface area in which the round can maneuver is limited. The optimum limits of maneuverability of the Copperhead round is called a footprint (Figure 13-l). The size of the footprint is determined by the GT range and the shape of the trajectory, but it can also be affected by cloud height. The ballistic aimpoint is on the GT line, usually short of the target location sent by the laser designator operator. The distance that the ballistic aimpoint is short of the target location varies and is called the offset correction. This offset distance is used to ensure that the maximum probability of hit occurs at the original target location sent by the observer. The larger the target location error, the lower the probability of hitting the target.

d. Copperhead missions, like conventional missions, can be fired on either planned targets or targets of opportunity. Planned targets are priority targets or on-call targets.

(1) Because of its relatively short response time, the Copperhead planned target is the preferred method for employing Copperhead. Unless otherwise specified on the target list, two Copperhead rounds are prepared in advance for each Copperhead priority target. DA Form 5711-R (Copperhead Planned Target List Work Sheet) may be used to quickly update data for planned Copperhead targets. These data can then be transferred to DA Form 4504 when the mission is fired. Figure 13-2 shows an example Copperhead planned target list work sheet.

NOTE: A reproducible copy of DA Form 571 I-R is provided at the back of this publication.

(2) On-call target procedures for Copperhead are the same as those for conventional on-call missions.

NOTE: FDC personnel must ensure that at least two howitzers and two Copperhead rounds are prepared for any mission. This action increases firing unit responsiveness if a round or howitzer malfunctions. The criteria in Table 13-1 are used for all Copperhead missions.

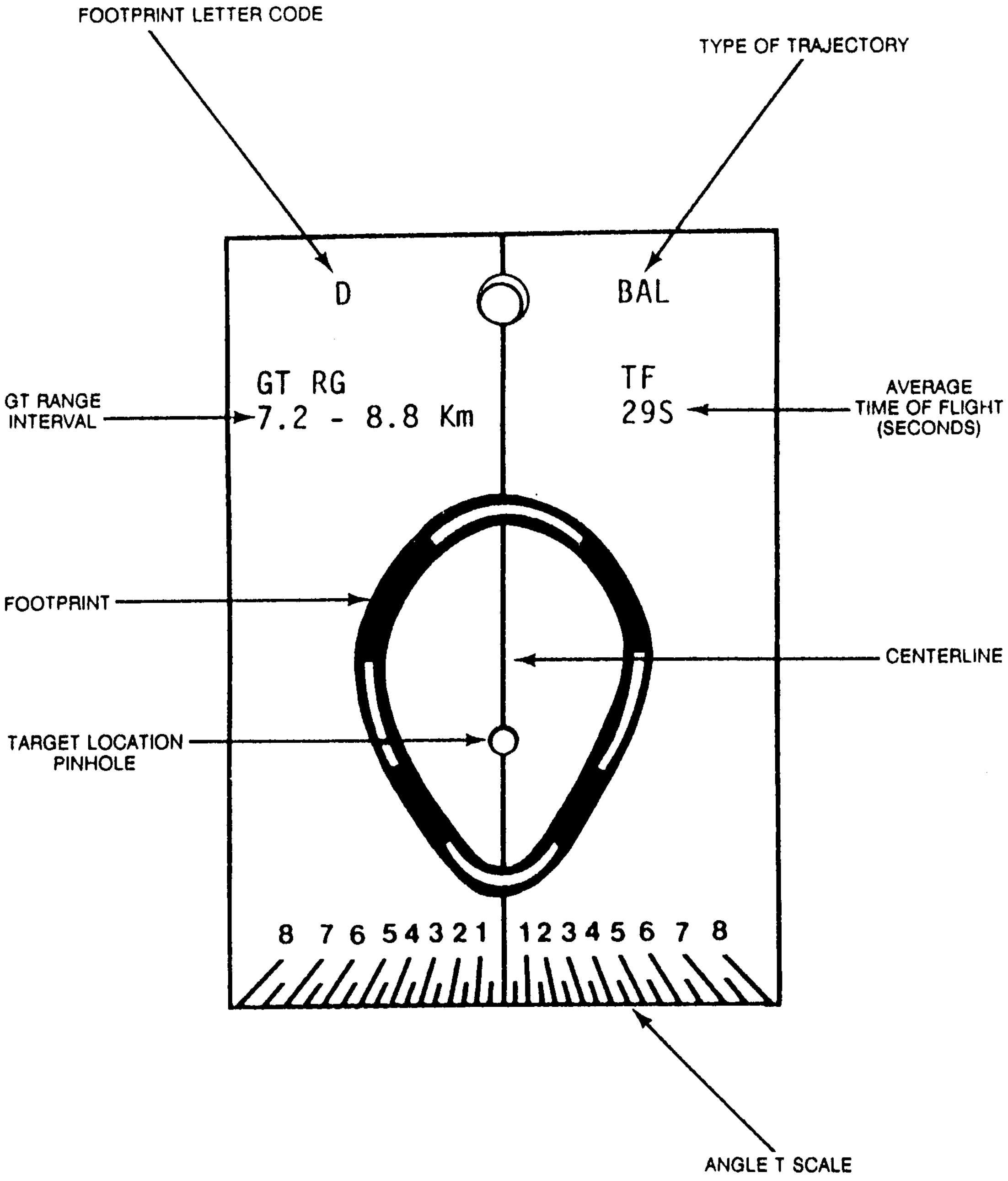
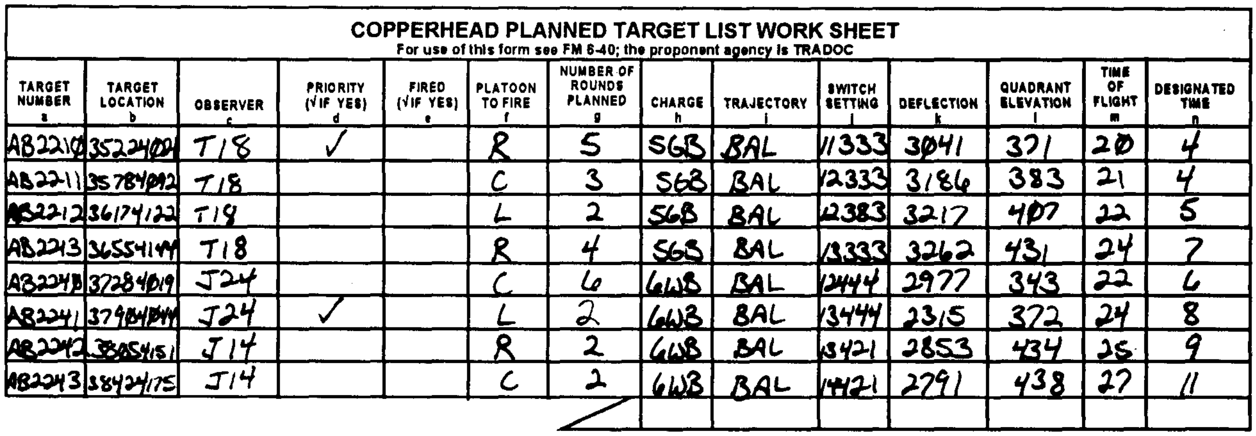


Figure 13-1. Copperhead Footprint Template.



COPPERHEAD PLANNED TARGET LIST WORK SHEET

For use of this form see FM 6-40; the proponent agency is TRADOC

TARGET NUMBER a	TARGET LOCATION b	OBSERVER c	PRIORITY (√IF YES) d	FIRED (√IF YES) e	PLATOON TO FIRE f	NUMBER OF ROUNDS PLANNED g	CHARGE h	TRAJECTORY i	SWITCH SETTING j	DEFLECTION k	QUADRANT ELEVATION l	TIME OF FLIGHT m	DESIGNATED TIME n
AB2210	35224004	T18	✓		R	5	SGB	BAL	11333	3041	371	20	4
AB2211	35784092	T18			C	3	SGB	BAL	12333	3186	383	21	4
AB2212	36174122	T19			L	2	SGB	BAL	12383	3217	407	22	5
AB2213	36554144	T18			R	4	SGB	BAL	13333	3262	431	24	7
AB2240	37284019	J24			C	6	6WB	BAL	12444	2977	343	22	6
AB2241	37904044	J24	✓		L	2	6WB	BAL	13444	2315	372	24	8
AB2242	38054151	J14			R	2	6WB	BAL	13421	2853	434	25	9
AB2243	38424175	J14			C	2	6WB	BAL	14421	2791	438	27	11

Figure 13-2. Example Copperhead Planned Target List Work Sheet.

Table 13-1. Copperhead Projectile Selection Table.

TARGET STRENGTH (OBSERVER ENTRY)	ROUNDS SPECIFED (FDC ENTRY)	NUMBER OF HOWITZERS
0	2	2
1[1]	2	2
2	2	2
3	3	2
4	4	2
5	5	2
6[2]	6	2

[1] If a single target element is important enough to warrant firing Copperhead, the observer will specify two rounds in target strength and coordinate with FDC to fire "by round, at my command." This reduces response time in case of a target miss and prevents wasting the second round if the first round succeeds in destroying the target. An optimum of one round per target is used for planning purposes.

[2] No more than six rounds will be prepared for any given mission.

13-2. Computations for Shell Copperhead

a. When a target list is received from the battalion FDC, Copperhead priority targets are **processed first.** Battery or platoon FDC personnel must know how to use the Copperhead footprint templates and must be aware of the maximum 800-mil angle T requirement. Priority target firing data usually are sent to two adjacent howitzers. The FDC transmits the message to observer and informs the observer when the unit is prepared to fire the priority target. Response time is excessive if the Copperhead rounds and the howitzers are not prepared in advance. Firing data for the rest of the targets on the target list are then computed and recorded by target number in the FDC.

b. As the situation changes, recomputation may be required and is done by the FDC.

13-3. Copperhead SOP

a. Unit SOPs dealing with Copperhead (Cphd) missions are helpful in rapidly disseminating mission-essential information with a minimum of discussion. When used with extensive training, a unit SOP can result in more responsive fires.

(1) An observer requesting Copperhead fires on planned targets and targets of opportunity will send a call for fire to the battery or platoon FDC over an established fire net.

(2) The standard target list is used to initiate a planned target.

(3) To fire on a planned target, the observer transmits a call for fire that includes the following elements:

Element	Example
Observer identification	THIS IS T18
Warning order	FIRE TARGET AB2213, OVER
Target description	FOUR TANKS I/O
Method of engagement	4 ROUNDS
Method of control	AT MY COMMAND, OVER

(4) To enhance mission responsiveness when engaging priority targets, the observer may omit the target description, method of engagement, and method of control; for example, **T46 THIS IS T18, FIRE TARGET AB2213, OVER.**

(5) If the number of rounds to be fired is not specified in the call for fire, the FDC will fire the number of rounds specified for that target on the Copperhead target list. If the number of rounds is not specified on the target list, the FDC will fire one round at the target and direct the howitzer(s) to prepare, but **DO NOT LOAD,** a second round. The MTO will reflect 1 round.

(6) When the observer requests **AT MY COMMAND,** the Copperhead rounds will be freed at intervals of at least 30 seconds when the observer gives the initial command to fire. When **BY ROUND AT MY COMMAND** is requested, the observer will control the firing of each Copperhead round. The observer must understand this and act accordingly so as not to waste rounds.

b. For targets of opportunity, the call for fire includes the following elements:

Element	Example
Observer identification	THIS IS T18
Warning order	FIRE FOR EFFECT, POLAR, OVER
Location of target	DIRECTION 1800, DISTANCE 3450, VERTICAL ANGLE +5, OVER
Target description	TWO TANKS I/O
Method of engagement	COPPERHEAD, 2 ROUNDS
Method of control	BY ROUND, AT MY COMMAND, OVER

NOTE: For a target of opportunity, the call for fire must specify Copperhead.

13-4. Message to Observer

a. After a call for fire is processed, an MTO is sent as soon as possible before firing.

b. The MTO for Copperhead missions includes the following elements:

Element	Example
Unit firing	**T46**
Number of rounds	**2 ROUNDS**
Laser pulse repetition frequency code	**CODE 241**
Angle T	**ANGLE T 300**
Range	**RG 7200**
Time of flight	**30 SECONDS**
Howitzer right or left of OT line	**RIGHT OF OT LINE**
Target Number	**TGT NUMBER AC4076**

c. For a Copperhead mission to be successful, the three-digit pulse repetition frequency (PRF) code set on the Copperhead round must match the PRF code set on the observer's designator. The FDC should have a list of all observer PRF codes by call sign. The FDC selects the proper PRF code on the basis of the identification of the observer sending the call for fire. The PRF code is then sent to the howitzers in the fire commands and is placed on the Copperhead round. The observer verifies the PRF code announced in the MTO.

13-5. Fire Order

The elements established as standard are not addressed unless a change in the standard is desired. Two howitzers will support a given Copperhead fire mission.

13-6. Computation of Firing Data

NOTE: FT 155-AS-1 is used to compute firing data for Copperhead. There are no GFTs for FT 155-AS-1. FT 155-AS-1 supersedes FT 155-AS-0 (Rev 1) firing tables.

a. Initial Chart Data. The computation of firing data for Copperhead begins with the determination of chart data. This applies to both planned targets (target locations taken from the Copperhead target list) and targets of opportunity (target location provided in the call for fire). The initial chart data required for Copperhead missions is chart range, chart deflection, and angle T. Chart data are determined and announced by the HCO.

b. Trajectory and Charge Selection. Given the chart range to the target, observer visibility, and target cloud height, the FDO enters the Copperhead charge selection table in the Copperhead TFT. Determine the charge to fire by entering the table with the visibility followed by cloud height. Identify the range interval that includes the chart range. To determine the visibility and cloud height to use, see the table on page xxx in the introduction of the TFT. For example, for an Ml09A3 unit with nominal visibility, cloud height of 900, and chart range of 6300, the unit would use the ballistic mode and fire charge 6 white bag.

c. Computations. Met corrections have a large impact on the Copperhead projectile; therefore, firing data should not be determined without compensating for nonstandard conditions.

(1) Priority or planned targets. Firing data for planned targets is based on the solving of a met to target with the AS-1 TFT.

(2) Targets of opportunity. Because of the decreased response time for targets of opportunity, solving a met to a target is not practical. The following procedures can be used to determine firing data for targets of opportunity.

(a) FDO selects charge(s) to cover area of operations. FDO must also consider expected visibility and cloud height.

(b) Solve a met + VE for selected charge(s) by using the center range of the range interval for the charge(s).

(c) Use the total range correction determined as a "range K" to be applied to other missions with that charge.

(d) When the observer requests a Copperhead target of opportunity, apply the range K to the chart range to determine the entry argument for Table F, Column 1.

(3) Manual met to target. The following guidelines apply when a met to target for Copperhead is solved manually:

(a) Use a position deflection correction of zero.

(b) Use MVV calibration data determined from the M90 velocimeter and corrected for nonstandard conditions as the velocity error.

NOTE: In most situations, an MVV for shell Copperhead will be unavailable. The loss in muzzle velocity due to tube erosion (as determined from a recent pullover gauge reading and/or from EFC rounds) can be used as the position VE. Be sure to use the AS-1 TFT to determine an estimated loss in MV base on the current pullover gauge reading. Refer to Chapter 4 for further information on predictive MVV techniques.

(c) No fuze setting correction is determined.

13-7. Angle T and Target Cloud Height Checks

a. The FDO makes the angle T check by listening to the announced angle T and determining if it meets the angle T requirement for Copperhead (800 mils or less). Copperhead should not be fired when the angle T is greater than 800 mils. An angle T of this magnitude may seriously degrade the ability of the round to successfully acquire and engage its intended target. The FDO should also check the observer location to ensure he is not located "long" along the GT line. If this were the situation, the Copperhead projectile may not be able to seek the reflected laser energy.

b. Depending on the method used to locate the target, the target cloud height can be computed in one of two ways.

(1) If the target is located by grid coordinates, subtract the OT VI from the observer cloud height to determine the target cloud height.

EXAMPLE

TARGET ALTITUDE	355
- OBSERVER ALTITUDE	- 460
OT VI	(-105)
OBSERVER CLOUD HEIGHT	740
- OT VI	- (-105)
TARGET CLOUD HEIGHT	845 METERS

(2) If the target is located by laser polar plot, as targets of opportunity nomally are, compute the target cloud height as follows: First, use the OT distance and the VA reportedly the observer to compute the OT VI with the C and D scales of the GST. Then subtract the OT VI from the observer cloud height to determine the target cloud height.

EXAMPLE

VERTICAL ANGLE	-32 (SET M GAUGE POINT ON D SCALE)
OT DISTANCE	3340 METERS (SLIDE MHL OVER C SCALE)
OT VERTICAL INTERVAL	-105 (READ FROM D SCALE UNDER MHL)
OBSERVER CLOUD HEIGHT	740
- OT VI	- (-105)
TARGET CLOUD HEIGHT	845 METERS

c. The VCO computes the target cloud height and reports it to the FDO. The FDO enters the table with the target cloud height to determine the cloud ceiling.

d. An OT vertical interval of less than 30 meters can be ignored for targets of opportunity. In such cases, target cloud height equals observer cloud height.

e. Insufficient target cloud height will adversely affect the accuracy of the Copperhead round.

13-8. Trajectories

a. The Copperhead projectile travels in a trajectory determined by the switch setting applied. The trajectory used is dependent on the chart range to the target observer visibility, and target cloud height. The targeting logic used in the FT 155-AS-1 allows the FDC to select from one of two trajectories--ballistic or shaped.

b. The ballistic trajectory has a greater angle of fall, resulting in greater target area effects. In the ballistic mode, the projectile travels in a ballistic trajectory. This trajectory is only affected near the end of the descending branch when the projectile acquires and homes in on the reflected laser energy. If the projectile fails to acquire the designator, the projectile would continue to follow the ballistic trajectory to the ballistic aimpoint. The ballistic aimpoint is the point to which the fining data are computed, usually offset along the GT line by 0 to 500 meters.

c. The angle of fall generated by the ballistic solution is so steep as to limit the time that the projectile has, after exiting the cloud cover, to acquire the laser energy. The shaped trajectory allows the projectile to approach the target at a shallow angle and thus stay below cloud cover. The projectile may be caused to glide at a constant angle in the descending branch of the trajectory, allowing longer exposure of the projectile to the reflected laser energy and thereby enhancing acquisition probability. (See Figure 13-3.)

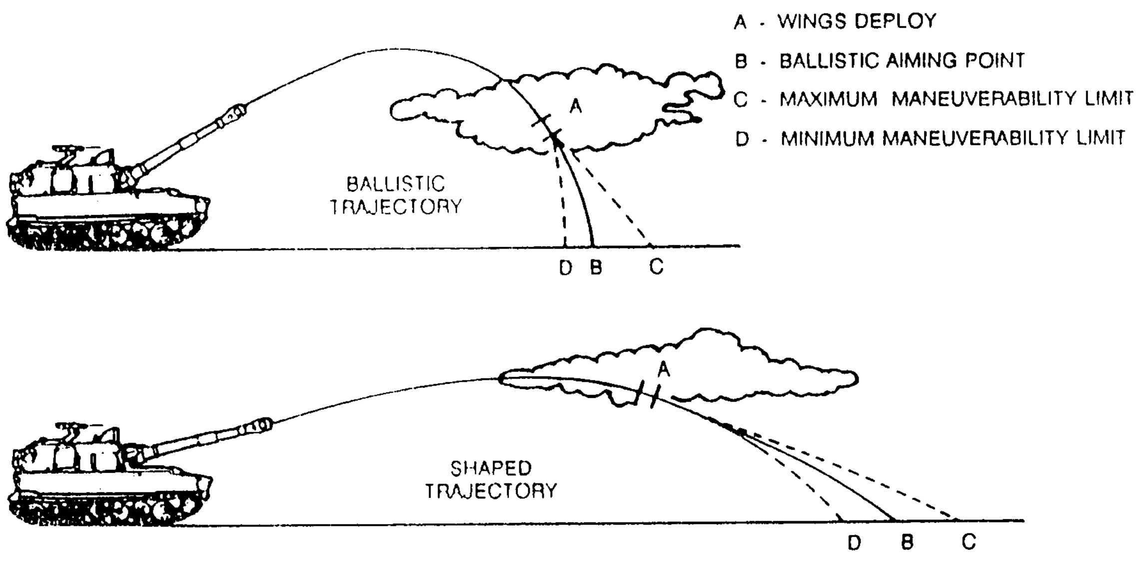


Figure 13-3. Comparison of Low-Angle Ballistic Trajectory and Shaped Trajectory.

13-9. Switch Setting

The Copperhead switch setting consists of five digits. (See Figure 13-4.) The first two numbers are the time setting determined by the FDC. The first digit programs the projectile for a specific trajectory. A first digit of 1 or 2 results in a ballistic trajectory, while a first digit of 3 through 8 results in a shaped trajectory. The second digit programs a time delay based on the duration of flight and type of trajectory. The program delay digits of 1 through 8 will result in a delay of 0 to 45 seconds for the ballistic mode and 0 to 48 seconds for the shaped trajectory. After the time delay has expired, the main portion of the battery will activate, providing power to the electronic circuits and deploying the wings. The last three digits are the PRF code for the G/VLLD or MULE operator. This setting establishes a common laser frequency between the projectile and the G/VLLD or MULE.

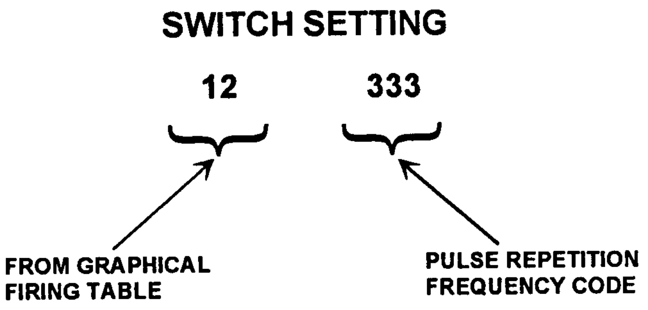


Figure 13-4. Copperhead Switch Setting.

13-10. Computing Site

The VCO manually computes site for Copperhead by using the ballistic aimpoint.

13-11. Computing Deflection Correction

The Copperhead round has no correction for drift. Therefore, the total deflection correction equals the GFT deflection correction and is applied without modification throughout that charge and mode.

13-12. Limits of the Base Piece Solution

a. Firing data for Copperhead is initially computed from the base piece location. If the center of the two howitzers firing the Copperhead mission is within 100 meters of the base piece, the firing data computed at the base piece may be used. If the two howitzers are located father than 100 meters from the base piece, deflection and elevation corrections from the two-howitzer subelement should be computed and applied to the base piece solution.

b. When time for computing data is limited, as is normally the case for targets of opportunity, and the two howitzers are located further than 100 meters from the base piece, the FDC should compute at least a deflection correction. The Copperhead round can compensate for errors in range easier than it can for errors in deflection.

13-13. Target Attack Contingencies

a. If the Copperhead round cannot be fired on a target because of insufficient target cloud height, the FDC must inform the observer requesting the mission. Coordination between the observer and the FDC can then be made to fire other types of munitions on the target.

b. If the Copperhead round cannot be fired on a target because the angle T is greater than 800 mils, the battery or platoon FDC should contact the battalion FDC to see if the mission can be taken by another unit having an angle T of 800 mils or less. If another unit is available, the original battery or platoon FDC tells the observer to contact the FDC of the unit taking the mission. If no other units are available, the observer and the FDC can coordinate to fire other types of munitions on the target.

c. The steps in Table 13-2 are used to determine firing data for planned targets.

Table 13-2. Determining Firing Data for Planned Targets.

STEP	ACTION
1	Call for fire is received.
2	FDO issues fire order.
3	Initial chart data are determined and announced by HCO. Chart data include chart range, chart deflection, and angle T.
4	The FDO performs the angle T check. Determine if angle T is 800 mils or less. The mission should not be fired if angle T is greater than 800 mils.
4a	Grid method of target location is as follows: **TGT ALT** **OBSR CLOUD HEIGHT** **-OBSR ALT** **- OT VI** **OT VI** **TGT CLOUD HEIGHT**

Table 13-2. Determining Firing Data for Planned Targets (Continued).

STEP	ACTION
4b	Laser polar method of target location is as follows: OT distance and VA are used to determine OT VI. **OBSR CLOUD HEIGHT** **- OT VI** **TGT CLOUD HEIGHT**
5	The computer determines the cloud ceiling from the Table of Intervals for Visibilities and Cloud Ceilings. Enter the interval column with the target cloud height, and extract the cloud ceiling. (Use page xxx of the 155-AS-1 TFT).
6	The FDO determines the visibility on the basis of the observer's reported visibility: Nominal, 100% (1.0), 50% (0.5), and 30% (0.3) from the Table of Intervals for Visibilities and Cloud Ceilings. Enter the interval column with the observer's reported visibility distance and extract the visibility.
7	The computer determines charge. The computer enters the charge selection table with the chart range visibility and cloud ceiling and determines the charge to fire and the mode from (pages xxiv - xxix of the 155-AS-1 TFT).
8	Use the met-to-target technique to determine the entry range for the TFT, Column I. The following guidelines apply:
8a	Use a position deflection correction of zero.
8b	Use MVV data as the velocity error.
8c	Total fuze setting corrections are not computed.
9	The computer determines the elevation to fire. This is the elevation (from Table F, Column 3) corresponding to chart range and the total range correction.
10	The computer determines the time setting. This is the time setting (from Table F, Column 4) corresponding to chart range and the total range correction.
11	The computer determines the switch setting. The first two digits are the time setting (step 10). The last three digits are the PRF code.
12	The computer determines the deflection to fire. The deflection to fire is the chart deflection plus the total deflection correction.
13	The VCO computes site manually. The VI is determined between the target and unit, and the range used is the ballistic aimpoint (Table F, Column 2) corresponding to the chart range and total range correction.
14	The computer determines the quadrant to fire by applying site (step 13) to the elevation to fire (step 9).
15	Determine the MTO. The Copperhead MTO includes the following: • Unit firing. • Number of rounds. • PRF code. • Angle T. • Range. • TOF. • Howitzers right or left of OT line. • Target number.

NOTE: Receipt of the CopperheadMTO by the observer indicates that the unit is ready to fire.

d. The steps in Table 13-3 are used to process a Copperhead mission with a record of fire.

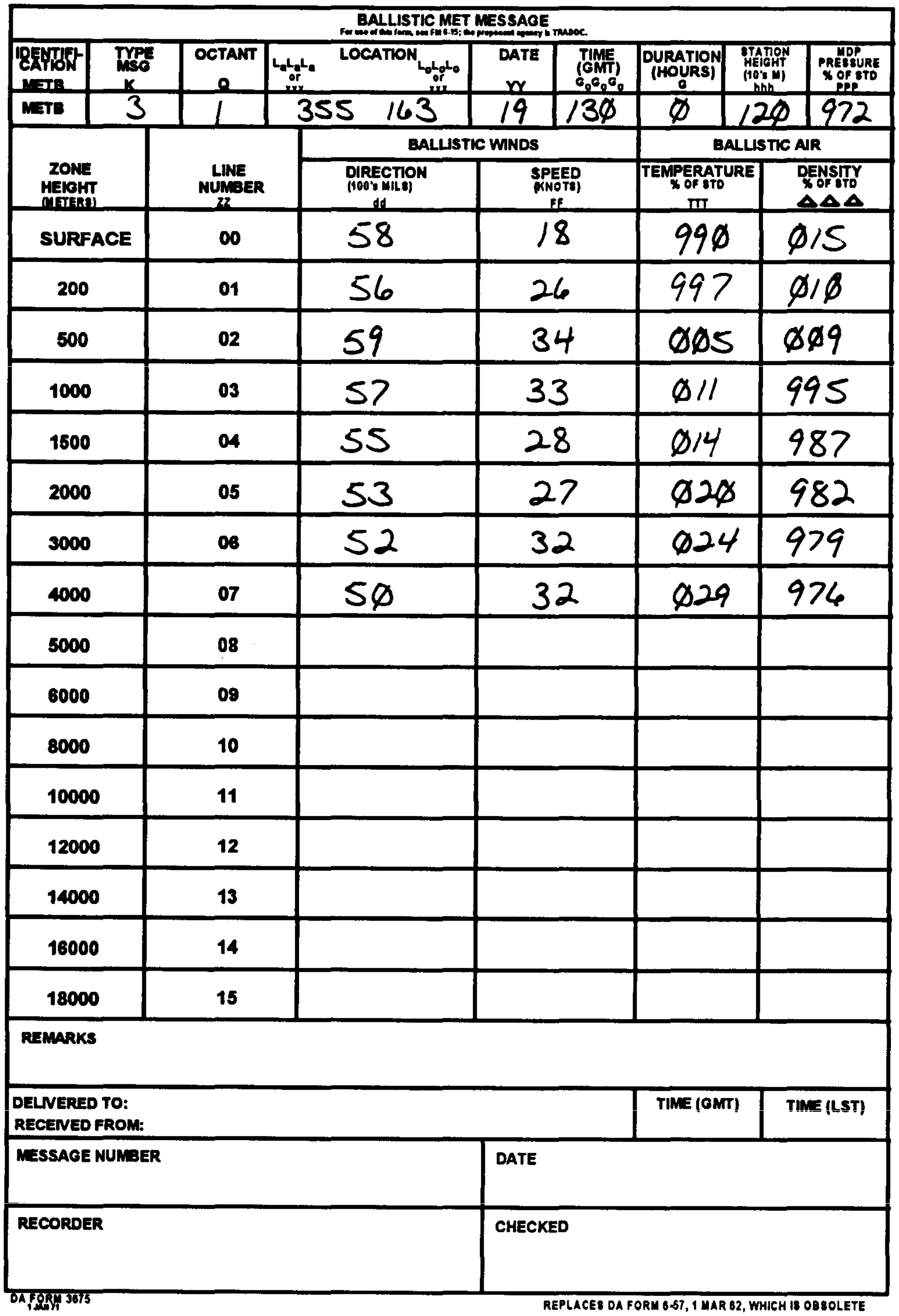
Table 13-3. Processing a Copperhead Fire Mission.

STEP	ACTION
1	**Records of fire** for Copperhead missions are completed in nearly the same manner as those for conventional fire missions. Divide the Rg block with a slant line. Enter the chart range in the left half of the Rg block and the ballistic aimpoint in the right half. Enter the switch (sw) setting in the fuze setting (Ti) block. Write the designated time in the TF block.
2	**DA Form 5711-R** or a target list board can be used to compute firing data for Copperhead planned targets. Actual firing data are then recorded on DA Form 4504.
3	The order in which **initial and subsequent fire commands** are given is the same as that for conventional fire missions except that fuze is omitted and switch setting is announced instead of time.
4	The **special instructions BY PIECE (BY ROUND), AT MY COMMAND** is sent to the howitzers for all Copperhead missions, regardless of the method of control specified by the observer. For each round, the FDC gives the command to fire to the howitzer section firing the mission after the observer has given the command **FIRE**.
	EXAMPLE The observer requested **AT MY COMMAND** in his call for fire and has given the command to fire. The FDC initiates firing at 30-second intervals. **NUMBER 1...FIRE (wait 30 seconds)** **NUMBER 2...FIRE (wait 30 seconds)** **NUMBER 1...FIRE (wait 30 seconds)** **NUMBER 2...FIRE**
	NOTE: If one howitzer is firing two rounds and the other is firing one round, the howitzer firing two rounds should be fired first to give it maximum time to load its second round. If the next howitzer to fire is not ready, the command to fire should be passed to the one that is ready. For priority missions, the FDC sends firing data to the howitzers in a do-not-load status.
5	**Engagement commands** consist of **SHOT** and **LASER ON**.
5a	**SHOT**. As soon as the first Copperhead round is fired in a mission and the observer specifies **AT MY COMMAND** (or omits the method of control from his call for fire), the FDC transmits **SHOT** only once (for the initial round). Any subsequent rounds for the mission are fired at intervals of at least 30 seconds without notification to the observer. The exact interval between rounds will be set by unit SOP. If the observer specifies **BY ROUND AT MY COMMAND**, the FDC transmits **SHOT** for each round fired. If the observer fails to acknowledge **SHOT** for a given round, **it is not retransmitted** because the observer's timing of the round would be affected. Instead, the FDC would verify communications before firing additional rounds.
5b	**LASER ON**. The next and most critical engagement command is **LASER ON**. When the observer receives the command **LASER ON** from the FDC, he begins designating the target with the laser designator (MULE or G/VLLD). This command is sent at least 20 seconds before impact. If the time of flight is 20 seconds or less, **LASER ON** and **SHOT** are sent in the same transmission.

Table 13-3. Processing a Copperhead Fire Mission (Continued).

STEP	ACTION
6	It is mandatory that the observer designate the target during the last 13 seconds of the time of flight. When the observer has received **SHOT**, he should begin his own countdown, subtracting 20 seconds from the time of flight received in the message to observer. The 7-second difference allows for human reaction and communication time to ensure that the 13-second requirement is met. If for some reason the observer does not receive a **LASER ON** command, he should begin designating when 20 seconds are left in his countdown. If the time of flight is less than 20 seconds, the observer begins designating on receipt of **LASER ON**.
7	If the unit is firing two or more Copperhead rounds at 30-second intervals, the command **LASER ON** is sent only for the first round fired. The observer continues designating for the subsequent rounds while moving the laser spot to the next target. (Observer specifies **AT MY COMMAND** as the method of control.)
8	If **SHOT** is given for each round or if the firing interval is greater than 30 seconds, **LASER ON** is given for each round. (Observer specifies **BY ROUND, AT MY COMMAND** as the method of control.)
9	If the observer fails to acknowledge the **LASER ON** command, the command is retransmitted repeatedly until the time of flight has expired. Communications are verified and **SHOT** and **LASER ON** are sent for the next round fired regardless of the method of control. Time intervals between the transmission of this command and impact must allow the observer time to acknowledge the command **LASER ON** and still leave 13 seconds for designating the target.
10	The FDC reports **ROUNDS COMPLETE** after the engagement command for the last round has been sent and acknowledged. If the observer wants to terminate firing before the last round is fired and the FDC is controlling the firing of subsequent rounds, he sends **CHECK FIRING, CANCEL CHECK FIRING, END OF MISSION**. If the observer is controlling the firing of subsequent rounds, he sends **END OF MISSION** to terminate the mission.
11	If additional rounds are required to engage the target, the observer may request them by sending **(so many) ROUNDS, REPEAT, OVER** after the last Copperhead round is fired. The criterion of one round per target is followed in requesting additional rounds. The observer should be prepared for a significant delay in response time because additional rounds were not prepared in advance.

NOTE: Figures 13-5 through 13-7 show a completed Copperhead fire mission using the 155-AS-1 TFT. The Met + VE Worksheet (DA Form 7352-R) is a new reproducible form located at the back of this book.



BALLISTIC MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or xxx $L_oL_oL_o$ or yyy	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	355 163	19	130	0	120	972

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	BALLISTIC WINDS		BALLISTIC AIR	
		DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE % OF STD TTT	DENSITY % OF STD △△△
SURFACE	00	58	18	990	015
200	01	56	26	997	010
500	02	59	34	005	009
1000	03	57	33	011	995
1500	04	55	28	014	987
2000	05	53	27	020	982
3000	06	52	32	024	979
4000	07	50	32	029	976
5000	08				
6000	09				
8000	10				
10000	11				
12000	12				
14000	13				
16000	14				
18000	15				

REMARKS

DELIVERED TO: RECEIVED FROM:	TIME (GMT)	TIME (LST)

MESSAGE NUMBER	DATE
RECORDER	CHECKED

DA FORM 3675, 1 JAN 91

REPLACES DA FORM 6-57, 1 MAR 82, WHICH IS OBSOLETE

Figure 13-5. Valid Ballistic Met Message (Copperhead Fire Mission).

M712 COPPERHEAD MET + VE WORKSHEET (APR 94)

Use FT 155-AS-1

STEP	ACTION	VALUE
1	Record the Chart Rg to Tgt	6000
2	Record the Chart Df to Tgt	3311
3	Record Obs Visibility	0.5 NOM
4	Record Obs Cld Ht	740
5	Record Tgt Altitude	1030
6	Record Obs Altitude	1127
7	Compute OT VI [5] - [6]	-97
8	Compute Tgt Cld Ht [4] - [7]	837
9	Enter Chg, Vis, Cld Ceiling Tbl with [1], [3], [8]; Extract Charge and Mode	6WB BALLISTIC
10	Record Tgt Altitude [5]	1030
11	Record Btry Altitude	1062
12	Compute VI [10] - [11]	-32
13	Compute ∢SI (GST) [12] , [1]	-5.4
14	Enter Tbl F with [1]; Record El from Col 3	298.7
15	Compute Trial QE VI [13] + [14]	293.3
16	Enter Tbl A with [15] & [9] **Record Met Message Line Number**	02
17	Record Wind Direction	5900
18	Record Wind Speed	34
19	Record Air Temperature	100.5
20	Record Air Density	100.9
21	Record Common Deflection	3200
22	Record Chart Deflection [2]	3311
23	Compute Diff [21] - [22] (+/-)	-111
24	Record AOL	4800
25	Comp Dir of Fire [23] + [24] (1 mil)	AZ TO TGT 4689

STEP	ACTION	VALUE
26	Record Dir of Fire [25] (≈ 100mils)	4700
27	Record 6400 (If [26] > 6400)	
28	Compute Dir of Fire [26] - [27]	4700
29	Record Wind Direction [17]	5900
30	Record 6400 (If [29] < [28])	
31	Compute Wind Direction [29] + [30]	5900
32	Record Dir of Fire [28] (≈ 100 mils)	4700
33	Compute Chart Dir Wind [31] - [32]	1200
34	Enter Tbl C with [33]; Record the Range Wind Component	H 0.38
35	Record Wind Speed [18]	34
36	Compute Rg Wind [34] X [35] (1 knot)	H 13
37	Enter Tbl C with [33]; Record the Cross Wind Component	R 0.92
38	Record Wind Speed [18]	34
39	Compute CW [37] X [38] (1 knot)	R 31
40	Enter Tbl F with [1]; Record the CW Unit Correction	0.52
41	Comp TOT DF Corr [39] X [40] (1 mil)	R 16
42	Record Chart Deflection [2]	3311
43	Compute Df to Fire [41] + [42]	3295
44	Record Btry Altitude [11] (10 meters)	1060
45	Record MDP Altitude from MET Msg	1200
46	Compute △h [44] - [45]	-140
47	Enter Tbl D with [46]; Record the Temp Correction	+ 0.3
48	Record Air Temperature [19]	100.5
49	Compute Corr Air Temp [47] + [48]	100.8
	DTG 191334Z APR 94	TGT Number AJ 7803

DA FORM 7352-R, JAN 96

Figure 13-6. Completed Met + VE Worksheet (Copperhead Fire Mission).

M712 COPPERHEAD MET + VE WORKSHEET (APR 94)

Use FT 155-AS-1

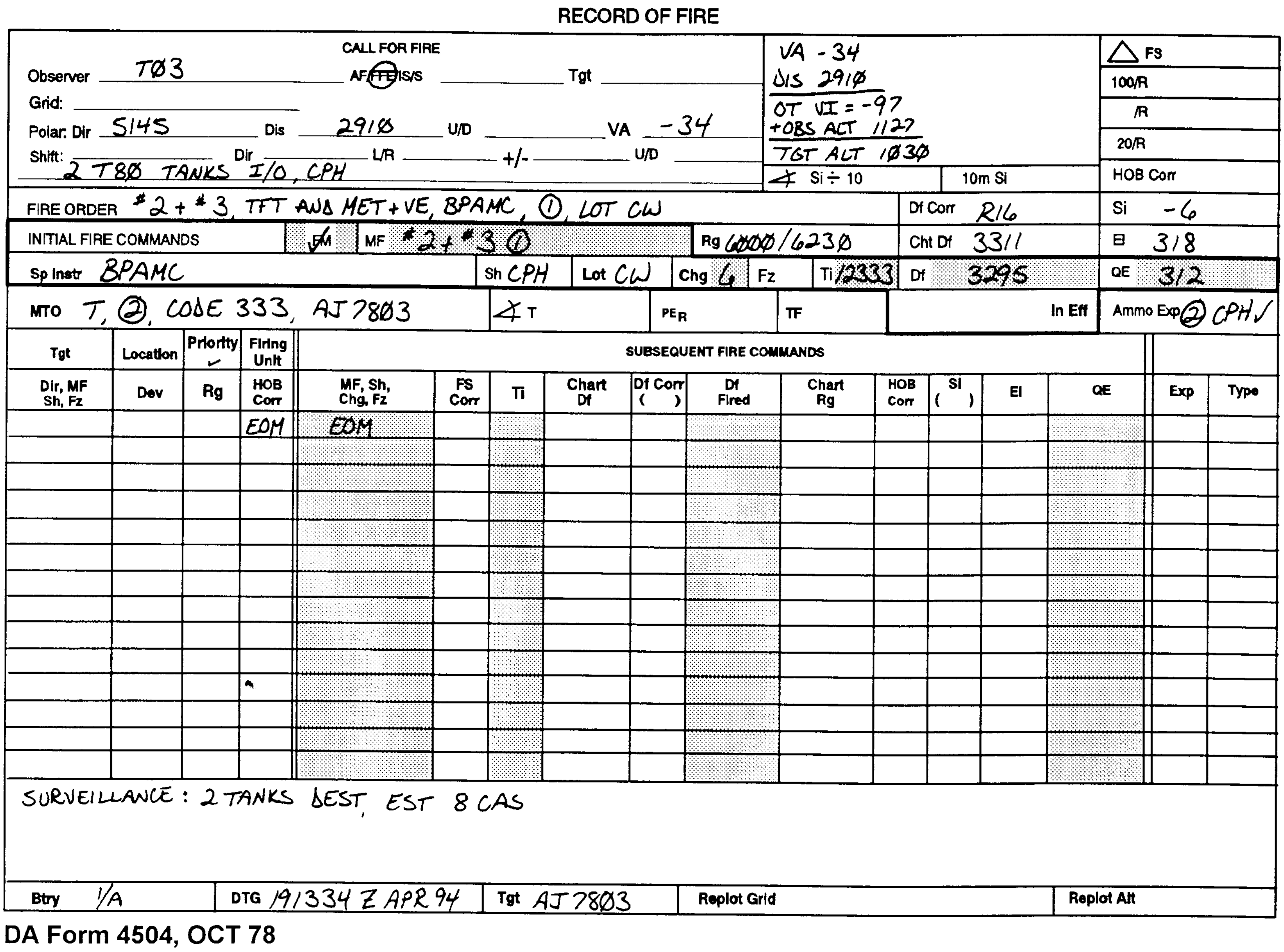
STEP	ACTION	VALUE
50	Enter Tbl D with [46]; Record the Density Correction	+ 1.4
51	Record Air Density [20]	100.9
52	Comp Corr Air Dens [50] + [51]	102.3
53	Record Propellant Temperature	+ 75
54	Enter Tbl E with [53]&[9]; Record the Change in MV (0.1 m/s)	+ 0.4
55	Record MVV; go to [62]; if unknown enter 0; go to [56]	0
56	Record Pullover Gauge Reading	6.134
57	Enter Approx Loss in MV Tbl with [56], Record EFCs equal to [56]	1000
58	Record the EROSION EFCs since last Pullover Gauge Reading	200
59	Compute total EFCs [57] + [58]	1200
60	Enter Approx Loss in MV Tbl with [59], Record loss in MV	-3.1
61	Record Propellant Efficiency	-3.3
62	Compute △ V [54] + [55] or [54]+ [60] + [61] (I/D) if no entry available	D6.0
63	Enter Tbl F with [1]; Record the MV Unit Correction	+14.5
64	Comp △V Rg Corr [62] X [63]	+87
65	Record Range Wind [36]	H13
66	Enter Tbl F with [1]; Record the Rg Wind Unit Correction	+8.6
67	Comp Rg Wind Corr [65] X [66] (0.1)	+111.8
68	Record Corr Air Temp [49]	100.8
69	Enter 100	100
70	Comp Var from Std [68] -[69]	I 0.8
71	Enter Tbl F with [1]; Record the Air Temp Rg Unit Correction	-10.8
72	Compute Air Temp Rg Corr [70] X [71] (0.1 meter)	-8.6

STEP	ACTION	VALUE
73	Record Corr Air Dens [52]	102.3
74	Enter 100	100
75	Compute Var from Std [73] - [74]	I2.3
76	Enter Tbl F with [1]; Record the Density Unit Correction	+16.0
77	Comp Dens Rg Corr [75] X [76] (0.1)	+36.8
78	Record △V Rg Corr [64]	+87
79	Record Range Wind Corr [67]	+111.8
80	Record Air Temp Corr [72]	-8.6
81	Compute TOT Range Correction [77] + [78] + [79] + [80] (10 meters)	+230
82	Record Chart Range [1]	6000
83	Compute Corrected Rg [81] + [82]	6230
84	Enter Tbl F with [83]; Interpolate the Elevation from col 3 (1 mil)	318
85	Record ∡ Site [13]	-5.4
86	Enter Tbl G with [82]; Record the CSF for 1 mil angle of site	-0.078
87	Compute CAS [85] X [86] Same sign as [86] (0.1 mil)	(-0.4212) -0.4
88	Record ∡ Site [85]	-5.4
89	Compute Site [87] + [88] (1 mil)	-6
90	Record Elevation [84] (1 mil)	318
91	Compute QE to Fire [89] + [90]	312
92	Enter Tbl F with [83]; Record the Time Setting	12
93	Record Switch Setting [92] followed by Obs PRF code	12333
94	Enter Tbl F with [83]; Record the Designate Time	5

Firing Data
Chg [9] 6WB Switch Setting [93] 12333
DF [43] 3295 QE [91] 312

PAGE 2, DA FORM 7352-R, JAN 96

Figure 13-6. Completed Met + VE Worksheet (Back) (Copperhead Fire Mission).



RECORD OF FIRE

CALL FOR FIRE

Observer T03 AF/[✓ FFE]/IS/S Tgt

Grid:

Polar: Dir 5145 Dis 2910 U/D VA -34

Shift: Dir L/R +/- U/D

2 T80 TANKS I/O, CPH

VA -34
DIS 2910
OT VI = -97
+OBS ALT 1127
TGT ALT 1030

∡ Si ÷ 10	10m Si

△ FS	
100/R	
/R	
20/R	
HOB Corr	
Si	-6
El	318
QE	312
Ammo Exp	② CPH ✓

FIRE ORDER #2 + #3, TFT AND MET + VE, BPAMC, ①, LOT CW

Df Corr R16

INITIAL FIRE COMMANDS ✓FM MF #2 + #3 ① Rg 6000/6230

Cht Df 3311

Sp Instr BPAMC Sh CPH Lot CW Chg 6 Fz Ti /2333 Df 3295

MTO T, ②, CODE 333, AJ7803 ∡T PER TF In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
			EOM	EOM												

SURVEILLANCE: 2 TANKS DEST, EST 8 CAS

Btry 1/A	DTG 191334 Z APR 94	Tgt AJ7803	Replot Grid	Replot Alt

DA Form 4504, OCT 78

Figure 13-7. Completed Record of Fire (Copperhead Fire Mission).

Section II

ROCKET-ASSISTEDPROJECTILE

Rocket-assisted projectiles are available for the 105-mm and 155-mm howitzers. They are designed to extend the range of the howitzers. The basic rocket-assisted projectiles are filled with HE material. They produce blast and fragmentation in the target area. Computation procedures for the two basic HE RAPs are identical. Firing tables are available for the rocket on mode only.

13-15. Description

a. The 105-mm RAPs are the M548 and M913. The 155-mm projectiles are the M549 and M549A1. For the Ml 09A2/A3 weapons, these projectiles are fired with charges 7 (M4A2), 8 (Ml 19A1), and 7 (Ml 19A2). The M198 howitzers may use charges 7 (M4A2), 8 (Ml 19A1), 7 (Ml 19A2), and 8S (M203 only for the M549A1 projectile).

b. Rocket-assisted projectiles should always be fired by using current GFT settings because most RAP missions are expected to be FFE missions. The multiplot GFT setting is recommended for use with RAP. When no RAP registration data are available, a met-to-target technique should be solved by using MV data, propellant temperature, and rocket motor temperature (assumed to be the same as the propellant temperature).

13-16. Manual Computations

a. Procedures for computing HE RAP firing data are identical to those for conventional HE rounds. The RAP GFTs and GSTs are similar to and are read in the same way as those for conventional HE rounds with two exceptions. The 155-mmM549A1 GFT has no fuze setting scale.

b. Table 13-4 shows the steps for determining firing data for the RAP.

NOTE: Figures 13-8 through 13-10 show a completed RAP fire mission. An Ml 09A3 howitzer, propellant Ml 19AI, and TFT 155-AO-0 were used.

Table 13-4. Determining Firing Data for a RAP Fire Mission.

STEP	ACTION
1	Upon receipt of the observer's call for fire, the FDO issues the fire order. The RATELO composes and transmits the message to observer.
2	The computer determines and sends initial fire commands.
3	The chart operator (HCO) determines and announces chart data.
4	The VCO determines and announces site by using the appropriate RAP GST.
5	The computer determines, records, and announces firing data. If a GFT setting is available for RAP, he determines firing data (drift, elevation, and time of flight) by using the appropriate gauge lines. If no GFT setting is available, the computer determines deflection and range corrections to GFT data by using the TFT and met correction techniques. (See Figure 13-9.)

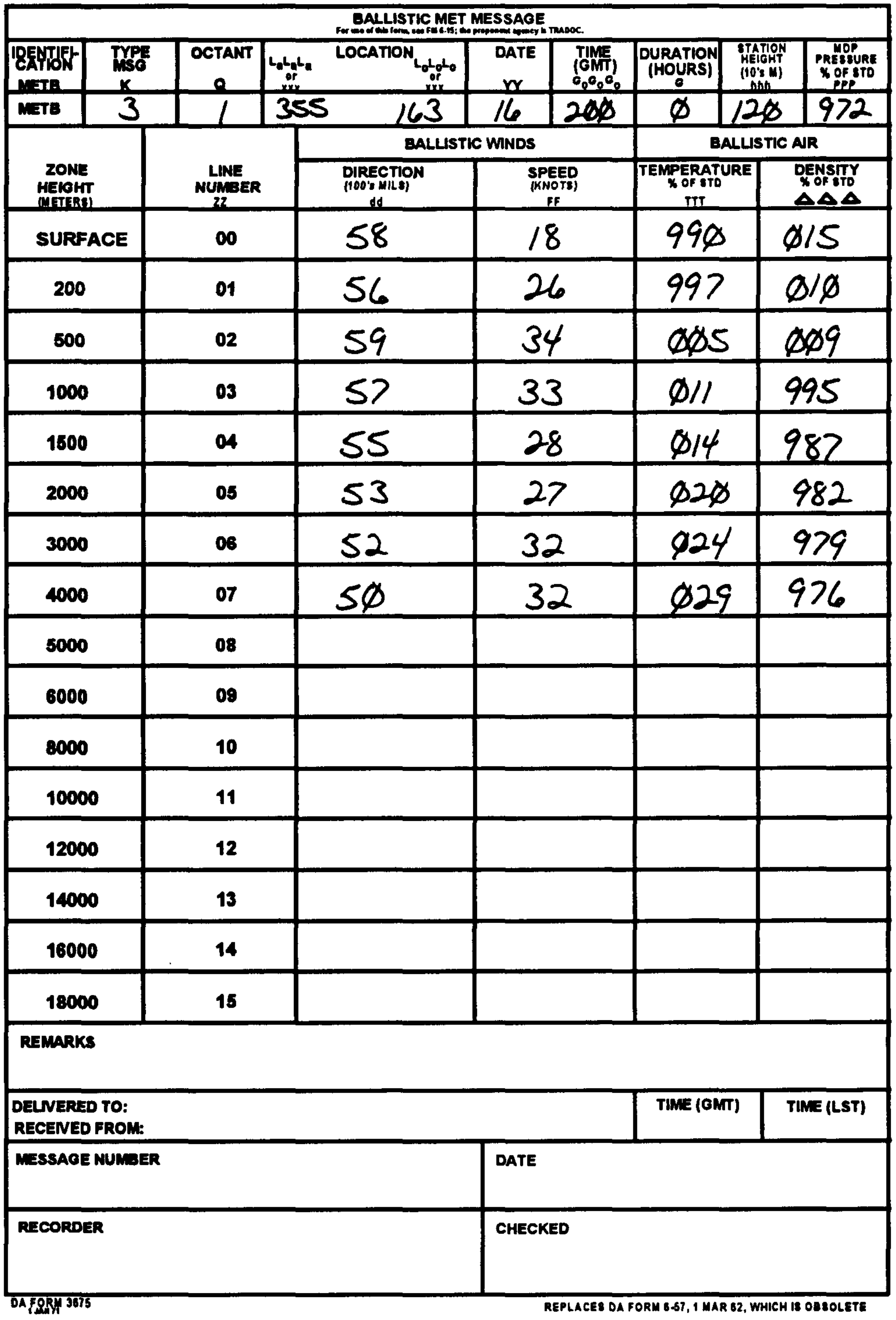
Table 13-4. Determining Firing Data for a RAP Fire Mission (Continued).

STEP	ACTION
6	Determine corrected chart data. Compute met data corrections on DA Form 4200, and manually apply the corrections to the chart range and deflection. All steps are the same as standard met-to-target procedures except that the rocket motor temperature correction is recorded in the upper range correction block and no FS corrections are determined. The rocket motor temperature correction is determined from the TFT, Table E-1.
7	Use the GFT to determine drift, elevation, and time of flight corresponding to the corrected chart data. If no GFTs are available, use the TFT, and interpolate elevation and fuze setting from Table F.
8	Determine, record, and announce the remainder of the fire commands. (See Figure 13-10.)

13-17. Registration and Determining a GFT Setting

a. Units most likely will not register with the rocket-assisted projectile. An inferred GFT setting can be computed without registration data. Use a subsequent met technique such as met + VE, met to target, or met to met-check gauge point. Assume position constants are zero. As time allows, compute a multiplot GFT setting to improve accuracy at all ranges. Include range corrections for rocket motor temperature (Table E-1) for solving RAP met techniques for rocket motor on mode. For 105-mm howitzers in the rocket motor on mode, met techniques or registrations for RAP will yield unacceptable fuze corrections because of the large fuze-related probable errors. Therefore, do not compute them. For 155-mm howitzers, there is no Table J for fuze correction computations in the RAP TFT, since it can only be fired in the rocket motor on mode.

b. In a combat environment, the unit may conduct registrations with RAP. All of the probable errors involved in firing RAP force the observer to modify a precision registration and severely degrade its accuracy. For this reason, an MPI registration is the best option. However, probable errors also affect the MPI registration. Since the observer obtains spottings of a number of impacts **without adjustment,** the effects of the probable errors are lessened in comparison to a precision registration. The determined mean point of impact most likely is not as accurate as one determined for an HE MPI registration. However, the RAP MPI registration still provides a GFT setting and increases accuracy. If the unit does register, it also solves a concurrent met and derives position constants for use with later RAP missions. Use the position constants and a subsequent met technique to determine a GFT setting for new missions. As time allows, use the position constants and subsequent met techniques to construct a multiplot GFT setting and improve accuracy at all ranges.



BALLISTIC MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION METB	TYPE MSG K	OCTANT Q	LOCATION $L_aL_aL_a$ or xxx	$L_oL_oL_o$ or xxx	DATE YY	TIME (GMT) $G_oG_oG_o$	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE % OF STD PPP
METB	3	1	355	163	16	200	0	120	972

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	BALLISTIC WINDS		BALLISTIC AIR	
		DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE % OF STD TTT	DENSITY % OF STD △△△
SURFACE	00	58	18	990	015
200	01	56	26	997	010
500	02	59	34	005	009
1000	03	57	33	011	995
1500	04	55	28	014	987
2000	05	53	27	020	982
3000	06	52	32	024	979
4000	07	50	32	029	976
5000	08				
6000	09				
8000	10				
10000	11				
12000	12				
14000	13				
16000	14				
18000	15				

REMARKS

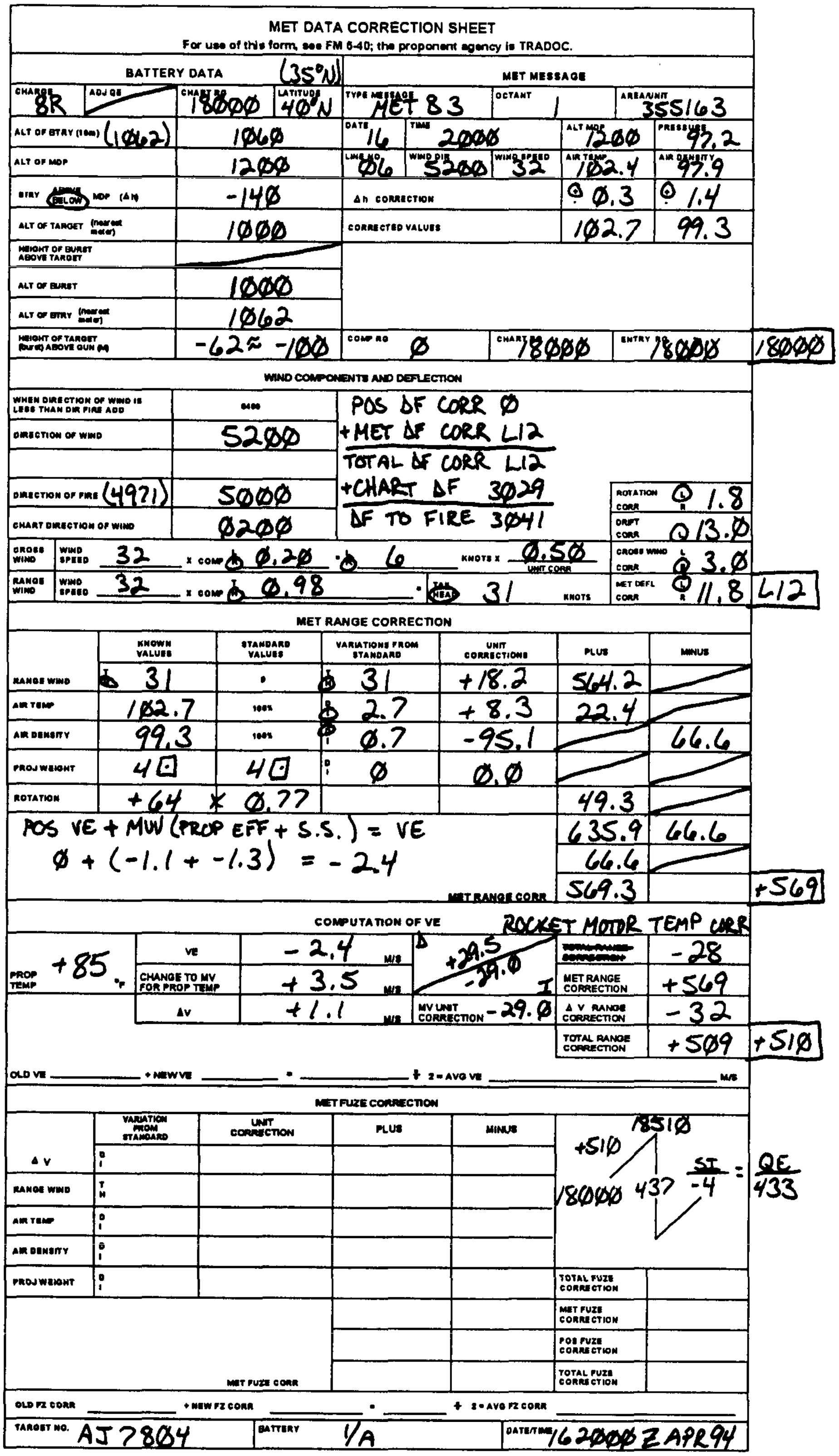
DELIVERED TO: RECEIVED FROM:	TIME (GMT)	TIME (LST)

MESSAGE NUMBER	DATE
RECORDER	CHECKED

DA FORM 3675
1 JAN 71

REPLACES DA FORM 6-57, 1 MAR 62, WHICH IS OBSOLETE

Figure 13-8. Valid Ballistic Met Message (RAP Fire Mission).



MET DATA CORRECTION SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

BATTERY DATA (35°N)

CHARGE 8R	ADJ QE
CHART RG 18000	LATITUDE 40°N
ALT OF BTRY (10m) (1062)	1060
ALT OF MDP	1200
BTRY ABOVE [✓ BELOW] MDP (Δh)	-140
ALT OF TARGET (nearest meter)	1000
HEIGHT OF BURST ABOVE TARGET	
ALT OF BURST	1000
ALT OF BTRY (nearest meter)	1062
HEIGHT OF TARGET (burst) ABOVE GUN (M)	-62 ≈ -100

MET MESSAGE

TYPE MESSAGE MET 83		OCTANT 1		AREA/UNIT 355163	
DATE 16	TIME 2000			ALT MDP 1200	PRESSURE 97.2
LINE NO. 06	WIND DIR 5200	WIND SPEED 32		AIR TEMP 102.4	AIR DENSITY 97.9
Δh CORRECTION				⊕ 0.3	⊕ 1.4
CORRECTED VALUES				102.7	99.3

COMP RG 0 | CHART RG 18000 | ENTRY RG 18000 | 18000

WIND COMPONENTS AND DEFLECTION

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	6400
DIRECTION OF WIND	5200
DIRECTION OF FIRE (4971)	5000
CHART DIRECTION OF WIND	0200

POS DF CORR 0

+MET DF CORR L12

TOTAL DF CORR L12

+CHART DF 3029

DF TO FIRE 3041

CROSS WIND — WIND SPEED 32 x COMP 0.20 = 6 KNOTS x 0.50 (UNIT CORR)

RANGE WIND — WIND SPEED 32 x COMP 0.98 = TAIL [✓ HEAD] 31 KNOTS

ROTATION CORR	[✓ L] R 1.8
DRIFT CORR	[✓ L] 13.0
CROSS WIND CORR	L [✓ R] 3.0
MET DEFL CORR	[✓ L] R 11.8

L12

MET RANGE CORRECTION

	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS
RANGE WIND	H 31	0	H 31	+18.2	564.2	
AIR TEMP	102.7	100%	I 2.7	+8.3	22.4	
AIR DENSITY	99.3	100%	D 0.7	-95.1		66.6
PROJ WEIGHT	4☐	4☐	0	0.0		
ROTATION	+64 × 0.77				49.3	
					635.9	66.6
					66.6	
				MET RANGE CORR	569.3	

POS VE + MW (PROP EFF + S.S.) = VE

0 + (-1.1 + -1.3) = -2.4

+569

COMPUTATION OF VE

ROCKET MOTOR TEMP CORR

PROP TEMP +85 °F	VE	-2.4 M/S	Δ +29.5 / -29.0 I	~~TOTAL RANGE CORRECTION~~	-28
	CHANGE TO MV FOR PROP TEMP	+3.5 M/S		MET RANGE CORRECTION	+569
	ΔV	+1.1 M/S	MV UNIT CORRECTION -29.0	Δ V RANGE CORRECTION	-32
				TOTAL RANGE CORRECTION	+509

+510

OLD VE ________ + NEW VE ________ = ________ ÷ 2 = AVG VE ________ M/S

MET FUZE CORRECTION

	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
Δ V	D I			
RANGE WIND	T H			
AIR TEMP	D I			
AIR DENSITY	D I			
PROJ WEIGHT	D I			
		MET FUZE CORR		

18510

+510

18000 437

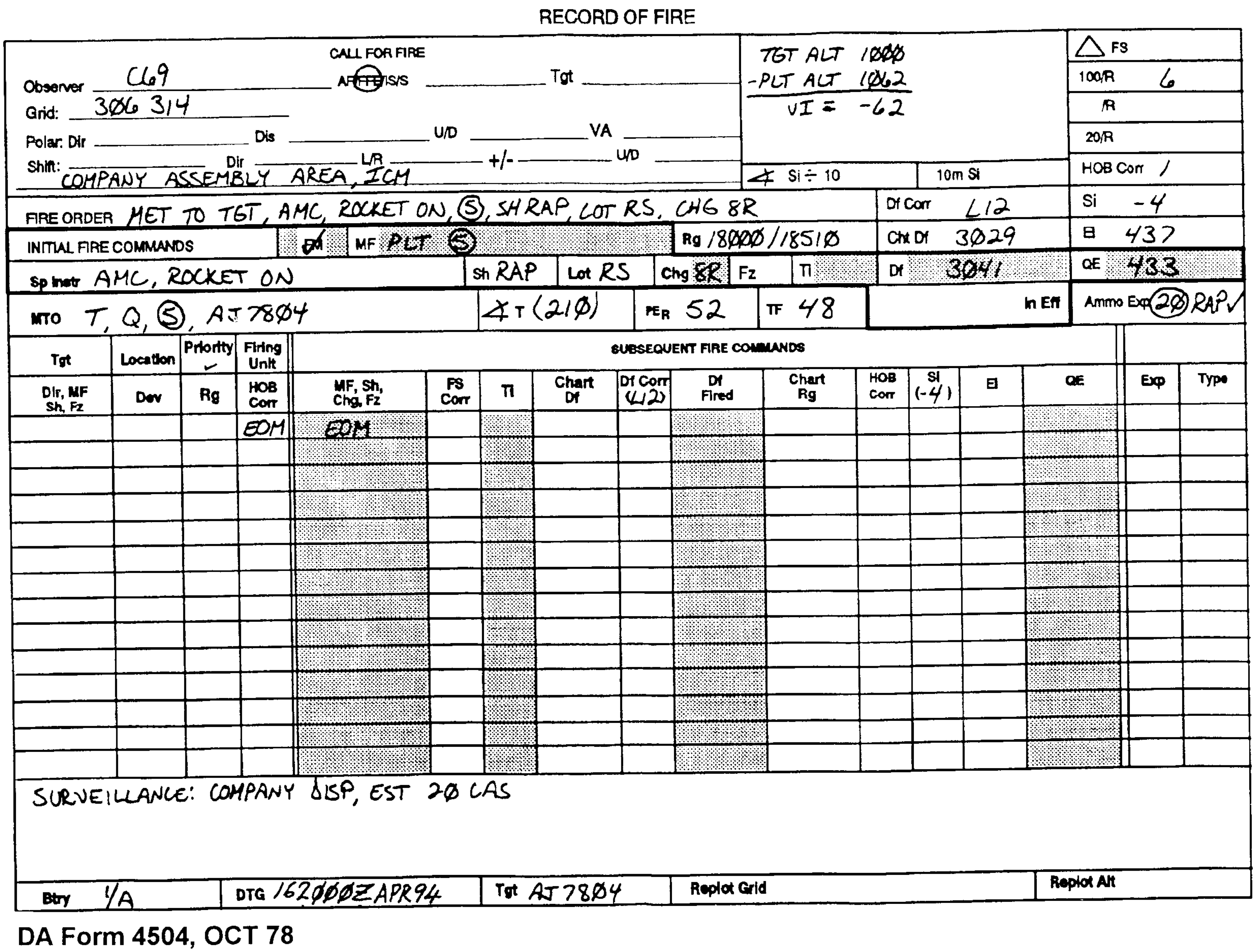
SI -4 = QE 433

TOTAL FUZE CORRECTION	
MET FUZE CORRECTION	
POS FUZE CORRECTION	
TOTAL FUZE CORRECTION	

OLD FZ CORR ________ + NEW FZ CORR ________ = ________ ÷ 2 = AVG FZ CORR ________

TARGET NO. AJ7804 | BATTERY 1/A | DATE/TIME 162000Z APR94

Figure 13-9. Completed Met Data Correction Sheet (RAP Fire Mission).



RECORD OF FIRE

CALL FOR FIRE

Observer C69 [✓ AF FFE] IS/S Tgt

Grid: 306 314

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

COMPANY ASSEMBLY AREA, ICM

TGT ALT 1000
-PLT ALT 1062
VI = -62

∡ Si ÷ 10

10m Si

△ FS

100/R 6

/R

20/R

HOB Corr /

Si -4

El 437

QE 433

Ammo Exp ⑳ RAP✓

FIRE ORDER MET TO TGT, AMC, ROCKET ON, ⑤, SHRAP, LOT RS, CHG 8R

Df Corr L12

Cht Df 3029

INITIAL FIRE COMMANDS [✓ FM] MF PLT ⑤

Rg 18000/18510

Sp Instr AMC, ROCKET ON

Sh RAP

Lot RS

Chg 8R

Fz

TI

Df 3041

MTO T, Q, ⑤, AJ7804

∡T (210)

PE R 52

TF 48

In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	TI	Chart Df	Df Corr (L12)	Df Fired	Chart Rg	HOB Corr	Si (-4)	El	QE	Exp	Type
			EOM	EOM												

SURVEILLANCE: COMPANY DISP, EST 20 CAS

Btry 1/A

DTG 162000ZAPR94

Tgt AJ7804

Replot Grid

Replot Alt

DA Form 4504, OCT 78

Figure 13-10. Completed Record of Fire (RAP Fire Mission).

Section III
SMOKE PROJECTILES

Smoke projectiles are used for smoke screens, obscuring smoke, and marking targets for aircraft.

13-18. Description

a. Types. The three types of smoke projectiles areas follows:

(1) Hexachloroethane. Hexachloroethane (HC) smoke (smk) projectiles are available for 105-mm and 155-mm howitzers. They are used for screening, obscuration, spotting, and signaling purposes. The projectile has no casualty-producing effects. This base-ejection projectile is ballistically simailar to the HE projectile. It is fitted with a mechanical time fuze M565 or M577. The round expels smoke canisters that emit smoke for a period of 40 to 90 seconds.

(2) Burster-type white phosphorus. White phosphorus projectiles are available for 105-rnm and 155-mm howitzers. They are bursting-tube type projectiles that can be fired with point-detonating (PD) or MTSQ fuzes. The projectile has an incendiary-producing effect and is ballistically similar to the HE projectile. Normally, shell WP is employed for its incendiary effect. The projectile also can be used for screening, spotting, and signaling purposes.

(3) M825 white phosphorus. The M825 WP projectile is an FA-delivered 155-mm base-ejection projectile designed to produce a smoke screen on the ground for a duration of 5 to 15 minutes. It consists of two major components--the projectile carrier and the payload. The projectile carrier delivers the payload to the target. The payload consists of 116 WP-saturated felt wedges. The smoke screen is produced when a predetermined fuze action causes ejection of the payload from the projectile. After ejection, the WP-saturated felt wedges in the payload fall to the ground in an elliptical pattern. Each wedge then becomes a point or source of smoke. The M825 is ballistically similar to the M483A1 (DPICM) family of projectiles.

b. Employment. Smoke is employed by using the quick smoke and immediate smoke techniques.

(1) Quick smoke. A quick smoke mission is used to build a screen 100 to 1,500 meters in length, depending on the munition selected. It may be fired as a preplanned target or as a target of opportunity. Targets greater than 250 meters in length should be preplanned because of ammunition constraints and the possible need to segment the target. Quick smoke may be processed as an adjust-fire or FFE mission. Accurate FFE mission processing on preplanned targets presupposes a positive correlation between wind direction at the screen location and that listed on line 00 of the current computer met message, in addition to meeting the five requirements for accurate predicted fire. The following is a list of quick smoke mission characteristics.

- Delivery technique: Quick smoke.
- Type of target: Planned, or target of opportunity, 100 to 1,500 meters.
- Number of howitzers: 2 to 16.
- Type of ammunition: M825, HC or WP.

- Sheaf: Linear.
- Obscuration Time: 5 to 15 minutes.
- Command and Control: Approval of maneuver commander.
- Computations (155 mm): FT 155-AM-2 for HC and WP data, FT 155-AM-2 and FT 155-ADD-T-0 or FT 155-AN-2 and FT 155-ADD-Q-0 for M825 data, and/or corresponding GFTs and GSTs.

NOTE: GFTs are available for 155 AM-2 that have M825 scales in place of ICM scales. The M825 data are determined on the basis of the HE quadrant and fuze setting.

(2) Immediate smoke. An immediate smoke mission may be fired as a separate mission or as a follow-up to immediate suppression. Immediate smoke missions normally are fired by platoon. The initial volley may be fired with shell WP, fuze quick, or a mix of shell WP and shell HC. If additional volleys are fired, all howitzers should fire HC smoke. When firing the M825 smoke round, all howitzers should fire the M825 projectile for the initial and any subsequent volleys. Unit SOP should dictate the number of volleys and which howitzers will fire WP and which will fire HC smoke, if applicable. The following is a list of immediate smoke mission characteristics.

- Delivery technique: Immediate smoke (point suppression). The immediate smoke technique can be used in an immediate suppression mission on a target of opportunity by unit SOP. A mix of WP and HC normally will follow the initial suppression rounds when immediate smoke is requested.
- Type of target: Point or small area of 150 meters or less.
- Number of howitzers: One platoon.
- Type of ammunition: First volley, WP and/or HC; subsequent volleys, HC; or all volleys M825 smoke.
- Sheaf: Parallel.
- Obscuration time: 30 seconds to 5 minutes.
- Command and control: By SOP and/or approval of maneuver commander.
- Computations (155 mm): FT 155-AM-2 for HC and WP data, FT 155-AM-2 and FT 155-ADD-T-0 or FT 155-AN-2 and FT 155-ADD-Q-0 for M825 data, and/or corresponding GFTs and GSTs.

13-19. Quick Smoke

a. Quick smoke missions are fired by using linear sheafs and TGPCs or special corrections. Depending on the atmospheric conditions and the type of smoke desired, the FDC may need to determine two sets of firing data--one set for the initial rounds and one set for the sustainment rounds. The initial rounds establish the smoke screen, and the sustainment rounds ensure the smoke screen is in place for the desired duration.

b. For the FDC to provide an effective smoke screen, the FDO needs to obtain additional information not normally provided for other missions. From the observer, the FDO needs the following:

The center grid of the desired smoke screen. The FDC will compute offset aimpoints on the basis of the type of munition, wind speed, and/or wind direction.

The length of the smoke screen.

The maneuver target (MT) direction. The direction from the point at which the maneuver element will be most susceptible to enemy observation to the target.

Wind direction in reference to the maneuver target line. The observer must let the FDC know if the wind is a head wind, tail wind, left crosswind, or right crosswind in relation to the maneuver target line.

The screen time (duration), in minutes.

NOTE: The acronym "LMDIRT" is used as a memory aid by the observer to report this information.

Length of smoke screen.

Maneuver-target line direction.

DIRection of wind.

Time (duration).

c. From the met station, the FDO will need to know the relative humidity for line 00 of the latest met message. This should be prearranged by unit SOP.

d. When the call for fire is received, the FDO will use a series of tables to determine the Pasquill weather category, mean wind speed, the number of rounds to fire to establish the smoke screen (initial rounds), and the number of rounds to fire to maintain the screen for the desired duration requested (sustainment rounds). If the number of aimpoints, rounds, or guns exceeds unit capabilities, the FDO will notify higher headquarters per unit SOP.

e. Once the number of rounds has been determined, the FDO will go through a series of computations to determine the number of meters between rounds (separation distance) and the necessary upwind offset corrections.

f. The HCO will plot the center grid of the smoke screen on the firing chart and will plot the upwind offset correction on the basis of the wind direction, the maneuver target direction, and the upwind offset correction. He will then plot the aimpoints and determine chart data to each aimpoint.

NOTE: It is necessary to determine individual piece data to each aimpoint. Proper manual computational procedures entail the use of the Ml 7 plotting board and the TGPC/Special Correction Worksheet. This must be prepared in advance. Different aimpoint values for the initial and sustainment volleys would normally require the computation of two sets of special corrections for each mission. An alternative method is to plot the aimpoints on the firing chart, and determine firing data for each howitzer on the basis of the base piece location. When converged sheaf TGPCs (recomputed for the appropriate sector and already relayed to each gun section) are applied, the solution approximates the previous method. Errors induced by this alternate method (that is, because of screen location at other than center of the TGPC sector) are offset by decreased computational time and complexity and the nature of the effects of smoke (large area covered per round). This latter method of computation will be used in this chapter.

g. The computer will determine and announce firing commands for each piece for the initial and sustainment volleys.

13-20. Quick Smoke Technique

The steps in Table 13-5 are used to determine firing data for the quick smoke technique.

Table 13-5. Quick Smoke Technique.

STEP	ACTION
1	A call for fire is received requesting quick smoke. If adjust fire is requested, the FDO will issue a partial fire order, and the adjust fire will proceed using standard procedures. If M825 is to be the FFE projectile, the adjust-fire phase of the mission can be conducted with HE or DPICM (in the self-registration mode). While the adjustment is being accomplished, the FDO would accomplish steps 2 through 9.
2	The FDO enters Table 13-6 on page 13-31 with the relative humidity furnished by the met station, the screen requirement determined from the call for fire (**if no screen requirement requested, use visible**), and the type of smoke desired. He extracts the table (Appendix I) that will be used to develop the fire order.
3	The FDO enters the decision tree in Figure 13-11 with the atmospheric conditions and wind speed (determined from the current ballistic met message and personal observation) and determines the Pasquill category.
4	The FDO enters the table determined in step 2 with the wind direction, Pasquill category determined in step 3, wind speed, screen length, and screen duration. The FDO will extract the number of initial aimpoints (R1) and sustainment aimpoints (R2) for the screen. In each box, the number left of the diagonal is R1, the number right of the diagonal is R2. In some tables, there is only an R1 factor. He will also determine the firing interval at the far right of the table (time between rounds).
	NOTE: For R1 and R2, 1 aimpoint = 1 round = 1 gun. If R1 or R2 exceeds the number of howitzers under the control of the FDC, reinforcing fires may be necessary. It is not practical for a unit FDC to assign aimpoints to additional howitzers of another unit. Higher headquarters may segment the screen. For example, a 500-meter screen may be segmented into two 250-meter screens.
5	To determine the **number of volleys to fire**, the FDO divides the number of minutes smoke is required by the firing interval from the appropriate smoke table.
6	To determine the **amount of ammunition required**, the FDO multiplies the number of volleys to fire minus one by the number of howitzers required to sustain the screen (R2). Then the FDO adds to this total the number of howitzers firing the first volley (R1).
7	The FDO issues the fire order (or an amendment, if adjust fire). The fire order should state that the FFE rounds will be fired by round at my command.

Table 13-5. Quick Smoke Technique (Continued).

<table>
<tr><th>STEP</th><th>ACTION</th></tr>
<tr><td>8</td><td>Determine the offset distance for initial volley:
<table>
<tr><th>Projectile</th><th>Crosswind</th><th>Head or Tail Wind</th></tr>
<tr><td>M825</td><td>110</td><td>55</td></tr>
<tr><td>HC (155/105)</td><td></td><td></td></tr>
<tr><td>$R1 \geq 4$</td><td>$\frac{\text{Screen Length}}{R1}$</td><td>120*WS</td></tr>
<tr><td>$R1 < 4$</td><td>$\frac{\text{Screen Length}}{R1*2}$</td><td>120*WS</td></tr>
<tr><td>WP (155/105)</td><td>30*WS</td><td>15*WS</td></tr>
</table></td></tr>
<tr><td></td><td>NOTE: WS = mean wind speed for Pasquill category. (See Table 13-7 on page 13-33.) This is an average wind speed in meters per second for the wind speed range listed for each Pasquill category. Enter the table with the Pasquill category and the wind speed in knots from line 00 of the current met message, and extract the mean WS (which is in meters per second).</td></tr>
<tr><td></td><td>NOTE: Mean WS is the average of the wind speed range in the center column. The average is converted from knots to meters per second.</td></tr>
<tr><td>9</td><td>Determine chart range to initial grid, and determine site.</td></tr>
<tr><td>10</td><td>Determine the offset distance for subsequent volley:
<table>
<tr><th>Projectile</th><th>Crosswind</th><th>Head or Tail Wind</th></tr>
<tr><td>M825</td><td>110</td><td>55</td></tr>
<tr><td>HC (155/105)</td><td></td><td></td></tr>
<tr><td>$R1 \geq 4$</td><td>$\frac{\text{Screen Length}}{R2}$</td><td>120*WS</td></tr>
<tr><td>$R1 < 4$</td><td>$\frac{\text{Screen Length}}{R2*2}$</td><td>120*WS</td></tr>
<tr><td>WP (155/105)</td><td>30*WS</td><td>15*WS</td></tr>
</table></td></tr>
<tr><td>11</td><td>The HCO determines the offset location for the initial volley.</td></tr>
<tr><td>11a</td><td>Place target grid over grid to center of the smoke screen. Orient to the north.</td></tr>
<tr><td>11b</td><td>Set off the wind direction (from line 00 of the current met message).</td></tr>
<tr><td>11c</td><td>Move pin in the direction of the arrow on the target grid the number of meters necessary to offset (from step 8 above).</td></tr>
<tr><td>11d</td><td>Relocate the target grid so that the center of the target grid is over the new offset location and oriented on the MT direction.</td></tr>
<tr><td>11e</td><td>If terrain is not relatively flat, site may be computed for each aimpoint.</td></tr>
<tr><td></td><td>NOTE: Steps 11a through 11d assume that the wind direction at the screen location is the same as measured at the met station. This may be the best available data, especially for a preplanned target. However, terrain conditions and other factors may preclude this. An alternate method is to orient the target grid along the MT line, offset the pin in the direction reported by the observer in the call for fire (that is, for a left cross, move the pin L110), and then reorient as in step 11d.</td></tr>
<tr><td>12</td><td>Determine the aimpoint separation.</td></tr>
<tr><td>12a</td><td>For M825, determine the aimpoint separation as follows:
CROSSWIND:
INITIAL AIMPOINT SEPARATION (SEP1) = $\frac{\text{SCREEN LENGTH + 110}}{R1}$
SUSTAINING AIMPOINT SEPARATION (SEP2) = $\frac{\text{SCREEN LENGTH + 110}}{R2}$
HEAD OR TAIL WIND:
INITIAL AIMPOINT SEPARATION (SEP1) = $\frac{\text{SCREEN LENGTH + 55}}{R1}$
SUSTAINING AIMPOINT SEPARATION (SEP2) = $\frac{\text{SCREEN LENGTH + 55}}{R2}$</td></tr>
</table>

Table 13-5. Quick Smoke Technique (Continued).

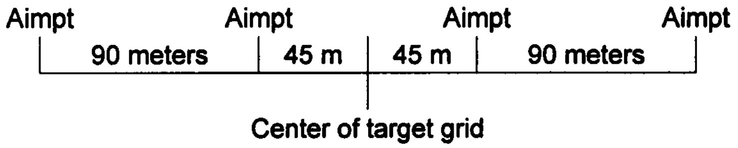
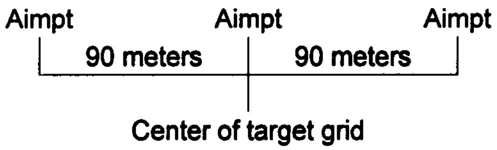
STEP	ACTION
12b	For HC (155/105), determine the aimpoint separation as follows: CROSSWIND or HEAD OR TAIL WIND: **INITIAL AIMPOINT SEPARATION (SEP1) =** $\frac{\text{SCREEN LENGTH}}{\text{R1}}$ **SUSTAINING AIMPOINT SEPARATION (SEP2) =** $\frac{\text{SCREEN LENGTH}}{\text{R2}}$
12c	For WP (155/105), determine the aimpoint separation as follows: CROSSWIND: **INITIAL AIMPOINT SEPARATION (SEP1) =** $\frac{\text{SCREEN LENGTH} + (30^{*}\text{WS})}{\text{R1}}$ **SUSTAINING AIMPOINT SEPARATION (SEP2) =** $\frac{\text{SCREEN LENGTH} + (30^{*}\text{WS})}{\text{R2}}$ HEAD OR TAIL WIND: **INITIAL AIMPOINT SEPARATION (SEP1) =** $\frac{\text{SCREEN LENGTH}}{\text{R1}}$ **SUSTAINING AIMPOINT SEPARATION (SEP2) =** $\frac{\text{SCREEN LENGTH}}{\text{R2}}$
	NOTE: For even number of initial aimpoints, go to step 13. For odd number of initial aimpoints, go to step 14.
13	Place pins at all initial aimpoint locations on the target grid (even number of aimpoints):
13a	Ensure that the target grid is oriented on the MT direction.
13b	Place all aimpoints along the heavy line running through the center of the target grid and perpendicular to the arrow.
13c	Place pins on either side of the center of the target grid by an amount equal to SEP1 divided by two. For example when SEP1 equals 90, place one pin left 45 meters and one pin right 45 meters.
13d	Place all other pins at a distance of SEP1 from these pins.
	EXAMPLE SEP1 = 90 and Aimpoints = 4 
13e	Go to step 15.
14	Place pins at all initial aimpoint locations on the target grid (odd number of aimpoints).
14a	Ensure that the target grid is oriented on the MT direction.
14b	All aimpoints will be placed along the heavy line running through the center of the target grid and perpendicular to the arrow.
14c	Leave one pin in the center of the target grid. Place all other pins on either side of the center of the target grid by an amount equal to SEP1.
	EXAMPLE SEP1 = 90 and Aimpoints = 3 

Table 13-5. Quick Smoke Technique (Continued).

STEP	ACTION
14d	Go to step 15.
	NOTE: Using an offset correction of 110 or 55 meters for M825 and applying an identical figure to the screen length to determine aimpoints appears arbitrary and repetitious. However, these are mean values of actual calculated figures, used to make computations manageable. The values derived from the tables reflect the use of those figures.
15	Determine chart range and chart deflection to each aimpoint (pin) location.
	NOTE: For WP, go to step 16. For HC, go to step 17. For M825, go to step 18.
16	Determine WP firing data to each aimpoint. Determine data with the HE GFT, remembering to add a range correction to the chart range to account for the difference in square weight between the WP round and the standard square weight. Go to step 19.
17	Determine HC firing data to each aimpoint. Determine data with the HE GFT, remembering to subtract 2.0 seconds from the HE fuze setting. Subtracting 2.0 seconds provides the desired height of fuze functioning (approximately 100 meters) to properly deploy the smoke canisters. Go to step 19.
18	Determine M825 firing data to each aimpoint.
	NOTE: To correct for inaccuracy in the ballistic solutions using any of the following methods, an HOB correction is applied to the fuze setting and QE determined. Using the appropriate addendum and table, enter with the appropriate graze burst QE and fuze setting. Extract the correction factors for a change in HOB for 50 meters. For ranges less than 10,000 meters, apply a +50-meter HOB correction to fuze setting and QE. For ranges greater than 10,000 meters, apply a 100-meter HOB correction to fuze setting and QE.
18a	**M825 GFT METHOD.** Determine HE graze burst time and quadrant with the 155-AM-2 GFT or TFT. Apply the appropriate HE site. If you have an HE GFT dated May 87 or later, place the MHL over the HE time and read up to the M825 FS M577 scale to determine the M825 time. Record this time on the left side of the MF, Sh, Chg, Fz column. Enter the FT 155-ADD-T-0 with the M582 fuze setting. Extract the correction factor for change in fuze setting for an increase of 50 meters in height (Table B, Column 3). If the range to the target is less than 10,000 meters, record this value on the right side of the MF, Sh, Chg, Fz column. If the range is greater than 10,000 meters, multiply the value by two and record the result to the nearest 0.1 on the right side of the MF, Sh, Chg, Fz column. Add the correction to the fuze setting determined to the M825 fuze setting extracted from the GFT; this is the M825 time to fire. Then place the MHL over the HE QE, and read up to the M825 QE and DEFL CORR scales. Read the drift (DEFL CORR), apply it to the GFT deflection correction, and apply the sum to the chart deflection. This is the M825 deflection to fire. Then read the M825 QE. Record this value in the HOB Corr column. Enter the TFT with the HE QE expressed to the nearest 5 mils. Extract the correction to QE for an increase of 50 meters in height (Table A, Column 3). If the range to the target is less than 10,000 meters, express this value to the nearest mil and record it in the Si column. If the range is greater than 10,000 meters, multiply the value from Table A, Column 3 by two, express the result to the nearest mil, and record the expressed result in the Si column. Add the correction to QE in the Si column to the M825 QE extracted from the GFT. This result is the M825 QE to fire.
18b	**M825 ADD-T-0 METHOD.** If you do not have M825 scales on your HE GFT, you may use addendum FT 155-ADD-T-0. Determine HE graze burst time and quadrant with the 155-AM-2 GFT or TFT. Apply the appropriate HE site. Enter Table A at the appropriate charge and with the HE QE expressed to the nearest 5 mils. Extract the correction to QE for projectile M825 (Column 2), and record this value in the HOB Corr column. Extract the correction to QE for an increase of 50 meters in height (Table A, Column 3). If the range to the target is less than 10,000 meters, express this value to the nearest mil and record it in the Si column. If the range is greater than 10,000 meters, multiply the value by two, express the result to the nearest mil, and record the expressed result in the Si column. Add the correction to QE recorded in the HOB Corr column and the HOB correction recorded in the Si column together, and apply the result to the HE QE. This is the M825 QE to fire. Also, extract the correction to deflection for projectile M825 (Column 8). This is a correction to the HE drift. It is usually minor and may be ignored. If used, apply it to the computed HE deflection and express it to the nearest whole mil. This is the M825 deflection to fire. Enter Table B with the HE fuze setting. Extract the correction to FS for projectile M825 (Column 2), and record this value on the left side of the MF, Sh, Chg, Fz column. Extract the correction factor for change in fuze setting for an increase of 50 meters in height (Column 3). If the range to the target is less than 10,000 meters, record this value on the right side of the MF, Sh, Chg, Fz column. If the range is greater than 10,000 meters, multiply the value by two and record the result to the nearest 0.1on the right side of the MF, Sh, Chg, Fz column. Add the correction to fuze setting and the HOB correction together, and apply the result to the HE fuze setting. This is the M825 FS to fire.

Table 13-5. Quick Smoke Technique (Continued).

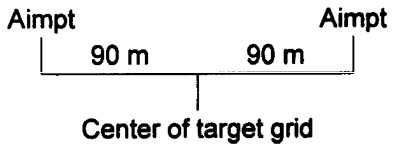
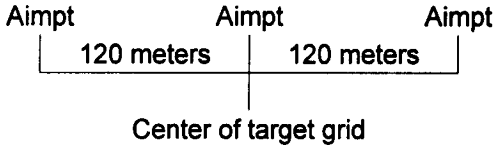
STEP	ACTION
18c	**M825 ADD-Q-0 METHOD.** (If firing M825, use FT 155-ADD-Q-0 [Rev]. If firing M825A1, use FT 155-ADD-Q-0, Change 2 [Rev].) An alternative method to determine M825 firing data is to use DPICM/SR data and addendum 155-ADD-Q-0 (see Chapter 13, Section IV). Determine DP/SR graze burst time and quadrant with the 155-AN-2 GFT or TFT. Apply appropriate DPICM site. Enter Table A at the appropriate charge and with the DP/SR QE expressed to the nearest 5 mils. Extract the correction to QE for projectile M825 (Column 2), and record this value in the HOB Corr column. Extract the correction to QE for an increase of 50 meters in height (Table A, Column 3). If the range to the target is less than 10,000 meters, express this value to the nearest mil and record it in the Si column. If the range is greater than 10,000 meters, multiply the value by two, express the result to the nearest mil, and record the expressed result in the Si column. Add the correction to QE recorded in the HOB Corr column and the HOB correction recorded in the Si column together, and apply the result to the DP/SR QE. This is the M825 QE to fire. Also, extract the correction to deflection for projectile M825 (Column 8). This is a correction to the DP/SR drift. It is usually minor, and may be ignored. If used, apply it to the computed DP/SR deflection and express it to the nearest whole mil. This is the M825 deflection to fire. Enter Table B with the DP/SR fuze setting. Extract the correction to fuze setting for projectile M825 (Column 2), and record this value on the left side of the MF, Sh, Chg, Fz column. Extract the correction factor for change in fuze setting for an increase of 50 meters in height (Column 3). If the range to the target is less than 10,000 meters, record this value on the right side of the MF, Sh, Chg, Fz column. If the range is greater than 10,000 meters, multiply the value by two and record the result to the nearest 0.1 on the right side of the MF, Sh, Chg, Fz column. Add the correction to fuze setting and the HOB correction together, and apply the result to the DP/SR FS. This is the M825 FS to fire.
	NOTE: For even number of sustaining aimpoints, go to step 19. For odd number of sustaining aimpoints, go to step 20.
19	Place pins at all sustaining aimpoint locations on the target grid (even number of aimpoints).
19a	Set off MT direction on target grid.
19b	All aimpoints will be placed along the heavy line running through the center of the target grid and perpendicular to the arrow.
19c	Place pins on either side of the center of the target grid by an amount equal to SEP2 divided by two. For example when SEP2 equals 180, place one pin to the left 90 meters and one pin to the right 90 meters.
19d	Place all other pins at a distance of SEP2 from these pins.
	EXAMPLE SEP2 = 180 and Aimpoints =2 
19e	Go to step 21.
20	Place pins at all sustaining aimpoint locations on the target grid (odd number of aimpoints).
20a	Ensure that target grid is set on MT direction.
20b	All aimpoints will be placed along the heavy line running through the center of the target grid and perpendicular to the arrow.

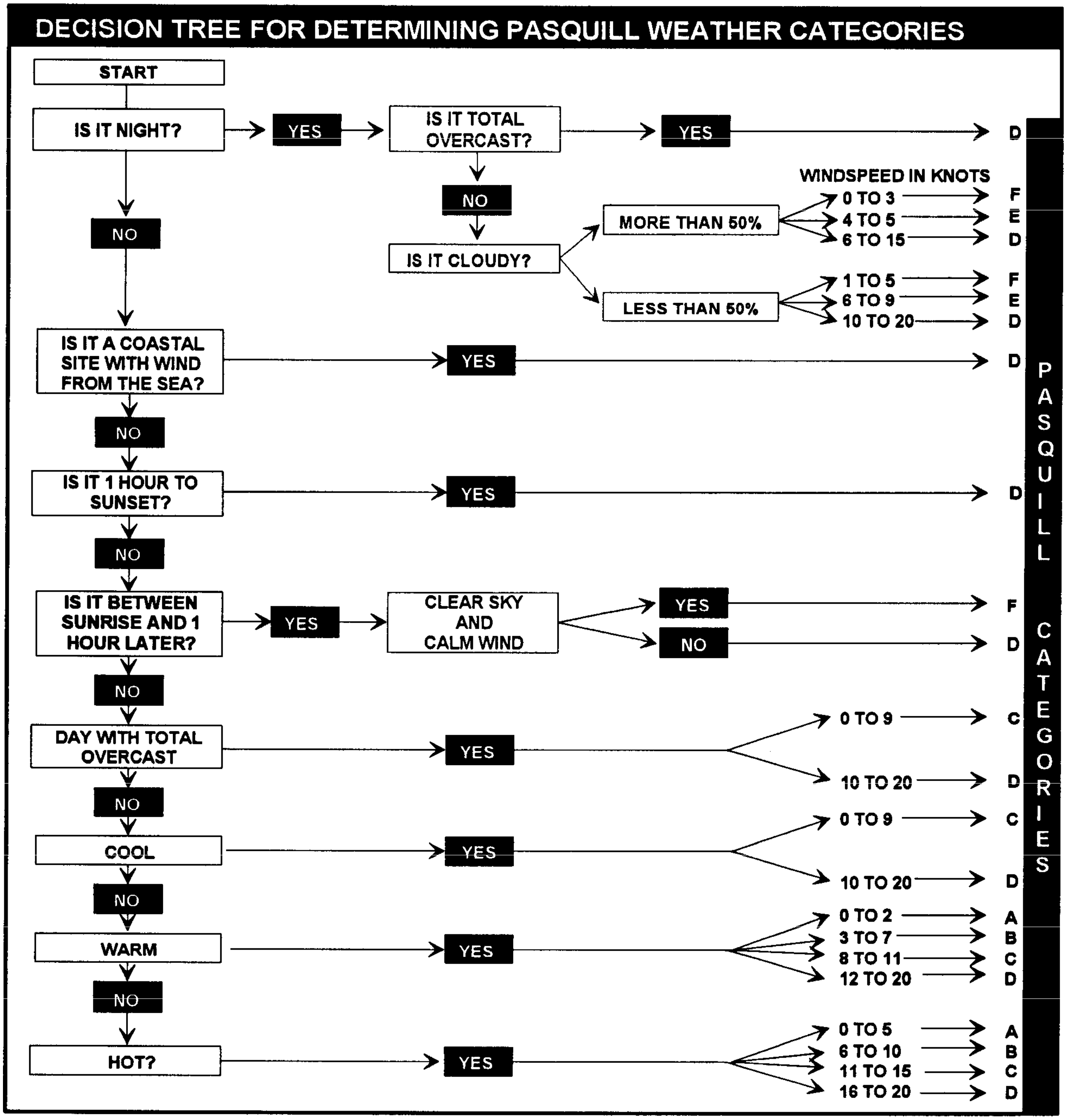
Table 13-5. Quick Smoke Technique (Continued).

STEP	ACTION
20c	Leave one pin in the center of the target grid. Place all other pins on either side of the center of the target grid by an amount equal to SEP2.
	EXAMPLE SEP 2 = 120 and Aimpoints = 3 
20d	Go to step 21.
21	Determine chart range and chart deflection to each aimpoint (pin) location.
22	Determine firing data as previously described in steps 16 through 18.

> **NOTE:** A study of the RI and R2 factors for HC and WP under poor conditions for smoke (calm, clear, warm, daylight) reveals an excessive number of aimpoints for a given screen width. The use of M825 or other means of screening should be considered in those instances.

Table 13-6. Determine Smoke Table.

Screen Requirement	Relative Humidity (Percent)	Tables				
		M825	HC (M116)	WP (M110)	HC (M84)	WP (M60)
Infrared	80	I-1	I-7	I-16	NA	NA
Infrared	50	I-2	I-8	I-17	NA	NA
Infrared	20	I-3	I-9	I-18	NA	NA
Visible	80	I-4	I-10	I-19	I-13	I-22
Visible	50	I-5	I-11	I-20	I-14	I-23
Visible	20	I-6	I-12	I-21	I-15	I-24



Select weather type from:

	COOL	WARM	HOT
Fahrenheit	<50 F	50< F <75	>75 F
Celsius	<10 C	10< C <24	>24 C
Kelvin (MET;CM)	<283.2 K	283.2< K <297.2	>297.2 K
% Std (METB3)	<98.3 %	98.3< % <103.1	>103.1 %

Figure 13-11. Decision Tree for Determining the Pasquill Weather Categories.

Table 13-7. Mean WS.

Pasquill Category	Wind Speed Range (Knots) (Enter With Line 00 of Met)	Mean WS (Meters/Sec)
A	2-5	2
B	3-6 6-10	2 4
C	0-8 9-10 11-15	2 5 7
D	6-10 11-15 16	4 6 8
E	4-5 6-9	2 4
F	1-3 4-5	1 2

NOTE: Mean WS is the average of the windspeed range in the center column. The average is converted from knots to meters per second.

13-21. Smoke Munitions Expenditure Tables and Equations

Smoke munitions (M825, M116, and M110) are used to establish and maintain smoke screens. The following tables and equations can help you determine data when firing M825, M116, or M110 smoke munitions. (See Tables 13-8 through 13-10.)

Table 13-8. Shell Separation and Upwind Offset for M825 Munitions.

Definitions:

R1 = Initial Rounds

R2 = Sustaining Rounds

UW1 = Initial Upwind Adjustment

UW2 = Sustaining Upwind Adjustment

SEP1 = Initial Volley Shell Separation

SEP2 = Sustaining Volley Shell Separation

SL = Screen Length (Meters)

WS = Wind Speed in Meters/Sec

Crosswind Cases:

UW = 110 meters

SEP1 = (SL + 110) ÷ R1

SEP2 = (SL + 110) ÷ R2

Head Wind and/or Tail Wind Cases:

UW = 55 meters

SEP1 = (SL + 55) ÷ R1

SEP2 = (SL + 55) ÷ R2

Table 13-9. Shell Separation and Upwind Offset for HC Munitions.

Definitions:

R1 = Initial Rounds
R2 = Sustaining Rounds
UW1 = Initial Upwind Adjustment
UW2 = Sustaining Upwind Adjustment
SEP1 = Initial Volley Shell Separation
SEP2 = Sustaining Volley Shell Separation
SL = Screen Length (Meters)
WS = Wind Speed in Meters/Sec

Crosswind Cases:

For R1 or R2 ≥4 Rounds:

UW1 = SL ÷ R1
SEP1 = SL ÷ R1
UW2 = SL ÷ R2
SEP2 = SL ÷ R2

For R1 or R2 <4 Rounds:

UW1 = SL ÷ R1*2
SEP1 = SL ÷ R1
UW2 = SL ÷ R2*2
SEP2 = SL ÷ R2

Head Winds and/or Tail Wind Cases:

UW1 = 120 * WS
SEP1 = SL ÷ R1
UW2 = 120 * WS
SEP2 = SL ÷ R2

Table 13-10. Shell Separation and Upwind Offset for WP Munitions.

Definitions:

R1 = Initial Rounds
R2 = Sustaining Rounds
UW1 = Initial Upwind Adjustment
UW2 = Sustaining Upwind Adjustment
SEP1 = Initial Shell Separations
SEP2 = Sustaining Shell Separations
SL = Screen Length (Meters)
WS = Wind Speed in Meters/Sec

Crosswind Cases:

UW1 = 30 * WS
SEP1 = (SL + UW) ÷ R1
UW2 = 30 * WS
SEP2 = (SL + UW) ÷ R2

Head Wind and/or Tail Wind Cases:

UW1 = 15 * WS
SEP1 = SL ÷ R1
UW2 = 15 * WS
SEP2 = SL ÷ R1

13-22. M825 Smoke Procedures

The steps in Table 13-11 are used to determine firing data for shell M825.

Table 13-11. M825 Smoke Technique.

STEP	ACTION
1	Observer transmits a call for fire after target description. Use the acronym "LMDIRT" as a memory aid. Length of smoke screen. **M**aneuver target line direction. **DIR**ection of wind: Head: Blowing from target along the maneuver target line (MTL). Tail: Blowing toward the target along the MTL. Right Cross: Blowing from the right in relation to the MTL. Left Cross: Blowing from the left in relation to the MTL. Time smoke is required (duration).
2	Request relative humidity for line 00 be transmitted with the met message.
3	Determine the appropriate smoke table to use.
4	Determine the Pasquill category.
5	Enter the smoke table determined from step 3 with the following: ● Direction of wind. ● Pasquill category. ● Wind speed. ● Screen width. ● Screen time. Determine the following: ● **R1 = NUMBER OF AIMPOINTS AND ROUNDS TO FIRE IN INITIAL VOLLEY (1 AIMPOINT = 1 ROUND).** ● **R2 = NUMBER OF AIMPOINTS AND ROUNDS TO FIRE FOR EACH SUSTAINING VOLLEY (1 AIMPOINT = 1 ROUND).** ● The firing interval.
6	Determine the number of volleys to fire and ammunition required. ● **DURATION ÷ FIRING INTERVAL = NUMBER OF VOLLEYS** ● **R2 (NUMBER OF VOLLEYS - 1) + R1 = AMOUNT OF AMMUNITION REQUIRED**
7	Issue the fire order.
8	Adjust with HE, DPICM, or M825 to center of desired screen if necessary.
9	Offset the FFE aimpoint into the wind in relation to the MTL by using the following: ● **CROSSWIND = 110 METERS.** ● **TAIL WIND AND/OR HEAD WIND = 55 METERS.**
10	Determine aimpoint separation as follows: ● **SEP1 = INITIAL VOLLEY SHELL SEPARATION** ● **SEP2 = SUSTAINING VOLLEY SHELL SEPARATION** ● **SL = SCREEN LENGTH (METERS)**
10a	Crosswind cases are as follows: ● **SEP1 = (SL + 110) ÷ R1** ● **SEP2 = (SL + 110) ÷ R2**

Table 13-11. M825 Smoke Technique (Continued).

STEP	ACTION
10b	Head wind and/or tail wind cases are as follows: ● **SEP1 = (SL + 55) ÷ R1** ● **SEP2 = (SL + 55) ÷ R2**
11	Plot aimpoints with the M17 plotting board or target grid.
11a	If using the **target grid**, determine chart data to each aimpoint. Use converged sheaf TGPCs.
11b	If using the **M17 plotting board**, determine chart data to aimpoint grid and apply special corrections.
12	Determine the graze burst data by using FT 155-AM-2 or FT 155-AN-2.
13	Firing data are determined by applying the appropriate ballistic corrections to graze burst data for shell M825. Use FT 155-AM-2 and FT 155-ADD-T-0 or FT 155-AN-2 and FT 155-ADD-Q-0.
14	Determine and apply appropriate HOB correction.

13-23. M825 Examples

The following data are used in the examples shown in Figures 13-12 through 13-14.

Known Data:

- Unit: 1/A, four-gun platoon
- Azimuth of fire: 4800
- Altitude: 1062

Conditions:

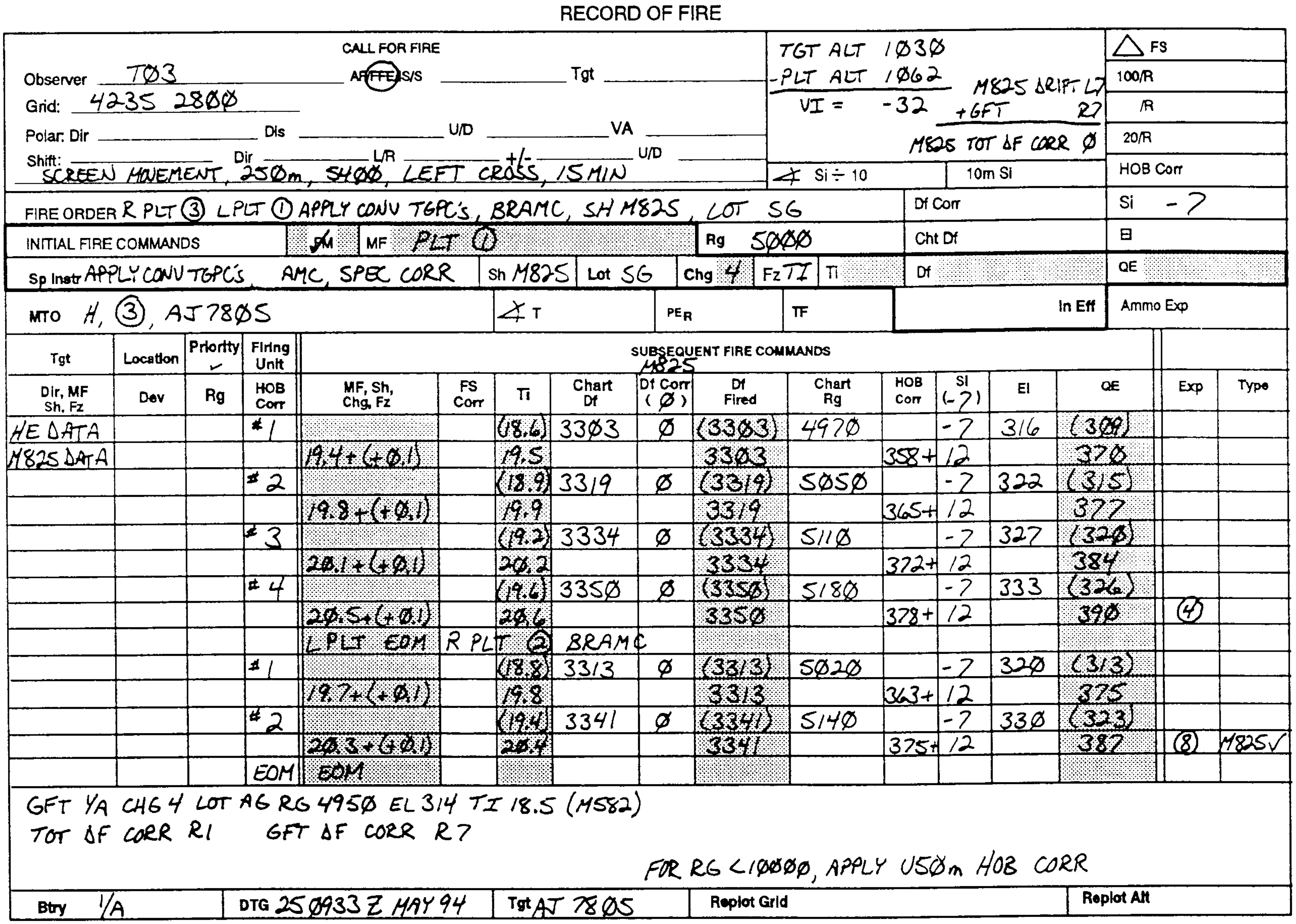
- Completely overcast afternoon
- Wind speed: 10 knots
- Humidity: 50 percent
- Wind direction: 3900 (left crosswind)
- Met line number: 00
- Assumed screening: Normal visibility
- Screen length: 250 meters
- Duration: 15 minutes

Tactical Solution:

- Pasquill category: D
- Table: I-5
- R1:4
- R2:2
- Firing interval: 5 min
- Number of volleys: 15 5 = 3

Aimpoint Separation:

- SEP1: 90 meters
- SEP2: 180 meters
- Offset aimpoint: 110 meters



RECORD OF FIRE

CALL FOR FIRE

Observer T03 AF [✓ FFE] I/S Tgt

Grid: 4235 2800

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

SCREEN MOVEMENT, 250m, 5400, LEFT CROSS, 15 MIN

TGT ALT 1030
-PLT ALT 1062
VI = -32

M825 DRIFT L7
+GFT 27

M825 TOT ΔF CORR 0

∡ Si ÷ 10

10m Si

△ FS

100/R

/R

20/R

HOB Corr

Si -7

⊟

QE

Ammo Exp

FIRE ORDER R PLT ③ L PLT ① APPLY CONV TGPC's, BRAMC, SH M825, LOT SG

Df Corr

INITIAL FIRE COMMANDS ✓FM MF PLT ①

Rg 5000

Cht Df

Sp Instr APPLY CONV TGPC's, AMC, SPEC CORR

Sh M825

Lot SG

Chg 4

Fz TI

Ti

Df

MTO H, ③, AJ7805

∡ T

PE R

TF

In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS M825												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (0)	Df Fired	Chart Rg	HOB Corr	Si (-7)	El	QE	Exp	Type
HE DATA			#1			(18.6)	3303	0	(3303)	4970		-7	316	(309)		
M825 DATA				19.4+(+0.1)		19.5			3303		358+	12		370		
			#2			(18.9)	3319	0	(3319)	5050		-7	322	(315)		
				19.8+(+0.1)		19.9			3319		365+	12		377		
			#3			(19.2)	3334	0	(3334)	5110		-7	327	(320)		
				20.1+(+0.1)		20.2			3334		372+	12		384		
			#4			(19.6)	3350	0	(3350)	5180		-7	333	(326)		
				20.5+(+0.1)		20.6			3350		378+	12		390	④	
				L PLT EOM	R PLT	②	BRAMC									
			#1			(18.8)	3313	0	(3313)	5020		-7	320	(313)		
				19.7+(+0.1)		19.8			3313		363+	12		375		
			#2			(19.4)	3341	0	(3341)	5140		-7	330	(323)		
				20.3+(+0.1)		20.4			3341		375+	12		387	⑧	M825✓
			EOM	EOM												

GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5 (M582)
TOT ΔF CORR R1 GFT ΔF CORR R7

FOR RG <10000, APPLY U50m HOB CORR

Btry 1/A

DTG 250933Z MAY 94

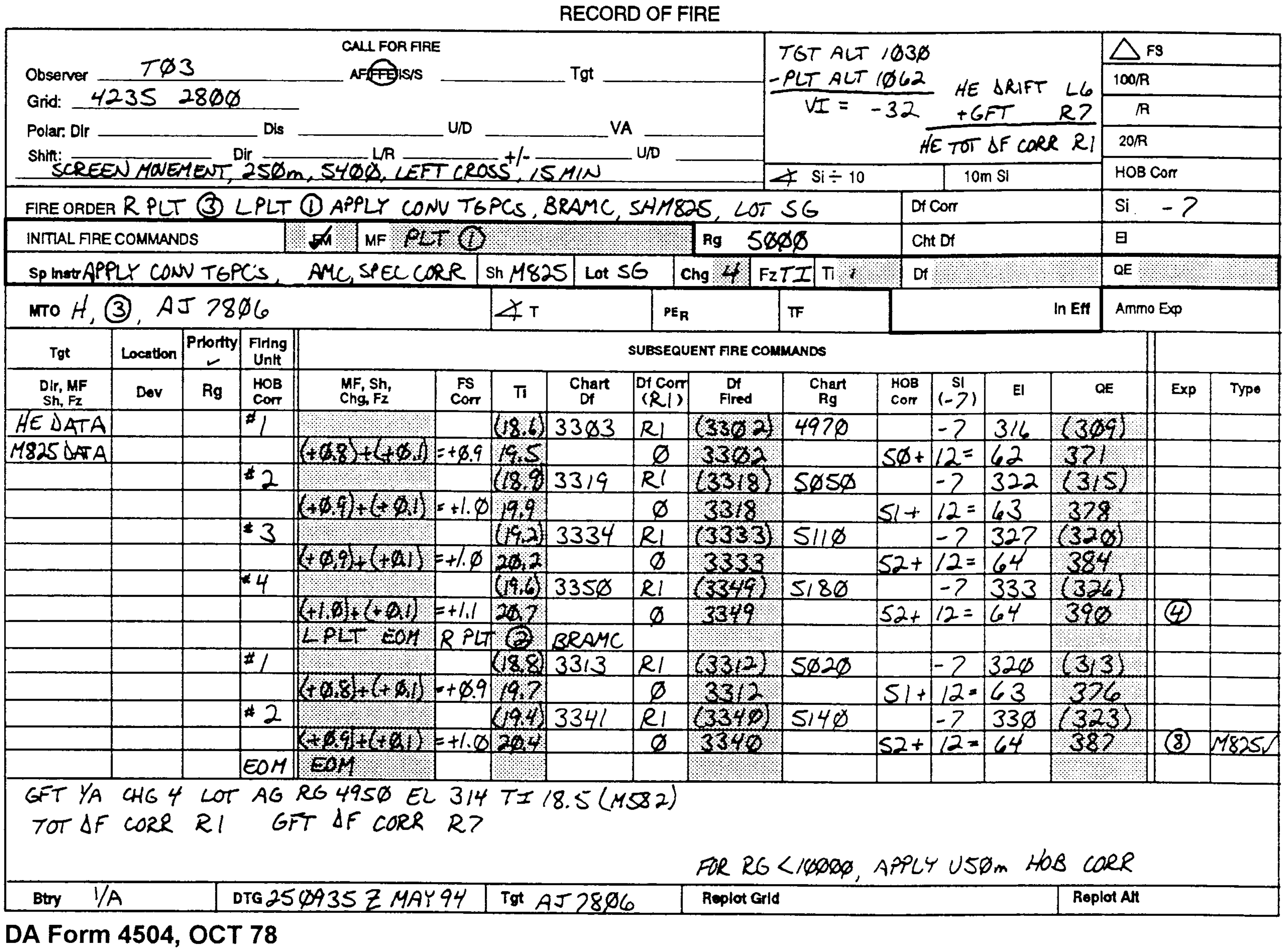
Tgt AJ7805

Replot Grid

Replot Alt

DA Form 4504, OCT 78

Figure 13-12. Completed ROF for Shell M825, Using a 155-AM-2 GFT With Supplementary M825 Scales.



RECORD OF FIRE

CALL FOR FIRE

Observer T03 [✓ AF] FFE IS/S Tgt

Grid: 4235 2800

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

SCREEN MOVEMENT, 250m, 5400, LEFT CROSS, 15 MIN

TGT ALT 1030
-PLT ALT 1062
VI = -32

HE DRIFT L6
+GFT R7
HE TOT ΔF CORR R1

∠ Si ÷ 10

10m Si

△ FS

100/R

/R

20/R

HOB Corr

FIRE ORDER R PLT ③ LPLT ① APPLY CONV T6PCs, BRAMC, SH M825, LOT SG

Df Corr

Si -7

INITIAL FIRE COMMANDS ☑ FM MF PLT ① Rg 5000

Cht Df

El

Sp Instr APPLY CONV T6PCs, AMC, SPEC CORR Sh M825 Lot SG Chg 4 Fz TI Ti

Df

QE

MTO H, ③, AJ 7806

∠ T

PE R

TF

In Eff

Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (R1)	Df Fired	Chart Rg	HOB Corr	Si (-7)	El	QE	Exp	Type
HE DATA			#1			(18.6)	3303	R1	(3302)	4970		-7	316	(309)		
M825 DATA				(+0.8)+(+0.1)	=+0.9	19.5		0	3302		50+	12=	62	371		
			#2			(18.9)	3319	R1	(3318)	5050		-7	322	(315)		
				(+0.9)+(+0.1)	=+1.0	19.9		0	3318		51+	12=	63	378		
			#3			(19.2)	3334	R1	(3333)	5110		-7	327	(320)		
				(+0.9)+(+0.1)	=+1.0	20.2		0	3333		52+	12=	64	384		
			#4			(19.6)	3350	R1	(3349)	5180		-7	333	(326)		
				(+1.0)+(+0.1)	=+1.1	20.7		0	3349		52+	12=	64	390	④	
				LPLT EOM	R PLT	②	BRAMC									
			#1			(18.8)	3313	R1	(3312)	5020		-7	320	(313)		
				(+0.8)+(+0.1)	=+0.9	19.7		0	3312		51+	12=	63	376		
			#2			(19.4)	3341	R1	(3340)	5140		-7	330	(323)		
				(+0.9)+(+0.1)	=+1.0	20.4		0	3340		52+	12=	64	387	⑧	M825✓
			EOM	EOM												

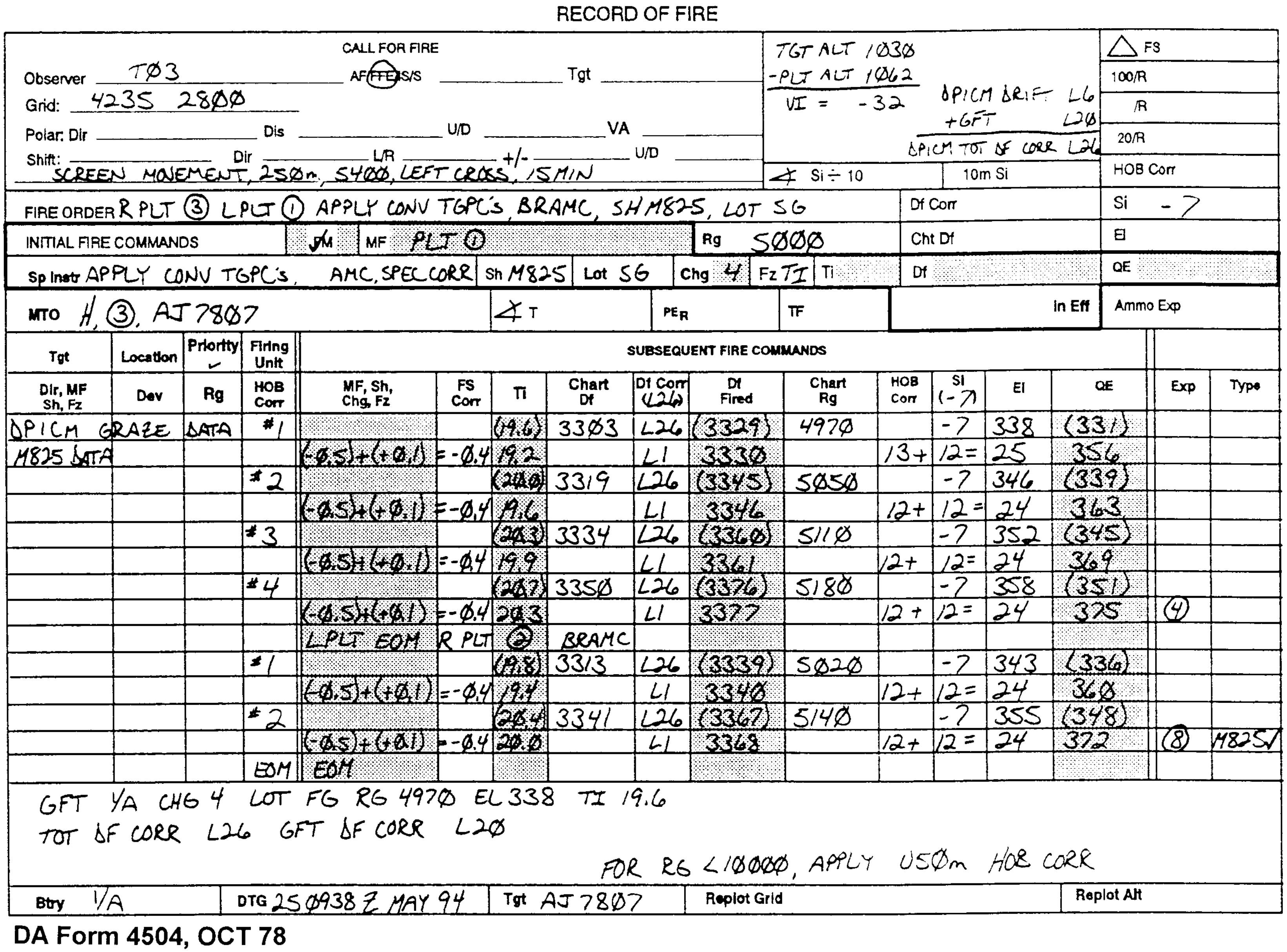
GFT Y/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5 (M582)
TOT ΔF CORR R1 GFT ΔF CORR R7

FOR RG < 10000, APPLY U50m HOB CORR

Btry 1/A DTG 250935 Z MAY 94 Tgt AJ 7806 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 13-13. Completed ROF for Shell M825, Using a 155-AM-2 GFT With Addendum T-0.



RECORD OF FIRE

CALL FOR FIRE

Observer T03 AF [✓ FFE] S/S Tgt

Grid: 4235 2800

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

SCREEN MOVEMENT, 250m, 5400, LEFT CROSS, 15MIN

TGT ALT 1030

-PLT ALT 1062

VI = -32

δPICM δRIFT L6

+GFT L20

δPICM TOT δF CORR L26

∡ Si ÷ 10

10m Si

△ FS

100/R

/R

20/R

HOB Corr

FIRE ORDER R PLT ③ L PLT ① APPLY CONV TGPC's, BRAMC, SH M825, LOT SG

INITIAL FIRE COMMANDS FM MF PLT ① Rg 5000

Sp Instr APPLY CONV TGPC's, AMC, SPEC CORR Sh M825 Lot SG Chg 4 Fz TI Ti

MTO H, ③, AJ7807 ∡ T PE_R TF In Eff

Df Corr

Cht Df

Df

Si -7

El

QE

Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS													
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L26)	Df Fired	Chart Rg	HOB Corr	Si (-7)	El	QE		Exp	Type
δPICM GRAZE		DATA	#1			(19.6)	3303	L26	(3329)	4970		-7	338	(331)			
M825 DATA				(-0.5)+(+0.1)	= -0.4	19.2		L1	3330		13+	12=	25	356			
			#2			(20.0)	3319	L26	(3345)	5050		-7	346	(339)			
				(-0.5)+(+0.1)	= -0.4	19.6		L1	3346		12+	12=	24	363			
			#3			(20.3)	3334	L26	(3360)	5110		-7	352	(345)			
				(-0.5)+(+0.1)	= -0.4	19.9		L1	3361		12+	12=	24	369			
			#4			(20.7)	3350	L26	(3376)	5180		-7	358	(351)			
				(-0.5)+(+0.1)	= -0.4	20.3		L1	3377		12+	12=	24	375		④	
				LPLT EOM	R PLT	②	BRAMC										
			#1			(19.8)	3313	L26	(3339)	5020		-7	343	(336)			
				(-0.5)+(+0.1)	= -0.4	19.4		L1	3340		12+	12=	24	360			
			#2			(20.4)	3341	L26	(3367)	5140		-7	355	(348)			
				(-0.5)+(+0.1)	= -0.4	20.0		L1	3368		12+	12=	24	372		⑧	M825✓
			EOM	EOM													

GFT 1/A CHG 4 LOT FG RG 4970 EL 338 TI 19.6

TOT δF CORR L26 GFT δF CORR L20

FOR RG < 10000, APPLY U50m HOB CORR

Btry 1/A DTG 250938 Z MAY 94 Tgt AJ7807 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 13-14. Completed ROF for Shell M825, Using a 155-AN-1 GFT With Addendum Q-0.

Section IV

Dual-Purpose Improved Conventional Munitions

Dual-purpose improved conventional munitions are base-ejection (155 mm only), payload-carrying projectiles. These projectiles are fired with M577 MT fuzes and are filled with 88 dual-purpose grenades. During flight, the base of the projectile is blown off and centrlfugal force disperses the grenades radially from the projectile line of flight.

13-24. Overview

The 155-mm DPICM projectile contains two types of dual-purpose grenades (64 M42 and 24 M46). Both types are capable of penetrating more than 2.5 inches of rolled homogeneous armor. They are also capable of fragmentation for incapacitating personnel. The M577 MT fuze is preset to function over the target area and initiate the expulsion charge. The expulsion charge pushes the grenades out of the container and onto the target area. The projectile can be modified for the SR mode. The SR mode causes the round to point detonate so as to be visible to the observer and destroy the submunitions. It also may produce an airburst for high-burst registrations.

13-25. Determining DPICM Firing Data

a. There are three ways to determine DPICM firing data. The preferred method is to use the 155-AM-2 GFT with the DPICM scales and a GFT setting. The second way is to use either the 155-AM-2 GFT without a GFT setting or the FT 155-AM-2 and the addendum for DPICM (ADD-R-l). The third way is to use the FT 155-AN-2 and the addendum for DPICM (ADD-J-l). Because the DPICM scales on the 155-AM-2 GFT are based on HE data, HE data from the base (graze burst) scale must be determined before DPICM data can be determined.

(1) To determine the DPICM fuze setting, you must first determine the HE fuze setting. Once the HE fuze setting has been determined, move the MHL over the HE fuze setting on the base scale and read up to the DPICM fuze scale. This is the DPICM fuze setting. Since DPICM is fired with the M577 fuze, the HE fuze setting must be determined from the M582 scale.

(2) To determine the DPICM deflection to fire, you must first have the chart deflection from the HCO. There are three different ways to determine the deflection to fire on the basis of the type of mission being fired.

(a) If DPICM is the only shell fired during the mission, to include the adjustment and fire for effect phases, or if a straight FFE mission was conducted, the drift is taken from the DPICM scale instead of the HE base scale. The MHL is placed over the HE QE on the base HE EL scale. Read up to determine the proper value for drift on the DPICM scale. This drift will be used throughout the remainder of the mission.

(b) If HE is used in the adjust-fire phase and DPICM is used to fire for effect, then as soon as the type of shell is changed (HE to DPICM) a new value for drift must be determined from the DPICM drift scale. This drift will be determined by placing the MHL over the HE QE on the base scale and then reading up to the DPICM drift scale. Compare this DPICM drift to the HE drift to determine the change in drift **(DPICM DRIFT - HE DRIFT= CHANGE IN DRIFT).** This change in drift is applied to the HE deflection fired (not to be

confused with the chart deflection) to determine the DPICM deflection. Another method is to use **DPICM DRIFT+ GFT DF CORR + CHART DF = DPICM DF TO FIRE.**

(c) The last method is to use the appropriate addendum. As soon as the projectile changes, go to the addendum and extract the drift correction from Table A, Column 8. Take this new drift correction, express it to the nearest mil, and add it to the HE deflection fired so that anew DPICM deflection can be determined for this mission.

(3) To determine the DPICM QE, first determine the HE QE. Place the MHL over the HE QE on the base HE EL scale. Now read up to the DPICM QE scale, and determine the QE to fire.

(4) To determine HOB corrections for DPICM, we must use the ADD-R-1. Table A is used to determine the correction factor that will be applied to the QE. Table B is used to determine the correction factor that will be applied to the fuze setting. Remember, the HE data are used to enter the tables, but the correction factors extracted are applied to the DPICM data.

b. To determine firing data without a GFT setting for DPICM, use the 155-AM-2 GFT or the FT 155-AM-2 and the ADD-R-1. This procedure is valid for low-angle fire only.

(1) Using the proper charge and range, begin by determining HE data from the FT 155-AM-2, Table F. Elevation is extracted from Column 2, the fuze setting is extracted from Column 7 (M582), and the drift that will be added to the chart deflection is in Column 8. Site is computed in the normal way and then algebraically added to the elevation.

(2) Once the base HE data have been determined, the ballistic corrections to compensate for the DPICM projectile need to be extracted from the ADD-R-1. Table A of the appropriate charge will yield corrections for QE and deflection. Table A is entered with the HE QE expressed to the nearest listed value. Column 2 will yield the correction factor that must be added to the HE QE to determine the DPICM QE. Column 8 has the deflection correction that must be applied to the HE deflection (chart deflection plus drift) before firing. Table B contains the correction factor that will be applied to the HE fuze setting. Enter Table B with the HE fuze setting, and extract the fuze correction. Apply this correction to the HE fuze setting to determine the DPICM fuze setting.

(3) The HOB of the DPICM projectile is dependent on the charge fired. If the observer transmits a request for an HOB correction, the ADD-R-1 will be used to determine the correction factors that must be applied to the DPICM fuze setting and QE. Table A, Column 3, of the appropriate charge will yield the correction factor for a 50-meter change in HOB. Multiply the correction factor by the number of 50-meter increments needed. Express the answer to the nearest mil. Apply the HOB correction to the DPICM QE. If it was an up correction, add the HOB correction to the DPICM QE; if it was a down correction, subtract the HOB correction from the DPICM QE. Table B, Column 3, of the appropriate charge will yield the FS correction for a 50-meter change in HOB. Multiply the correction factor by the number of 50-meter increments needed. Express the answer to the nearest FS increment. Apply the HOB correction to the DPICM fuze setting. If it was an up correction, add the HOB correction to the DPICM fuze setting; if it was a down correction, subtract the HOB correction from the DPICM fuze setting.

c. To determine firing data without a GFT setting for DPICM, use the FT 155-AN-2 and the ADD-J-1. This procedure is valid for low-angle fire only.

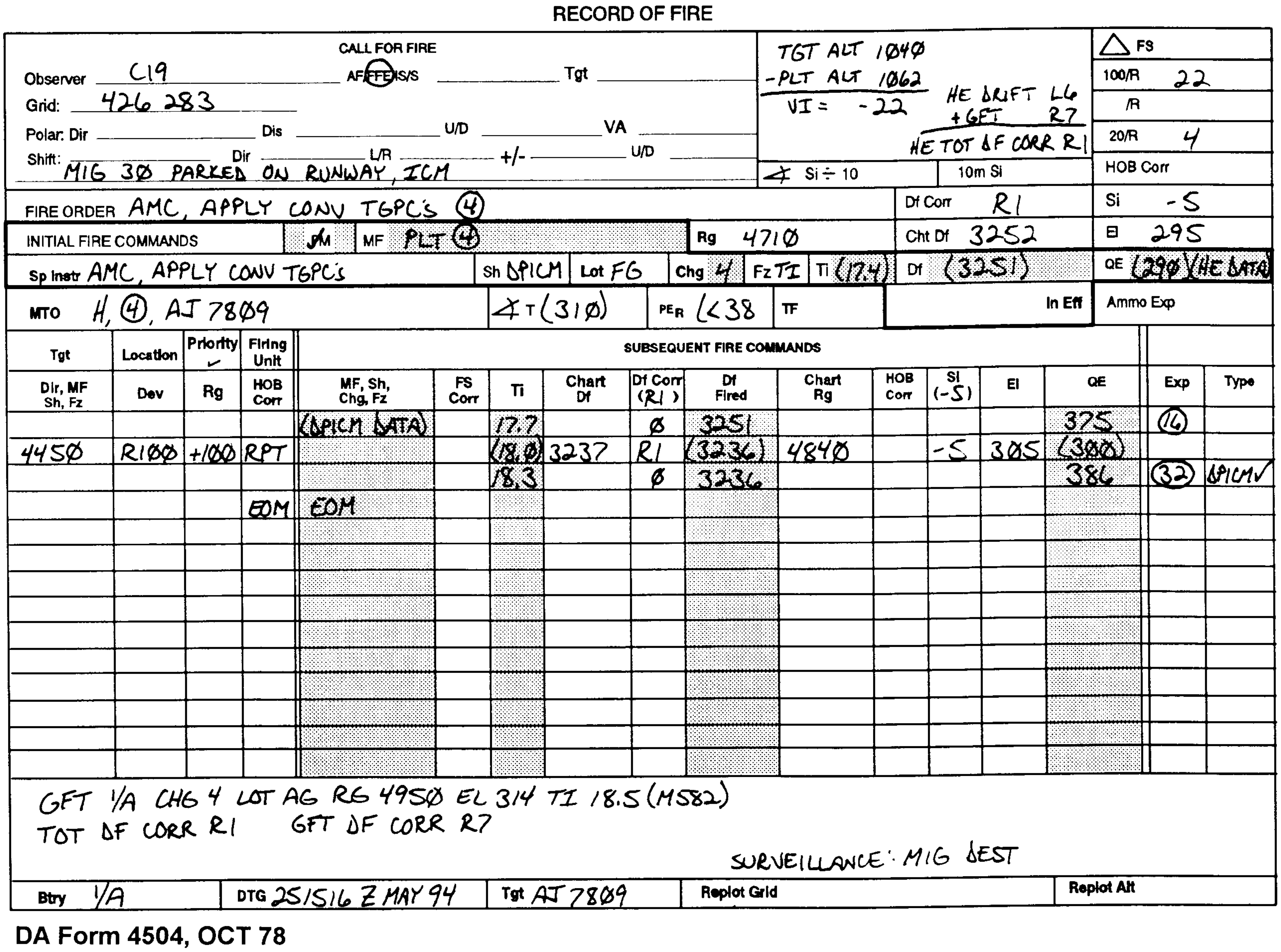
(1) Begin by determining DPICM graze burst data from the FT 155-AN-2, Table F, by using the proper charge and range. Elevation is extracted from Column 2, the graze burst fuze setting is extracted from Column 3 (M577), and the drift that will be added to the chart deflection is extracted from Column 8. Site is computed manually or by using the 155-AN-1 GST and then algebraically adding it to the elevation.

(2) Once the graze burst DPICM data have been determined, the ballistic corrections to compensate for the HOB of the DPICM projectile need to be extracted from the ADD-J-1. Table A of the appropriate charge will yield the corrections for QE. Table A is entered with the DPICM graze burst QE expressed to the nearest listed value. Column 2 will yield the correction factor that must be added to the DPICM graze burst QE so that the actual DPICM QE can be determined. Table B contains the correction factor that will be applied to the DPICM graze burst fuze setting. Enter Table B with the DPICM graze burst fuze setting, and extract the fuze correction. Apply this correction to the DPICM graze burst fuze setting so that the actual DPICM fuze setting can be determined.

(3) If during the course of a fire mission an HOB correction is sent to the FDC for shell DPICM, the ADD-J-1 will be used to determine the correction factors that must be applied to the DPICM fuze setting and QE. Table A, Column 3, of the appropriate charge will yield the correction factor for a 50-meter change in HOB. Multiply the correction factor by the number of 50-meter increments needed. Express the answer to the nearest mil. Apply the HOB correction to the DPICM QE. If it was an up correction, add the HOB correction to the DPICM QE; if it was a down correction, subtract the HOB correction from the DPICM QE. Table B, Column 3, of the appropriate charge will yield the FS correction for a 50-meter change in HOB. Multiply the correction factor by the number of 50-meter increments needed. Express the answer to the nearest FS increment. Apply the HOB correction to the DPICM fuze setting. If it was an up correction, add the HOB correction to the DPICM fuze setting; if it was a down correction, subtract it from the DPICM fuze setting.

NOTE: APICM data can be determined in a similar manner. The preferred method is to use the 155-AM-2 GFT with the APICM scales and a GFT setting. The other way is to use the 155-AM-2 GFT without a GFT setting or the FT 155-AM-2 and the addendum for APICM (ADD-l-2).

d. Figures 13-15 through 13-17 show completed ROFs for all three methods of determining firing data for shell DPICM.



RECORD OF FIRE

CALL FOR FIRE

Observer C19 AF/[✓ FFE]/S/S Tgt

Grid: 426 283

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

MIG 30 PARKED ON RUNWAY, ICM

TGT ALT 1040
-PLT ALT 1062
VI = -22

HE DRIFT L6
+GFT R7
HE TOT DF CORR R1

∡ Si ÷ 10

10m Si

△ FS

100/R 22

/R

20/R 4

HOB Corr

FIRE ORDER AMC, APPLY CONV TGPC'S ④

Df Corr R1

Si -5

INITIAL FIRE COMMANDS ✓M MF PLT ④

Rg 4710

Cht Df 3252

El 295

Sp Instr AMC, APPLY CONV TGPC'S

Sh DPICM

Lot FG

Chg 4

Fz TI

Ti (17.4)

Df (3251)

QE (290) (HE DATA)

MTO H, ④, AJ 7809

∡T (310)

PER (238

TF

In Eff

Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (R1)	Df Fired	Chart Rg	HOB Corr	Si (-5)	El	QE	Exp	Type
				(DPICM DATA)		17.7		0	3251					375	⑯	
4450	R100	+100	RPT			(18.0)	3237	R1	(3236)	4840		-5	305	(300)		
						18.3		0	3236					386	㉜	DPICM✓
			EOM	EOM												

GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5 (M582)
TOT DF CORR R1 GFT DF CORR R7

SURVEILLANCE: MIG DEST

Btry 1/A

DTG 251516 Z MAY 94

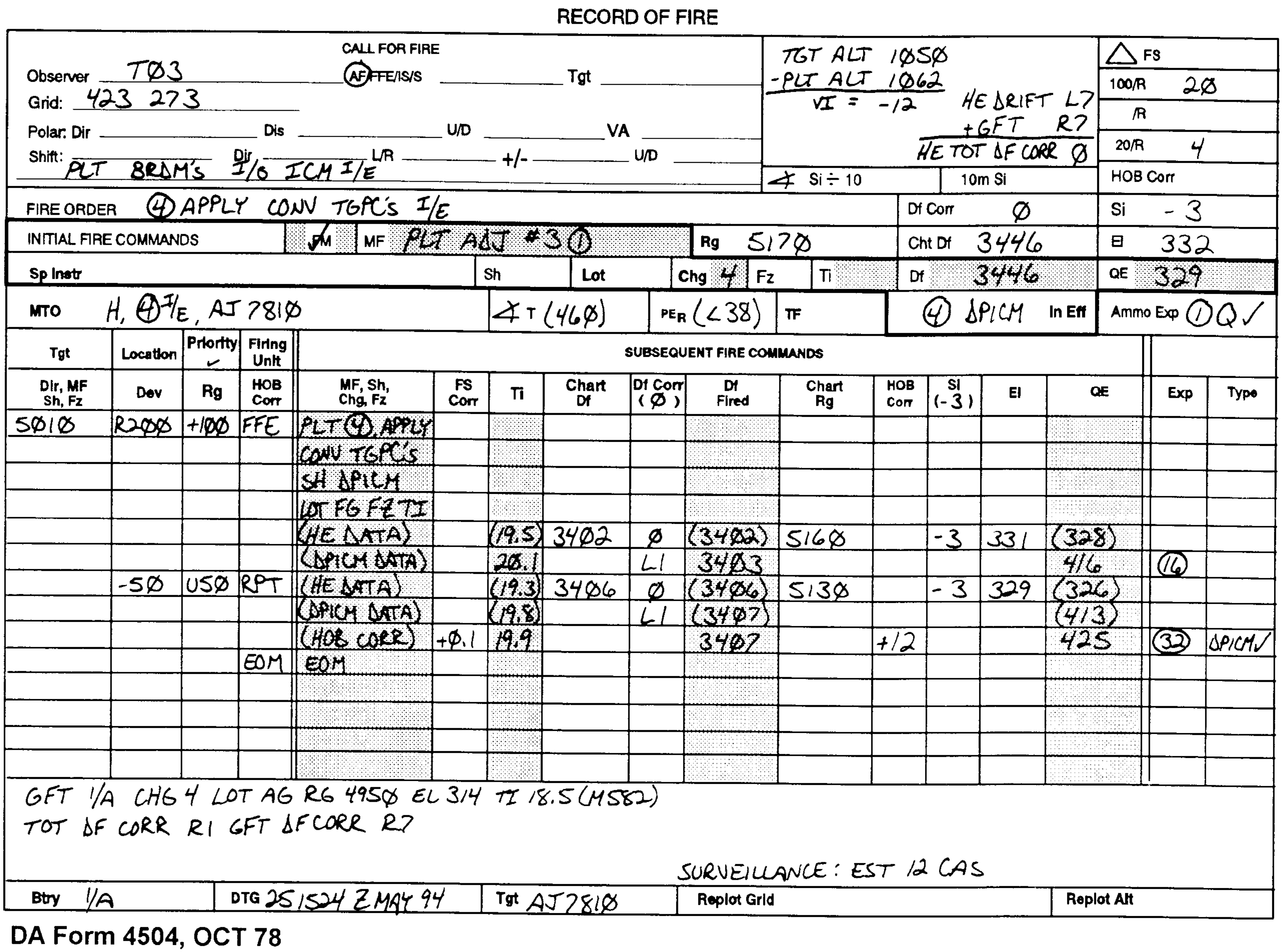
Tgt AJ 7809

Replot Grid

Replot Alt

DA Form 4504, OCT 78

Figure 13-15. Completed ROF for Shell DPICM, Using a 155-AM-2 GFT With Supplementary DPICM Scales and a GFT Setting Applied.



RECORD OF FIRE

CALL FOR FIRE [✓ AF] FFE/IS/S

Observer T03 Tgt

Grid: 423 273

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

PLT 8BDM's I/6 ICM I/E

TGT ALT 1050
-PLT ALT 1062
VI = -12

HE DRIFT L7
+GFT R7
HE TOT DF CORR 0

∢ Si ÷ 10

10m Si

△ FS

100/R 20

/R

20/R 4

HOB Corr

Si -3

El 332

QE 329

FIRE ORDER ④ APPLY CONV TGPC's I/E

Df Corr 0

INITIAL FIRE COMMANDS ✓FM MF PLT ADJ #3 ①

Rg 5170

Cht Df 3446

Sp Instr

Sh

Lot

Chg 4

Fz

Ti

Df 3446

MTO H, ④ I/E, AJ 7810

∢ T (460)

PE R (<38)

TF

④ DPICM In Eff

Ammo Exp ① Q ✓

Tgt Dir, MF Sh, Fz	Location Dev	Priority ✓ Rg	Firing Unit HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (0)	Df Fired	Chart Rg	HOB Corr	Si (-3)	El	QE	Exp	Type
5010	R200	+100	FFE	PLT ④ APPLY												
				CONV TGPC's												
				SH DPICM												
				LOT FG FZ TI												
				(HE DATA)		(19.5)	3402	0	(3402)	5160		-3	331	(328)		
				(DPICM DATA)		20.1		L1	3403					416	⑯	
	-50	U50	RPT	(HE DATA)		(19.3)	3406	0	(3406)	5130		-3	329	(326)		
				(DPICM DATA)		(19.8)		L1	(3407)					(413)		
				(HOB CORR)	+0.1	19.9			3407		+12			425	㉜	DPICM ✓
			EOM	EOM												

GFT 1/A CHG 4 LOT AG RG 4950 EL 314 TI 18.5 (M582)
TOT DF CORR R1 GFT DF CORR R7

SURVEILLANCE: EST 12 CAS

Btry 1/A

DTG 251524Z MAY 94

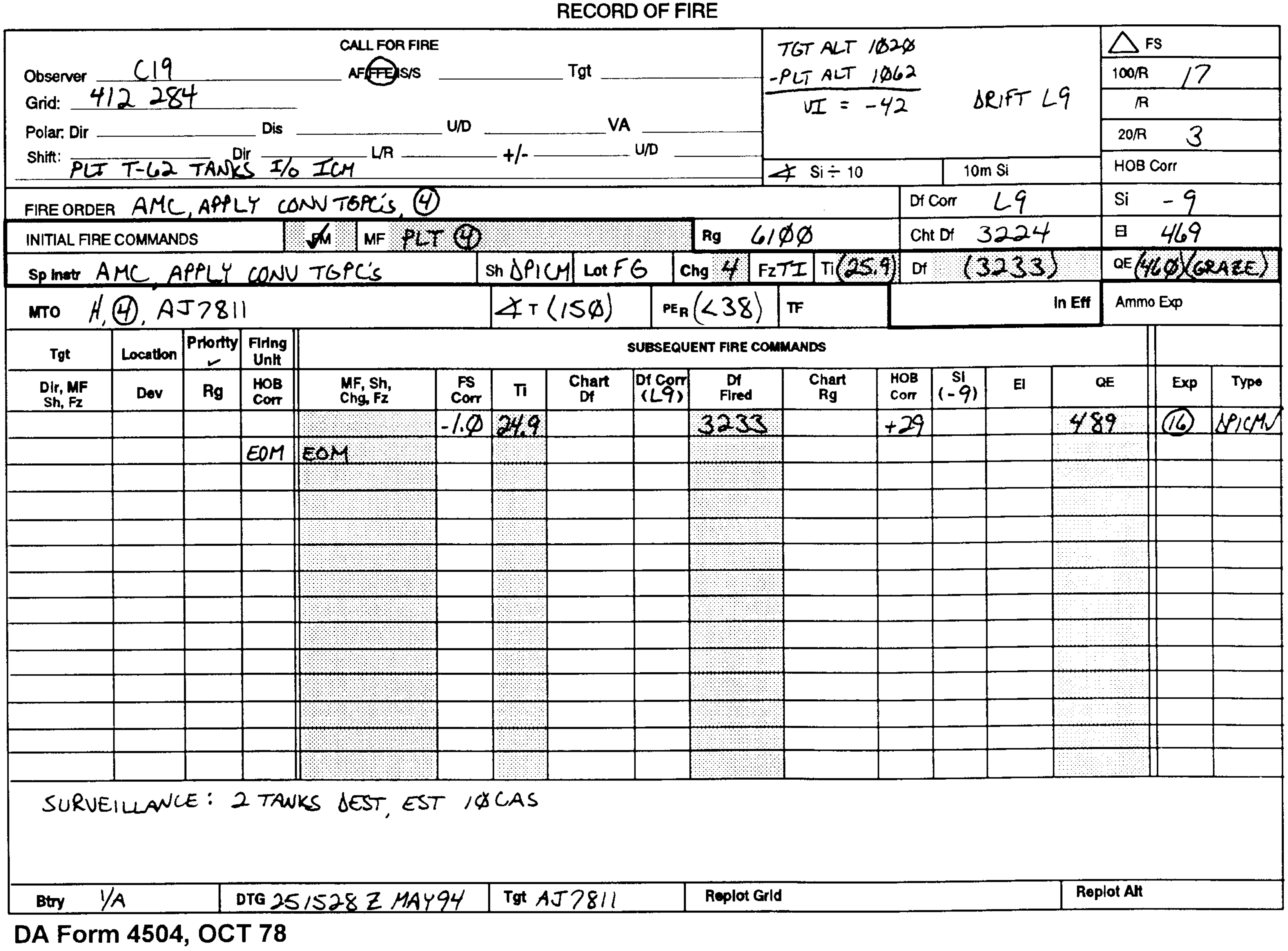
Tgt AJ7810

Replot Grid

Replot Alt

DA Form 4504, OCT 78

Figure 13-16. Completed ROF for Shell DPICM, Using a 155-AM-2 GFT With a GFT Setting Applied and Addendum R-1.



RECORD OF FIRE

CALL FOR FIRE

Observer C19 AF/[✓ FFE]/IS/S Tgt

Grid: 412 284

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

PLT T-62 TANKS I/o ICM

TGT ALT 1020
-PLT ALT 1062
VI = -42

DRIFT L9

∠ Si ÷ 10

10m Si

△ FS

100/R 17

/R

20/R 3

HOB Corr

FIRE ORDER AMC, APPLY CONV TGPC's, ④

Df Corr L9

Si -9

INITIAL FIRE COMMANDS ✓ FM MF PLT ④

Rg 6100

Cht Df 3224

⊟ 469

Sp Instr AMC, APPLY CONV TGPC's

Sh DPICM Lot FG Chg 4 Fz TI Ti (25.9)

Df (3233)

QE (460) (GRAZE)

MTO H, ④, AJ7811

∠T (150)

PER (<38)

TF

In Eff

Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L9)	Df Fired	Chart Rg	HOB Corr	Si (-9)	El	QE	Exp	Type
					-1.0	24.9			3233		+29			489	⑯	DPICM✓
			EOM	EOM												

SURVEILLANCE: 2 TANKS DEST, EST 10 CAS

Btry 1/A | DTG 251528 Z MAY94 | Tgt AJ7811 | Replot Grid | Replot Alt

DA Form 4504, OCT 78

Figure 13-17. Completed ROF for Shell DPICM, Using FT-155-AN-2 With Addendum J-1.

Section V

Family of Scatterable Mines

This section implements STANAG 2963 and QSTAG 802.

The family of scatterable mines adds new dimension to mine warfare, providing the maneuver commander with a rapid, flexible means of delaying, harassing, paralyzing, canalizing, or wearing down the enemy forces in both offensive and defensive operations. Mines can force the enemy into kill zones, change their direction of attack, spend time in clearing operations, or take evasive actions. FASCAM presents an array of air and FA-delivered scatterable mines available to maneuver force commanders. The two types of FA-delivered scatterable mines are ADAM and RAAMS.

13-26. Types of Scatterable Mines

a. ADAM is an antipersonnel mine activated by deployed trip lines. There are 36 wedge-shaped mines contained in the 155-mm projectile. Minefield density can be selectively determined by altering the number of rounds applied. There are currently three densities: low, medium, and high. The mines are expelled from the projectile (approximately 600 meters) over the designated target. Shortly after ground impact, up to seven trip line sensors are released out to a maximum length of 20 feet. The detonators are armed to fiction in the event of any small disturbance. The ADAM mine has lethality out to 15 feet. Self-destruct times are 4 hours for short self-destruct (M731) and 48 hours for long self-destruct (M692). Figure 13-18 shows an ADAM projectile.

b. RAAMS is effective against armored vehicles. The mines are expelled from the rear of the projectile over the target. After ground impact and roll, the mine is armed and ready to detonate upon sensing a proper armored vehicle signature (electromagnetic). A percentage of the nine RAAMS mines are equipped with an antidisturbance device. RAAMS is highly effective when used in conjunction with the ADAM mine, which helps prevent neutralization by enemy ground troops. There are nine RAAMS mines per 155-mm projectile. Minefield densities and self-destruct times are the same as ADAM (M741 short-destruct, M718 long-destruct). Figure 13-19 shows a RAAMS projectile.

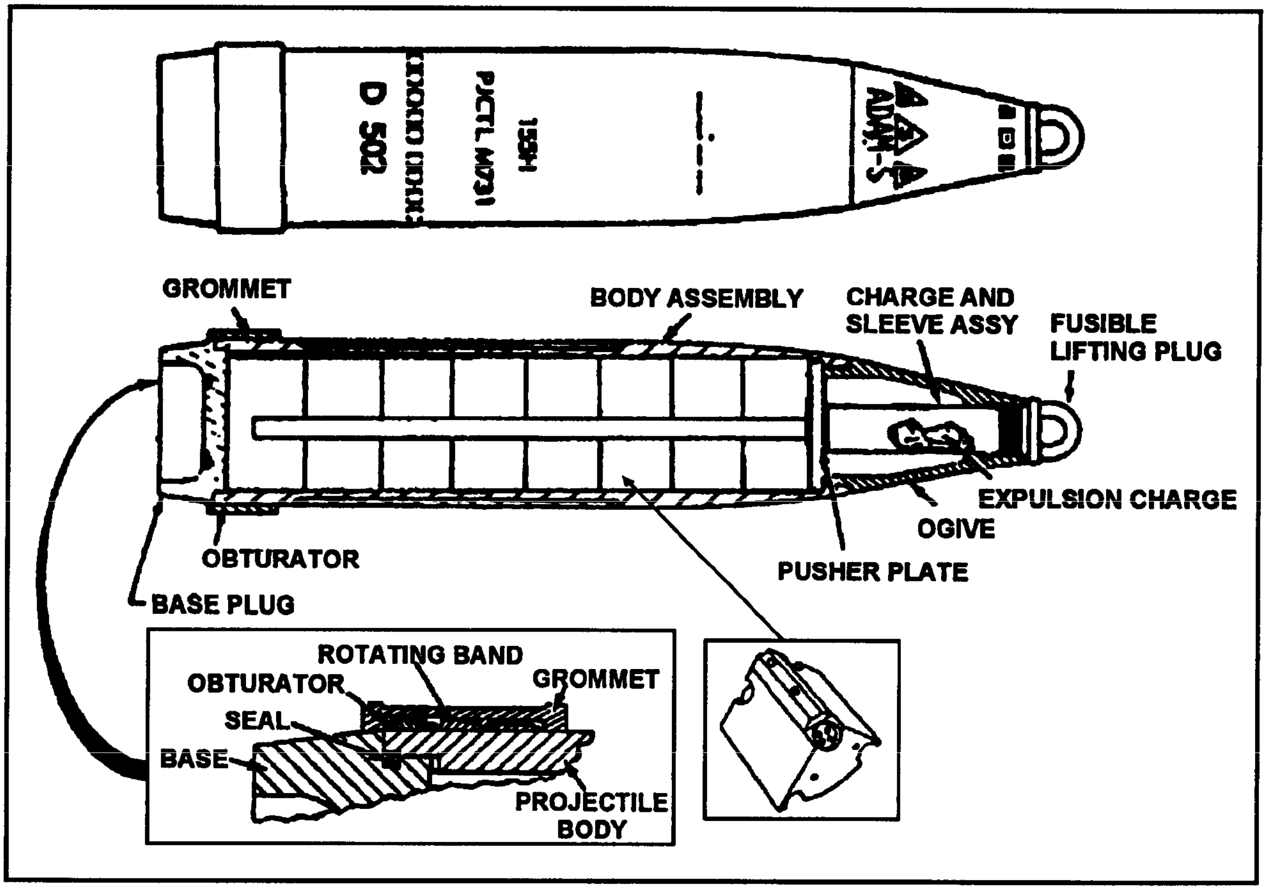


Figure 13-18. ADAM Projectile.

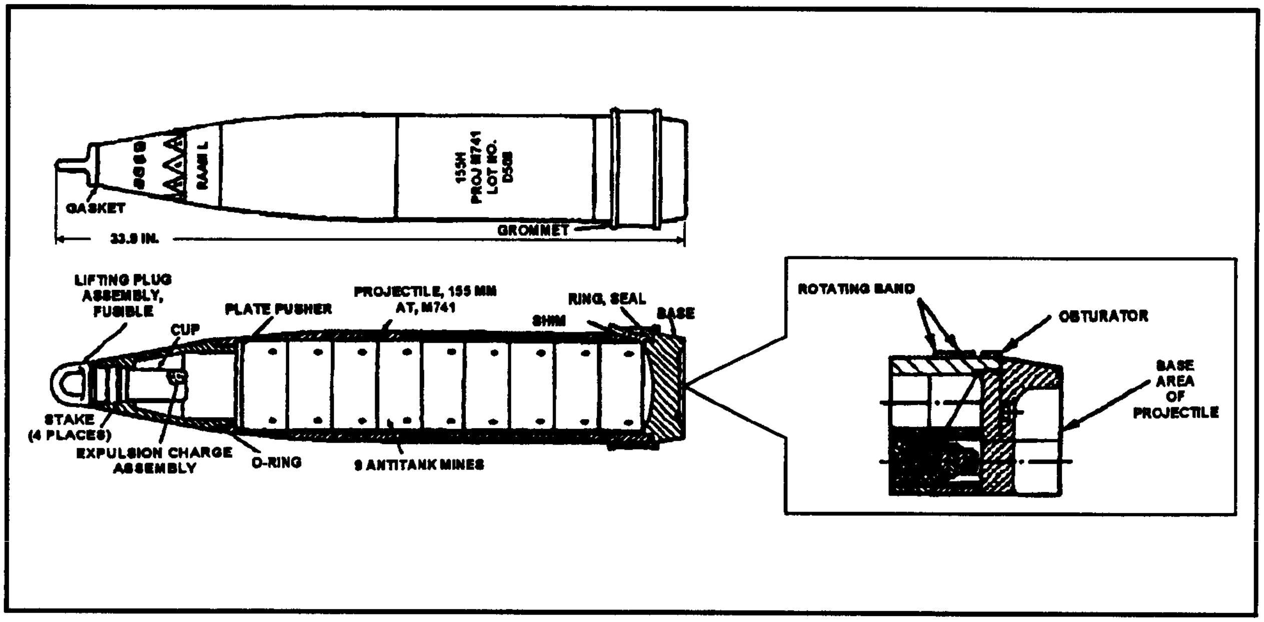


Figure 13-19. RAAMS Projectile.

13-27. FASCAM Tactical Considerations and Fire Order Process

a. Two types of minefields can be developed with FASCAM--planned minefield and target of opportunity minefields.

(1) Planned minefields begin with the development of the scheme of maneuver and then the barrier and/or obstacle plan by the G3 and/or S3 and engineer. Before deciding on the employment of ADAM and/or RAAMS, the FSCOORD is brought into the planning process to provide guidance on the availability of FA mines and delivery units. The process is then initiated with the DA Form 5032-R (Field Artillery Delivered Minefield Planning Sheet).

(2) Minefields employed against targets of opportunity (unplanned) must be emplaced immediately because of the tactical nature of the targets. They are requested through the fire support channels at any level. Once the maneuver brigade or division commander has approved the use of FA mines, they can be emplaced appropriately. Normally, targets of opportunity are used when the delivery of the mines can be observed. Aimpoints for target of opportunity minefields can be computed as in a planned minefield. However, this will be time-consuming and may not meet the demands of the tactical situation. Therefore, it is recommended that units establish an SOP for a “standard minefield” to fire when the tactical situation requires an immediate minefield. For example, the unit SOP may be for a 400 x 400 minefield, high angle, medium density, with two aimpoints. The SOP will allow FSOs to determine the number of target of opportunity minefields that are available for the maneuver commander. This determination is based on the unit’s FASCAM unit basic load (UBL).

b. Upon receiving a request for a FASCAM minefield, the FDO must begin a detailed process to determine the fire order. The first thing that the FDO must understand is that FASCAM employment is based on a concept known as planning modules. The planning module for RAAMS low angle is 200 meters x 200 meters. The planning module for RAAMS high angle and for ADAM low or high angle is 400 meters x 400 meters. This does not mean that the minefield planner cannot request a minefield that is larger than the planning module. In any FASCAM minefield, the requesting agency defines the minefield size in terms of the length, width, and attitude. The length of the minefield is always the longest axis. The concept of the planning modules is based on the minefield width. In other words, the width of all minefields must be in multiples of the planning module defined above. The FDO will use the length, width, and planning module to determine the number of linear sheafs required to establish the required minefield. The linear sheafs will evenly divide each module and will be parallel to the long axis (length) of the minefield. Refer to paragraph (13) for an example that illustrates this concept.

(1) Once the call for fire on a DA Form 5032-R is received, the FDO will plot the target. In FASCAM missions, DPICM graze burst data, battery-minefield angle (BMA), angle of fire, number of aimpoints, and the desired minefield density must be determined before issuing the fire order.

(2) Plot the minefield linear sheaf, determine the minefield center point of each linear sheaf, and determine the chart range and deflection to the minefield center point(s). Record the chart range and chart deflection on the ROF.

(3) Determine DPICM graze burst data to the center point computed in (2) above. For RAAMS only, determine chart range. For ADAM, determine chart range and DPICM QE.

(4) Determine the battery minefield angle. The BMA is defined as the smaller angle formed by the intersection of the attitude of the minefield and the GT line with the vertex at the center point of the minefield. Using the target grid, set off the minefield attitude and with the vertex at the battery or platoon location, place the RDP against the center point. The smaller interior angle is the BMA. BMA is **always** less than 1,600 mils. Record this in the computation block of the ROF.

(5) To determine the appropriate mine employment table to use, the FDO must ask three questions:

- What delivery technique am I using?
  - Met + VE (FFE).
  - Observer adjust (AF).
- What shell and trajectory will I fire?
  - M718/M741 (RAAMS) low angle.
  - M718/M741 (RAAMS) high angle.
  - M692/M731 (ADAM) low or high angle.
- What is the BMA?
  - Less than or **equal** to 800.
  - Greater than 800.

(6) The matrix key is used to determine the mine employment table to use. The table number that is displayed for each of the three entry arguments is the table used for mine employment. See the matrix shown in Table 13-12.

Table 13-12. Mine Employment Matrix.

ENTRY	EMPLOYMENT TABLE							
	1	2	3	4	5	6	7	8
Transfer or met + VE	X	X	X	X				
Observer adjust					X	X	X	X
M718/741 (RAAMS) low angle	X	X			X	X		
M718/741 (RAAMS) high angle			X	X			X	X
M692/731 (ADAM) low or high angle			X	X			X	X
BMA ≤ 800 mils	X		X		X		X	
BMA > 800 mils		X		X		X		X

(7) The trajectory makes a difference in the minefield module that can be achieved. RAAMS low-angle planning module is 200 x 200. RAAMS high-angle planning module is 400 x 400. ADAM low- or high-angle planning module is 400 x 400. So, only with RAAMS low angle can you achieve a minefield width of 200 meters, or every 200 meters.

NOTE: If ADAM and RAAMS are employed together, then the process for determination of the appropriate mine employment table is done for each shell.

(8) The mine employment tables are used to determine the number of aimpoints required. Review the header information to verify the appropriate table is being used. The entry argument into the mine employment tables are the length (greatest axis) along the top and chart range for entering along the left side of the table (enter with the nearest listed value). If the chart range falls **exactly** halfway between two ranges, use the lower listed range. The mine employment tables are shown in Tables 13-13 through 13-20.

NOTE: These tables are number of aimpoints per linear sheaf (planning module width).

Table 13-13. Mine Employment Table Number 1.

Delivery Technique: Transfer or met + VE
Shell: M718/741 (RAAMS)
Trajectory: Low angle
BMA: Equal to or less than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	2	3	3	4	4	5	5	6	6	7
6,000	2	3	3	4	4	5	5	6	6	7
8,000	2	3	3	4	4	5	5	6	6	7
10,000	3	3	4	4	5	5	6	6	7	7
12,000	3	4	4	5	5	6	6	7	7	8
14,000	4	4	5	5	6	6	7	7	8	8
16,000	4	4	5	5	6	6	7	7	8	8
17,500	4	5	5	6	6	7	7	8	8	9

Table 13-14. Mine Employment Table Number 2.

Delivery Technique: Transfer or met + VE
Shell: M718/741 (RAAMS)
Trajectory: Low angle
BMA: Greater than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	1	2	2	3	3	4	4	5	5	6
6,000	1	2	2	3	3	4	4	5	5	6
8,000	1	2	2	3	3	4	4	5	5	6
10,000	2	2	3	3	4	4	5	5	6	6
12,000	2	3	3	4	4	5	5	6	6	7
14,000	2	3	3	4	4	5	5	6	6	7
16,000	3	3	4	4	5	5	6	6	7	7
17,500	3	3	4	4	5	5	6	6	7	7

Table 13-15. Mine Employment Table Number 3.

Delivery Technique: Transfer or met + VE
Shell: M692/731 (ADAM)
M718/741 (RAAMS)

Trajectory: Low angle or high angle (ADAM)
High angle (RAAMS)
BMA: Equal to or less than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	1	2	2	2	2	3	3	3	3	4
6,000	1	2	2	2	2	3	3	3	3	4
8,000	1	2	2	2	2	3	3	3	3	4
10,000	2	2	2	2	3	3	3	3	4	4
12,000	2	2	2	3	3	3	3	4	4	4
14,000	2	2	3	3	3	3	4	4	4	4
16,000	2	2	3	3	3	3	4	4	4	4
17,500	2	3	3	3	3	4	4	4	4	5

Table 13-16. Mine Employment Table Number 4.

Delivery Technique: Transfer or met + VE
Shell: M692/731 (ADAM)
M718/741 (RAAMS)

Trajectory: Low angle or high angle (ADAM)
High angle (RAAMS)
BMA: Greater than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	1	1	1	2	2	2	2	3	3	3
6,000	1	1	1	2	2	2	2	3	3	3
8,000	1	1	1	2	2	2	2	3	3	3
10,000	1	1	2	2	2	2	3	3	3	3
12,000	1	2	2	2	2	3	3	3	3	4
14,000	1	2	2	2	2	3	3	3	3	4
16,000	2	2	2	2	3	3	3	3	4	4
17,500	2	2	2	2	3	3	3	3	4	4

Table 13-17. Mine Employment Table Number 5.

Delivery Technique: Observer Adjust
Shell: M718/741 (RAAMS)
Trajectory: Low angle
BMA: Equal to or less than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	2	2	3	3	4	4	5	5	6	6
6,000	2	2	3	3	4	4	5	5	6	6
8,000	2	3	3	4	4	5	5	6	6	7
10,000	2	3	3	4	4	5	5	6	6	7
12,000	2	3	3	4	4	5	5	6	6	7
14,000	2	3	3	4	4	5	5	6	6	7
16,000	3	3	4	4	5	5	6	6	7	7
17,500	3	3	4	4	5	5	6	6	7	7

Table 13-18. Mine Employment Table Number 6.

Delivery Technique: Observer Adjust
Shell: M718/741 (RAAMS)
Trajectory: Low angle
BMA: Greater than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000 through 17,500	1	2	2	3	3	4	4	5	5	6

Table 13-19. Mine Employment Table Number 7.

Delivery Technique: Observer Adjust
Shell: M692/731 (ADAM)
M718/741 (RAAMS)
Trajectory: Low angle or high angle (ADAM)
High angle (RAAMS)
BMA: Equal to or less than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000 through 17,500	1	1	1	2	2	2	2	3	3	3

Table 13-20. Mine Employment Table Number 8.

Delivery Technique: Observer Adjust
Shell: M692/731 (ADAM)
M718/741 (RAAMS)

Trajectory: Low angle or high angle (ADAM)
High angle (RAAMS)
BMA: Greater than 800 mils

RANGE (METERS)	DESIRED MINEFIELD LENGTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	1	1	2	2	2	2	3	3	3	3
6,000	1	1	2	2	2	2	3	3	3	3
8,000	1	2	2	2	2	3	3	3	3	4
10,000	1	2	2	2	2	3	3	3	3	4
12,000	1	2	2	2	2	3	3	3	3	4
14,000	1	2	2	2	2	3	3	3	3	4
16,000	2	2	2	2	3	3	3	3	4	4
17,500	2	2	2	2	3	3	3	3	4	4

(9) On the basis of the module size and the number of aimpoints, the location of the aimpoints is determined.

(a) Module size 400- by 400-meters--even number of aimpoints. Place aimpoints 200 meters left and right of the center point along each centerline. Place the others at intervals of 400 meters. (See Figure 13-20.)

(b) Module size 400- by 400-meters--odd number of aimpoints. Place the first aimpoint at the center point of the minefield. Place the others at intervals of 400 meters left and right of the center point along each centerline. (See Figure 13-21.)

(c) Module size 200- by 200-meters--even number of aimpoints. Place the aimpoints 100 meters left and right of the center point along each centerline. Place the others at intervals of 200 meters. (See Figure 13-22.)

(d) Module size 200- by 200-meters--odd number of aimpoints. Place the first aimpoint at the center point of the minefield. Place the others at intervals of 200 meters left and right of the center point along each centerline. (See Figure 13-23.)

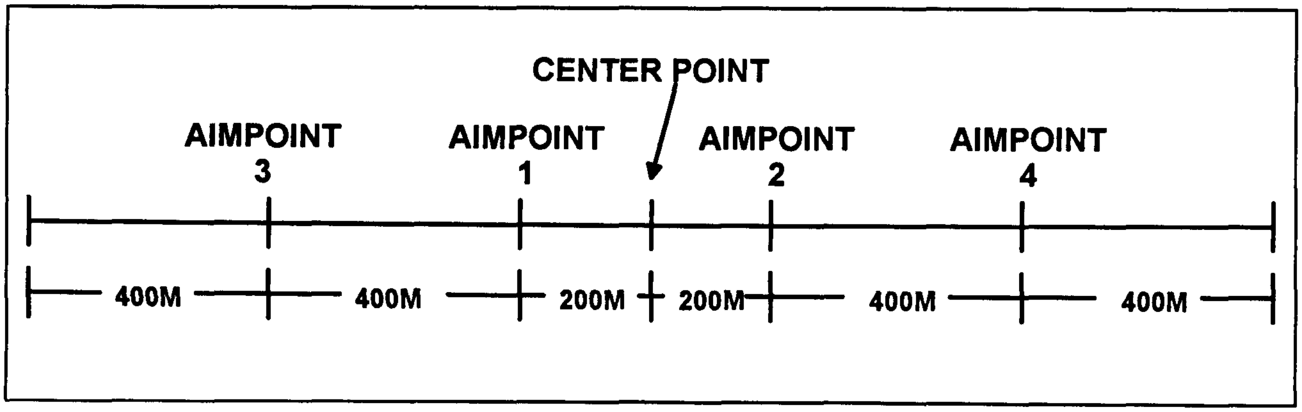


Figure 13-20. Module Size 400 x 400--Even Number of Aimpoints.

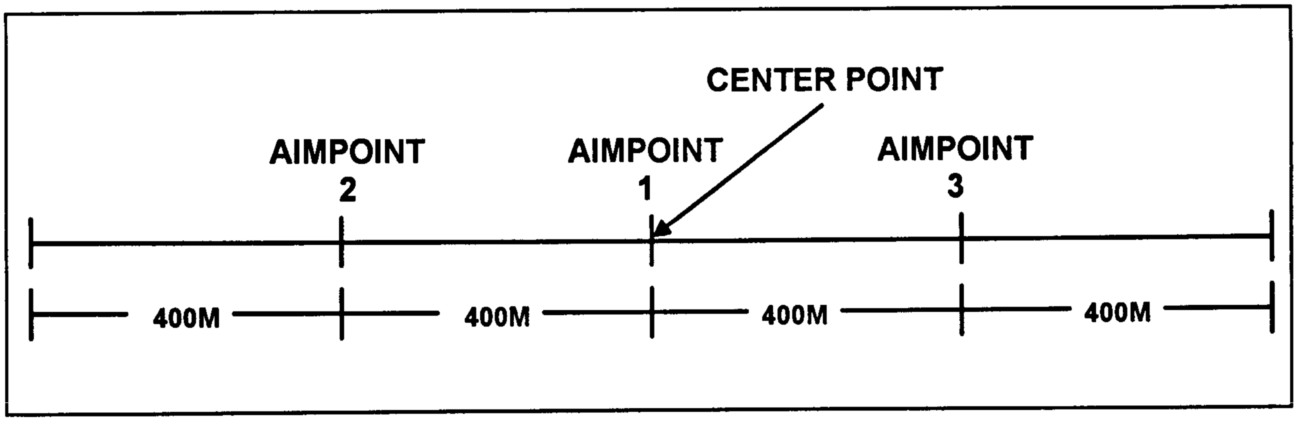


Figure 13-21. Module Size 400 x 400--Odd Number of Aimpoints.

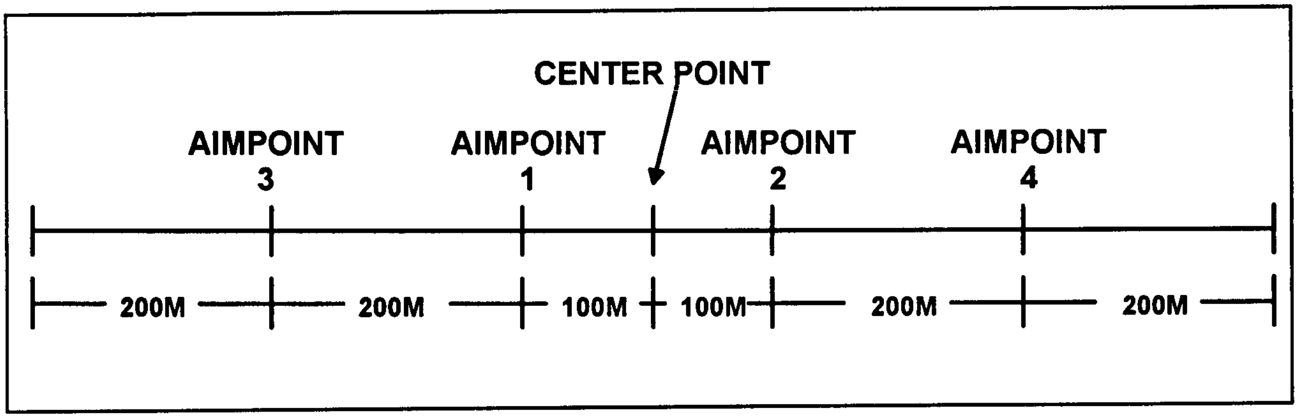


Figure 13-22. Module Size 200 x 200--Even Number of Aimpoints.

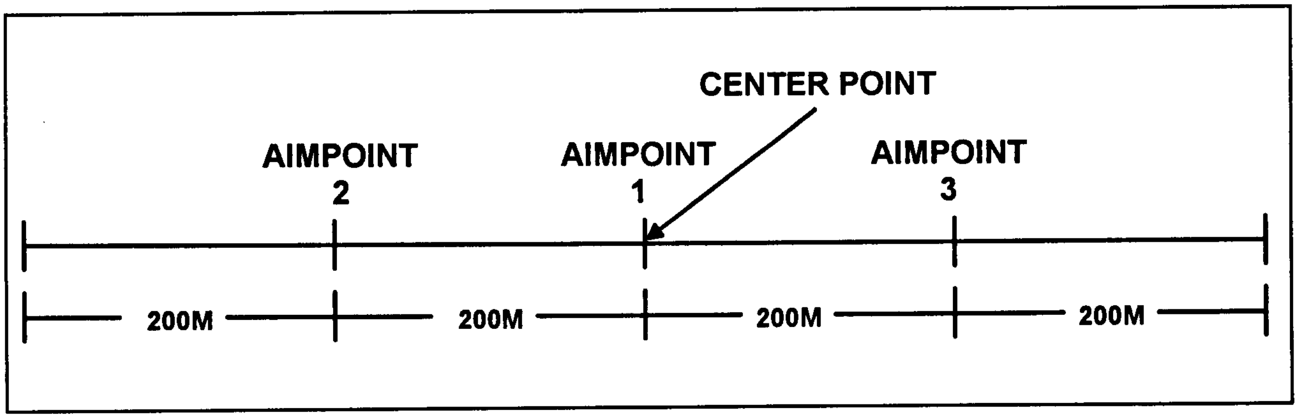


Figure 13-23. Module Size 200 x 200--Odd Number of Aimpoints.

(10) On the basis of the desired density, enter Table 13-21 below to determine the number of rounds needed to achieve that density.

Table 13-21. Desired Density Rounds per Aimpoint.

HIGH-ANGLE RAAMS			
	LOW	**MEDIUM**	**HIGH**
Desired density	0.001	0.002	0.004
Rounds per aimpoint	24	48	96
LOW-ANGLE RAAMS			
	LOW	**MEDIUM**	**HIGH**
Desired density	0.0005	0.001	0.002
Rounds per aimpoint	6	12	24
HIGH- OR LOW-ANGLE ADAM			
	LOW	**MEDIUM**	**HIGH**
Desired density	0.0005	0.001	0.002
Rounds per aimpoint	3	6	12

NOTE: A density of .001 means that there will be approximately one mine every 1,000 square meters. In other words, there will be one mine in every 32-x 32-meter area. These density numbers are used for planning purposes only. Dispersion of the projectiles in the target area will dictate the actual pattern of mines. Tables 13-22 and 13-23 show recommended minefield densities.

Table 13-22. Recommended Minefield Density for Shell RAAMS.

PURPOSE OF MINEFIELD	HARASSMENT	MINEFIELD COVERED BY HEAVY DIRECT FIRE	MINEFIELD COVERED BY LIGHT DIRECT FIRE
DENSITY DESIGNATION FOR MINEFIELD PLANNING SHEET	LOW	MEDIUM	HIGH
DENSITY MINES	0.001	0.002	0.004

Table 13-23. Recommended Minefield Density for Shell ADAM.

PURPOSE OF MINEFIELD	USED WITH RAAMS or OTHER AT OBSTACLES or HARASSMENT	MINEFIELD COVERED BY HEAVY DIRECT FIRE	MINEFIELD COVERED BY LIGHT DIRECT FIRE
DENSITY DESIGNATION FOR MINEFIELD PLANNING SHEET	LOW	MEDIUM	HIGH
DENSITY MINES	0.001	0.002	0.004

(11) Now, using all available information, the FDO issues the fire order and the computer records it on the ROF.

(12) There are some additional tactical considerations to consider when determining which firing unit(s) will deliver the mines on target. The FDO must consider the total emplacement time, the BMA angles of the firing units, the units available, distribution of FASCAM ammunition, and distribution of aimpoints. When firing a minefield containing both ADAM and RAAMS mines, RAAMS should be fired first to Prevent Premature detonation of ADAM mines.

EXAMPLE	
FIRING UNIT A	FIRING UNIT B
M109A3 Platoon (4 Guns)	Two Batteries of M109A3 (16 Guns)
KNOWN DATA	
a. Rg 10,000 m b. Technique: Met + VE c. BMA > 800 d. Low ∢ e. RAAMS Table 2 f. ADAM Table 4 g. 400 x 400 high-density minefield h. Shell ADAM and RAAMS i. Two ADAM aimpoints, 12 rounds each j. Six RAAMS aimpoints, 24 rounds each (TOTAL ROUNDS = 168) k. Max rate: 3 rounds per minute for 3 minutes l. Sustained rate: 1 round per minute m. Shift time between aimpoints: 1 minute	
FIRING UNIT A	FIRING UNIT B
M109A3 Platoon (4 Guns)	Two Batteries of M109A3 (16 Guns)
@ MAX RATE 36 RDS/3 MIN **@ SUST RATE 132 RDS/33 MIN** **TOTAL EMPLACE TIME: 36 MIN**	@ MAX RATE 144 RDS/3 MIN **@ SUST RATE 24 RDS/ <2 MIN** **TOTAL EMPLACE TIME: <5 MIN**

NOTE: The above example is for illustrative purposes only and does not include the time required to shift between aimpoints.

(13) The FDO must also consider how to segment a target that is larger than the established planning modules. Segmenting a large target may require the FDO to establish two or more linear sheafs in the target area. The tactical considerations discussed in paragraph (12) are considered for each linear sheaf as if it were a separate fire mission. This decision to segment a large target is normally the responsibility of the battalion FDO.

(a) To illustrate this concept, consider the following situation:

- Weapon: M109A3
- Minefield size: 1,000 x 800
- Attitude: 0400
- Munitions: RAAMS
- Angle of fire: High angle
- Module size: 400 x 400

(b) Since the width of the minefield is a multiple of the planning module (800/400 = 2), the FDO can continue with the fire order process. If the establishing agency requests a minefield width that is **not** a multiple of the planning module, this must be resolved before the FDO can properly segment the target to achieve the desired density. In this example, the FDO will segment the minefield into two targets of 1,000 x 400 each. On the firing chart, the FDO will establish a centerline along each separate minefield. The easiest way to do this is to place the target grid over the center of the grid to the minefield and orient along the attitude. Next, place plotting pins left and right of the attitude (200 meters) to establish the offset center points.

(c) The FDO will use the offset center points to determine chart range and the BMA. In some cases, this may cause the number of aimpoints to be different for each centerline, In this example, the chart operator determined the following data:

Centerline 1: 1/A RG 10,930, BMA 1150

Centerline 2: 1/A RG 11,350, BMA 1170

(d) The FDO will enter the appropriate minefield employment table and determine the number of aimpoints for each centerline. Finally, he will determine the aimpoint spacing along each centerline. In this example, the FDO determined the following data

Centerline 1	Centerline 2
Mine Table: 4	Mine Table: 4
Entry Range: 10,000	Entry Range: 12,000
No Aimpoints: 3	No Aimpoints: 4
Spacing: Center, 400 L/R	Spacing: 200 L/R, 400

(e) The remainder of the tactical considerations are performed as described in the steps from paragraph 13-27b(l3). Figure 13-23 depicts the results achieved from the above situation.

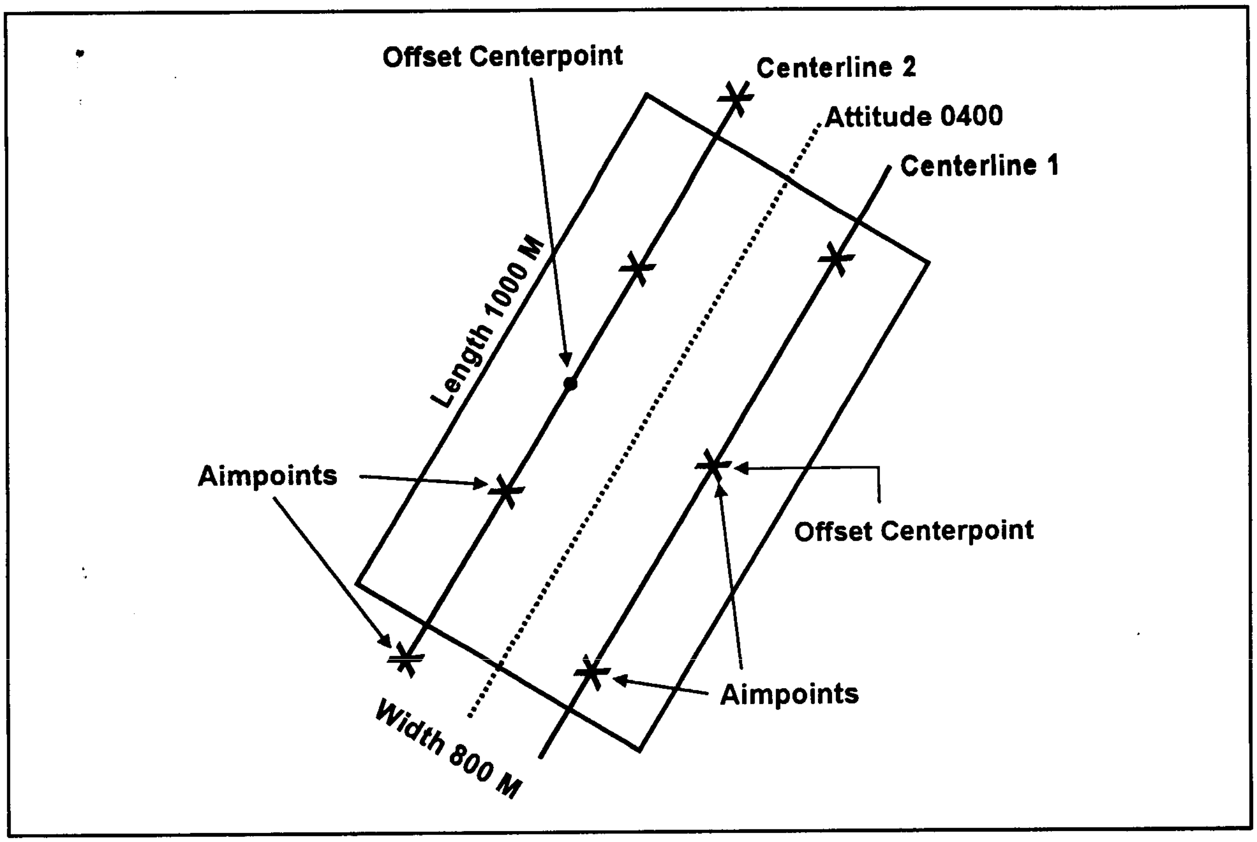


Figure 13-24. Segmenting a Large FASCAM Target.

13-28. Technical Fire Direction Procedures

a. Now that the fire order is issued, technical fire direction must be determined by using DPICM graze burst data and then converting these DPICM data to either RAAMS or ADAM data. To convert these DPICM data, use the FT 155-ADD-L-1 (for ADAM) or FT 155-ADD-N-1 (for RAAMS). The preferred technique is to conduct a DPICM registration and transfer the GFT setting. Other techniques used are met + VE or met to target. The computer records the initial fire commands through the Fz block and the MTO block on the ROF.

b. Now plot the aimpoints on the (target grid) firing chart (placing plotting pins left and right along the centerline arrow, representing the attitude) and determine chart data to the aimpoints. These are aimpoints where you want the rounds to impact. For ADAM, these chart data are not recorded on the ROF but are used to determine VI and site (we determine site to the actual impact of the rounds, not to an offset aimpoint location). For future use, record the chart range, VI, and site in the computational space of the ROF. For RAAMS, record the chart data, VI, and site for each aimpoint.

c. Since low-level winds will cause ADAM mines to be blown away from the intended aimpoint, a modification in meters must be made to the location of the aimpoints. This will allow the mines to impact at the intended location. Low-level wind corrections are not computed for RAAMS. For RAAMS, go to paragraph f(3).

d. The computer must enter FT 155-ADD-L-1, Table A, Column 1, with the DPICM graze burst quadrant determined to the center point grid (paragraph 13-27b(3)) and extract the correction for low-level winds from Column 5. This offset correction allows the delivered ADAM mines to be on target for a wind speed of 1 knot. The Low-level wind correction is recorded in the subsequent fire commands portion of the ROF.

(1) Since ADAM has a 600-meter HOB, line 02 from a current met message is used to determine the wind speed and direction. Line 02 is used because 00 = 0 to 250 meters, 01 = 250 to 500 meters, and line 02= 500 to 1,000 meters.

(2) The computer multiplies the correction factor in paragraph d by the wind speed in paragraph d(1) to determine the total distance, in meters, needed to offset each aimpoint to compensate for low-level winds. Express this value to the nearest 10 meters, and record it on the ROF. This distance in meters, in conjunction with the direction of the wind, will be used to offset the aimpoints.

e. The HCO uses the target grid to offset the aimpoints.

(1) The HCO places the target grid over the center point and sets off the direction of wind. Remember, this is the direction from which the wind is blowing. The HCO then offsets the center point into the wind by the distance determined in step d(2). (See Figure 13-25.)

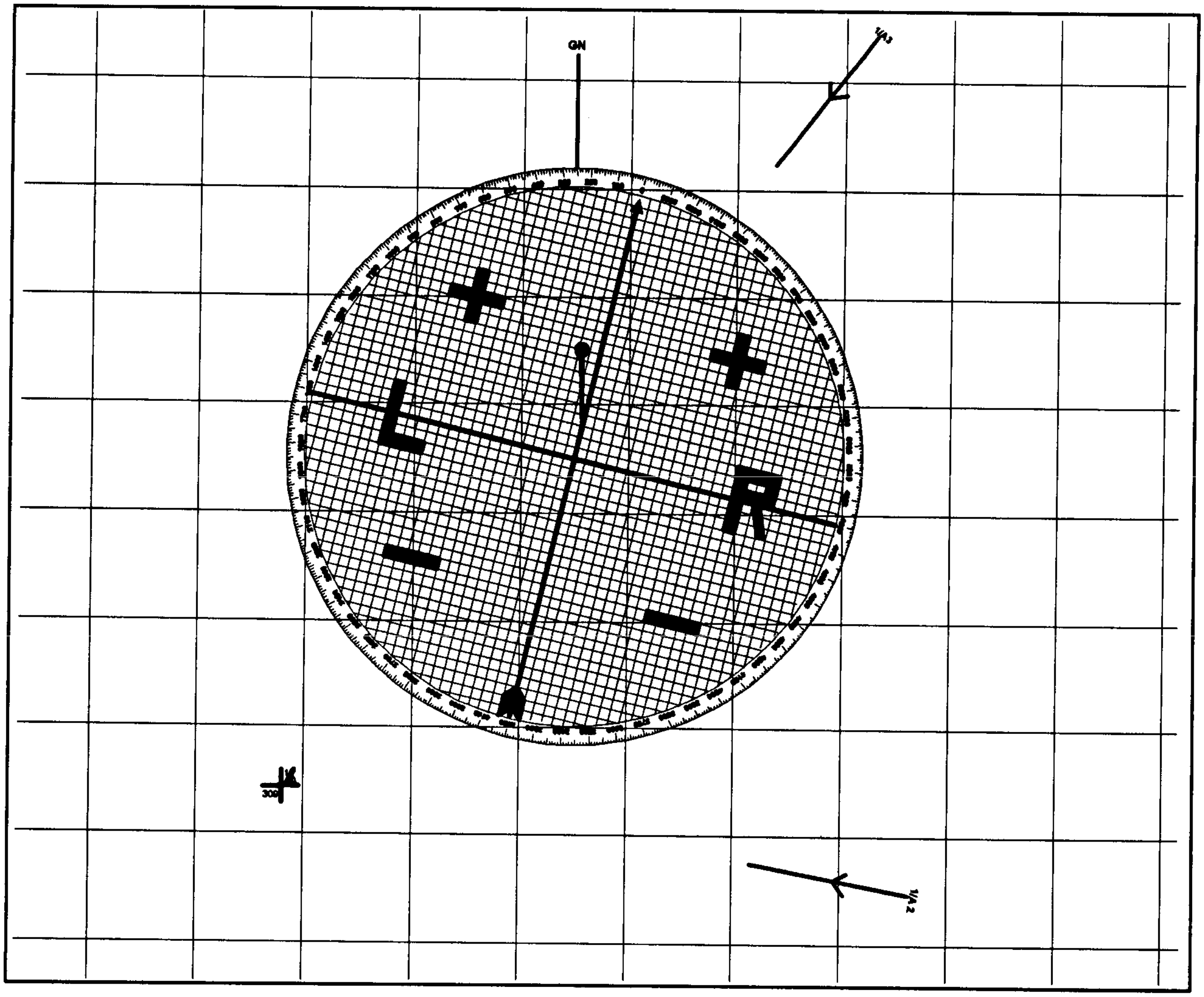


Figure 13-25. Target Grid Oriented on the Direction of Wind.

(2) The HCO reorients the target grid over this point, resets the minefield attitude off, and places plotting pins left and right of the center point as determined in step (9) above, **using the target grid centerline (arrow).** Note that the "head and tail" of the target grid represents the attitude. (See Figure 13-26.)

f. The computer determines FASCAM firing data to each offset aimpoint.

(1) The HCO determines and announces chart range and deflection to the two aimpoints.

(2) The VCO determines site. Using the location and range to the original aimpoints which are recorded in the computational space of the ROF, the VCO determines VI and site.

(3) The computer determines DPICM graze burst time, deflection, elevation, and quadrant elevation to each aimpoint. Since these are not the data to be fired, place the time, deflection, and quadrant in parentheses.

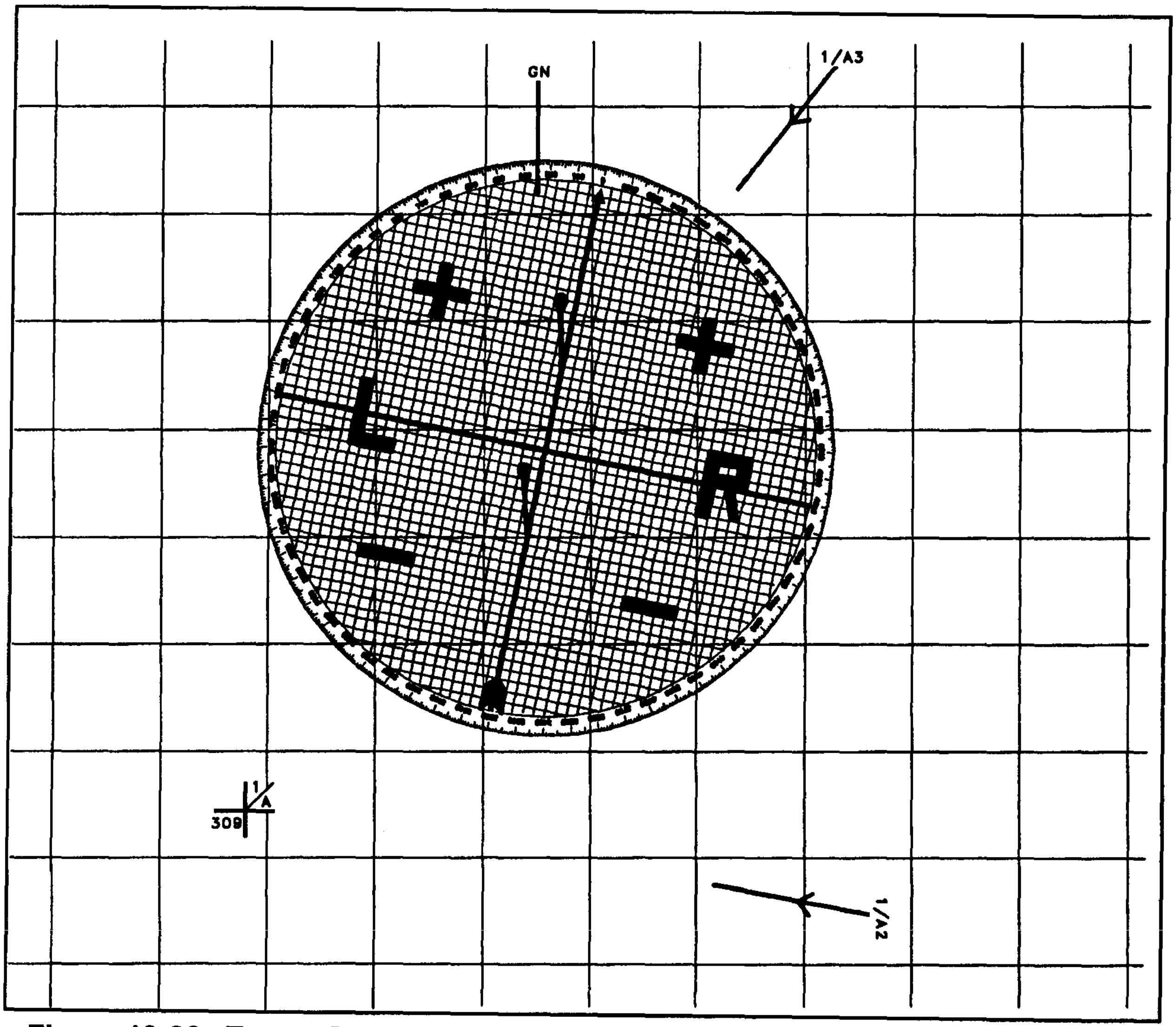


Figure 13-26. Target Grid Reoriented Over Offset Point Aligned on the Attitude.

(4) The computer determines and records FASCAM firing data by placing the MHL over the DPICM graze burst time and quadrant. The deflection to fire is the chart deflection to the aimpoint plus the total deflection correction **(GFT DF CORR + DPICM DRIFT).**

(5) The preliminary FT 155-AN-2 and FT 155-AN-1 TFTs can be used to determine graze burst data for DPICM. The FT 155-AN-2 supersedes the FT 155-AN-1 and is the preferred source of firing data.

(6) The firing table addendums are used in conjunction with the firing tables to determine the firing data FASCAM.

13-29. ADAM

a. Firing Table Addendum L-1 is used in conjunction with the AN-l/AN-2 base TFT to determine firing data for shell ADAM.

b. Table A, Column 1, is entered with the graze burst QE that was determined by using the AN-1/AN-2 TFT. The correction to quadrant is found in Column 2 and is added to the graze burst data.

c. Table B, Column 1, is entered with the graze burst fuze setting that was determined by using the AN-1/AN-2 TFT. The correction to fuze setting is found in Column 2 and is added to the graze burst data.

d. Subsequent corrections for quadrant are determined from Table A, Columns 3 and 4; for fuze setting, Table B, Columns 3 and 4.

13-30. RAAMS

a. Firing Table Addendum N-1 is used in conjunction with the AN-1/AN-2 base TFT to determine firing data for shell RAAMS.

b. Table A, Column 1, is entered with the graze burst QE that was determined by using the AN-1/AN-2 TFT. The correction to quadrant is found in Column 2 and is added to the graze burst data.

c. Table B, Column 1, is entered with the graze burst fuze setting that was determined by using the AN-1/AN-2 TFT. The correction to fuze setting is found in Column 2 and is added to the graze burst data.

d. Subsequent corrections for quadrant are determined from Table A, Columns 3 and 4; for fuze setting, Table B, Columns 3 and 4.

13-31. DA Form 5032-R

a. DA Form 5032-R (Figure 13-27) is used for planned FA-delivered barrier or obstacle minefields, target of opportunity minefields, and minefields established in conjunction with other munitions.

b. The sections shown on this sheet are completed at different levels during the planning and execution sequence. The purpose of the planning sheet is as follows:

(1) Provide a standard procedure for placing planned minefield data into fire support channels.

(2) Provide data for computation and dissemination of a safety zone after minefield emplacement.

13-32. Planned Minefields

The planning sequence starts with the G3, S3, and engineer with guidance from the FSCOORD.

a. Section A is completed by the G3, S3, and/or engineer when requesting an FA-delivered scatterable minefield to support a barrier or obstacle plan.

b. Section B is completed by the G3, S3, and/or engineer to record dissemination of safety zones.

c. Section C is completed by the FSE.

d. Section D is completed by the firing unit FDO.

13-33. Target of Opportunity Minefields and Minefields Established in Conjunction With Other Munitions

These minefields are initiated over fire support channels directly to the firing units. Therefore, the use of the planning sheet starts in reverse sequence.

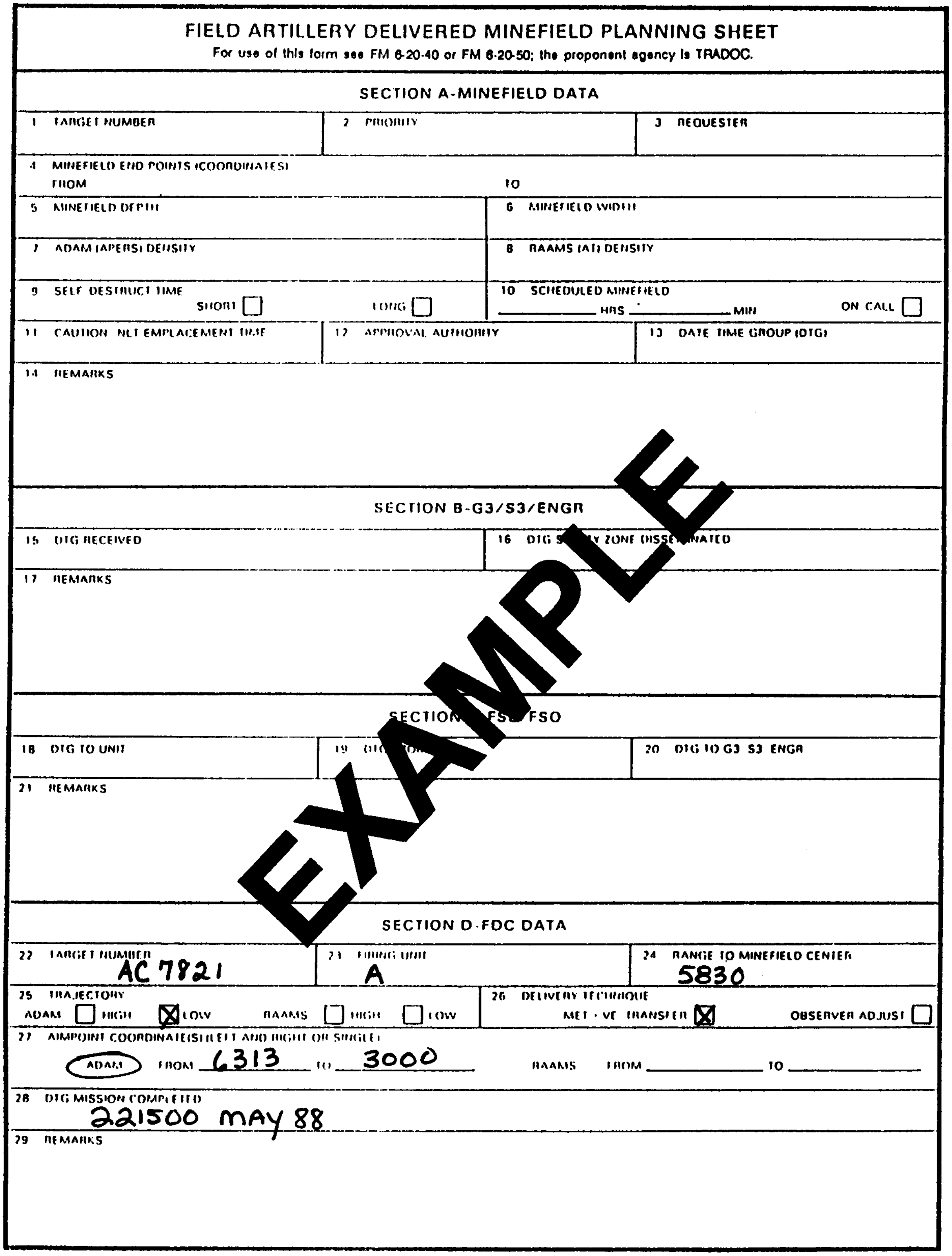
a. Section D is completed by the firing unit FDO.

b. Section C is completed by the FSE.

c. Section B is completed by the G3, S3, and/or engineer to record dissemination of safety zones.

d. Section A is not applicable.

NOTE: A blank DA Form 5032-R is shown in Figures 13-27 and 13-28, and a description of each block is shown in Table 13-24.



FIELD ARTILLERY DELIVERED MINEFIELD PLANNING SHEET

For use of this form see FM 6-20-40 or FM 6-20-50; the proponent agency is TRADOC.

SECTION A-MINEFIELD DATA

1 TARGET NUMBER

2 PRIORITY

3 REQUESTER

4 MINEFIELD END POINTS (COORDINATES) FROM TO

5 MINEFIELD DEPTH

6 MINEFIELD WIDTH

7 ADAM (APERS) DENSITY

8 RAAMS (AT) DENSITY

9 SELF DESTRUCT TIME SHORT ☐ LONG ☐

10 SCHEDULED MINEFIELD ____ HRS ____ MIN ON CALL ☐

11 CAUTION NLT EMPLACEMENT TIME

12 APPROVAL AUTHORITY

13 DATE TIME GROUP (DTG)

14 REMARKS

SECTION B-G3/S3/ENGR

15 DTG RECEIVED

16 DTG S[illegible]Y ZONE DISSE[illegible]NATED

17 REMARKS

SECTION[illegible] FS[illegible]FSO

18 DTG TO UNIT

19 DT[illegible]

20 DTG TO G3 S3 ENGR

21 REMARKS

SECTION D-FDC DATA

22 TARGET NUMBER AC 7821

23 FIRING UNIT A

24 RANGE TO MINEFIELD CENTER 5830

25 TRAJECTORY ADAM ☐ HIGH ☒ LOW RAAMS ☐ HIGH ☐ LOW

26 DELIVERY TECHNIQUE MET + VE TRANSFER ☒ OBSERVER ADJUST ☐

27 AIMPOINT COORDINATE(S) (LEFT AND RIGHT OR SINGLE)

[✓ ADAM] FROM 6313 TO 3000 RAAMS FROM ____ TO ____

28 DTG MISSION COMPLETED 221500 MAY 88

29 REMARKS

DA Form 5032-R, Jan 82

Figure 13-27. DA Form 5032-R.

SECTION E - MINEFIELD SKETCH WORK SHEET (SCALE 1:50,000)

(To be completed by minefield planners)

REVERSE OF DA FORM 5032-R

Figure 13-28. DA Form 5032-R (Reverse Side).

Table 13-24. Block-By-Block Explanation of DA Form 5032-R.

STEP	BLOCK	ACTION
		SECTION A—MINEFIELD DATA
1	Target Number	The number used to indentify the minefield is provided by the FSCOORD at the maneuver level directing the emplacements.
2	Priority	This block is used if the employing unit uses an obstacle priority system.
3	Requester	The commander of the maneuver element requesting the minefield.
4	Minefield End Points from/to (Coordinates)	The two sets of coordinates that represent the endpoints of the minefield.
5	Minefield Depth	This block indicates the depth of the minefield. When planning the depth, there is only a 400- by 400-meter module size except for RAAMS fired at low angle, which is 200 by 200 meters.
6	Minefield Width	This block shows the width of the minefield and should agree with the distance between end point coordinates in Block 4.
7	ADAM (APERS) Density	The density is expressed as HIGH, MEDIUM, or LOW, according to the density per square meter required. The recommended densities are shown in Table13-29.
8	RAAMS (AT) Density	The density is expressed as HIGH, MEDIUM, or LOW, according to the density per square meter required. Recommended densities are shown in Table 13-30.
9	Self-Destruct Time Short ☐ Long ☐	An X is placed in the block designating the self-destruct time desired. Only one self-destruct time should be used when both RAAMS and ADAM are used together. If an exception is made, it should be entered in the REMARKS block.
10	Scheduled Minefield__Hrs ±___Min	If the requester wants the minefield emplaced at a certain time, he enters the time in the hour portion of the block. The second portion of the block is variable time, in minutes, the minefield may be emplaced before or after the desired time.
	On Call ☐	If the requester wants the minefield delivered at his command, he places an X in the ON-CALL MINEFIELD block. If this block is used, NA is placed in the SCHEDULED MINEFIELD block.
11	Caution NLT Emplacement Time	The requester can provide a not later than (NLT) time (date-time) for the minefield to be emplaced. This is a safety factor that may or may not be used. If not used, NA is placed in the block.
12	Approval Authority	This block is used to record the approval authority for the emplacement of the minefield.
13	Date-Time Group	This block gives the date-time group (DTG) of the initiation of the request. The DTG is entered after Section A is completed and approved.
14	Remarks	Enter distance from closest friendly unit to nearest point on minefield centerline.
		SECTION B—G3/S3 ENGR
15	DTG Received	The date-time group is entered when the G3, S3, and/or engineer receives the minefield emplacement data in Section D.
16	DTG Safety Zone Disseminated	The date-time group that safety zone information is disseminated to higher, lower, or adjacent units, as required, is entered in this block.
17	Remarks	As appropriate.

Table 13-24. Block-By-Block Explanation of DA Form 5032-R (Continued).

STEP	BLOCK	ACTION
		SECTION C—FSE/FSO
18	DTG to Unit	The date-time group that Section D data are received from the firing unit.
19	DTG from Unit	This is the date-time group that Section D data are received from the firing unit.
20	DTG to G3/S3/Engr	This is the date-time group that Section D data are passed to the G3, S3, and/or engineer for computation and dissemination of safety zones.
21	Remarks	As appropriate.
		SECTION D—FDC DATA
22	Target number	For planned minefields, the target number is the same as in Section A, Block 1. Unplanned minefields are given a target number by the FA firing unit.
23	Firing Unit	The unit firing in the minefield is entered in this block.
24	Range to Minefield Center	The range from the firing unit to the minefield center is entered in this block. Range is necessary to compute the safety zone.
25	Trajectory ADAM☐ High☐Low☐ RAAMS☐ High☐ Low☐	The use of high- or low-angle fire to emplace the minefield is indicated by an X in the appropriate block corresponding to mines emplaced (ADAM/RAAMS). The angle of fire is needed to compute the safety zone.
26	Delivery Technique Met + VE ☐ Observer adjust☐	An X indicates the delivery technique used. Delivery technique is necessary for computation of the safety zone.
27	Aimpoint Coordinate(s) Left and Right or Single ADAM From_To RAAMS From_ To_	The aimpoint coordinates for the leftmost aimpoint are placed in the FROM block and for the rightmost aimpoint in the TO block. If there is just one aimpoint, the coordinates are entered in the FROM block and NA is placed in other blocks. In all cases, coordinates are placed in the block corresponding to the mines fired (ADAM/RAAMS). The aimpoint coordinate(s) and the mines fired (ADAM/RAAMS) are needed to compute the safety zone.
28	DTG Mission Completed	This is the date-time group the emplacement of the minefield is completed (that is, last mines fired impact).
29	Remarks	As appropriate.
		SECTION E—MINEFIELD SKETCH WORK SHEET
30	Reverse side of form	The minefield planners sketch the minefield location and safety zones on the work sheet in Section E (back). (See Figure 13-28.)

13-34. Safety Zone Determination

a. The G3, S3, and/or engineers are normally responsible for determining the safety zones for FASCAM and disseminating them to the appropriate higher, lower, and adjacent units. The FSCOORD at any level can also determine safety zones for minefields that are fired into the maneuver area for which he is providing support. This would only be done for expediency to support maneuver operations.

b. As a safety check, the FDO should also determine the safety zone before firing FASCAM. The determined safety zone should be compared to the situation map to ensure there are no units within the safety zones for FA-delivered scatterable minefields. The two techniques used to determine the safety zone are as follows:

- Safety zone tables.
- Safety zone templates.

NOTE: About 99 percent of all mine delivery missions will result in the entire minefield (minefield modules) being inside the safety squares.

For both techniques, the following information is required:

- Type of projectile (ADAM or RAAMS).
- Trajectory (high angle or low angle).
- Range to center of the minefield.
- Aimpoint coordinates.
- Delivery technique (met+ VE, or observer adjust).

13-35. Safety Zone Tables

The steps for using the safety zone tables are shown in Table 13-25.

Table 13-25. Use of Safety Zone Tables.

STEP	ACTION
1	Select the appropriate table on the basis of the projectile type and trajectory. (See Tables 13-26 through 13-28.)
2	Enter the table with the nearest listed range and delivery technique, and extract the safety zone size.
3	Draw the aimpoints on the situation map.
4	Draw the determined safety zone so that it is centered over each of the aimpoints. This will establish the minefield safety zone.
5	Compare the minefield safety zone to friendly locations on the situation map. Notify the battalion FDC or supported FSO if any friendly units plot inside the minefield safety zone.

Table 13-26. RAAMS—Low Angle.

Range (km)	Met + VE	Observer Adjust
4	500 x 500	500 x 500
7	550 x 550	500 x500
10	700 x 700	550 x 550
12	850 x 850	550 x 550
14	1000 x 1000	650 x 650
16	1050 x 1050	650 x650
17.5	1200 x 1200	650 x650

Table 13-27. ADAM—Low Angle.

Range (km)	Met + VE	Observer Adjust
4	700 x700	700 x 700
7	750 x750	700 x700
10	900 x900	750 x750
12	1050 x 1050	750 x750
14	1200 x 1200	850 x 850
16	1250 x 1250	850 x 850
17.5	1400 x 1400	850 x 850

Table 13-28. RAAMS and ADAM—High Angle.

Range (km)	Met + VE	Observer Adjust
4	750 x 750	700 x700
7	900 x900	700 x 700
10	1050 x 1050	750 x 750
12	1200 x 1200	750 x750
14	1400 x 1400	850 x 850
16	1500 x 1500	850 x850
17.5	1400 x 1400	850 x 850

13-36. Safety Zone Templates

If safety zone templates are available, the steps are basically the same as the safety zone tables. The selected template is centered over the aimpoint locations and the safety zone is traced onto the situation map. The field artillery mine safety template is shown in Figure 13-28.

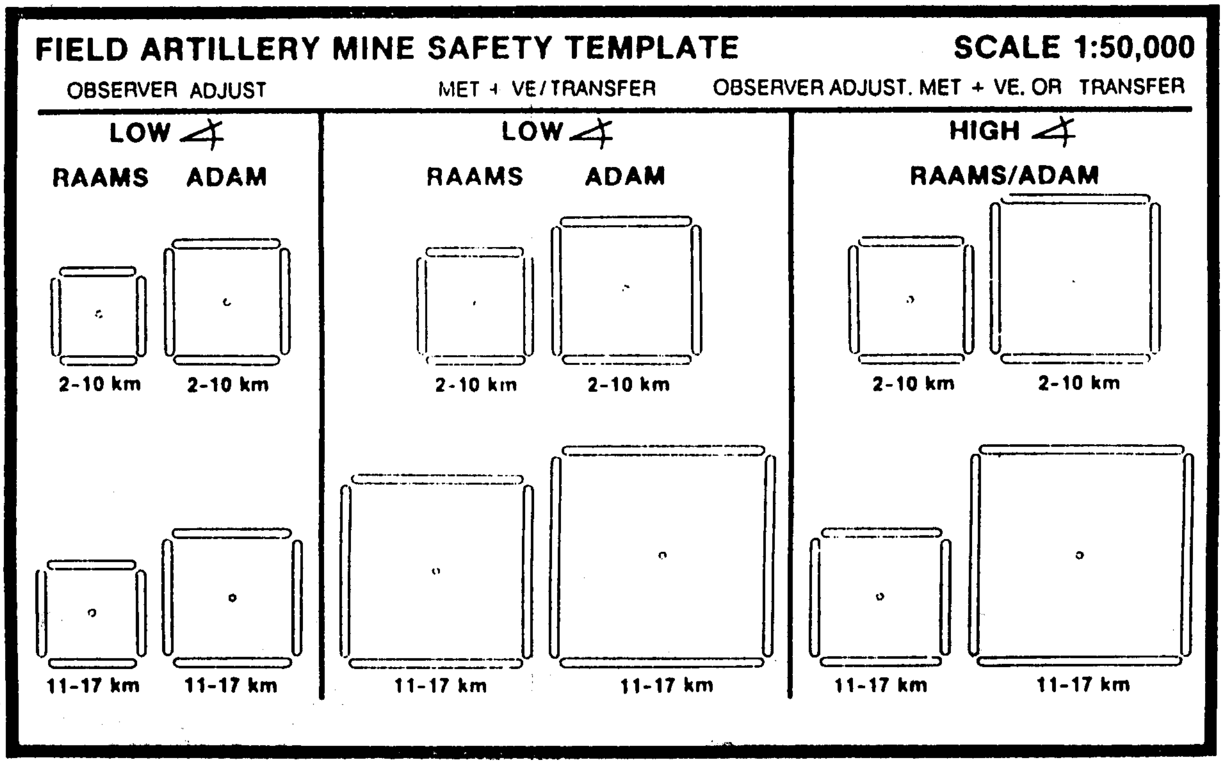


Figure 13-29. Field Artillery Mine Safety Template.

13-37. FASCAM Employment Steps

a. Table 13-29 shows the employment procedures for shell ADAM.

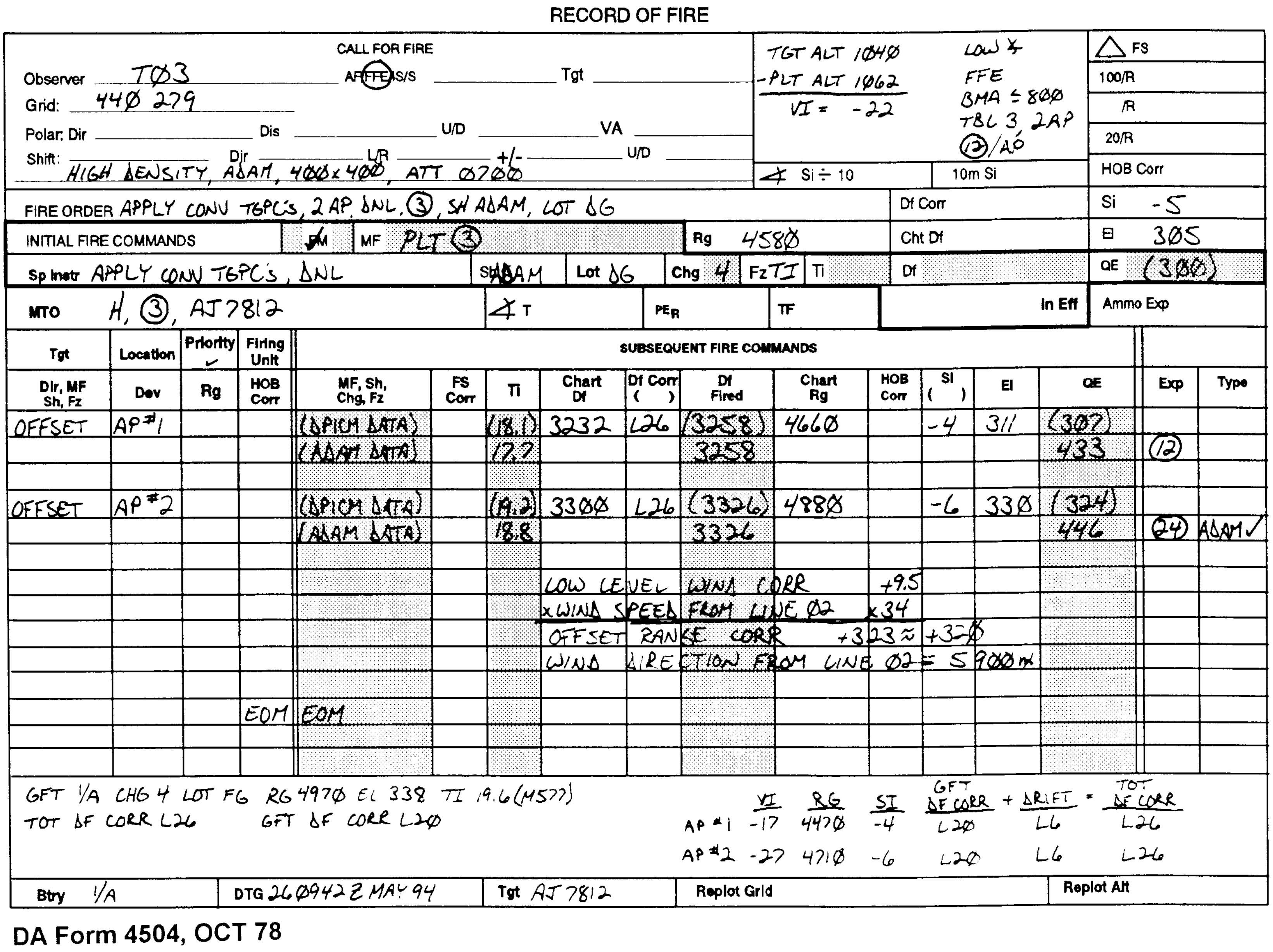
Table 13-29. Shell ADAM Employment Procedures.

STEP	ACTION
1	The computer records the target information on the ROF (from DA Form 5032-R or observer call for fire).
2	The HCO plots the minefield center and determines the chart range.
3	Using the target grid, the HCO sets off the minefield attitude and with the vertex at the unit location, places the RDP arm against the center point. Now determine the battery minefield angle.
4	The FDO enters the mine employment matrix to determine which employment table to use.
5	The FDO enters the appropriate mine employment table and extracts the appropriate number of aimpoints.
6	The FDO determines aimpoint spacing.
7	The FDO enters the appropriate table to determine the required number of rounds per aimpoint on the basis of the desired density.
8	The FDO issues the fire order.
9	The computer determines DPICM graze burst quadrant to center point.
10	Using the target grid along the attitude requested, the HCO plots the aimpoints.
11	The HCO determines chart range to the aimpoints.

Table 13-29. Shell ADAM Employment Procedures (Continued).

STEP	ACTION
12	The VCO determines the VI to each aimpoint and computes site.
13	The computer determines the low-level wind corrections.
13a	Enter **FT 155-ADD-L-1**, Table A, with DPICM graze burst quadrant. Extract the correction factor for a 1-knot wind.
13b	Extract the wind speed from line 02 of a current, valid ballistic met message.
13c	Multiply the value from step 13a by the value from step 13b to determine the total distance, in meters, needed to offset each aimpoint(s) into the wind. Express this value to the nearest 10 meters.
14	The HCO places the target grid over the center point and sets off the direction of the wind for line 02 of a current, valid ballistic met message.
15	The HCO offsets the center aimpoint into the wind by the distance determined in step 13c above.
16	The HCO reorients the target grid over this point, sets the minefield attitude and places plotting pins left and right of the center point along the attitude as determined in step 6.
17	The HCO determines and announces the chart range and chart deflection to each offset aimpoint.
18	The computer determines DPICM graze burst data to each offset aimpoint.
19	The computer determines the ADAM fuze setting and quadrant from the AN-1/AN-2 GFT by using the DPICM graze burst fuze setting and quadrant. **OR** The computer can determine the ADAM fuze setting and quadrant by using the DPICM graze burst fuze setting and quadrant as entry arguments for Tables A and B of FT 155-ADD-L-1. The determined corrections are then applied to the graze burst data.
20	The ADAM deflection to fire is the offset aimpoint chart deflection plus the total deflection correction (GFT deflection correction and DPICM drift).
21	Subsequent corrections are determined by using FT 155-ADD-L-1.
	NOTE: The above steps are used only after the center grid and altitude to the minefield are determined. The following steps are considered for determining the center grid and altitude.
22	For **met + VE**, the center grid and altitude are given by the establishing agency to an accuracy of 10 meters.
23	For **observer adjust** technique, the observer would first adjust DPICM-SR graze burst data to the desired location. The FDC would then replot the target to determine an accurate grid and altitude to the center of the minefield.

NOTE: Figure 13-30 shows a completed ROF for shell ADAM.



RECORD OF FIRE

CALL FOR FIRE

Observer T03 AF [✓ FFE] S/S Tgt

Grid: 440 279

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

HIGH DENSITY, ADAM, 400x400, ATT 0700

TGT ALT 1040
-PLT ALT 1062
VI = -22

LOW ∢
FFE
BMA ≤ 800
TBL 3 2AP
⑫/AO

∢ Si ÷ 10

10m Si

△ FS

100/R

/R

20/R

HOB Corr

FIRE ORDER APPLY CONV TGPC'S, 2 AP, DNL, ③, SH ADAM, LOT DG

Df Corr

Si -5

INITIAL FIRE COMMANDS [✓ FM] MF PLT ③

Rg 4580

Cht Df

⊟ 305

Sp Instr APPLY CONV TGPC'S, DNL

Sh ADAM

Lot DG

Chg 4

Fz TI

Ti

Df

QE (300)

MTO H, ③, AJ7812

∢ T

PE$_R$

TF

In Eff

Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
OFFSET	AP#1			(DPICM DATA)		(18.1)	3232	L26	(3258)	4660		-4	311	(307)		
				(ADAM DATA)		17.7			3258					433	⑫	
OFFSET	AP#2			(DPICM DATA)		(19.2)	3300	L26	(3326)	4880		-6	330	(324)		
				(ADAM DATA)		18.8			3326					446	㉔	ADAM✓
							LOW LEVEL		WIND CORR		+9.5					
							xWIND SPEED		FROM LINE 02		x34					
							OFFSET RANGE		CORR		+323 ≈	+320				
							WIND DIRECTION		FROM LINE 02		=	5900m				
			EOM	EOM												

GFT 1/A CHG 4 LOT FG RG 4970 EL 338 TI 19.6 (M577)
TOT DF CORR L26 GFT DF CORR L20

	VI	RG	SI	GFT DF CORR	+ DRIFT	= TOT DF CORR
AP#1	-17	4470	-4	L20	L6	L26
AP#2	-27	4710	-6	L20	L6	L26

Btry 1/A

DTG 260942Z MAY 94

Tgt AJ7812

Replot Grid

Replot Alt

DA Form 4504, OCT 78

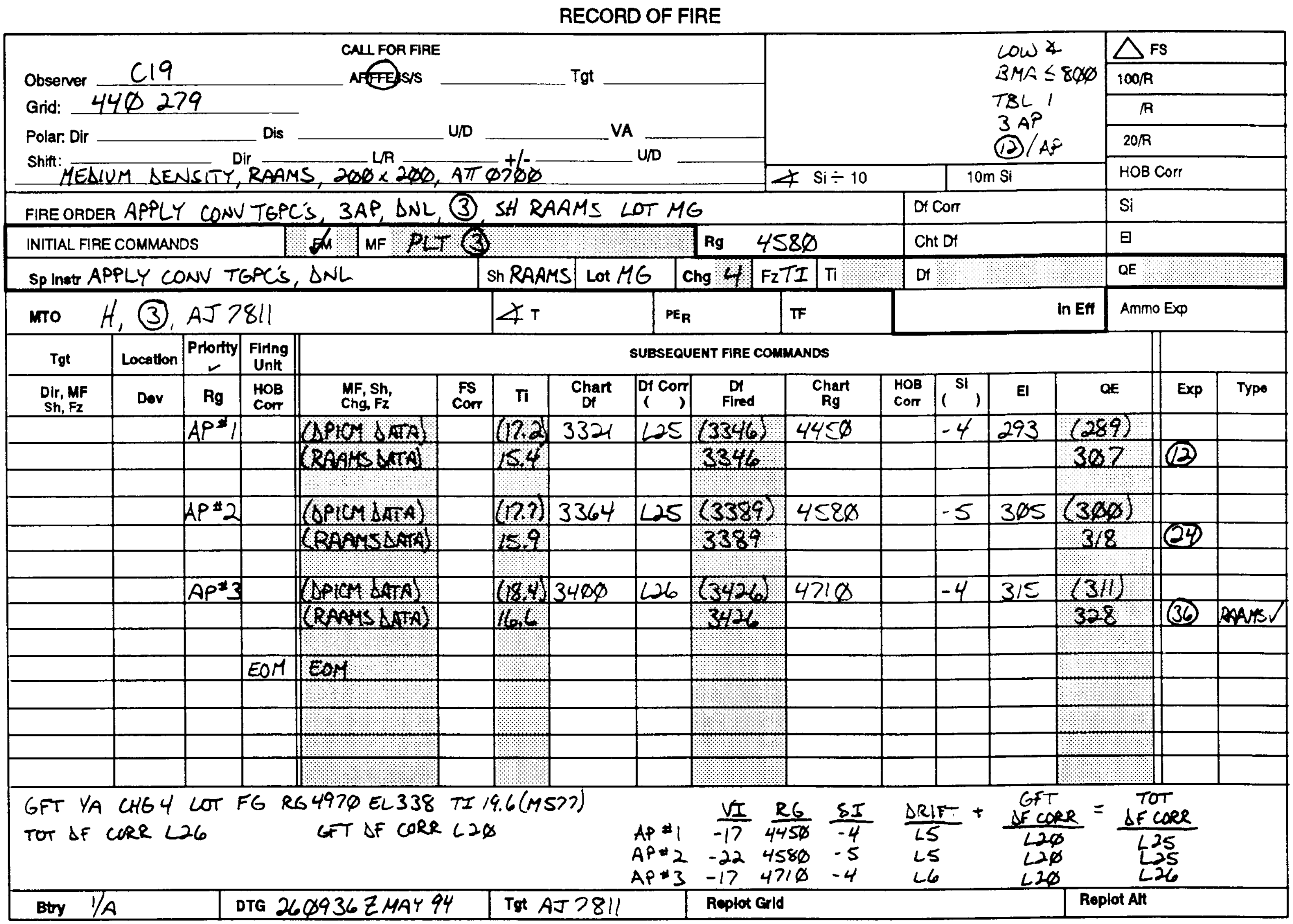
Figure 13-30. Completed ROF for Shell ADAM, Using a 155-AN-1 GFT With a GFT Setting Applied and Addendum L-1.

b. Table 13-30 shows the employment procedures for shell RAAMS.

Table 13-30. Shell RAAMS Employment Procedures.

STEP	ACTION
1	The computer records the target information on the ROF (from DA Form 5032-R or observer call for fire).
2	The HCO plots the minefield center and determines the chart range.
3	Using the target grid, the HCO sets off the minefield attitude and with the vertex at the battery location, places the RDP arm against the center point. He now determines the battery minefield angle.
4	The FDO enters the mine employment matrix to determine which employment table to use.
5	The FDO enters the appropriate mine employment table and extracts the appropriate number of aimpoints.
6	The FDO determines aimpoint spacing.
7	The FDO enters the appropriate table to determine the required number of rounds per aimpoint on the basis of the desired density.
8	The FDO issues the fire order.
9	Using the target grid along the attitude requested, the HCO plots the aimpoints.
10	The HCO determines chart range to the aimpoints.
11	The VCO determines the VI to each aimpoint and computes site.
12	The computer determines DPICM graze burst data to each aimpoint.
13	Using the DPICM graze burst fuze setting and quadrant, the computer determines the RAAMS fuze setting and quadrant from the AN-1/AN-2 GFT. **OR** The computer can determine the RAAMS fuze setting and quadrant by using the DPICM graze burst fuze setting and quadrant as entry arguments for Tables A and B of FT 155-ADD-N-1. The determined corrections are then applied to the graze burst data.
14	The computer determines firing data for shell RAAMS. The RAAMS deflection to fire is the aimpoint chart deflection plus the total deflection correction (GFT deflection correction and DPICM drift).
15	Subsequent corrections are determined by using **FT 155-ADD-N-1**.
	NOTE: The above steps are used only after the center grid and altitude to the minefield are determined. The following steps are considered for determining the center grid and altitude.
16	For **met + VE,** the center grid and altitude are given by the establishing agency to an accuracy of 10 meters.
17	For the **observer adjust** technique, the observer would first adjust DPICM-SR graze burst data to the desired location. The FDC would then replot the target to determine an accurate grid and altitude to the center of the minefield.

NOTE: Figure 13-31 shows a completed ROF for shell RAAMS.



RECORD OF FIRE

CALL FOR FIRE

Observer C19 AF [✓ FFE] S/S Tgt

Grid: 440 279

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

MEDIUM DENSITY, RAAMS, 200 x 200, AT 0700

LOW ∠ BMA ≤ 800 TBL I 3 AP ⑫/AP	△ FS
	100/R
	/R
	20/R
∠ Si ÷ 10 / 10m Si	HOB Corr
Df Corr	Si
Cht Df	El
Df	QE
In Eff	Ammo Exp

FIRE ORDER APPLY CONV TGPC'S, 3AP, DNL, ③, SH RAAMS LOT MG

INITIAL FIRE COMMANDS [✓ FM] MF PLT ③ Rg 4580

Sp Instr APPLY CONV TGPC'S, DNL Sh RAAMS Lot MG Chg 4 Fz TI Ti

MTO H, ③, AJ 7811 ∠ T PE_R TF

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
		AP#1		(DPICM DATA)		(12.2)	3321	L25	(3346)	4450		-4	293	(289)		
				(RAAMS DATA)		15.4			3346					307	⑫	
		AP#2		(DPICM DATA)		(17.7)	3364	L25	(3389)	4580		-5	305	(300)		
				(RAAMS DATA)		15.9			3389					318	㉔	
		AP#3		(DPICM DATA)		(18.4)	3400	L26	(3426)	4710		-4	315	(311)		
				(RAAMS DATA)		16.6			3426					328	㊱	RAAMS ✓
			EOM	EOM												

GFT 1/A CHG 4 LOT FG RG 4970 EL 338 TI 19.6 (M577)

TOT DF CORR L26 GFT DF CORR L20

	VI	RG	SI	DRIFT +	GFT DF CORR =	TOT DF CORR
AP#1	-17	4450	-4	L5	L20	L25
AP#2	-22	4580	-5	L5	L20	L25
AP#3	-17	4710	-4	L6	L20	L26

Btry 1/A DTG 260936Z MAY 94 Tgt AJ 7811 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure 13-31. Completed ROF for Shell RAAMS, Using a 155-AN-1 GFT With a GFT Setting Applied and Addendum N-1.

13-38. Base Burn DPICM (M864)

The M864 projectile is a dual-purpose ICM projectile that incorporates base burn technology to increase its range. Base burn technology was developed to reduce the amount of base drag on a projectile, thereby increasing the achieved range. The drag is reduced by a (base) burner unit located on the base of the projectile. Once ignited, the base burner unit bleeds hot gas which causes the flow of air at the base to be less turbulent. The decrease in turbulence causes less base drag. (Base drag accounts for about 50 percent of total drag.) The amount of thrust produced by the base burner unit is negligible and does not serve the same function as the rocket motor on RAP. (See Figure 13-32.)

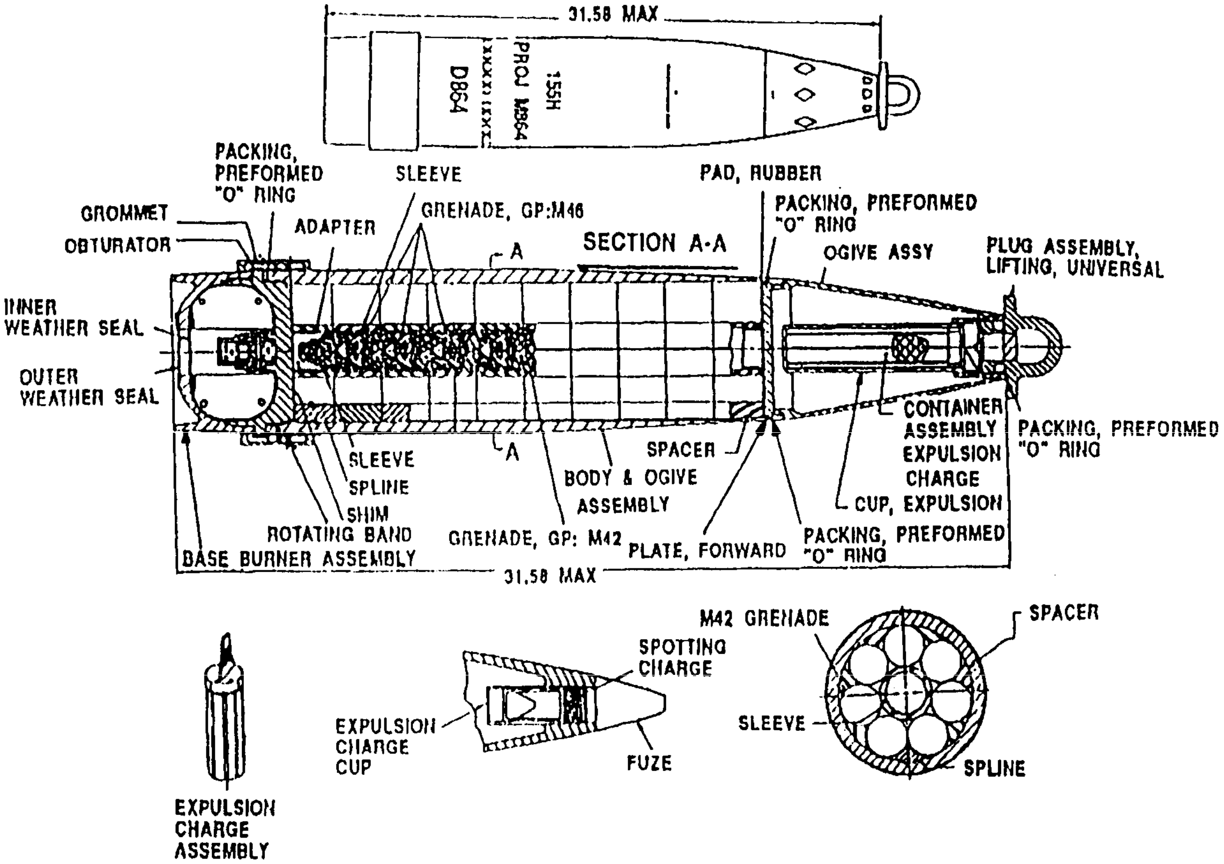


Figure 13-32. Base Burner DPICM (M864).

13-39. M864 Firing Data Computations

a. The current sources of firing data for M864 are the FT 155-AU-PAD ~~an~~d FT 155-ADD-U-PAD. There is also an M864 addendum to the FT 155-AO-0 (RAP). This is an unnamed provisional aiming data (PAD) addendum that is authorized for combat use only. It is used much in the same manner as the FT 155-ADD-R-1 is used to determine M483A1 firing data from M107 firing data.

b. The M864 projectile is not ballistically matched to any projectile currently in the inventory, but because of the similarity of the trajectories, firing data for the M864 can be determined from the M549A1 firing data. Once accurate M549A1 data are determined, corrections for the ballistic difference can be determined from a PAD addendum. The M549A1 QE, which is used to enter Table A of the addendum, can be no higher than 450 mils for charge 7WB (M4A2) or 500 mils for charges 7R (Ml19A2) and 8S (M203). These are the maximum quadrants for which data in the addendum were determined. The quadrant limitations do not allow the maximum range of M864 to be achieved with this technique. Table 13-31 shows the M864 maximum QE and Range to a target (including the desired HOB) that can be determined from M549A1 data. Table 13-32 depicts the designed M864 maximum QE and ranges. This technique can be used for both FFE missions and adjust-fire missions in which RAP is the adjusting projectile. While this technique of applying ballistic corrections to accurate M549A1 firing data has limitations in range, it represents the most accurate technique. The accuracy of this technique will be increased if used in conjunction with a RAP GFT setting.

Table 13-31. Actual M864 Maximum QEs and Range to Target.

CHARGE	M864 MAX QE	M864 MAX RANGE TO TGT
7W	571	13800
7R	581	18700
8R*	542	23900
NOTE: * = M198 or M109A5/A6 only		

Table 13-32. Designed M864 Maximum QEs and Range to Target.

CHARGE	M864 MAX QE	M864 MAX RANGE TO TGT
7W	803	17100
7R	818	21900
8R*	873	28100
NOTE: * = M198 or M109A5/A6 only		

13-40. Met to a Target

Because of the amount of time needed to work a met to a target, this technique would be best employed for planned targets. The FT 155-AU-PAD is designed in the same basic format as the FT 155-AN-2 TFT for DPICM and provides graze burst data. Once the graze burst data are determined, corrections from the FT 155-ADD-U-PAD are applied to the fuze setting deflection and quadrant to determine data to yield the appropriate HOB. If MV information has been determined with the M90 chronograph, the MVV is used as the velocity error.

NOTE: An MVV for M864 determined by calibration may not be available. The loss in muzzle velocity because of tube erosion (as determined from a recent pullover gauge reading and/or from EFC rounds) can be used as the position VE.

13-41. M864 Registrations

M864 projectiles can be fired in the SR mode by using the same procedures as for the M483A1. Because of the increased range, registrations may be difficult. Observers may have difficulty determining spottings and corrections, and radar, in the friendly fire mode, has an effective range of 14.7 kilometers.

NOTE: If a registration is conducted with the extended range dual-purpose improved conventional munitions (ERDPICM) projectile, the values for range K and fuze K would be computed in the same manner as conventional techniques.

Chapter 14

EMERGENCY FDC PROCEDURES

Field artillery units must be capable of delivering fire at all times. Requests for immediate fires may be received when the unit is moving or when the FDC is not yet set up. The loss of personnel or equipment may cause the battery to rely on some type of emergency backup procedures. The firing battery executing an emergency fire mission has two priority technical fire direction tasks:

- *Determine initial firing data to the target.*
- *Prepare for determination of subsequent data on the basis of the observer's corrections.*

14-1. Methods of Determining Initial Data

The first priority is to compute initial data, announce it to the piece, and fire a round. Depending on the call for fire, the XO or FDC may accomplish this by using one of several methods:

a. Adjust Fire. The platoon leader determines direction and range to the target grid location from the map-spotted platoon location. This is done most rapidly by using a map and a range-azimuth fan of the correct scale (Figure 14-1). The platoon leader directs that the platoon be laid on the azimuth to the target, or he may orient the base piece himself by using the howitzer backlay method or a distant aiming point. If he has time, the platoon leader should lay the base piece with an aiming circle. The platoon leader selects a charge, or uses the standard charge, and converts the range to an elevation. The initial firing data are announced to the piece(s).

(1) Deflection equals the common deflection for the weapon system in use.

(2) QE equals elevation corresponding to range to target (GFT, TFT, and so on). Site is ignored unless it is excessively large. The FDO or platoon leader is responsible for analyzing the terrain in the target area and checking intervening crests to determine if he should include site.

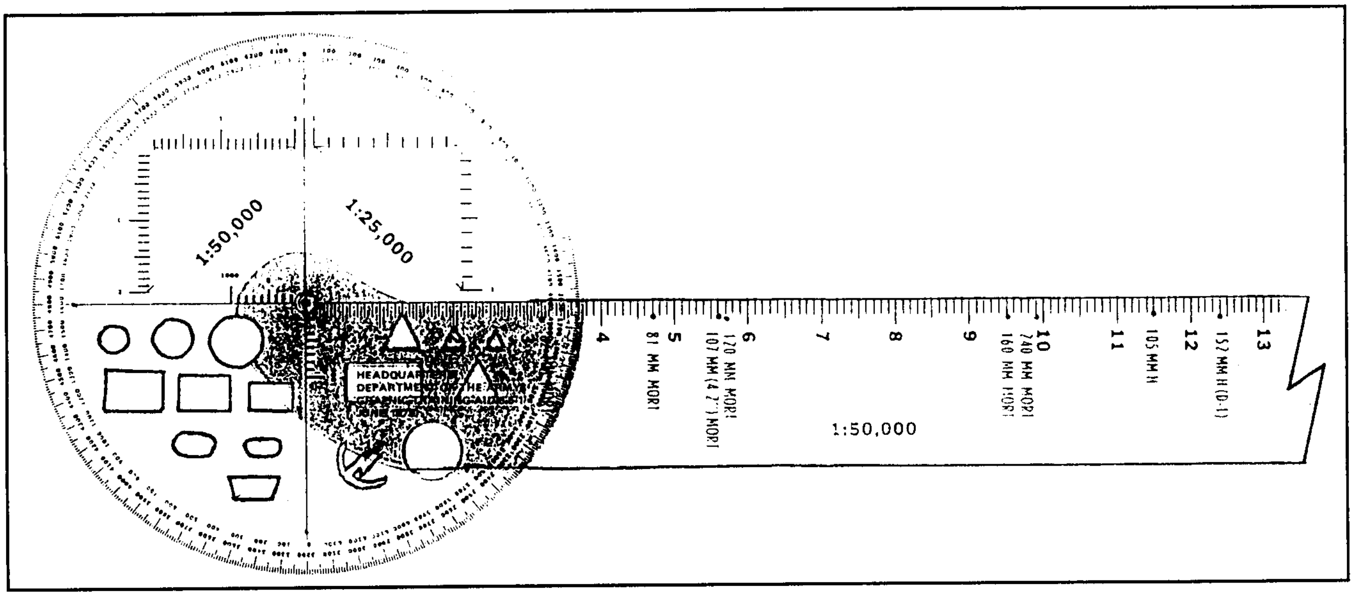


Figure 14-1. Range-Azimuth Fan.

b. Mark Center of Sector. This is requested when the observer is not oriented to the terrain. The platoon leader determines direction and range to the center of the supported unit's zone of action from the map-spotted battery location.If the platoon leader is not sure of the situation or the location of the sector center or if he feels a center of sector round may be unsafe, a white phosphorus with fuze time for an airburst should be fired. The platoon leader directs that the platoon be laid on the azimuth he determines to the sector center. The platoon leader determines the elevation corresponding to the range and charge. The initial firing data are announced to the piece.

(1) For a WP or an HE high airburst, the trajectory is raised to a 200-meter HOB by using the100/R factor. The FS corresponding to the initial elevation is used. The error introduced by a vertical interval greater than 100 meters is ignored.

(2) If shell HC smoke or WP is requested, HE data are fired without making corrections for projectile weight. For shell HC smoke, the time fuze setting to fire is determined by subtracting 2 seconds from the FS corresponding to the HE elevation.

NOTE: A grid location is preferred over mark center of sector because the first round fired engages the target directly.

14-2. Methods of Determining Subsequent Data

After the initial fire commands are announced, emergency equipment must be prepared to convert the observer's corrections into subsequent fire commands. There are several expedient means of obtaining subsequent data that are available to the XO. He or the FDO must be able to quickly convert observer corrections into firing data.

a. Emergency Firing Chart. Use of the emergency firing chart to adjust fire is discussed in paragraph 14-3.

b. M10 or M17 Plotting Board. Use of the Ml 0 or Ml 7 plotting board to adjust fire is discussed in paragraph 14-4.

c. Black Magic. If no other means of adjusting fire is available, the Black Magic technique may be used as a last resort. Certain information must be available, as detailed in paragraph 14-5.

14-3. Emergency Firing Chart

a. The emergency firing chart employs the same basic techniques as observed firing charts. Establish location and direction by using the relationship between the firing unit and its targets. The relationship is determined by firing and will contain errors. The emergency chart is only a temporary expedient to be used until a surveyed chart can be constructed.

b. The emergency chart may be constructed on any surface suitable for plotting (can accommodate an RDP and plotting pins).

c. Use Table 14-1 to construct an emergency firing chart.

Table 14-1. Emergency Firing Chart Procedures.

STEP	ACTION
1	Determine the azimuth and range to the target or center of sector.
2	Announce deflection 3200, the common deflection, to fire.
3	From the range determined in step 1, determine the elevation corresponding to the charge and range. This will be the QE to fire. If time permits or the situation dictates, determine and add site to the elevation determined above. This will be the QE to fire.
4	Place the RDP in the middle of the plotting surface.
5	Orient the RDP in the general azimuth of fire, as announced by the FDO, XO, or platoon commander.
6	Place a pin in the vertex of the RDP. This pin represents the location of the platoon. (See Figure 14-2 on page 14-5.)
7	Without moving the RDP, establish the primary deflection index by placing a pin opposite the graduation on the arc of the RDP that represents the common deflection. (See Figure 14-3 on page 14-6.)
8	Insert a pin through the center of the target grid.
9	Without moving the RDP, place the pin from step 8 opposite the range to the center sector or the range to the target.
10	Move the RDP and allow the target grid to rest on the plotting surface. Keep the vertex of the RDP at the platoon location.
11	Move the RDP until the arm is against the pin marking the center sector or target location. The arm of the RDP should be on top of the target grid.
12	Align the arrow (0-3200 line) on the target grid so that it is parallel to the arm of the RDP. The head of the arrow on the target grid should point away from the vertex of the RDP along the GT line. (See Figure 14-4 on page 14-7.)
13	Place a pin opposite the target grid graduation corresponding to the azimuth of fire (from step 1 above). This pin represents a north index for the target grid and graphically shows the relationship between grid north and the azimuth of fire. (See Figure 14-4.)
14	Move the RDP away from the target grid.
15	Rotate the target grid until the announced observer's target direction is opposite the north index pin. The target grid is now properly oriented for the plotting of the observer's subsequent corrections. After the target grid is oriented, at least two pins should be inserted in the target grid at all times. Angle T is measured in the normal fashion. (See Figure 14-5 on page 14-8, which shows a target oriented on observer direction 0250.)
16	Plot the left or right correction given by the observer by measuring the appropriate number of squares left or right of the pin in the center sector or target location. Each square on the target grid represents 100 meters and can be visually interpolated to the nearest 10 meters.
17	Plot the add or drop correction given by the observer by measuring the appropriate number of grid squares **UP** or **DOWN** along the observer's direction from the point plotted in step 16 above. Place a pin in this location.
18	Move the RDP so that the arm is against the pin from step 17.
19	Determine and announce the range opposite the pin to the nearest 10 meters. The platoon designation is announced first followed by the range. For example, 1/A range 3400 would be announced as **ONE ALPHA RANGE THREE FOUR HUNDRED.**
20	Determine and announce the chart deflection from the arc opposite the pin marking the primary deflection index to the nearest mil. For example, **deflection 3280** would be announced as **DEFLECTION THREE TWO EIGHT ZERO.**
21	The deflection announced to the firing piece(s) is the chart deflection.
22	The QE announced to the firing piece(s) is the elevation corresponding to the announced range plus site (if previously included in the mission).

Table 14-1. Emergency Firing Chart Procedures (Continued).

STEP	ACTION
23	Repeat steps 16 through 22 for all subsequent corrections, to include the observer's final refinement.
24	After plotting the observer's final refinement, determine the final chart range and deflection.
25	Remove the plotting pin marking the final adjusted location, and construct and label a tick mark to mark this location. The tick mark should be constructed with a red pencil since the target was located by firing.
26	Remove the pin at the platoon location, and construct and label a tick mark to mark this location.
	NOTE: A permanent north index will be constructed.
27	Orient the target grid, with the pin in the middle, and RDP over the final adjusted location as in steps 5 through 9.
28	Determine the azimuth to the final pin location by comparing the initial deflection to the final deflection. Apply the difference to the azimuth of fire from step 2. If the change in deflection is left, subtract its value from the direction of fire. If the change in deflection is right, add its value to the azimuth of fire. **FINAL DEFLECTION 3257** **INITIAL DEFLECTION 3200** **CHANGE IN DF L57 (INITIAL TO FINAL)** **AZIMUTH OF FIRE 0820** **+ CHANGE IN DF (RALS) L57** **AZIMUTH TO TARGET 0763**
29	Remove the old north index pin, and place it opposite the graduation on the target grid corresponding to the value determined in step 28. This pin represents the new grid north index.
30	Align the arm of the RDP with the pin in the target location and the north index pin, and construct a permanent north index. Remove the north index pin. Use a 6H pencil to construct a line along the left-hand edge of the arm beginning at the north index pinhole and extending out 1 inch. Using a 4H pencil, label the line "N." The labeling should be done immediately above the end of the line.
31	Replace the pin representing the temporary 3000 deflection index with a permanent deflection index.
	NOTE: If it appears the firing unit will remain in this position for a sustained period of time, a surveyed firing chart should be constructed.

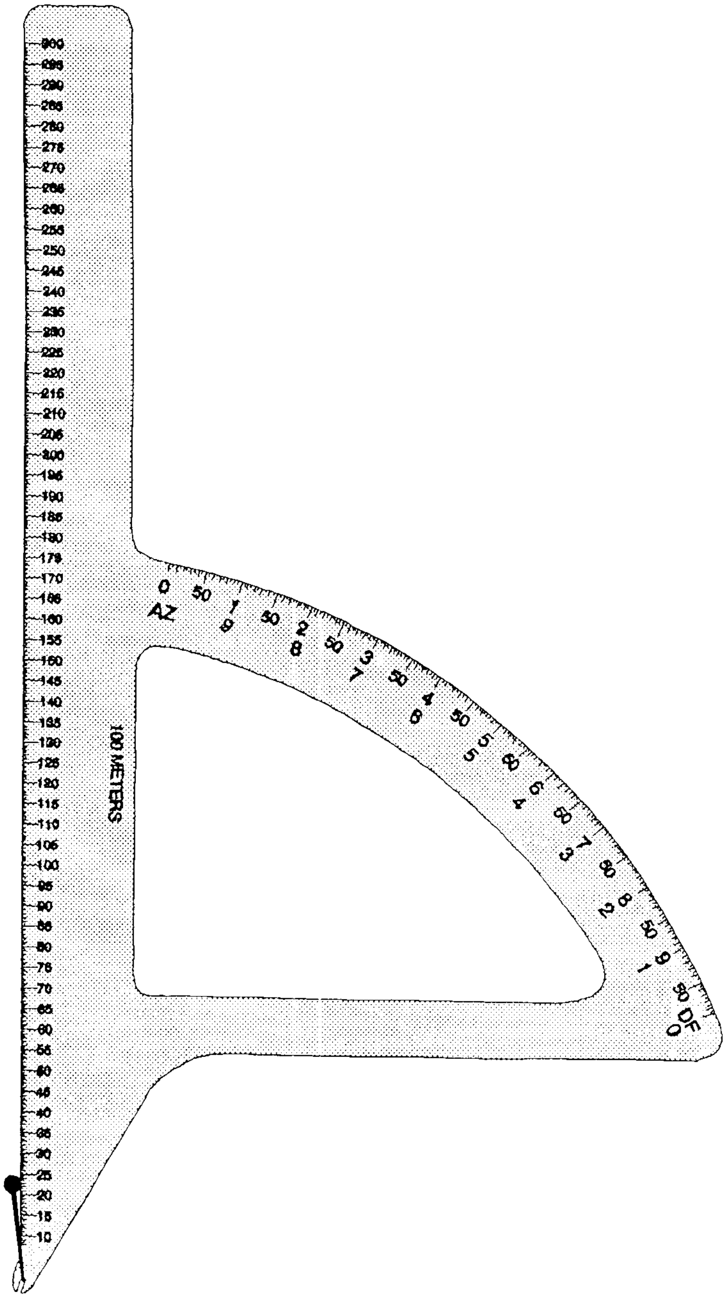


Figure 14-2. Platoon Location.

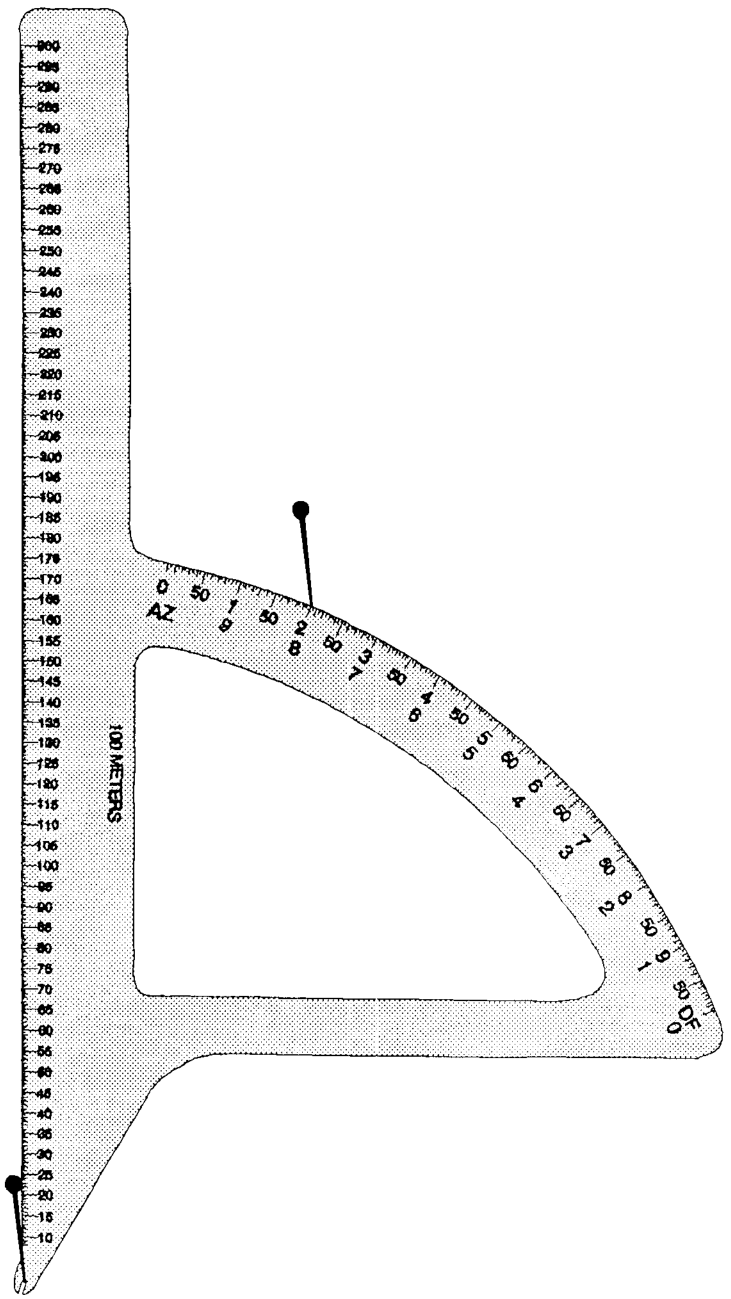


Figure 14-3. Common Deflection 3200.

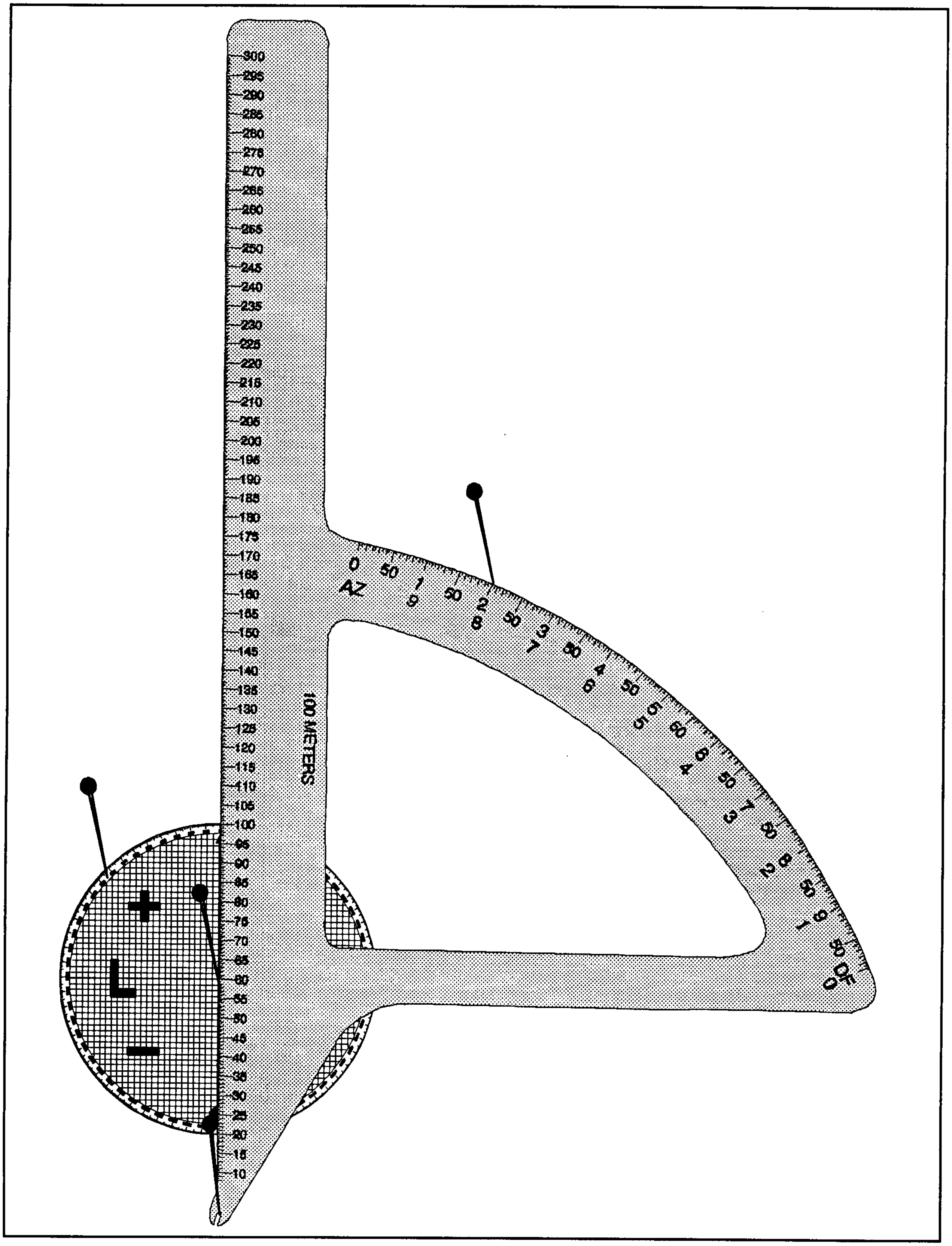


Figure 14-4. RDP With the Target Grid Oriented.

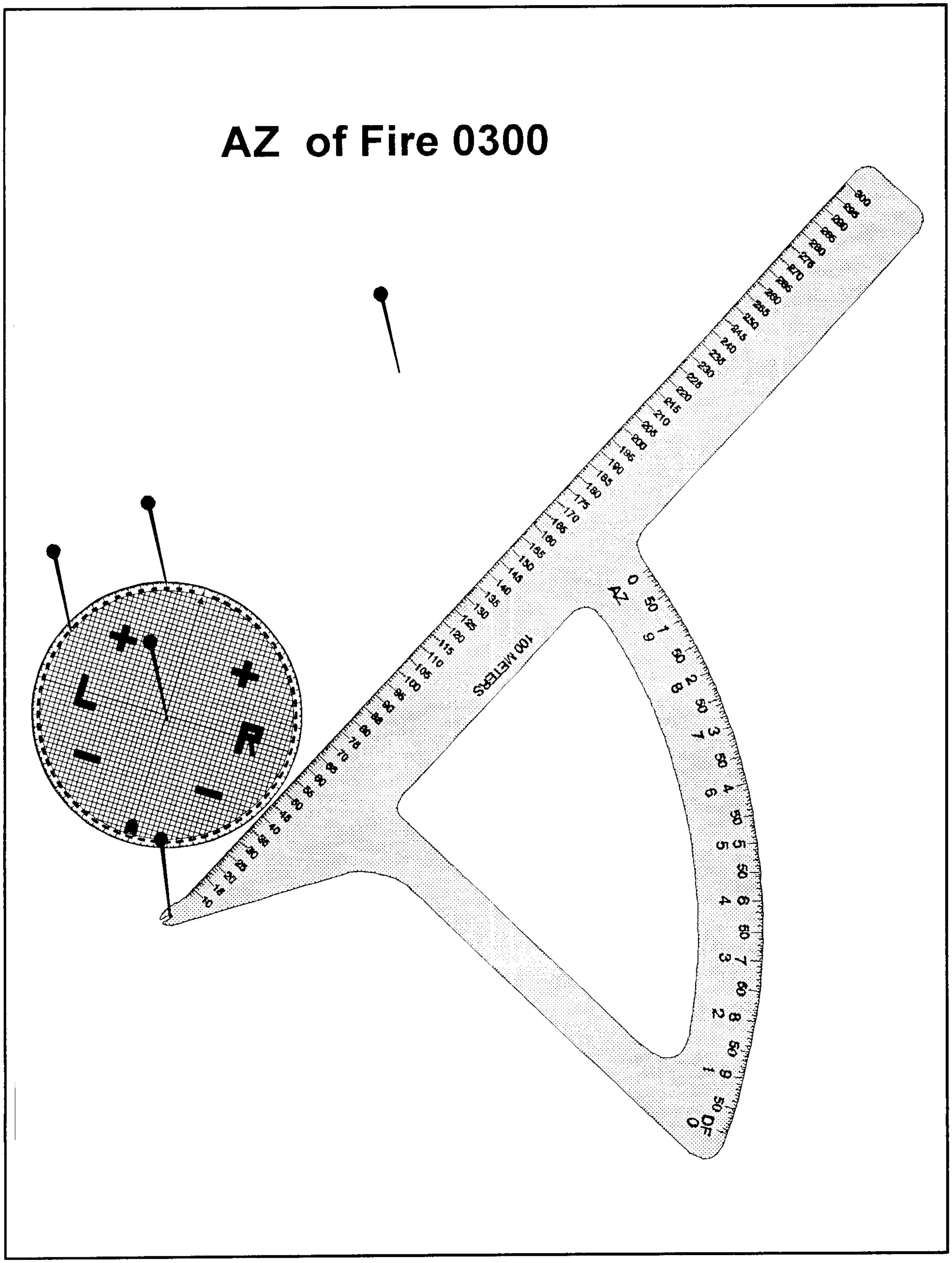


Figure 14-5. Target Oriented on Observer Direction.

14-4. M10 or M17 PLOTTING BOARD

a. The M10 or M17 plotting board may be used for determining data for subsequent corrections in place of an emergency firing chart. Once prepared, observer corrections along the OT line can be converted to corrections along the GT line. For this procedure, the rivet (center) of the plotting board represents the location of the last burst.

b. Use Table 14-2 to determine data for subsequent corrections in place of an emergency firing chart.

Table 14-2. M10 or M17 Plotting Board Procedures.

STEP	ACTION
1	Place a mark on the clear plastic disk opposite the number on the outer scale that corresponds to the OT direction. Label it "O."
2	Place a mark on the clear plastic disk opposite the number on the outer scale that corresponds to the GT direction. Label it "GT."
3	Determine angle T by comparing the OT direction to the GT direction. Angle T is represented by the angle formed by the OT direction and the GT direction.
	NOTE: Following normal adjust-fire procedures, the observer will determine and announce his subsequent corrections.
4	Rotate the clear plastic disk until the mark representing the OT direction is over the red arrow on the base. The plotting board is now oriented in the OT direction.
5	Plot the observer's deviation correction on the clear plastic disk.
6	Plot the observer's range correction on the clear plastic disk, and mark this location.
	NOTE: The observer's corrections should be plotted in reference to the rivet (center). If possible, the scale used should be 10 meters. This will allow for rapid conversion of OT corrections to GT corrections.
7	Rotate the disk until the GT mark is over the red arrow. The plotting board is now oriented on the GT line.
8	Determine the GT deviation correction by measuring the number of meters the location marked in step 6 is left or right of the rivet (center).
9	Determine the GT range correction by measuring the number of meters the location marked in step 6 is above or below the rivet (center).
10	Determine 100/R by dividing the 100 by the initial range to the target (in thousands), and express the result to the nearest mil. **100/R = 1/RANGE (in thousands)**
11	Determine the correction to deflection by multiplying the GT deviation correction (step 8) by 100/R (step 10) and dividing the product by 100. Express the result to the nearest 1 mil.
12	Determine and announce the deflection to fire by applying the correction to deflection (step 11) to the last deflection fired.
13	Determine the range to fire by applying the GT range correction to the last range fired.
14	Using standard procedures, determine the elevation to fire from the GFT (with or without a GFT setting).
15	Determine and announce QE by applying site (if previously included) to the elevation to fire (step 14).
	NOTE: There are two methods for determining new elevation. The first option is to use the new range determined in step 13 as the entry argument (arg) to determine elevation. The second option is to divide the value of the GT range correction determined in step 9 by the change in range per 1-mil change in elevation corresponding to the last range fired (TFT, Table F, Column 5). Add this value to the last elevation fired to determine the new elevation.

Table 14-2. M10 or M17 Plotting Board Procedures (Continued).

STEP	ACTION
	EXAMPLE **FIRED RANGE 5000 CHG 4GB EL 304** **RG CORR +100** **ENTRY ARG RG 5100 = EL 312.3 ≈ EL 312** **OR** **ENTRY ARG RG 5000 EL 304.5 DR PER 1 MIL D EL 13** **RG CORR 100/DR R/1MIL D EL = 7.7 + 304.5 = 312.2 ≈ EL 312**

14-5. Black Magic

a. Black magic can be used to determine both initial firing data and firing data that are based on subsequent corrections. This technique can be done by FDC personnel or the observer and should only be used as a last resort.

b. Table 14-3 gives the steps for the Black Magic procedure.

Table 14-3. Black Magic Procedures.

STEP	ACTION
1	Estimate the range from the unit to the target.
2	Determine the charge by use of the following rules:
2a	**105-mm**. charge equals range in thousands plus 1; for example, for range 4000, the charge is 5.
2b	**155-mm**. Charge equals range in thousands; for example, for range 5000, the charge is 5.
2c	**203-mm.** Charge equals range in thousands minus 1; for example, for range 5000, the charge is 4.
3	Determine the deflection to the target by converting the azimuth to the target into deflection. You must know the azimuth of lay of the firing unit.
	AZ OF LAY 0050 **AZ TO TGT 0150** **DIFF R100 MILS (RALS RULE APPLIES)** **COMMON DF OF WEAPON SYSTEM 3200** **DIFF IN AZ TO TGT R100** **DEFLECTION TO TGT 3100 (LARS RULE APPLIES)**
4	Determine the fuze setting to fire by estimating time of flight. If you are adjusting, use a stopwatch to determine time of flight.
	NOTE: If standard muzzle velocity is known for charge, divide the range to target by the MV to determine fuze setting.
5	Fire quadrant 240 (standard quadrant; site is ignored).
	NOTE: Use common sense. If you have been firing a greater quadrant at the same range, use that quadrant.

c. Subsequent corrections are processed by using the steps in Table 14-4.

NOTE: Subsequent corrections are made with respect to the GT line.

Table 14-4. Processing Subsequent Corrections Using Black Magic.

STEP	ACTION
1	Determine 100/R. 100/R equals 100 divided by the range in thousands and the result expressed to the nearest hundred.
2	Determine the correction in deflection. The correction in deflection, in mils, equals the change in meters (divided by 100) times 100/R.
3	Determine the deflection to fire by applying the correction to deflection to the last deflection fired.
4	Determine ▲ FS by dividing 2 by the initial fuze setting. Express the result to the nearest 0.01 fuze setting increment (▲FS = 2/FS).
5	Determine the FS correction by multiplying ▲FS by the observer's HOB correction divided by 10. Express the result to the nearest 0.1 FS increment. If the HOB correction is an up, the correction is a minus. If the HOB correction is a down, the correction is a plus.
6	Determine the fuze setting to fire by applying the FS correction to the last FS fired.
7	Determine the number of mils change to QE that will give a 100-meter range change (C-factor) (see Table 14-5).
	(C-FACTOR) x (RG CORR ÷ 100) = CHANGE IN ELEVATION
	NOTE: Change in quadrant is expressed in mils. Range change is expressed in hundreds of meters.
8	Determine the QE to fire by applying the change to QE to the last QE fired.

Table 14-5. Black Magic Technique.

WEAPON SYSTEM	R	CHG	C-FACTOR	INITIAL QE	100/R
105-mm M101A1	Range in 1,000s	R +1	13–Chg	240	100 ÷ R
105-mm M102	Range in 1,000s	R + 1	12–Chg	240	100 ÷ R
155-mm M114A1	Range in 1,000s	R	12–Chg	240	100 ÷ R
155-mm M109/M114A2	Range in 1,000s	R	11–Chg	240	100 ÷ R
155-mm M109A1 M198	Range in 1,000s	R	11–Chg	240	100 ÷ R
8-inch M110/M110A1	Range in 1,000s	R - 1	10–Chg	240	100 ÷ R

NOTE: The Black Magic technique is only valid for charges 3, 4, and 5 of the listed weapon systems. The technique uses the following steps:

- Conduct a GT line adjustment.
- Compute subsequent data.
- Multiply lateral deviation in hundreds of meters, to the nearest 10 meters, by 100/R at initial estimated range. The result is the correction to the previous deflection, in mils.
- Multiply the range change in hundreds of meters by the C-factor. The result is the correction to QE, in mils.
- For time fuze, apply 20/R to the QE. Estimate the initial fuze setting. Adjust HOB arbitrarily.
- Divide 2 by the FS. The result is ▲FS.

14-6. Emergency Firing Chart Example

a. You receive a call for fire while traveling to your next position. From a map spot, you determine the range to the target to be 4200 and the direction to be 4950.

b. Use Table 14-6 to process the mission.

Table 14-6. Emergency Fire Mission.

STEP	ACTION
1	Determine the azimuth and range to the target or center of sector. On the basis of the range, determine the charge to fire **(range 4200, direction 4950, charge 4GB)**.
2	Announce deflection **3200**, the common deflection, to fire.
3	From the range determined in step 1, determine the elevation corresponding to the charge and range. This will be the QE to fire. If time permits, determine site and add site to the elevation determined. The result will be the QE to fire **(QE = EL of 246). Announce QE 246 to the howitzer(s)**.
4	Place the RDP in the middle of the plotting surface.
5	Orient the RDP in the general azimuth of fire as announced by the FDO, XO, or *platoon commander* **(direction 4950)**.
6	Place a pin in the vertex of the RDP. This pin represents the location of the firing unit.
7	Without moving the RDP, establish the primary deflection index by placing a pin opposite the graduation on the arc of the RDP that represents the common deflection **(deflection 3200)**.
8	Insert a pin through the center of the target grid.
9	Without moving the RDP, place the pin from step 5 opposite the range to the center of sector or the range to the target **(range 4200)**.
10	Move the RDP, and allow the target grid to rest on the plotting surface. Keep the vertex of the RDP at the firing unit location.
11	Move the RDP until the arm is against the pin marking the center of sector or target location. The arm of the RDP should be on top of the target grid.
12	Align the arrow (0-3200 line) on the target grid so that it is parallel to the arm of the RDP. The head of the arrow on the target grid should point away from the vertex of the RDP along the GT line.
13	Place a pin opposite the target grid graduation corresponding to the azimuth of fire (from step 2 above). This pin represents a north index for the target grid and graphically shows the relationship between grid north and the azimuth of fire. **Place the pin at 4950**.
14	Move the RDP away from the target grid.
15	Rotate the target grid until the announced observer target direction is opposite the north index pin. **Observer announces DIRECTION 0250**. The target grid is now properly oriented for the plotting of the observer's subsequent corrections. After the target grid is oriented, at least two pins should be inserted in the target grid at all times. Angle T is measured in the normal fashion.
16	Plot the left or right correction given by the observer by measuring the appropriate number of squares left or right of the pin in the center of sector or target location. Each square on the target grid represents 100 meters and can be visually interpolated to the nearest 10 meters **(right 200, drop 500)**.
17	Plot the add or drop correction given by the observer by measuring the appropriate number of grid squares up or down from the point plotted in step 13 above. Place a pin in this location.
18	Move the RDP so that the arm is against the pin from step 14.

Table 14-6. Emergency Fire Mission (Continued).

STEP	ACTION
19	Determine and announce the range to the nearest 10 meters. The unit designation is announced first followed by the range **(1/A range 4080) (ONE ALPHA RANGE 4080).**
20	Determine and announce the chart deflection from the arc opposite the pin marking the primary deflection index **(DEFLECTION 3328).**
21	The QE announced to the howitzer(s) is the elevation corresponding to the announced range plus site (if previously included in the mission) **(QE = EL OF 237). Announce QE 237 to the howitzer(s).**
22	Repeat steps 13 through 20 for all subsequent corrections, to include the observer's final refinement. Obsr Subsequent Corr: **Right 50, add 100** Firing Data: **1/A range 4020, df 3307, QE 233** Obsr Subsequent Corr: **Add 50, fire for effect** Firing Data: **1/A range 4000, df 3284, QE 232** Obsr Final Refinement: **Left 20, drop 20, record as target**
23	After plotting the observer's final refinement, determine the final chart range and deflection. **Chart data are 1/A range 4020, deflection 3289.**
24	Remove the plotting pin marking the final adjusted location, and construct and label a tick mark to mark this location. The tick mark should be constructed with a red pencil, since the target was located by firing.
25	Remove the pin at the firing unit location, and construct and label a tick mark to identify this location.
	NOTE: A permanent north index will be constructed.
26	Orient the target grid, with the pin in the middle and RDP over the final adjusted location, as in steps 5 through 9.
27	Determine the azimuth to the final pin location by comparing the initial deflection to the final deflection. Apply the difference to the azimuth of fire from step 2. If the change in deflection is left, subtract its value from the direction of fire. If the change in deflection is right, add its value to the azimuth of fire.
	EXAMPLE **FINAL DEFLECTION 3299** **INITIAL DEFLECTION 3200** **CHANGE IN DF L99 (INITIAL TO FINAL)** **AZIMUTH OF FIRE 4950** **+ CHANGE IN DF L99 (RALS)** **AZIMUTH TO TARGET 4851**
28	Place a pin opposite the graduation on the target grid corresponding to the value determined in step 27. This pin represents the new grid north index.
29	Remove the old north index pin.
30	Align the arm of the RDP with the pin in the target location and the north index pin.
31	Remove the north index pin.
32	Beginning at the north index pinhole, draw a line along the left-hand edge of the arm and extend the line out 1 inch. Using a 4H pencil, label the line "N." The labeling should be done immediately above the end of the line.
33	Replace the pin representing the temporary 3000 deflection index with a permanent deflection index.
	NOTE: If it appears the unit will remain in this position for a sustained period of time, a surveyed firing chart should be constructed.

14-7. Black Magic Example

a. You receive a call for fire against a platoon of infantry in a trench line. You estimate the range to be 3,400 meters and the direction of fire to be 4750. The observer requests time in effect.

b. Use Table 14-7 to process the mission.

Table 14-7. Black Magic Fire Mission.

STEP	ACTION
1	Estimate the range from the firing unit to the target **(range 3400)**.
2	Determine the charge by use of the following rules:
2a	**105-mm.** Charge equals range, in thousands, plus 1; for example, for range 4000, the charge is 5.
2b	**155-mm.** Charge equals range, in thousands; for example, for range 5000, the charge is 5.
2c	**203-mm.** Charge equals range, in thousands, minus 1; for example, for range 5000, the charge is 4.
3	Determine the deflection to the target by converting the azimuth to the target into deflection. You must know the azimuth of lay of the firing unit.
	AZ OF LAY 4800 **- AZ TO TGT 4750** **DIFFERENCE +50 MILS** **REF DF OF WEAPON SYSTEM 3200** **+ DIFF IN AZ TO TGT L50 (LARS RULE APPLIES)** **DEFLECTION TO TGT 3250**
4	Fire quadrant 240 (standard quadrant; site is ignored).
	NOTE: Use common sense. If you have been firing a greater quadrant at the same range, use that quadrant. If standard muzzle velocity is known for charge, divide the range to target by the MV to determine fuze setting.
	NOTE: Subsequent corrections are made with respect to the GT line. **Observer subsequent corrections are left 300, add 600.**
5	Determine 100/R. 100/R equals 100 divided by the range, in thousands, and the result expressed to the nearest hundred. **100/R = 100 ÷ 3.4 = 29.4 ≈ 29**
6	Determine the correction to deflection. Correction to deflection, in mils, equals the change in meters (divided by 100) times 100/R. **(300/100) x 29 = 87**
7	Determine the deflection to fire by applying the correction to deflection to the last deflection fired.
	LAST DF FIRED 3250 **+ DF CORR L87** **DF TO FIRE 3337**
8	Determine the FS correction by multiplying FS by the observer's HOB correction divided by 10. Express the result to the nearest 0.1 FS increment. If the HOB correction is an up, the correction is a minus. If the HOB correction is a down, the correction is a plus.
9	Determine the fuze setting to fire by applying the FS correction to the last FS fired.

Table 14-6. Emergency Fire Mission (Continued).

STEP	ACTION
10	Determine the number of mils change to QE that will give a 100-meter range change (C-factor). (See Table 14-5.) **(C-FACTOR) X (RG CORR ÷ 100) = CHANGE IN EL** **C-FACTOR = 11 - CHG = 11 - 3 = 8** **C-FACTOR (8) X RANGE CHANGE IN HUNDREDS (+6) = +48**
	NOTE: Change in quadrant is expressed in mils. Range change is expressed in hundreds of meters.
11	Determine the QE to fire by applying the change to QE to the last QE fired. **LAST QE FIRED 240** **+ CHANGE TO QE +48** **QE TO FIRE 288** **Observer subsequent corrections are right 50, drop 200.** **(R50 ÷ 100) x 29 = R14** **LAST DF FIRED 3337** **+ CORRECTION R14** **DF TO FIRE 3323** **(DROP 200 ÷ 100) X C-FACTOR (8) = QE CORRECTION (-16)** **LAST QE FIRED 288** **+ QE CORRECTION -16** **QE TO FIRE 272** **Observer subsequent corrections are fuze time, drop 50.**
12	Determine the fuze setting to fire by estimating time of flight. If you are adjusting, use a stopwatch to determine time of flight. **From the stopwatch, the TOF is 12.0. The M582 time to fire equals 12.0.** **DROP 50 20/R = 20 ÷ 3.4 = 6** **(-50 ÷ 100) X C-FACTOR (8) = -4**
	LAST QE FIRED 272 **+ QE CORRECTION -4** **+ 20/R +6** **QE TO FIRE 274**
13	Determine ▲FS by dividing 2 by the initial fuze setting. Express the result to the nearest 0.01 FS increment **(2 ÷ FS =▲FS)**. **2 ÷ 12.0 = 0.17**
14	Determine the FS correction by multiplying ▲FS by the observer's HOB correction divided by 10. Express the result to the nearest 0.1 FS increment. If the HOB correction is an up, the correction is a minus. If the HOB correction is a down, the correction is a plus. **Observer subsequent corrections are down 20, fire for effect.** **▲ FS 0.17** **x HOB CORR 20** **÷ 10 10** **FUZE CORR +0.3**

Table 14-6. Emergency Fire Mission (Continued).

STEP	ACTION
15	Determine the fuze setting to fire by applying the FS correction to the last FS fired. **LAST FS FIRED 12.0** **+ FS CORR +0.3** **FS TO FIRE 12.3**
	The firing data transmitted to the howitzers are: ● Time: 12.3 ● Df: 3323 ● QE: 274

Chapter 15

SAFETY

AR 385-63 (MCOP3570.1A), Chapter 11, implements the chain-of command safety concept. Under this concept, the firing battery chain of command is responsible for safety during firing, training, and combat. This chapter reinforces AR 385-63. However, if local range regulations are more restrictive than the material in this chapter, the local range regulations must be followed.

Section I

Responsibilities and Duties

This section describes safety responsibilities, the duties of safety personnel, and the safety aids used by those personnel.

15-1. Responsibilities

a. Commanders of Field Artillery Units. Commanders establish and maintain a safety training and certification program for their personnel. The purpose of this program is to train and qualify personnel of the firing battery in the safety procedures for their specific areas of responsibility. When the commander is satisfied that the personnel are qualified to perform the safety duties as required, he certifies them.

b. Battalion Commander. The FA battalion commander is responsible for safety during all phases of a firing exercise under his control. He selects, trains, and certifies the personnel needed to help him discharge this responsibility. These personnel include, but are not limited to, the following:

- Battery commander.
- Executive officer.
- Fire direction officer.
- XO or platoon leader.
- Chief of firing battery.
- Gunnery sergeant.
- FDC chief computer.
- Howitzer section chief.

If any position is not filled by a command safety-certified individual, another individual who is certified and qualified to fill that position performs the safety checks.

c. Officer in Charge. The officer in charge (OIC) is the battery commander or his command safety-certified representative. The OIC is responsible for all aspects of safety in the firing unit and on the assigned firing range. Before the firing exercise, the range officer provides the OIC with the required safety data and any firing limitations. The OIC verifies that the unit is in the proper firing position. He supervises the conversion of the safety data into a safety diagram and ensures that this diagram is verified by another command safety-certified individual. The safety data determined from the safety diagram provide right and left deflection limits, minimum and maximum quadrant elevations for authorized charges, and minimum safe fuze times. The safety T, modified as needed by the XO's minimum QE, is given to the appropriate members of the firing battery.

d. XO or Platoon Leader. The XO or platoon leader is responsible for the safety practices of the firing element. He ensures that the section chiefs have safety data. He is responsible for determining the lowest QE that can be fired safely from his firing position and will ensure that projectiles clear all immediate crests (XO's minimum QE). He is assisted by the FDO, the platoon sergeant, and/or the gunnery sergeant.

e. Fire Direction Officer. The FDO has primary responsibility for computing safety data and for ensuring that all safety data are updated after registrations and receipt of current met data. He is responsible for plotting the impact area on a map or chart in the FDC. He is assisted in his duties by the chief computer. He ensures that all firing data are within prescribed safety limits before they are sent to the firing sections. He is responsible for adjusting minimum QE for intervening crests.

f. Platoon Sergeant. The platoon sergeant helps the XO or platoon leader in his duties and must be prepared to perform many of the duties in his absence. His main responsibilities are laying the battery, performing the duties of the XO or platoon leader, and working in shifts with the XO or platoon leader.

g. Howitzer Section Chief. The section chief is responsible for supervising all practices that take place at or near his weapon. These include verifying that the announced safety data are applied to his weapon and that the proper charge, fuze, and projectiles are fired. He has the final responsibility for the firing of his weapon.

h. Range Officer. The range officer gives the OIC of the firing unit the following safety data:

- Grid coordinates of the firing position.
- Lateral safety limits.
- Minimum and maximum ranges.
- Authorized ammunition to be fired (fuze, projectile, and charge).
- Maximum ordinate (high angle or low angle).
- Hours during which firing is conducted.

15-2. Duties of Safety Personnel

In accordance with AR 385-63 (MCOP3470.1A), a separate battery safety officer is not required during the firing of field artillery. Normally, the XO or platoon leader performs this function. The XO or platoon leader is not required to verify all data placed on the on-carriage fire control equipment. He may rely on safety stakes, safety tape, or physical constraints on the weapon to ensure that the safety limits are not exceeded. All key personnel must be thoroughly familiar with six references:

- AR 385-63 (MCOP3570.1A).
- FM 6-40.
- FM 6-50.
- TM 43-0001-28.
- Appropriate TM for the weapon.
- Local range regulations.

In case of conflict, the most restrictive, usually local range regulations, takes precedence.

NOTE: The following are guidelines that can help units develop SOPs.

a. Specific duties of safety personnel before firing are, but are not limited to, the following:

(1) Verify that the data the range officer gives the OIC apply to the unit firing, that the unit is in the correct location, and that the data are correct. (OIC and safety officer)

(2) Compute and verify the safety diagram (at least two safety-certified personnel. (normally XO or platoon leader and FDO)

(3) Check DA Form 581 (Request for Issue and Turn-in of Ammunition) and the range safety card to ensure that only authorized ammunition is fired. (XO or platoon leader or platoon sergeant)

(4) Ensure that no safety violations occur at or near the weapon(s). (all members of the firing unit)

(5) Check the weapons for correct boresighting. (section chief)

(6) Verify the lay of the battery. (XO, platoon leader, or platoon sergeant)

(7) Compute and verify minimum QE. (XO, platoon leader, or FDO)

(8) Compare minimum QE with the QE for minimum range shown on the safety diagram. Use the larger of the two as the minimum QE. (XO, platoon leader, or FDO)

(9) Verify that the section chief has safety data (safety T). (XO, platoon leader, or platoon sergeant)

(10) Supervise and check the emplacement of safety aids (stakes, tape, and other devices). (XO, platoon leader, platoon sergeant, or gunnery sergeant)

(11) Verify that range clearance has been obtained. (XO, platoon leader, or FDO)

b. Specific duties of safety personnel during firing are, but are not limited to, the following:

(1) Verify the serviceability of ammunition. (section chief)

(2) Supervise key safety personnel in the performance of their duties. (OIC or safety officer)

(3) Verify that the charges, projectiles, and fuzes being fired are only those prescribed on the safety card. (section chief, XO, platoon leader, or platoon sergeant)

(4) Verify that rounds are not fired below the minimum QE or above the maximum QE. (section chief, XO, platoon leader, or platoon sergeant)

(5) Verify that rounds are not fired outside the lateral (deflection) safety limits specified on the safety card. (section chief, XO, platoon leader, or platoon sergeant)

(6) Verify that time-fuzed rounds are not fired with fuze settings that are less than the minimum time prescribed on the safety T. (section chief, XO, platoon leader, or platoon sergeant)

(7) On all commands that are unsafe to fire, command **CHECK FIRING** and give the reason(s) why the command(s) is(are) unsafe. (any person)

(8) Recompute and issue updated safety Ts under the following conditions: (FDO or chief computer)

- When a registration is completed.
- When met conditions change.

(9) Suspend firing when any unsafe condition exists. (Any person who sees an unsafe act) Examples of unsafe conditions areas follows:

- Powder bags exposed to fire.
- Personnel smoking near pieces or ammunition.
- Improper handling of ammunition.
- Time fuze previously set and not reset to safe.
- Personnel or aircraft directly in front of the weapon.
- Primer inserted into the firing assembly before the breech is closed (separate-loading ammunition).
- Failure to inspect the powder chamber and bore after each round is fired.
- Failure to swab powder chamber after each round of separate-loading ammunition is fired.

c. All safety personnel will perform their duties in a manner that ensures compliance with all safety regulations and limits.

15-3. Safety Aids

From the range safety card, the FDO prepares a safety diagram, computes safety data, and safety Ts for use by the safety-certified personnel. Safety aids are used to ensure that only safe data are fired from the position. The most common safety aids are the safety stakes and safety tape. These aids are then used as a visual check to ensure that the howitzer is laid within safety limits.

a. Emplace safety aids for the M102 howitzer as follows:

(1) For deflection safety aids--

- Set off the left deflection limit on the pantel by using the deflection counter. Traverse the tube to establish the proper sight picture on the aiming point.
- Emplace the safety stake against the right side of the lunette, and drive it firmly into the ground.
- Mark the right deflection limit in the same manner, but emplace the safety stake on the left side of the lunette.

(2) For QE safety aids--

- Use the cam follower as an index mark.
- Set off the maximum QE on the fire control quadrant. Elevate the tube until the bubbles center in the elevation level vials.
- Mark the cam with apiece of tape in line with the cam follower.
- Mark the minimum QE in the same manner.

b. Emplace safety aids on the M119 howitzer as follows:

(1) For deflection safety aids--

- Determine the left deflection limit. Set off the left deflection limit on the pantel by using the deflection counter.
- Traverse the tube to the left as much as possible.
- Traverse the carriage (shift trails) until the correct left deflection limit sight picture on the aiming point is established.
- Place a left limit safety stake against the right side of the spade.
- Mark the right deflection limit in the same manner, but emplace the safety stake on the left side of the spade.

(2) For quadrant elevation aids--

- Use the stationary bracket on the elevation gear box as an index mark.
- Set off the maximum QE on the fire control quadrant. Elevate the tube until the bubbles center in the elevation level vials.
- Mark the elevation arc with a piece of tape in line with the stationary bracket on the elevation gear box.
- Mark the minimum QE in the same manner.

c. Emplace safety tape on the Ml98 howitzer as follows:

(1) For deflection safety aids--

- With the tube parallel to the azimuth of lay, place a piece of tape over the azimuth counter (bottom carriage).

- Set off the left deflection limit on the pantel by using the deflection counter. Traverse the tube to establish the proper sight picture on the aiming point.
- Using a straight edge, draw a line on the tape placed on the bottom carriage directly below the azimuth counter index mark found on the upper carriage. Record the left deflection limit next to that line.
- Mark the right deflection limit in the same manner.

(2) For quadrant elevation safety aids--

- With the tube elevated to 0 mils, place a piece of tape on the trunnion support and draw a straight line as an index.
- Set off the minimum QE on the fire control quadrant. Elevate the tube until the bubble centers in the elevation level vial.
- Place a piece of tape on the quadrant mount, and draw a line across from the index line established on the trunnion support. Record the minimum QE next to that line.
- Mark the maximum QE in the same manner.

d. Emplace safety aids on the Ml09A3, A4, or A5 howitzer as follows:

(1) Deflection safety aids. These may be marked on the exterior and/or interior of the hull.

- Make an index mark on the top carriage with a piece of tape.
- Set off the left deflection limit on the pantel by using the reset counter. Traverse the tube to establish a proper sight picture on the aiming point.
- Place a piece of tape on the bottom of the carriage directly under the index mark.
- Mark the right deflection limit in the same manner.

(2) Quadrant elevation safety aids. These may be marked on the exterior or the interior of the weapon. To emplace the safety aids on the interior of the weapon, follow the steps in paragraph c(2) above. To mark the exterior of the weapon, perform the following steps:

- Mark an index on the tube with a piece of tape.
- Set off the maximum QE on the fire control quadrant. Elevate the tube until the bubble centers in the elevation level vial.
- Place a mark on the top carriage in line with the index mark.
- Mark the minimum QE in the same manner.

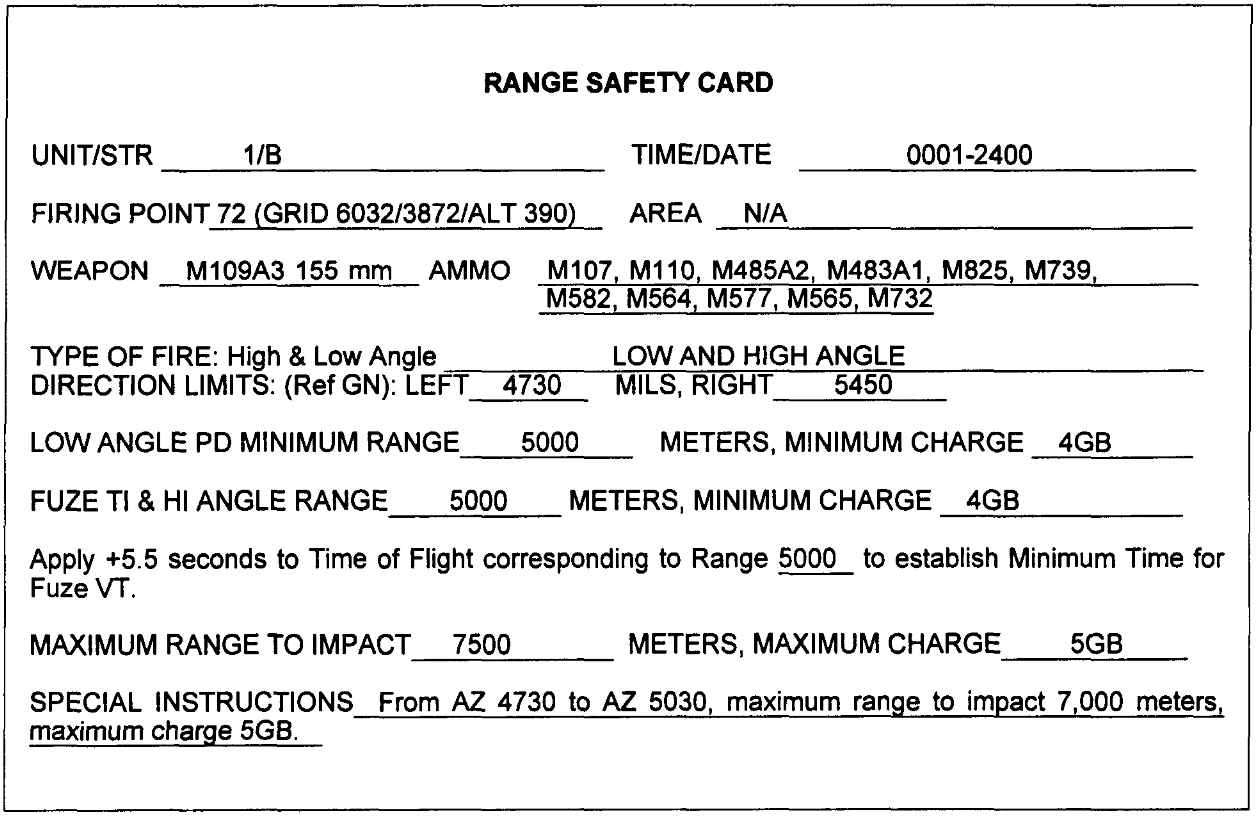
Section II

Manual Computation of Low-Angle Safety Data

Minimum and maximum quadrants, deflection limits, and minimum fuze settings must be computed to ensure that all rounds fired impact or function in the target area. These data are presented and arranged in a logical manner on a safety T. This section describes the manual computation of safety data by use of tabular and graphical equipment. As stated earlier, the range officer gives the OIC the lateral safety limits and the minimum and maximum ranges of the target areas. These data must be converted to fuze settings, deflections, and quadrants. The computations discussed in this section should be done by two safety-certified personnel working independently.

15-4. Safety Card

A safety card (Figure 15-1), which prescribes hours of firing, the area where the firing will take place, the location of the firing position, limits of the target area (in accordance with AR 385-63), and other pertinent data is approved by the range officer and sent to the OIC of firing. The OIC of firing gives a copy of the safety card to the position safety officer, who constructs a safety diagram based on the prescribed limits.



RANGE SAFETY CARD

UNIT/STR 1/B TIME/DATE 0001-2400

FIRING POINT 72 (GRID 6032/3872/ALT 390) AREA N/A

WEAPON M109A3 155 mm AMMO M107, M110, M485A2, M483A1, M825, M739, M582, M564, M577, M565, M732

TYPE OF FIRE: High & Low Angle LOW AND HIGH ANGLE
DIRECTION LIMITS: (Ref GN): LEFT 4730 MILS, RIGHT 5450

LOW ANGLE PD MINIMUM RANGE 5000 METERS, MINIMUM CHARGE 4GB

FUZE TI & HI ANGLE RANGE 5000 METERS, MINIMUM CHARGE 4GB

Apply +5.5 seconds to Time of Flight corresponding to Range 5000 to establish Minimum Time for Fuze VT.

MAXIMUM RANGE TO IMPACT 7500 METERS, MAXIMUM CHARGE 5GB

SPECIAL INSTRUCTIONS From AZ 4730 to AZ 5030, maximum range to impact 7,000 meters, maximum charge 5GB.

Figure 15-1. Example of a Range Safety Card.

15-5. Basic Safety Diagram

a. The FDO, on receipt of the safety card, constructs a basic safety diagram. The basic safety diagram is a graphical portrayal of the data on the safety card or is determined from the surface danger zone (AR 385-63, Chapter 11) and need not be drawn to scale. Shown on the basic safety diagram are the minimum and maximum range lines the left, right, and intermediate (if any) azimuth limits; the deflections corresponding to the azimuth limits; and the azimuth of lay. The safety diagram header is labeled with a minimum of firing point grid and altitude (location) and charge. Other optional entries are angle of fire, shell, fuze and azimuth of lay.

b. The steps for constructing a basic safety diagram are shown in Table 15-1. An example of a completed safety diagram is shown in Figure 15-2.

Table 15-1. Construction of Basic Safety Diagram.

STEP	ACTION
1	On a sheet of paper, draw a line representing the AOL for the firing unit. Label this line with its azimuth and the common deflection for the weapon system.
	NOTE: To determine the AOL, subtract the maximum left azimuth limit from the maximum right azimuth limit. Divide this value by two, add the result to the maximum left azimuth limit, and express the result to the nearest 100 mils. Expressing to the nearest 100 mils makes it easier for the aiming circle operator to lay the guns
2	Draw lines representing the lateral limits in proper relation to the AOL. Label these lines with the corresponding azimuth.
3	Draw lines between the lateral limits to represent the minimum and maximum ranges. Label these lines with the corresponding range.
	NOTE: If the minimum range for fuze time is different from the minimum range, draw a dashed line between the lateral limits to represent the minimum range for fuze time. Label this line with the corresponding range.
4	Compute the angular measurements from the AOL to each lateral limit. On the diagram, draw arrows indicating the angular measurements and label them.
5	Apply the angular measurements to the deflection corresponding to the AOL (common deflection) to determine deflection limits. Use the LARS memory aid for deflection.
6	Label the diagram with the minimum of firing point grid and altitude (location) and charge. Other optional entries are angle of fire, shell, fuze, and AOL.

c. When the basic safety diagram is complete, it will be constructed to scale, in red, on the firing chart. Plot the firing point location as listed on the range safety card. Using temporary azimuth indexes, an RDP, and a red pencil to draw the outline of the basic safety diagram. To do this, first draw the azimuth limits to include doglegs. Then, by holding the red pencil firmly against the RDP at the appropriate ranges, connect the azimuth limits.

d. Only after drawing the basic safety diagram on the firing chart may the base piece location be plotted and deflection indexes be constructed. Should the diagram be drawn from the base piece location, it would be invalid unless the base piece was located over the firing point marker.

e. After the basic safety diagram has been drawn on a sheet of paper and on the firing chart it is drawn on a map of the impact area by using an RDP and a pencil. These limits must be drawn accurately, because they will be used to determine altitudes for vertical intervals. Determine the maximum altitude along the minimum range line. This is used to ensure that the quadrant fired will cause the round to clear the highest point along the minimum range line and impact (function) within the impact area. At the maximum range, select the minimum altitude to ensure that the round will not clear the lowest point along the maximum range. Once the altitudes have been selected, label the basic safety diagram with the appropriate altitudes for the given ranges.

NOTE: The rule for determining the correct altitude for safety purposes is called the **mini-max rule.** At the minimum range, select the maximum altitude; at the maximum range, select the minimum altitude. If the contour interval is in feet, use either the GST or a feet-to-meters conversion table to convert the altitude to meters. This rule applies to both manual and automated procedures.

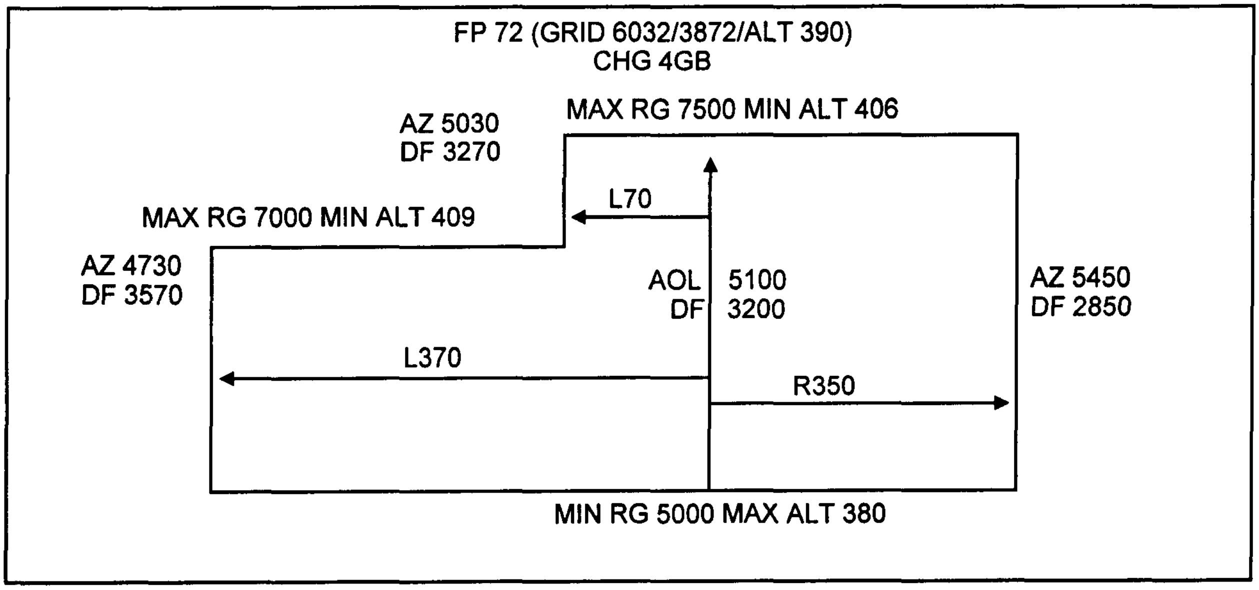


Figure 15-2. Example of Completed Safety Diagram.

15-6. Computation of Low-Angle Safety Data for Shell HE, Standard Square Weight (No GFT Setting Available)

Use the steps outlined in Table 15-2 and the matrix in Figure 15-3 as examples for organizing computations. Only charge 4GB is shown. Use artillery expression for all computations except where noted.

Table 15-2. Low-Angle HE Procedures.

STEP	ACTION
1	Construct a basic safety diagram.
2	Construct a matrix with the appropriate header information for each column.
3	Record range.
4	Record charge.
5	Determine the VI by using the mini-max rule, and record it.
6	Compute and record site. Use the GST whenever possible.
7	Determine elevation from the GFT, and record it. (See Appendix F.)
8	Determine QE (**SI + EL**).
9	Determine and record the minimum fuze setting for the appropriate time fuze (M564 and/or M582). (See Appendix F.) If there is a separate minimum range for fuze time designated on the range safety card, use it.

Table 15-2. Low-Angle HE Procedures (Continued).

STEP	ACTION
10	Determine and record the minimum fuze setting for fuze VT. Determine TOF (nearest 0.1 seconds from GFT TOF scale or TFT TOF column for safety only) at the minimum PD range. Add 5.5 seconds, and express the result up to the next whole second.
	NOTE: Fuze VT is designed to arm 3.0 seconds before the time set. It has been known to arm up to 5.5 seconds before the time set. That is why this value is added and **always** expressed up to the next whole second.
11	Ensure computations are verified by a second safety-certified person.
12	Record data on the safety T. (See Figure 15-4.)

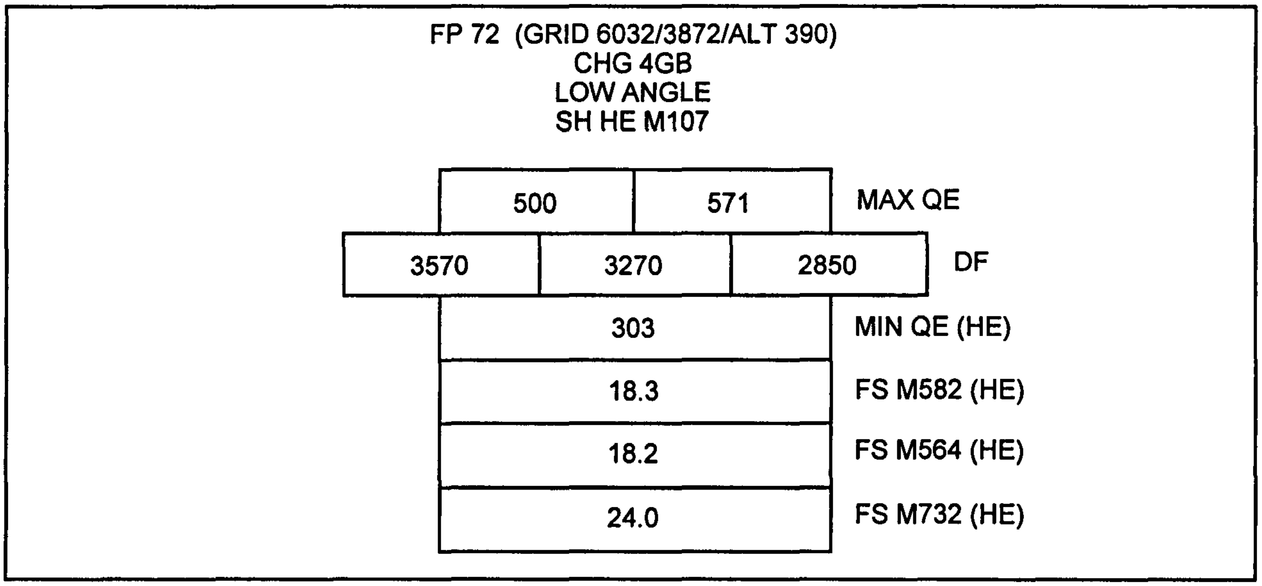
RANGE	CHG	VI	SI	+	EL	=	QE	M582	M564	TF + 5.5 = MIN VT
5000	4GB	-10	-2		305		303	18.3	18.2	18.3 + 5.5 = 23.8 ≈ 24.0
7000	4GB	+19	+4		496		500			
7500	4GB	+16	+4		567		571			

Figure 15-3. HE Low-Angle Matrix.

15-7. Safety T

The safety T is a convenient method of arranging safety data and is used to verify the safety of fire commands (Figure 15-4). The information needed by the FDO, XO or platoon leader, and section chief is organized in an easy-to-read format. The safety T is labeled with a minimum of firing point location, charge, and projectile(s). Other optional entries are angle of fire and effective DTG. Anytime new safety data are determined, new safety Ts are constructed and issued only after the old safety Ts have been collected (that is, after a move or after a registration). **Use only one charge per safety T.**

NOTE: A reproducible copy of DA Form 7353-R (Universal Safety T) is included at the back of this book.



FP 72 (GRID 6032/3872/ALT 390)
CHG 4GB
LOW ANGLE
SH HE M107

500 | 571 MAX QE
3570 | 3270 | 2850 DF
303 MIN QE (HE)
18.3 FS M582 (HE)
18.2 FS M564 (HE)
24.0 FS M732 (HE)

Figure 15-4. Example of a Completed Safety T.

15-8. Computation of Low-Angle Safety Data for Nonstandard Square Weight (Shell HE, WP, or HC) (No GFT Setting Available)

Use the steps outlined in Table 15-3 and the matrix in Figure 15-5 as examples for organizing computations.

a. WP and HC smoke are ballistically similar to HE but often differ in weight. The deflection limits and site computed for HE are accurate for different weight projectiles, but corrections must be applied to determine QEs and minimum FS.

b. At most charges and ranges, heavier projectiles fall short. This phenomenon is a safety concern with all projectiles, especially with shell WP, since WP will **never** weigh the same as a standard HE square weight (■ wt) projectile.

NOTES:

1. The following example uses WP (always heavier than standard square weight HE), since it is the most common nonstandard square weight projectile fired.

2. If the square weight is unknown, assume the worst case (heaviest) for minimum range.

3. Generally, a range correction is not determined for the maximum range, since the QE determined for a standard square weight projectile will cause the heavier square weight projectile to impact short of the maximum range. If a unit wants to maximize the safety box, compute maximum QE by applying the range correction corresponding to the known square weight (if unknown, use lightest possible square weight).

WARNING

For range 9100, M119A1 charge 8, the opposite is true. A heavier than standard projectile actually travels farther than a lighter projectile.

4. For lighter than standard square weight projectiles, compute a maximum QE, since a lighter projectile will generally travel farther than a standard square weight projectile.

5. The easiest way to remember which weight to use at a specific range is minimum range, maximum weight; maximum range, minimum weight.

Table 15-3. Low-Angle, Nonstandard Square Weight Procedures.

STEP	ACTION
1	Construct a matrix with the appropriate header information for each column.
2	Record range.
3	Record charge.
4	Record ■ wt of projectile. If unknown, use the worst case: ● 105 mm: 6 ■ ● 155 mm: 8 ■
5	Determine and record Δ (change in) ■ wt from standard (Increase or Decrease). Standard ■ wt is: ● 105 mm: 2 ■ ● 155 mm: 4 ■
6	Record the range correction factor for Δ ■wt (I/D) determined from the TFT, Table F, Columns 18 and 19.
7	Determine the range correction. Multiply the Δ ■wt by the range correction factor. Express the result to the nearest 10 meters.
8	Determine corrected range (**RG CORR + INITIAL MIN RG**).
9	Record the HE site computed earlier in the HE low-angle computations.
10	Determine elevation corresponding to the corrected range, and record it.
11	Determine minimum QE (**HE SI + EL ~ CORRECTED RG**).
12	Determine the minimum fuze time setting at this corrected minimum range for the appropriate fuze (M564 and/or M582). If there is a separate minimum range for fuze time designated on the range safety card, the appropriate range correction must be determined. The corrected range computed is then used to determine the minimum fuze setting.
13	Ensure computations are verified by a second safety-certified person.
14	Record data on the safety T.

RG	CHG	■WT	Δ ■WT	x	RG CORR FACTOR	=	RG CORR	CORR RG	HE SI	+	EL	=	QE	M582	M564
5000	4GB	8■	I 4■	x	+33	=	+132 ≈ +130	5130	-2	+	315	=	313	18.9	18.8

Figure 15-5. Nonstandard Square Weight Projectile Matrix.

15-9. Updating Safety Data After Registration

a. After a GFT setting is determined (result of registration or met+ VE technique), the FDO must compute new safety data by using the GFT setting. New elevations are determined which correspond to the minimum and maximum ranges (using the elevation gauge line). Deflections are modified by applying the total deflection correction to each lateral limit. Minimum fuze settings are recomputed (using the time gauge line, if applicable). The basic safety diagram drawn in red on the firing chart **does not change.** It was drawn on the basis of azimuths and ranges, and it represents the actual limits.

NOTE: The basic low-angle HE and nonstandard square weight projectile matrixes are shown in Figures 15-6 and 15-7 after applying the following GFT setting. WP square weight is now known. It is 6 squares. Use Appendix F for help with determining data with a GFT setting.

GFT 1/B: Chg 4, Lot AG, Rg 5160, El 306, Ti 17.5 (M582)
Tot Df Corr L3, GFT Df Corr R3

RG	CHG	VI	SI	+	EL	=	QE	M582	M564	TF + 5.5 = MIN VT
5000	4GB	-10	-2		294		292	16.9	17.6	17.7 + 5.5 = 23.2 ≈ 24.0
7000	4GB	+19	+4		468		472			
7500	4GB	+16	+4		529		533			

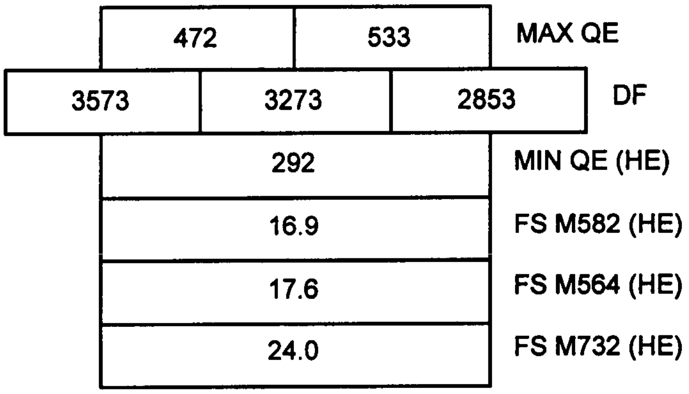
Figure 15-6. HE Low-Angle Matrix With GFT Setting Applied.

RG	CHG	■WT	Δ■WT	x	RG CORR FACTOR	=	RG CORR	CORR RG	HE SI	+	EL	=	QE	M582	M564
5000	4GB	6■	I 2■		+33		+66 ≈ +70	5070	-2		299		297	17.1	17.9

Figure 15-7. Nonstandard Square Weight Matrix With GFT Setting Applied.

b. Determine and issue new safety Ts with the corrected data. Figure 15-8 shows the updated safety T for HE only.

FP 72 (GRID 6032/3872/ALT 390)
CHG 4GB
LOW ANGLE
SH HE M107



	472	533	MAX QE
3573	3273	2853	DF
	292		MIN QE (HE)
	16.9		FS M582 (HE)
	17.6		FS M564 (HE)
	24.0		FS M732 (HE)

Figure 15-8. Example of Updated Safety T (HE Only).

15-10. Low-Angle Illumination

a. The illuminating GFT is the preferred method for computing low-angle illum safety data. However, illum GFTs do not exist for all charges. Therefore, units may have to use the

TFT method for computing safety in some situations. A basic safety diagram is constructed in the same manner as for low angle HE safety. The purpose of computing illum safety is to determine the minimum and maximum QE at which a nonfunctioning (dud) projectile would impact. It is not to determine the minimum and maximum QE that will keep the spent cannister of a functioning projectile in the impact area. There is no way to compute the trajectory of a spent cannister because it becomes ballistically unstable after fuze fiction.

b. The GFT method uses the elevation determined from the illum GFT elevation-to-impact (ETI) scale at the minimum and maximum ranges. HE site is added to account for the vertical interval.

c. The TFT method uses the range-to-impact (RTI) column of Part 2 of the TFT to extract an elevation (column 2). These data approximate what is obtained from the ETI scale of the GFT. HE site is added to account for the vertical interval. However, this method does not always work at each **minimum** range for which safety is computed because the RTI may not be listed. Therefore, it is necessary to use a method that tries to approximate the value for elevation corresponding to the RTI column. This method assumes an average HOB of 750 meters for the 105-mm illumination and 600 meters for the 155-mm illumination. The QE from Column 2 is adjusted to ground level in 50-meter increments by use of the factor in Column 4 (change in QE for a 50-meter change in HOB).

d. The GFT ETI method is **always** preferred over the TFT method. When the situation allows, units should try to fire charges for which an illum GFT exists. When a GFT is not available, using the RTI column of the TFT is preferred over the HOB method mentioned above.

15-11. Computation of Safety Data for Illumination, GFT Method, Low Angle (No GFT Setting Available)

NOTE: Use the steps outlined in Table 15-4 and the matrix in Figure 15-9 for organizing computations. The same range safety card and safety diagram as above are used.

Table 15-4. Illumination, Low-Angle, GFT Method.

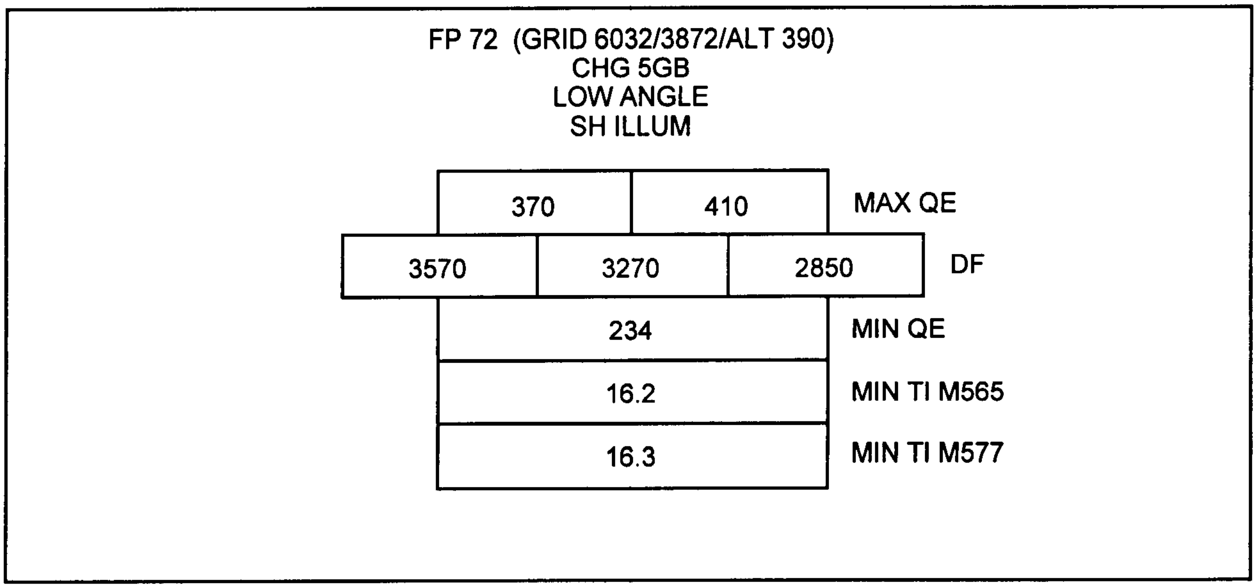
STEP	ACTION
1	Construct a matrix with the appropriate header information for each column.
2	Record range.
3	Record charge.
4	Determine and record HE site.
5	Determine and record elevation. Set the MHL over range, and determine the elevation by looking under the MHL on the ETI scale.
6	Determine QE (**HE SI + EL**).
7	Determine and record minimum fuze time setting.
7a	Use the HE AM-2 GFT (same charge) as follows: ● **M565.** Place the MHL over the minimum range. Determine the FS for M565 by looking under the MHL on the FS M564 scale. ● **M577.** Place the MHL over the minimum range. Determine the FS for M577 by looking under the MHL on the FS M582 scale.

Table 15-4. Illumination, Low-Angle, GFT Method (Continued).

STEP	ACTION
7b	Use the HE AM-2 TFT (same charge) as follows: **M565.** Enter Table F with the minimum range, and extract the FS for M565 from Column 3 (FS M564 graze burst). **M577.** Enter Table F with the minimum range, and extract the FS for M577 from Column 7 (HE TOF).
8	Deflections are the same as determined in low-angle HE.
9	Ensure the computations are verified by a second safety-certified person.
10	Record data on the safety T. (See Figure 15-10.)

RANGE	CHG	HE SI	+	ETI	=	QE	M565	M577
5000	5GB	-2		236		234	16.2	16.3
7000	5GB	+3		367		370		
7500	5GB	+3		407		410		

Figure 15-9. Illum Matrix Using GFT ETI Scale.



FP 72 (GRID 6032/3872/ALT 390)
CHG 5GB
LOW ANGLE
SH ILLUM

	370	410	MAX QE
3570	3270	2850	DF
	234		MIN QE
	16.2		MIN TI M565
	16.3		MIN TI M577

Figure 15-10. Illumination Safety T.

15-12. Computation of Safety Data for Illumination, TFT Method, Low Angle

Use the steps outlined in Tables 15-5 and 15-6 and the matrixes in Figures 15-11, 15-12, and 15-13 for organizing computations. The same range safety card and safety diagram as above are used.

Table 15-5. Low-Angle Illum, TFT Method, Minimum Range.

STEP	ACTION
1	Construct a matrix with the appropriate header information for each column.
2	Record range.
3	Record charge.
4	Record VI (expressed to the nearest 50 meters).
5	Determine and record HOB (**600 + VI [DETERMINED IN STEP 4]**). Use 750 instead of 600 for 105 mm.
6	Determine and record the number of 50-meter increments (**HOB [STEP 5] ÷ 50**).
7	Record change in QE for a decrease of 50 meters in HOB. Enter TFT, Part 2, Column 4, with the range. Since the listed values in Column 4 are for an increase in HOB, record the opposite sign listed for a decrease in HOB.
8	Determine and record correction to QE. Multiply the number of 50-meter increments by the change in QE for a decrease of 50 meters in HOB. Express the result to the nearest mil.
9	Record QE from TFT, Part 2, Table A, Column 2.
10	Determine and record minimum QE for graze burst. Add correction to QE to QE from TFT, Part 2, Table A, Column 2.
11	Determine and record minimum fuze time setting. Follow the same procedures as outlined in Table 15-4, step 7.
12	Deflections are the same as determined in low-angle HE data.
13	Ensure computations are verified by a second safety-certified person.
14	Record data on the safety T.

RG	CHG	VI ≈ NEAREST 50 M	600 + VI = HOB	HOB ÷ 50	x	ΔQE FOR DEC OF 50 M HOB	=	CORR TO QE	+	QE COL 2	MIN =QE	M565	M577
5000	5GB	-10 ≈ 0	600 + 0 = 600	600 ÷ 50 = 12		-10.6	=	-127		403	276	16.2	16.3

Figure 15-11. Illum Matrix for Minimum Range Using TFT HOB Correction.

Table 15-6. Low-Angle Illum, TFT Method, Maximum Range.

STEP	ACTION
1	Construct a matrix with the appropriate header information for each column.
2	Record range.
3	Record charge.
4	Determine and record HE site.
5	Determine the QE corresponding to RTI, Part 2, Column 7, and record it. Enter the table with the nearest listed range without exceeding the maximum range.
6	Determine QE. Add HE site and QE corresponding to RTI.
7	Ensure computations are verified by a second safety-certified person.
8	Record data on the safety T.

NOTE: Since the maximum range of 7000 is not listed in RTI, Column 7, the maximum QE is determined by using the HOB correction method outlined in Table 15-5. See Figure 15-12.

RG	CHG	VI ≈ NEAREST 50 M	600 + VI = HOB	HOB ÷ 50	x	ΔQE FOR DEC OF 50 M HOB	=	CORR TO QE	+	QE COL 2	=	MAX QE
7000	5GB	+19 ≈ 0	600 + 0 = 600	600 ÷ 50 = 12	x	-8.6	=	-103	+	500	=	397

Figure 15-12. Illum Matrix for Maximum Range Using HOB Correction.

RANGE	CHG	RTI	HE SI	+	QE ≈ RTI COL 7	=	QE
7500	5GB	7487	+3	+	406	=	409

Figure 15-13. Illum Matrix for Maximum Range Using TFT RTI.

15-13. Determination of Maximum Effective Illumination Area

All illum safety data are for a graze burst. Therefore, when illum fire mission data are computed, the QE determined includes the appropriate HOB. This will prevent achieving a 600-meter HOB (750-meter HOB for 105 mm) at the minimum range and maximum range lines. Before processing illum fire missions, it is beneficial to determine the maximum effective illum area for the current range safety card. This area should be plotted on the chart to help determine if illum can be fired and to let the FOs know where they can fire illum effectively. This area will always be significantly smaller than the HE safety area. See Table 15-7 for steps outlining the general procedure. To increase this area, determine HA illum safety data (paragraph 15-22).

Table 15-7. Maximum Effective Illumination Area.

STEP	ACTION
1	Enter the TFT, Part 2, Column 7 (RTI) with the nearest listed range without exceeding the maximum range.
2	Determine the corresponding range to target in Column 1. This is the maximum range the unit can achieve a 600-meter (155 mm) HOB and keep the projectile in the safety box if the fuze fails to function.
3	Determine the minimum range for which a 600-meter (155 mm) HOB is achieved and have the fuze function no earlier than the minimum range. Enter TFT, Part 2, Column 3, with the nearest listed FS that is not less than the determined minimum FS. Determine the corresponding range to target in Column 1.
4	The area between these two lines is the maximum effective illum area where a 600-meter HOB (155 mm) is achieved, the fuze functions no earlier than the minimum range line, and the round does not exceed the maximum range line if the fuze fails to function.

15-14. Low-Angle Safety Data for Shell 155 mm M483A1 DPICM, M825 Smoke, M692/M731 ADAM, M718/M741 RAAM, and M449 APICM (TFT Method, No GFT Setting Available)

a. The procedures for determining safety data for DPICM, M825, FASCAM, and APICM depend on the weapon system and the availability of TFTs and firing table addendums. See Table 15-8.

Table 15-8. TFT and Addendum Combinations.

Weapon System	Safety required for?	Base Proj	Firing Table of Base Projectile	ICM/M825 Addendum
M101A1	APICM	HE	105-H-7	ADD-B-2
M102	APICM	HE	105-AS-2	ADD-F-1
M119	APICM	HE	105-AS-3	ADD-F-2
M198 or M109A3/A5	(1) M449	HE	155-AM-2	ADD-I-2
	(2) M483A1	HE	155-AM-2	ADD-R-1
	(3) M483A1	DPICM	155-AN-2	ADD-J-1
	(4) M825	HE	155-AM-2	ADD-T-0
	(5) M825	DPICM	155-AN-2	ADD-Q-0 (REV)
	(6) M825A1	DPICM	155-AN-2	ADD-Q-0 (REV) C2
	(7) M692/M731	DPICM	155-AN-2	ADD-L-1
	(8) M718/M741	DPICM	155-AN-2	ADD-N-1

b. The steps in Tables 15-9 and 15-10 outline the procedures for determining safety for DPICM. To determine safety data for the other projectiles listed in Table 15-8, replace ADD-R-1 with the appropriate addendum. Use the matrixes in Figures 15-14 and 15-15 for organizing computations.

NOTE: In accordance with AR 385-63 (MCOP3570.1A), Chapter 11, ICM must be fired into a dedicated impact area and the submissive drift factors must be accounted for in safety computations. Refer to the above manual for specific guidance concerning your situation. This does not apply to M825 computations. The example below is generic and does not include a submissive drift factor.

Table 15-9. Low-Angle DPICM, Minimum Range.

STEP	ACTION
1	Construct a matrix with the appropriate header information for each column.
2	Record range.
3	Record charge.
4	Enter ADD-R-1, Table A, Column 7 (RTI), with the nearest listed range that exceeds the minimum range. Extract and record QE for projectile M107 (Column 1) and correction to QE for M483A1 (Column 2).
	NOTE: It is possible that the range safety card minimum range is less than the minimum listed range in the RTI column of Table A. If this happens, use the lowest listed range in the RTI column of Table A.
5	Determine and record HE site.
6	Determine and record DPICM minimum QE (**QE FOR PROJ M107 + CORR TO QE FOR M483A1 + HE SI**).
7	Determine and record DPICM M577 FS. Enter AN-2 Table F with the minimum range and extract the FS for M577 from column 3 (FS for Graze Burst, Fuze M577).
	NOTE: If no AN-2 TFT is available, use the extract in Appendix J.
8	Ensure computations are verified by a second safety-certified person.
9	Record data on the safety T.

Table 15-10. Low-Angle DPICM, Maximum Range.

STEP	ACTION
1	Construct a matrix with the appropriate header information for each column.
2	Record range.
3	Record charge.
4	Enter ADD-R-1, Table A, Column 7 (RTI), with the nearest listed range without exceeding the maximum range. Extract and record QE for projectile M107 (Column 1) and correction to QE for M483A1 (Column 2).
	NOTE: It is possible that the range safety card maximum range is greater than the maximum listed range in the RTI column of Table A. If this happens, use the highest listed range in the RTI column of Table A.
5	Determine and record HE site.
6	Determine and record DPICM maximum QE (**QE FOR PROJ M107 + CORR TO QE FOR M483A1 + HE SI**).
7	Ensure computations are verified by a second safety-certified person.
8	Record data on the safety T.

MINIMUM RANGE:

RG	CHG	RTI	QE M107	+	QE CORR	+	HE SI	=	DPICM MIN QE	M577 GRAZE MIN TI
5000	4GB	5007	265		85		-2		348	19.8

MAXIMUM RANGE:

RG	CHG	RTI	QE M107	+	QE CORR	+	HE SI	=	DPICM MAX QE
7000	4GB	6993	480		148		+4		632
7500	4GB	7262	520		224		+4		748

Figure 15-14. DPICM Matrix Using ADD-R-1.

MINIMUM RANGE:

RG	CHG	RTI	QE M107	+	QE CORR	+	HE SI	=	M825 MIN QE	M577 GRAZE MIN TI
5000	4GB	5038	300		49		-2		347	19.8

MAXIMUM RANGE:

RG	CHG	RTI	QE M107	+	QE CORR	+	HE SI	=	M825 MAX QE
7000	4GB	6982	490		116		+4		610
7500	4GB	7351	540		207		+4		751

Figure 15-15. M825 Matrix Using ADD-T-0.

NOTE: The above matrixes and procedures can also be used to determine ICM/M825 using the AN-2 TFT and appropriate addendum. Replace HE elevation, HE site, HE FS, and HE QE with DPICM graze burst data.

15-15. Safety Procedures for M712 Copperhead

a. Copperhead safety data are determined from ballistic data developed specifically for the Copperhead. Computations are much like those for normal HE safety data. The Copperhead round should not be fired with cold stick data. Therefore, the computation of safety data requires the solving of a Copperhead met-to-target technique for each listed range by using TFT AS-1, as covered in Chapter 13, Section 1. See Table 15-11 for steps to compute Copperhead safety. Surface danger zones (SDZs) for shell Copperhead are significantly different than normal indirect fire SDZs. AR 385-63 (MCO P3570.1A), Chapter 11, contains SDZs for Copperhead fired in both ballistic and glide mode.

b. All ranges listed on the range safety card may not fall within the ranges listed in the TFT charge selection table for that charge and mode. Therefore, additional safety computations may be required for additional charge(s) and mode(s) to adequately cover the impact area. If ranges listed on the range safety card overlap charge and mode range limitations in the charge selection table, then safety for both affected charges and modes must be computed.

Table 15-11. Copperhead Safety Data Procedures.

STEP	ACTION
1	Construct basic safety diagram.
2	For low angle, circle the lower left-hand corner of the safety diagram. Proceed in a clockwise manner, and circle every other corner. For high angle, start in the lower right-hand corner.
3	Complete a Copperhead met-to-target technique for each circled corner. Record the FS, deflection, and QE in the safety T. For example, the lower left-hand corner will provide minimum FS, maximum left deflection, and minimum QE. The upper right-hand corner will provide maximum right deflection and maximum QE.

15-16. Safety Procedures for M549A1 RAP

RAP safety data are computed in the same manner as Copperhead safety data. Use the FT 155 AO-0. Complete a RAP met-to-target technique for each listed range. Follow the same steps as listed in Table 15-11. Minimum FS is not determined. An additional safety buffer of 6,000 meters is constructed short of the minimum range line in case the rocket motor does not ignite. No personnel are allowed in this safety buffer.

15-17. Safety Procedures for M864 Base Burn DPICM

a. M864 safety data are computed in the same manner as DPICM safety data (paragraph 15-14) by using one of the following methods:

(1) Use the FT 155-AU-PAD and FT ADD-U-PAD. Solve a met-to-target technique by following the steps in Table 15-11.

(2) Use the FT 155-AO-0 and provisional aiming data addendum to FT 155-AO-0 for projectile HE M864. Use registration data for projectile HE M549A1, low-angle fire only (no short title has been established).

b. An additional safety buffer of 5,000 meters is constructed short of the minimum range line in case the base burner element fails to function. No personnel are allowed in this safety buffer.

c. In accordance with AR 385-63 (MCOP3570.1A), Chapter 11, ICM must be fired into a dedicated impact area and the submissive drift factors must be accounted for in safety computations. Refer to the above manual for specific guidance concerning your situation.

Section III

Manual Computation of High-Angle Safety Data

The safety data for high-angle fire is computed in much the same manner as that for low-angle fire except for the variations caused by the trajectory of high-angle fire.

15-18. Safety Data for High-Angle Fire

NOTE: The same range safety card (Figure 15-1) used during low-angle HE safety computations is used in this section.

a. Deflection.

(1) Before registration. The deflection limits for HA fire are computed in the same manner as those for low-angle fire except that the limits are modified by the large amount of drift characteristic to HA fire. The left deflection limits are moved to the left by the amount of the minimum drift for the charge to be fired within the range limits. The right deflection limits are moved to the left by the amount of maximum drift for the charge to be fired, within the range limits. The values for drift are determined from either the HA GFT or the HA portion of the appropriate TFT.

(2) After high-angle registration. The deflection limits for HA fire are further modified. Since the elevation changes after registration deflection limits are modified by redetermining new drifts and adding GFT deflection correction.

b. Quadrant Elevation.

(1) Before registration. The minimum and maximum quadrants for HA fire are computed in the same manner as those for low-angle fire except for the computation of site **(≮ SI÷10 x 10-MIL SITE FACTOR).** The 10-mil site factor is determined from the GFT. Angle of site is computed from the GST by use of the C and D scales. If a 10-mil site factor is not available, HA site is computed manually (Table 15-13, step 5) by using the procedures in Chapter 8.

(2) After high-angle registration. An HA registration is valid for all charges in that charge group. Fire missions throughout safety limits usually require that more than one charge be used. Minimum and maximum QEs are computed for each charge by using corrections determined from the registration. The minimum and maximum elevations are read under the MHL when a GFT setting has been applied. Site must be recomputed.

c. Fuze Setting. Minimum fuze settings are not computed for HA fire. Mechanical time and/or superquick fuzes (M564 and M582) should not be used because of large probable errors in height of burst. The FDO must verify that VT fuze settings are determined to correspond to the appropriate target range.

15-19. Construction of Basic Safety Diagram

a. Initially compute the deflection limits in the same manner as low angle. Then modify the limits by the large amount of drift that is peculiar to HA fire.

b. For the charges listed on the range safety card, extract from the TFT (or GFT) the HA drifts corresponding to the elevations appropriate to the minimum and maximum ranges. When extracting from the TFT, express the value to the nearest 1 mil. If the range desired is not attainable for the particular charge, locate the nearest listed range and extract the corresponding value for drift. See Table 15-12.

Table 15-12. Drift at the Minimum and Maximum Ranges (Charge 4GB only).

RANGE	CHG	DRIFT
5000	4GB	L92
7500	4GB	L36

c. As seen in Table 15-12, the minimum drift is L36 and the maximum drift is L92. Each deflection limit is now modified by the appropriate drift correction. The example below shows the effect of using the least drift at a right limit.

EXAMPLE

Max Rg 7500	MAX RG: Projectile drifts R36 mils, and you apply a drift correction of L36 mils. SAFE
Min Rg 5000	MIN RG: Projectile drifts R92 mils, and you apply a drift correction of L36 mils. UNSAFE

The correct procedure is to add the least drift to all left deflection limits and add the most drift to all right deflection limits. A common memory aid is **least, left; most, right**. Once applied, the HA basic safety diagram is completed as shown in Figure 15-16.

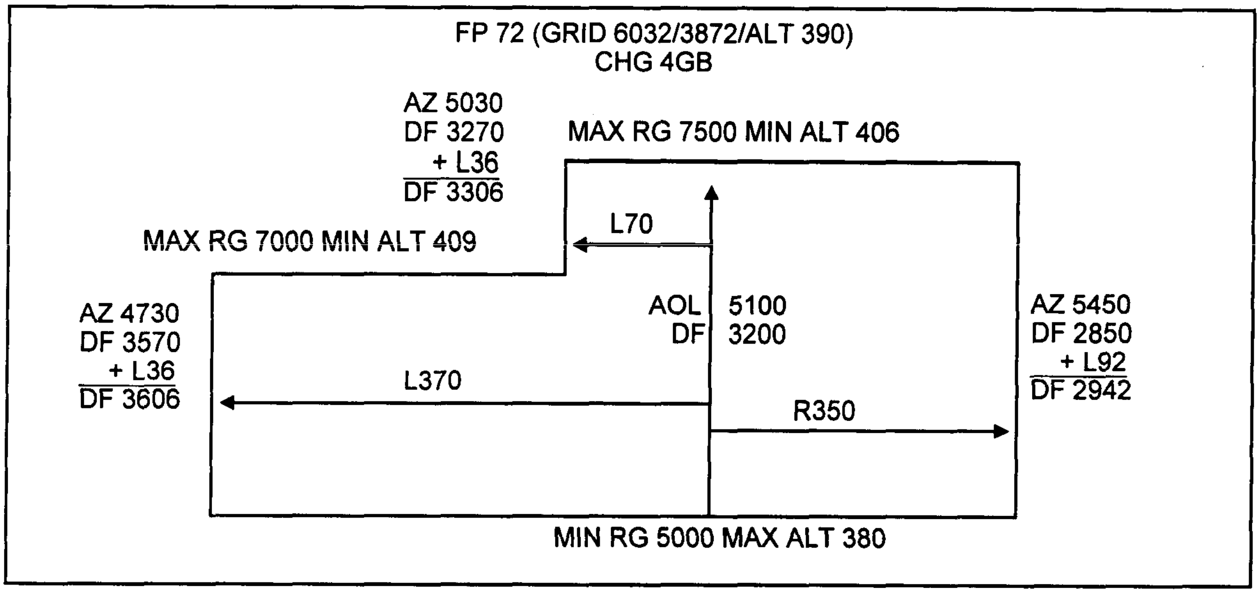


Figure 15-16. Example of Completed HA Safety Diagram.

15-20. Computation of Safety Data for HA (No GFT Setting Available)

Use the steps outlined in Table 15-13 and the matrix in Figure 15-17 as examples for organizing computations. Only charge 4GB is shown. Use artillery expression for all computations except where noted.

Table 15-13. High-Angle HE Procedures.

STEP	ACTION
1	Record range.
2	Record charge.
3	Record VI. Use the mini-max rule.
4	Determine and record angle of site. Divide this by 10, and express the result to the nearest 0.1 mil.
5	Record the 10-mil site factor. Place the MHL over the range, and determine the 10-mil site factor from the same named scale. This value is always negative.
	NOTE: If the 10-mil site factor is not listed at the maximum range, use the last listed value from the GFT. If the 10-mil site factor is not listed at the minimum range compute site manually by using the appropriate CSF from the TFT in Table G. If the CSF is not listed in Table G, use the last listed value in Table G.
6	Determine and record site (**[∢ SI ÷ 10] x 10-MIL SI FACTOR**). Express the result to the nearest mil.
7	Determine and record elevation. Since ranges on a range safety card are in hundreds, it is easier to use the TFT than the GFT. The GFT requires visual interpolation.
8	Determine and record QE (**SI + EL**).
9	Record maximum drift at the minimum range and minimum drift at the maximum range. Apply drift to the basic safety diagram by using the memory aid least, left; most, right.
10	Ensure computations are verified by a second safety-certified person.
11	Record data on the safety T. (See Figure 15-18.)

RANGE	CHG	VI	∢SI ÷ 10	X	10-MIL SI FAC	=	SI	+	EL	=	QE	DRIFT
5000	4GB	-10	10-MIL SI FACTOR NOT LISTED, COMPUTE SI MANUALLY				+0		1248		1248	L92
7000	4GB	+19	+0.3		-4.6		-1		1066		1065	
7500	4GB	+16	+0.2		-8.5		-2		996		994	L36

Figure 15-17. High-Angle HE Matrix.

FP 72 (GRID 6032/3872/ALT 390)
CHG 4GB
HIGH ANGLE
SH HE M107

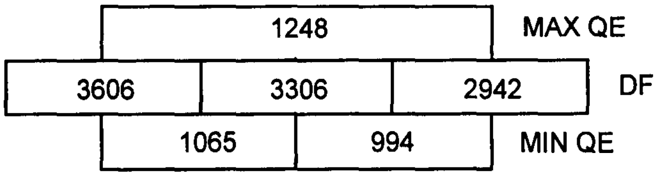


Figure 15-18. High-Angle Safety T.

15-21. Computation of Safety Data for HA Fire (GFT Setting Available)

Like low-angle safety data, HA safety data are updatd a GFT setting is determined. See Chapter 10 for the application of a GFT setting to the HA GFT. Follow the same steps outlined in Table 15-13. Use the matrix in Figure 15-19 to organize computations. Use Appendix F for help with for help with determining data with an HA GFT setting applied. To determine new deflection limits, add the appropriate drift and GFT deflection correction to the low-angle deflection limit. Use the following GFT setting to update HA safety data.

GFT 1/B, Chg 4, Lot AG, Rg 5100, El 1233
Tot Df Corr L93, GFT Df Corr L11

RG	CHG	VI	∢SI ÷ 10	x	10-MIL SI FAC	=	SI	+	EL	=	QE	DRIFT
5000	4GB	-10	+0.2		-1.1		+0		1240		1240	L87
7000	4GB	+19	+0.3		-5.3		-2		1049		1047	
7500	4GB	+16	+0.2		-11.4		-2		969		967	L34

NOTE: Site must be recomputed.

Figure 15-19. High-Angle HE Matrix With GFT Setting Applied.

15-22. Computation of Safety Data for HA Illumination (TFT Method)

Some impact areas are so small that low-angle illumination safety procedures can restrict firing this round. High-angle illumination will significantly increase the maximum effective illum area for a range safety card or enable a unit to fire illumination when low angle is not practical. Therefore, it is necessary to compute safety data for HA illumination.

NOTE: The adjustments of HOB will be unrealistic. This is because the only movement in HOB will parallel a change in QE fired.

Use the matrixes in Figure 15-20 and 15-21 to organize computations. The same steps are followed as listed in Tables 15-5 and 15-6. Minimum FS is not determined for HA illumination.

NOTE: Minimum FS is not determined because this FS must then be used with all QEs fired.

WARNING

The FDC is responsible for ensuring that the FS computed and announced will not function short of the minimum range line.

RG	CHG	VI ≈ NEAREST 50 M	600 + VI = HOB	HOB ÷ 50	x	Δ QE FOR DEC OF 50 M HOB	=	CORR TO QE	QE COL 2	MAX QE
5000	5GB	-10 ≈ 0	600+0=600	600 ÷ 50 = 12		+0.5		+6	1297	1303

Figure 15-20. Illum Matrix for Minimum Range Using TFT HOB Correction.

RG	CHG	RTI	HE SI	+	QE ≈ RTI COL 7	=	MIN QE
7000	5GB	6975	-1		1197		1196
7500	5GB	7402	0		1167		1167

Figure 15-21. Illum Matrix for Maximum Range Using TFT RTI.

15-23. Safety Computations Matrixes

There are many different ways to organize safety computations for the different projectile and fuze combinations. Figure 15-22 shows all the matrixes used throughout this chapter. These are recomeded because they follow a logical flow.

Low angle, shell HE, fuzes Q, TI, and VT:

RANGE	CHG	VI	SI	+	EL	=	QE	M582	M564	TF + 5.5 = MIN VT

Low angle, shell nonstandard ■ wt:

RG	CHG	■WT	Δ■WT	x	RG CORR FAC	=	RG CORR	CORR RG	HE SI	+	EL	=	QE	M82	M564

Low angle, shell illumination, GFT, ETI scale method:

RANGE	CHG	HE SI	+	ETI	=	QE	M565	M577

Low angle, shell illumination, TFT, HOB correction method:
(155 mm: HOB = 600 m, 105 mm: HOB = 750 m

RG	CHG	VI ≈ NEAREST 50 M	ILLUM HOB+ VI = HOB	HOB ÷ 50	x	Δ QE FOR DEC OF 50 M HOB	=	CORR TO QE	+	QE COL 2	=	MIN QE	M565	M577

Low angle, shell illumination, TFT, RTI (graze burst) method:

RANGE	CHG	RTI	HE SI	+	QE ≈ RTI COL 7	=	QE

Low angle, shell DPICM family QE, RTI (graze burst) method:

RG	CHG	RTI	QE M107	+	QE CORR	+	HE SI	=	DPICM MIN QE

Figure 15-22. Safety Matrixes.

Low angle, shell DPICM family, TFT, HOB correction method:
(Use the HOB listed on the first page for the charge in the appropriate addendum.)

RG	CHG	VI ≈ NEAREST 50 M	DPICM HOB + VI = HOB	HOB ÷ 50	x	Δ QE FOR DEC OF 50 M HOB	=	CORR TO QE	+	QE COL 2	=	MIN QE

Low angle, shell DPICM family minimum FS, TFT HOB correction (graze burst) method:
(Use the HOB listed on the first page for the charge in the appropriate addendum.)

HE M582	+	FS CORR	M577 AIRBURST MIN TI	VI ≈ 50 M	DPICM HOB ≈ 50 M + VI	HOB ÷ 50	x	CORR DEC HOB 50 M	=	FS HOB CORR	+	M577 AIRBURST MIN TI	=	M577 GRAZE MIN TI

High angle, shell HE, fuze Q:

RG	CHG	VI	∢SI ÷10	x	10-MIL SI FAC	=	SI	+	EL	=	QE	DRIFT

High angle, shell illumination, TFT, HOB correction method:
(155 mm: HOB = 600 m, 105 mm: HOB - 750 m

RG	CHG	VI ≈ NEAREST 50 M	ILLUM HOB + VI = HOB	HOB ÷ 50	x	Δ QE FOR DEC OF 50 M HOB	=	CORR TO QE	+	QE COL 2	=	MAX QE

High angle, shell illumination, TFT, RTI (graze burst) method:

RANGE	CHG	RTI	HE SI	+	QE ≈ RTI COL 7	=	MIN QE

Figure 15-22. Safety Matrixes (Continued).

Section IV
Minimum Quadrant Elevation

The XO or platoon leader is responsible for determining the lowest QE that can be safely fired from his position that will ensure projectiles clear all visible crests (minimum QE).

15-24. Elements of Computation

A minimum quadrant for EACH howitzer is ALWAYS determined. The maximum of these minimum quadrants is the XO's minimum quadrant. Use of the rapid fire tables in ST 6-50-20 is the fastest method of computing minimum QE. The QE determined from ST 6-50-20 is always equal to or greater than (more safe) than manual computations. Manual computations are more accurate than the rapid fire tables and are used if the sum of the site to crest and the angle needed for a 5-meter vertical clearance is greater than 300 mils. Figure 15-23 shows the elements of minimum QE.

a. Piece-to-crest range (PCR) is the horizontal distance between the piece and the crest, expressed to the nearest 100 meters. Procedures for measurement are discussed in paragraph 15-26.

NOTE: All angles are determined and expressed to the next higher mil.

b. Angle 1 (Figure 15-23) is the angle of site to crest measured by the weapons. See paragraph 15-25 for procedures.

c. Angle 2 (Figure 15-23) is the vertical angle required to clear the top of the crest. For quick, time, and unarmed proximity (VT) fuzes, a vertical clearance of 5 meters is used. For armed VT fuzes, see paragraph 15-28.

d. Angle 3 (Figure 15-23) is the complementary angle of site. It is the complementary site factor (TFT, Table G) for the appropriate charge at the piece-to-crest range multiplied by the sum of angles 1 and 2. Site is the sum of angles 1, 2, and 3.

NOTE: The entry argument for Table G is PCR. If it is not listed, do not interpolate, use the next higher listed value.

e. Angle 4 (Figure 15-23) is the elevation (TFT, Table F) for the appropriate charge corresponding to the PCR.

f. Angle 5 (Figure 15-23) is a safety factor equivalent to the value of 2 forks (TFT, Table F) for the appropriate charge at the PCR.

g. The sum of angles 1 through 5 (Figure 15-23) is the minimum QE for the weapon and the charge computed.

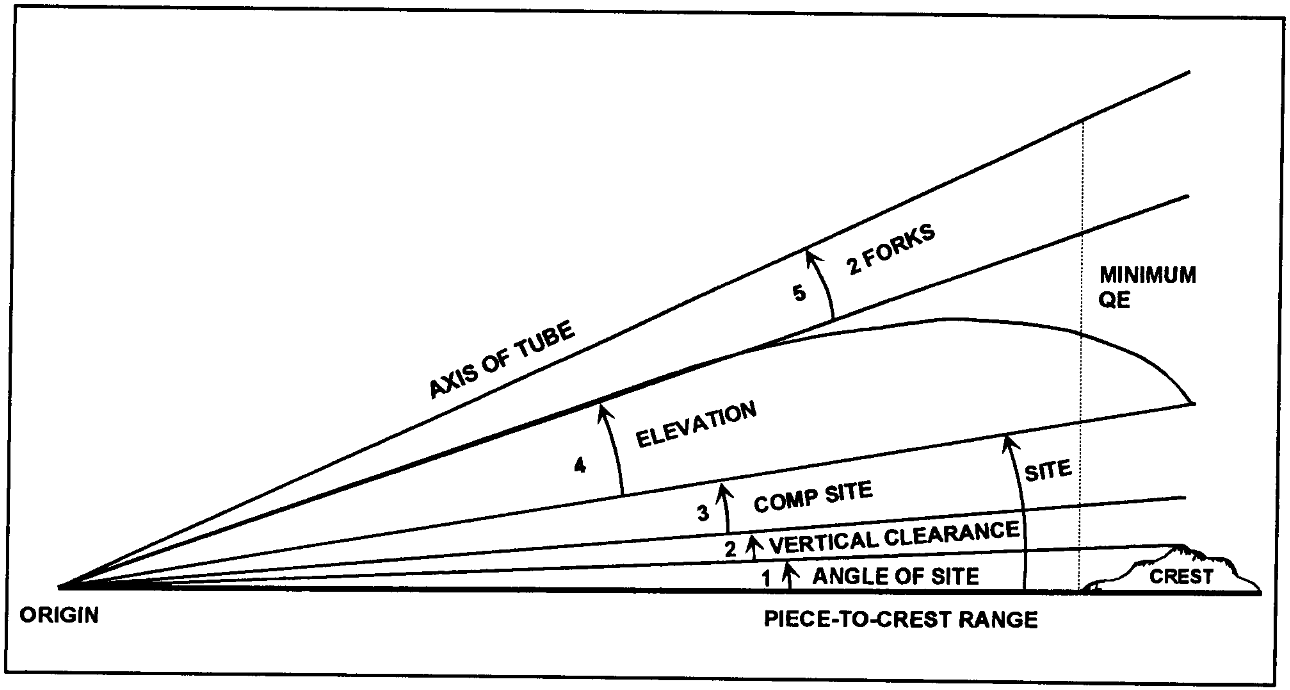


Figure 15-23. Angles of Minimum QE.

15-25. Measuring Angle of Site to Crest

As soon as the piece is "safed," prefire checks conducted, and ammunition prepared, position improvement begins with verification of site to crest as measured by the advance party. The advance party measures site to crest with an M2 compass or aiming circle. The section chief measures the angle of site to crest and reports it to the XO or platoon leader. To measure the angle of site to crest, the section chief sights along the bottom edge of the bore, has the tube traversed across the probable field of fire, and has the tube elevated until the line of sight clears the crest at the highest point. He then centers all bubbles on the elevation mount and reads the angle of site to the crest from the elevation counter. This angle of site and the PCR are reported as part of the section chief's report.

15-26. Measuring Piece-To-Crest Range

a. There are five methods that can be used to measure piece-to-crest range:

(1) Taping. This is the most accurate method; however, it is normally too time-consuming.

(2) Subtense. This method is fast and accurate.

(3) Map Measurement. This method is fast and accurate if the obstacle can be accurately located (for example, a lone tree will not appear on a map).

(4) Pacing. This method is time-consuming and depends on the distance and accessibility to the crest.

(5) Estimation. This method is least accurate, but it is used when other methods are not feasible.

b. Regardless of the method used to measure PCR, the XO or platoon leader must verify PCR before he computes QE. He can do this by using any of the five methods.

15-27. Computation for Fuzes Other Than Armed VT

a. The XO or platoon leader does the computations indicated in this section if the sum of angles 1 and 2 (Figure 15-23) exceeds 300 mils or if the rapid fire tables (RFTs) are not available. All angles are determined and expressed to the next higher mil. Table 15-14 lists the steps and solves an example of an XO's or platoon leader's manual computations.

Table 15-14. Manual Minimum QE Computations.

STEP	ACTION
1	Howitzer 1 (M109A3) reports a site to crest of 16 mils at a PCR of 1,100 meters. Charge 3GB is used.
2	∢1 = site to crest = **16 mils**
3	∢2 = (VI x 1.0186) ÷ PCR (in 1,000s) = (5 x 1.0186) ÷ 1.1 = 4.6 ≈ **5 mils** This VI is a 5-meter vertical clearance safety factor. It can also be computed by using one of the following methods: ● Use the GST. Solve in the same way as angle of site **(4.6 ≈ 5)**. ● Use ST 6-50-20, page B-1 **(5)**.

Table 15-14. Manual Minimum QE Computations (Continued).

STEP	ACTION
4	**∢3** = (∢1 + ∢2) x CSF = (16 + 5) x 0.010 = 0.210 ≈ **1 mil**
5	∢4 = EL = 74.1≈ **75 mils**
6	∢5 = 2 Forks (TFT, Table F, Column 6) = 2 x 2 = **4 mils**
7	Min QE = ∢1 +∢2 +∢3 +∢4 +∢5 = 16 + 5 + 1 + 75 + 4 = **101 mils**

b. The same example is solved in Table 15-15 by using the RFTs in ST 6-50-20, Appendix B.

Table 15-15. RFT Minimum QE Computations.

STEP	ACTION
1	Determine if the RFT can be used (**∢1 + ∢2 ≤ 300 mils**). Use ST 6-50-20, page B-1. Since the sum of angles 1 and 2 is less than or equal to 300 (**16 + 5 = 21**), the RFT can be used.
2	Determine RFT value. Enter the appropriate RFT. The entry arguments are howitzer (M109A3), propellant (M3A1, GB), fuze (PD), PCR (1100), and charge (3). The correct table is on page B-30. The RFT value is 86. This value equals the sum of angles 2, 3, 4, and 5 (**∢2 + ∢3 + ∢4 + ∢5**).
	NOTE: Use the RFT labeled "M557, M564" for **all** minimum QE computations except armed VT. For armed VT, use the RFT labeled "M728."
3	Determine the RFT minimum QE. This value equals the sum of angle 1 and the RFT value (**16 + 86 = 102**).

c. One howitzer section may report a site to crest that is unusually high. If the XO or platoon leader determines that it is the result of a single narrow obstruction (such as a tree), the piece can be called out of action when firing a deflection that would engage the obstruction. This would enable the platoon to use the next lower site to crest. Other alternatives are to remove the obstruction or move the weapon.

d. Table 15-16 illustrates why minimum QE is computed for all guns, regardless of which has the largest site to crest.

Table 15-16. RFT Example for Howitzer Platoon.

GUN	CHG	PCR	SITE TO CREST	+	RFT	=	MIN QE
1	3GB	800	128		64		192
2	3GB	1000	105		80		185
3	3GB	1500	92		116		208
3	3GB	1200	115		93		208

15-28. Computations for Armed VT Fuze (Low-Angle Fire)

a. The method of computing the XO's minimum QE for firing a projectile fuzed with an M728 or M732 fuze depends on the method in which the fuze is used. The proximity (VT) fuze is designed to arm 3 seconds before the time set on the fuze; however, some VT fuzes have armed as early as 5.5 seconds before the time set on the fuze. Because of the probability of premature arming, a safety factor of 5.5 seconds is added to the time of flight to the PCR. Since time on the setting ring is set to the whole second, the time determined in computing minimum safe time is expressed up to the nearest whole second. A VT fuze is designed so that it will not arm earlier than 2 seconds into time of flight, which makes it a bore-safe fuze.

b. In noncombat situations, the XO or platoon leader determines the minimum safe time by adding 5.5 seconds to the time of flight to the minimum range line as shown on the range safety card. The minimum QE determined for fuzes quick and time is also valid for fuze VT.

c. In combat situations, the XO or platoon leader determines the minimum QE and a minimum safe time for fuze VT. The minimum QE determined for PD fuzes is safe for VT fuzes if the fuze setting to be fired equals or is greater than the minimum safe time determined in paragraph a above. If the XO or platoon leader finds it necessary to fire a VT fuze with a time less than the minimum safe time, he must modify the minimum QE. He does this by increasing the vertical clearance to ensure that the fuze will not function as it passes over the crest.

d. If the projectile is to be fired with the VT fuze set at a time less than the minimum safe time, allowance must be made for vertical clearance of the crest. Vertical crest clearances for armed M728 and M732 VT fuzes fired over ordinary terrain for all howitzer systems is 70 meters.

e. If the projectile is to be fired over marshy or wet terrain, the average height of burst will increase. The vertical clearance is increased to 105 meters. If the projectile is fired over water, snow, or ice, the vertical clearance is 140 meters.

f. The minimum QE for armed fuze VT when a fuze setting less than the minimum safe time is fired is based on the piece-to-crest range and a vertical clearance as indicated in paragraphs d and e above.

g. Figure 15-24 shows a decision tree for application of armed VT minimum QE.

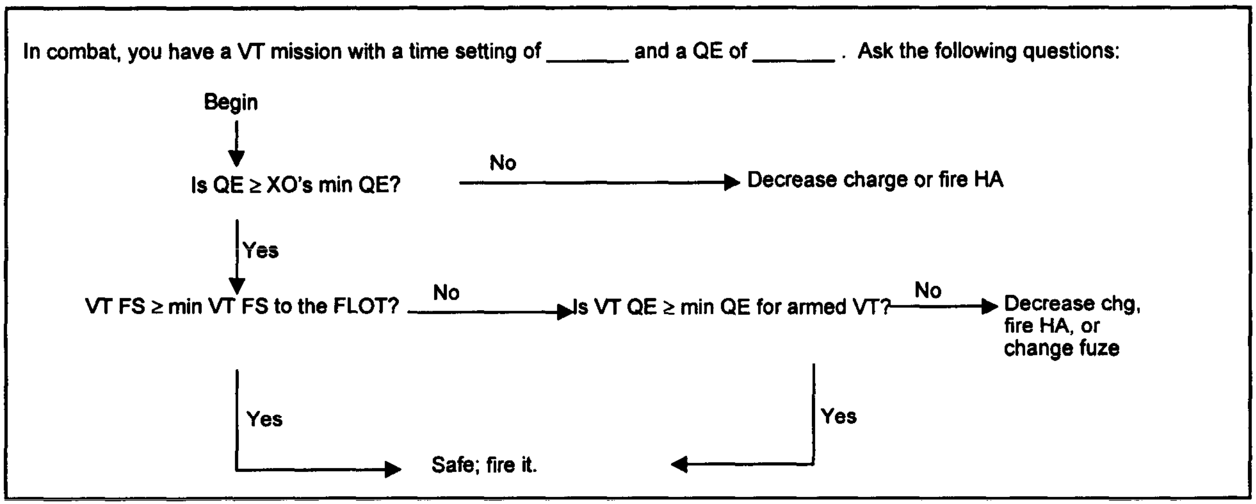


Figure 15-24. Armed VT decision tree.

h. Table 15-17 is an example of computations to determine minimum OE for an armed VT fuze.

Table 15-17. Manual Armed VT Minimum QE Computations.

STEP	ACTION
1	Howitzer 1 (M109A3) reports a site to crest of 16 mils at a PCR of 1,100 meters. Charge 3GB is used.
2	∢1 = site to crest = **16 mils**
3	∢2 = (VI x 1.0186) ÷ PCR (in 1,000s) = (70 x 1.0186) ÷ 1.1 = 64.8 ≈ **65 mils** This VI is a 70-meter vertical clearance safety factor. It can also be computed by using the GST. Solve in the same way as angle of site **(64.7 ≈ 65)**.
4	∢3 = (∢1 + ∢2) x CSF = (16 + 65) x 0.010 = 0.710 ≈ **1 mil**
5	∢4 = EL = 74.1≈ **75 mils**
6	∢5 = 2 Forks (TFT, Table F, Column 6) = 2 x 2 = **4 mils**
7	Min QE = ∢1 + ∢2 + ∢3 + ∢4 + ∢5 = 16 + 65 + 1 + 75 + 4 = **161 mils**
8	Determine minimum safe time. This value is the sum of TOF to PCR and 5.5 expressed up to the next higher second (**4.1 + 5.5 = 9.6 ≈ 10.0 sec**).

i. The same example is solved in Table 15-18 by using the RFT in ST 6-50-20, Appendix B.

Table 15-18. RFT Minimum QE Computations.

STEP	ACTION
1	Determine if the RFT can be used (∢ 1 + ∢ 2 ≤ 300 mils). This is done manually, since page B-1 uses a vertical clearance of 5 meters. See step 3 in Table 15-17 for ∢2. Since the sum of angles 1 and 2 is less than or equal to 300 (**16 + 65 = 81**), the RFT can be used.
2	Determine RFT value. Enter the appropriate RFT. The entry arguments are howitzer (M109A3), propellant (M3A1, GB), fuze (M728 or M732), PCR (1100), and charge (3). The correct table is on page B-36. The RFT value is 147. This value equals the sum of angles 2, 3, 4, and 5.
	NOTE: Use the RFT labeled "M557, M564" for **all** minimum QE computations except armed VT. For armed VT, use the RFT labeled "M728."
3	Determine the RFT minimum QE. This value equals the sum of angle 1 and the RFT value (**16 + 147 = 163**).
4	Determine minimum safe time. Use the same entry arguments as in step 2. The minimum safe time is **10.0**.

j. If the fuze setting to be fired is equal to or greater than the minimum safe time, the minimum QE for fuzes quick and time applies. If the fuze setting to be fired is less than the minimum safe time, the minimum QE determined for armed VT applies.

15-29. Using Minimum Quadrant Elevation

After computing minimum QE for each charge authorized, the XO or platoon leader must compare the minimum QE to the QE required to clear the minimum range line. The XO must then select the highest quadrant for each charge to be used as the minimum QE to be fired from that position.

15-30. Intervening Crest

a. FDOs must ensure that artillery fires clear intervening crests. Intervening crests are defined as any obstruction between the firing unit and the target not visible from the firing unit. The following are the possible options, listed in order of preference:

(1) Determine firing data to the crest (include all nonstandard conditions) and add 2 forks (Table 15-19).

(2) Determine a minimum QE in a similar manner as XO's minimum QE (Table 15-20).

(3) Use the trajectory tables in the appendix of the TFT.

b. Option 1 is preferred because it incorporates all current nonstandard conditions that will affect the projectile along the trajectory. The **FDO has the responsibility to determine on the basis of availability of corrections for nonstandard conditions if this really is the best option.** Table 15-19 lists the steps.

Table 15-19. Intervening Crest, Option 1.

STEP	ACTION
1	Upon occupation, the FDO analyzes the terrain for intervening crests.
2	Upon determining the altitude of this crest, he computes firing data to this point (QE). The best solution includes all available corrections for nonstandard conditions (current and valid GFT setting).
3	Add the value of 2 forks (TFT, Table F, Column 6) to the QE determined in step 2 to ensure that round-to-round variations (probable errors) will clear this crest.
4	The FDO then records this QE and charge on his situation map as a check to ensure that rounds will clear the intervening crest.
5	Upon receipt of a fire mission, the FDO will compare his intervening crest QE to his fire mission quadrant. One of the three following situations will occur: 1) The target is located short of the intervening crest. The FDO does not consider the effects of the crest at this time. 2) The mission QE exceeds intervening crest QE by a significant margin, indicating the round will clear the crest. 3) Fire mission QE exceeds intervening crest QE by only a small margin or is less than intervening crest QE, indicating the round may or may not clear the crest. The FDO must determine if the round will clear after considering the following: ● Have all nonstandard conditions been accounted for? ● How old is the current met message? ● Are registration corrections being applied to this mission? Upon realizing that the round may not or will not clear the crest, the FDO can either fire high angle or a reduced charge. The quickest choice would be to fire high angle, but tactical situations may prevent this. Firing a lower charge will increase dispersion more than high angle. For example, at a range of 6,000 meters, the following applies:

Table 15-14. Manual Minimum QE Computations (Continued).

STEP	ACTION
	● Low angle, charge 5: Probable error in range = 15 meters. ● High angle, charge 5: Probable error in range = 17 meters. ● Low angle, charge 4: Probable error in range = 23 meters. If a lower charge is selected, steps 2 through 5 must be repeated.
6	If VT fuzes are to be fired (M700 series), the FDO must take additional steps to ensure that the VT fuze does not arm before passing over the crest. Follow the steps for determining armed VT minimum QE and FS in paragraph 15-24.

c. Option 2 does not include current corrections for all nonstandard conditions. Table 15-20 lists the steps.

Table 15-20. Intervening Crest, Option 2.

STEP	ACTION
1	Upon occupation, the FDO analyzes the terrain for intervening crests.
2	The FDO determines and announces the grid and map spot altitude to the crest.
3	The HCO plots the grid and determines and announces range to the crest.
4	The VCO computes angle of site to the crest. This is the same as determining site to crest with a howitzer.
5	Determine if the RFT can be used (**∢ 1 + ∢ 2 ≤ 300 mils**). Angle 1 equals angle of site to the crest. Refer to ST 6-50-20, page B-1. Since ∢ 1 and ∢ 2 decrease with range, this should not be a problem.
6	Determine RFT value. Enter the appropriate RFT. The entry arguments are howitzer, propellant, fuze, PCR (chart range to the crest), and charge. This value equals the sum of angles 2, 3, 4, and 5.
	NOTE: Use the RFT labeled "M557, M564" for **all** minimum QE computations except armed VT. For armed VT, use the RFT labeled "M728."
7	Determine RFT intervening crest QE. This value is the sum of the angle of site to the crest and the RFT value.
8	If VT is fired, enter the appropriate table and extract the correct information.
9	Follow steps 4 and 5 of Table 15-19.

d. The least preferred option is using the trajectory charts in the appendix of the TFT. This offers a quicker but less accurate method to clear the intervening crest. The FDO must make a judgment call when to use these charts. **The FDO must use caution when making this decision.**

Appendix A

BATTERY OR PLATOON FIRE DIRECTION CENTER SOP

NOTE: The following SOP is to be used only as a guideline to help the FDO or fire direction section chief in developing an SOP for their unit.

The organization of the FDC generally is standard throughout the Field Artillery. The actual organization will vary depending upon unit size and their particular mission. However, the FDC in any unit must meet certain standards and be able to function on a continuous 24-hour basis. This requires that each individual within the FDC be cross-trained in every job in the FDC and understand that their primary function is to process all fire missions received with the maximum speed consistent with safety by using the most accurate data available, while ensuring necessary checks to preclude errors which might endanger friendlypersonnel. The FDC also receives operational and intelligence information for the platoon. In autonomous operations, the FDC will communicate directly with the observer in receiving the above-mentioned information.

A-1. Operational Concepts

The organization of the FDC must allow for the following goals to be accomplished:

- Continuous, accurate, timely, and safe artillery fire support under all weather conditions and terrain.
- Ability to engage all types of targets over a wide area.
- Massing of fires of all available units within range.
- Processing simultaneous missions.
- Disemmination of pertinent information.
- Efficient division of duties.
- Adherence to standard techniques and procedures.
- Teamwork and adherence to a definite specified sequence of operations to aviod and elimiante errors and to save time.
- Efficient use of communications.

A-2. Duties and Responsibilities Within the FDC

a. Fire Direction Officer.

(1) Establishes, coordinates, and supervises the operations of the FDC.

(2) Issues the fire order.

(3) Ensures that the computer processes all fire missions with technically correct procedures.

(4) Reviews and approves the solution on all fire missions, to include any violations of safety data.

(5) Develops and enforces fire command standards and ensures that proper fire commands are transmitted to the cannon sections.

(6) Ensures that ammo distribution is maintained correctly within the platoon and notifies the platoon leader if an ammo shift becomes necessary.

(7) Ensures that the FDC maintains current tactical data on maps and charts.

(8) Ensures that firing unit and ammo status are reported to the battalion FDC.

(9) Supervises the preparation for and execution of prearranged fires.

(10) Computes all safety data, to include verification of the platoon leader's minimum quadrant elevation.

(11) Analyzes intervening crests.

(12) Establishes and maintains communications.

b. Chief Fire Direction Computer (USMC--Operations Chief).

(1) Responsible for the training of all personnel within the FDC.

(2) Ensures that the FDC is prepared within Army training and evaluation program (ARTEP) (Marine Corps combat readiness evaluation system [MCRES]) standards to fire missions with the most accurate data available.

(3) Supervises the preparation of the firing chart(s). Ensures that chart checks are performed and are within tolerances between both the horizontal and vertical control operators' charts.

(4) Determines center range and charge for the computation of TGPCs. Ensures that TGPCs are correctly computed.

(5) Ensures that the safety box is correctly constructed.

(6) Supervises the installation of equipment in the FDC.

(7) Assumes the duties of the FDO in his absence.

c. Senior Fire Direction Specialist (USMC--Operations Assistant).

(1) Prepares the primary means for computing firing data and processes and records all missions fired on DA Form 4504.

(2) Transmits all firing commands to the howitzer sections in accordance with prepared fire command standards.

(3) Reports current firing unit and ammo status to the battalion FDC.

(4) Ensures that accurate information is maintained within the FDC.

(5) Ensures that all required equipment for processing missions is present and keeps the FDO and section chief informed of any shortages.

d. Fire Direciton Specialist (HCO)(USMC--Fire Control Man).

(1) Prepares the primary chart for operation. The HCO will determine range, deflection, and angle-T.

(2) Assists the fire direction computer in manual fire direction procedures when necessary.

(3) Updates the primary firing chart in accordance with the tactical situation.

(4) Assists the section chief in installation of section equipment when necessary.

e. Fire Direction Specialist (VCO) (USMC--Fire Control Man).

(1) Plots known data as directed by the assistant chief computer.

(2) Plots the initial target location and subsequent corrections when received.

(3) Checks chart data with the HCO.

(4) Plots the initial target location on the situation map and determines and announces site for the appropriate battery.

f. RATELO/Driver (USMC--Fire Control Man/Driver).

(1) Maintains the section vehicle.

(2) Maintains the generator(s).

(3) Helps the fire direction specialist in posting the current tactical situation on the situation map. Also, helps in maintaining in a current status all charts and records.

(4) Operates and maintains the FDC radios.

g. Advance Party Man. Not mentioned above are the additional duties of the advance party man. This individual is normally selected and trained by the section chief. His duties areas follows:

- Prepares the position for the arrival of the FDC.
- Establishes wire communications with the aiming circle and the gun guides.
- Sets up the OE-254 antenna.
- Receives initial data from the aiming circle and inputs it into the BUCS computer.
- Establishes position voice communication with battalion.
- Guides the FDC vehicle into position.
- Helps set up camouflage nets.
- Ensures wire and radio communications are functioning properly. If they are not, he troubleshoots them.
- Sets up the second 0E-254 as needed.

NOTE: Successful accomplishment of the battery fire direction mission depends on the fully coordinated efforts of all members of the FDC.

A-3. FIRE DIRECTION CENTER OPERATIONS CHECKLIST

The following checklists are provided to help the FDO or section chief in preparation and sustainment during any major field exercise.

a. Actions Before Departing Garrison.

(1) Design physical setup of the FDC to allow the FDO and section chief to observe the work of all personnel with a minimum amount of movement and provide each individual ready access to the equipment, forms, and information necessary to perform his duties.

(2) Ensure all necessary supplies and equipment are located within the FDC. (For a complete list of required equipment in a standard FDC, refer to the end of this appendix.)

(3) Ensure muzzle velocity logbook is present.

(4) Ensure adequate supply of expendable forms is on hand. The following forms are used in all FA units:

- DA Form 4982-R, *Muzzle Velocity Record.*
- DA Form 4982-1-R, *M90 Velocimeter Work Sheet.*
- DA Form 4504, *Record of Fire.*
- DA Form 4200, *Met Data Correction Sheet.*
- DA Form 3677, *Computer Met Message.*
- DA Form 3675, *Ballistic Met Message.*
- DA Form 5338-R, *Computer Checklist.*
- DA Form 4757, *Registration and Special Correction Work Sheet,*
- DA Form 4201, *High Burst (Mean Point of Impact) Registration.*
- DA Form 7353-R, *Universal Safety T.*
- DA Form 7352-R, *Copperhead Met + VE Work Sheet.*
- DA Form 4655-R, *Target List Work Sheet.*

NOTE: The following forms are only for use in 155-mm units:

- DA Form 5032-R, *Field Artillery Delivered Minefield Planning Sheet.*
- DA Form 5711-R, *Copperhead Planned Target List Work Sheet.*

(5) Ensure that the fire direction vehicle is loaded in accordance with your unit load plan. The load plan located at the end of this appendix maybe used as a guideline.

(6) Ensure the communications system has been verified as operational.

b. Actions Upon Occupation of a Position. These actions are not listed in any particular order and are as follows:

(1) Establish voice communications with battalion operations center and the FDC, guns, and other subscribers; that is, observers and range control.

(2) Verify the azimuth of lay with the platoon leader.

(3) Transmit current update to battalion on firing unit and ammo status.

(4) Establish fire order and fire command standards, and transmit them to the howitzer sections.

(5) Maintain the muzzle velocity logbook.

(6) Request observer locations.

(7) Complete average site map.

(8) Request current met.

(9) Verify howitzer ammo count and whether or not the ammo status is readily available to the FDO and section chief.

(10) Perform all necessary chart checks.

(11) Compute safety and have a verification check completed as well.

(12) Verify the platoon leader's minimum QE.

(13) Verify the safety computed does not violate the platoon leader's minimum QE.

(14) Ensure safety data have been posted within the FDC and distributed to all howitzer sections and leadership within the platoon.

(15) Ensure the VCO's map is color-coded and marked for average site and altitude.

(16) Compute TGPCs and special correcitons.

(17) Verify that all sensitive items are accounted for.

(18) Verify GFT settings are applied to the GFTs.

(19) Obtain an accurate propellant temperature and projectile weight.

(20) Ensure situation map is readily available and posted with the current tactical situation and fire support coordinating measures.

(21) Ensure the generator has been serviced and started.

(22) Ensure after-operation checks have been completed on the FDC vehicle.

(23) Ensure all howitzers have reported safe and in order.

(24) Check for intervening crests.

(25) Check the following to ensure that they are plotted correctly on the firing chart:

- Center of battery location or base piece and altitude.
- Azimuth of fire.
- Azimuth and deflection indexes,
- Safety box.
- Observer locations.
- Fire support coordinating measures.
- Frontline of troops.
- Radar.
- Other batteries within the battalion.
- TGPC sectors if applicable.

(26) Ensure the firing chart is neat and clean.

(27) Ensure the chart is prepared for 6,400-mil operation, if necessary.

(28) Ensure the five requirements for accurate predicted fire have been met.

(29) Ensure a wet code has been requested for live fire from range control.

(30) Ensure the FDC is neat and orderly with equipment readily available but stored so as not to interfere with the FDC operations.

(31) Ensure fire order and fire command standards are visible to all personnel.

(32) Ensure the following information is easily accessible.

- Laying data.
- Piece distribution.
- MV information.
- Call signs.
- Residuals.
- GFT settings.
- Propellant temperature.
- Projectile weight.
- Terrain gun position corrections.

c. Actions Upon Receipt of a Fire Mission. Upon receipt of a fire mission, the FDC does the following:

RATELO: Records CFF and announces **FIRE MISSION** to the FDC.

ALL: Announce **FIRE MISSION.**

COMPUTER: Announces **FIRE MISSION** to gun line.

RATELO: Announces (or records on mission board) the CFF to the FDC (loud readback to FO).

HCO: Reads back target location, plots target, and determines chart range and deflection.

VCO: Plots target and determines chart range and deflection.

FDO AND SECTION CHIEF:

1) Plot the target on the situation map and verify it is safe and does not violate any FSCMs.

2) Determine the fire order and issue it to the computer.

COMPUTER:

1) Reads back the fire order and records it on ROF.

2) Records initial fire commands up to and including fuze on the basis of the FDO's fire order.

3) Announces initial fire commands to the guns. (FDO and section chief monitor.)

RATELO: Composes and transmits the MTO on the basis of the fire order. (FDO and section chief monitor.)

COMPUTER: Requests range; for example, **RANGE, ONE ALPHA.**

HCO: Announces chart range to the computer; for example, **ONE ALPHA, RANGE 5980.**

VCO: Announces **CHECK** or **HOLD** (±30 meters) to HCO.

COMPUTER:

1) If the VCO announces **CHECK,** places announced range under MHL on appropriate GFT. If the VCO announces **HOLD,** has the section chief verify charts and determine which range to use.

2) Records and reads back range placed on GFT; for example, **RANGE 5980.**

3) Requests deflection; for example, **DEFLECTION.**

HCO: Announces chart deflection to computer; for example, **DEFLECTION** 3286.

VCO: Announces **CHECK** or **HOLD** (±3 mils) to HCO.

COMPUTER:

1) Records chart deflection on ROF and reads back chart deflection.

2) Records elevation on ROF.

3) If time or VT fuze is used, determines time setting.

4) If time or VT fuze is used, announces **FZ TI (or VT), TIME (such-and-such)** to gun line and records on ROF.

5) Determines deflection correction and records it on ROF.

6) Determines deflection to fire.

7) Announces deflection to fire as **DEFLECTION (so much)** to the gun line and records it on ROF.

FDO AND SECTION CHIEF: Ensure all data determined by computer are correct. (May follow with TFT and GFT or BUCS.)

VCO: Determines and announces site. (FDO and section chief perform common-sense check [VI/RG in thousands].)

COMPUTER:

1) Records site on ROF.

2) Determines QE and records it on ROF.

3) Announces data to FDO and section chief for safety verification.

FDO AND SECTION CHIEF: Verify the data from the safety T are safe. If the data are safe, announce **SAFE.** If the data are unsafe, announce UNSAFE and state the reason why; for example, **UNSAFE, QE 3 MILS BELOW MIN SAFE QE.**

COMPUTER:

1) If data are safe, announces QE to the gun line.

2) Records MOF I/E, if applicable, as announced in the fire order.

3) Maintains the ROF.

HCO AND VCO: Orient target grid on firing charts and await any subsequent corrections from the observer.

VCO: Updates ammo board as time permits.

d. Actions During Fire Missions. These actions areas follows:

(1) Verify the met was valid with registration.

(2) Ensure safety data have been updated after the registration mission.

(3) Ensure situation map has been checked for occupation of intervening crests by friendly elements.

(4) Verify fire order has been issued.

(5) Ensure the fire mission is from a valid subscriber.

(6) Authenticate the call for fire, if necessary.

(7) Ensure the current communications-electronics operation instructions (CEOI) are available.

(8) Ensure the MTO is transmitted promptly and in accordance with the fire order.

(9) Ensure fire commands are being transmitted as soon as individual items are determined and that they are in the correct format.

(10) Ensure ammo count has been updated after every mission by piece.

(11) Verify how old met data are.

(12) Complete a chart-to-chart check on firing data for each mission.

(13) Check safety on each and every mission.

(14) Determine angle T and, if necessary, transmit it to the observer.

(15) Properly update safety.

(16) Ensure proper reports are given to the battalion FDC and tactical operations center (TOC).

(17) Ensure current situation map has been updated lately to reflect the current tactical situation.

(18) Ensure the record of fire is legible and complete.

(19) Ensure propellant temperature has been updated within the last hour.

(20) Ensure the communications system allows all personnel to hear the call for free.

e. Actions Before Displacement. These actions areas follows:

(1) Ensure FDC is set up for emergency missions.

(2) Clean off old GFT settings from GFT.

(3) Ensure start point has been reported to battalion.

(4) Ensure communications check has been performed with battalion while moving.

(5) Ensure all sensitive items have been accounted for.

(6) Ensure chart has been prepared for the next position.

(7) Ensure checkout information has been obtained from range control.

(8) Always keep copies of ROFs and safety computations for permanent records.

(9) File forms in an orderly manner.

A-4. Fire Direction Center Journal (Logbook)

To maintain a record of FDC activities during field operations, it is recommended that a journal be kept of each day’s activities. This journal, or logbook, will reflect all significant events that have occured during all field operations. These significant events include, but are not limited to, the following:

- Check firings.
- Reports.
- All range control information.
- Receipt of all messages (date, time, and content).
- Met messages.
- The journal should be closed out every 24 hours so as to prevent any unnecessary confusion.

A-5. Fire Direction Center Equipment and Configurations

a. Although this appendix focuses on the manual FDC, it should be noted that the following is the priority in determining the method to be used in the computation of firing data.

(1) The lightweight computer unit (LCU)-BCS is the primary means of computing technical firing data within the platoon.

(2) The LCU-BCS-BUCS is the backup means of computing technical firing data.

(3) The ability to perform manual fire direction must be maintained to change to manual fire direction techniques at any time. Each FDC should maintain one firing chart with the appropriate fire direction equipment and manuals to support all manual cannon gunnery operations. The firing charts should serve as an emergency backup for BCS and BUCS,

b. Each FDC is authorized the following: fire direction set 3, artillery (NSN 1290-00-299-6892), 30,000 meters maximum range (line item number [LIN] H55843), 19200 (Table A-l); fire direction set 4, artillery (NSN 1290-00-299-6893), 15,000 meters maximum range (LIN H55706) (Table A-2); and plotting set, artillery fire control @JSN 6675-00-641 -3630) (LIN P09818) (Table A-3).

c. Figures A-1 through A-5 show suggested layouts of battery FDCs, including manual, automated, and howitzer improvement program (HIP) configurations. Applicability of these configurations will depend on the inherent mission and equipment of the unit concerned. Address questions or comments concerning these layouts to:

Commandant
US Army Field Artillery School
ATTN: ATSF-GSP
Fort Sill, OK 73503-5600

Table A-1. Contents of Fire Direction Set 3.

ITEM	NSN	QTY
Carrying case, field artillery fire direction center equipment: canvas, 50 inches long, 40 inches high, 8 inches thick, folded	1290-00-694-5190	1 each
Drawing board and trestle: 48 inches long, 36 inches wide, nonsiope, folding trestle, 36 inches high	5675-00-248-1244	1 each
Plotting sheet 1,000-meter grid, 47 inches long, 35 inches wide	7530-00-656-0612	12 each
Protractor, fan, range-deflection: 30,000 meters range, 11834239(19200)	1290-00-266-6891	1 each

Table A-2. Contents of Fire Direction Set 4.

ITEM	NSN	QTY
Carrying case, field artillery fire direction center equipment: canvas, 45 inches long, 33 inches high, 8 inches thick, folded	1290-00-694-5191	1 each
Drawing board and trestle: 42 inches long, 31 inches wide	5675-00-248-1243	1 each
Plotting sheet 1,000-meter grid, 41 1/2 inches long, 30 inches wide	7530-00-656-0613	12 each
Protractor, fan, range-deflection: 25,000 meters range	1290-00-266-6890	1 each

Table A-3. Contents of Plotting Set.

ITEM	NSN	QUANTITY
Chest, plotting equipment: command post, 81349 C-12044, D7242-1	6675-00-561-0122	1 each
Map, tack, 1 1/8 inch (plotting needle) (100 per box)	1	2 boxes each color
Pad, writing paper: ruled two sides, white, 10 1/2 inches long, 8 inches wide, 100 sheets per pad, 12 pads per package (pkg), 81348 UU-P-21	7530-00-285-3038	1 pkg
Paper, tracing, high transparency, white: Substance 25 to 29 per 1,000 sheets of 17 X 22 inches; basic size 18 inches long, 12 inches wide, 100 sheets per pad, 81348 UU-P-00561 type III	7530-00-235-4033	1 pad
Substance 31 to 25 per 1,000 sheets of 17 X 22 inches; basic size 20-yard roll, 21 inches wide, 81348 UU-P-00561 type III	7530-00-236-9305	1 roll
Pencil: thin lead, wood-cased, class A:		
Blue 76364 mephisto 1345	7510-00-233-2027	1 dozen
Green 81348 SSP201	7510-00-264-4610	1 dozen
Orange 75364 mephisto 1343	7510-00-787-2430	1 dozen
Red 75364 mephisto 1340	7510-00-233-2021	1 dozen
Drawing, black, with eraser, FED spec SS-P-1605, number (no) H:		
No H	7510-00264-4614	1 dozen
No 3H	7510-00-189-7881	1 dozen
No 5H	7510-00-189-7883	1 dozen
General writing, black thin lead, medium hardness, no. 2, with eraser, 81348 SS-P-166 type IV	7510-00-281-5234	2 dozen
Glazed surface marking, extra thick lead, paper-cased:		
Black, 12 per package class C	7510-00-240-1526	1 dozen
Blue, 12 per package class A	7510-00-436-5210	1 dozen
Red, 12 per package class B	7510-00-174–3205	1 dozen
Pencil pointer: flint, 7 1/4 inches long, 1 1/4 inches wide, 1/8 inch thick, 81348 SS-P-551, type II	7510-00-237-4926	2 each
Plastic sheet: cellulose acetate, transparent, matte finish 1 side, colorless, 0.0075 inch thick, 20 inches wide, 50-ft roll, 81348 L-P-504, type I	9330-00-282-8324	1 roll
Plotting needle: red head, tapered shaft, 11/16 inch long, 0.020 to 0.030-inch diameter; 1 1/8 inches long, 4 per folder (pachage), 81349 FF-T-51	7510-00-851-9354	12 pkg
Protractor, semicircular:		
Brass: 4 1/4 inch, 1-degree graduations, numbered 0 to 180 degrees, 81348 GG-P-681, type I, class A, style 1	6675-00-641-3166	1 each
Plastic: 16-inch diameter; graduation units, mils, and meters; scales 1 to 25,000 and 1 to 50,000; 10-mil graduatins numbered 100 to 3,100 mils; 81349 MIL-P-20385, type I	6675-00-556-0118	1 each
Scale, plotting:		
Plastic, flat, eight bevel, hollow square shape, graduation units, meters, and yards; scale 1 to 25,000 and 1 to 50,000; 4 inches square outside and 2 inches square inside; 81349 MIL-S-10987	6675-01-NIIN	4 each
Wood and plastic, triangular, relieved facet, graduation units, 1 to 25,000 yd, 1 to 25,000 meters, 1 to 50,000 and 1 to 62,500 inches and centimeters, 12 inches long; 81348 GG-8-161/7, shape D, notice 2	6675-00-283-0040	2 each
Sharpener, pencil: pocket size, draftsman's point cut, 75264 catalog no 1000	7520-00-227-1451	2 each
Shears, straight trimmers: steel blade and handle, sharp pointed blades, 9 inch, 81348 GGG-S-00278, type I, class 1 style A	5110-01-241-4373	1 each
Tape, pressure-sensitive adhesive: 0.75 inch nominal width, 72.00 yd nominal length; cellulose acetate film backing; transparent material; clear color, adhesive coating one side; 3.00 inch nominal core inside diameter, (58536) commercial item description (CID) AA-113, type II, class A: (78381) Minnesota Mining and Manufacturing Company, P/N 810, 0.75 inch wide, 72 yards long, or equal	7510-00-551-9824	2 rolls
Tape, pressure-sensitive adhesive: 1.00 inch nominal width, 60.00 yard nominal length; opaque material; natural color; adhesive one side; iner; 3.00 inch nominal core inside diameter; usage design for holding drawing board; (58536) commercial item description AA-194; (76381) Minnesota Mining and Manufacturing Company, P/N 230, 1.00 inch ide, 60 yards long, or equal	7510-00-198-5831	2 rools
Thumbtack: 0.312 inch nominal pin length, steel material; 100 per pack; (81348) federal specifications FF-T-311, type II, class 1	7510-00-272-6887	1 pack

Map tacks are a local-purchase item. Order from LABELON/GRAFFCO, #10 Chapin Street, Canadaqua, New York 14424. Order numbers by color are as follows: orange, LL01; red, LL02; blue, LL06; black, LL07.

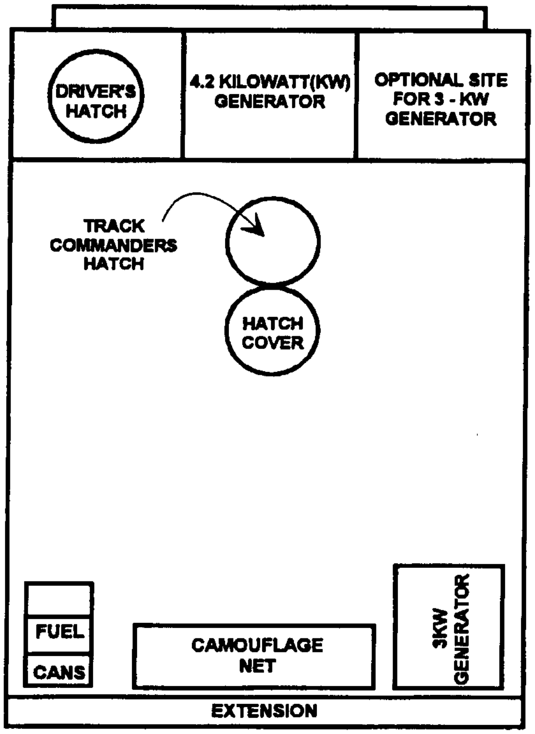


Figure A-1. External Top View of Battery FDC in an M577A1/A2 Command Post Vehicle.

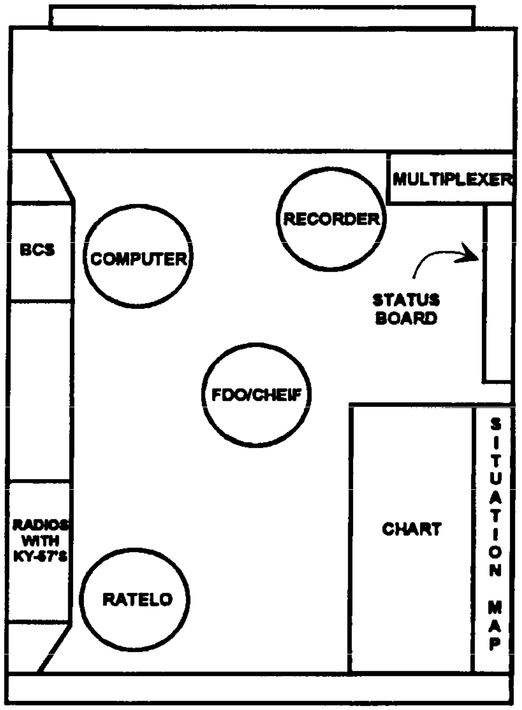


Figure A-2. Internal Top View of Battery FDC in an M577A1/A2 Command Post Vehicle.

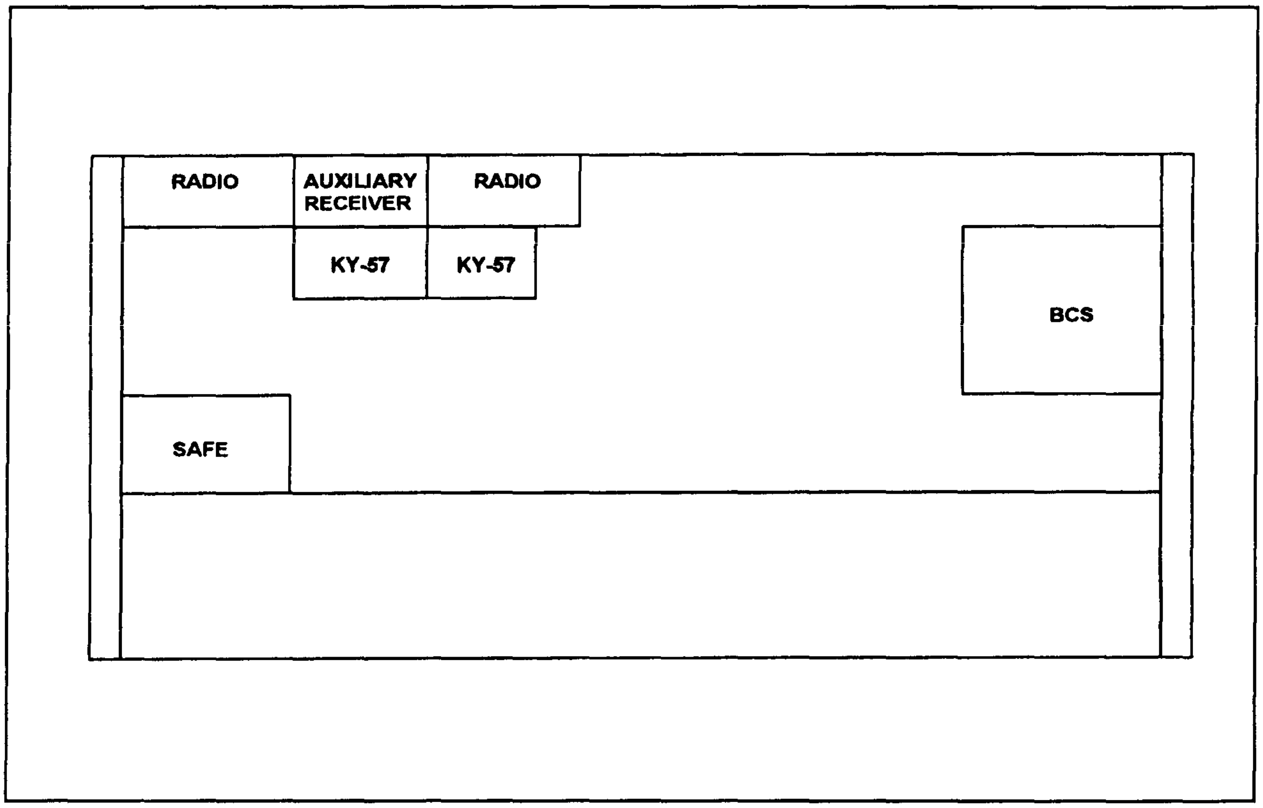


Figure A-3. Internal Left Side View, M577A1/A2.

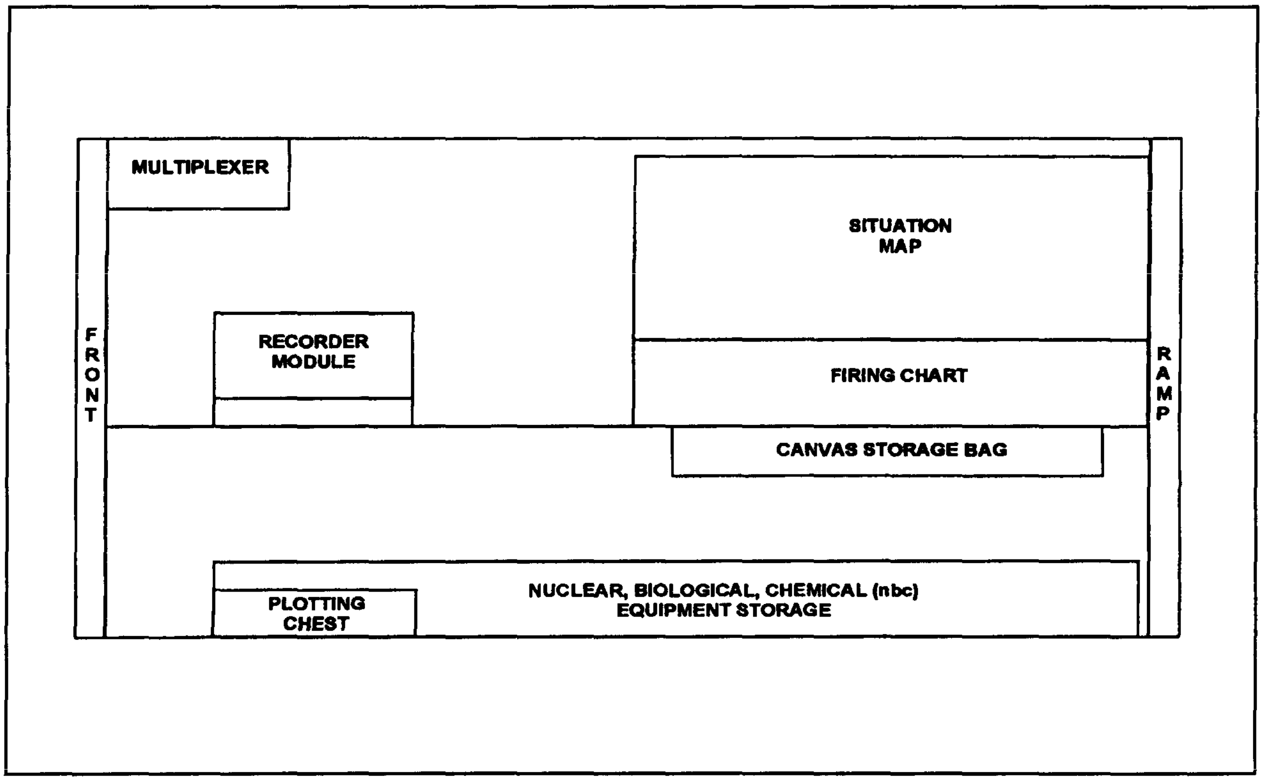


Figure A-4. Internal Right Side View, M577A1/A2.

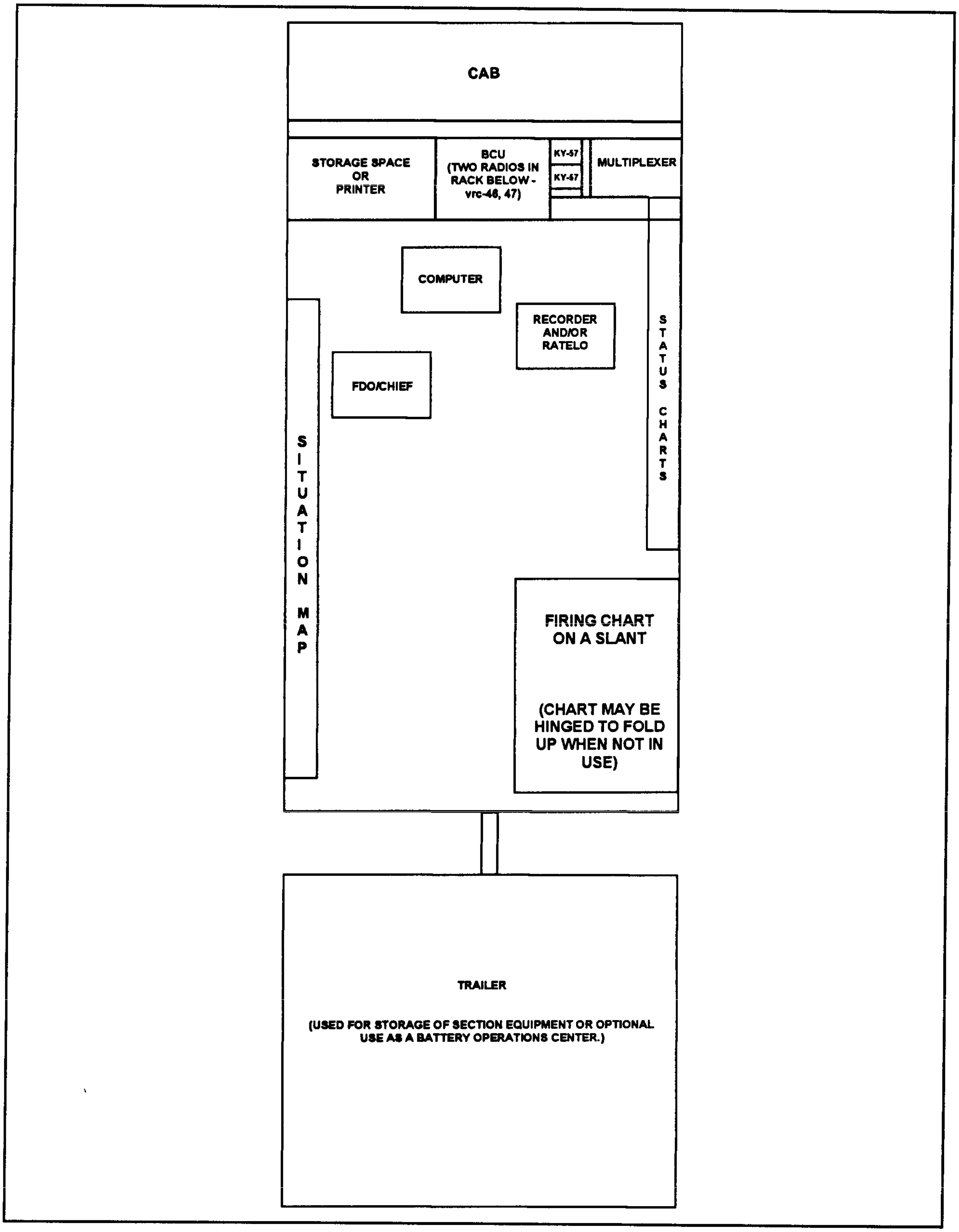


Figure A-5. Top View of Battery FDC in High-Mobility Multipurpose Wheeled Vechicle (HMMWV) or 2 1/2 Ton Truck.

c. Table A-4 shows a list of components needed for the FDC.

Table A-4. Components List.

NATIONAL STOCK NO	DESCRIPTION	UNIT OF ISSUE	QTY AUTH
9330-01-284-5609	PLASTIC SHEET: polyester resin matl; clear, film, natural color; 0.004 in. thk, 20.0 in w; 600 in lg; roll form; Transilwrap Co. of Philadelphia Inc. (30025) P/N PFilm, Polyester Film, .004 in thk; 20 in w; 20 ft, or equal Union Instrument Co./UIC Inc. (88997) P/N 87TG2, .004 in thk; 20 in w; 50 ft, or equal	RO	1
	PLOTTING PIN: steel pin matl; plastic or glass head matl; 1-1/8 in. lg pin lg; 1/4 in. head dia; colors as specified; Spherical head shape; 50 per box;		
7510-01-269-3839	black; Moore Push Pin Co.(74083)P/N 807, or equal Labelon Corp.(83017)P/N LL07, black; or equal	BX	4
7510-01-269-3838	blue; Moore Push Pin Co.(74083)P/N 804, or equal Labelon Corp.(83017)P/N LL06, blue; or equal	BX	4
7510-01-269-9747	green; Moore Push Pin Co.(74083)P/N 806, or equal Labelon Corp.(83017)P/N LL04, green; or equal	BX	4
7510-01-269-3838	orange; Moore Push Pin Co.(74083)P/N 801, or equal Labelon Corp.(83017)P/N LL01, orange; or equal	BX	4
7510-01-269-3836	red; Moore Push Pin Co.(74083) P/N 802, or equal Labelon Corp.(83017) P/N LL02, red; or equal	BX	4
6675-00-283-0018	SCALE, PLOTTING: plastic matl; flat shape; eight beveled edge type; hollow sq view shape; two scales, 1:25,000 and 1:50,000 map ratio, inscription in meters; 4 in. sq o/a dim; Mil Spec(81349) MIL-S-10987 Allegheny Plastics Inc.(84010) P/N MIL-S-19087, plastic matl, or equal	EA	4
6675-00-283-0040	BOX WOOD SCALE: plastic and wood matl; triangular shape; relieved facet type; graduation units, 1:25,000 yd and meters; 1:50,000 and 1:62,500 in and cm; 12 in. o/a lg; FED Spec (81348) GG-S-161/7, type VII, shape 7, comp A, grade 2, size B, graduation 2, numbering A, style E, sheath 4 Sterling Mfg Co.(7D595) P/N GG-S-161/7, type VII, shape 7, comp A, grade 2, size B, graduation 2, numbering A, style E, sheath 4, or equal	EA	4
5110-01-241-473	SHEARS, STRAIGHT TRIMMERS: ambidextrous oper designed; 2 sharp point blades; CRES blade; rust-proof and no sharpening required; lightweight molded high impact plastic handle grips; 8.5 in. o/a lg; Alvin and Co. Inc.(23366) P/N 1093, or equal	EA	2

Table A-4. Components List (Continued).

NATIONAL STOCK NO	DESCRIPTION	UNIT OF ISSUE	QTY AUTH
	PENCIL:		
7510-01-134-5506	4H hardness; Berol Corp., Berol USA Div.(9V632) P/N E375-4H, or equal Faber Castell Corp. (32988) P/N 05014, or equal	DZ	2
7510-01-294-7979	6H hardness; Berol Corp., Berol USA Div.(9V632) P/N E375-6H, or equal Faber Castell Corp. (32988) P/N 05016, or equal	DZ	2
	glazed surface marking; thick marking core; spiral paper cased; Commercial Item Decsription (CID) (58536) A-A-87, type I, colors as specified; 12 per box;		
7510-00-240-1526	black; Alvin and Co. Inc.(23366) P/N 173T, or equal Berol Corp., Berol USA Div. (9V632) P/N 173T, or equal	DZ	1
7510-00-436-5210	blue; Alvin and Co. Inc.(23366) P/N 168T, or equal Berol Corp., Berol USA Div. (9V632) P/N 168T, or equal	DZ	1
7510-00-174-3205	red; Alvin and Co. Inc.(23366) P/N 165T, or equal Berol Corp., Berol USA Div. (9V632) P/N 165T, or equal	DZ	1
7510-00-237-4926	PENCIL POINTER: 7.25 in. lg, 1.25 in. w, 0.125 in. thk; wood block and handle; twelve sheets of flint paper 1.25 X 4.0 in. o/a dim; Alvin and Co. Inc.(23366)P/N 3435, or equal colored; thin lead, wood cased, FED Spec SS-P-201 (81348) type I, class A, colors as specified;	EA	2
7510-00-233-2027	blue; Berol Corp., Berol USA Div. (9V632) P/N 758, or equal Faber Castell Corp. (32988), P/N 1276, or equal	DZ	2
7510-00-264-4610	green; Berol Corp., Berol USA Div. (9V632) P/N 739, or equal Faber Castell Corp.(32988), P/N 1278, or equal	DZ	2
7510-00-787-2430	orange; Berol Corp., Berol USA Div. (9V632) P/N 737, or equal Faber Castell Corp.(32988), P/N 1295, or equal	DZ	2
7520-00-233-2021	red; Berol Corp., Berol USA Div. (9V632) P/N 745, or equal Faber Castell Corp.(32988), P/N 1297, or equal	DZ	2
	Lead drawing type; black color; w/ eraser; 12 per pkg; Commercial Item Description (CID) (58536) A-A-976		
7510-00-264-4614	H hardness; Berol Corp., Berol USA Div. (9V632) P/N E375-H, or equal Faber Castell Corp.(32988), P/N 05010, or equal	DZ	2

Appendix B

FIRE DIRECTION CENTER SECTION EVALUATION GUIDE

This evaluation guide tests the skills essential to the accomplishment of the mission of the FDC section. Although many of the tasks are evaluated on the basis of individual performance, the collective skills evaluation will measure the ability of the platoon FDC to function as a team. Commanders may use the guide to accomplish the following:

- Provide a basis for a section training program.
- Evaluate the current state of training proficiency of the section.
- Serve as a supplement to other performance-oriented training.

The tasks laid out in this guide also serve as a program of training objectives. The platoon FDC section should practice each task to acquire the degree of proficiency required by the standards set in the evaluation.

B-1. Scope

This is an evaluation guide for the platoon FDC section of a cannon battalion or separate battery. It is generic in scope and can be adapted readily to all platoon FDC sections associated with all artillery units. It is a performance-oriented evaluation and training guide designed to collectively identify the performance objectives for the platoon FDC sections. Commanders should modify this evaluation to meet local mission-essential task list (METL) tasks and current modification tables of organization and equipment (MTOE) requirements. It may be administered as follows:

- Internally or externally.
- With a minimum of admin support.
- In the local training area.
- In a tactical nonfiring environment.

B-2. Conduct of the Evaluation

The evaluation consists of three phases. The first two phases evaluate the ability of the section chief to organize and train his section into a cohesive, effective team. The last phase is a critique of the evaluation. Each phase is a separate annex and can be administered independently.

a. Phase I. This phase begins with an orientation period to include a statement of the purpose, scope, and description of the evaluation. Evaluators give a written test, on military occupational specialty (MOS) knowledge. Soldiers take this phase in a classroom environment before the remaining phases.

b. Phase II. This phase (section performance) evaluates the collective skills needed by the platoon FDC section to perform mission-oriented collective tasks in a tactical environment. The commander may choose to evaluate during day or night conditions. Live firing is not necessary to complete this phase. Commanders at various levels may direct the intensity to include all or only part of tasks for evaluation.

c. Phase III. This is a critique of the evaluation by the platoon FDC section. Evaluators will note and take recommendations from the soldiers to improve training and future evaluations.

B-3. Evaluation Format

a. Phase I consists of 25 multiple choice and true-false questions.

b. Phase II consists of specific section performance tasks.

(1) The **task** is a general statement of the requirement for the particular evaluation.

(2) The **conditions** define the specific environment or situation for the evaluation. They state what assistance, reference materials, equipment, or personnel are required.

(3) Standards or **evaluation checklists** are the requirements for successful completion of a particular task. Specific technical procedures required in the task are in the appropriate technical or field manual.

c. Phase III consists of a period after the evaluation where the section comments on the evaluated tasks, conditions, and standards.

B-4. Scoring

Phases I and II combine for a maximum total point value of 1,000 points. The evaluator will base his judgment on the criteria stated in the standards or evaluation checklist and on the most current references for the task.

B-5. Qualification

a. Formal scoring is optional. The commander can determine the strengths and weaknesses of his section by analyzing the GO-NO GO ratings received for each task performed.

b. The evaluation maybe used to determine the best platoon FDC section in a battalion ard/or div arty by determining a formal score. To determine the score for individual sections, add the numerical scores attained in each of the two phases. (See Table B-1.) Sample score sheets are shown in Figures B-1 through B-3. A sample critique for Phase III is shown in Figure B-4.

Table B-1. Formal Scoring.

PHASE	REQUIREMENTS	TOTAL POSSIBLE
I	WRITTEN TEST (25 Questions)	100
II	SECTION PERFORMANCE TEST	900
	TOTAL POINTS POSSIBLE	1,000

The following is a breakdown of the section performance test by task and total points possible for that task.

TASK NO	TASK	POSSIBLE POINTS
1	Predeployment Checks and Services.	50
2	Establish and Maintain the Platoon FDC.	100
3	Establish and Maintain the Platoon FDC After a Deliberate Occupation of a Prepared Position.	100
4	Attack Targets.	50
5	Conduct Fire Mission Processing.	600
	SUBTASKS OF TASK 5	
A	Bn Mass Large, Irregularly Shaped Target (HE/Q).	20
B	Bn FFE, TOT (HE/Ti).	20
C	Bn Mass, Low-Angle Adjust With Radar (HE/Q).	20
D	Bn Mass, Low-Angle Adjust With FO (HE/Q).	20
E	Bn Mass Under Coordinated Illumination (Illum/Ti, HE/Q).	20
F	Bn Mass, High-Angle Adjust With Radar (HE/Q).	20
G	Bn Mass, High-Angle Adjust With FO Using GVLLD (HE/Q).	20
H	Bn Mass, Low-Angle Adjust With FO Using GVLLD (HE/Q).	20
I	Bn Mass, High-Angle Adjust With FO (HE/Q).	20
J	Bn FFE, At My Command (HE/Ti).	20
K	Plt FFE With Immediate Smoke (WP/Q).	20
L	Plt Area Adjust with Quick Smoke (Smk/Ti, HE/Q).	20
M	Plt Area Adjust with Coordinated Illumination (Illum/Ti, HE/Q).	20
N	Plt Area Adjust With Illumination (Illum/Ti).	20
O	Plt High-Angle Adjust With Radar (HE/Q).	20
P	Plt Low-Angle Adjust With FO (HE/Ti).	20
Q	Plt Low-Angle Adjust With FO Using GVLLD (HE/Q).	20
R	Plt FFE, Copperhead Target of Opportunity (Cphd).	20
S	Plt Low-Angle Adjust With FA Aerial Observer (HE/Q).	20
T	Plt FFE, When Ready.	20
U	Plt FFE, At My Command.	20
V	Plt FFE, Copperhead Priority Mission (Cphd).	20
W	Plt FFE, Fire Priority Target (HE/Ti).	20
X	Plt FFE, Large, Irregularly Shaped Target (HE/Q).	20
Y	Plt FFE, Fire FPF (HE/Q).	20
Z	Plt FFE, Immediate Suppression.	20
AA	Plt High-Angle Adjust With FO Using GVLLD (HE/Q).	20
AB	Plt High-Angle Adjust With FO (HE/Q).	20
AC	Plt Low-Angle Adjust Simultaneous Mission (HE/Q).	20
AD	Plt Low-Angle Adjust With Radar.	20
Phase III	CRITIQUE	None

UNIT OR SECTION INFORMATION AND SCORE SHEET

DATE: ____________________ UNIT: ____________________

EVALUATOR: ________________ SECTION EVALUATED: ________________

SECTION CHIEF: ________________________________

	NAME	**GRADE**	**DUTY POSITION**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

TOTAL PERSONNEL AUTH: _____

TOTAL PERSONNEL TESTED: _____

PHASE I SCORE _____

PHASE II SCORE + _____

SCORE TOTAL _____ (MAX 1,000)

QUALIFICATION	(1,000-950)	DISTINGUISHED	_____
	(949-900)	EXCELLENT	_____
	(899-800)	OUTSTANDING	_____
	(799-700)	SATISFACTORY	_____
	(699-0)	UNQUALIFIED	_____

Figure B-1. Sample Unit or Section Information and Score Sheet.

PHASE I: WRITTEN TEST SCORE SHEET

	Soldier's Name	Raw Score		Percentage
1.			/100 =	
2.			/100 =	
3.			/100 =	
4.			/100 =	
5.			/100 =	
6.			/100 =	
7.			/100 =	
8.			/100 =	
9.			/100 =	
10.			/100 =	

Total Percentage ________ /No of soldiers x 100 = Total Score ________

Figure B-2. Sample Phase I: Written Test Score Sheet.

PHASE II: SECTION PERFORMANCE TEST SCORE SHEET

	Task Name	Raw Score
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
Score Total		

Figure B-3. Sample Phase II: Section Performance Test Score Sheet.

PHASE III: CRITIQUE

1. Did the tasks realistically evaluate the section's ability to perform its mission?

COMMENTS: ______________________________

2. Were the conditions proper for the tasks evaluated?

COMMENTS: ______________________________

3. Were the standards too easy, too hard, or just right?

COMMENTS: ______________________________

Figure B-4. Sample Phase III: Critique.

B-6. Phase I: Test and Answer Key

A sample Phase I written test is shown below. The Phase I written test answer key follows the sample written test.

SAMPLE

PHASE I: WRITTEN TEST INSTRUCTIONS

1. Evaluator conducts the following actions the day before Phase II, the performance test.
   a. Brief personnel as to overall concept of the evaluation.
   b. Explain the organization of the training area and general admin and safety procedures.
   c. Explain the scoring system.
   d. Answer questions.
   e. Administer the written test.
   f. Obtain a copy of the unit SOP, if applicable, to use during evaluation.
2. Administration of the written test.
   a. All soldiers in the section will take the written test.
   b. Select 25 questions from the list of questions contained in this annex.
   c. Average the score of the soldiers to determine the section score. Each of the 25 questions is worth 4 points.
   d. Allow 30 minutes for the test.
   e. There is only one correct answer to each question.
   f. Answers for the written questions are provided on the pages following the exam questions.

PHASE I: WRITTEN TEST

1. List the five requirements for accurate predicted fire.
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________

2. Define technical fire direction.

____

____

____

3. Define tactical fire direction.

____

____

____

4. If the azimuth from point A to point B is 1,800 mils, what is the back azimuth?
   a. 1,600 mils
   b. 5,000 mils
   c. 3,200 mils
   d. 4,800 mils

5. A map with a scale of 1:25,000 will show more detail than a map of 1:50,000.
   a. True
   b. False

6. An eight-digit grid coordinate will give you a location to the nearest 10 meters.
   a. True
   b. False

7. An observed firing chart is a chart on which the locations of all required points (platoon positions, known points, and observation posts) are plotted in correct relation to one another and reflect actual grid coordinates.
   a. True
   b. False

8. What color is used to designate your battery tick mark on a firing chart?
   a. Black
   b. Blue
   c. Red
   d. Orange

9. Tick marks for targets located by firing are constructed by using a __________ pencil.

10. When plotting your platoon on a firing chart, your plotting is located to an accuracy of __ meter(s).
    a. 100
    b. 10
    c. 1,000
    d. 1

11. Supplementary deflection indexes are placed how far from your primary deflection index?
    a. 400 mils
    b. 800 mils
    c. 200 mils
    d. 1,000 mils

12. The three methods used to plot targets on a firing chart are the grid coordinate, polar plot, and shift from a known point.
    a. True
    b. False

13. Chart data are announced in what order?
    a. Chart range, angle T, azimuth, deflection
    b. Deflection, chart range, azimuth, angle T
    c. Angle T, deflection, chart range, azimuth
    d. Chart range, deflection, angle T

14. Chart range is determined and announced from the RDP to the nearest ______ meter(s).
    a. 1 meter
    b. 5 meters
    c. 10 meters
    d. 50 meters

15. Chart deflection is determined and announced to the nearest ______ mil(s).
    a. 1 mil
    b. 5 mils
    c. 10 mils
    d. 50 mils

16. Angle T is determined and announced to the nearest ______ mil(s).
    a. 1 mil
    b. 5 mils
    c. 10 mils
    d. 50 mils

17. Which of the following is the correct sequence for transmitting an MTO?
    a. Changes to the call for fire, units to fire, number of rounds, target number.
    b. Units to fire, changes to the call for fire, number of rounds, target number.
    c. Target number, number of rounds, units to fire, changes to the call for fire.
    d. Number of rounds, target number, changes to the call for fire, units to fire.

18. Angle T is sent to the observer when it is greater than or equal to ______ mils or when requested by the observer.
    a. 100 mils
    b. 200 mils
    c. 500 mils
    d. 600 mils

19. When must **SPLASH** be sent to the observer?
    a. When working with aerial observers
    b. During illumination missions
    c. During high-angle missions
    d. During both a and c

20. What additional information can be sent by MTO?
    a. High angle and PRF code
    b. Special corrections and azimuth
    c. Angle T and time of flight
    d. Both a and c

21. Target number is an additional item that can be sent in the message to observer.
    a. True
    b. False

22. List in order the 10 elements of a fire order.
    1. ______________________________
    2. ______________________________
    3. ______________________________
    4. ______________________________
    5. ______________________________
    6. ______________________________
    7. ______________________________
    8. ______________________________
    9. ______________________________
    10. ______________________________

23. Define quadrant elevation.

____

____

24. Fire commands are used to tell the FDC how to attack a target.
    a. True
    b. False

25. Which subsequent fire command element(s) must always be announced?
    - a. QE
    - b. Deflection
    - c. Time
    - d. Both a and b

26. Site is the algebraic sum of angle of site and complementary angle of site.
    - a. True
    - b. False

27. Probable error in range is announced to the observer during area fire missions when it is greater than or equal to ______ meters.
    - a. 25
    - b. 30
    - c. 38
    - d. 28

28. Given:
    - a. VI +37 meters
    - b. Chart range 5,460 meters

    Determine which of the following is the correct angle of site.
    - a. +7 mils
    - b. -8 mils
    - c. -7 mils
    - d. +8 mils

29. Given:
    - a. VI -30 meters
    - b. Charge 4GB
    - c. Chart range 6,000 meters

    Determine which of the following is the correct site.
    - a. -8 mils
    - b. -6 mils
    - c. +8 mils
    - d. +6 mils

30. Given:
    - a. Charge 4GB
    - b. Chart range 4,000 meters
    - c. Si -4

    Determine which of the following is the correct HE QE.
    - a. 325 mils
    - b. 444 mils
    - c. 232 mils
    - d. 228 mils

31. Given:
    - a. Charge 4GB
    - b. Chart range 4,800 meters

    Determine which is the correct M582 fuze setting increment.
    - a. 16.5
    - b. 17.0
    - c. 13.8
    - d. 17.5

32. The common deflection for M109-series howitzers is ______ mils.
    - a. 2,800
    - b. 2,400
    - c. 3,200
    - d. 1,600

33. You should disconnect your radio antenna when trying to determine whether or not you are being jammed.
    - a. True
    - b. False

ANSWER KEY FOR FDC EVALUATION QUESTIONS

1. a. Accurate target location and size.
   b. Accurate firing unit location.
   c. Accurate weapon and ammunition information.
   d. Accurate meteorological information.
   e. Accurate computational procedures.
2. Technical fire direction is the process of converting weapon and ammunition characteristics, weapon and target locations, and meteorological information to firing data.
3. Tactical fire direction includes processing calls for fire and determining the appropriate method of fire, ammunition expenditure, unit(s) to fire, and time of attack.
4. B. 5000
5. A. True
6. A. True
7. B. False
8. A = Bravo battery, B = Charlie battery, C = Alpha battery, D = Delta battery
9. Red
10. B. 10
11. D. 1000
12. A. True
13. D. Chart range, deflection, and angle T
14. C. 10 meters
15. A. 1 mil
16. C. 10 mils
17. B. Unit to fire, changes to the call for fire, number of rounds, target number.
18. C. 500 mils

19. D. Both A and C
20. D. Both A and C
21. B. False
22. (1) Unit to fire.
    (2) Adjusting element/MF of adjusting element, proj in adj, ammo lot and charge in adj, fuze in adj
    (3) Basis for corrections
    (4) Distribution
    (5) Special instructions
    (6) Method of fire for effect
    (7) Projectile in effect
    (8) Ammo lot and charge in effect
    (9) Fuze in effect
    (10) Target number
23. Quadrant elevation is the algebraic sum of site and the angle of elevation.
24. B. False
25. A. QE
26. A. True
27. C. 38
28. A. +7 mils
29. B. -6 mils
30. D. 228 mils
31. D. 17.5
32. C. 3,200
33. A. True

B-7. Phase II: Section Performance Test

A sample Phase II section performance testis shown below.

SAMPLE

PHASE II: SECTION PERFORMANCE TEST INSTRUCTIONS

1. During this phase, the entire section will participate in the section performance test.
2. Ensure each soldier understands the task, condition and standard before starting.
3. Evaluate the section with all the tasks.
4. For those tasks receiving a GO, award points on the basis of either of the two systems listed below:
    a. In a formal pass or fail evaluation, each GO will score 100% of the allowable points for that subtotal.
    b. In an informal subjective evaluation, each GO will score as many of the allowable points as the evaluator feels were earned.
5. Evaluators may conduct Phase II during day or night as agreed by the commander and the evaluator.

PHASE II: SECTION PERFORMANCE TEST

Task 1: Predeployment Checks and Services.

Conditions:

The FDC section is in the unit motor pool and is read the following situation by the evaluator.

YOUR SECTION HAS BEEN ALERTED AND IS PREPARING TO DEPART THE UNIT MOTOR POOL FOR THE TAA. THE PLATOON SERGEANT HAS JUST INFORMED YOU THAT THE ADVANCE PARTY WILL DEPART IN 15 MINUTES. YOUR SECTION SHOULD MAKE ALL NECESSARY PREPARATION FOR THE MOVEMENT, TO INCLUDE PREVENTIVE MAINTENANCE CHECKS AND SERVICES ON YOUR VEHICLE(s), AND ALL ASSIGNED EQUIPMENT NECESSARY TO ACCOMPLISH THE MISSION.

Evaluation Checklist:

GO	NO GO	
____	_____	Did the section have all section equipment installed and/or stowed in accordance with (IAW) all applicable manuals and unit loading plans? (5 pts)
____	_____	Were all necessary items on hand for performing the before-operation checks and services on the vehicle(s), and all assigned equipment needed to accomplish the mission (that is, basic issue items, operator's manuals, lubrication orders, DA Forms 2404, cleaning materials, and log books)? (5 pts)
____	_____	Did the chief of section use all personnel to perform preventive maintenance checks and services (PMCS) on section equipment in an orderly and efficient manner? (5 pts)
____	_____	Did the section inspect each item listed in the "before" column of the PMCS tables of the operator's manual(s) for the vehicle(s) and all assigned equipment needed to accomplish the mission? (5 pts)
____	_____	Did the section perform operator maintenance on the computer equipment on hand IAW the appropriate TM? (5 pts)
____	_____	Did the section perform operator maintenance on the alternate computer equipment on hand IAW the appropriate TM? (5 pts)
____	_____	Did the section correct all faults discovered that they were authorized to correct IAW the PMCS tables and troubleshooting tables of the operator's manual? (5 pts)
____	_____	Did the section use DA Form 2404 to list all faults that they were not able to correct and that were not already listed on the DA Form 2408-14 for all assigned equipment? (10 pts)
____	_____	Was the advance party man ready to depart on (15 minutes) time with all necessary equipment? Was section ready to depart within 45 minutes? (5 pts)

Scoring: For each GO rating, points will be awarded as indicated up to a maximum of 50 points. NO GOs will receive 0 points.

Task 2: Establish and Maintain Platoon FDC.

Conditions:

The platoon is in the tactical assembly area. Information relative to the battery's mission has been handed to the FDO for input into the computer system on hand. Initialize your computer and build your data base. You have 30 minutes to complete this task.

Evaluation Checklist:

GO	**NO GO**	
____	______	Did the computer operator initialize the computer on hand IAW the appropriate TM? (22 pts possible. -1 pt for any steps performed incorrectly, out of order, or omitted)
____	______	Did the FDC install FM and secure radio equipment to facilitate the best transmission and/or reception available? (5 pts)
____	______	Did the FDC set up and use antenna group OE-254 IAW TM 11-5985-357-13? (5 pts)
____	______	Did the FDC enter external radio nets as directed by unit SOP? (2 pts)
____	______	Did the FDC establish and maintain wire communications with the howitzer sections and platoon operations center (POC) as directed by unit SOP? (2 pts)
____	______	Did the FDC input and execute the new met data and specify the correct met file to be used? (4 pts)
____	______	Observer locations are received from battalion FDC. Did the FDC input and execute the observer locations? (4 pts)
____	______	Did the FDC power up the alternate computer system on hand and activate the program IAW the appropriate TM? (2 pts)
____	______	Did the FDC construct the database with all available information? (2 pts)
____	______	Did the FDC call up, display, review, and verify all files? (12 pts)
____	______	Did the FDC establish a situation map with maneuver control and FSCMs plotted? (2 pts)
____	______	Did the FDC update the situation map continually as the situation developed? (2 pts)
____	______	Did the FDC actively seek information from battalion and FIST to keep the map current? (2 pts)
____	______	Did the FDC maintain locations of friendly units, patrols, and so forth on the situation map? (2 pts)

Task 3: Establish and Maintain the Platoon FDC After a Deliberate Occupation of a Prepared Position.

Conditions:

The platoon has occupied a position area. The tactical mission remains the same. The platoon leader's report, the azimuth of fire, and the battery location have been received by the FDC.

Evaluation Checklist:

GO	NO GO	
____	______	Did the FDC initialize the computer on hand with a database recording IAW the appropriate TM? (5 pts)
____	______	Did the FDC establish communications (voice and digital) with higher and adjacent units? (5 pts)
____	______	Did the FDC establish a communications link (wire and digital) with all howitzer sections? (5 pts)
____	______	Did the FDC update the computer database with current tactical and technical data? (10 pts)
____	______	Did the FDC send a plaintext message and current unit information to battalion FDC? (5 pts)
____	______	Did the FDC perform position improvement to include nets being put up? (5 pts)
____	______	Was the FDC prepared to process calls for fire within presribed time limits after the vehicle stopped in position, using the most accurate data and/or means available? (5 pts)

Scoring: Each GO scores the points indicated; a NO GO receives 0 points. Two occupations will be accomplished.

Task 4: Attack Targets.

Conditions:

A fire plan has been received. Commander's target guidance, weapon and ammunition status, and situation are known. Battalion fire order standards have been received. The computer on hand is operational, and the platoon is receiving data from battalion.

Evaluation Checklist:

GO	NO GO	
____	______	Did the FDC review and execute the battalion fire order? (10 pts)
____	______	Did the FDC display and execute each fire plan target? (10 pts)
____	______	Did the FDC review the fire plan target summary? (10 pts)
____	______	Did the FDC place the targets into the input queue within 10 minutes of TOT? (10 pts)
____	______	Did the FDC display and/or execute the fire mission format and send fire commands in such a way to meet the TOT and fire plan schedule? (10 pts)

Scoring: Maximum points possible is 50.

Task 5, Subtask A: Bn Mass Large, Irregularly Shaped Target (HE/Q)

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (5 pts)
____	______	Review and transmit FFE data to the howitzers. (3 pts)
____	______	Report shot and rounds complete to Bn FDC. (2 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask B: Bn FFE, TOT (HE/Ti).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (4 pts)
____	______	Review and transmit FFE data to the howitzers. (2 pts)
____	______	Report ready and TOF to battalion FDC. (2 pts)
____	______	Report shot and rounds complete to battalion FDC (to cause rounds to impact within ±3 sec of TOT time). (2 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask C: Bn Mass, Low-Angle Adjust With Radar (HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit mission data to the howitzers within 20 seconds from time of receipt. (5 pts)
____	______	Review and execute the subsequent correction fire mission format. (2 pts)
____	______	Review and transmit FFE data to the howitzers within 25 seconds. (5 pts)
____	______	Report shot and rounds complete to battalion FDC. (1 pt)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but no less than 0 points per task.

Task 5, Subtask D: Bn Mass, Low-Angle Adjust With FO (HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (1 pt)
____	______	Review and transmit mission data to the howitzers within 20 seconds from time of receipt. (3 pts)
____	______	Review and execute the subsequent correction fire mission format. (1 pt)
____	______	Review and transmit subsequent correction mission data to the howitzers within 20 seconds. (3 pts)
____	______	Review and execute the FFE fire mission format. (1 pt)
____	______	Review and transmit FFE data to the howitzers within 25 seconds of receipt. (5 pts)
____	______	Send shot and rounds complete to battalion FDC. (1 pt)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask E: Bn Mass Under Coordinated Illumination (ILLUM/TI, HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review, execute, and transmit initial illum data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit initial HE data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit subsequent illum data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit subsequent HE data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit FFE HE data to the howitzers within 25 seconds. (3 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask F: Bn Mass, High-Angle Adjust With Radar (HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit mission data to the howitzers within 20 seconds of receipt of the mission. (5 pts)
____	______	Review and execute FFE data to the howitzers within 25 seconds. (5 pts)
____	______	Send shot and rounds complete to battalion FDC. (1 pt)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask G: Bn Mass, High-Angle Adjust With FO Using GVLLD (HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (1 pt)
____	______	Review and transmit mission data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and execute the FFE fire mission format. (1 pt)
____	______	Review and transmit FFE data to the howitzers within 25 seconds. (4 pts)
____	______	Send shot and rounds complete to battalion FDC. (1 pt)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask H: Bn Mass, Low-Angle Adjust With FO Using GVLLD (HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (1 pt)
____	______	Review and transmit mission data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and execute the FFE fire mission format. (1 pt)
____	______	Review and transmit FFE data to the howitzers within 25 seconds. (4 pts)
____	______	Send shot and rounds complete to battalion FDC. (1 pt)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask I: Bn Mass, High-Angle Adjust With FO (HE/Q).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (1 pt)
____	______	Review and transmit mission data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and execute the subsequent correction fire mission format. (1 pt)
____	______	Review and transmit subsequent correction data to the howitzers within 20 seconds. (3 pts)
____	______	Review and execute the FFE fire mission format. (1 pt)
____	______	Review and transmit FFE data to the howitzers within 25 seconds of receipt. (5 pts)
____	______	Send shot and rounds complete to battalion FDC. (1 pt)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask J: Bn FFE, At My Command (HE/TI).

Conditions:

A fire mission format has been received from a battalion computer shelter in the platoon FDC computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (3 pts)
____	______	Review and transmit FFE data to the howitzers. (5 pts)
____	______	Report shot and rounds complete to the battalion FDC. (2 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask K: Plt FFE With Immediate Smoke (WP/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (5 pts)
____	______	Review and transmit FFE data to the howitzers. (5 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask L: Plt Area Adjust With Quick Smoke (SMK/TI, HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit HE data to the howitzers within 20 seconds of receipt of the mission. (4 pts)
____	______	Review and execute the subsequent fire mission format for smoke within 25 seconds of receipt, and transmit data to the howitzers. (5 pts)
____	______	Review and execute the subsequent fire mission format for HE within 20 seconds of receipt, and transmit data to the howitzers within 35 seconds. (4 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask M: Plt Area Adjust With Coordinated Illumination (ILLUM/TI, HE/Q)

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation checklist:

GO	NO GO	
____	______	Review, execute, and transmit initial illum data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit initial HE data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit subsequent illum data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit subsequent HE data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit FFE HE data to the howitzers within 20 seconds. (3 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask N: Plt Area Adjust With Illumination (ILLUM/TI).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (3 pts)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review, execute, and transmit subsequent data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit next subsequent data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit FFE data to the howitzers within 20 seconds. (3 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask O: Plt High-Angle Adjust With Radar (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and execute the FFE correction. (2 pts)
____	______	Review and transmit to the howitzers the FFE data within 25 seconds of receipt. (3 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask P: Plt Low-Angle Adjust With FO (HE/TI).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review, execute, and transmit subsequent data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit next subsequent data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit FFE data to the howitzers within 25 seconds. (4 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask Q: Plt Low-Angle Adjust With FO Using GVLLD (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and execute the FFE correction. (2 pts)
____	______	Review and transmit to howitzers the FFE data within 25 seconds of receipt. (3 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask R: Plt FFE, Copperhead Target of Opportunity (Cphd).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (5 pts)
____	______	Review and transmit FFE data to the howitzers. (5 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask S: Plt Low-Angle Adjust With FA Aerial Observer (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (1 pt)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and execute the FFE correction. (2 pts)
____	______	Review and transmit to the howitzers the FFE data within 25 seconds of receipt. (4 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask T: Plt FFE, When Ready.

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO NO GO

____ ______ Review and execute the fire mission format. (5 pts)

____ ______ Review and transmit FFE data to the howitzers. (5 pts)

____ ______ Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask U: Plt FFE, At My Command

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO NO GO

____ ______ Review and execute the fire mission format. (5 pts)

____ ______ Review and transmit FFE data to the howitzers. (5 pts)

____ ______ Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask V: Plt FFE, Copperhead Priority Mission (Cphd).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO NO GO

____ ______ Review and execute the fire mission format. (3 pts)

____ ______ Review and transmit data to the selected howitzer(s). (2 pts)

____ ______ Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

____ ______ Review, execute, and transmit to the howitzer(s) the command to fire format within 10 seconds. (10 pts)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask W: Plt FFE, Fire Priority Target (HE/TI).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (3 pts)
____	______	Review and transmit data to the selected howitzer(s). (2 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)
____	______	Review, execute, and transmit to the howitzer(s) the command to fire format within 10 seconds. (10 pts)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask X: Plt FFE, Large, Irregularly Shaped Target (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review fire mission format, and select aimpoints to effectively attack target. (5 pts)
____	______	Display and input aimpoints, and execute fire mission formats. (5 pts)
____	______	Transmit firing data to the howitzers within 50 seconds of receiving the mission. (10 pts)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask Y: Plt FFE, Fire FPF (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (3 pts)
____	______	Review and transmit data to the selected howitzer(s). (2 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1pt for each second over time limit, not to exceed 5 points)
____	______	Review, execute, and transmit to the howitzer(s) the command to fire format within 10 seconds. (10 pts)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask Z: Plt FFE Immediate Suppression

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (5 pts)
____	______	Review and transmit data to the howitzers. (5 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20.

Task 5, Subtask AA: Plt High-Angle Adjust With FO Using GVLLD (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of the mission. (3 pts)
____	______	Review and transmit to the howitzers the FFE data within 25 seconds of receipt. (3 pts)
____	______	Total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask AB: Plt High-Angle Adjust With FO (HE/Q).

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (2 pts)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of mission. (3 pts)
____	______	Review, execute, and transmit subsequent data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit next subsequent data to the howitzers within 20 seconds. (3 pts)
____	______	Review, execute, and transmit FFE data to the howitzers within 25 seconds. (4 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask AC: Plt Simultaneous Low-Angle Mission (HE/Q).

Conditions:

Two fire mission formats have been received from a battalion computer shelter in the platoon FDC computer. Both targets are of equal priority, and both requests are received within 60 seconds of each other.

Evaluation Checklist:

GO	NO GO	
____	______	Review, execute, and transmit initial data to the howitzers within 20 seconds of receipt of fire mission format for mission 1. (2 pts)
____	______	Review, execute, and transmit subsequent data to the howitzers within 20 seconds for mission 1. (2 pts)
____	______	Review, execute, and transmit initial data to the howitzers within 20 seconds of receipt of fire mission format for mission 2. (2 pts)
____	______	Review, execute, and transmit FFE data to the howitzers within 25 seconds for mission 1. (4 pts)
____	______	Review, execute, and transmit subsequent data to the howitzers within 20 seconds for mission 2. (2 pts)
____	______	Review, execute, and transmit FFE data to the howitzers within 25 seconds for mission 2. (3 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (5 pts; subtract 1 pt for each second over time limit, not to exceed 5 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

Task 5, Subtask AD: Plt Low-Angle Adjust With Radar.

Conditions:

A battalion computer shelter is not available. The platoon computer is operational, and you are operating in an autonomous mode. The FO is equipped with a computer.

Evaluation Checklist:

GO	NO GO	
____	______	Review and execute the fire mission format. (1 pt)
____	______	Review and transmit initial data to the howitzers within 20 seconds of receipt of mission. (3 pts)
____	______	Review and execute the FFE correction. (2 pts)
____	______	Review and transmit to the howitzers the FFE data within 25 seconds of receipt. (4 pts)
____	______	Ensure total platoon FDC mission time does not exceed current MTP standards. (10 pts; subtract 1 pt for each second over time limit, not to exceed 10 points)

Scoring: Maximum points possible is 20. Subtract 1 point per second for timings over specified time, but not less than 0 points per task.

B-8. Phase III: Critique Instructions

a. The evaluator will address comments to the critique quedstions in the front of this annex. The evaluator should conduct this phase at the end of each e-valuated phase or after Phase II only.

b. The references for this critique are:

- FM 6-40.
- STP 6-13E14-SM-TG, dated Jul 92.
- Current ARTEP MTP manual.

NOTE: This appendix was taken from examples of div arty FDC evaluation guides.

Appendix C

TARGET ANALYSIS AND MUNITION EFFECTS AND TERMINAL BALLISTICS

Target analysis is the examination and evaluation of an enemy target situation to determine the most suitable weapon, ammunition, and method required to defeat, neutralize, or otherwise disrupt, delay, or limit the enemy. Not only does target analysis involve determining the amount and type of ammunition required to inflict a given damage (or casualty) level on a particular target, it also involves a continuous process of consultation and cooperation between the commander and the FDO.

C-1. Target Analysis

The amount of time devoted to target analysis and the thoroughness of the analysis depends on the following:

- Amount of target information.
- Weapons and ammunition available to attack the target.
- Urgency of the engagement.

C-2. Determining the Precedence of Attack

When an FDO receives a fire mission, his options include the following (see Figure C-1):

- Attack the target immediately.
- Defer attacking the target until an existing fire mission is complete.
- Pass the fire mission to another FDC.
- Request reinforcing fires.
- Deny the mission.

An FDO selects a particular precedence of attack after considering the following:

- Call for fire.
- Terrain.
- Target location.
- Weather.
- Target characteristics.
- Units available.
- Commander’s criteria.
- Availability of corrections.
- Munition effects.
- Enemy target acquisition.
- Commander’s intent.
- Ammunition availability.

a. Commander's Criteria. All phases of target analysis are conducted within constraints established by the commander. In determining the precedence for attacking a target, primary consideration is given to the commander's target priorities.

(1) Attack guidance matrix. The commander's target priorities are organized into an attack guidance matrix that lists the type of target, when to attack, degree of destruction, and any restrictions. Figure C-2 is an example of a commander's attack guidance matrix. The following example explains how it would be used.

EXAMPLE

Your FDC received a call for fire, and the target description was a POL dump. While processing this mission, you received another call for fire requesting fires on an infantry platoon. Referring to the attack guidance matrix, you would determine that the infantry platoon is a higher priority. In this case, you process this mission first. Upon completion of this mission, you would fire on the POL dump.

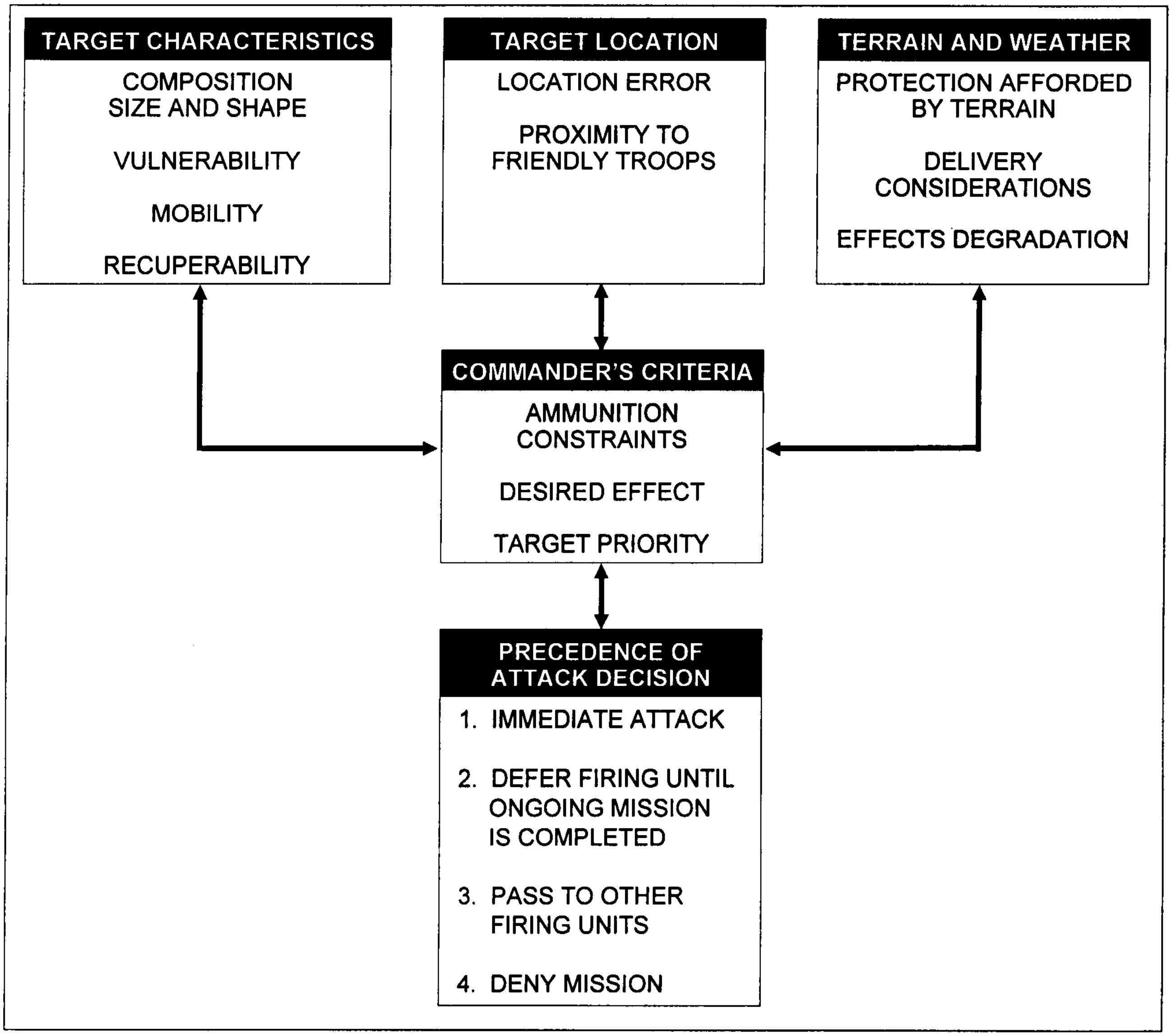


Figure C-1. Determining the Precedence of Attack.

> **NOTE:** For a more detailed discussion on the attack guidance matrix, see FM 6-20-40.

(2) Target effects categories. On the basis of ammunition constraints, a commander also specifies the type of effects he desires against specific target categories. The three target effects categories are as follows:

(a) Suppression. Suppression of a target limits the ability of enemy personnel to perform their mission. Firing HE, fuze VT reduces the combat effectiveness of personnel and armored targets by creating apprehension and surprise and by causing tracked vehicles to button up. Smoke is used to blind or confuse. The effect of suppressive fires usually lasts only as long as the fires are continued. This type of fire is used against likely, suspected, or inaccurately located enemy units where time is essential. It can be delivered by small delivery units or means and requires little ammunition.

(b) Neutralization. Neutralization of a target knocks the target out of the battle temporarily. Casualties of 10 percent or more neutralize a unit. The unit is effective again when the casualties are replaced and/or damage is repaired. Neutralization fires are delivered against targets located by accurate map inspection, indirect fire adjustment, or a TA device. The assets required to neutralize a target vary according to the type and size of the target and the weapon-ammunition combination.

CATEGORY	HIGH PAYOFF	WHEN	HOW	RESTRICTIONS
1(C^3)	25, 29, 30, 34	I	N/EW	Coordinate attack with EW
2(FS)	1, 2, 5, 18	I	N	Plan all calibers greater than 122 mm
3(MAN)	46, 48, 50, 51	I	10%	
4(ADA)	63, 64	A	N	
5(ENGR)	69, 70	P	N	Not high-payoff target
6(RSTA)	14, 16, 17, 84, 85, 107	A	D	Not high-payoff target
7(REC)	91, 92	A	S/EW	Coordinate attack with EW
8(N/CH)	77, 79	P	D	Forward targets to division
9(POL)	115, 116	A	D	
10(AMMO)	120, 121	A	N	
11(MAINT)		A	S	
12(LIFT)		A	S	
13(LOG)	118	A	N	Not high-payoff target

LEGEND:
A = as acquired
ADA = air defense artillery
C^3 = command, control, and communications
D = destroy
engr = engineer
FS = fire support
I = immediate
log = logistics
man = maneuver
N = neutralize
N/CH = nuclear and chemical
REC = radio electronic combat
RSTA = reconnaissance, surveillance, and target acquisition
S = suppress

Figure C-2. Example Attack Guidance Matrix.

(c) Destruction. Destruction puts the target out of action permanently. Thirty percent casualties or materiel damage inflicted during a short time span normally renders a unit permanently ineffective. Direct hits are required to destroy hard materiel targets. Targets must be located by accurate map inspection, indirect fire adjustment, or a TA device. Destruction usually requires a large amount of ammunition from many units.

b. Target Characteristics.

(1) Targets encountered on the battlefield vary considerably in composition, degree of protection, shape, mobility, and recuperability. For simplicity, targets are divided into four categories (Table C-1) to compare the effectiveness of particular weapons and rounds. Examples axe listed for each category. Under certain conditions, some examples could be listed in more than one category. For example, a motorized rifle battalion could be listed under the first category and the fourth category.

(2) For personnel targets in particular, the posture of the target is extremely important. Normally, target postures us d for personnel targets are standing, prone, and in fighting positions. For computation, it is assumed that the personnel are wearing helmets and that personnel in fighting positions are in a crouching position. In describing posture of a target, consider the protection afforded by the terrain. For example, an infantry platoon may be attacking in a standing posture. However, irregular terrain may provide protection equivalent to the prone position. Usually, personnel targets seek a more protective posture during an engagement; for example, from a standing to a prone position. This change is called posture sequencing. Posture sequencing causes considerable degradation of effects as additional volleys are fired and is the reason for the continual emphasis on surprise or mass fires. For the purposes of analysis, personnel targets in the offense are considered to be one-half standing and one-half prone during the first volley of fire and all prone for subsequent volleys. In a defensive configuration, personnel targets are considered to be one-half prone and one-half in fighting positions during the initial volley and all in fighting positions for subsequent volleys.

(3) A target must be analyzed to determine its weak points. Where the target is most vulnerable and what fires will best exploit its weaknesses are influenced by the degree of damage desired. Often there is a tendency to overkill the target when less combat power would suffice. On the basis of the commander’s criteria, the FDO must ascertain the degree of effects needed (destruction, neutralization, suppression) to support the tactical plan. The acceptable degree of damage is the level that yields a significant military advantage. For example, fire from a heavily protected machine-gun emplacement may be silenced by obscuration through smoke and subsequent engagement by direct fire as opposed to the expenditure of a large number of HE rounds required for its destruction.

(a) Target location. The FDO must check the target location relative to friendly forces, fire support coordinating measures, zones of fire, and registration transfer limits. Target location accuracy is also considered. The range affects the choice of units to fire and charge selection. The terrain around the target may influence ammo selection or type of trajectory. High intervening crests may require selection of a lower charge or high angle.

Table C-1. Categories of Targets.

CATEGORY	EXAMPLE
Area (personnel	Squad Platoon Battery Company
Small (personnel)	Observation post Small patrol Command post
Small (materiel) (point)	Tank Armored personnel carrier Bunker, machine gun
Area (materiel)	Armored formation Truck park Ammunition dump

(b) Target characteristics. The size of the target affects the number of units to fire, the type of sheaf, the selection of ammo, and the number of rounds in the fire for effect. The type of target (troops, vehicles, hard, soft) influences the ammo type and amount, the priority placed on the mission, and whether surprise fire (for example, time on target) is possible.

(c) Ammo availability. The FDO must consider the amount and type of ammunition available and the controlled supply rate.

(d) Units available. The number of units available not only affects which units are used, but also the type of attack. Sweep and/or zone fire or other techniques may be needed to cover large targets when enough units are not available.

(e) Commander's criteria or commander's intent. Restrictions on ammo, operation order (OPORD), and SOPs may govern the selection of units and ammunition, target priority, and method of attack.

(f) Call for fire. The FDO must consider the observer's request carefully since he is observing the target and talks directly to the maneuver commander. The observer's request is honored when possible. The call for fire will also include information on the target activity (for example, attacking, defending, digging in).

(g) Munitions effects. If time permits, the FDO may use the JMEMs to determine the type munition and volume of fire. The FDO most often relies on the GMET or experience.

(h) Availability of corrections. The availability of corrections to firing data for nonstandard conditions is a guiding factor in the choice of charge and munitions, since it directly affects the ability to provide accurate first round fire for effect.

*(i) Enemy target acquisition capability.*Knowledge of the current enemy counterbattery radar and sound ranging capabilities allows the FDO to attack the target in a manner most likely to evade detection.

d. Terrain. The terrain in the target area has a direct effect on the vulnerability of the target. Rugged terrain affords considerable natural cover and makes target location difficult. Certain terrain provides complete protection from some angles of approach but not others and thus influences the unit and munitions to be employed. The nature of the vegetation in the target area should be considered when selecting ammunition.

e. Weather. Weather is of little consequence in evaluating a target to attack with fuze quick or time. However, precipitation and wind are of particular importance in evaluating a target to attack with ICM, smoke, FASCAM, or illum projectiles. Low clouds, thick fog, surface water, and rain degrade the effectiveness of VT fuze.

C-3. Determining Most Suitable Weapon and Ammunition

When an FDO decides to attack a target, he selects a weapon-ammunition combination that achieves the desired effect with a minimum expenditure of available ammo. Figure C-3 depicts weapon-ammunition selection.

a. Munitions.

(1) Type and quantity available. The nature of the target, its surroundings, and the desired effects dictate the type and amount of ammo to use. For a detailed discussion of ammo and fuzes, refer to FM 6-141-1 and (C)FM 6-141-2. The ammo resupply system sometimes rules out the best ammo selection. For example, extensive smoke fires may be needed to screen maneuver movement, but such fires may cause a resupply problem. Some fires require more ammo than others. Suppression and neutralization fires normally use less ammo than destruction fires.

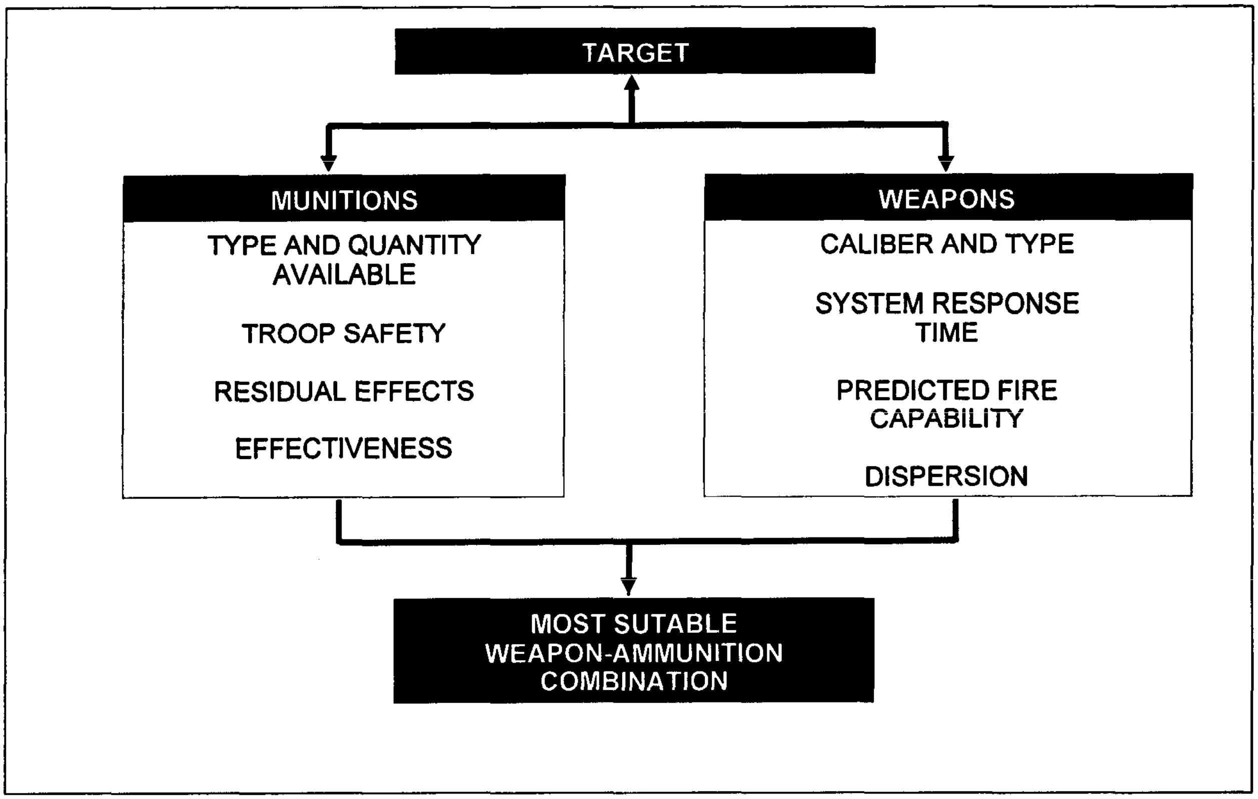


Figure C-3. Weapon-Ammunition Selection.

(2) Troop safety. Troop safety is a major concern in considering the weapon-ammunition selection for firing close-in targets. The FDO must ensure that fires do not endanger friendly troops, equipment, and facilities.

(3) Residual effects in target area. The supported unit must be advised of the residual effects from certain munitions. For example, the self-destruct times from FASCAM munitions may preclude the desired movement of supported units through a particular area. Weather changes may alter choices of certain munitions (smoke, illumination, and white phosphorous). The incendiary effects of certain munitions may make areas untenable for supported forces. However, these effects can also deny the enemy use of selected terrain.

(4) Effectiveness. When properly delivered against appropriate targets, artillery fire support can be the decisive factor in a battle. The FDO must ensure that the desired result is attained from every mission. To match a munition to a target, the FDO must know what damage a munition can produce and the damage required to defeat the target. The lethality of a munition must be matched to the specific vulnerability of the target. Thus, the FDO must understand the damage potential (blast, cratering, fragmentation, incendiary, and penetration) of specific munitions. Specific information regarding the effects of various munitions is found in the appropriate JMEM, FM 6-141-1, and (C) FM 6-141-2. For details on predicting weapon effects, see paragraphs C-5 through C-8.

b. Weapons.

(1) Caliber and type available. In certain instances, an FDO may control the fires of reinforcing (R) or general support reinforcing (GSR) units that fire a different caliber. The FDO must have a thorough knowledge of the characteristics, capabilities, and vulnerabilities of each weapon system. Weapons with slow rates of fire and poor delivery accuracy are best suited for long-range fires. Weapons with rapid rates of fire and good delivery accuracy are suited for close fires.

(2) System response time. An FDO must ascertain the urgency of each fire mission. Small and medium weapons have a quicker firing response time than heavy weapons. Fire missions sent by the direct support (DS) battalion to reinforcing or GSR units require more processing time than those sent directly to the firing batteries of the battalion.

(3) Predicted fire capability. The FDO must know the current survey, registration, and met status of all firing units under his control. FFE missions should be assigned to units that have the best predicted fire capability.

C-4. Determining the Method of Attack

The final step in the FDO's target analysis is the selection of a method of attack. The FDO selects a method of attack that ensures target area coverage and desired target effects. To determine the best method of attack, the FDO must consider aimpoints, density, and duration of fire, Figure C-4 shows the method-of-attack selection considerations.

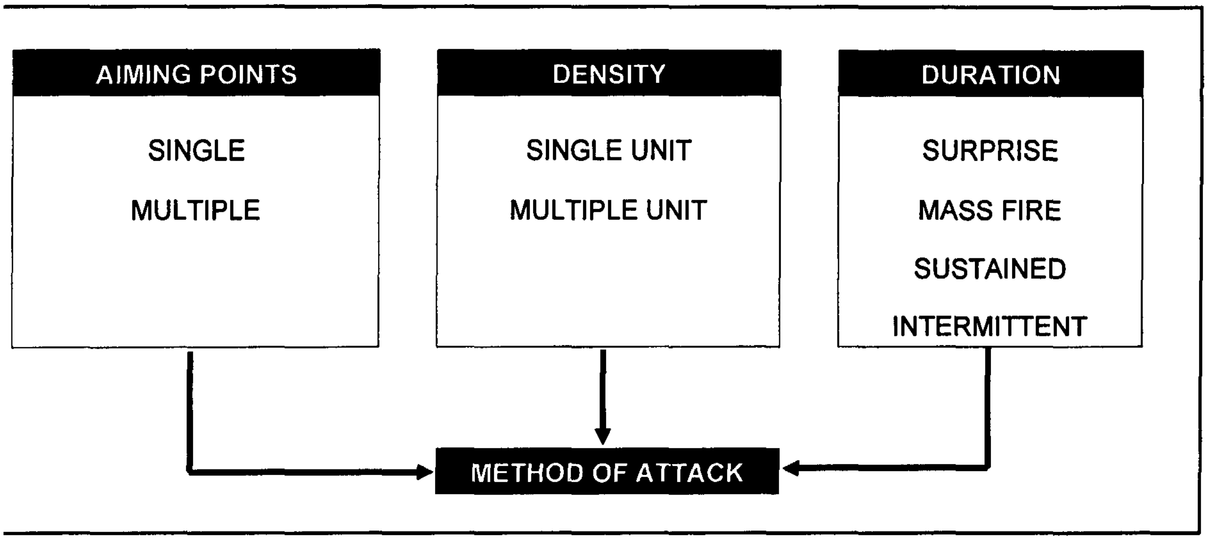


Figure C-4. Considerations in Selecting a Method of Attack.

a. Aimpoints. Normally, the size of the area to be attacked depends on the size of the target or the size of the area in which the target location is known or suspected. A single aiming point in the center of the target is used to attack small targets. For attacking large targets, multiple aimpoints are designated to distribute the fires and ensure adequate coverage. Appendix E gives procedures for establishing multiple aimpoints.

b. Density. For most targets, uniform density of fires is needed. Several techniques for indirect fire weapons produce such results. These include zone and sweep fires either from a single unit or simultaneous attack by multiple units on different portions of the target.

c. Duration. Accurate surprise fires produce the most effective results. Time on target procedures place initial rounds from all units on the target at the same time and achieve the greatest surprise. While intense fires of short duration generally produce the best results, the tactical situation may require that fires be continued over a longer period of time. Some examples are harassing and interdiction fires, screening smoke, continuous illumination, and suppressive fires supporting a maneuver final assault on an objective.

C-5. Predicting Weapons and Munitions Effects

a. The most important step in performing target analysis is determining the number and type of rounds required to produce the desired effects on a target. The time available to perform the target analysis largely determines the tools used to predict effects. An analyst at the division fire support level can use the JMEMs for guidance while the FDO at battalion or battery level, because of time constraints, can used the GMET.

b. A JMEM for world artillery and mortar systems will be distributed in fiscal year 1997 on a compact disk (CD). It will be a single source of information on US and foreign weapon systems and their effectiveness and the data and methodologies used to generate these effects. Information will be provided on the following:

- US and foreign artillery and mortar weapon systems characteristics.
- Damage mechanisms.

- Delivery accuracy.
- Reliability.
- Mission planning.
- Target acquisition.
- Target characteristics.
- Target environments.
- How weapon effectiveness is determined.

Additionally, expected fractional damage and casualties can be generated for user-selected weapon-target-engagement condition combinations. This JMEM on a CD can be used as a training tool and a source of combat effectiveness information.

A-6. Joint Munitions Effectiveness Manuals

Effectiveness tables published in JMEMs for surface-to-surface weapons (JMEM/SS) provide guidance for determining the expected fraction of casualties to personnel targets or damage to materiel targets. The JMEM/SS are published as field manuals. The current manuals are as follows:

- FM 101-60-25, Change 3, *Effectiveness Data for Howitzer, 155-mm M198 and M109A2/A3* (23 Oct 94). Revision 1 is scheduled for distribution in fiscal year 1996. It will be titled *Effectiveness Data for Howitzer, 155-mm, M109A6, M198, and M109A2/A3/A4* (1 Sep 84).
- FM 101-60-35, *Effectiveness Data for the Army Tactical Missile System: M39 (Army-TACMS Block I)* (S) (18 Nov 94).
- FM 101-60-28, *Effectiveness Data for the Multiple Launch Rocket System (MLRS): 227-mm, M270* (3 May 94).

Each of these manuals contains a personal computer (PC) program and associated database to compute weapon effectiveness for conditions not displayed in the manual. Effectiveness data in these manuals are listed for the following targets and conditions.

a. Personnel Targets. Square target sizes of 100,250,500, and (for MLRS only) 1,000 meters on a side are given. Data are listed for standing, prone, prone protected, and fighting position postures.

b. Materiel Targets. A short description of the following targets and their vulnerabilities are included:

- T-62, medium tank.
- T-72Ml/T-80, medium tank.
- BMP-1, armored infantry combat vehicle.
- BDRM-2, armored amphibious reconnaissance vehicle.
- BTR-60pB, armored personnel carrier.
- 122-mm and 152-mm self-propelled howitzers.

- 122-mm and 152-mm towed howitzers.
- 122-mm multiple rocket launcher.
- ZSU-23-4, antiaircraft gun.
- ZIL-157, medium truck.
- KrAZ-214, heavy truck.
- FROG-7B, rocket and launcher.
- Scud-B, missile and transporter-erector-launcher.
- SA-8, missile system.
- SA-13, missile system.
- Straight Flush radar.

The JMEM/SS are constantly updated, and other materiel targets will be added to the above list as data become available.

c. Environment. Data for personnel targets are listed for open terrain, marsh grass, temperate forrest, coniferous forest, and several urban environments. Data for materiel targets are listed for open terrain and a limited set of targets for several urban environments.

d. Methods of Delivery. Data are given for observer-adjusted and BCS techniques.

e. Aim Policy. Data are given for BCS aimpoint techniques for howitzers, MLRS aiming policy for MLRS, and a single aimpoint for the Army tactical missile system (ATACMS).

f. Ammunition. Data are given for HE and DPICM (M483A1 and M864).

CAUTION

There is no assurance that the expected fraction of damage or casualties will be provided by any number of volleys in a given situation. Although not precisely within the mathematical definition, the method of averaging data used for the tables will result in less damage being realized for approximately 50 percent of the rounds and, conversely, greater damage for the other 50 percent of the rounds.

C-7. Graphical Munitions Effects Tables (GMETs)

a. Purpose. Although the JMEMs provide excellent effectiveness data, the usefulness of these publications to the FDO during field operations is limited by their volume and difficulty of easily cross-referencing information. The GMETs overcome these limitations by providing quick access to munitions effectiveness data. The effectiveness data found on a GMET is not as accurate as the JMEM, but the compromise in accuracy is offset by the speed of obtaining information.

b. Table Description.

(1) The GMET consists of a loose-leaf binder with introductory text and instructions for use followed by the tabulated data. The tabulated data allows the user to determine the number of battery or battalion volleys needed to achieve the desired fractional damage. The number of volleys determined is a function of the following:

- Weapon system.
- Environment.

- Delivery accuracy.
- Target location error (TLE).
- Size of target.
- Target posture.
- Ammunition selected.

The following assumptions were made when compiling data for the GMET:

(a) Targets are engaged by using BCS aimpoint techniques. The GMETs for the M102/M119 and M198 assume that you are engaging targets with a six-gun battery. The GMETs for the Ml09-series howitzer assume you are engaging targets with a four-gun platoon.

(b) To maintain a constant probable error, all volleys are considered to be fired at two-thirds of the maximum range of the specific weapon system.

(c) The GMETs use a center-of-battery to center-of-target solution for effects.

(d) If the number of rounds needed to achieve the desired results exceeds 30 battery or 10 battalion volleys, the letter "P" (prohibited) is listed because any additional volleys will not achieve a significant increase in casualties. The letter "E" (excessive) indicates that the casualties obtained would be in excess of the specified casualty level.

(e) The percentage of casualties (%CAS) is expressed as the average expected fraction of casualties. Against personnel targets in an offensive posture, the assumed desired average expected fraction of casualties are 30, 20, and 10 percent (.30, .20, and .10). For targets in a defensive posture, the assumed casualties are 10, 5, and 2 percent. The casualty percentages for the defense are lower than those for the offense because of greater shielding of targets. Also shown is the average expected fraction of casualties for one battalion and one battery volley. The number of expected casualties is the product of the average expected fraction of casualties and the number of personnel in the target area.

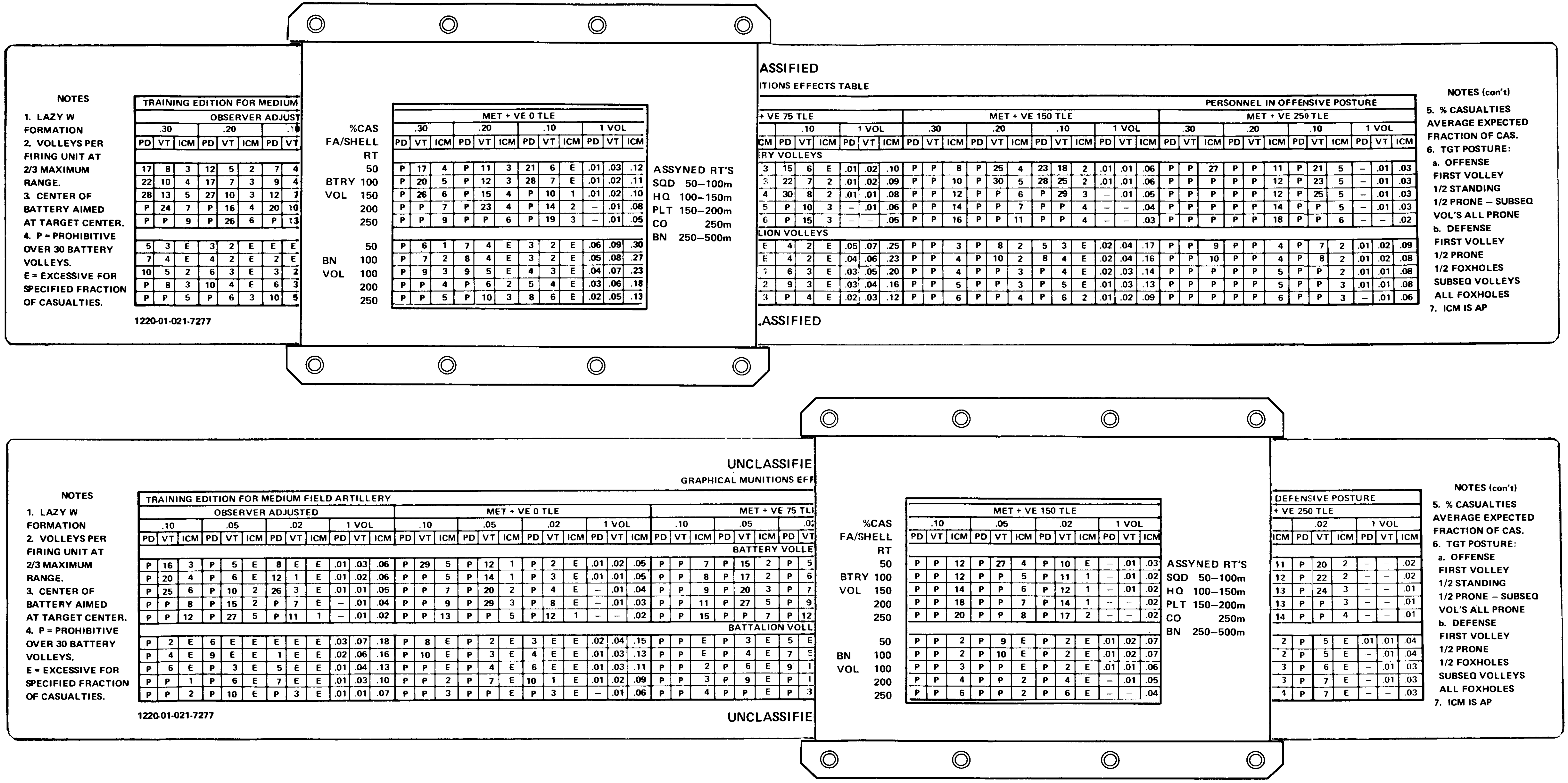
(f) The target posture for personnel in an offensive posture is assumed to be one half standing and one half prone for the first volley and all prone for sustaining volleys. For personnel in the defensive posture, one half are assumed to be prone and one half are in foxholes for the initial volley, and all personnel are assumed to be in foxholes for subsequent volleys.

(g) ICM is APICM. The ICM reflected on the GMET are only for APICM.

(h) The effects listed are based on targets located by observer adjustment (observer adjusted) and met + VE delivery techniques. If the FDO is confident of target location, he may select TLE O, or if the FDO's confidence of the accuracy of target location is suspect, TLE + 75 can be selected.

(i) The target size for various targets is listed on each table of the GMET.

(2) The current GMETs were produced in fiscal year 1996 and represent a significant improvement over previous GMETs. Previous GMETs consisted of a body and cursor similar to GFTs and used aimpoint techniques used for a six-gun battery firing a parallel sheaf. Also, there were no data for the DPICM family of projectiles. Unclassified versions of the previous editions of the GMETs (with body and cursor) are available and can be used for training purposes only. See Figure C-5.



NOTES

1. LAZY W FORMATION
2. VOLLEYS PER FIRING UNIT AT 2/3 MAXIMUM RANGE.
3. CENTER OF BATTERY AIMED AT TARGET CENTER.
4. P = PROHIBITIVE OVER 30 BATTERY VOLLEYS.
E = EXCESSIVE FOR SPECIFIED FRACTION OF CASUALTIES.

TRAINING EDITION FOR MEDIUM							
OBSERVER ADJUST							
.30			.20			.1	
PD	VT	ICM	PD	VT	ICM	PD	VT
17	8	3	12	5	2	7	4
22	10	4	17	7	3	9	4
28	13	5	27	10	3	12	7
P	24	7	P	16	4	20	10
P	P	9	P	26	6	P	13
5	3	E	3	2	E	E	E
7	4	E	4	2	E	2	E
10	5	2	6	3	E	3	2
P	8	3	10	4	E	6	3
P	P	5	P	6	3	10	5

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	%CAS	MET + VE 0 TLE											
		.30			.20			.10			1 VOL		
	FA/SHELL	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM
	RT												
	50	P	17	4	P	11	3	21	6	E	.01	.03	.12
BTRY	100	P	20	5	P	12	3	28	7	E	.01	.02	.11
VOL	150	P	26	6	P	15	4	P	10	1	.01	.02	.10
	200	P	P	7	P	23	4	P	14	2	–	.01	.08
	250	P	P	9	P	P	6	P	19	3	–	.01	.05
	50	P	6	1	7	4	E	3	2	E	.06	.09	.30
BN	100	P	7	2	8	4	E	3	2	E	.05	.08	.27
VOL	100	P	9	3	9	5	E	4	3	E	.04	.07	.23
	200	P	P	4	P	6	2	5	4	E	.03	.06	.18
	250	P	P	5	P	10	3	8	6	E	.02	.05	.13

ASSYNED RT'S
SQD 50–100m
HQ 100–150m
PLT 150–200m
CO 250m
BN 250–500m

ASSIFIED

ITIONS EFFECTS TABLE

																		PERSONNEL IN OFFENSIVE POSTURE												
+ VE 75 TLE							MET + VE 150 TLE												MET + VE 250 TLE											
	.10			1 VOL			.30			.20			.10			1 VOL			.30			.20			.10			1 VOL		
CM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM
RY VOLLEYS																														
3	15	6	E	.01	.02	.10	P	P	8	P	25	4	23	18	2	.01	.01	.06	P	P	27	P	P	11	P	21	5	–	.01	.03
3	22	7	2	.01	.02	.09	P	P	10	P	30	5	28	25	2	.01	.01	.06	P	P	P	P	P	12	P	23	5	–	.01	.03
4	30	8	2	.01	.01	.08	P	P	12	P	P	6	P	29	3	–	.01	.05	P	P	P	P	P	12	P	25	5	–	.01	.03
5	P	10	3	–	.01	.06	P	P	14	P	P	7	P	P	4	–	–	.04	P	P	P	P	P	14	P	P	5	–	.01	.03
6	P	15	3	–	–	.05	P	P	16	P	P	11	P	P	4	–	–	.03	P	P	P	P	P	18	P	P	6	–	–	.02
LION VOLLEYS																														
E	4	2	E	.05	.07	.25	P	P	3	P	8	2	5	3	E	.02	.04	.17	P	P	9	P	P	4	P	7	2	.01	.02	.09
E	4	2	E	.04	.06	.23	P	P	4	P	10	2	8	4	E	.02	.04	.16	P	P	10	P	P	4	P	8	2	.01	.02	.08
1	6	3	E	.03	.05	.20	P	P	4	P	P	3	P	4	E	.02	.03	.14	P	P	P	P	P	5	P	P	2	.01	.01	.08
2	9	3	E	.03	.04	.16	P	P	5	P	P	3	P	5	E	.01	.03	.13	P	P	P	P	P	5	P	P	3	.01	.01	.08
3	P	4	E	.02	.03	.12	P	P	6	P	P	4	P	6	2	.01	.02	.09	P	P	P	P	P	6	P	P	3	–	.01	.06

.ASSIFIED

NOTES (con't)

5. % CASUALTIES AVERAGE EXPECTED FRACTION OF CAS.
6. TGT POSTURE:
   a. OFFENSE
   FIRST VOLLEY
   1/2 STANDING
   1/2 PRONE – SUBSEQ
   VOL'S ALL PRONE
   b. DEFENSE
   FIRST VOLLEY
   1/2 PRONE
   1/2 FOXHOLES
   SUBSEQ VOLLEYS
   ALL FOXHOLES
7. ICM IS AP

UNCLASSIFIE

GRAPHICAL MUNITIONS EFF

NOTES

1. LAZY W FORMATION
2. VOLLEYS PER FIRING UNIT AT 2/3 MAXIMUM RANGE.
3. CENTER OF BATTERY AIMED AT TARGET CENTER.
4. P = PROHIBITIVE OVER 30 BATTERY VOLLEYS.
E = EXCESSIVE FOR SPECIFIED FRACTION OF CASUALTIES.

TRAINING EDITION FOR MEDIUM FIELD ARTILLERY																															
OBSERVER ADJUSTED												MET + VE 0 TLE												MET + VE 75 TL							
.10			.05			.02			1 VOL			.10			.05			.02			1 VOL			.10			.05			.0	
PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT
																								BATTERY VOLLE							
P	16	3	P	5	E	8	E	E	.01	.03	.06	P	29	5	P	12	1	P	2	E	.01	.02	.05	P	P	7	P	15	2	P	5
P	20	4	P	6	E	12	1	E	.01	.02	.06	P	P	5	P	14	1	P	3	E	.01	.01	.05	P	P	8	P	17	2	P	6
P	25	6	P	10	2	26	3	E	.01	.01	.05	P	P	7	P	20	2	P	4	E	–	.01	.04	P	P	9	P	20	3	P	7
P	P	8	P	15	2	P	7	E	–	.01	.04	P	P	9	P	29	3	P	8	E	–	.01	.03	P	P	11	P	27	5	P	9
P	P	12	P	27	5	P	11	1	–	.01	.02	P	P	13	P	P	5	P	12	1	–	–	.02	P	P	15	P	P	7	P	12
																								BATTALION VOLL							
P	2	E	6	E	E	E	E	E	.03	.07	.18	P	8	E	P	2	E	3	E	E	.02	.04	.15	P	P	E	P	3	E	5	E
P	4	E	9	E	E	1	E	E	.02	.06	.16	P	10	E	P	3	E	4	E	E	.01	.03	.13	P	P	E	P	4	E	7	E
P	6	E	P	3	E	5	E	E	.01	.04	.13	P	P	E	P	4	E	6	E	E	.01	.03	.11	P	P	2	P	6	E	9	1
P	P	1	P	6	E	7	E	E	.01	.03	.10	P	P	2	P	7	E	10	1	E	.01	.02	.09	P	P	3	P	9	E	P	1
P	P	2	P	10	E	P	3	E	.01	.01	.07	P	P	3	P	P	E	P	3	E	–	.01	.06	P	P	4	P	P	E	P	3

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UNCLASSIFIE

	%CAS	MET + VE 150 TLE											
		.10			.05			.02			1 VOL		
	FA/SHELL	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM
	RT												
	50	P	P	12	P	27	4	P	10	E	–	.01	.03
BTRY	100	P	P	12	P	P	5	P	11	1	–	.01	.02
VOL	150	P	P	14	P	P	6	P	12	1	–	.01	.02
	200	P	P	18	P	P	7	P	14	1	–	–	.02
	250	P	P	20	P	P	8	P	17	2	–	–	.02
	50	P	P	2	P	9	E	P	2	E	.01	.02	.07
BN	100	P	P	2	P	10	E	P	2	E	.01	.02	.07
VOL	100	P	P	3	P	P	E	P	2	E	.01	.01	.06
	200	P	P	4	P	P	2	P	4	E	–	.01	.05
	250	P	P	6	P	P	2	P	6	E	–	–	.04

ASSYNED RT'S
SQD 50–100m
HQ 100–150m
PLT 150–200m
CO 250m
BN 250–500m

DEFENSIVE POSTURE						
+ VE 250 TLE						
	.02			1 VOL		
ICM	PD	VT	ICM	PD	VT	ICM
11	P	20	2	–	–	.02
12	P	22	2	–	–	.02
13	P	24	3	–	–	.01
13	P	P	3	–	–	.01
14	P	P	4	–	–	.01
2	P	5	E	.01	.01	.04
2	P	5	E	–	.01	.04
3	P	6	E	–	.01	.03
3	P	7	E	–	.01	.03
4	P	7	E	–	–	.03

NOTES (con't)

5. % CASUALTIES AVERAGE EXPECTED FRACTION OF CAS.
6. TGT POSTURE:
   a. OFFENSE
   FIRST VOLLEY
   1/2 STANDING
   1/2 PRONE – SUBSEQ
   VOL'S ALL PRONE
   b. DEFENSE
   FIRST VOLLEY
   1/2 PRONE
   1/2 FOXHOLES
   SUBSEQ VOLLEYS
   ALL FOXHOLES
7. ICM IS AP

Figure C-5. Training Graphical Munitions Effects Tables.

C-8. Quick Reference Tables

a. If JMEMs or GMETs are not available, the FDO can use the guide for cannon attack of typical targets (Table C-2). The table lists selected personnel and materiel targets and indicates the order of effectiveness for each shell-fuze combination. Targets not indicted should be equated to targets that are listed. The table can be used for all calibers.

b. The expected area of coverage table (Table C-3) can be used to determine the appropriate size of a battery one volley or battalion one volley of both HE and ICM for the various caliber weapon systems. The FDO can use Table C-3 to determine the size target that can be attacked by use of battery or battalion volleys. The density of coverage is not considered, but the density of coverage of ICM is much greater than that of HE.

c. The expected fraction of casualties or personnel table (Table C-4) can be used to determine the optimum method of attacking a personnel target of 50 meters radius to achieve the commander's criteria. Table C-4 cannot be used for material targets.

Table C-2. Guide for Cannon Attack of Typical Targets.

TARGET TYPE	OBSERVATION	WEAPONS	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
PERSONNEL						
In open or in fighting positions without overhead cover	Observed and/or unobserved	All	HE	Proximity (VT), time	Destruction	Massing is required.[1] TOT missions are most effective. First volley is most effective.
		All	HE	Proximity (VT), time	Neutralization	Massing is required except for small targets.
		All	HE	Quick, proximity, time	Suppression	Response time is critical against active targets. Preferred fuze is proximity.
		All	APICM	M577	Destruction	Massing is required on large targets. TOT missions are most effective.
		All	APICM		Neutralization	Cannon battery volleys are sufficient.
In fighting positions with overhead cover	Observed	All	HE	Quick/delay (ricochet)	Neutralization	Massing is required. TOT missions are most effective. Consider use of WP to drive personnel out of fighting positions.
		All	HE	Proximity, time, delay, quick	Suppression	Response time is critical against active targets. Proximity fuze is preferred. Consider use of smoke for obscuration.

Table C-2. Guide for Cannon Attack of Typical Targets (Continued).

TARGET TYPE	OBSERVATION	WEAPONS	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
PERSONNEL						
In fighting positions with overhead cover	Observed	All	APICM	M577	Neutralization	Massing is required. TOT missions are most effective.
		All	APICM	M577	Suppression	Consider use of ICM on intermittent basis for increased effectiveness.
In dugouts or caves	Observed	All (preferably 155 mm or larger)	HE	Delay, quick	Destruction	Use direct fire or assault techniques. Fire HE quick at intervals to clear away camouflage, earth cover, and rubble.
Attacking battery position	Observed	105 mm All	Beehive HE APICM	Time	Destruction	Set fuze to detonate on the ascending branch of the trajectory for close-in defense of battery area.
VEHICLES[2]						
Tanks	Observed	All	HE	Proximity, time	Suppression	Fire projectile HE to force tanks to button up and personnel outside to take cover or disperse. WP may blind vehicle drivers, and fires may be started from incendiary effect on outside fuel tanks. WP or fires may obscure adjustment. DPICM is preferred munition for unobserved fire.
	Observed and/or unobserved	155 mm	DPICM	M577	Suppression	See (C)FM 6-141-2, paragraph 7-7. Massing is effective. ICM is preferred.
		203 mm	DPICM	M577	Suppression	See (C) FM 6-141-2. Massing is effective. ICM is preferred.
	Observed	155 mm	FASCAM	M577	Not applicable (NA)	Both antitank and antipersonnel projectiles should be used.
	Observed	155 mm	Copperhead	NA	Destruction	
	Direct fire	105 mm	HEP, HEP-T HEAT	NA	Destruction	
Armored Personnel Carriers	Observed	All	HE	Proximity, time	Suppression	Force vehicles to button up and personnel outside to take cover or disperse.
	Observed and/or unobserved	155 mm	APICM DPICM	M577	Neutralization	See (C) FM 6-141-2. Massing is effective.
		203 mm	APICM DPICM	M577	Neutralization	See (C) FM 6-141-2. Massing is effective.
		155 mm	FASCAM	M577	NA	See remarks for tanks.
	Observed	155 mm	Copperhead	NA	Destruction	
Trucks	Observed and/or unobserved	All	HE	Proximity, time	Destruction	ICM is preferred munition.
		155 mm	DPICM	M577	Destruction	
		203 mm	DPICM	M577	Destruction	

Table C-2. Guide for Cannon Attack of Typical Targets (Continued).

TARGET TYPE	OBSERVATION	WEAPONS	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
WEAPONS						
Antitank missile	Observed	All	HE	Quick	Suppression	Response time is critical. Intermittent fire may be required. Change to fuze proximity or DPICM for materiel damage if antitank guided missile platform on BRDM is raised.
Air Defense						
ZSU-23-4, SA 6	Observed and/or unobserved	All	HE	Proximity	Firepower kill	Smoke may also be used to obscure gunner's line of sight to friendly aircraft. ICM is preferred munition. Consider converged sheaf if weapon is point target and accurately located.
		155 mm	DPICM	M577	Firepower kill	
		203 mm	DPICM	M577	Firepower kill	
SA 8, 9	Observed	All	HE	Quick	Suppression	Response time is critical. Intermittent fire may be required.
		All	HE	Quick	Firepower kill	Same as above.
Towed FA, mortars, multiple rocket launcher	Unobserved	All	HE, WP	Proximity, time	Firepower kill	WP is used to ignite materiel. See personnel targets for results desired.
		All	APICM	M577		See personnel targets section for results desired. TOT missions are most effective. Massing is usually required.
		155 mm	FASCAM	M577	NA	Use ADAM projectile in conjunction with HE or ICM for sustained effects.
Self-propelled FA battery	Unobserved	All	HE, WP	Proximity, time	Suppression	WP is used to ignite materiel.
		All (less) 105 mm	DPICM	M577	Suppression	ICM is preferred munition.
		155 mm	FASCAM	M577	NA	Use ADAM projectile in conjunction with HE or ICM for sustained effects.
Surface-to-surface missile	Unobserved	All (less 105 mm)	HE	Proximity, time	Firepower kill	Use converged sheaf if time and target location accuracy permit. TLE in excess of 200 meters requires massing of fires. ICM is preferred munition.
			DPICM	M577	Firepower kill	
MISCELLANEOUS						
Radar	Unobserved	All	HE	Quick, time, proximity	Firepower kill	Use converged sheaf if time and target location accuracy permit. TLE in excess of 200 meters requires massing of fires. ICM is preferred munition.
		155 mm	DPICM	M577	Firepower kill	
		203 mm	DPICM	M577		

Table C-2. Guide for Cannon Attack of Typical Targets (Continued).

TARGET TYPE	OBSERVATION	WEAPONS	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
Artillery command and observation posts	Observed	All	HE	Quick	Suppression	Intermittent fire may be required. HE is preferred munition when response time is critical.
		155 mm	DPICM	M577	Suppression	
		203 mm	DPICM	M577		
Command post	Unobserved	All	HE	Proximity, time	Neutralization or destruction	Use ADAM for sustained effects. When target contains personnel and light materiel targets, DPICM is preferred munition.
		155 mm	DPICM	M577	NA	
		203 mm	DPICM	M577		
Supply installation	Unobserved	All	HE, WP	Quick	Fires	Large target location errors require massing to ensure target coverage.
Boats	Observed	All	HE	Time	Suppression	Attack as moving personnel target.
Bridges	Observed and/or unobserved	All (preferably 155 mm or larger)	HE	Quick, concrete piercing, delay	Destruction	Direction of fire is preferably with long axis of bridge. Destruction of permanent bridges is best accomplished by knocking out bridge support. Use fuze quick for wooden or pontoon bridges.
	Observed	155 mm	Copperhead	NA	Destruction	
Fortifications	Observed	All (preferably 155 mm or larger)	HE	Concrete piercing, delay, quick	Destruction	Use highest practical charge in assault and direct fire.
		155 mm	Copperhead	NA	Destruction	

[1] Targets, regardless of type, with an estimated target radius greater than 150 meters usually require massing for effective attack.

[2] The first objective of firing on moving vehicles is to stop the movement. For this purpose, a deep bracket is established so that the target will not move out of the initial bracket during adjustment. Speed of adjustment is essential. If possible, the column should be stopped at a point where vehicles cannot change their route and where one stalled vehicle will cause others to stop. Vehicles moving on a road can be attacked by adjusting on a point on the road and then timing the rounds fired so that they arrive at that point when a vehicle is passing it. A firing unit or units, if available, may fire at different points on the road simultaneously.

Table C-3. Expected Area of Coverage (Meters).

MUNITIONS	105 mm	155 mm	203 mm
APICM	BTRY ① BN ①	BTRY ① BN ①	BTRY ① BN ①
Square	250 x 250 380 x 380	266 x 266 390 x 390	239 x 239 320 x 320
Circle (Radius)	140 215	150 220	135 180
HE	BTRY ① BN ①	BTRY ① BN ①	BTRY ① BN ①
Square	248 x 248 380 x 380	275 x 275 390 x 390	239 x 239 319 x 319
Circle (Radius)	140 215	155 220	135 180

Table C-4. Expected Fraction of Casualties or Personnel.

PROJECTILE	IF TARGET RADIUS IS 50 METERS, THEN			
		APICM	HE/VT	HE/PD
105 mm	BTRY ①	07	07	04
	BN ①	20	20	12
155 mm	BTRY ①	15	05	03
	BN ①	35	16	11
203 mm	BTRY ①	15	03	02
	BN ①	38	10	15

C-9. EXAMPLES

The following examples are to be used for training only. They are based on previous versions (Figure C-5) of the GMET that are still available. To determine the amount and type of munitions needed to achieve suppression, neutralization, and destruction of targets, use the procedures in Tables C-5 and C-7.

Table C-5. Determining Amount and Type of Munitions.

STEP	ACTION
1	Determine the posture of the target--whether it is defensive or offensive. The considerations are: **Offensive:** Half standing, half prone on the first volley. All are prone on subsequent volleys. **Defensive:** On the first volley, half prone, half in foxholes. All are in foxholes on subsequent volleys.
2	On the basis of the posture of the target, choose the appropriate side of the GMET to use.
3	Determine methods of control (AF or FFE). If AF, go to step 5 and use the observer adjust column.
4	Determine the target location error. Use Table C-6 to determine over which column of the body to place the cursor.
5	Move the cursor over the appropriate column. (See Figure C-6.)

Table C-6. Target Acquisition Method.

TLE = 0 Meters (CEP)	TLE = 75 Meters (CEP)	TLE = 150 Meters (CEP)	TLE = 300 Meters (CEP)
Forward observer with laser Target area base Photointerpretation Airborne target location	Counterbattery radar Airborne infrared system Flash ranging Countermortar radar	Sound ranging	Forward observer without laser Air observer POW reports Tactical air Forward observer (nonartillery) Long-range patrol Side-looking airborne radar Communications intelligence Electronics intelligence Shell reports

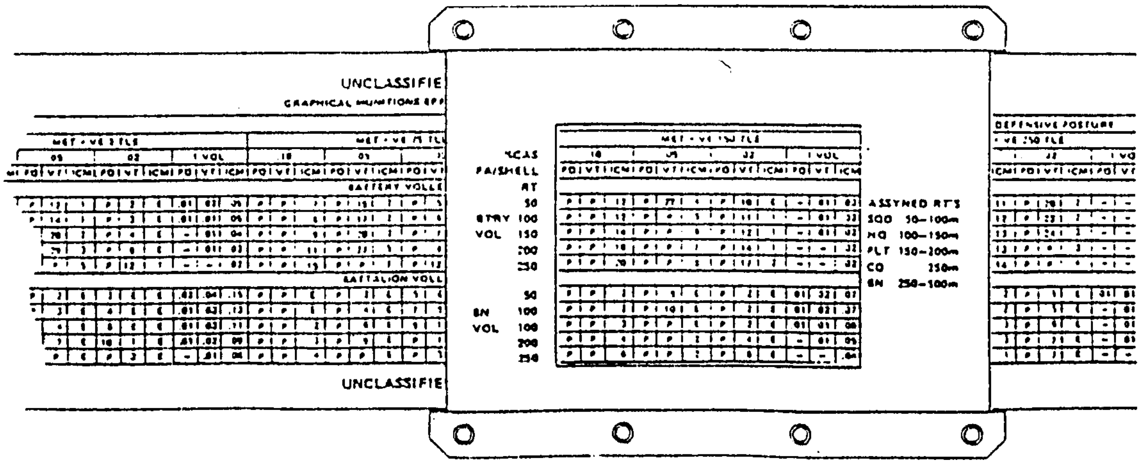


Figure C-6. Cursor Position.

Table C-5. Determining Amount and Type of Munitions (Continued).

STEP	ACTION
6	On the basis of the commander's guidance, the observer's call for fire, and the tactical situation, decide which unit to fire (battalion or battery).
7	On the basis of the target size, in meters, enter the corresponding row and extract the number of volleys to fire.
8	On the basis of the commander's guidance, the observer's call for fire, and the tactical situation, determine the desired number of casualties. Enter the appropriate column. Percentage of casualties are expressed to 30 percent, 20 percent, and 10 percent in the offense and 10 percent, 5 percent, and 2 percent in the defense.
9	On the basis of the commander's guidance, ammunition availability, observer's request, and tactical situation, choose the ammunition to fire. Enter the appropriate shell-fuze combination column. To determine the ammunition to fire, use the following rules: ● All letters are bad (Prohibitive and Excessive). ● Blue is better than red. ● If two numbers are the same color, choose the smaller.
10	Issue your fire order on the basis of the extracted values as the number of volleys in effect.

Table C-7. Determining Amount of ICM to Achieve 30 Percent Casualties.

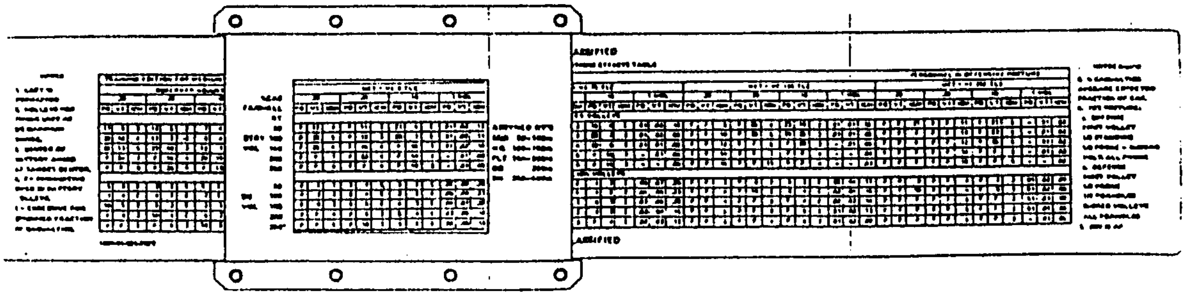
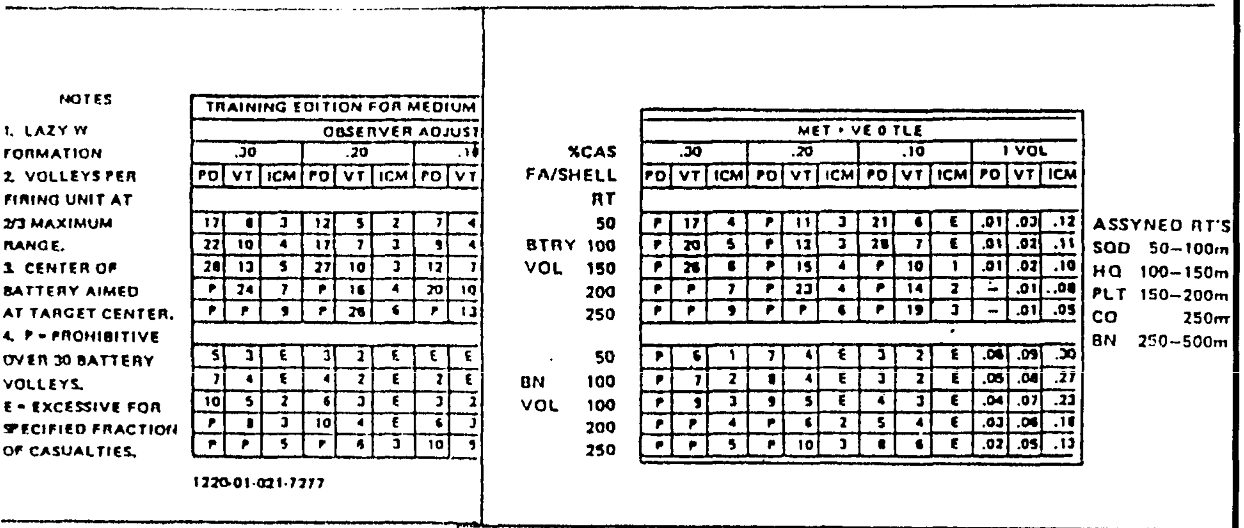
STEP	ACTION
	CONDITION: An observer with a laser calls fire on an infantry squad in the open (FFE). You desire 30 percent casualties. The observer requests ICM.
1	The target is attacking and all are standing; you determine the posture of the target is offensive.
2	On the basis of the posture of the target, choose the appropriate side of the GMET to use. In this case, it will be the offensive side.
3	Since the mission is FFE and the observer is employing a laser, the target location error is 0-TLE. (See Figure C-7.)
	 Figure C-7. Cursor Position (TLE of 0).

Table C-5. Determining Amount and Type of Munitions (Continued).

STEP	ACTION
4	On the basis of the TLE, move the cursor over the appropriate column. You have a TLE of 0, move the cursor over the MET + VE 0 TLE column. (See Figure C-8.)



NOTES
1. LAZY W FORMATION
2. VOLLEYS PER FIRING UNIT AT 2/3 MAXIMUM RANGE.
3. CENTER OF BATTERY AIMED AT TARGET CENTER.
4. P = PROHIBITIVE OVER 30 BATTERY VOLLEYS.
E = EXCESSIVE FOR SPECIFIED FRACTION OF CASUALTIES.

TRAINING EDITION FOR MEDIUM
OBSERVER ADJUST

.30			.20			.1	
PD	VT	ICM	PD	VT	ICM	PD	VT
17	8	3	12	5	2	7	4
22	10	4	17	7	3	9	4
28	13	5	27	10	3	12	7
P	24	7	P	16	4	20	10
P	P	9	P	26	6	P	13
5	3	E	3	2	E	E	E
7	4	E	4	2	E	2	E
10	5	2	6	3	E	3	2
P	8	3	10	4	E	6	3
P	P	5	P	6	3	10	5

1220-01-021-7277

		MET + VE 0 TLE											
%CAS		.30			.20			.10			1 VOL		
FA/SHELL		PD	VT	ICM	PD	VT	ICM	PD	VT	ICM	PD	VT	ICM
RT													
	50	P	17	4	P	11	3	21	6	E	.01	.03	.12
BTRY	100	P	20	5	P	12	3	28	7	E	.01	.02	.11
VOL	150	P	26	6	P	15	4	P	10	1	.01	.02	.10
	200	P	P	7	P	23	4	P	14	2	–	.01	.08
	250	P	P	9	P	P	6	P	19	3	–	.01	.05
	50	P	6	1	7	4	E	3	2	E	.08	.09	.30
BN	100	P	7	2	8	4	E	3	2	E	.06	.04	.27
VOL	100	P	9	3	9	5	E	4	3	E	.04	.07	.23
	200	P	P	4	P	6	2	5	4	E	.03	.06	.18
	250	P	P	5	P	10	3	8	6	E	.02	.05	.13

ASSYNED RT'S
SQD 50–100m
HQ 100–150m
PLT 150–200m
CO 250m
BN 250–500m

Figure C-8. MET + VE 0 TLE and .30 Columns.

5	You decide to fire the battery.
6	The target is a large squad, and its radius is 100 meters. Choose the corresponding row.
7	You desire 30 percent casualties, and you enter the .30 column.
8	The observer requested ICM, which is APICM on the GMET. Because of the observer's request, you choose APICM.
9	Extract the number of volleys to fire, which is 5. For six howitzers, the total rounds fired would be 30 (**5 x 6 = 30**).
10	Issue the fire order, which would be for five rounds.

C-10. Terminal Ballistics

Terminal ballistics may be defined as the study of the effects of projectiles on a target. The theory of terminal ballistics is relatively new compared to the theory of internal and external ballistics. The techniques of investigation for impact on solid targets consist primarily of empirical relations (based on experiments), analytical models, and computer simulations. In terminal ballistics, we are dealing with the shock caused by the detonation of the HE filler. The effects are most pronounced if the shell penetrates the surface of a target before detonation.

C-11. Munitions Effects

a. High Explosive. The use of the HE with its many different fuze combinations (PD-Superquick or Delay, Ti, or VT) is very effective against personnel targets except when they have a high degree of protection. The HE projectile is available for the 105-mm and 155-mm howitzers.

b. HERA Projectile. This projectile has two distinct advantages over normal HE--increased range and fragmentation. The RAP round is primarily used against antipersonnel and material targets at increased ranges. The RAP round is available for the 105-mm and 155-mm howitzers.

c. Smoke. There are four different types of smoke in our inventory: HC smoke, colored smoke, white phosphorus, and M825/M825A smoke. The hexachloroethane, or HC smoke, and the colored smoke are used for screening, marking, and obscuring targets with no casualty-producing effect. The WP projectile is primarily used for incendiary purposes; that is, POL sites and equipment. White phosphorus may also be used as a screening or marking round. The M825/M825Al, new smoke, is a WP projectile which dispenses 116 WP impregnated felt wedges. The build-up time is much quicker, and the duration (5 to 10 minutes) is longer than normal HC or WP. The smoke projectile (HC, colored, and WP) are available for the 105-mm and 155-mm howitzers. The M825/M825A1 is only available for the 155-mm howitzer.

d. Chemical (Gas). This munition incapacitates the enemy either by choking, blistering exposed tissue, or attacking the nervous system. The chemical projectile is most effective when deployed with other types of munitions. The chemical projectile is available for the 105-mm and 155-mm howitzers.

e. Illumination. The illum projectile is primarily used for night attack or defense, as a ground marking round for a particular target, and for harassment. The illum projectile is available for the 105-mrn and 155-mm howitzers.

f. Antipersonnel (Beehive). The Beehive projectile was designed for direct fire battery defense. The projectile acquired its name because of the 8,000 flechettes, or “steel darts,” housed within the body. The projectile is available for the 105-mm howitzer only and comes fuzed with the M563 fuze set on muzzle action.

g. Antipersonnel Improved Conventional Munitions. This projectile contains antipersonnel grenades (the number varies depending on the caliber of the weapon) which are extremely effective on antipersonnel targets. APICM is available for 105-mm and 155-mm howitzers.

h. Dual-Purpose Improved Conventional Munitions. This projectile contains antipersonnel and antimaterial grenades. As with APICM, the number of each type of submunition depends on the caliber of the weapon. This projectile was designed for use against equipment, lightly armored vehicles, and personnel. DPICM is available for the 155-mm howitzer.

i. Family of Scatterable Mines. There are two types of artillery delivered mines: ADAM and RAAMS. The ADAM was developed for use against personnel targets, to deny terrain, and to block avenues of approach. RAAMS was developed for use against armored targets. Both the ADAM and RAAMS have preset self-destruct times of either short (within 4 hours) or long (within 48 hours). FASCAM is available for the 155-mm howitzer only.

j. Copperhead. The CLGP, or Copperhead projectile, was designed for high-payoff targets such as enemy armor or command bunkers. The projectile has three distinct sections: guidance, warhead, and control. The round is loaded and fired the same as with other projectiles but with a special switch setting placed on the projectile before firing. It is laser-guided to the target. The Copperhead projectile is only available for the 155-mm howitzer.

k. M864 Base Burn DPICM. This projectile is a 155-mm projectile that extends the maximum range of DPICM to 22.2 km for the Ml09A2/A3 and 28.4 km for the M109A5/A6 M198 howitzers. The projectile contains 72 dual-purpose grenades. A base burner assembly containing 2.6 pounds of HTPB-AP propellant is assembled to the base of the projectile body. When the weapon is fired, the propelling charge ignites the propellant in the base burner assembly. The gases expelled from the base burner unit greatly reduce drag behind the base, thus increasing projectile range. The projectile will not be used for training; all assets will become war reserve. Data may be computed manually by using FT 155-AU-PAD and FT 155-ADD-U-PAD. Automated procedures will become available with the fielding of version 10 software for the battery computer system.

C-12. New Experimental Projectiles

a. M898 Sense and Destroy Armor. M898 SADARM artillery munitions are in engineering and manufacturing development for the 155-mm howitzer delivery systems. The SADARM submunitions are delivered by a DPICM-family projectile and are dispensed over the target area. The submunitions will orient, stabilize, and descend by parachute over the target area. When a target is identified within the submunition scan area by millimeter wave or infrared sensors, an explosively formed penetrator will fire from the submunition into the target.

b. XM915/916 105-mm DPICM. The XM915 cartridge is a semifixed 105-mm DPICM projectile which is compatible with the Ml19 howitzer. It uses the M229 zone 8 propelling charge. The maximum range is 14 km. The XM916 cartridge is a semifixed 105-mm DPICM projectile which is compatible with the M101A1, M102, and M119 howitzers. It uses the standard M67 propelling charge. The maximum range is 11 km. Both projectiles contain a submunition payload of 42 dual-purpose XM80 submunitions, which will be approximately twice as effective as the current M444 APICM projectile.

c. M913 105-mm RAP. The M913 cartridge is a semifixed 105-mm RAP which is compatible with the M119 howitzer. It uses the M229 zone 8 propelling charge. The maximum range is 19.5 km. The M913 will be produced for all M119 units Armywide and will be held in war reserve.

Appendix D

PLANNING RANGES

This appendix provides information on the minimum and maximum ranges for planning purposes for the following weapon systems:

- *105 mm (Table D-1).*
- *155 mm (Tables D-2,* D-3, and D-4).
- *203 mm.*
- *MLRS.*

Table D-1. 105-mm Planning Ranges (M67 and M200).

PROJECTILES		M67 CHG 1-7			M200 CHG 8	
		MIN RG		MAX RG	MIN RG	MAX RG
APERS	M546	75	–	3000	----	----
APICM	M444	1800	–	11300	----	----
BLANK	M395	0	–	0	----	----
CS	M629	400	–	11500	----	----
HE	M1	68	–	11500		----
HE	M760	----	–	----	9600	14000 [1]
HERA PROJ	M548	68	–	15000	----	----
HC	M84A1	400	–	11500	----	----
HEP-T	M327	0	–	5000	----	----
ILLUM	M314A2E1	800	–	9100	----	----
LEAFLET	M84B1	400	–	9000	----	----
WP	M60	68	–	11500	----	----

[1] M200 propellant may only be fired from M119 howitzer.

LEGEND:
APERS = antipersonnel
CS = chlorobenzaimalononitrile (riot control agent)
HEP-T = high-explosive plastic-tracer

Table D-2. 155-mm Planning Ranges (M3A1 and M4A2).

PROJECTILES		M3A1 CHG 2-5			M4A2 CHG 3-7		
		MIN RG		MAX RG	MIN RG		MAX RG
ADAM	M692[1]	950/2750	–	8850	3200	–	14150
ADAM	M731[1]	950/2750	–	8850	3200	–	14150
CPHD	M712	3000	–	5400	5400	–	13000
APICM	M449[2]	2000	–	9800	2700	–	14600
	M449[3]	2400	–	9800	2700	–	14600
DPICM	M483A1	1900	–	9000	2600	–	14200
DPICM BB	M864	----	–	----	3900	–	17100
HC	M116A1	400	–	9800	400	–	14700
HE	M107[4]	134	–	9800[4]	134	–	14700
HE RAP	M549A1	----	–	----[4]	134	–	19500
ILLUM	M485[1]	500/2500	–	9200[1]	900/3300	–	14200
PRACT	M804[4]	134	–	9800[4]	134	–	14700
RAAMS	M718/A1	2000	–	9100	2100	–	14300
RAAMS	M741/A1	2000	–	9100	2100	–	14300
SUBCAL	M181/2/3	25	–	730	----	–	----
WP	M110A1[4]	134	–	9800[4]	134	–	14700
WP	M825	1500	–	9300	4150	–	14400

[1] Minimum ranges along the ascending and descending branch.
[2] Minimum range for the M185 cannon tube.
[3] Minimum range for the M199 cannon tube.
[4] Minimum arming range for fuze PD.

LEGEND:
BB = base burn
pract = practice
subcal = subcaliber

Table D-3. 155-mm Planning Ranges (M119/A1 and M119/A2).

PROJECTILES		M119/A1 CHG 8			M119/A2 CHG 7R		
		MIN RG		MAX RG	MIN RG		MAX RG
ADAM	M692	6400	–	17750	6400	–	17750
ADAM	M731	6400	–	17750	6400	–	17750
CPHD	M712	11000	–	15500	11000	–	15500
APICM	M449	6100	–	18000	6100	–	18000
DPICM	M483A1	5900	–	17600	5900	–	17600
DPICM BB	M864	- - - -	–	- - - -	4500	–	22000
HC	M116A1	400	–	18100	400	–	18100
HE	M107[1]	134	–	18100[1]	134	–	18100
HERA PROJ	M549A1	134	–	23000[1]	134	–	23000
ILLUM	M485[2]	2500/6000	–	17500[2]	2500/6000	–	17500
PRACT	M804[1]	134	–	18100[1]	134	–	18100
RAAMS	M718/A1	3900	–	17900	3900	–	17900
RAAMS	M741/A1	3900	–	17900	3900	–	17900
SUBCAL	M181/2/3	25	–	730	- - - -	–	- - - -
WP	M110A1[1]	134	–	18100[1]	134	–	18100
WP	M825	3500	–	17800	3500	–	17800

[1] Minimum arming range for fuze PD.

[2] Minimum ranges along the ascending and descending branch.

Table D-4. 155-mm Planning Ranges (M203/A1).

PROJECTILES		M203/A1 CHG 8S		
		MIN RG		MAX RG
ADAM	M692	----	–	----
ADAM	M731	----	–	----
CPHD	M712	----	–	----
APICM	M449	----	–	----
DPICM	M483A1	----	–	----
DPICM BB	M864	5400	–	28100
HC	M116A1	----	–	----
HE	M107	----	–	----
HERA PROJ	M549A1	134	–	30100
ILLUM	M485	----	–	----
PRACT	M804	----	–	----
RAAMS	M718/A1	----	–	----
RAAMS	M741/A1	----	–	----
SUBCAL	M181/2/3	25	–	730
WP	M110A1	----	–	----
WP	M825	3500	–	22400

Table D-6. 203-mm Planning Ranges (M1 and M2).

PROJECTILES		M1 CHG 1-5			M2 CHG 5-7		
		MIN RG		MAX RG	MIN RG		MAX RG
APICM	M404[1]	950/2700	–	11500	4500	–	16950
DPICM	M509A1[1]	550/1850	–	11400	3100	–	16800
HE	M106[2]	183	–	118002	183	–	17200
HERA PROJ	M650A1[3]	183	–	118003	183	–	17800
	M650A1[4]	----	–	----[4]	183	–	21000

[1] Minimum ranges along the ascending and descending branch.
[2] Minimum arming range for fuze PD.
[3] Ranges with rocket motor **off**.
[4] Ranges with rocket motor **on**.

Table D-6. 203-mm Planning Ranges (M188A1).

PROJECTILES		M188A1 CHG 8-9		
		MIN RG		MAX RG
APICM	M404	----	–	----
DPICM	M509A1	4900	–	22900
HE	M106[1, 2]	183	–	20600
HERA PROJ	M650A1[1, 3]	183	–	24400
	M650A1[1, 4]	183	–	30000

[1] Minimum arming range for fuze PD.
[2] Charge 8 maximum allowable charge.
[3] Ranges with rocket motor **off**.
[4] Ranges with rocket motor **on**.

Table D-7. MLRS Planning Ranges.

MUNITIONS				
		MIN RG		MAX RG
DPICM	M77	8000	–	30000
PRACT	M28	8000	–	30000
ATACMS	M39[1]	----	–	----

[1] Ranges are classified

Appendix E

REPLOT PROCEDURES

In many instances, the refinement data transmitted by the observer after the FFE phase may not reflect the actual location of the target as defined by its grid coordinates and altitude. This inaccuracy results from errors in initial target location and errors in determining the initial site fired in an adjust-fire mission. For other units to mass fires on the same point and for the observer to accurately shift from a known point located by firing, the actual target location and altitude must be determined as accurately as possible. The replot process is used for this purpose. Targets are replotted on request of the observer or when directed by the FDO. Replot gives a deflection and range with which the target location can be polar plotted from the location of the firing unit. The manual replot procedures are the same for PD and VT fuzes. The procedures for the time fuze are somewhat different.

NOTE: The resulting target location reflects any errors that exist in the firing data and unit location. The replot grid and altitude may differ from the survey location of the same target for this reason.

E-1. Reasons for Replot

a. Inaccurate target location by the observer may result in an inaccurate altitude and an inaccurate site being determined by the FDC. For example, in Figure E-1, the observer's inaccurate target location included an altitude greater than the actual target altitude. On the basis of the inaccurate target altitude, a false site is determined and used. The observer sends a subsequent correction of **DROP 400.** The firing data computed reflect the data needed to cause the round to impact at Point A. Because no adjustment has been made to altitude, the projectile continues beyond Point A and impacts over the target. As shown in Figure E-2, the observer's next correction **(DROP 50)** results in accurate fire for effect. Figure E-2 also shows that there is a difference between the final pin location on the firing chart and the actual target location. Target replot is required to correct for this error. Replot procedures use successive approximation to determine the true site and the actual (replot) range and deflection to the target.

b. Requirements for replot are as follows:

- A map.
- Accurate refinement data from the observer.
- Valid GFT setting that accurately accounts for the nonstandard conditions existing at the time of firing.

These elements will ensure that the replot procedure is as accurate as possible. Should the GFT setting or firing chart be later corrected to more accurately reflect the conditions that existed when the mission was fired, the replot should be recomputed with the more accurate data.

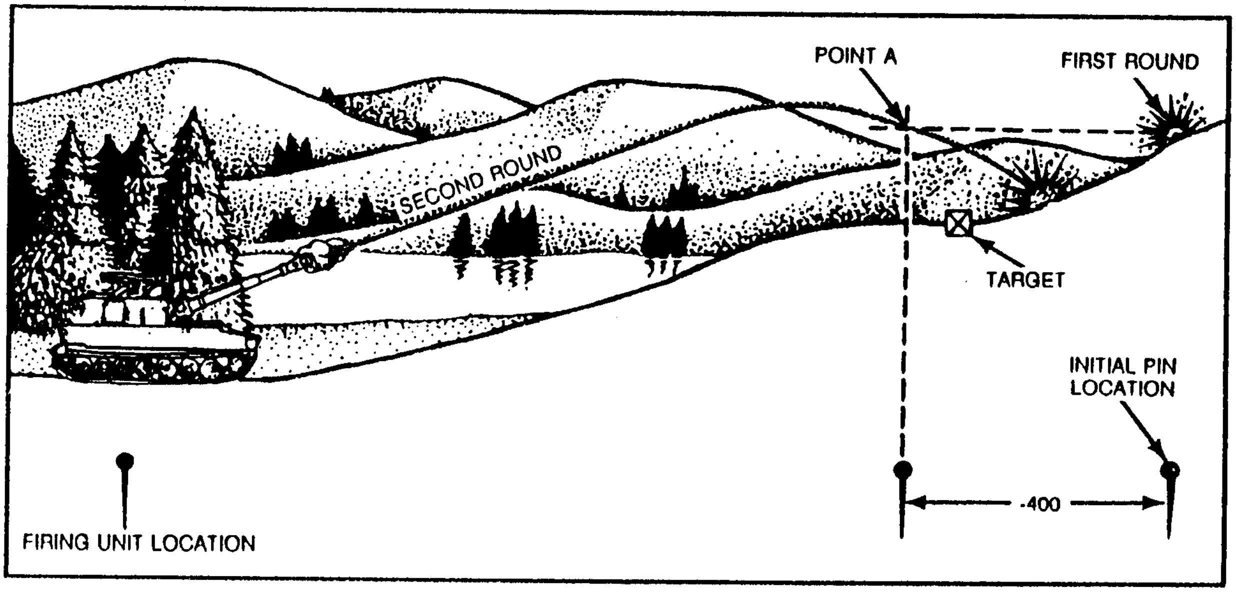


Figure E-1. Initial Target Location.

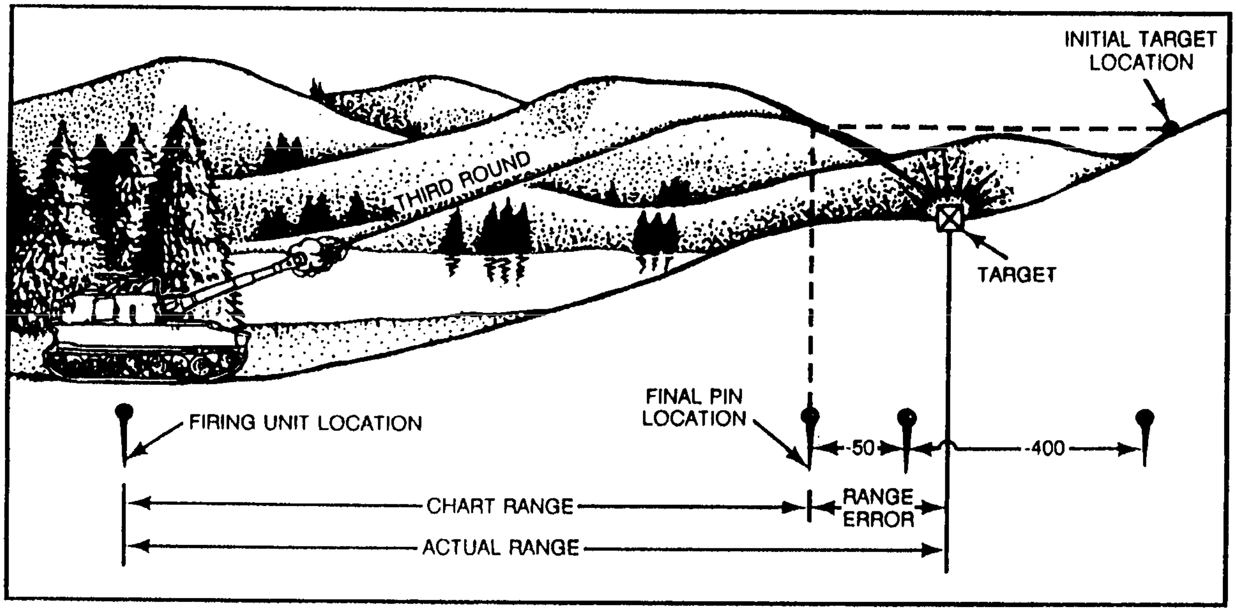


Figure E-2. Observer's Final Correction.

E-2. Replot With PD and VT Fuzes

a. Replot Deflection. The replot (true) deflection to the target may or may not be the final piece deflection. Because drift may have changed during the conduct of the adjustment, determine the true total deflection correction as shown in Table E-1. (See Figure E-3.)

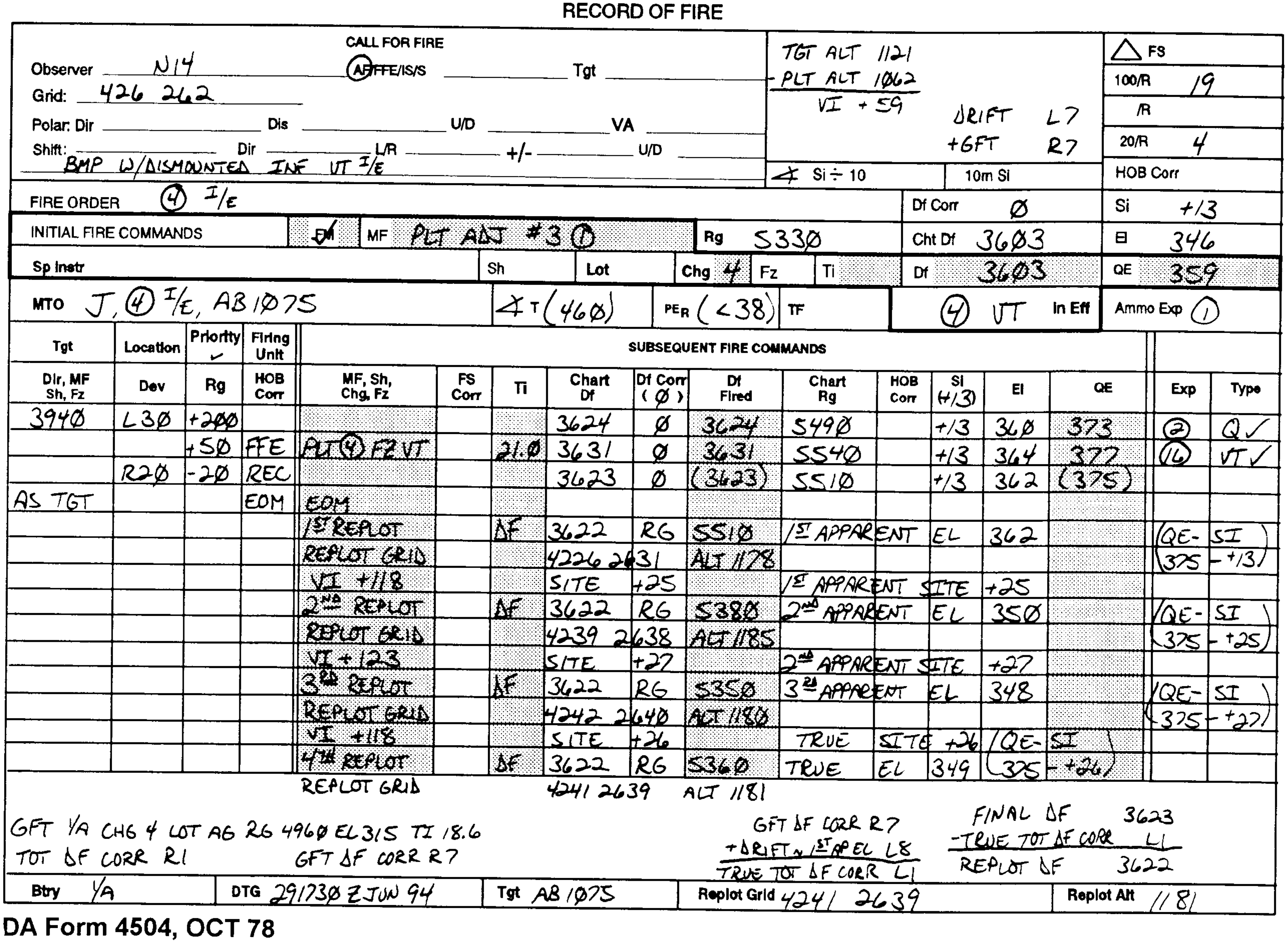
Table E-1. Determining Replot Deflection.

STEP	ACTION
1	HCO plots observer's refinement and determines and announces chart data.
2	Determine final firing data from the observer's refinement, and place the data in the appropriate blocks of the ROF in parentheses.
3	The computer determines the first apparent elevation by algebraically subtracting site from the final quadrant elevation.
4	The computer determines drift corresponding to the first apparent elevation.
5	The computer adds the drift determined in step 4 to the GFT deflection correction. The result is the true total deflection correction.
6	The computer determines the replot deflection by algebraically subtracting the true total deflection correction from the final deflection.

b. Replot Grid and Altitude. Determine the replot grid and altitude by successive approximation: The procedures are described in Table E-2.

Table E-2. Determining Replot Grid and Altitude by Successive Approximation.

STEP	ACTION
1	The computer determines the replot deflection as described in Table E-1 and announces it to the HCO.
2	The computer reads the range corresponding to the apparent elevation under the MHL with the elevation gauge line over the apparent elevation and announces this range to the HCO.
3	The HCO polar plots the target from the base piece at the deflection and range announced and determines and announces the grid to the VCO.
4	The VCO plots the replot grid and determines the map altitude of the replotted location. Using the new altitude and the range last announced, the VCO determines the apparent site.
5	The computer determines if the apparent site is within 1 mil of the site fired.
5a	If the apparent site is within 1 mil of the site fired, the apparent site is true site. To determine true elevation algebraically, subtract the true site from the final quadrant. Using the procedure described in Table E-1, step 6, determine the replot range. The replot deflection remains the same throughout the process of successive approximation. Announce the final replot deflection and range to the HCO. The HCO determines replot grid and records the replot grid and the altitude used to determine true site. This altitude is replot altitude.
5b	If the site is not within 1 mil of the last computed site, repeat step 6 in Table E-1 and steps 1 though 3 above until a true site is determined that agrees within 1 mil with the last computed site. Subtract the last computed site from the quadrant elevation to determine the new apparent elevation.



RECORD OF FIRE

CALL FOR FIRE

Observer N14 [✓ AF]FE/IS/S Tgt
Grid: 426 262
Polar: Dir Dis U/D VA
Shift: Dir L/R +/- U/D
BMP W/DISMOUNTED INF VT I/E

TGT ALT 1121
-PLT ALT 1062
VI +59
DRIFT L7
+GFT R7

∡ Si ÷ 10
10m Si

△ FS
100/R 19
/R
20/R 4
HOB Corr

FIRE ORDER ④ I/E
Df Corr 0
Si +13

INITIAL FIRE COMMANDS [✓ FM] MF PLT ADJ #3 ①
Rg 5330
Cht Df 3603
⊟ 346

Sp Instr
Sh
Lot
Chg 4
Fz
Ti
Df 3603
QE 359

MTO J, ④ I/E, AB1075
∡T (460)
PER (<38)
TF
④ VT In Eff
Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (0)	Df Fired	Chart Rg	HOB Corr	Si (+13)	El	QE	Exp	Type
3940	L30	+200					3624	0	3624	5490		+13	360	373	②	Q✓
		+50	FFE	PLT ④ FZ VT		21.0	3631	0	3631	5540		+13	364	377	⑯	VT✓
	R20	-20	REC				3623	0	(3623)	5510		+13	362	(375)		
AS TGT			EOM	EOM												
				1ST REPLOT		ΔF	3622	RG	5510	1ST APPARENT		EL	362		(QE-	SI)
				REPLOT GRID			4226 2631		ALT 1178						375	- +13)
				VI +118			SITE	+25		1ST APPARENT SITE			+25			
				2ND REPLOT		ΔF	3622	RG	5380	2ND APPARENT		EL	350		(QE-	SI)
				REPLOT GRID			4239 2638		ALT 1185						375	- +25)
				VI +123			SITE	+27		2ND APPARENT SITE			+27			
				3RD REPLOT		ΔF	3622	RG	5350	3RD APPARENT		EL	348		(QE-	SI)
				REPLOT GRID			4242 2640		ALT 1180						375	- +27)
				VI +118			SITE	+26		TRUE	SITE +26		(QE-	SI)		
				4TH REPLOT		ΔF	3622	RG	5360	TRUE	EL	349	375	- +26)		

REPLOT GRID 4241 2639 ALT 1181

GFT 1/A CHG 4 LOT AG RG 4960 EL 315 TI 18.6
TOT ΔF CORR R1
GFT ΔF CORR R7

GFT ΔF CORR R7
+DRIFT ≈ 1ST AP EL L8
TRUE TOT ΔF CORR L1

FINAL ΔF 3623
-TRUE TOT ΔF CORR L1
REPLOT ΔF 3622

Btry 1/A	DTG 291730 Z JUN 94	Tgt AB1075	Replot Grid 4241 2639	Replot Alt 1181

DA Form 4504, OCT 78

Figure E-3. Record of Fire (Replot With Fuze Quick).

E-3. Time Refinement

To accurately replot targets when firing fuze time, determine refinement data to correct for inaccurate HOB.

a. During the adjustment phase of the mission, the observer usually adjusts the trajectory to within 50 meters of the target before requesting FFE rounds. Upon completion of the FFE phase, the observer sends refinement data to the FDC. Elements of refinement may include deviation, range, and/or HOB. These refinement data place the mean point of the FFE bursts over the actual target location, thereby allowing the FDC to compute accurate data to the target if future fires are required. Application of refinement is a requirement for replot of targets, which allows for transfer and massing of fires.

b. Fuze time procedures are slightly different. During the time adjustment phase of the mission, the FDC applies ▲ FS to the fuze setting to correct for the difference in the height of burst above the target. Therefore, when he requests fire for effect, we assume the observer has adjusted the height of burst to 20 meters.

c. Time refinement procedures **without** an HOB correction are shown in Table E-3.

Table E-3. Determining Time Refinement Data Without an HOB Correction.

STEP	ACTION
1	The HCO plots any deviation and/or range correction and determines new chart data.
2	The computer determines a new time, deflection, and elevation.
3	To determine the refinement time, the computer applies the total fuze correction from the time adjustment phase of the mission to the new time determined.
4	The refinement deflection is the new chart deflection plus the total deflection correction used during the mission.
5	The refinement quadrant elevation is the new elevation plus the total site fired.

e. Time refinement procedures **with** an HOB correction are shown in Table E-4.

Table E-4. Determining Time Refinement Data With an HOB Correction.

STEP	ACTION
1	The HCO plots any deviation and/or range correction and determines new chart data.
2	The computer determines a new time, deflection, and elevation.
3	Determine a new quadrant elevation to correct the HOB.
3a	Use the value of 100/R determined initially, and multiply this value by the HOB refinement correction divided by 100. Express the result to the nearest 1 mil.
3b	Apply the correction determined to the total site used during the time adjustment phase of the mission. If the observer sends an up correction, the HOB refinement correction is added to the total site used. If the HOB correction is a down correction, the HOB correction is subtracted.
3c	Add the HOB correction, the total site used during adjustment, and the new elevation determined to find the refinement quadrant elevation.

E-4. Replot With Time Fuze

a. When a target is attacked with a mechanical time fuze, the observer adjusts the height of burst to 20 meters above the target. The final fuze setting provides an accurate representation of the target location and the altitude of a point 20 meters above the target. Consequently, when the time gauge line is placed over the final time, the range and 100/R (read under the MHL) and the elevation and drift correction (read under the elevation gauge line as a function of elevation) are true. The replot grid and altitude can then be determined (See Figure E-4.)

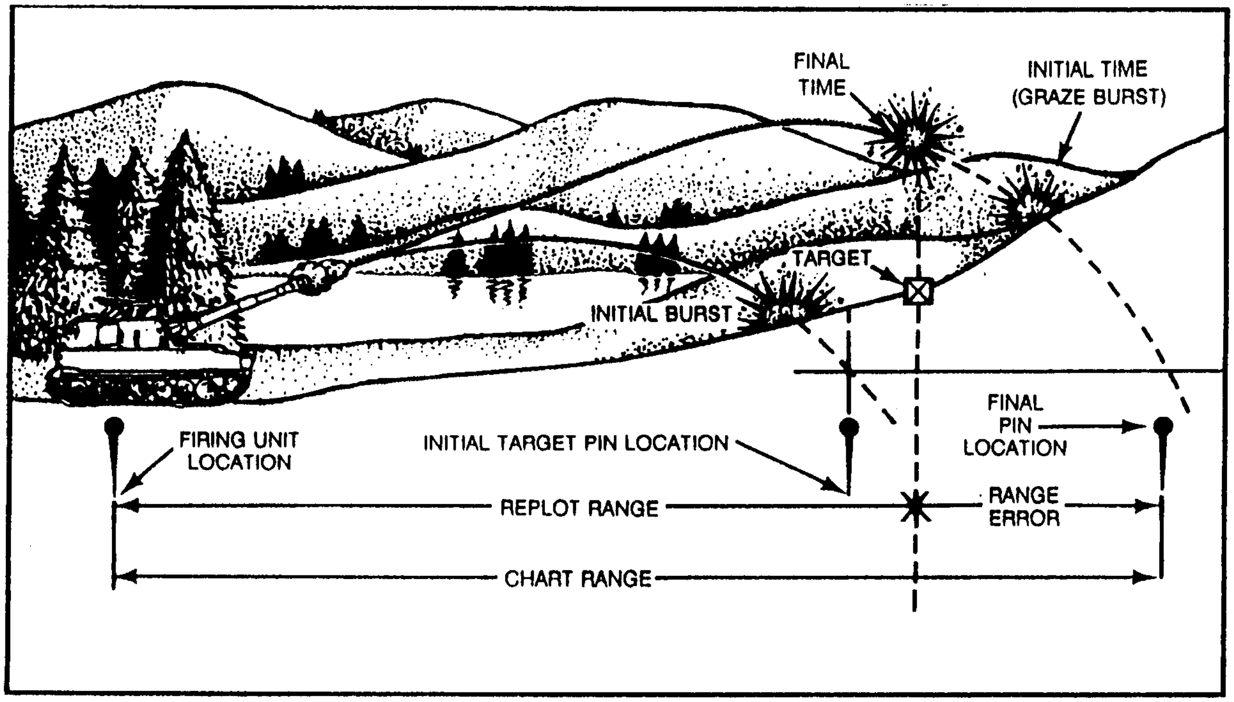


Figure E-4. Time Replot.

b. Replot deflection procedures are shown in Table E-5. (See Figure E-5 on page E-8.)

Table E-5. Determining Replot Deflection (Time Fuze).

STEP	ACTION
1	The computer places the time gauge line over the final time.
2	The computer determines replot range and 100/R under the manufacturer's hairline and true elevation under the elevation gauge line.
3	The computer reads drift under the manufacturer's hairline with the MHL over the elevation determined in step 2.
4	The computer determines the true total deflection correction by adding the drift (step 3) to the GFT deflection correction.
5	The computer determines the replot deflection by subtracting the true total deflection correction from the final piece deflection.

c. The procedures for determining replot grid and altitude are shown in Table E-6.

Table E-6. Determining Replot Grid and Altitude (Time Fuze).

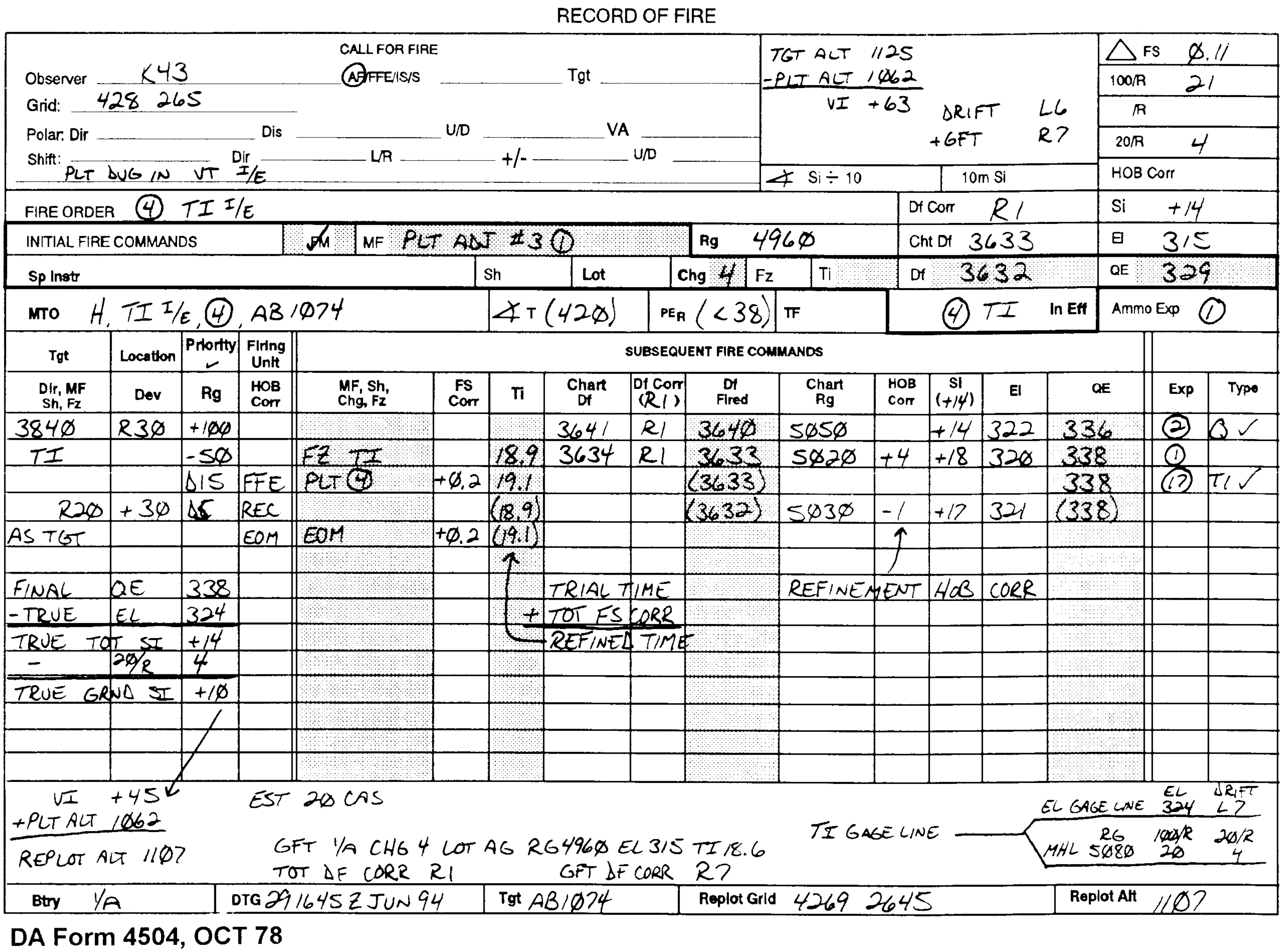
STEP	ACTION
1	The computer determines replot range and deflection as described in Table E-5, steps 1 through 4.
2	Using the replot range and deflection, the HCO polar plots the target and determines the replot grid.
3	The computer subtracts true elevation from the final quadrant to determine true total site. Determine elevation from the elevation gauge line.
4	To obtain true ground site, the computer subtracts the value of 20/R (replot range 100/R) from the total site determined in step 2 above.
5	Using the GST, the VCO determines the VI by multiplying the true ground site by the replot range.
6	The VCO algebraically adds the VI to the battery altitude to determine the target altitude.

E-5. Attack of Large Targets

In a manual FDC or one equipped with the BCS operating autonomously, the FDO decides how to attack a target. In determining the volume of fire to place on a target, he uses the GMET and the JMEM as guides. Calls for fire may include targets too large to be considered with the GMET, since the largest target radius considered in the GMET is 250 meters. Large or irregularly shaped targets require special fire distribution techniques to ensure proper coverage with the most effective use of the ammunition available. The following paragraphs describe various methods of attacking large targets that have proved successful. The FDO and S3 should use the technique that best accomplishes the mission.

a. Target Division Method. Targets that exceed the firing capability of one battery should be sent to battalion FDC for additional fires. There are times, however, when the battery is forced to fire on targets that exceed its capability. When this occurs, the battery FDO may divide the target into several targets to distribute his fires effectively.

(1) Determining aimpoints for a linear target. Because the basic linear sheaf for a four-gun 155-mm platoon is 200 meters, a linear target must be segmented into 200-meter lengths. For a six-gun 155-mm platoon, the length is 300 meters; 8-inch six-gun platoon, 480 meters; and 105-mm four-gun platoon, 120 meters. The procedures for determining aimpoints for a linear target are shown in Table E-7.



RECORD OF FIRE

CALL FOR FIRE

Observer K43 [✓ AF]FFE/IS/S Tgt

Grid: 428 265

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

PLT DUG IN VT I/E

TGT ALT 1125
-PLT ALT 1062
VI +63 DRIFT L6
+GFT R7

∢ Si ÷ 10 10m Si

△ FS	0.11
100/R	21
/R	
20/R	4
HOB Corr	
Si	+14
El	315
QE	329

FIRE ORDER ④ TI I/E — Df Corr R1

INITIAL FIRE COMMANDS ✓FM — MF PLT ADJ #3 ① — Rg 4960 — Cht Df 3633

Sp Instr — Sh — Lot — Chg 4 — Fz — Ti — Df 3632

MTO H, TI I/E, ④, AB1074 — ∢T (420) — PE$_R$ (<38) — TF — ④ TI In Eff — Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (R1)	Df Fired	Chart Rg	HOB Corr	Si (+14)	El	QE	Exp	Type
3840	R30	+100					3641	R1	3640	5050		+14	322	336	②	Q ✓
TI		-50		FZ TI		18.9	3634	R1	3633	5020	+4	+18	320	338	①	
		ΔIS	FFE	PLT ④	+0.2	19.1			(3633)					338	⑰	TI ✓
R20	+30	Δ5	REC			(18.9)			(3632)	5030	-1	+17	321	(338)		
AS TGT			EOM	EOM	+0.2	(19.1)										
FINAL	QE	338					TRIAL TIME			REFINEMENT		HOB	CORR			
-TRUE	EL	324					+ TOT FS CORR									
TRUE	TOT SI	+14					REFINED TIME									
-	20/R	4														
TRUE	GRND SI	+10														

VI +45
+PLT ALT 1062
REPLOT ALT 1107

EST 20 CAS

GFT 1/A CHG 4 LOT AG RG4960 EL 315 TI 18.6
TOT DF CORR R1 GFT DF CORR R7

TI GAGE LINE

	EL	DRIFT
EL GAGE LINE	324	L7

	RG	100/R	20/R
MHL	5080	20	4

Btry 1/A — DTG 291645Z JUN 94 — Tgt AB1074 — Replot Grid 4269 2645 — Replot Alt 1107

DA Form 4504, OCT 78

Figure E-5. Record of Fire (Replot With Fuze Time).

Table E-7. Determining Aimpoints for Linear Target.

STEP	ACTION
1	Divide the length of the target by 200 to determine the number of aimpoints for a linear target. ● Six-gun 203-mm platoon, divide by 480. ● Eight-gun 155-mm platoon, divide by 400. ● Six-gun 155-mm, divide by 300. ● Four-gun 155-mm, divide by 200. ● Four-gun 105-mm, divide by 120.
2	Plot the target grid at the target center as described by the observer.
3	Align the target grid along the attitude announced by the observer. The target grid is now aligned to the target, and the pin now represents the center aimpoint.
4	Determine BP to center of target (COT) range and deflection.
5	Obtain drift at the BP to COT range, and determine site at the aimpoint.
6	Compute firing data by following the steps in Chapter 9. Determine TGPCs for the linear sheaf as described in Chapter 12.
7	Move the pin in 200-meter increments left and right until you have determined the necessary aimpoint data for the linear target. At each aimpoint, determine the range and deflection to the aimpoint.
8	Obtain drift at the range, and determine site at the aimpoint.
9	Compute firing data by following the steps in Chapter 9. Determine TGPCs for the linear sheaf as described in Chapter 12.
	NOTE: The HCO could also plot the target on the chart as described in the call for fire, and the FDO could determine how best to attack the target.

(2) **Determining aimpoints for a rectangular target.** Because the four-gun platoon optimum rectangular sheaf is a 100- by 100-meter sheaf, the target must be broken into 100- by 100-meter boxes to effectively engage a large rectangular target.

Table E-8. Determining Aimpoints for a Rectangular Target.

STEP	ACTION
1	Plot the target grid at the target center as described by the observer.
2	Align the target grid along the attitude announced by the observer. The target grid is now aligned to the target, and the pin now represents the center aimpoint.
3	Divide the rectangular target into 100- by 100-meter squares.
4	At the center of each 100- by 100-square, place a pin. This pin represents the center aimpoint of the particular target subdivision.
5	Determine BP-COT range, and determine site at the aimpoint.
6	Obtain drift at the BP-COT range, and determine site at the aimpoint.
7	Compute firing data as discussed in Chapter 9. Determine TGPCs for the rectangular sheaf as described in Chapter 12.
8	Move the RDP to each of the squares until you have determined the necessary aimpoint data for the rectangular target. At each aimpoint, determine the range and deflection to the aimpoint.
9	Obtain drift at the range, and determine site at the aimpoint.
10	Compute firing data as discussed in Chapter 9. Determine TGPCs for the linear sheaf as described in Chapter 12.
	NOTE: The HCO could also plot the target on the chart as described in the call for fire, and the FDO could determine how best to attack the target. If the target is very large, the FDO could decide to use a sweep, zone, or zone and sweep.

c. Determining Aimpoints for Subtargets. The battalion could receive a call for fire for a large target, or if a battery receives a call for fire and requests reinforcing fires, the battalion FDO must also be able to attack a large target. He uses the firing elements of his battalion to attack the large target, and must be able to determine aimpoints for each firing unit. The battalion FDO will normally divide large or irregularly shaped targets into subtargets for each firing unit. The appropriate subtargets are announced for each unit in the battalion fire order. The fire order should include the center grid and if necessary the attitude. The battalion FDO can also issue guidance in the fire order as to how the subtargets should be subdivided. To determine the aimpoints for the subtargets, the FDO can use the same techniques discussed in paragraphs a and b.

EXAMPLE

A target is submitted to the battalion FDC by division artillery. A map inspection indicates that the center battery can fire grid 617232, the leftmost battery fires grid 618234, the rightmost battery fires grid 615229. (See Figure E-6.)

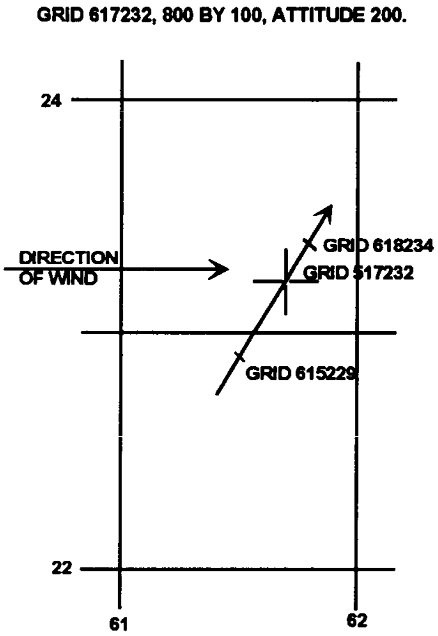


Figure E-6. Division of Target Into Two 200-Meter Lengths.

The linear target table may be used to divide linear targets into platoon subtargets. Table E-9 is for the 155-mm, 6-gun battery, but a table may be easily constructed for any caliber. The left column lists the target length, the center column lists the number of meters each battery must add or drop along the long axis of the target to determine the center grid for its subtarget, and the right column lists the interval between platoon targets.

Table E-9. Linear Target Table.

Tgt Length	+/-	Platoon Interval
1500	700	165
1400	650	150
1300	600	140
1200	550	130
1100	500	120
1000	450	110
950	425	100
900	400	100
850	375	90
800	350	85
750	325	80
700	300	75
650	275	70
600	250	65
550	225	55
500	200	50

The battalion FDC receives the following call for fire:

D26 THIS IS D12, FIRE FOR EFFECT, OVER.
GRID 938182, OVER.
INFANTRY COMPANY IN TREE LINE, LENGTH 800, ATTITUDE 1900, OVER.

The procedure for determining aimpoints for subtargets is shown in Table E-10.

Table E-10. Determining Aimpoints for Subtargets.

STEP	ACTION
1	The chart operator plots the target and orients the target grid along the attitude of the target.
2	All computers ensure that each battery monitors the call for fire or pass the call for fire to the battery.
3	Each battery chart operator also plots the target and orients the target grid.
4	The battalion FDO examines the plot and, on the basis of the attitude of the target with reference to the position of the firing batteries, determines that Battery A will attack the left portion of the target, Battery B the center of the target, and Battery C the right portion of the target.
5	On the basis of step 4, the FDO issues the fire order: **FIRE FOR EFFECT, BATTALION: ALPHA, LEFT PLATOON, DROP 350, INTERVAL ADD 85; BRAVO, CENTER, INTERVAL 85; CHARLIE, RIGHT PLATOON, ADD 350, INTERVAL DROP 85; ALTITUDE 370, 3 ROUNDS, TIME ON TARGET.**
6	The Battery A chart operator drops 350 meters along the attitude and announces the chart data for the left platoon. He then adds 85 meters and announces the data for the right platoon.
7	The Battery B chart operator announces the chart data to the announced grid for the center platoon, adds 85 meters, announces the data for the right platoon, drops 85 meters from the center of the target, and then announces the data for the left platoon.
8	The Battery C chart operator adds 350 meters along the attitude and announces the chart data for the right platoon. He then drops 85 meters and announces the data for the center platoon and drops another 85 meters and announces the data for the left platoon.

If the subtargets described above had required further subdivision (for example, sweep and zone), the battalion FDO could have designated how the batteries were to attack the target:

FIRE FOR EFFECT, BATTALION, ALPHA GRID 618234, BRAVO GRID 617232, CHARLIE GRID 615229, ALTITUDE 380, VT, EIGHT ROUNDS, SWEEP AND ZONE, TIME ON TARGET.

As an alternate method, the FDO could have said:

FIRE FOR EFFECT, BATTALION, ALPHA GRID 618234, BRAVO GRID 617232, CHARLIE GRID 615229, ALTITUDE 380, ATTITUDE 200, PLACE BURSTS 60 METERS APART, VT, EIGHT ROUNDS, TIME ON TARGET.

This indicates to each battery not only center grid, but also the type of sheaf they are to fire.

c. Massed Fire Distribution Template. In this method, the large or irregularly shaped target is plotted on the firing chart. A locally constructed massed fire distribution template drawn to scale for the firing chart is placed over the plotted target to allow the user to determine the optimum aimpoints for the required number of firing elements to mass fires.

(1) Constructing the Template. Overlay paper is the best material for constructing the template. Each tick mark placed on the template represents an aimpoint for a firing element (Figure E-6). A separate template is required for each caliber, munition type, and size of firing element (one gun, platoon, or battery). (Refer to the appropriate JMEM for this information.) Distance between tick marks is based on the radius of effects of the particular weapon system and munitions to be fired. (Refer to (C) FM 101-60-25.)

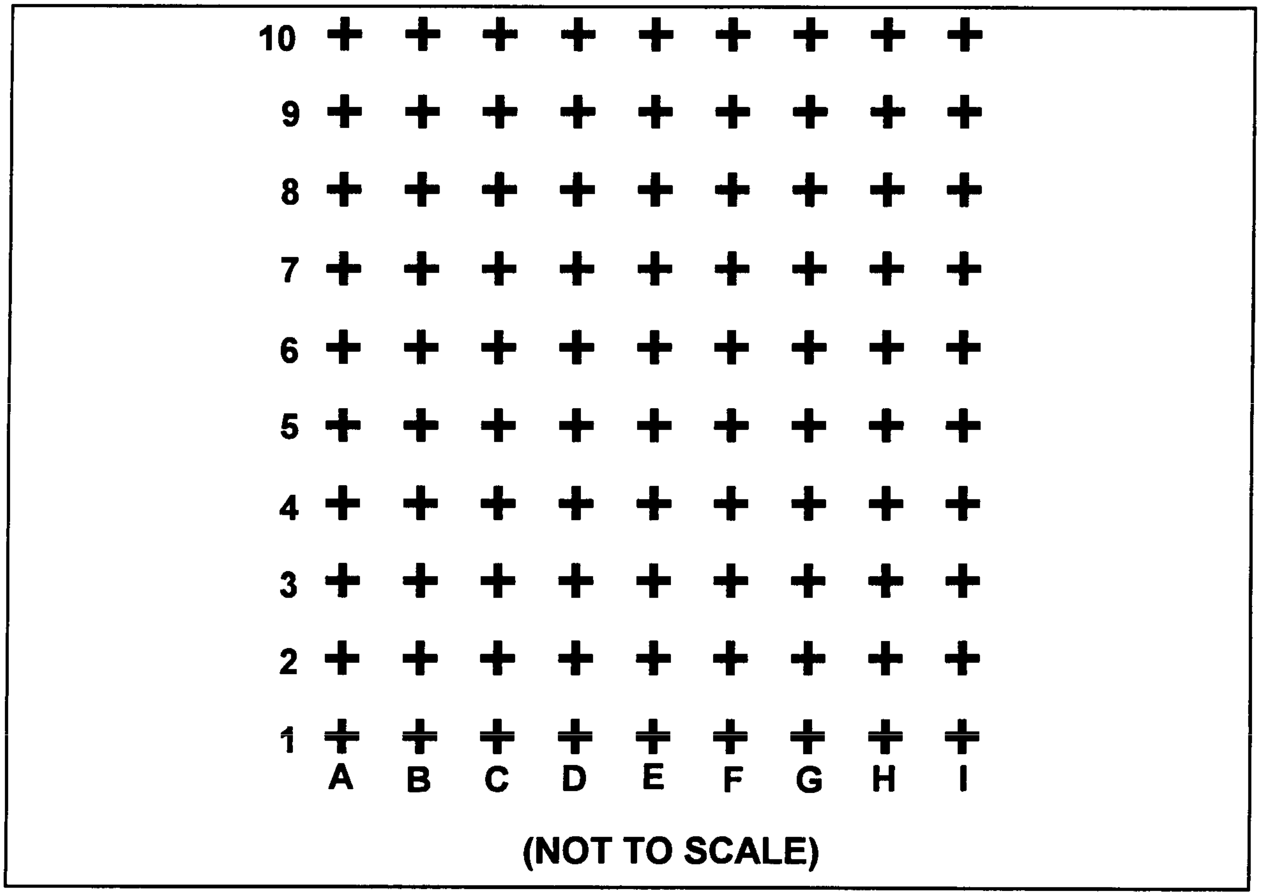


Figure E-6. HE Distribution Template.

(2) Using the Template. Table E-11 discusses how to use the template.

Table E-11. Using the Template.

STEP	ACTION
1	Place the center tick mark (E-5 in Figure E-6) over the center of the target or the nearest intersection.
2	Orient the template north-south on firing chart or east-west if necessary for better coverage of the target area.
3	Determine points within the target area to attack to achieve effective results.

Appendix F

AUTOMATED FDC

While the means of technical fire direction is different, the basic operation of an automated FDC is similar to that of a manual FDC.

F-1. Personnel

Duties of the FDO and chief fire direction specialist are the same as in a manual FDC. The equivalent USMC billet description is operations chief.

a. Senior Fire Direction Specialist. The senior fire direction specialist (computer) operates the computer that is the primary means of determining firing data. He is responsible for the transmission of fire commands (voice or digital) to the howitzer sections. The equivalent USMC billet description is operations assistant.

b. Fire Direction Specialist (USMC--Fire Control Man).

(1) Recorder. The recorder maintains the record of fire, recording information as directed by the FDO. The recorder may also be required to operate the computer that is the backup means of determining firing data.

(2) HCO and VCO. The HCO and VCO maintain a firing chart and follow each mission. The HCO and VCO check the coordinates on the firing chart and provide target altitude as required. The HCO and VCO maybe required to operate the backup computer as well.

F-2. Fire Order

The FDO considers the same factors when determining a fire order in an automated or manual FDC. The order in which the fire order is announced and the elements of the fire order are also the same. The biggest difference between the fire order for an automated FDC and for a manual FDC is the SOP. On the basis of the computer's ability to determine individual piece firing data and the computer programs, certain elements would be standardized differently.

a. Adjusting Element/Method of Fire of the Adjusting Element. On the basis of the computer's ability to compute firing data based on individual piece locations, muzzle velocities, and aimpoints, the use of base piece is not necessary (a base piece should be selected for ease of transition from automated to manual). Depending on the computer's programming, it may automatically select an adjusting piece in sequential order, or the operator may have to input an adjusting piece. Method of fire of the adjusting element would be included in the SOP, which may or may not be a programmed computer default.

b. Basis for Corrections. The SOP for this element should reflect the primary means of computing firing data.

c. Distribution. As in a manual FDC, the observer or FDO will announce the sheaf to fire. In a manual FDC, the normal sheaf is parallel. In an automated FDC, the normal or default sheaf will be the default sheaf programmed into the computer.

d. Ammunition Lot and Charge. The SOP for this element will allow the computer to select the lot and charge to fire on the basis of its programmed selection routines. Safety constraints, availability of registration corrections, and muzzle velocity information, are additional considerations when determining the SOP.

e. Target Number. The SOP for this element is normally the next available, as in manual gunnery. The computer may or may not be programmed to automatically assign a target number.

F-3. Fire Commands

Fire commands for automated gunnery are exactly the same as for manual gunnery. Depending on the computer systems in use, fire commands may be transmitted by voice or digitally.

F-4. Establish a Manual Backup for Automated Operations

a. Concept. The manual backup should be set up to allow the automated (BCS and BUCS primary) FDC to continue operations should the computers fail. Manual backup should be established as a form of "position improvement" and should not impede setup or processing with automated means. The manual backup also serves as a basis of rapidly "checking" the automated solution. The basis for the manual backup is that a piece will be designated as the base piece. The location of this piece is plotted on the firing chart. GFT settings are derived by using this piece and reflect its muzzle velocity and TGPCs. Once the FDC converts from automated to manual operations, all adjustments are conducted with the base piece. All ranges are measured from base piece to the center of the target and all data computed reflects base piece muzzle velocity and location. When the observer requests fire for effect, the adjusted data from base piece is converted to data for the **remaining pieces by applying special corrections, or terrain gun position corrections.** These corrections take into account the differences in piece locations (displacement) and the differences in shooting strength (comparative VEs). TGPCs can be determined by using automated means or the Ml 7 plotting board.

b. Establishment of the Manual Backup. The manual backup is established in five steps as follows:

- Select a base piece.
- Construct a surveyed firing chart.
- Determine and apply GFT settings.
- Determine comparative velocity errors for the remainder of the guns.
- Determine position constants.

Table F-1 elaborates on these steps.

Table F-1. Establishing Manual Backup.

STEP	ACTION
1	**SELECT A BASE PIECE.** For ease in the computation of special corrections, the base piece should be a gun close to the center of battery (COB). The piece nearest the center is determined by examining the computer COB and individual gun grid coordinates. Compare the COB grid with each gun grid, and select the gun whose grid is closest to the center of battery. This piece is the base piece, and its location is plotted on the firing chart.
2	**CONSTRUCT A SURVEYED FIRING CHART**. Using the grid determined in step 1, construct a surveyed firing chart. All observer locations, targets, fire support coordinating measures and other locations are plotted as directed by the situation. The procedures for the construction of a surveyed firing chart are in Chapter 6.
3	**DETERMINE AND APPLY GFT SETTINGS**. GFT settings are determined for the shell-charge combinations that the unit may be called upon to fire. A GFT setting can be derived by using automated means. To determine the GFT setting, use the steps in 3a through 3c.
3a	Enter the base piece grid and altitude into the database as an observer.
3b	Select a range near the center of the zone action. Preferably, this should be a met gauge point range from the appropriate GFT.
3c	Process a polar mission by using the azimuth of lay as the direction, the range from step b as the distance, and down 20 as the vertical shift. "Dry fire" shell HE and fuze time with the desired charge. Record the time, deflection, and quadrant. The time is the GFT setting time; the quadrant is the GFT setting elevation. The total deflection correction may be computed by the formula **DEFLECTION FIRED - COMMON DEFLECTION = TOTAL DEFLECTION CORRECTION. TOTAL DF - DRIFT ~ ADJ EL = GFT DF CORR.** **NOTE:** For additional information on the determination of GFT settings, see Chapter 10.
4	**DETERMINE POSITION CONSTANTS**. Position constants must be determined to allow continued accurate firing as weather changes and new met data becomes available. If a registration was conducted, a concurrent met solution is computed to determine position constants. If the five requirements for accurate predicted fire were met by using the computer, a concurrent met may be completed by using the range at which a GFT setting was computed in step 3 above. For detailed instructions on met techniques, see Chapter 11. The FDO must be careful to ensure that the met message used is concurrent with the firing data (GFT setting) used. In an automated FDC, a ballistic met message may not be available. Units should request transmission of a ballistic met to facilitate the ability to isolate position constants that can be used manually.

F-5. Convert a Mission in Progress From Automated to Manual Processing

a. General. Should automated means fail, a battery must continue to process fire missions. With a manual backup established, the FDC continues operations with minimal delay.

b. Procedure. If during the processing of a fire mission the computer fails, the mission is switched to manual processing. If the observer’s total corrections are applied to the firing chart, a significant difference in point of impact in the target area may be noticed because of the difference in automated accuracy. To make the transition as smooth as possible, the steps in Table F-2 are used.

Table F-2. Switching to Manual Processing.

STEP	ACTION
1	Alert the observer by voice communication of the change to manual computation. This should make him aware of a possible unexpected change in the location of the impact of the next round. Also he should be aware of the computational aspects of manual gunnery, especially the delay inherent in computation of special sheafs and the possibility of parallel sheaf fire for effect.
2	The VCO uses the GST to determine the site for the fire mission. The VI is determined by subtracting the altitude of the battery from the target altitude determined by the automated system. The range used to compute site is the COB range determined by the automated system.
3	The computer directs the HCO to polar plot the location of the aimpoint of the last correction. To determine the polar plot location, follow steps 3a through 3e.
3a	The computer subtracts the site from the last quadrant computed by the automated system to determine the last elevation computed.
3b	The computer places the elevation gauge line of the GFT over the elevation scale at the elevation determined in step 3a. The computer determines range from the range scale under the manufacturer's hairline. **This range is the polar plot range.**
3c	The computer determines the polar plot deflection by determining drift corresponding to the elevation in step 3b. This drift is added to the GFT deflection correction to determine the total deflection correction for this mission. The computer subtracts the total deflection correction determined from the last deflection computed by the automated system. **The difference is the polar plot deflection.**
3d	The computer announces **POLAR PLOT DEFLECTION** followed by the numerical value of the deflection computed in 3c. The HCO places the vertex of the RDP on the base piece location and orients the RDP to the deflection announced by the computer. The HCO then reads backs the deflection. The computer, on hearing the deflection read back correctly, announces **POLAR PLOT RANGE** followed by the range determined in step 3b. The HCO places a plotting pin in the chart along the arm of the RDP at the graduation representing the announced range. The HCO then reads back the range.
3e	The HCO places a target grid on the target and orients it to the OT direction.
4	The computer records the site computed in step 2 and the total deflection correction computed in step 3c on the record of fire for this mission. The computer determines 100/R at the COB-COT range.
	NOTE: The FDC is now ready to process the subsequent corrections. Subsequent corrections are computed in the manner described in Chapter 9 except that the adjusting piece is changed to the base piece.

F-6. Range K and Fuze K

a. The proportion of correction to range and fuze setting that results from a registration or the solution of a met message is referred to as range K or fuze K. Once determined, range K and fuze K may be used to apply the determined corrections at lesser or greater ranges than that at which the corrections are determined. This procedure allows the application of a "GFT setting" to a TFT.

b. Range K can be determined and applied by using two techniques. These techniques are discussed in Tables F-3 and F-4.

Table F-3. Determining Range K (Technique 1).

STEP	ACTION
1	Determine the range corresponding to the adjusted elevation (Table F of the TFT).
2	Subtract the chart range (range at which the registration corrections were determined) from the range corresponding to the adjusted elevation. The difference is the total range correction. **RANGE ~ ADJ EL - CHART RANGE = TOT RG CORR**
3	Divide the total range correction by the range at which the corrections were determined (expressed in thousands). The result is expressed to the nearest meter and is range K. **TOTAL RANGE CORRECTION ÷ (CHART RG ÷ 1000) = RG K** Once range K is determined, it can be applied to other missions to determine firing data.
4	Divide the chart range to the target by 1000. **CHART RANGE ÷ 1000 = RG IN THOUSANDS**
5	Multiply the result by the range K. This is the range correction. **RG IN THOUSANDS x RG K = RG CORR**
6	Add the range correction and the chart range to determine the corrected range. **CHART RANGE + RG CORR = CORR RG**
7	Enter Table F with the corrected range expressed to the nearest 10 meters. From Column 2, extract the elevation. From Column 3 (M564) or Column 7 (M582), extract the corresponding fuze setting. **This is NOT the fuze setting to fire.**

Table F-4. Determining Range K (Technique 2).

STEP	ACTION
1	Determine the range corresponding to the adjusted elevation.
2	Divide the range corresponding to the adjusted elevation by the chart range. This is expressed to the ten thousandth as range K. **RANGE ~ ADJ EL ÷ CHART RANGE = RANGE K** Once range K is determined, it can be applied to other missions to determine firing data.
3	To apply the range K determined, multiply the chart range to a target by the range K. The result is expressed to the nearest 10 meters and is the corrected range for entry into Table F of the TFT.
4	Enter Table F with the corrected range expressed to the nearest 10 meters. From Column 2, extract the elevation. From Column 3 (M564) or Column 7 (M582), extract the corresponding fuze setting. **This is NOT the fuze setting to fire.**

c. Fuze K can be determined and applied by using two techniques. These techniques are discussed in Tables F-5 and F-6.

Table F-5. Determining Fuze K (Technique 1).

STEP	ACTION
1	Enter Table F of the TFT with the adjusted elevation from the registration. Extract the fuze setting corresponding to the adjusted elevation (use Column 3 for the M564 fuze and Column 7 for the M582).
2	Subtract the fuze setting corresponding to the adjusted elevation from the adjusted fuze setting. The difference is the total fuze correction and can be used as a fuze K. **ADJUSTED FS - FS ~ ADJ EL = TOT FS CORR** **27.5 - 26.7 = +0.8** **NOTES:** **1.** If the registration was fired with a large vertical interval, complementary angle of site will affect the total fuze correction. In this case, the total fuze correction is determined as the difference between the adjusted fuze setting and the fuze setting corresponding to adjusted elevation plus CAS. As a general rule, a large vertical interval is defined as a VI exceeding 100 meters. However, be aware that CAS may have a pronounced effect at lesser VIs. **2.** The total fuze correction may be considered a constant that is applied to the fuze setting corresponding to the adjusted elevation in a fire mission. Once fuze K is determined, it can be applied to other missions to determine fuze settings to fire.
3	Determine the fuze setting corresponding to the adjusted elevation for the fire mission.
4	Determine the fuze setting to fire by applying the total fuze correction (step 2) to the fuze setting corresponding to the adjusted elevation (step 3).

Table F-6. Determining Fuze K (Technique 2).

STEP	ACTION
1	Enter Table F of the TFT with adjusted elevation from the registration. Extract the fuze setting corresponding to the adjusted elevation (use Column 3 for the M564 fuze and Column 7 for the M582).
2	Determine fuze K by dividing the adjusted fuze setting by the fuze setting corresponding to the adjusted elevation. **ADJ FS ÷ FS ~ ADJ EL = FUZE K** Once fuze K is determined, it can be applied to other missions to determine fuze settings to fire.
3	Determine the fuze setting corresponding to the adjusted elevation for the fire mission.
4	Determine the fuze setting to fire by multiplying the fuze setting corresponding to the adjusted elevation for the fire mission (step 3) by the fuze K (step 2). Express the result to the nearest 0.1 increment. **FS ~ ADJ EL x FZ K = FS TO FIRE**

Appendix G

DETERMINING DATA

The purpose of this appendix is to assist in determining data with a GFT.

G-1. Basic HE Data (155AM2HEMI07 GFT)

The procedures for using the 155AM2HEM107 GFT are discussed in Table G-1.

Table G-1. Determining Basic HE Data With the 155AM2HEM107 GFT.

TO DETERMINE	IS A FUNCTION OF	WITHOUT A GFT SETTING APPLIED	WITH A GFT SETTING APPLIED
DRIFT	ELEVATION	Place MHL over range; read up to drift scale.	Place MHL over range; determine elevation under EL gauge line; place MHL over that elevation; read up to the drift scale under MHL.
100/R	RANGE	Place MHL over range; read up to 100/R scale.	Place MHL over range; read up to 100/R scale under MHL.
ELEVATION	RANGE	Place MHL over range; read down to range scale.	Place MHL over range; determine elevation under EL gauge line.
M582 FUZE SETTING	ELEVATION	Place MHL over range; read down to M582 FS scale.	**When registered with M582 fuze:** Place MHL over range; determine M582 FS under TI gauge line. **With impact registration only, M582 not registered, or when M564 is the registered fuze:** Place the MHL over range; determine elevation under EL gauge line; place MHL over that elevation; read down to the M582 FS scale under MHL.
M564 FUZE SETTING	ELEVATION	Place MHL over range; read down to M564 FS scale.	**When registered with M564 fuze:** Place MHL over range; determine M564 FS under TI gauge line. **With impact registration only, M564 not registered, or when M582 is the registered fuze:** Place the MHL over range; determine elevation under EL gauge line; place MHL over that elevation; read down to the M564 FS scale under MHL.

Table G-1. Determining Basic HE Data With the 155AM2HEM107 GFT (Continued).

TO DETERMINE	IS A FUNCTION OF	WITHOUT A GFT SETTING APPLIED	WITH A GFT SETTING APPLIED
M732/M728 VARIABLE TIME FUZE SETTING	ELEVATION	Place MHL over range; read down to TF scale.	Place MHL over range; determine elevation under EL gauge line; place MHL over that elevation; read down to TF scale under MHL.
▲FS/▲10MHOB	FUZE SETTING	Place MHL over range, read down to ▲FS/▲10MHOB scale.	Place MHL over M582/M564 FS; read down to ▲FS/▲10MHOB scale under MHL.
TIME OF FLIGHT	ELEVATION	Place MHL over range; read down to TF scale.	Place MHL over range; determine elevation under EL gauge line; place MHL over that elevation; read down to the TF scale under MHL.

NOTES:

1. Determine **drift, 100/R, and elevation** to the nearest mil.
2. Determine **M582 and M564 FS** to the nearest 0.1 fuze setting increment.
3. Determine **VT FS** to the nearest 0.1 FS; then vanish the tenths (12.9 = 12.0).
4. Determine **▲FS/▲10MHOB** to the nearest listed value.
5. Determine **time of flight** to the nearest second.

G-2. Determine Firing Data From an HA GFT (GFT Setting Applied)

Table G-2 shows the procedures used to determine firing data from a high-angle GFT with the GFT setting applied.

Table G-2. Determine Firing Data by Using an HA GFT (GFT Setting Applied).

STEP	ACTION
1	Move the cursor of the GFT until the range gauge line is over the chart range announced by the HCO.
2	100/R is a function of range. Under the range gauge line, determine 100/R from the 100/R scale to the nearest mil.
3	Use the charge announced by the computer, and read all scales on the basis of this charge.
4	Elevation is a function of range. Under the MHL, determine elevation from the elevation scale to the nearest 1 mil.
5	Under the MHL, determine the 10-mil site factor from the 10-mil site factor scale to the nearest 0.1 mil.
6	Drift is a function of elevation. Under the MHL, determine drift from the drift scale to the nearest 1 mil.
7	TOF is a function of elevation. Under the MHL, determine TOF from the time of flight scale to the nearest tenth (0.1) of a second. Express the TOF determined to the nearest whole second.

G-3. DPICM Data (155AM2HEM107 GFT)

The procedures for using the 155AM2HEM107 GFT to determine DPICM data are discussed in Table G-3.

Table G-3. Determining DPICM Data With the 155AM2HEM107 GFT.

TO DETERMINE	PROCEDURE WITH AN HE GFT SETTING APPLIED TO THE 155AM2HEM107 GFT, DETERMINED FROM AN HE M107 REGISTRATION OR A MET + VE SOLUTION
DPICM TIME M577 FUZE ONLY	Place MHL over range; determine M582 FS under TI gauge line; place MHL over that M582 FS; read up to M483A1 FS M577 scale under the MHL.
DPICM DRIFT	Place MHL over range; determine M107 elevation under EL gauge line; compute HE GRAZE QE; place MHL over HE GRAZE QE; read up to the M483A1 DEFL CORR scale under the MHL.
DPICM QE	Place MHL over range; determine M107 elevation under EL gauge line; compute HE GRAZE QE; place MHL over HE GRAZE QE; read up to the M483A1 QE scale under the MHL.
NOTES: 1. The preferred method of determining data is with the GFT, but corrections to HE graze burst data may also be determined from the addendum FT 155-ADD-R-1. 2. **HOB corrections require the use of the addendum.** 3. Determine DPICM drift the first time the observer requests a DPICM projectile. a. For FFE missions, determine DPICM drift initially. b. For AF missions, determine DPICM drift when the observer requests a DPICM projectile, add the GFT df corr, and determine the total DPICM df corr.	

G-4. M825 Smoke Data (155AM2HEM 107/M825 GFT)

The procedures for using the 155AM2HEM107M4825 GFT to determine smoke data are discussed in Table G-4.

Table G-4. Determining M825 Smoke Data With 155AM2HEM107/M825 GFT.

TO DETERMINE	PROCEDURE WITH AN HE GFT SETTING APPLIED TO THE 155AM2HEM107/M825 GFT, DETERMINED FROM AN HE M107 REGISTRATION OR A MET + VE SOLUTION
M825 TIME M577 FUZE ONLY	Place MHL over range; determine M582 FS under TI gauge line; place MHL over that M582 FS; read up to M825 FS M577 scale under the MHL.
M825 DRIFT	Place MHL over range; determine M107 elevation under EL gauge line; compute HE graze QE; place MHL over HE graze QE, read up to the M825 DEFL CORR scale under the MHL.
M825 QE	Place MHL over range; determine M107 elevation under EL gauge line; compute HE graze QE; place MHL over HE graze QE; read up to the M825 QE scale under the MHL.
NOTES: 1. The preferred method of determining data is with the GFT, but corrections to HE graze burst data may also be determined from the addendum FT 155-ADD-T-0. 2. **HOB corrections require the use of the addendum.** 3. Determine M825 drift the first time the observer requests an M825 projectile. a. For FFE missions, determine M825 drift initially. b. For AF missions, determine M825 drift when the observer requests an M825 projectile, add GFT df corr, and determine the total M825 df corr.	

G-5. ADAM and RAAMS Data (155ANIM483A1 GFT)

The procedures for using the 155AN1M483A1 GFT to determine ADAM and RAAMS are discussed in Table G-5.

Table G-5. Determining ADAM and RAAMS Data With 155AN1M483A1 GFT.

PROJECTILE	TO DETERMINE	PROCEDURE WITH A DPICM GFT SETTING APPLIED TO THE 155AN1M483A1 GFT, DETERMINED FROM A DPICM (SR) M483A1 REGISTRATION OR A MET + VE SOLUTION
RAAMS M718-L M741-S	RAAMS TIME M577 FUZE ONLY	Place MHL over range; determine M483A1 M577 graze FS under TI gauge line; place MHL over that M577 graze FS; read up to RAAMS FS M577 scale under the MHL.
RAAMS	RAAMS DRIFT (Function of DPICM EL)	Place MHL over range; determine M483A1 graze elevation under EL gauge line; place MHL over that elevation; read up to M483A1 DEFL CORR/DRIFT scale under the MHL.
RAAMS	RAAMS QE	Place MHL over range; determine M483A1 graze elevation under EL gauge line; compute DPICM graze QE; place MHL over DPICM graze QE; read up to RAAMS QE scale under the MHL.
ADAM M692-L M731-S	ADAM TIME M577 FUZE ONLY	Place MHL over range; determine M483A1 M577 graze FS under TI gauge line; place MHL over that M577 graze FS; read up to ADAM FS M577 scale under the MHL.
ADAM	ADAM DRIFT (Function of DPICM EL)	Place MHL over range; determine M483A1 graze elevation under EL gauge line; place MHL over that elevation; read up to M483A1 DEFL CORR/DRIFT scale under the MHL.
ADAM	ADAM QE	Place MHL over range; determine M483A1 graze elevation under EL gauge line; compute DPICM graze QE; place MHL over DPICM graze QE; read up to ADAM QE scale under the MHL.

NOTES:

1. Base scales on AN-1 GFT are for DPICM graze burst data in the self-registration mode. The preferred method of determining data is with a GFT, but corrections to DPICM graze burst data can also be determined from the appropriate addendum. **HOB corrections require the use of an addendum.**
   - **a.** FT 155-ADD-J-1 to FT 155-AN-1: corrections to HE M483A1 for DPICM data.
   - **b.** FT 155-ADD-L-1 to FT 155-AN-1: corrections to HE M483A1 for ADAM data.
   - **c.** FT 155-ADD-N-1 to FT 155-AN-1: corrections to HE M483A1 for RAAMS data.
   - **d.** FT 155-ADD-Q-0 (Rev) to FT 155-AN-1: corrections to HE M483A1 for M825 data.
   - **e.** FT 155-ADD-Q-0 (Rev) Change 2 to FT 155-AN-1: corrections to HE M483A1 for M825A1 data.
2. All scales printed on AN-1 GFT are only valid for members of the DPICM projectile family.
3. Only one DEFL CORR/DRIFT scale. Drift is a function of DPICM elevation.
4. M483A1 QE scale is incorrectly labeled "EL."

G-6. Construct a GFT Setting From an HE Registration on an Illuminating GFT

Table G-6 shows the procedure for constructing a GFT setting from an HE registration on an illum GFT.

Table G-6. Construct GFT Setting on Illuminating GFT (HE Registration.

STEP	ACTION
1	Place the MHL over the HE adjusted elevation on the HE GFT.
2	Under the MHL, determine the HE range corresponding to the HE adjusted elevation from the range scale.
3	Place the MHL of the illum GFT over the adjusted HE range determined in step 2 above.
4	On the illum GFT, draw a 1-inch line parallel to the MHL at the chart range from the HE GFT setting. Label this line "RG."

G-7. Determine Firing Data From an Illuminating GFT (GFT Setting Applied)

Table G-7 shows the procedures for determining firing data from an illuminating GFT with a GFT setting applied.

Table G-7. Determine Firing Data by Using an Illum GFT (GFT Setting Applied).

STEP	ACTION
1	Place the range gauge line over the chart range announced by the HCO.
2	Determine 100/R from the 100/R scale to the nearest mil.
3	Under the MHL, determine elevation to impact (ETI) from the ETI scale to the nearest 1 mil.
4	Under the MHL, determine QE from the QE scale corresponding to the desired HOB to the nearest 1 mil.
5	Under the MHL, determine FS from the FS scale corresponding to the desired HOB to the nearest tenth (0.1).

G-8. Examples

a. Table G-8 shows the procedures for determining firing data from a low-angle HE GFT (GFT setting applied) for an HE adjust fire mission with fuze VT in effect. The GFT setting determined from the registration is:

GFT I/A: Chg 4, Lot AG, Rg 4960, El 315, Ti 18.6
Tot Df Corr RIGFT Df Corr R7

Apply the GFT setting to the appropriate GFT. The HCO announces the following chart data:

ONE ALPHA, RANGE 6220, DEFLECTION 3214.

The VCO announces **SITE -6.**

Table G-8. HE Adjust-Fire Mission With Fuze VT I/E.

STEP	ACTION
1	Place the MHL over range 6220.
2	Under the MHL, determine 100/R from the 100/R scale to the nearest mil **(16)**.
3	Under the EGL, determine elevation from the elevation scale to the nearest mil **(430)**.
4	Under the TGL, determine the time fuze setting for fuze M582 from the M582 scale to the nearest tenth **(24.8)**.
5	To determine drift, move the MHL over elevation 430 and read drift from the drift scale under the MHL to the nearest mil **(L9)**.
6	To determine the time fuze setting for M564, place the MHL over the elevation and read the time fuze setting from the M564 scale to the nearest tenth **(25.1)**.
7	To determine TOF, move the MHL over elevation 430 and read TOF from the TF/FS M582 scale to the nearest tenth of a second **(0.1)**. Express the TOF determined to the nearest whole second **(25.2 ≈ 25)**.
8	To determine the variable time fuze setting, place the MHL over elevation 430 and read TOF from the TF/FS M582 scale to the nearest tenth of a second **(0.1)**. Express the TOF to the lower whole second by vanishing the tenths of seconds and applying a .0 to determine the VT FS **(25.2 ≈ 25.0)**.
9	To determine ▲FS/▲10M HOB, place the MHL over the M582 FS determined in step 4 and read ▲FS/▲10M HOB from the ▲FS scale to the nearest hundredth **(0.09)**.
10	For immediate type missions, the deflection to fire is determined by applying the total deflection correction to the chart deflection **(3214 + R1 = 3213)**. For other low-angle missions, the deflection to fire is determined by applying the deflection correction (GFT deflection correction plus drift corresponding to the determined elevation) to the chart deflection **(3214 + L2 = 3216)**.
NOTE: Figure G-1 shows a completed ROF for an HE adjust-fire mission with fuze VT in effect. Firing data were determined by using a GFT setting.	

RECORD OF FIRE

CALL FOR FIRE [✓ AF] FFE/IS/S Tgt

Observer L21

Grid: 430 287

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

TROOPS DIGGING IN, VT I/E

TGT ALT 1030
- PLT ALT 1062
VI -32

DRIFT L9
+6FT R7

∡ Si ÷ 10	10m Si

△ FS	
100/R	16
/R	
20/R	
HOB Corr	3
Si	-6
El	430
QE	424
Ammo Exp	①

FIRE ORDER ④ I/E

Df Corr L2

INITIAL FIRE COMMANDS	FM ✓	MF PLT ADJ #3 ①		Rg 6220		Cht Df 3214
Sp Instr	Sh	Lot	Chg 4	Fz	Ti	Df 3216
MTO H, ④ I/E, AB1024	∡T (420)	PE_R (<38)	TF	④ VT	In Eff	

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L2)	Df Fired	Chart Rg	HOB Corr	Si (-6)	El	QE	Exp	Type
4420	L100	+100					3229	L2	3231	6310		-6	440	434	②	Q ✓
		-50	FFE	PLT ④ FZ VT		25.0	3231	L2	3233	6260		-6	435	429	⑯	VT ✓
			EOM	EOM												

GFT 1/A CHG 4 LOT AG RG 4960 EL 315 TI 18.6

TOT DF CORR R1 GFT DF CORR R7

Btry 1/A	DTG 231420Z JUN 94	Tgt AB1024	Replot Grid	Replot Alt

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Figure G-1. Completed ROF for HE AF Mission With Fuze VT I/E.

b. Table G-9 shows the procedures for determining firing data from a low-angle HE GFT (GFT setting applied) for an HE adjust-fire mission with shell DPICM in effect. The GFT setting determined from the registration is:

GFT I/A: Chg 4, Lot AG, Rg 4960, El 315, Ti 18.6
Tot Df Corr RI GFT Df Corr R7

Apply the GFT setting to the appropriate GFT. The HCO announces the following chart data:

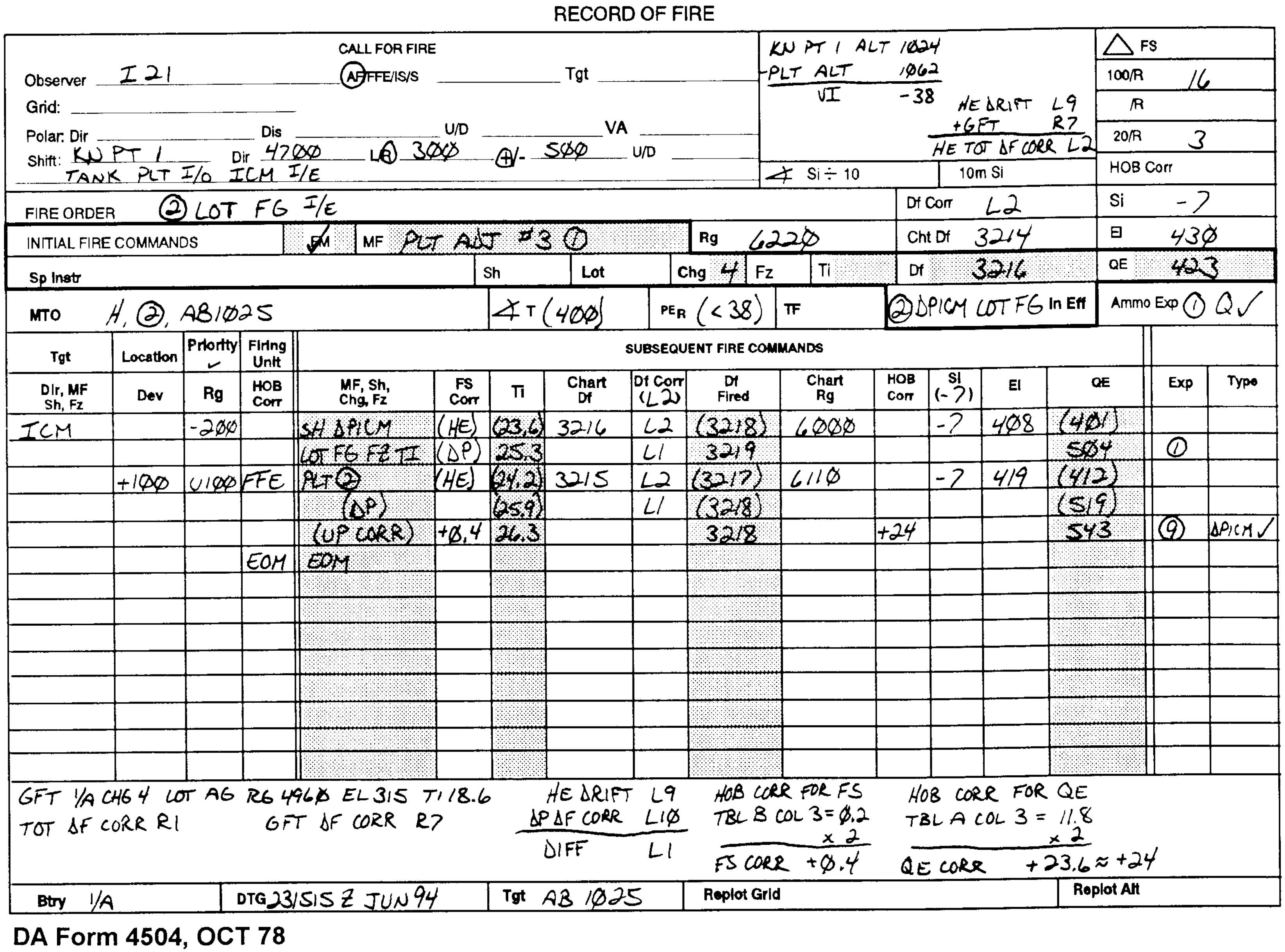
ONE ALPHA, RANGE 6220, DEFLECTION 3214.

The VCO announces **SITE -7.**

NOTE: The steps in Table G-9 are for determining DPICM firing data once the HE rounds have been adjusted. The steps for determining HE firing data are the same as shown earlier.

Table G-9. HE Adjust-Fire Mission With Shell DPICM I/E.

STEP	ACTION
1	Place the MHL over range 6000.
2	Under the EGL, determine HE elevation from the elevation scale to the nearest mil **(408)**.
3	Under the TGL, determine the time fuze setting for fuze M582 from the M582 scale to the nearest tenth **(23.6)**.
4	Determine the HE QE by applying the site (-7) to the HE elevation (408)**(408 + -7 = 401)**.
	NOTE: For DPICM, use the black scales labeled "DPICM M483A1."
5	Place the MHL over the M582 fuze setting **(23.6)**.
6	Under the MHL, determine the DPICM fuze setting from the FS M577 scale **(25.3)**.
7	Place the MHL over the HE QE **(401)**.
8	Under the MHL, determine the DPICM deflection correction from the DEFL CORR scale **(L10)**. Determine the difference between the HE drift and the DPICM deflection correction. **DPICM DEFLECTION CORRECTION L10** **HE DRIFT L 9** **DIFFERENCE IN DEFLECTION CORRECTION L 1** Apply the computed difference in deflection correction to the HE deflection to fire to determine the DPICM deflection to fire. **HE DEFLECTION TO FIRE 3218** **DIFFERENCE IN DEFLECTION CORRECTION L 1** **DPICM DEFLECTION TO FIRE 3219**
9	Under the MHL, determine the DPICM QE from the QE scale **(504)**.
NOTE: Figure G-2 shows a completed ROF for an HE adjust-fire mission with shell DPICM in effect. Firing data were determined by using a GFT setting.	



RECORD OF FIRE

CALL FOR FIRE

Observer I21 [✓ AF]/FFE/IS/S Tgt

Grid:

Polar: Dir Dis U/D VA

Shift: KN PT 1 Dir 4700 L/[✓ R] 300 [✓ +]/- 500 U/D

TANK PLT I/O ICM I/E

KN PT 1 ALT 1024
-PLT ALT 1062
VI -38

HE DRIFT L9
+GFT R7
HE TOT DF CORR L2

∡ Si ÷ 10 | 10m Si

△ FS	
100/R	16
/R	
20/R	3
HOB Corr	
Si	-7
El	430
QE	423
Ammo Exp	① Q ✓

FIRE ORDER ② LOT FG I/E

INITIAL FIRE COMMANDS [✓ FM] MF PLT ADJ #3 ① Rg 6220

Df Corr L2

Cht Df 3214

Sp Instr | Sh | Lot | Chg 4 | Fz | Ti | Df 3216

MTO H, ②, AB1025 | ∡ T (400) | PE_R (< 38) | TF | ② DPICM LOT FG In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L2)	Df Fired	Chart Rg	HOB Corr	Si (-7)	El	QE	Exp	Type
ICM		-200		SH DPICM	(HE)	(23.6)	3216	L2	(3218)	6000		-7	408	(401)		
				LOT FG FZ TI	(DP)	25.3		L1	3219					504	①	
	+100	U100	FFE	PLT ②	(HE)	(24.2)	3215	L2	(3217)	6110		-7	419	(412)		
				(DP)		(25.9)		L1	(3218)					(519)		
				(UP CORR)	+0.4	26.3			3218		+24			543	⑨	DPICM ✓
			EOM	EOM												

GFT 1/A CHG 4 LOT AG RG 4960 EL 315 TI 18.6
TOT DF CORR R1 GFT DF CORR R7

HE DRIFT L9
DP DF CORR L10
DIFF L1

HOB CORR FOR FS
TBL B COL 3 = 0.2
x 2
FS CORR +0.4

HOB CORR FOR QE
TBL A COL 3 = 11.8
x 2
QE CORR +23.6 ≈ +24

Btry 1/A | DTG 231515Z JUN 94 | Tgt AB 1025 | Replot Grid | Replot Alt

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Figure G-2. Completed ROF for an AF Mission With Shell DPICM I/E.

c. Table G-10 shows the procedures for determining firing data from a high-angle GFT (GFT setting applied). The GFT setting determined from the registration is:

GFT I/A: Chg 3, Lot AG, Rg 4960, El 1114
Tot Df Corr L34 GFT Df Corr R18

Apply the GFT setting to the appropriate GFT. The HCO announces the following chart data:

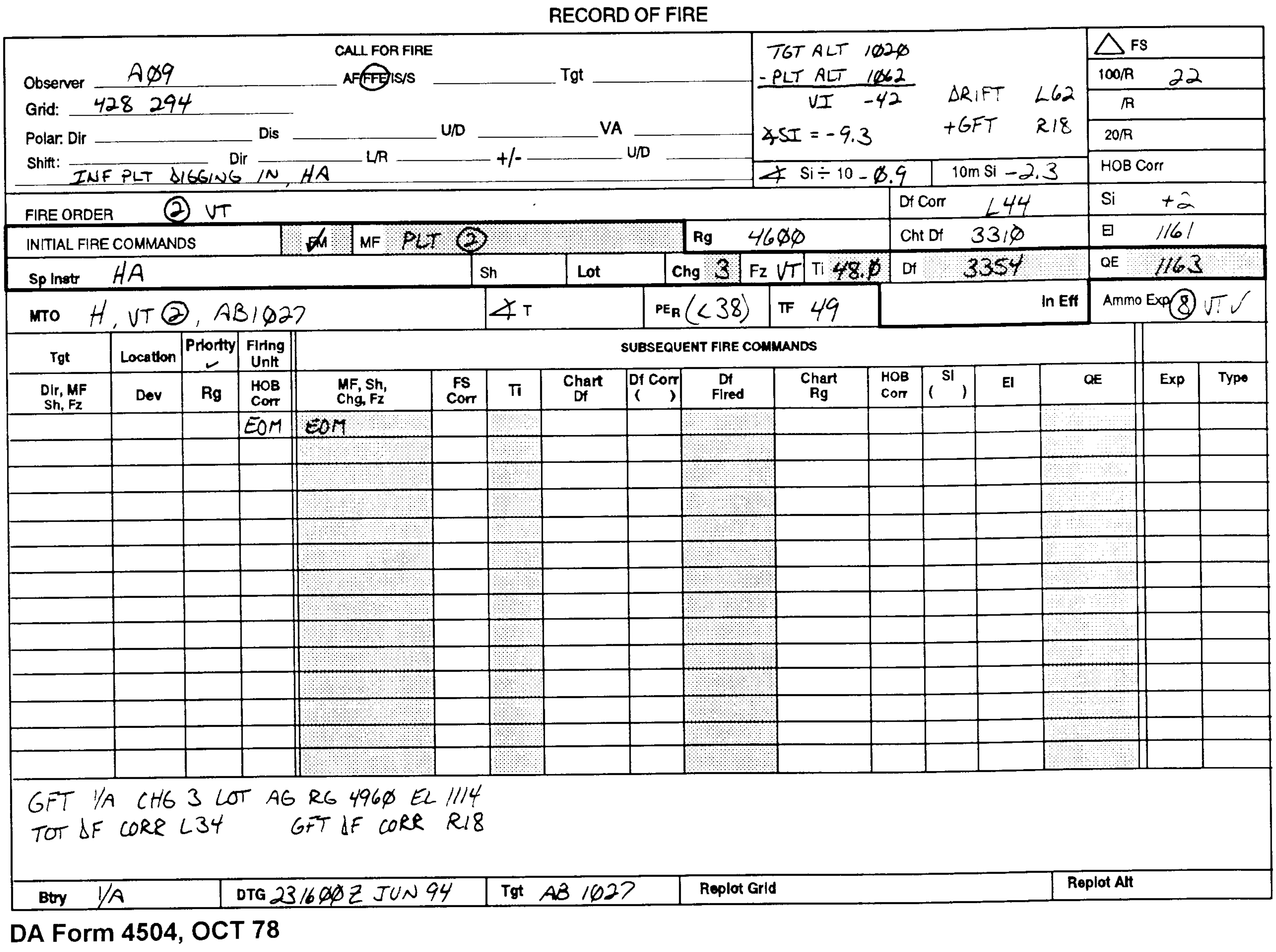
ONE ALPHA, RANGE 4600, DEFLECTION 3310.

The VCO announces **ANGLE OF SITE -9.**

Table G-10. Steps for Determining Firing Data From a High-Angle GFT (GFT Setting Applied).

STEP	ACTION
1	Move the cursor of the GFT until the **range gauge line** is over range 4600.
2	Under the RGL, determine 100/R from the 100/R scale to the nearest mil **(22)**.
3	Use the charge announced by the computer, and read all scales on the basis of this charge **(charge 3)**.
4	Under the MHL, determine elevation from the elevation scale to the nearest 1 mil **(1161)**.
5	Under the MHL, determine the 10-mil site factor from the 10-mil site factor scale to the nearest 0.1 mil **(2.3)**.
6	Under the MHL, determine drift from the drift scale to the nearest 1 mil **(L62)**.
7	Under the MHL, determine TOF from the time of flight scale to the nearest tenth of a second (0.1). Express the TOF determined to the nearest whole second **(48.8 ≈ 49)**.
7a	TOF is announced to the observer to the nearest whole second **(49)**.
7b	Fuze setting for fuze VT is determined by vanishing the tenths from the TOF and applying a .0 **(48.8 ≈ 48.0)**.
8	For immediate suppression type missions, the deflection to fire is determined by applying the total deflection correction to the chart deflection **(3310 + L34 = 3344)**. For other high-angle missions, the deflection to fire is determined by applying the deflection correction (GFT deflection correction plus drift corresponding to the determined elevation) to the chart deflection **(3310 + L44 = 3354)**.
NOTE: During high-angle fire missions, drift is determined for each correction and applied to the GFT deflection correction to determine a new deflection correction, which will be used to determine the deflection to fire.	

NOTE: Figure G-3 shows a completed ROF for an HE high-angle FFE mission with fuze VT in effect. Firing data were determined by using a GFT setting.



RECORD OF FIRE

CALL FOR FIRE

Observer A09 AF [✓ FFE] IS/S Tgt
Grid: 428 294
Polar: Dir Dis U/D VA
Shift: Dir L/R +/- U/D
INF PLT DIGGING IN, HA

TGT ALT 1020
- PLT ALT 1062
VI -42
∡SI = -9.3
DRIFT L62
+GFT R18
∡ Si ÷ 10 - 0.9
10m Si -2.3

△ FS
100/R 22
/R
20/R
HOB Corr
Si +2
El 1161
QE 1163
Ammo Exp ⑧ VT ✓

FIRE ORDER ② VT

INITIAL FIRE COMMANDS [✓ FM] MF PLT ②
Rg 4600
Df Corr L44
Cht Df 3310
Df 3354
Sp Instr HA
Sh
Lot
Chg 3
Fz VT
Ti 48.0

MTO H, VT ②, AB1027
∡T
PER (<38)
TF 49
In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
			EOM	EOM												

GFT 1/A CHG 3 LOT AG RG 4960 EL 1114
TOT DF CORR L34 GFT DF CORR R18

Btry 1/A
DTG 231600Z JUN 94
Tgt AB 1027
Replot Grid
Replot Alt

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Figure G-3. Completed ROF for an HE High-Angle FFE Mission With Fuze VT I/E.

d. Table G-11 shows the procedures for constructing a GFT setting on an illum GFT (HE registration). The GFT setting determined from the registration is:

GFT I/A: Chg 7, LOT AW, Rg 12100, El 472, Ti 38.8
Tot Df Corr LO GFT Df Corr L14

Apply the GFT setting to the appropriate illum GFT.

Table G-11. Steps for Constructing a GFT Setting on an Illum GFT (HE Registration).

STEP	ACTION
1	Place the MHL over elevation **472** on the HE GFT.
2	Determine the HE range corresponding to elevation 472 from the range scale on the HE GFT **(12390)**.
3	Place the MHL of the illum GFT on range **12390**.
4	On the illum GFT, draw a 1-inch line parallel to the MHL at range **12100**. Label this line "RG."

e. Table G-12 shows the procedure for determining firing data from an illum GFT with a GFT setting applied. Use the GFT setting shown in paragraph d to determine firing data.

The HCO announces the following chart data:

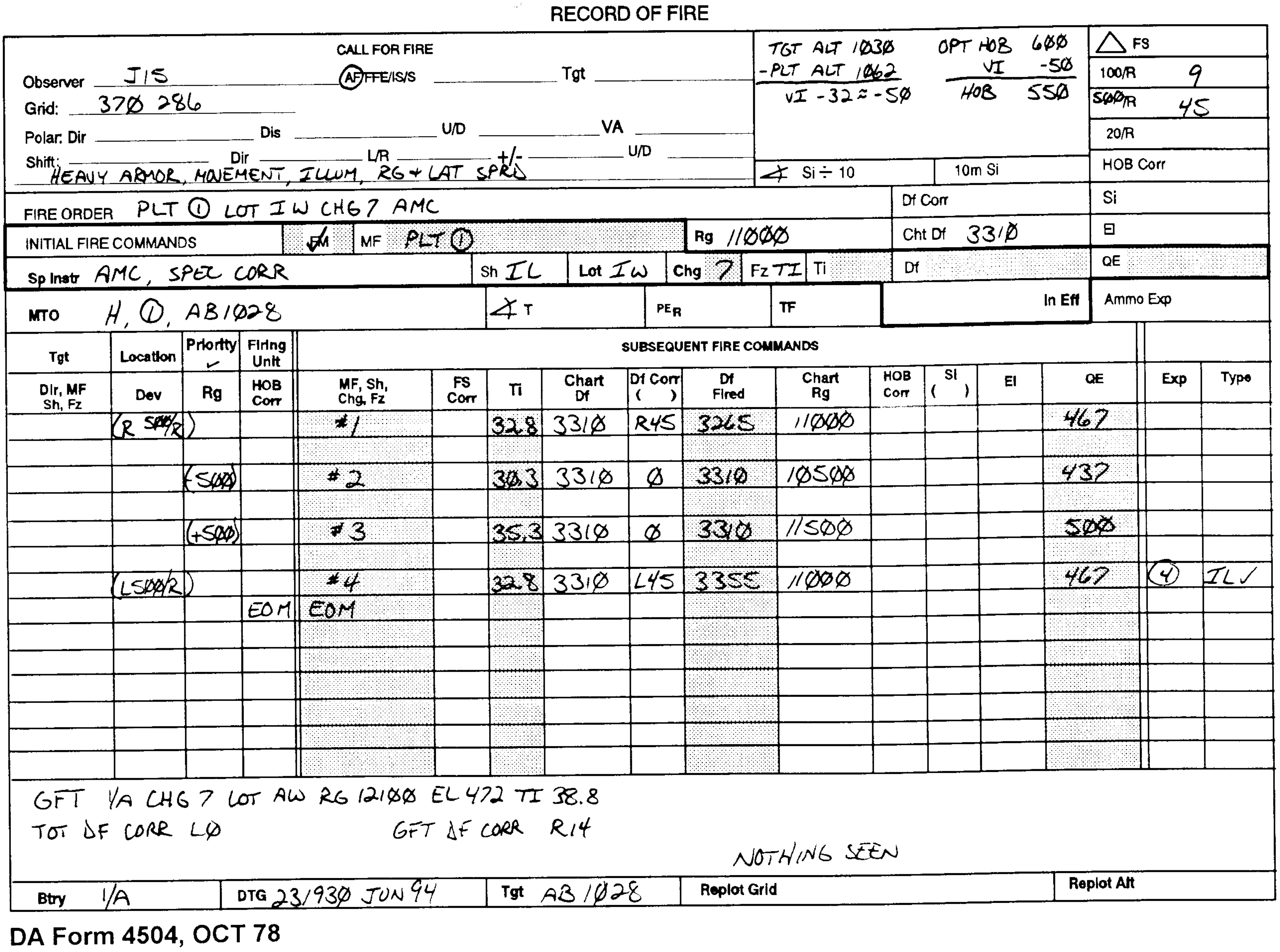
ONE ALPHA, RANGE 11000, DEFLECTION 3310.

NOTE: Use the 550 HOB scale to determine firing data.

Table G-12. Steps for Determining Firing Data From Illum GFT (GFT Setting Applied).

STEP	ACTION
1	Place the range gauge line over range 11000.
2	Under the RGL, determine 100/R from the 100/R scale to the nearest mil **(9)**.
3	Under the MHL, determine elevation to impact from the ETI scale to the nearest 1 mil **(392)**.
4	Under the MHL, determine QE from the QE scale corresponding to HOB 550 to the nearest 1 mil **(467)**.
5	Determine FS under the MHL from the FS scale corresponding to HOB 550 to the nearest tenth **(32.8)**.
	NOTE: Steps 1 through 4 are for a one- or two-gun illumination. If firing a range spread, individual firing data would be determined for the howitzers firing the range spread.
6	Unless you are firing a lateral spread, the deflection to fire is the announced chart deflection. If firing a lateral spread, determine and apply 500/R only to the chart deflection for the howitzers firing the lateral spread.

NOTE: Figure G-4 shows a completed ROF for an illum range and lateral spread fire mission. Firing data were determined by using a GFT setting.



RECORD OF FIRE

CALL FOR FIRE

Observer J15 [✓ AF]/FFE/IS/S Tgt

Grid: 370 286

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

HEAVY ARMOR, MOVEMENT, ILLUM, RG + LAT SPRD

TGT ALT 1030
-PLT ALT 1062
VI -32 ≈ -50

OPT HOB 600
VI -50
HOB 550

∆ FS

100/R 9

500/R 45

20/R

HOB Corr

∢ Si ÷ 10

10m Si

Si

El

QE

FIRE ORDER PLT ① LOT IW CHG7 AMC

Df Corr

INITIAL FIRE COMMANDS ☑ FM MF PLT ① Rg 11000 Cht Df 3310

Sp Instr AMC, SPEC CORR Sh IL Lot IW Chg 7 Fz TI Ti Df

MTO H, ①, AB1028 ∢ T PE_R TF In Eff Ammo Exp

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS											Ammo Exp	
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
	(R 500/R)			#1		32.8	3310	R45	3265	11000				467		
		(-500)		#2		30.3	3310	0	3310	10500				437		
		(+500)		#3		35.3	3310	0	3310	11500				500		
	(L500/R)			#4		32.8	3310	L45	3355	11000				467	④	IL ✓
			EOM	EOM												

GFT 1/A CHG 7 LOT AW RG 12100 EL 472 TI 38.8

TOT DF CORR L0 GFT DF CORR R14

NOTHING SEEN

Btry 1/A DTG 231930 JUN 94 Tgt AB1028 Replot Grid Replot Alt

DA Form 4504, OCT 78

Figure G-4. Completed ROF for Illum Range and Lateral Spread Fire Mission.

Appendix H

SPECIAL SITUATIONS

This appendix is a supplement to Chapter 13, which details the more common "special situations" missions.

H-1. Final Protective Fires

A final protective fire is an immediately available prearranged barrier of fire designed to protect friendly troops and installations by impeding enemy movements across defensive lines or areas. The normal use of an FPF is to establish prearranged close-in defensive fires, which include other artillery fires, minefield, obstacles, final protective machine gun lines and small-arms fire, and final protective fire of mortars. Each battery is assigned one FPF and normally is laid on that FPF when not firing other missions. The FPF may be fired on prearranged signal or on call from the supported unit. The firing of an FPF maybe repeated on call as often as necessary. When time and ammunition permit, the FPF can be adjusted or check rounds fired. A battery FPF may be fired either individually or in coordination with those of other batteries.

a. Width of FPF. The width (or length) of the FPF that can be covered by a single battery without shifting its fire should not exceed the width of an open sheaf for the battery concerned. When necessary, the width (length) of the FPF may be increased by agreement between the commanders of the artillery and the supported unit. However, the effectiveness of fire will be decreased.

b. Preparation of Data. The actual map location of the FPF is reported by the supported unit through the various fire support channels. The FPF is assigned to an artillery unit, which is responsible for computing the firing data. Since the FPF usually is located within a very short distance of positions occupied by friendly troops, precise computational procedures must be employed and all available corrections must be applied. Special corrections in the form of calibration corrections and position corrections, obtained by use of the M17 plotting board, are determined and applied as individual piece corrections. When the axis of the FPF is other than perpendicular to the direction of fire, additional computations must be made to bring each burst to a desired point on the FPF line.

c. Call for Fire. The call for fire for final protective fires is as outlined in FM 6-30, Chapter 7.

H-2. Computational Procedures

There are two techniques for determining FPF data: observer-adjusted FPF and nonadjusted FPF. Both techniques will result in the determination of firing data that are announced to the howitzers and that are used to lay the howitzers when they are not involved in other fire missions.

b. Observer Adjusted FPF. The observer will adjust the burst of each round to its desired location on the FPF sheaf. He starts with the flank round that impacts to the location of the desired sheaf and continues the adjustment until all howitzers have been adjusted. (See Table H-1.)

Table H-1. Computational Procedure for Observer-Adjusted FPF.

STEP	ACTION
1	A battery one volley at 5-second internals is fired initially to the center range and deflection with TGPC applied. This allows the observer to determine the flank piece and begin adjustment. Data fired are to the initial grid sent by the observer.
2	The observer selects the flank piece closest to the desired FPF line and using appropriate (danger close, if necessary) adjustment procedures, the observer adjusts the weapon onto the FPF line. Once the first gun is adjusted, the observer sends to the next weapon **NUMBER (such-and-such), REPEAT.**
3	Initial firing data for the second weapon are the adjusted firing data from the first weapon. The observer then adjusts the second weapon onto the FPF line. The initial firing data for each succeeding piece are the adjusted firing data from the previous piece. This procedure continues until all weapons are adjusted.
4	End of mission is announced to the howitzers.
5	The adjusted FPF data are announced to the howitzers, and the howitzers are laid on these data when not involved in other missions.
	NOTE: The TGPC in effect at the time the FPF was adjusted must be set off on the howitzers each time they are laid on the adjusted FPF data.

c. Nonadjusted FPF. When the situation does not permit the adjustment of each burst to its location on the FPF sheaf, the FDC determines firing data by using standard FFE techniques, In the call for fire, the observer should include the altitude of FPF and the length, if different from that of an open sheaf. The FDC will compute special corrections with the M17 for a linear sheaf and determine the FPF firing data. The FPF firing data will be announced to the howitzers and, as in observer adjusted FPFs, the howitzers will lay on the FPF data when not involved in other fire missions.

H-3. Laser Adjust Missions

a. An observer equipped with a laser can determine accurate target locations if the laser is accurately located. If the observer has directional control and his accurate location has been recorded at the FDC, he should request first-round fire for effect. If the observer does not feel he can achieve first-round fire for effect on the target, he should request an adjust-fire mission, The FDO may also decide to fire an adjustment if the FDC cannot account for some of the requirements for accurate fire. This may occur even if the observer requests first-round fire for effect.

b. Most laser missions, if not fire for effect initially, should require only one adjusting round. Fire for effect should be requested by the observer unless he determines the lasing of the burst is not satisfactory. Many variables could cause an unsatisfactory lase. For example, an observed burst partially obscured by trees or intermediate hill mass would yield inaccurate land distance to the burst. The **total deviation** between the target and the adjusting burst does not generally determine if fire for effect is requested. Rather, the observer need only determine if an accurate lase to the burst has been obtained.

c. The observer uses the polar method of target location to determine the target location. He transmits the target location in his call for fire. (See Figure H-1.)

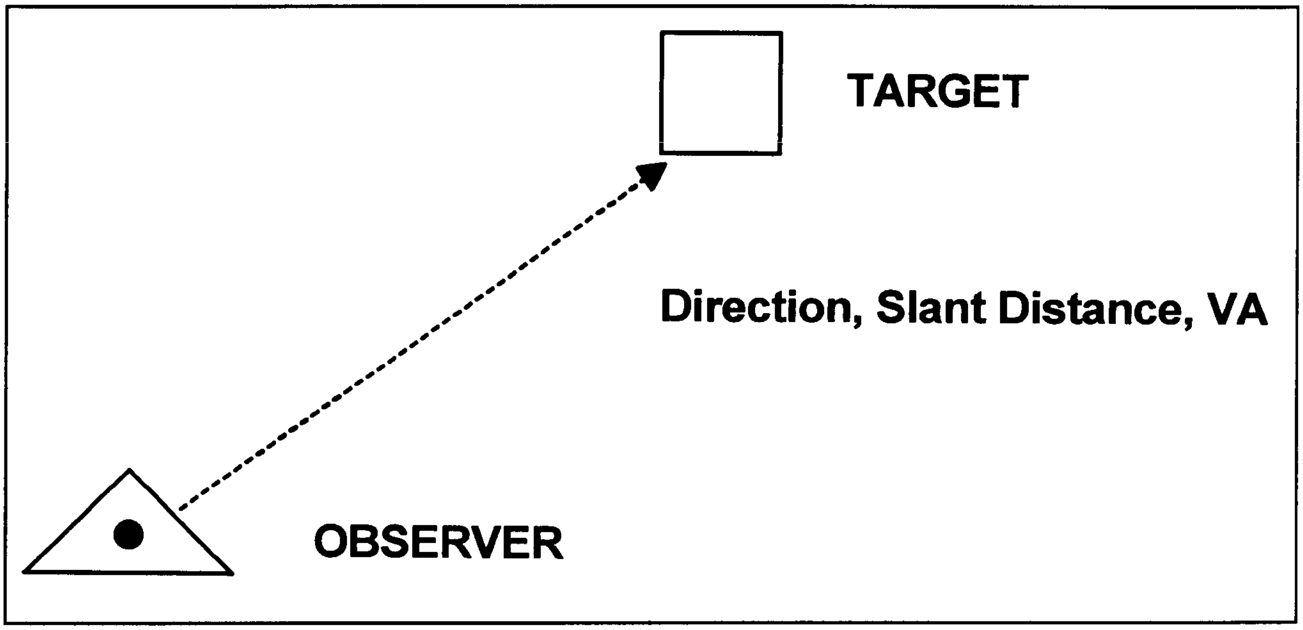


Figure H-1. Laser Polar Target Location.

d. The adjusting round is fired and the observer reports the direction, slant distance, and VA to the burst. (See Figure H-2.)

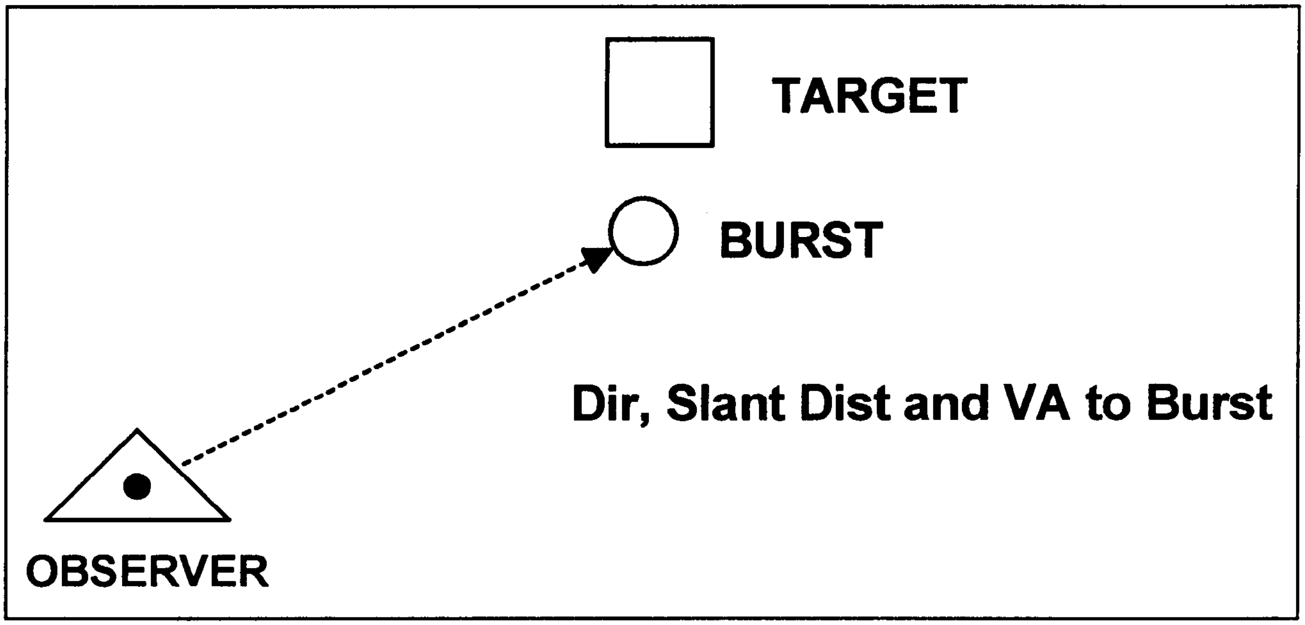


Figure H-2. Lase of Burst.

e. The FDC determines the fire for effect aimpoint from the total corrections necessary to engage the target. (See Figures H-3 and H-4 on page H-4.)

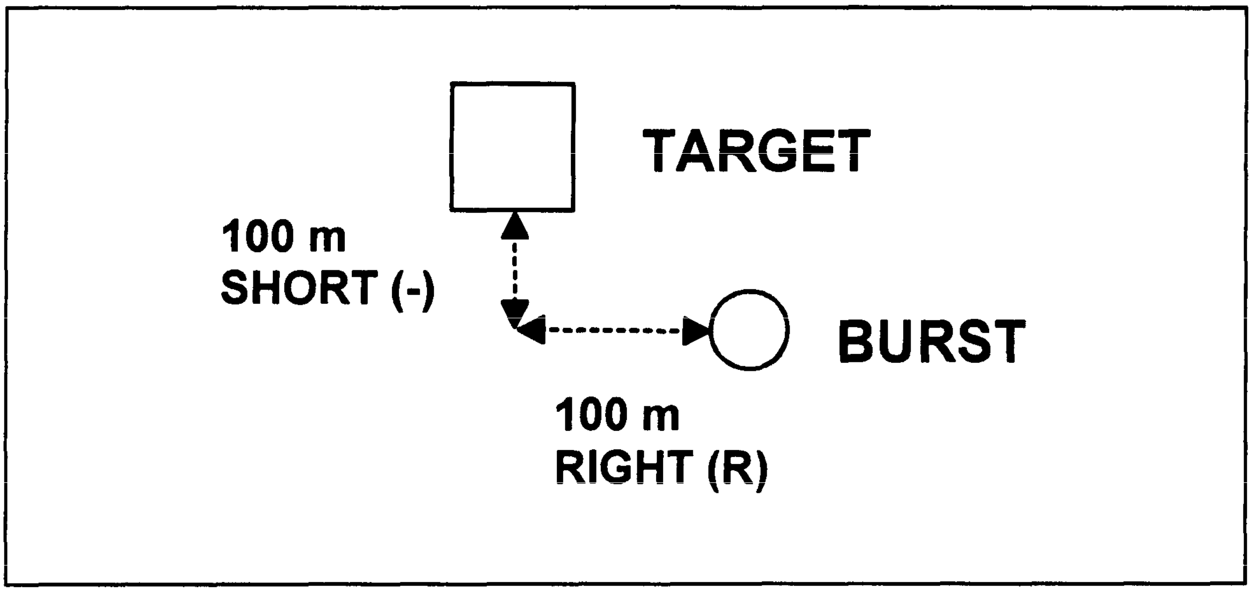


Figure H-3. Burst Spotting.

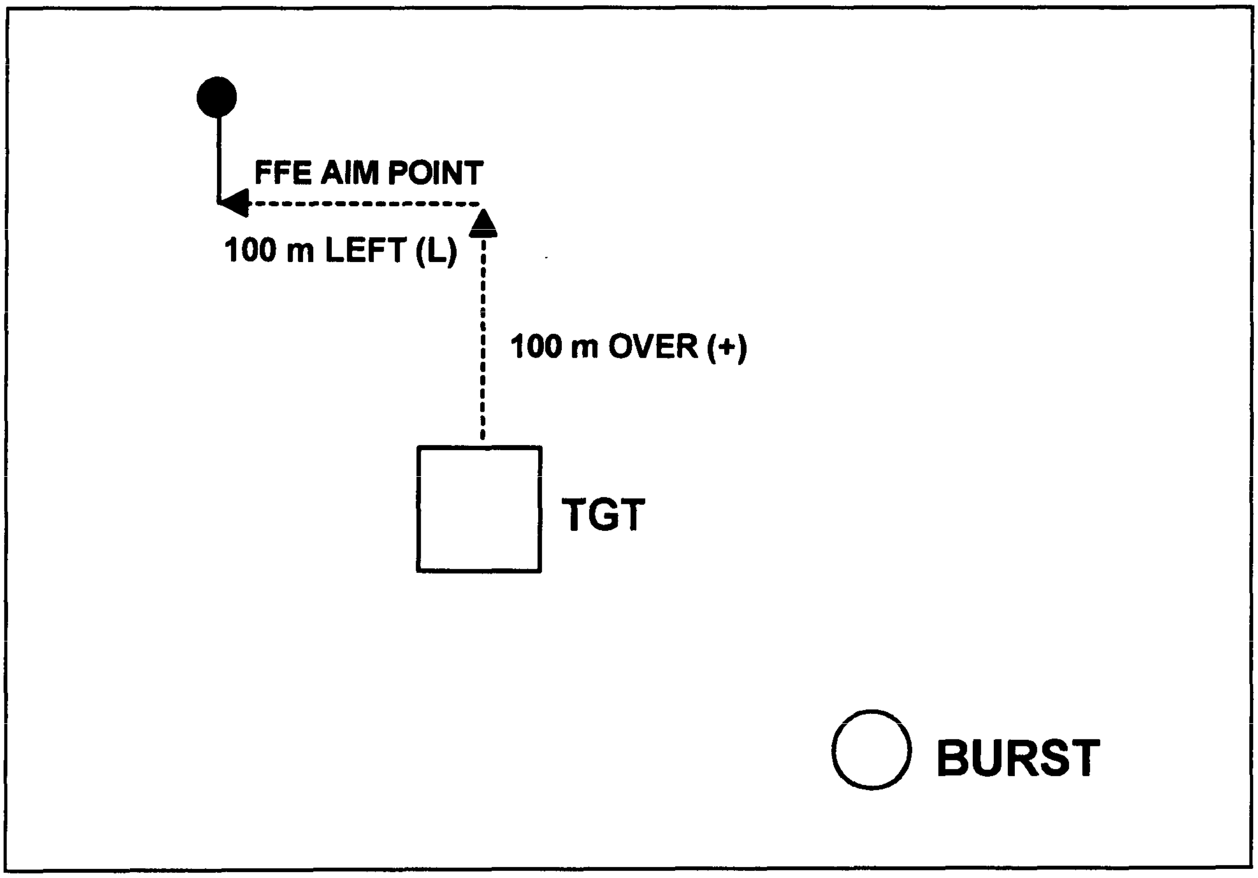


Figure H-4. FFE Aimpoint.

f. If additional adjustment is required, continue to plot the burst locations and compare each to the initial target location. Apply each correction determined to the previous aimpoint location **not** the initial target location.

g. The M17 plotting board may also be used to determine corrections (see Chapter 12).

H-4. Laser Adjust-Fire Mission

Table H-2 shows the procedures for a laser adjust-fire mission.

Table H-2. Procedures for Laser Adjust-Fire Mission.

STEP	ACTION
1	The HCO plots the target location from the observer's location by using the direction and slant distance received in the fire request. (Direction will be received to the nearest 1 mil; slant distance, nearest 10 meters.)
2	The HCO determines and announces the initial chart data.
3	The VCO converts the VA received in the fire request into a vertical interval.
4	The VCO determines the target altitude by applying the VI (step 3) to the altitude and determines and announces site.
5	The computer determines the initial fire commands in compliance with the fire order.
6	The HCO positions the target grid over the initial target location.
7	The HCO orients the target grid by using the initial OT direction.
	NOTE: After the observer spots and lases the initial round, he will transmit the burst direction distance and VA to the FDC.
8	The HCO plots the burst location by using the direction and slant distance as received from the observer.
9	The HCO determines the difference between the initial target location (step 1) and the burst location (step 7) to the nearest 10 meters LEFT (L)/RIGHT (R) and OVER (+)/SHORT (-).
10	The HCO places a pin in the **opposite** direction and magnitude (from the initial target location) of the burst. (LEFT [L] spotting becomes a RIGHT [R] correction, over [+] spotting becomes a drop [-] correction.) This is the FFE aimpoint. (See Figure H-5 on page H-6.)
11	The HCO determines chart data to the FFE aimpoint (step 10).
12	The VCO converts the burst VA to a burst vertical interval.
13	The VCO determines the burst altitude by applying the burst VI (step 12) to the observer's altitude.
14	The VCO determines the vertical correction by subtracting the initial target altitude (step 4) from the burst altitude (step 12).
15	The VCO applies the vertical correction to the VI (step 3) and uses this value to recompute and announce site.
16	The computer determines corrections for the adjustment of fuze time by using standard procedures.
17	The computer determines FFE fire commands in compliance with the fire order.

H-5. Radar Adjust-Fire Missions

a. The AN/TPQ-36 and -37 radars are used as counterbattery radars. They have survey capability, which allows them to determine accurate locations of enemy firing bursts. If used in the friendly mode, the radars are capable of determining burst locations of rounds fired by friendly units.

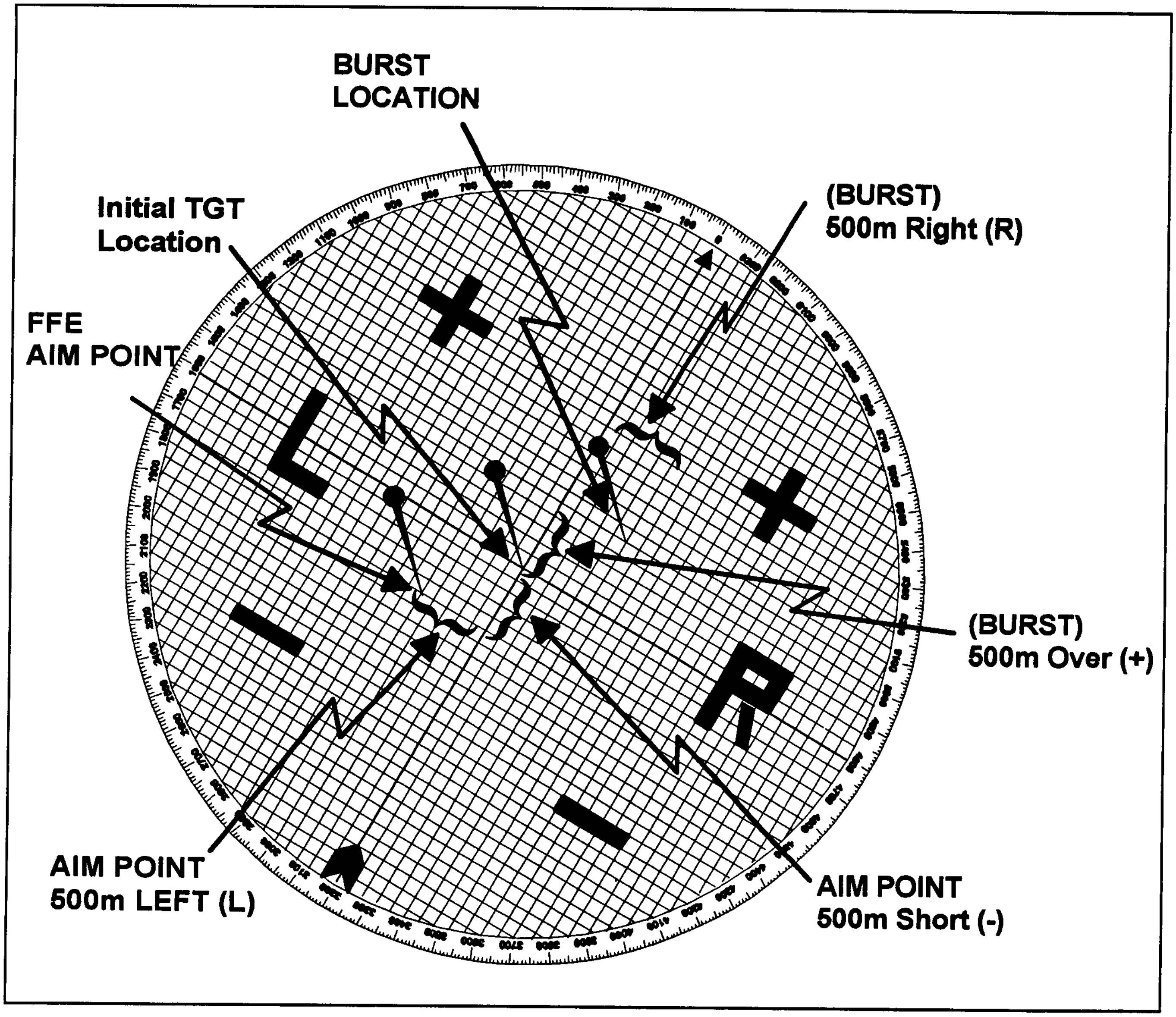


Figure H-5. Laser Polar Mission Processing.

b. The initial target location for a radar adjust-fire mission can be determined by radar in the case of enemy firing units or by another observer. Once the initial target location is established and the initial round is fired, the radar will trace the round and report the spotting of the burst by grid coordinates and altitude. (See Figure H-6.)

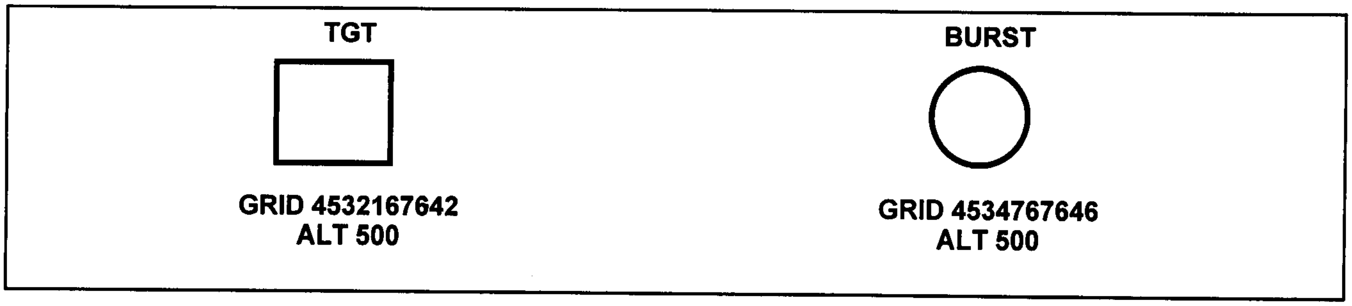


Figure H-6. Radar Spotting.

c. The FDC then determines the corrections needed to move the burst to the target and determines the FFE aimpoint. (See Figure H-7.)

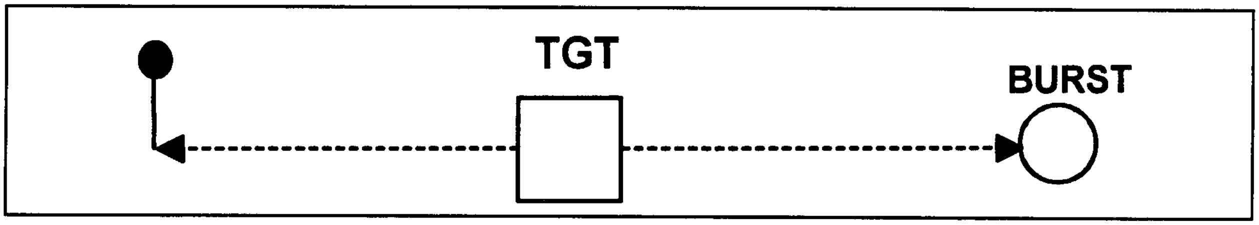


Figure H-7. FFE Aimpoint.

d. Once the FFE aimpoint location is established, FFE fire commands can be determined.

e. If additional adjustment is required, continue to plot the burst locations and compare each to the initial target location. **Apply** each correction determined to the previous aimpoint location, **not** the initial target location. When orienting the target grid for direction, **any** direction will produce the desired results. Each burst location will be reported by using grid coordinates. The target grid is used only to determine the magnitude of the correction needed and the direction of the corrections relative to the orientation (direction) of the target grid that has been chosen.

f. Another way to determine the corrections would be to mathematically determine the difference between the grid coordinates of the target location and burst location (Table H-3). The corrections would be applied by using a target grid oriented to grid north (0000). Continued adjustment would be performed by determining the difference between each burst location and the initial target location. Each correction would be applied to the previous aimpoint.

Table H-3. Determining Difference Between Grid Coordinates of Target Location and Burst Location.

STEP	ACTION
1	The HCO plots the target location on the firing chart by using the grid as received in the fire request.
2	The HCO determines and announces initial chart data.
3	The VCO determines and announces site that is based on the target altitude.
4	The computer determines the initial fire commands in compliance with the fire order.
5	The HCO positions the target grid over the target location (Step 1).
6	The HCO orients the target grid to grid north.
	NOTE: After the radar spots the first round, the burst location will be transmitted to the FDC. (See Figure H-8 on page H-8.)
7	The HCO plots the subsequent grid (burst location) as received from the radar.
8	The HCO determines the difference between the initial target location (step 1) and the burst location (step 4) to the nearest 10 meters, LEFT (L)/RIGHT (R) and OVER (+)/SHORT(-).
9	The HCO places a pin in the opposite direction and magnitude (from the initial target location) of the burst. (LEFT [L] spotting becomes a RIGHT [R] correction, OVER [+] spotting becomes a DROP [-] correction.) This is the FFE aimpoint.
10	The HCO determines chart data to the FFE aimpoint location (step 9).
11	The VCO determines vertical correction by subtracting the initial target altitude from the burst altitude.
12	The VCO applies the vertical correction to the VI and uses the result to recompute and announce site.
13	The computer determines the FFE fire commands in compliance with the fire order.

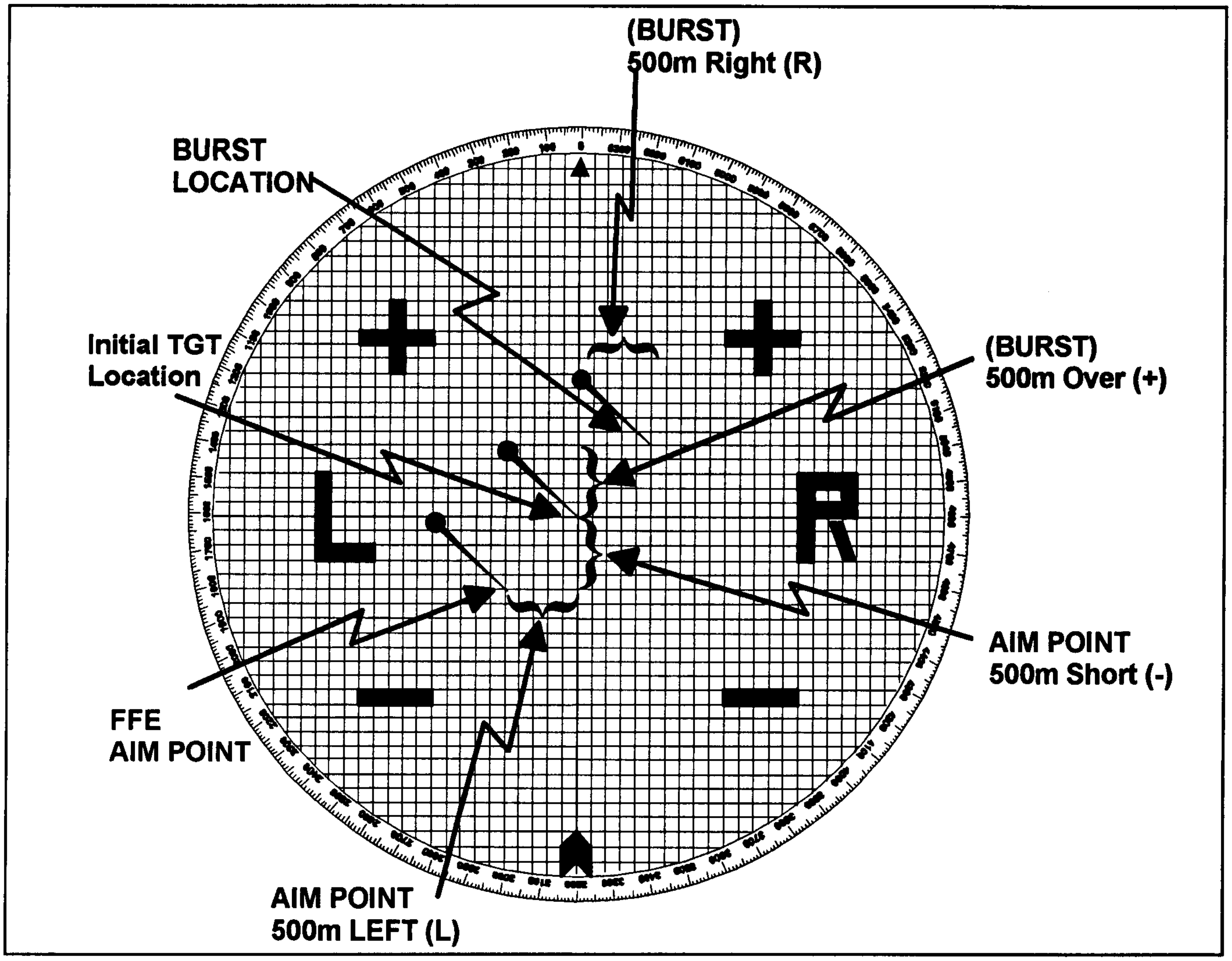


Figure H-8. Radar Mission Processing.

H-6. Destruction Mission

a. General. The purpose of the destruction mission is, as the name implies, to destroy the target. This requires a target hit. The mission is conducted with a single gun and closely parallels precision registration procedures. Given the dispersion suffered by indirect fire weapons and the requirement for a target hit, the great expenditure of ammunition required becomes apparent. This requirement for ammunition and the ensuing possible disclosure of the firing unit make a destruction mission a less desirable method of engaging targets. Whenever possible, other methods or other means of attack should be considered.

b. Conduct of the Destruction Mission. The destruction mission follows the same procedures as a precision registration until the observer establishes a 25-meter bracket. Once it is established, the observer will split the 25-meter bracket by adding or dropping 10 meters and will continue to fire additional rounds. After every third round, additional corrections are announced if necessary. The observer may make corrections after each round. This will continue until the target is destroyed or the observer or FDO chooses to end the mission. At intervals, the observer may request a change of fuze from delay or concrete-piercing to fuze quick to clear rubble and debris around the target.

H-7. Sweep and Zone

Sweep and zone fires provide a method for the attack of large or irregularly shaped targets. The advantage of sweep and zone fires is the ease with which they may be computed in comparison to attacking the target by using special corrections. The disadvantages are the great quantity of ammunition that must be expended and the time required to do so. The resulting loss of surprise and potential for disclosing the firing unit location make sweep and zone fires a less appealing alternative. The FDO should weigh these considerations before attacking targets by using sweep and zone techniques. Possible alternatives are the use of special corrections or dividing the target among a number of firing units.

a. Computation of Sweep.

(1) Sweep fires are used to cover a wide target with fire. (Wide target is described as a target whose long axis lies perpendicular or nearly perpendicular to the GT line.) Sweep fire is similar to traversing fire applied with direct fire weapons. The purpose of the sweep is to cause the guns to fire a number of deflections (at the same quadrant elevation) to place a number of sheafs side by side over the target.

(2) Chart data are computed as with any area target.

(3) The number of deflections to fire is determined on the basis of the width of the target and by the sheaf front.

(a) Determination of sheaf front. The sheaf front is the lateral distance between the center of the flank bursts, plus one effective burst width. The size of the sheaf front depends on the type of sheaf fired and the burst width of the projectile. For an open sheaf, the sheaf front is computed as number of bursts multiplied by the burst width for the projectile. The sheaf front for a circular sheaf is the distance across the center of the circle from burst to burst plus one burst width. If special corrections or TGPCs are being used, the size of the sheaf front will correspond with the sheaf front used to determine those corrections. Converged sheaf should not be used as the concentration of fire on a single point. This is contrary to the purpose for sweep fire. The front for a converged sheaf is one burst width. (See Table H-4.)

Table H-4. Sheaf Fronts.

CALIBER	BURST WIDTH	OPEN	100 M CIRCULAR	CONVERGED
105 mm (4 guns)	35 m	140 m	135 m	35 m
155 mm (4 guns)	50 m	200 m	150 m	50 m
8 inch (6 guns)	80 m	480 m	180 m	80 m

(b) Determination of the number of deflections to fire. To determine the number of deflections to fire, divide the target width by the sheaf front. If the result is an even number, the result must be expressed **UP** to the next higher odd number. Because fire commands will be sent to the guns with the center data and special instructions addressing the size and number of shifts, a center sheaf and equal number of sheafs on either side require that an odd number of deflections be fired.

$$\frac{\text{TARGET WIDTH}}{\text{SHEAF FRONT}} = \text{NUMBER OF DEFLECTIONS}$$

(4) The number of mils by which the guns must change the center deflection in order to fire the sheafs is the deflection shift. The deflection shift is computed as the sheaf front divided by chart range in thousands.

$$\frac{\text{(SHEAF FRONT)}}{\text{CHART RANGE IN 1000s}} = \text{SWEEP IN MILS}$$

(5) Fire commands are sent as with any area fire mission. The time, deflection and quadrant to the center are announced. The special instruction **SWEEP, (the value of the deflection shift) MILS, (the number of deflections) DEFLECTIONS** is announced. The number of rounds announced in the method of fire for effect is the number of rounds to be fired **at each deflection.**

c. Computation of Zone.

(1) Zone fires are used to cover a deep target with fire. (Deep target is described as a target whose long axis lies parallel or nearly parallel to the GT line.) Zone fire is similar to searching fire applied with direct fire weapons. The purpose of the zone is to cause the guns to fire a number of quadrants (at the same deflection) to place a number of sheafs “stacked” over the target.

(2) Chart data are computed as with any area target.

(3) The number of quadrants to fire is determined by dividing the depth of the target by the sheaf depth.

(a) Determination of sheaf depth. The sheaf depth is the distance between the center of the foremost and rearmost burst. The size of the sheaf depth depends on the type of sheaf fired and the burst width of the projectile. For an open sheaf, the sheaf depth is computed as the burst width for the projectile. The sheaf depth for a circular sheaf is the distance across the center of the circle from burst to burst plus one burst width. If special corrections or TGPCs are being used, the size of the sheaf depth will correspond with the sheaf depth used to determine those corrections. Converged sheaf should not be used as the concentration of fire on a single point. This is contrary to the purpose of zone fire. The depth for a converged sheaf is one burst width. (See Table H-5.)

Table H-5. Sheaf Depths.

CALIBER	OPEN	100 M CIRCULAR	CONVERGED
105 mm (4 guns)	140 m	135 m	35 m
155 mm (4 guns)	200 m	150 m	50 m
8 inch (6 guns)	480 m	180 m	80 m

(b) Determination of the number of quadrants to fire. To determine the number of quadrants to fire, divide the target depth by the sheaf depth. If the result is an even number, the result must be expressed **UP** to the next higher odd number. (Because fire commands will be sent to the guns with the center data and special instructions addressing the size and number of shifts, a center sheaf and equal number of sheafs on either side require that an odd number of quadrants be fired.)

TARGET WIDTH = NUMBER
SHEAF DEPTH OF QUADRANTS

(4) The number of mils by which the guns must change the center quadrant to fire the sheafs is the quadrant shift. The quadrant shift is computed by comparing the elevation corresponding to the range to the center of the target to the elevation corresponding to the center range plus the sheaf depth. The difference is the quadrant shift.

ELEVATION ~ (CHART RANGE + SHEAF DEPTH) - ELEVATION ~ CHART RANGE = ZONE

(5) Fire commands are sent as with any area fire mission is announced. The time, deflection, and quadrant to the center are announced. The special instruction **ZONE, (the value of the quadrant shift) MILS, (the number of quadrants) QUADRANTS** is announced. The number of rounds announced in the method of fire for fire for effect is the number of rounds to be fired **at each quadrant.**

NOTE: Zone fires are less effective when fired with HE/ti. Since an FS correction is not applied, the chance of graze or high airburst increases as the zone moves from the center. VT is the preferred airburst fuze for shell HE.

d. Sweep and Zone Fires Combined. Sweep and zone fires are used to attack targets that are both wider and deeper than the sheaf covers. The procedures used are the same as when firing sweep or zone fires individually. The special instructions announced in the fire commands are **SWEEP, (the value of the deflection shift) MILS, (the number of deflections) DEFLECTIONS, ZONE, (the value of the quadrant shift) MILS, (the number of quadrants) QUADRANTS.** (See Table H-6 on page H-12.)

Table H-6. Determining Combination of Sweep and Zone Fires.

STEP	ACTION
1	The FDO analyzes the target description and determines that it would be best engaged by using sweep and/or zone fires and issues the fire order. If sweep fire is announced in the fire order, go to step 2. If zone fire is announced in the fire order, go to step 6.
2	Determine the sheaf width by using Table 1 on the basis of the sheaf type announced in the fire order and the weapon caliber.
3	Determine the number of deflections to fire by dividing the target width announced by the observer by the sheaf width (step 2). If the result is an even number, express it up to the next higher odd number.
4	Determine the deflection shift by dividing the sheaf width (step 2) by the chart range (in thousands) as announced by the HCO. Express the result to the nearest whole mil. $\frac{\text{SHEAF WIDTH}}{\text{CHART RANGE (IN THOUSANDS)}} = \text{DF SHIFT}$
5	If zone fire was not announced in the fire order, special instructions for the sweep are announced **SWEEP, (the value of the deflection shift [step 4]) MILS, (the number of deflections [step 3]) DEFLECTIONS**. Go to step 11. If zone fire was announced in fire order, go to step 6.
6	Determine the sheaf depth by using Table 2. Use the sheaf type announced in the fire order and the weapon caliber to enter the table.
7	Determine the number of quadrants to fire by dividing the target depth by the sheaf depth (step 6). If the result is an even number, express it up to the next higher odd number. $\frac{\text{TARGET DEPTH}}{\text{SHEAF DEPTH}} = \text{NUMBER OF QUADRANTS}$
8	Determine the quadrant shift by subtracting the elevation corresponding to the chart range from the elevation corresponding to the chart and sheaf depth.
9	If sweep fire is not announced in the fire order, special instructions for the zone are **ZONE, (the value of the quadrant shift [step 8]) MILS, (the number of quadrants [step 7]) QUADRANT**. Go to step 11. If sweep fire was also announced in the fire order, go to step 10.
10	Special instructions for sweep and zone are **SWEEP, (the value of the deflection shift [step 4]) MILS, (the number of deflections [step 3]) DEFLECTIONS, ZONE, (the value of the quadrant shift [step 8]) MILS, (the number of quadrants [step 7]) QUADRANTS.**
11	The computer announces the remainder of the fire commands. The initial data are based on the chart range and deflection determined and announced by the HCO.

H-8. Zone-To-Zone Transformation

a. Zone-to-zone transformation is the technique of converting the coordinates and / or azimuths as expressed in one grid zone to coordinates and / or azimuths of an adjacent grid zone. When operating near a grid zone boundary, one of the grid zones will be designated as the primary, or base, grid zone. The other will be referred to as a secondary, or adjacent, grid zone. The decision as to which zone will be primary zone is based on the tactical situation, unit SOP, the directives of the commander, or anticipated location of future operations.

b. Maps printed by the Army Map Service show the differences between universal transverse mercator (UTM) grid zones. Maps that cover an area within 40 kilometers of a UTM zone junction are printed along the border with two sets of grid line numbers (one set for each zone). One set is printed in black. The other set is printed in blue and corresponds to the adjacent grid zone. Marginal information on the maps also indicates the color that applies to each zone.

c. There are two methods of performing zone-to-zone transformation--the two grid sheets method and the graphic method. The two grid sheets method is considered the fastest and simplest.

(1) Two grid sheets method. For this technique, two grid sheets are prepared and joined to form a large chart (a constructed grid sheet) from which chart data across the zone junction can be determined automatically. (See Figure H-9 on page H-14.)

(a) Preparing the grid sheets. The HCO prepares a piece of chart paper (a grid sheet) for each zone involved. Using a plotting scale and a sharp pencil, the HCO reproduces on the grid sheets the exact orientation of the zone junction longitudinal and latitudinal lines as they appear on the map of the area of overlap. The HCO marks the edges to be joined with a fine line that is based on accurate measurements taken from the map. He takes care in cutting and taping so that, when the sheets are put together to form one large chart, measurements from the large chart can be made accurately.

(b) Using the constructed grid sheet. No transformation or computation is needed when firing data are determined from a constructed grid sheet. The coordinates are measured and plotted from the grid lines for the respective area. The observer’s azimuth is used as announced, and the target grid is emplaced by using grid north of the observer’s zone.

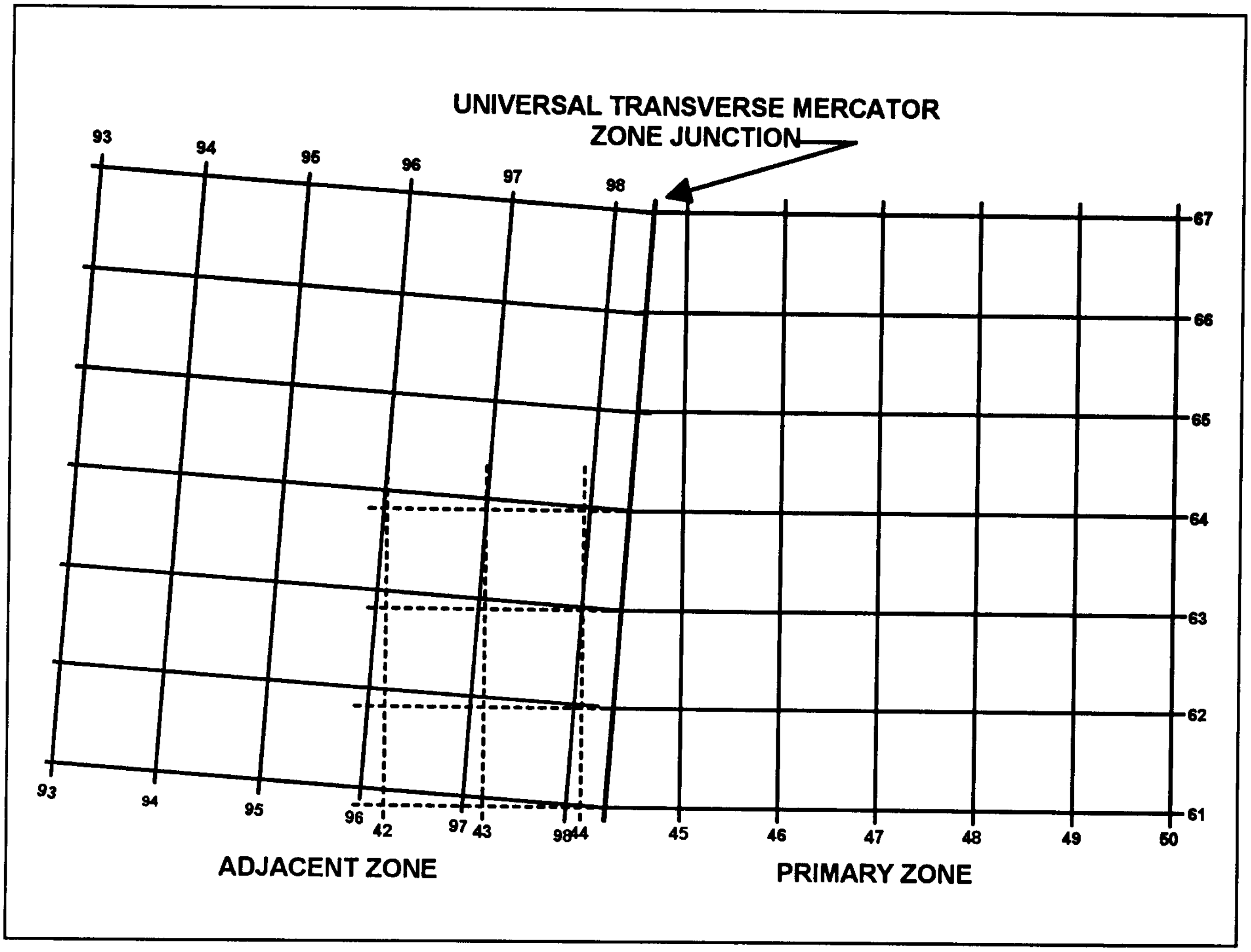


Figure H-9. Joining Two Grid Sheets for Zone-To-Zone Transformation.

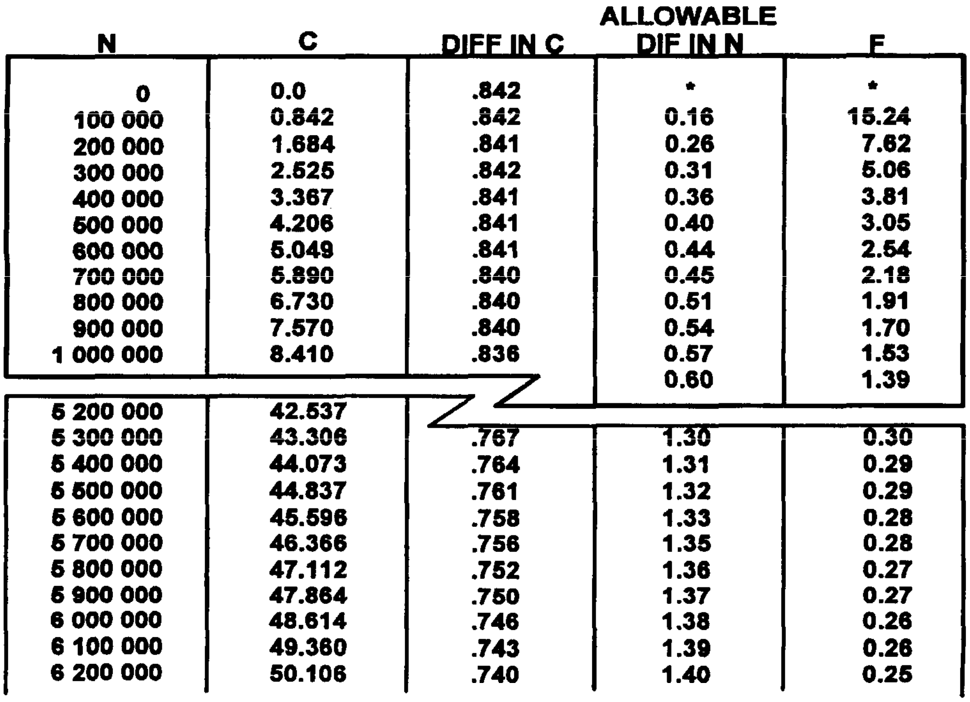
(2) Graphic method (battery in primary zone). The procedures for this method are discussed in Table H-7.

Table H-7. Determining Zone-To-Zone Transformation (Graphic Method).

STEP	ACTION
Preparing the Map	
1	Once the primary zone has been designated, the map of each zone should be prepared for transformation. If two maps are used, they are aligned along the common UTM zone junction longitudinal line.
2	Using the arm of the RDP or a long straightedge, the FDO and a chart operator trace the grid lines of the primary zone into the secondary zone on the map.
3	The chart operator extends the east-west grid lines of the primary zone by using the tick marks around the border, and he numbers the lines with the appropriate values. He constructs the north-south grid lines similarly. The superimposed grid lines are drawn with a colored pen to facilitate the rapid transformation of data and reduce the possibility of errors.
Determining Chart Data	
4	Number the firing chart with the number designations of the grid lines of the primary zone.
5	When a call for fire is received and the observer's target location lies in the adjacent zone, plot the target location on the map by using the normal grid lines of the adjacent zone.
6	Using the superimposed grid lines of the primary zone, determine a new set of coordinates for the target. Plot the new coordinates on the firing chart, and determine chart data by using standard fire direction procedures.
7	For adjust-fire missions, the next step is to convert the observer direction in the secondary zone to the corrected direction in the primary zone.
8	Compute the correction factor to be applied to the observer's direction by using Table 14 of the current Army ephemeris (FM 6-300) (Figure H-10 on page H-16).
8a	Using the superimposed grid lines, determine the northing coordinate (seven significant digits) of the target in the primary zone. Also, determine the northing coordinate of the target by using the printed grid lines
8b	Add the values of the coordinates, and divide the sum by 2 to obtain the average northing.
	EXAMPLE **PRIMARY GRID FROM MAP 5551650** **SECONDARY GRID FROM FO +5552100** **11103750 ÷ 2 = 5551875**
	NOTE: When the observer is in the Southern Hemisphere, subtract the average northing coordinate from 10,000,000 before entering Table 14.
8c	Using the average northing and latitude of the target at the nearest listed value, enter Column N of Table 14. Find the correction factor in mils in Column C. The nearest listed value to 5551875 is 5600000. The correction factor is 45.598.
8d	Express the correction factor to the nearest 10 mils (45.598 ~ 50), and apply it to the observer-target direction by using the following rules: ● When the point is transformed in the Northern Hemisphere from east to west, the sign is minus (-). When the point is transformed from west to east, the sign is plus (+). ● When the point is transformed in the Southern Hemisphere from east to west, the sign is plus. When the point is transformed from west to east, the sign is minus.
9	Use the corrected direction to orient the target grid. Determine the chart data for the adjustment by using standard fire direction procedures.
	EXAMPLE East to west transformation in Northern Hemisphere, change sign to minus (-). **DIRECTION (AZIMUTH) 1,870 MILS** **CORRECTION FACTOR +(-50)** **CORRECTED DIRECTION 1,820 MILS**

Table H-7. Determining Zone-To-Zone Transformation (Graphic Method) (Continued).

STEP	ACTION
	Observer in Secondary Zone and Firing Unit in Primary Zone
10	**Polar Plot.** Before the target location is plotted on the firing chart, a corrected direction must first be determined. In this case, use the northing coordinates of the observer's location in both zones to determine the average northing.
11	**Shift From a Known Point.** As in polar plot, the corrected direction must be determined before the target is plotted. In this case, use the northing coordinates of the known point to obtain the average northing. Orient the target grid by using the corrected direction. Then plot the shift in the usual manner.
12	**Observer Procedures.** The observer determines target location and OT direction as he does for any mission. He is not required to superimpose an additional grid over his map. When the observer sends target location, he must prefix his grid with the letter designator of the UTM grid zone in which he is located; for example, **ADJUST FIRE, GRID PK 515478.**
	Observer in Primary Zone and Firing Unit in Secondary Zone
13	Either zone may be designated as the primary zone. The procedures are essentially the same in both cases. The firing unit and the target or observer must be plotted on a common grid when the firing chart is constructed. Before the target grid is oriented for plotting subsequent correction, the OT direction must be corrected.
14	The firing unit may have to fire into either zone. Therefore, when the observer's grid zone is primary, the following alternatives exist: ● The firing unit must be plotted twice on the firing chart. This requires double numbering. ● Two charts must be constructed. ● One chart covering both zones must be constructed. This requires superimposing one grid over another.



N	C	DIFF IN C	ALLOWABLE DIF IN N	F
0	0.0	.842	*	*
100 000	0.842	.842	0.16	15.24
200 000	1.684	.841	0.26	7.62
300 000	2.525	.842	0.31	5.06
400 000	3.367	.841	0.36	3.81
500 000	4.206	.841	0.40	3.05
600 000	5.049	.841	0.44	2.54
700 000	5.890	.840	0.45	2.18
800 000	6.730	.840	0.51	1.91
900 000	7.570	.840	0.54	1.70
1 000 000	8.410	.836	0.57	1.53
			0.60	1.39
5 200 000	42.537			
5 300 000	43.306	.767	1.30	0.30
5 400 000	44.073	.764	1.31	0.29
5 500 000	44.837	.761	1.32	0.29
5 600 000	45.596	.758	1.33	0.28
5 700 000	46.366	.756	1.35	0.28
5 800 000	47.112	.752	1.36	0.27
5 900 000	47.864	.750	1.37	0.27
6 000 000	48.614	.746	1.38	0.26
6 100 000	49.360	.743	1.39	0.26
6 200 000	50.106	.740	1.40	0.25

* F CORRECTION NOT REQUIRED

Figure H-10. Extract of Table 14 of the Army Ephemeris.

H-9. Aerial Observers

a. Problems Requiring FDC Assistance. Aerial observers may encounter three problems that require special assistance from the fire direction center:

(1) The AO has no fixed direction to the target. Normally, he is moving in relation to the target area. Hence, FDC personnel must be prepared for unusual and changing observer directions or spotting lines. Each adjustment may have a different observer direction (that is, different magnetic or cardinal direction).

(2) While in the air, the AO may lose his perception of distance and direction. He may request ranging rounds (two rounds impacting 400 meters apart) to help visualize distance and direction in the target area. The observer and FDC personnel must realize that ranging rounds fired along the GT line may disclose to the enemy the general location of the firing unit.

(3) The AO must minimize the time he is exposed to enemy detection. In forward areas, the pilot must fly close to the earth and behind cover as much as possible. Therefore, the AO and his pilot require from the FDC very accurate time of flight, **SHOT,** and **SPLASH** so that the pilot can unmask the aircraft 2 to 3 seconds before the round impacts.

b. Observer Direction and/or Spotting Line.

(1) Using GT line adjustment. If the AO knows the location of the firing unit with respect to the target, he may choose to adjust along the GT line. When the AO announces **DIRECTION, GUN-TARGET LINE,** the HCO plots the target and centers the target grid over the plot with the 0-3200 line (the center arrow) parallel to the GT line.

(2) Using a shift from a known point along the GT line. The AO may announce **DIRECTION, GUN-TARGET LINE** for a shift from a known point. In this instance, the HCO plots the known point, centers the target grid, and orients it parallel to the gun-target line. He then plots the observer's shift and determines chart data. He then rotates the target grid around the new pinhole so that the arrow is parallel to the GT line.

(3) Using helicopter instrument readings for direction. When the AO's aircraft is moving in relation to the target area, the AO may use an aircraft instrument reading for his observer direction. As this direction is expressed in degrees, FDC personnel must convert the reading to mils by using the following formula:

DIRECTION IN DEGREES X 17.8 = DIRECTION IN MILS

For example, if the direction is 250°, the direction in mils is 4,450 (250° x 17.8 mils= 4,450 mils).

> **NOTE:** In preparing for AO missions, the VCO (recorder) should mark a target grid in degrees or prepare a conversion chart for quick conversion from degrees to mils.

(4) Using a cardinal direction. The AO may choose to adjust along a cardinal direction (one of the eight principal points of the compass) (Figure H-11, page H-18). When the observer announces a cardinal direction, the HCO converts the direction to mils and orients the target grid to that direction. For example, FDC personnel would convert direction southwest (SW) to direction 4,000 mils. The observer may also shift from a known point by using a cardinal direction. The preferred method for sending direction to the FDC is to send it in degrees if possible.

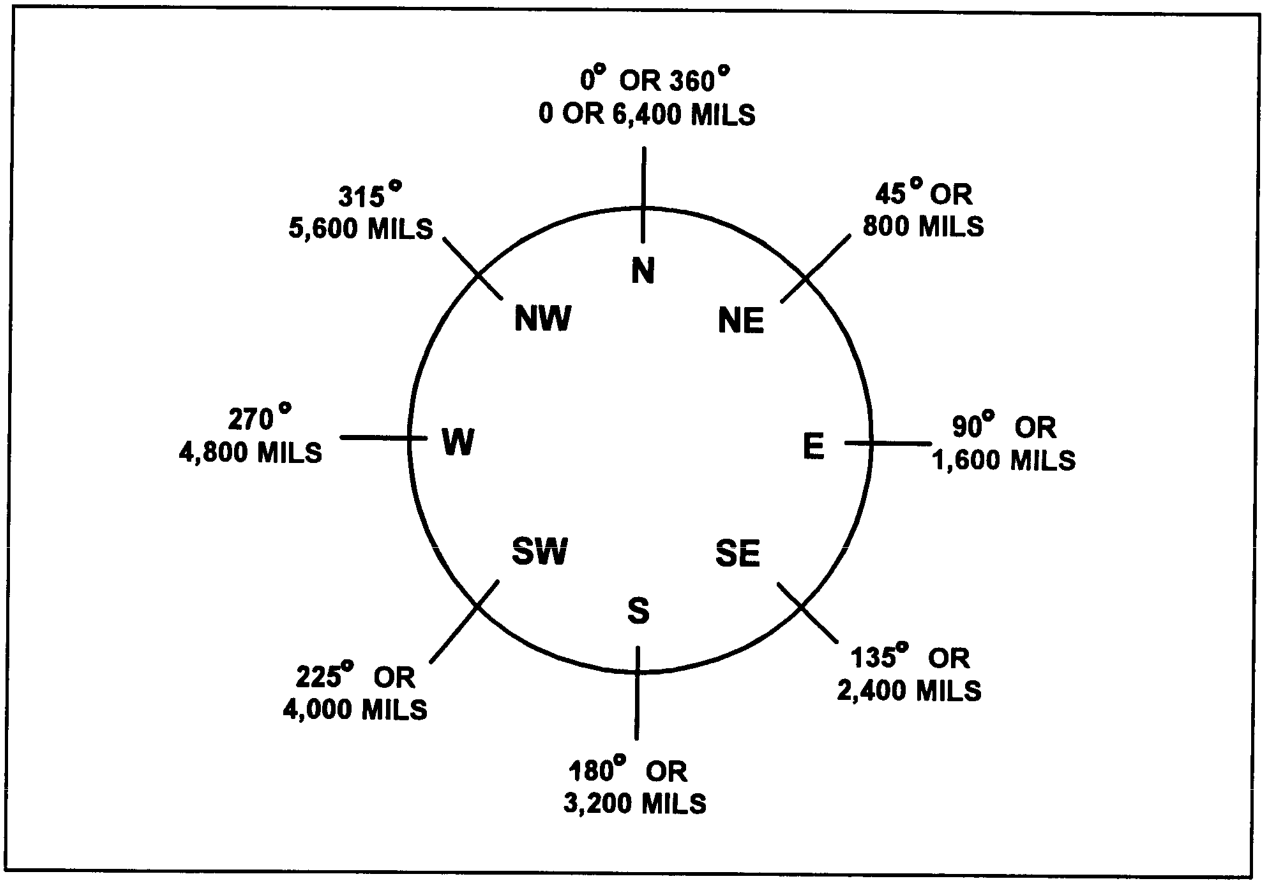


Figure H-11. Cardinal Directions.

(5) Using a spotting line. The AO may adjust along a spotting line formed by natural or man-made terrain features, such as roads, railroads, canals, or ridge lines. Before flight, if possible, the AO selects the line, determines the direction, and notifies the fire direction center. While in flight, he may select a line that is more readily identifiable and convenient. The AO may describe the feature in detail and have FDC personnel use a protractor to determine the direction from a map. The HCO orients the target grid over the target location on this new direction.

H-10. Ranging Rounds

In his call for fire, the AO may announce **REQUEST RANGING ROUNDS.** This indicates that he wants to see a volley of two rounds that impact 400 meters apart at relatively the same time. Ranging rounds (Figure H-12) are fired only as a last resort, since they reveal the general location of the firing position. These rounds are fired along the GT line. The HCO determines initial chart data, and the computer determines initial firing data for the adjusting piece. The computer then adds 400 meters to the announced chart range. Using the new range and the initial chart deflection, the computer determines firing data for the second piece to fire in the volley (usually the other piece in the center platoon). Ranging rounds are fired at the same time by firing **AT MY COMMAND.** The AO observes the impact of the round and determines the corrections necessary to hit the target. He bases his corrections on the round that lands nearest the target. He bases his corrections on the round that lands nearest the target. He must specify to the FDC from which round he is adjusting, and the HCO plots the shift accordingly (Figure H-13).

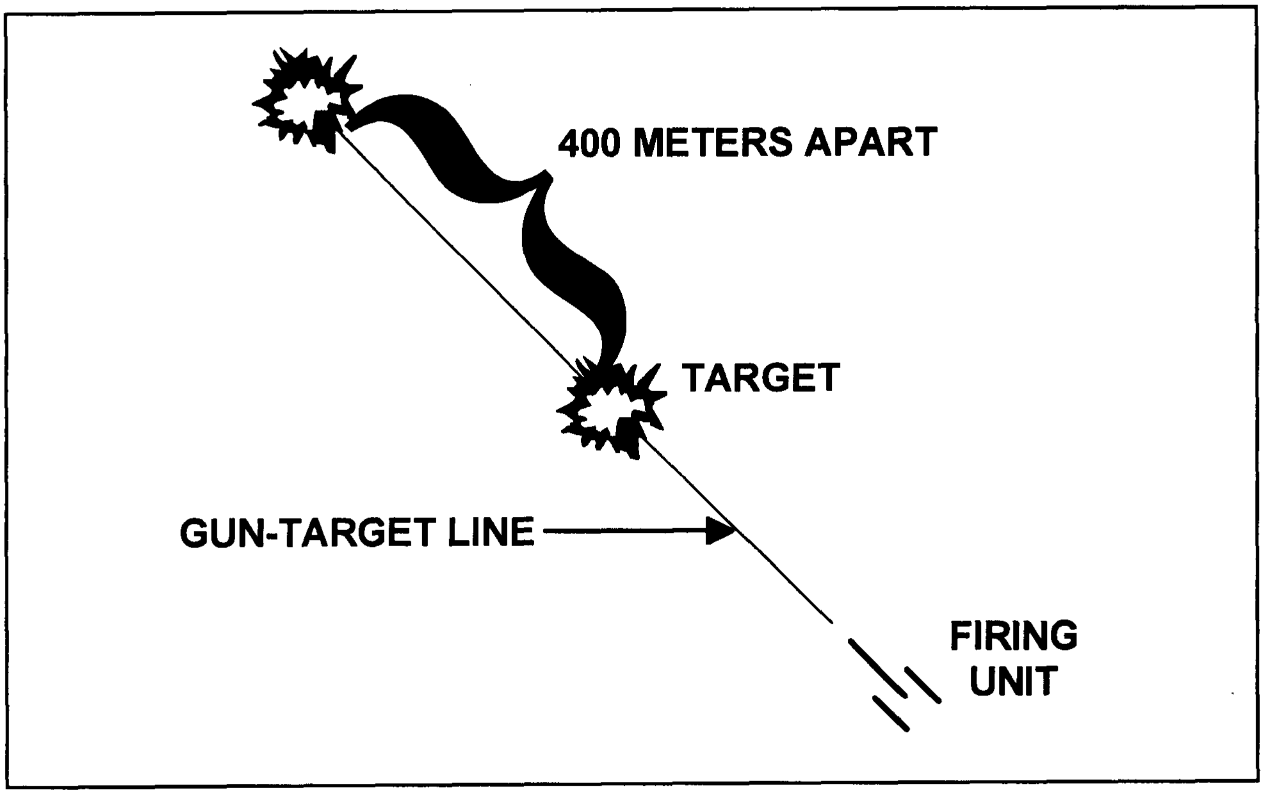


Figure H-12. Ranging Rounds.

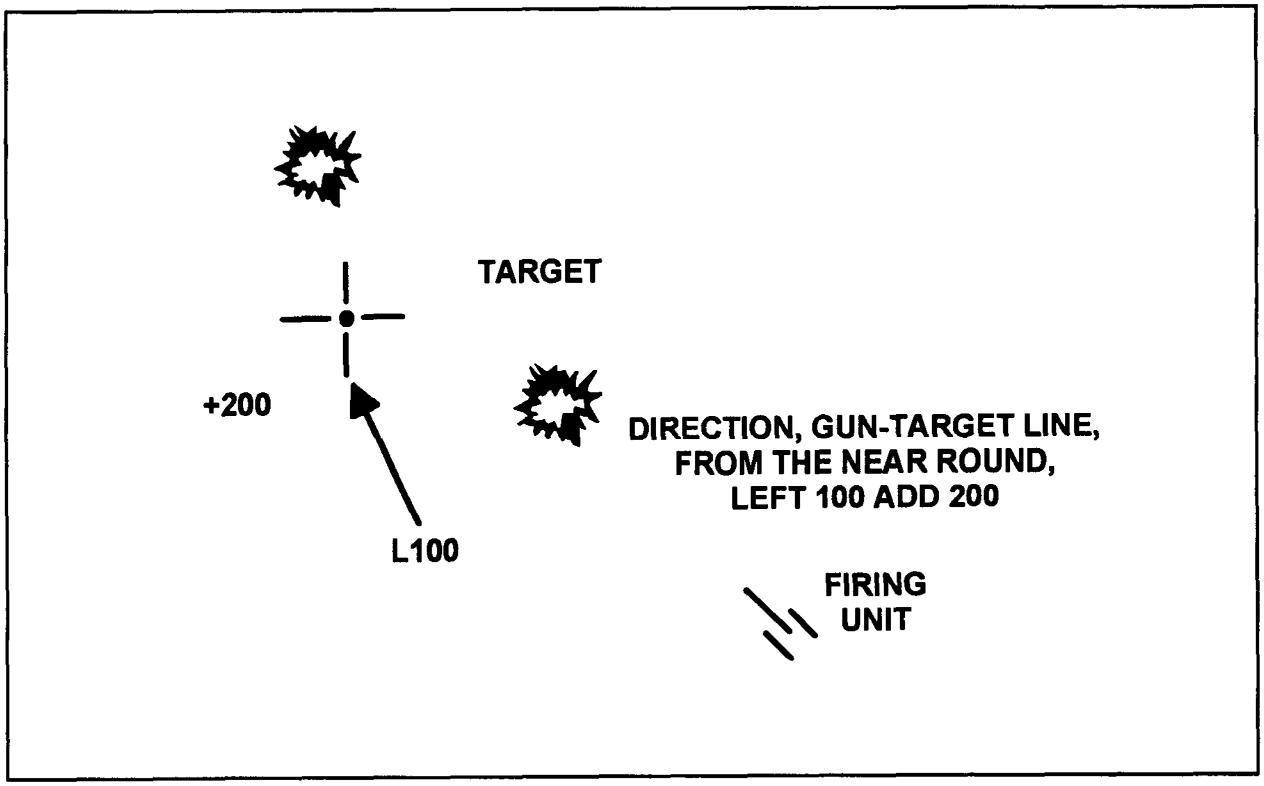


Figure H-13. Adjusting From Ranging Round.

H-11. Time of Flight, Shot, and Splash

In the message to observer, the FDC must specify the time of flight. On all volleys, the FDC must promptly announce **SHOT** and **SPLASH.** The FDC should report changes in the time of flight as the mission progresses.

H-12. Untrained Observers

a. Calls for fire from untrained personnel acting as ground observers require close attention and initiative from every member of the fire direction center. The FDC personnel must be prepared to assist the untrained observer in his call for fire and adjustment of artillery.

b. FDC personnel must take the initiative if the observer is hesitant or confused in his request for fire support. They must ask leading questions, such as the following:

(1) Where is the target?

(a) What are the grid coordinates of the target?

(b) Where is the target in relation to a readily identifiable natural or man-made feature?

(c) Where are you? How far is the target from you and in what direction is it?

(2) What is the target?

(a) Is the target personnel, vehicles, installations, or equipment?

(b) What is the size of the enemy force?

(c) What is the enemy force doing at present?

(d) If the enemy force is moving, in what direction is it moving? How fast is the force moving?

(3) How close is the target to you? If the target is within 600 meters or closer to other friendly troops, the observer may need to “creep” the rounds to the target.

(4) What is your direction to the target?

(a) What is the azimuth to the target in degrees or mils?

(b) What is the cardinal direction to the target (N, NE, E, SE, S, SW, W, NW)?

(c) Is the direction along a natural or man-made feature?

(5) What effect do you need on target?

(a) Is the target shooting at you?

(b) Is it necessary to obscure vision of the target?

(c) Do we need to neutralize or destroy the target?

c. The FDC personnel must explain to the observer what artillery fire he is getting. If necessary, the FDC members must educate or inform the observer as follows:

(1) You will see one round that will look like a cloud of dust. You will get more rounds when you move the burst within 50 meters of the target.

(2) The round is now on the way and will impact in (so many) seconds.

d. The FDC personnel must help the observer in making corrections. They must help the observer move the rounds to the target and must be prepared for unusual shifts. To obtain corrections, they should ask leading questions such as the following:

(1) Where did the round land in relation to the target?

(a) Did it land left or right? How far?

(b) Did it land over or short? How far? Ask for distances in meters or in the number of football field lengths.

(2) Did the round land closer than the previous round?

> **NOTE:** The FDO should consider using shell WP to help the observer locate initial rounds.

e. The FDC personnel must use sound judgment. They must decide whether to require the observer to authenticate. They must watch for possible observer misorientation. Also, FDC personnel must help the observer determine when satisfactory effects on the target have been achieved. In all cases, the FDC personnel must take the initiative.

H-13. Example Problems

a. Process a Laser Adjust-Fire Mission. The observer transmits the following call for fire:

H57 THIS IS C19, AF POLAR, OVER.
DIRECTION 4950, DISTANCE 6990, VA PLUS 5, OVER.
BMP WITH DISMOUNTED INFANTRY, ICM IN EFFECT, OVER.

The procedures for processing a laser adjust-fire mission are discussed in Table H-8.

Table H-8. Processing a Laser Adjust-Fire Mission.

STEP	ACTION
1	The HCO plots the target location from the observer's location by using the direction (4950) and slant distance (6990) received in the fire request. (Direction will be received to the nearest 1 mil, and slant distance to the nearest 10 meters.)
2	The HCO determines and announces the initial chart data. (**Range 9760, deflection 3053**)
3	The VCO converts the vertical angle received in the fire request into a vertical interval. (**VI = +34**)
4	The VCO determines the target altitude by applying the VI (step 3) to the observer's altitude and determines and announces site. (**+34 + 1103 = 1137 and site = +4**)
5	The computer determines the initial fire commands in compliance with the fire order. (Check and announce **FIRE MISSION MF PLATOON ADJUST, CHARGE 6, DEFLECTION 3065, QUADRANT ELEVATION 437**).
6	The HCO positions the target grid over the initial target location.
7	The HCO orients the target grid by using the initial OT direction. (**4950**) After the observer spots and lases the initial round, he will transmit the burst direction distance and vertical angle to the FDC. (**BURST DIRECTION 5028, DISTANCE 6500, VERTICAL ANGLE +10**)

Table H-8. Processing a Laser Adjust-Fire Mission (Continued).

STEP	ACTION
8	The HCO plots the burst location by using the direction and slant distance as received from the observer.
9	The HCO determines the difference between the initial target location (step 1) and the burst location (step 8) to the nearest 10 meters LEFT (L)/RIGHT (R) and OVER (+)/SHORT (-). (**R500, -500**)
10	The HCO places a pin in the **opposite** direction and magnitude (from the initial target location) of the burst. (LEFT (L) spotting becomes a RIGHT (R) correction, **OVER** (+) spotting becomes a **DROP** (-) correction). This is the FFE aimpoint (**L500, +500**).
11	The HCO determines chart data to the FFE aimpoint (step 10). (**Range = 10600, df = 3102**)
12	The VCO converts the burst vertical angle to a burst vertical interval (from the observer's position). (**+96**)
13	The VCO determines the burst altitude by applying the burst VI (step 12) to the observer's altitude. (**96 + 1103 = 1199**)
14	The VCO determines the vertical correction by subtracting the initial target altitude (step 4) from the burst altitude (Step 13). (**1199 - 1137 = 62**)
15	The VCO applies the vertical correction to the VI (step 3) and uses this value to recompute and announce site. (**62 + (34) = 96 and site = +12**)
16	The computer determines corrections for the adjustment of fuze time using standard procedures. (See Figure H-15 on page H-23.)
17	The computer determines FFE fire commands in compliance with the fire order. (See Figure H-15.)

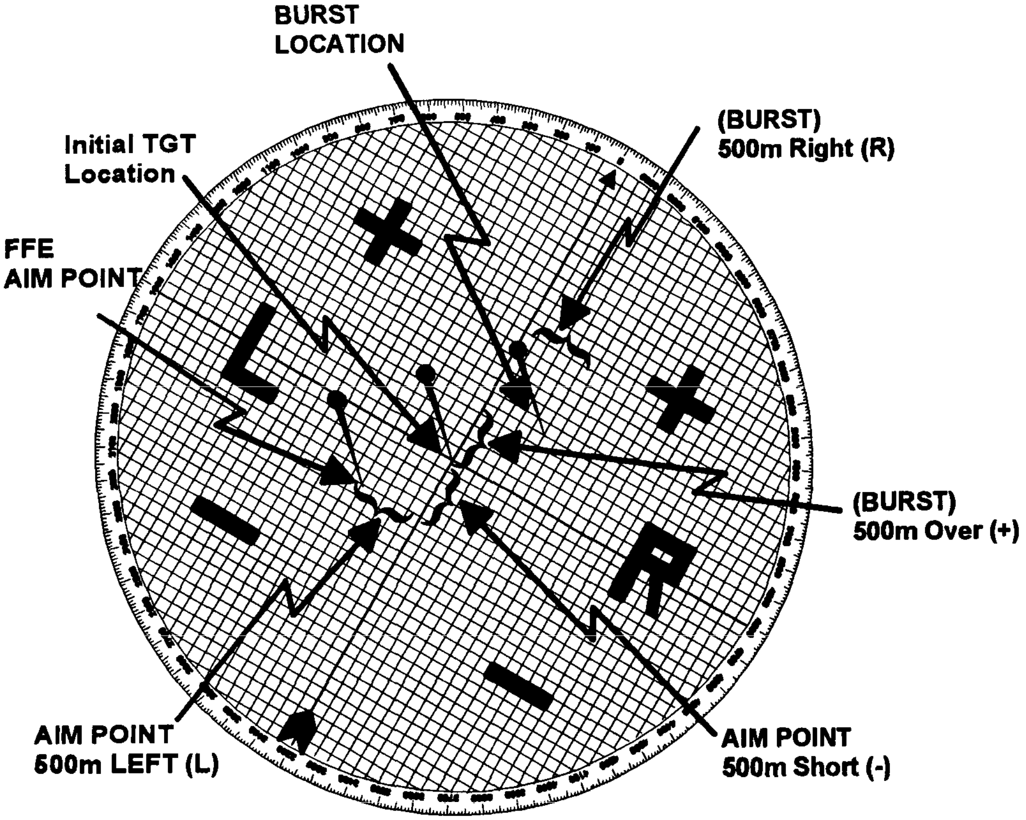
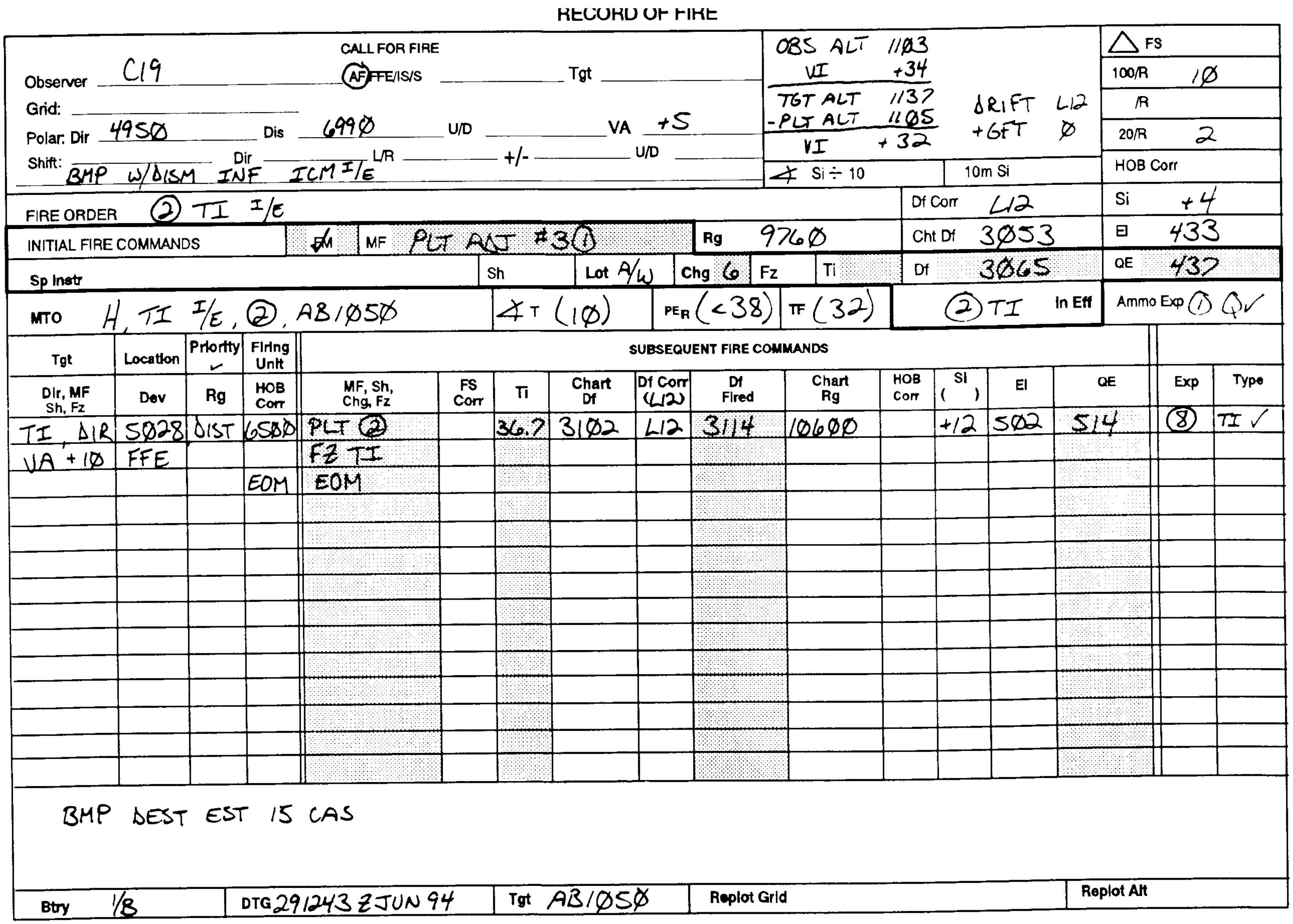


Figure H-14. Laser Polar Mission Processing.



RECORD OF FIRE

Observer C19 CALL FOR FIRE [✓ AF] FFE/IS/S ____ Tgt ____
Grid: ____
Polar: Dir 4950 Dis 6990 U/D ____ VA +5
Shift: ____ Dir ____ L/R ____ +/- ____ U/D ____
BMP W/DISM INF ICM I/E

OBS ALT 1103
VI +34
TGT ALT 1137
-PLT ALT 1105
VI +32
DRIFT L12
+GFT 0
∠ Si ÷ 10 ____ 10m Si ____

△ FS
100/R 10
/R
20/R 2
HOB Corr
Si +4
El 433
QE 437
Ammo Exp ① Q✓

FIRE ORDER ② TI I/E
Df Corr L12

INITIAL FIRE COMMANDS ~~FM~~ MF PLT ADJ #3 ① Rg 9760 Cht Df 3053
Sp Instr ____ Sh ____ Lot A/W Chg 6 Fz ____ Ti ____ Df 3065
MTO H, TI I/E, ②, AB1050 ∠T (10) PER (<38) TF (32) ② TI In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L12)	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
TI, DIR	5028	DIST	6500	PLT ②		36.7	3102	L12	3114	10600		+12	502	514	⑧	TI ✓
VA +10	FFE			FZ TI												
			EOM	EOM												

BMP DEST EST 15 CAS

Btry 1/B DTG 291243ZJUN94 Tgt AB1050 Replot Grid ____ Replot Alt ____

DA Form 4504, OCT 76

Figure H-15. ROF (Laser Adjust-Fire Mission).

b. Process a Radar Adjust-Fire Mission. The procedures for processing a radar adjust-fire mission are discussed in Table H-9.

Table H-9. Processing a Radar Adjust-Fire Mission.

STEP	ACTION
1	The HCO plots the target location on the firing chart by using the grid as received in the fire request. **(412260)**
2	The HCO computer determines and announces initial chart data. **(Range 6630, df 3602)**
3	The VCO determines and announces site on the basis of the target altitude. **(+20)**
4	The computer determines the initial fire commands in compliance with the fire order. (Circle and announce **FIRE MISSION MF PLATOON ADJUST, CHARGE 5GB, DEFLECTION 3609, and QUADRANT ELEVATION 366**).
5	The HCO positions the target grid over the target location (step 1).
6	The HCO orients the target grid to grid north. After the radar spots the first round, the burst location will be transmitted to the FDC.
7	The HCO plots the subsequent grid (burst location) as received from the radar.
8	The HCO determines the difference between the initial target location (step 1) and the burst location (step 3) to the nearest 10 meters, LEFT (L)/RIGHT (R) and OVER (+)/SHORT(-). **(R500, +500)**
9	The HCO places a pin in the opposite direction and magnitude (from the initial target location) of the burst. (LEFT [L] spotting becomes a RIGHT [R] correction, OVER [+] spotting becomes a DROP [-] correction.)**(L500, -500)**
10	The HCO determines chart data to the FFE aimpoint location (step 9). **(Range 7280, df 3638)**
11	The VCO determines the vertical correction by subtracting the initial target altitude (step 1) from the burst altitude (step 7). **(1190 - 1180 = +10)**
12	The VCO applies the vertical correction to the VI and uses the result to recompute and announce site. **(+10 + 118 = 128 and site = +21)**

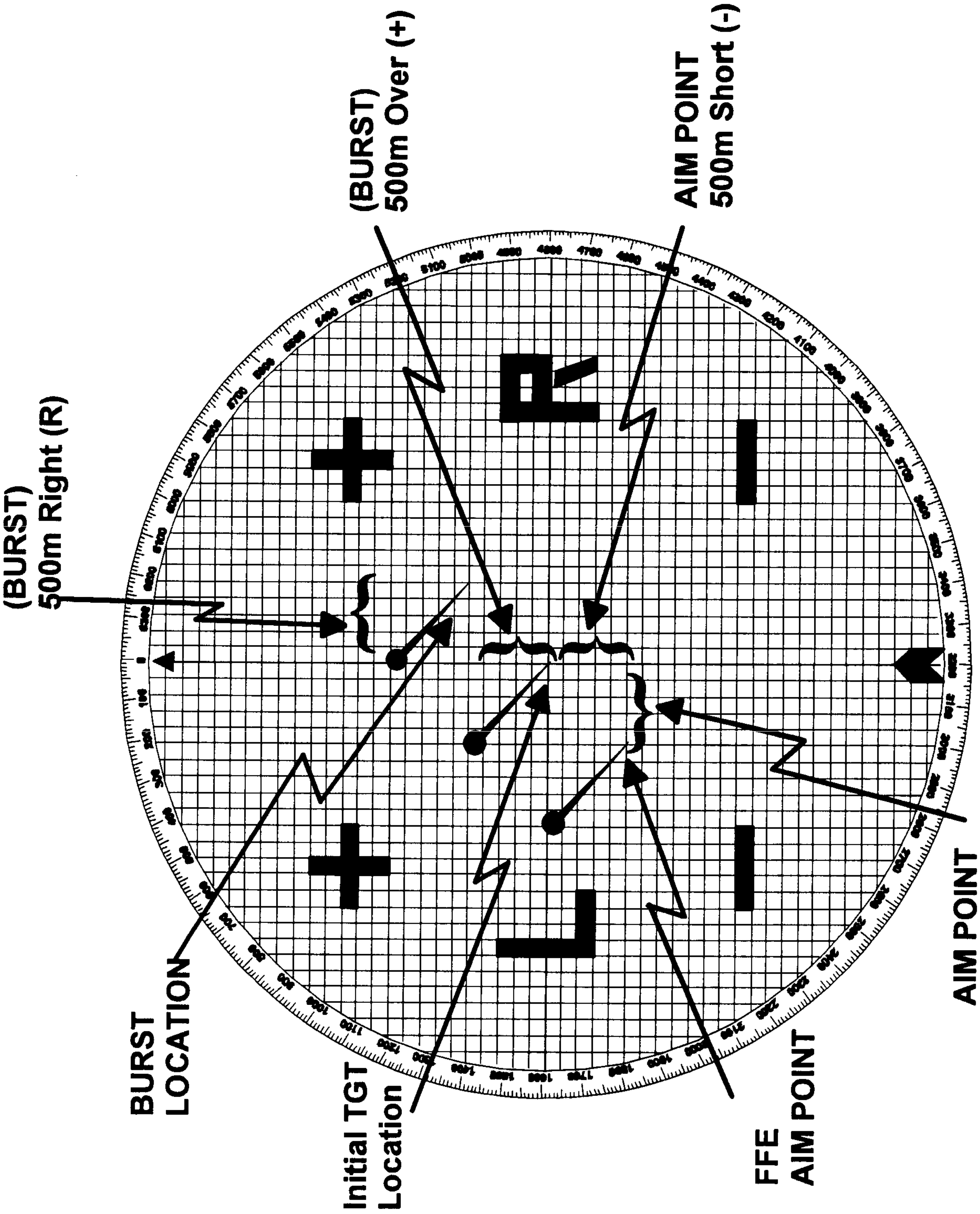


Figure H-16. Radar Mission Processing.

RECORD OF FIRE

CALL FOR FIRE

Observer T/3 [✓ AF]/FFE/IS/S Tgt

Grid: 375 257

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

CONCRETE BUNKER, DESTRUCTION, CP I/E

TGT ALT 1130
-PLT ALT 1062
VI +68

DRIFT L10
+GFT R14

∢ Si ÷ 10

10m Si

△ FS	
100/R	10
/R	
20/R	2
HOB Corr	
Si	+7
El	349
QE	356
Ammo Exp	①

FIRE ORDER ① LOT AW

Df Corr R4

INITIAL FIRE COMMANDS ~~FM~~ MF # 3 ① Rg 10200 Cht Df 3488

Sp Instr Sh Lot AW Chg 7 Fz Ti Df 3484

MTO H, ①, AB1052 ∢T (90) PER 25 TF (31) ① CP In Eff

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (R4)	Df Fired	Chart Rg	HOB Corr	Si (+7)	El	QE	Exp	Type
4600	R30	+400					3484	R4	3480	10590		+7	372	379	②	
		-200					3486	R4	3482	10390		+7	360	367	③	
		+100					3485	R4	3481	10470		+7	365	372	④	
②		-50		②			3486	R4	3482	10390		+7	360	367	⑥	
①		+50		①			3487	R4	3483	10450		+7	364	371	⑦	Q ✓
CP	L20	-20		FZ CP			3487	R4	(3483)	10440/10510		+7	368	375	①	
			RPT						(3483)					375	②	
			RPT						(3483)					375	③	
	R10	-10					3486	R4	3482	10440/10510		+7	368	375	④	
			RPT						(3482)					375	⑤	CP ✓
			EOM	EOM												

GFT 1/A CHG 7 LOT AW RG 12100 EL 476 TI 39.3

TOT ΔF CORR 0 GFT ΔF CORR R14

BUNKER DESTROYED 10 CAS CORR FOR 1% INCREASE IN DENSITY @RG10200 = +31.1 ≈ +40

Btry 1/A DTG 291345Z JUN 94 Tgt AB1052 Replot Grid Replot Alt

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Figure H-17. Record of Fire (Radar Adjust-Fire Mission).

c. Process a Destruction Mission. The observer transmits the following call for fire:

H57 THIS IS T03, ADJUST FIRE, OVER.
GRID 375 257, OVER
CONCRETE BUNKER, DESTRUCTION, CP IN EFFECT, OVER.

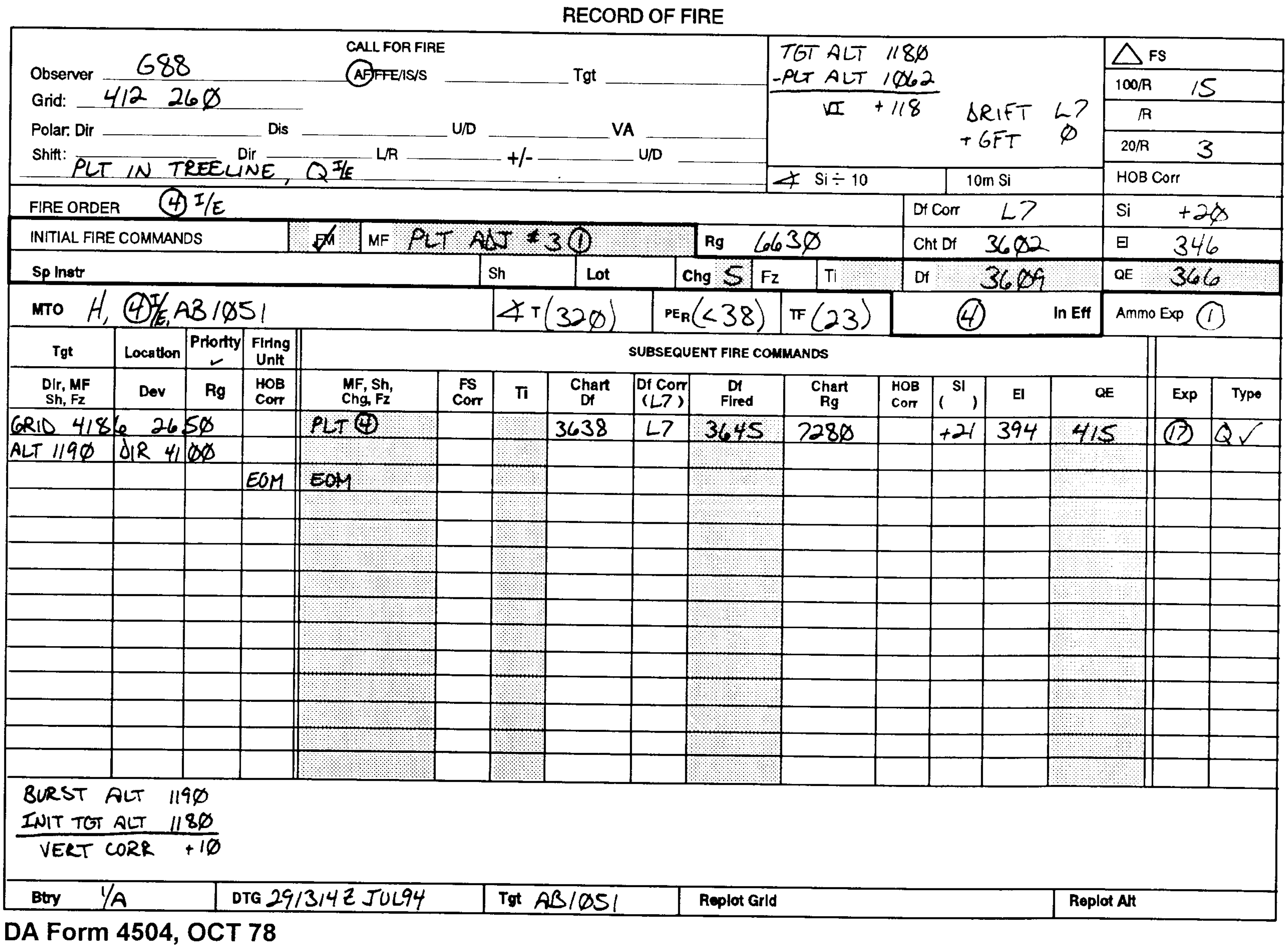
The following GFT setting is available:

> **NOTE:** This GFT setting was obtained from the radar registration mission located in Chapter 10.
>
> **GFT 1/A, Chg 7, Lot AW, Rg 12100, El 476, Ti 39.3 (M582)**
> **Total Df Corr = 0**
> **GFT Df Corr = R14**

The procedures for processing a destruction mission are discussed in Table H-10. Figure H-18 on page H-28 shows a ROF for a destruction mission.

Table H-10. Processing a Destruction Mission.

STEP	ACTION
1	The RATELO authenticates the call for fire.
2	The chart operators plot the target and determine chart data. (**Range 10200, df 3488**)
3	The VCO determines site. (**+7**)
4	The RATELO sends the MTO to the observer: **H, 1 ROUND, AB1052, RANGE PROBABLE ERROR GREATER THAN 25**.
	NOTE: Because range probable error exceeds 25 meters, the observer need only split the 100-meter bracket.
5	The computer announces initial fire commands: **FIRE MISSION, NUMBER 3 1 ROUND, LOT AW, CHARGE 7, DEFLECTION 3484, QUADRANT ELEVATION 356, 1 ROUND CP IN EFFECT**.
6	The observer sends the following corrections: R30, +400 -200 +100 2 RDS, -50 1 RD, +50 Fuze CP,L20, -20
7	Upon receiving the refinement, the HCO plots the correction and determines chart range and deflection. (**Range 10470, df 487**)
8	The computer applies a 1 percent increase in air density (determined at the initial chart range) to the chart range (10440 + 40 = 10510) to correct for the firing of the concrete-piercing fuze. The commands **FUZE CP, DEFLECTION 483, QUADRANT ELEVATION 375** are sent to the guns.
9	The observer requests the next two rounds at the same data.
10	The observer requests the refinement **RIGHT 10, MINUS 10**. The FDC complies.
11	The observer requests **REPEAT**.
12	A target hit is achieved, and the observer requests end of mission and provides surveillance. The computer sends the command **END OF MISSION**.



RECORD OF FIRE

CALL FOR FIRE

Observer 688
Grid: 412 260
[✓ AF] FFE/IS/S Tgt
Polar: Dir Dis U/D VA
Shift: Dir L/R +/- U/D
PLT IN TREELINE, Q I/E

TGT ALT 1180
-PLT ALT 1062
VI +118

DRIFT L7
+ 6FT 0

∡ Si ÷ 10
10m Si

△ FS
100/R 15
/R
20/R 3
HOB Corr

FIRE ORDER ④ I/E

INITIAL FIRE COMMANDS [✓ FM] MF PLT ADJ #3 ①
Rg 6630
Df Corr L7
Cht Df 3602
Si +20
El 346

Sp Instr
Sh
Lot
Chg 5
Fz
Ti
Df 3609
QE 366

MTO H, ④ I/E, AB1051
∡ T (320)
PE_R (<38)
TF (23)
④ In Eff
Ammo Exp ①

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L7)	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
GRID 418	6 26	50		PLT ④			3638	L7	3645	7280		+21	394	415	⑰	Q ✓
ALT 1190	DIR 41	00														
			EOM	EOM												

BURST ALT 1190
INIT TGT ALT 1180
VERT CORR +10

Btry 1/A
DTG 291314Z JUL94
Tgt AB1051
Replot Grid
Replot Alt

DA Form 4504, OCT 78

Figure H-18. Record of Fire (Destruction Mission).

d. Process a Sweep and Zone Fire Mission. The observer transmits the following all for fire:

H57 THIS IS T03, FIRE FOR EFFECT, OVER.
GRID 359 284, OVER
BATTALION ASSEMBLY AREA, LENGTH 600,
WIDTH 300, ALTITUDE 0800, ICM, OVER.

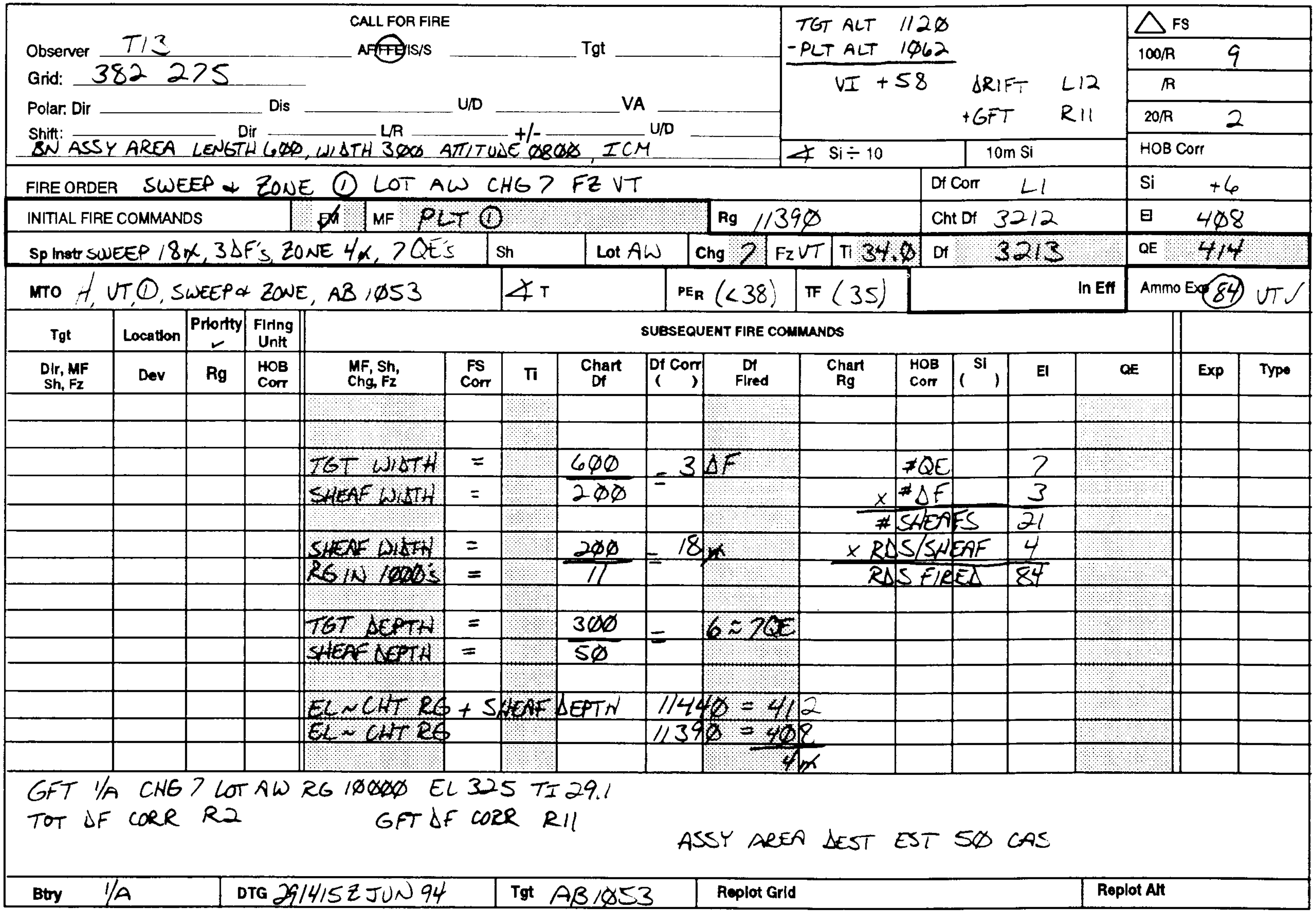
The following GFT setting is available:

GFT 1/A, Chg 7, Lot A/W, Rg 10,000, El 325, Ti 29.1 (M482)
Tot Df Corr R2
GFT Df Corr R11

The procedures for processing a sweep and zone fire mission are discussed in Table H-11. Figure H-19 on page H-30 shows a ROF for a sweep and zone fire mission.

Table H-11. Processing a Sweep and Zone Fire Mission.

STEP	ACTION
1	The FDO examines the plot of the target. By comparing the deflection and the attitude from the call for fire, he determines the long axis of the target is almost perpendicular to the GT line. (The deflection is converted to an azimuth on the basis of the azimuth of lay.) **COMMON DF 3200** **- CHART DF -3212** **-12** **+ AZ OF LAY 5650** **GT AZ 5638** The angle formed by the intersection of the attitude (0800) and the GT azimuth is 2412 (0800 + 6400 = 7200, 7200 - 4788 = 2412). The FDO decides to fire a sweep and zone.
2	The FDO issues the fire order: **SWEEP AND ZONE, ONE ROUND, LOT AW, CHARGE 7, VT**.
3	The RATELO sends the MTO **H, VT, ONE SWEEP AND ZONE, AB1053**.
4	The fire direction NCO determines the number of deflections to fire: **TGT WIDTH ÷ SHEAF WIDTH = NUMBER OF DEFLECTIONS** **600 ÷ 200 = 3**
5	The operations chief determines the deflection shift: $\frac{\text{SHEAF WIDTH}}{\text{CHART RANGE IN 1000s}} = \text{DF SHIFT}$ $\frac{200}{11.39} = 18$
6	The fire direction NCO determines the number of quadrants to fire: **TGT DEPTH ÷ SHEAF DEPTH = NUMBER OF QUADRANTS** **300 ÷ 50 = 6** The fire direction NCO expresses the result to the next higher odd number. **(7)**
7	The fire direction NCO determines the quadrant shift: **EL AT CHART RG + SHEAF DEPTH OR** **EL ~ RG (11390 + 50) 11440 412** **- EL AT CHART RG 11390 -408** **ZONE 4**
8	The computer announces initial fire commands **FIRE MISSION, PLATOON 1**.
9	The fire direction NCO directs the computer to announce **SWEEP, 18 MILS, 3 DEFLECTIONS, ZONE, 4 MILS, 7 QUADRANTS**.
10	The computer determines the remainder of the fire commands: **LOT AW, CHARGE 7, FUZE VT, TIME 34.0, DEFLECTION (drift L12 + GFT df corr R11 + cht df 3121) 3213, QUADRANT ELEVATION (si (+6) + el 406) 412**.
11	The number of rounds that will be expended is: **NUMBER OF QEs 7** **X NUMBER OF DFs 3** **NUMBER OF SHEAFS 21** **X RDS PER SHEAF 4** **RDS FIRED 84**



RECORD OF FIRE

CALL FOR FIRE

Observer T13 AF [✓ FFE] IS/S Tgt

Grid: 382 275

Polar: Dir Dis U/D VA

Shift: Dir L/R +/- U/D

BN ASSY AREA LENGTH 600, WIDTH 300 ATTITUDE 0800, ICM

TGT ALT 1120
-PLT ALT 1062
VI +58 ΔRIFT L12
+GFT R11

∡ Si ÷ 10

10m Si

△ FS

100/R 9

/R

20/R 2

HOB Corr

FIRE ORDER SWEEP + ZONE ① LOT AW CHG 7 FZ VT

Df Corr L1

Si +6

INITIAL FIRE COMMANDS ~~FM~~ MF PLT ①

Rg 11390

Cht Df 3212

El 408

Sp Instr SWEEP 18m, 3ΔF's, ZONE 4m, 7QE's

Sh

Lot AW

Chg 7

Fz VT

Ti 34.0

Df 3213

QE 414

MTO H, VT, ①, SWEEP + ZONE, AB 1053

∡ T

PER (<38)

TF (35)

In Eff

Ammo Exp ⑧④ VT ✓

Tgt	Location	Priority ✓	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ( )	Df Fired	Chart Rg	HOB Corr	Si ( )	El	QE	Exp	Type
				TGT WIDTH	=		600	= 3ΔF			#QE		7			
				SHEAF WIDTH	=		200			x	#ΔF		3			
											#SHEAFS		21			
				SHEAF WIDTH	=		200	= 18m		x	RDS/SHEAF		4			
				RG IN 1000's	=		11				RDS FIRED		84			
				TGT DEPTH	=		300	=	6 ≈ 7QE							
				SHEAF DEPTH	=		50									
				EL ~ CHT RG + SHEAF DEPTH				11440 = 412								
				EL ~ CHT RG				11390 = 408								
									4m							

GFT 1/A CHG 7 LOT AW RG 10000 EL 325 TI 29.1

TOT ΔF CORR R2

GFT ΔF CORR R11

ASSY AREA DEST EST 50 CAS

Btry 1/A

DTG 291415Z JUN 94

Tgt AB1053

Replot Grid

Replot Alt

Figure H-19. Record of Fire (Sweep and Zone Fire Mission).

Appendix I

SMOKE TABLES

This appendix contains the tables for firing smoke missions.

Table I-1. M825 Munition Expenditure Table (Near Infrared, 80%Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5	5/3	5/2	7	7/5	8/3	9	9/7	10/4	11	11/9	12/5	15	15/13	16/7	5
B	3-6	5	5/3	5/2	7	7/5	7/3	8	8/6	9/4	10	10/8	11/5	14	14/12	16/7	5
	6-10	5	5/3	6/2	7	7/5	8/3	9	9/7	10/4	11	11/9	12/5	15	15/13	16/7	5
C	0-8	4	4/3	4/2	5	5/4	6/3	7	6/7	8/4	8	8/7	10/5	12	12/11	14/7	5
	9-10	4	4/3	5/2	6	6/5	7/3	8	8/7	9/4	10	10/9	11/5	14	14/13	15/7	5
	11-15	4/2	4/2	5/2	6/2	6/2	7/2	9/2	9/2	9/2	11/2	11/2	11/2	15/2	15/2	16/2	1.5
D	6-10	4	4/3	4/2	6	6/5	7/3	8	8/7	9/4	9	9/8	11/5	13	13/12	15/7	5
	12	4/2	4/2	5/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/2	11/2	14/2	14/2	15/2	1.5
	16	4/2	4/2	5/2	6/2	6/2	7/2	9/2	9/2	9/2	11/2	11/2	11/2	15/2	15/2	16/2	1.5
E	4-5	2	2	3/2	3	3/2	3/2	4	4/3	6/3	5	5/4	8/4	8	8/7	11/6	5
	6-9	3	3/2	3/2	4	4/3	5/3	6	6/5	7/4	7	7/6	9/5	10	10/9	13/7	5
F	1-3	2	2	2	4	4/3	4/2	5	5/4	5/3	6	6/5	6/3	9	9/8	9/5	5
	4-5	2	2	2	3	3/2	4/2	3	3/2	5/3	6	6/5	7/4	8	8/7	9/5	5
HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
B	3-6	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
	6-10	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	14/2	*	*	*	2
C	0-8	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	9-10	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	11-15	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/2	11/2	15/8	15/8	15/9	*	*	*	1
D	6-10	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	12	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/2	11/2	14/2	14/2	14/2	*	*	*	1
	16	5/3	5/3	5/3	8/4	8/4	8/5	11/6	11/6	11/6	14/7	14/8	14/8	*	*	*	1
E	4-5	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
	6-9	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
F	1-3	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
	4-5	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2

* Exceeds 16 rounds.

Table I-2. M825 Munition Expenditure Table (Near Infrared, 50% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5	5/3	6/2	8	8/6	8/3	10	10/8	10/4	12	12/10	12/5	16	16/14	*	5
B	3-6	5	5/3	6/2	7	7/5	8/3	9	9/7	10/4	11	11/9	12/5	15	15/13	16/7	5
	6-10	6	6/4	6/2	8	8/6	8/3	10	10/8	10/4	12	12/10	12/5	16	16/14	16/7	5
C	0-8	4	4/3	4/2	6	6/5	7/3	8	8/7	9/4	10	10/9	11/5	14	14/13	15/7	5
	9-10	5	5/4	5/2	7	7/6	7/3	9	9/8	9/4	11	11/10	11/5	15	15/14	16/8	5
	11-15	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	11/2	11/2	11/2	15/2	15/2	16/2	1.5
D	6-10	4	4/3	5/2	6	6/5	7/3	8	8/7	9/4	11	11/10	11/5	15	15/14	16/8	5
	12	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	11/2	11/2	11/2	15/2	15/2	16/2	1.5
	16	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	11/2	11/2	11/2	15/2	15/2	16/2	1.5
E	4-5	3	3/2	3/2	4	4/3	5/3	6	6/5	7/4	8	8/7	9/5	11	11/10	13/7	5
	6-9	3	3/2	4/2	5	5/4	6/3	7	7/6	8/4	9	9/8	10/5	13	13/12	14/7	5
F	1-3	2	2	3/2	4	4/3	5/3	4	4/3	6/3	6	6/5	8/4	8	8/7	12/6	5
	4-5	2	2	3/2	4	4/3	5/3	5	5/4	7/4	6	6/5	9/5	9	9/8	12/6	5

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
B	3-6	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
	6-10	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2				2
C	0-8	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	9-10	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2				2
	11-15	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/2	11/2	15/8	15/8	15/9				1
D	6-10	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	12	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/2	11/2	14/2	14/2	14/2				1
	16	5/3	5/3	5/3	8/4	8/4	8/5	11/6	11/6	11/6	14/7	14/8	14/8				1
E	4-5	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
	6-9	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2				2
F	1-3	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
	4/5	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2				2

* Exceeds 16 rounds.

Table I-3. M825 Munition Expenditure Table (Near Infrared, 20% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	6	6/4	6/2	8	8/6	8/3	10	10/8	10/4	12	12/10	12/5	16	16/14	*	5
B	3-6	5	5/3	6/2	7	7/5	8/3	10	10/8	10/4	12	12/10	12/5	16	16/14	*	5
	6-10	6	6/4	6/2	8	8/6	8/3	10	10/8	10/4	12	12/10	12/5	16	16/14	*	5
C	0-8	4	4/3	5/2	6	6/5	7/3	8	8/7	9/4	10	10/9	11/5	14	14/13	15/7	5
	9-10	5	5/4	5/2	7	7/6	7/3	9	9/8	9/4	11	11/10	11/5	15	15/14	16/8	5
	11-15	5/4	5/4	5/4	8/7	8/7	8/7	11/10	11/9	11/10	13/12	13/11	13/12	*	*	*	1.5
D	6-10	4	4/3	5/2	7	7/6	7/3	9	9/8	9/4	11	11/10	11/5	15	15/4	16/8	5
	12	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	11/2	11/2	11/2	15/2	15/2	16/2	1.5
	16	5/4	5/4	5/4	8/7	8/7	8/7	10/9	10/8	10/9	13/12	13/11	13/12	*		*	1.5
E	4-5	3	3/2	3/2	5	5/4	5/3	6	6/5	8/4	8	8/7	10/5	12	12/11	14/7	5
	6-9	3	3/2	4/2	5	5/4	6/3	7	7/6	8/4	9	9/8	10/5	13	13/12	14/7	5
F	1-3	2	2	3/2	4	4/3	5/3	5	5/4	7/4	7	7/6	9/5	9	9/8	13/7	5
	4-5	3	3/2	3/2	4	4/3	5/3	6	6/5	7/4	7	7/6	9/5	10	10/9	13/7	5

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
B	3-6	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
	6-10	6/2	6/2	6/2	9/2	9/2	9/2	12/2	12/3	12/2	15/2	15/3	15/2	*	*	*	2
C	0-8	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	9-10	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	11-15	6/3	6/3	6/3	9/5	9/5	9/5	12/6	12/7	12/7	15/8	15/8	15/9	*	*	*	1
D	6-10	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/3	11/2	14/2	14/3	14/2	*	*	*	2
	12	5/2	5/2	5/2	8/2	8/2	8/2	11/2	11/2	11/2	14/2	14/2	14/2	*	*	*	1
	16	5/3	5/3	5/3	8/4	8/4	8/5	11/6	11/6	11/6	14/7	14/8	14/8	*	*	*	1
E	4-5	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
	6-9	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
F	1-3	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2
	4/5	4/2	4/2	4/2	7/2	7/2	7/2	10/2	10/3	10/2	13/2	13/3	13/2	*	*	*	2

* Exceeds 16 rounds.

Table I-4. M825 Munition Expenditure Table (Visible, 80% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5	5/3	5/2	6	6/4	7/3	8	8/6	9/4	10	10/8	11/5	13	13/11	15/7	5
B	3-6	4	4/2	5/2	6	6/4	7/3	7	7/5	9/4	8	8/6	10/4	11	11/9	14/6	5
	6-10	5	5/3	5/2	7	7/5	7/3	8	8/6	9/4	10	10/8	11/5	13	13/11	15/7	5
C	0-8	3	3/2	4/2	4	4/3	5/2	5	5/4	7/3	6	6/5	9/4	9	9/8	12/6	5
	9-10	4	4/3	4/2	6	6/5	6/3	7	7/6	8/4	9	9/8	10/5	12	12/11	14/7	5
	11-15	4/2	4/2	4/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/3	11/2	13/2	13/4	15/3	2.5
D	6-10	3	3/2	4/2	5	5/4	6/3	6	6/5	8/4	8	8/7	10/5	10	10/9	13/6	5
	12	4/2	4/2	4/2	5/2	5/2	6/2	7/2	7/2	8/2	9/2	9/3	10/2	12/2	12/4	14/3	2.5
	16	4/2	4/2	4/2	6/2	6/2	7/2	8/2	8/2	9/2	9/2	9/3	11/2	13/2	13/4	15/3	2.5
E	4-5	2	2	2	3	3/2	3/2	4	4/3	5/3	6	6/5	6/3	8	8/7	8/4	5
	6-9	2	2	3/2	3	3/2	4/2	4	4/3	6/3	5	5/4	7/4	7	7/6	7/6	5
F	1-3	2	2	2	2	2	2	3	3/2	3/2	4	4/3	4/2	5	5/4	5/3	5
	4-5	2	2	2	2	2	2	3	3/2	3/2	4	4/3	4/2	6	6/5	6/3	5

HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
B	3-6	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
	6-10	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
C	0-8	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	9-10	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	11-15	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	14/2	1.5
D	6-10	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	12	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
	16	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
E	4-5	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
	6-9	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
F	1-3	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
	4-5	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2

Table I-5. M825 Munition Expenditure Table (Visible, 50% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5	5/3	5/2	7	7/5	7/3	8	8/6	9/4	10	10/8	11/5	14	14/12	15/7	5
B	3-6	5	5/3	5/2	6	6/4	7/3	8	8/6	9/4	9	9/7	11/5	12	12/10	15/7	5
	6-10	5	5/3	5/2	7	7/5	7/3	9	9/7	10/4	10	10/8	12/5	14	14/12	16/7	5
C	0-8	3	3/2	4/2	5	5/4	6/3	6	6/5	7/3	7	7/6	9/4	10	10/9	13/6	5
	9-10	4	4/3	4/2	6	6/5	6/3	8	8/7	9/4	9	9/8	10/5	12	12/11	14/7	5
	11-15	4/2	4/2	5/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/3	11/2	14/2	14/4	15/3	2.5
D	6-10	4	4/3	4/2	5	5/4	6/3	7	7/6	8/4	8	8/7	10/5	11	11/10	14/7	5
	12	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	9/2	9	9/3	11/2	13/2	13/4	15/3	2.5
	16	4/2	4/2	5/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/3	11/2	14/2	14/4	15/3	2.5
E	4-5	2	2	2	3	3/2	4/2	3	3/2	5/3	6	6/5	7/4	8	8/7	9/5	5
	6-9	2	2	3/2	3	3/2	3/2	4	4/3	6/3	6	6/5	8/4	8	8/7	11/6	5
F	1-3	2	2	2	3	3/2	3/2	3	3/2	3/2	4	4/3	4/2	6	6/5	6/3	5
	4-5	2	2	2	3	3/2	3/2	4	4/3	4/2	5	5/4	5/3	7	7/6	7/4	5

HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
B	3-6	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
	6-10	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
C	0-8	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	9-10	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	11-15	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
D	6-10	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	12	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
	16	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
E	4-5	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
	6-9	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
F	1-3	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
	4-5	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2

Table I-6. M825 Munition Expenditure Table (Visible, 20% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5	5/3	5/2	7	7/5	8/3	9	9/7	10/4	11	11/9	12/5	15	15/13	16/7	5
B	3-6	5	5/3	5/2	7	7/5	7/3	8	8/6	9/4	10	10/8	11/5	13	13/11	15/7	5
	6-10	5	5/3	6/2	7	7/5	8/3	9	9/7	10/4	11	11/9	12/5	15	15/13	16/7	5
C	0-8	4	4/3	4/2	5	5/4	6/3	7	7/6	8/4	8	8/7	10/5	11	11/10	14/7	5
	9-10	4	4/3	5/2	6	6/5	7/3	8	8/7	9/4	10	10/9	11/5	14	14/13	15/7	5
	11-15	4/2	4/2	5/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/3	11/2	15/2	15/5	15/3	2.5
D	6-10	4	4/3	4/2	6	6/5	6/3	7	7/6	9/4	9	9/8	11/5	13	13/12	15/7	5
	12	4/2	4/2	5/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/3	11/2	14/2	14/4	15/3	2.5
	16	4/2	4/2	5/2	6/2	6/2	7/2	8/2	8/2	9/2	10/2	10/3	11/2	15/2	15/5	15/3	2.5
E	4-5	2	2	3/2	3	3/2	4/2	4	4/3	6/3	5	5/4	8/4	7	7/6	11/6	5
	6-9	3	3/2	3/2	4	4/3	5/3	5	5/4	7/4	7	7/6	9/5	10	10/9	13/7	5
F	1-3	2	2	2	3	3/2	3/2	4	4/3	4/2	6	6/5	6/3	8	8/7	8/4	5
	4-5	2	2	2	3	3/2	4/2	4	4/3	5/3	6	6/5	6/3	8	8/7	9/5	5
HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		250			500			750			1000			1500			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN															FIRE INTERVAL (MINUTES)
A	2-5	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
B	3-6	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
	6-10	5/2	5/2	5/2	7/2	7/2	7/2	9/2	9/2	9/2	12/2	12/3	12/2	16/2	16/4	16/2	2
C	0-8	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	9-10	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	11-15	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
D	6-10	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/3	11/2	15/2	15/4	15/2	2
	12	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
	16	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	11/2	11/2	11/2	15/2	15/2	15/2	1.5
E	4-5	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
	6-9	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
F	1-3	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2
	4-5	3/2	3/2	3/2	5/2	5/2	5/2	7/2	7/2	7/2	10/2	10/3	10/2	14/2	14/4	14/2	2

Table I-7. M116 HC Munition Expenditure Table (Near Infrared, 80% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			6/2			8/2			10/2			14/4			2
B	3-6	4/2			4/2	6/2	6/2	6/2	8/2	8/2	8/2	10/2	10/2	12/2			2
	6-10	2			4/2			6/2			6/4			8/4			
C	0-8	4/2			6/2			8/2	4	4	10/2			12/2	6/4	6	2
	9-10	2			4/2			4/2			4			6/4			
	11-15	2			4/2	4/2	4	4			4			6/4			
D	6-10	2			4/2			4/2			6/2			6/4			2
	12	2			2			4			4			4			
	16	2			2			4/2			4			4			
E	4-5	2			4/2			6/2			8/2			10/2			2
	6-9	2			4/2			4/2			6/2			6/2			
F	1-3	6/2			8/2			10/2			12/2			14/2			2
	4-5	2			4/2			6/2			8/2			10/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			10			12			14			2
B	3-6	4			6			8			10			12			2
	6-10	4			6			8			10			12			
C	0-8	4			6			8			10			12			2
	9-10	4			6			8			10			10			
	11-15	4			6			8			10			14			
D	6-10	4			4			6			6			8			2
	12	2			4			6			8			10			
	16	4			6			8			10			12			
E	4-5	2			4			6			8			10			2
	6-9	2			4			4			6			6			
F	1-3	4			8			12			16			*			2
	4-5	2			4			6			8			10			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-8. M116 HC Munition Expenditure Table (Near Infrared, 50% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			4			8/4			10/4			12/6			2
B	3-6	2			4/2			6/4			8/4			10/4			2
	6-10	2			4/2	4	4	4			6/4	6	6	6			
C	0-8	4/2			6/2			8/2			8/4			10/4	6	6	2
	9-10	2			2			4			4			6/4	8/6	8	
	11-15	2			4/2	4/2	4	4			6			8/6			
D	6-10	2			4/2			4			4			6/4			2
	12	2			4/2	4	4	4			4			6/4	6/4	6	
	16	4/2	4/2	4	4			6/4	6/4	6	6			8/6	8/6	8	
E	4-5	2			4/2			6/2			8/2			10/2			2
	6-9	2			4/2			4/2			6/2			6/4			
F	1-3	6/2			8/2			10/2			12/2			14/2			2
	4-5	2			4/2			6/2			8/2			10/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			10			12			14			2
B	3-6	4			6			8			10			12			2
	6-10	6/4			10/8			12			16			*			
C	0-8	4			6			8			10			12			2
	9-10	6			8			12			14			*			
	11-15	6			12			16			*			*			
D	6-10	4			6			6			8			10			2
	12	4			8			10			12			16			
	16	6			10			14			16			*			
E	4-5	4			6			8			10			12			2
	6-9	2			4			4			6			8			
F	1-3	6			10			14			*			*			2
	4-5	4			6			8			10			12			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-9. M116 HC Munition Expenditure Table (Near Infrared, 20% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			6/2			8/2			10/2			14/4			2
B	3-6	4/2	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	10/2	10/2	12/2			2
	6-10	2			4/2			6/2	4	4	6/4			8/4			
C	0-8	4/2			6/2			8/2			10/2			12/2			2
	9-10	2			4/2			4/2			4			6/4	6/4	6	
	11-15	2			4/2	4/2	4	4			4			6/4			
D	6-10	2			4/2			4/2			6/2			6/2			2
	12	2			2			4			4			4			
	16	2			2			4/2			4			4			
E	4-5	2			4/2			6/2			8/2			6/4			2
	6-9	2			4/2			4/2			6/2			6/2			
F	1-3	6/2			8/2			10/2			12/2			14/2			2
	4-5	2			4/2			6/2			8/2			10/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			10			12			14			2
B	3-6	4			6			8			10			12			2
	6-10	4			6			8			10			12			
C	0-8	4			6			8			10			12			2
	9-10	4			6			8			10			10			
	11-15	4			6			8			10			14			
D	6-10	4			4			6			6			8			2
	12	2			4			6			8			10			
	16	4			6			8			10			12			
E	4-5	2			4			6			8			10			2
	6-9	2			4			4			6			6			
F	1-3	4			8			12			16			*			2
	4-5	2			4			6			8			10			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-10. M116 HC Munition Expenditure Table (Visible, 80% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			6/2			8/2			10/2			14/2			2
B	3-6	2	4/2	4/2	4/2	6/2	6/2	6/2	8/2	8/2	8/2	10/2	10/2	12/2			2
	6-10	2	4/2	4/2	4/2			6/2			6/2	6/4	6/4	6/4			
C	0-8	4/2			6/2			8/2			10/2			12/2			2
	9-10	2			2	4/2	4/2	4/2	4/2	4	6/2			6/4			
	11-15	2			2			4/2			4			6/4			
D	6-10	2			4/2			4/2			6/2			6/2			2
	12	2			2			4/2			4			4			
	16	2			2			4/2			4			4			
E	4-5	2			4/2			6/2			8/2			10/2			2
	6-9	2			4/2			4/2			6/2			6/2			
F	1-3	6/2			8/2			10/2			12/2			14/2			2
	4-5	2			4/2			6/2			8/2			10/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			8			12			14			2
B	3-6	2			6			8			10			12			2
	6-10	4			4			6			8			10			
C	0-8	4			6			8			10			12			2
	9-10	4			4			6			8			8			
	11-15	2			4			6			8			10			
D	6-10	2			4			6			6			8			2
	12	2			4			4			6			8			
	16	4			6			6			8			10			
E	4-5	2			4			6			8			10			2
	6-9	2			4			4			6			6			
F	1-3	4			8			12			16			*			2
	4-5	2			4			6			8			10			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-11. M116 HC Munition Expenditure Table (Visible, 50% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			6/2			8/4			10/4			12/4			2
B	3-6	2			4/2			6/2			8/4			10/4			2
	6-10	2			4/2	4/2	4	4			6/4			6/4			
C	0-8	4/2			6/2			8/2	4	4	10/2			12/2			2
	9-10	2			2			4/2	4	4	4			6/4			
	11-15	2			2			4/2			4/2	4	4	4			
D	6-10	2			4/2			4/2	4/2	4	6/2			6/4			2
	12	2			4/2			4/2	4	4	4/2	4	4	4			
	16	2			4/2	4/2	4	4/2			4			4			
E	4-5	2			4/2			6/2			8/2			10/2			2
	6-9	2			4/2			4/2			6/2			6/2			
F	1-3	6/2			8/2			10/2			12/2			14/2			2
	4-5	2			4/2			6/2			8/2			10/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			10			12			14			2
B	3-6	4			6			8			10			12			2
	6-10	4			6			8			10			12			
C	0-8	4			6			8			10			12			2
	9-10	4			8			8			10			10			
	11-15	4			8/6			10			12			16			
D	6-10	2			4			6			6			8			2
	12	4			4			6			8			10			
	16	4			6			8			10			12			
E	4-5	4			6			8			10			12			2
	6-9	2			4			4			6			6			
F	1-3	6/2			10/2			14/2			*						2
	4-5	4			6			8			10			12			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.
*Exceeds 16 rounds.

Table I-12. M116 HC Munition Expenditure Table (Visible, 20% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			6/2			8/4			10/4			12/4			2
B	3-6	2			4			6/4			8/4			10/6			2
	6-10	2			4/2			4			6/4			6			
C	0-8	4/2			6/2			8/2	4/2	4	10/2			10/4			2
	9-10	2			2			4/2			4			6/4	6/4	6	
	11-15	2			2			4			4			6/4			
D	6-10	2			4/2			4/2			6/4			6/4			2
	12	2			2			4/2			4			4			
	16	2			2			4			4			6/4			
E	4-5	2			4/2			6/2			8/2			10/2			2
	6-9	2			4/2			6/2			6/2			6/4			
F	1-3	6/2			8/2			10/4			12/2			14/2	14/2	16/2	2
	4-5	2			4/2			6/2			8/2			10/2			

HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	6			6			10			12			14			2
B	3-6	4			6			8			10			12			2
	6-10	4			8			10			12			14			
C	0-8	4			6			8			10			12			2
	9-10	4			8			8			10			12			
	11-15	6			8			10			14			*			
D	6-10	4			6			8			10			12			2
	12	4			6			8			10			12			
	16	4			8			10			12			16			
E	4-5	4			6			8			10			12			2
	6-9	2			4			4			6			6			
F	1-3	6			10			14			*			*			2
	4-5	4			6			8			10			12			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-13. M84A1 HC Munition Expenditure Table (Visible, 80% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			7			9			12			15			2
B	3-6	4			6			8			10			12			2
	6-10	4			11			15			*			*			
C	0-8	4/2			6/4			8/5			10/6			12/8			2
	9-10	6			10			15			*			*			
	11-15	8			15			*			*			*			
D	6-10	4			6			8			10			12			2
	12	5			9			13			*			*			
	16	8			14			*			*			*			
E	4-5	3/2			5/2			7/2			9/3			11/3			2
	6-9	3/2			4			5			6			7			
F	1-3	6/2			10/2			14/2			*			*			2
	4-5	3/2			5/2			7/2			9/2			11/2			

HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	11			*			*			*			*			2
B	3-6	10			*			*			*			*			2
	6-10	*			*			*			*			*			
C	0-8	6			11			16			*			*			2
	9-10	*			*			*			*			*			
	11-15	*			*			*			*			*			
D	6-10	10			*			*			*			*			2
	12	16			*			*			*			*			
	16	*			*			*			*			*			
E	4-5	3			5			7			9			11			2
	6-9	5			9			13			*			*			
F	1-3	6			10			14			*			*			2
	4-5	3			5			7			9			11			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.
*Exceeds 16 rounds.

Table I-14. M84A1 HC Munition Expenditure Table (Visible, 50% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	5			9			13			*			*			2
B	3-6	5			8			11			15			*			2
	6-10	8			15			*			*			*			
C	0-8	4			6			8			10			12			2
	9-10	8			15			*			*			*			
	11-15	12			*			*			*			*			
D	6-10	5			8			12			15			*			2
	12	8			14			*			*			*			
	16	11			*			*			*			*			
E	4-5	3/2			5/2			7/3			9/4			11/5			2
	6-9	3			5			7			8			10			
F	1-3	6/2			10/2			14/2			*			*			2
	4-5	3/2			5/2			7/2			9/2			11/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	16			*			*			*			*			2
B	3-6	14			*			*			*			*			2
	6-10	*			*			*			*			*			
C	0-8	9			*			*			*			*			2
	9-10	*			*			*			*			*			
	11-15	*			*			*			*			*			
D	6-10	14			*			*			*			*			2
	12	*			*			*			*			*			
	16	*			*			*			*			*			
E	4-5	4			7			10			13			16			2
	6-9	8			14			*			*			*			
F	1-3	6			10			14			*			*			2
	4-5	3			5			7			9			11			

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-15. M84A1 HC Munition Expenditure Table (Visible, 20% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	6			10			15			*			*			2
B	3-6 6-10	5 10			9 *			13 *			* *			* *			2
C	0-8 9-10 11-15	4 10 14			6 * *			9 * *			11 * *			14 * *			2
D	6-10 12 16	6 9 13			10 * *			14 * *			* * *			* * *			2
E	4-5 6-9	3/2 4			5/3 6			7/4 8			9/5 10			11/6 12			2
F	1-3 4-5	6/2 3/2			10/2 5/2			14/2 7/2			* 9/2			* 11/3			2
HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		200			400			600			800			1000			
SCREEN TIME (MINUTES)		4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	*			*			*			*			*			2
B	3-6 6-10	16 *			* *			* *			*			*			2
C	0-8 9-10 11-15	11 * *			* * *			* * *			* * *			* * *			2
D	6-10 12 16	* * *			* * *			* * *			* * *			* * *			2
E	4-5 6-9	5 9			9 *			12 *			16 *			* *			2
F	1-3 4-5	6 3			10 5			14 7			* 9			* 11			2

[1] 6 and 8 minute screens not shown require the same number of initial and/or sustaining rounds as a 4 minute screen requires.

*Exceeds 16 rounds.

Table I-16. M110 WP Munition Expenditure Table (Near Inrared, 80% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			8			10/8			12/10			60
B	3-6	4			6/4			6/4			6			8/6			60
	6-10	4			6/4			8/4			8/6			8			40
C	0-8	4/2			4/2			6/4			6/4			8/6			40
	9-10	4/2			4/2			6/4			6/4			6			
	11-15	4/2			4			6/4			6/4			8/6			
D	6-10	4/2			4/2			4			4			6/4			40
	12	4/2			4/2			6/4			6/4			6			
	16	4/2			4/2			6/2			4			6			
E	4-5	2			2			4/2			4/2			4/2			40
	6-9	2			4/2			4/2			4/2			4			
F	1-3	2			2			2			4/2			4/2			40
	4-5	2			2			2			2			4/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	8			10			10			12			16			40
B	3-6	6			8			8			10			12			40
	6-10	6			8			8			10			12			
C	0-8	4			6			6			8			8			60
	9-10	6			6			6			8			8			40
	11-15	6			6			6			8			10			
D	6-10	4			6			6			6			8			40
	12	4			6			6			6			8			
	16	6			6			6			6			8			
E	4-5	4			4			4			4			4			60
	6-9	4			4			4			4			6			
F	1-3	4			4			4			4			4			60
	4-5	4			4			4			4			4			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

Table I-17. M110 WP Munition Expenditure Table (Near Inrared, 50% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	8/4			10/8			14/12			*			*			40
B	3-6	6/4			8/6			10/8			12/10			16/14			40
	6-10	6/4			8/6			10/8			12/10			16/14			
C	0-8	4			6/4			8/6			8			12/10			40
	9-10	4			6/4			8/6			8			12/10			
	11-15	4			6/4			8/6			8			12/10			
D	6-10	4/2			4			6/4			6			8			40
	12	4/2			4			6/4			6			8			
	16	4/2			4			6/4			6			8			
E	4-5	2			2			4			4			6			40
	6-9	2			2			4			4			6			
F	1-3	2			2			2			2			4			40
	4-5	2			2			2			4			4			

HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	10			12			16			*			*			40
B	3-6	8			10			12			14			*			40
	6-10	8			10			12			14			*			
C	0-8	6			8			8			10			12			60
	9-10	6			8			10			10			14			40
	11-15	6			8			10			10			14			
D	6-10	4			6			8			8			10			40
	12	6			6			8			8			10			
	16	6			6			8			8			10			
E	4-5	4			4			6			6			6			60
	6-9	4			4			6			6			6			
F	1-3	4			4			4			4			6			60
	4-5	4			4			4			4			6			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

* Exceeds 16 rounds.

Table I-18. M110 WP Munition Expenditure Table (Near Inrared, 20% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	8/6			12/10			16/14			*			*			40
B	3-6	6/4			8			12/10			14/12			*			40
	6-10	6/4			8			12/10			14/12			*			
C	0-8	4			6			8			10/8			12			40
	9-10	4			6			8			10			14/12			
	11-15	4			6			8			10			14/12			
D	6-10	4			6/4			6			6			10			40
	12	4			6/4			6			6			10			
	16	4			6/4			6			8/6			10			
E	4-5	2			4			4			4			6			40
	6-9	2			4			4			6			6			
F	1-3	2			2			2			4			4			40
	4-5	2			2			2			4			4			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	10			14			*			*			*			40
B	3-6	8			12			14			*			*			40
	6-10	8			12			14			16			*			
C	0-8	6			8			10			12			16			60
	9-10	6			8			10			12			16			40
	11-15	6			8			10			12			16			
D	6-10	4			8			8			10			12			40
	12	6			8			8			10			12			
	16	6			8			8			10			12			
E	4-5	4			4			6			6			8			60
	6-9	4			6			6			6			8			
F	1-3	4			4			4			6			6			60
	4-5	4			4			4			6			6			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

* Exceeds 16 rounds.

Table I-19. M110 WP Munition Expenditure Table (Visible, 80% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			4			6/4			6			8			60
B	3-6	4/2			4			4			6/4			6			60
	6-10	4/2			4			4			6/4			6			40
C	0-8	2			4/2			4			4			6/4			40
	9-10	4/2			4/2			4			4			6/4			
	11-15	4/2			4/2			4/2			4			4			
D	6-10	2			2			4/2			4/2			4			40
	12	2			4/2			4/2			4			4			
	16	2			4/2			4/2			4			6/4			
E	4-5	2			2			2			2			4/2			60
	6-9	2			2			4/2			4/2			4			
F	1-3	2			2			2			2			2			60
	4-5	2			2			2			2			4/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	6			8			8			8			10			60
B	3-6	6			6			6			8			8			60
	6-10	6			6			8			8			8			40
C	0-8	4			4			6			6			6			60
	9-10	4			4			6			6			6			40
	11-15	4			6			6			6			6			
D	6-10	4			4			6			6			6			40
	12	4			4			6			6			6			
	16	6			6			6			6			6			
E	4-5	4			4			4			4			4			60
	6-9	4			4			4			4			6			
F	1-3	2			4			4			4			4			60
	4-5	4			4			4			4			4			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

Table I-20. M110 WP Munition Expenditure Table (Visible, 50% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4/2			4			6			8/6			10/6			60
B	3-6	4/2			4			4			6/4			6			60
	6-10	4/2			4			6/4			6/4			8/6			40
C	0-8	2			4/2			4			4			6/4			40
	9-10	4/2			4/2			4			4			6/4			
	11-15	4/2			4/2			4			4			6/4			
D	6-10	2			4/2			4/2			4/2			4			40
	12	2			4/2			4/2			4			4			
	16	2			4/2			4/2			4			6/4			
E	4-5	2			2			2			2			4/2			60
	6-9	2			2			4/2			4/2			4			
F	1-3	2			2			2			2			2			60
	4-5	2			2			2			2			4/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	6			8			8			10			12			60
B	3-6	6			6			8			8			10			60
	6-10	6			6			8			8			10			40
C	0-8	4			6			6			6			8			40
	9-10	6			6			6			6			8			
	11-15	6			6			6			6			8			
D	6-10	4			4			6			6			6			40
	12	4			6			6			6			8			
	16	4			6			6			6			8			
E	4-5	4			4			4			4			6			60
	6-9	4			4			4			4			6			
F	1-3	2			4			4			4			4			60
	4-5	4			4			4			4			4			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

Table I-21. M110 WP Munition Expenditure Table (Visible, 20% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	4			6			8/6			10/8			12			60
B	3-6	4/2			4			6/4			6			8			60
	6-10	4			6/4			6			8/6			10/8			40
C	0-8	2			4/2			4			6/4			6			40
	9-10	4/2			4			4			6/4			6			
	11-15	4/2			4			4			6/4			6			
D	6-10	2			4/2			4/2			4			6/4			40
	12	4/2			4/2			4			4			6/4			
	16	4/2			4/2			4			4			6/4			
E	4-5	2			2			2			2			4/2			60
	6-9	2			2			4/2			4/2			4			
F	1-3	2			2			2			2			2			60
	4-5	2			2			2			2			4/2			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	8			8			10			12			16			60
B	3-6	6			8			8			10			12			60
	6-10	6			8			8			10			12			40
C	0-8	4			6			6			8			8			60
	9-10	6			6			6			8			8			40
	11-15	6			6			6			8			8			
D	6-10	4			6			6			6			8			40
	12	6			6			6			6			8			
	16	6			6			6			6			8			
E	4-5	4			4			4			4			6			60
	6-9	4			4			4			4			6			
F	1-3	4			4			4			4			6			40
	4-5	4			4			4			4			6			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

Table I-22. M60A2 WP Munition Expenditure Table (Visible, 80% Relative Humidity).

CROSSWIND																
SCREEN WIDTH (METERS)		100			200			300			400			600		
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	8/6			13/11			*			*			*			40
B	3-6	6/4			9/7			12/10			15/13			*			40
	6-10	6/4			9/7			12/10			15/13			*			
C	0-8	4/3			6/5			8/7			10/9			13/12			60
	9-10	4/3			6/5			8/7			10/9			12/12			40
	11-15	4/3			6/5			8/7			10/9			13/12			40
D	6-10	4/3			5/4			6/5			7/6			9/8			40
	12	4/3			5/4			6/5			7/6			9/8			
	16	4/3			5/4			6/5			7/6			9/8			
E	4-5	2			2			3			4			5			30
	6-9	2			3			3			4			5			
F	1-3	2			2			2			2			3			30
	4-5	2			2			2			3			4			

HEAD OR TAIL WIND																
SCREEN WIDTH (METERS)		100			200			300			400			600		
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	10			15			*			*			*			40
B	3-6	8			11			14			*			*			40
	6-10	8			11			14			*			*			
C	0-8	6			8			10			12			15			60
	9-10	6			8			10			12			15			40
	11-15	6			8			10			12			15			
D	6-10	6			7			8			9			11			40
	12	6			7			8			9			11			
	16	6			7			8			9			11			
E	4-5	4			4			5			6			7			30
	6-9	4			5			5			6			7			
F	1-3	4			4			4			4			5			30
	4-5	4			4			4			5			6			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

* Exceeds 16 rounds.

Table I-23. M60A2 WP Munition Expenditure Table (Visible, 50% Relative Humidity).

CROSSWIND																	
SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	10/8			16/14			*			*			*			40
B	3-6	7/5			11/9			14/12			*			*			40
	6-10	7/5			11/9			14/12			*			*			
C	0-8	5/4			7/6			9/8			12/11			16/15			60
	9-10	5/4			7/6			9/8			12/11			16/15			
	11-15	5/4			7/6			9/8			12/11			16/15			
D	6-10	4/3			5/4			7/6			8/7			11/10			60
	12	4/3			5/4			7/6			8/7			11/10			
	16	4/3			5/4			7/6			8/7			11/10			
E	4-5	2			3			4			5			6			30
	6-9	2			3			4			5			7			
F	1-3	2			2			2			3			4			30
	4-5	2			2			3			3			4			

HEAD OR TAIL WIND																	
SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	12			*			*			*			*			40
B	3-6	9			13			16			*			*			40
	6-10	9			13			16			*			*			
C	0-8	7			9			11			14			*			60
	9-10	7			9			11			14			*			40
	11-15	7			9			11			14			*			
D	6-10	6			7			9			10			13			40
	12	6			7			9			10			13			
	16	6			7			9			10			13			
E	4-5	4			5			6			7			8			30
	6-9	4			5			6			7			9			
F	1-3	4			4			4			5			6			30
	4-5	4			4			5			5			6			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

Table I-24. M60A2 WP Munition Expenditure Table (Visible, 20% Relative Humidity).

CROSSWIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	12/10			*			*			*			*			40
B	3-6	9/7			14/12			*			*			*			40
	6-10	9/7			14/12			*			*			*			
C	0-8	6/5			9/8			12/11			15/14			*			40
	9-10	6/5			9/8			12/11			15/14			*			
	11-15	6/5			9/8			12/11			15/14			*			
D	6-10	4/3			6/5			8/7			10/9			14/13			40
	12	4/3			6/5			8/7			10/9			14/13			
	16	4/3			6/5			8/7			10/9			14/13			
E	4-5	3			4			5			6			9			30
	6-9	3			4			5			6			9			
F	1-3	2			2			3			4			6			30
	4-5	2			3			4			4			6			

HEAD OR TAIL WIND

SCREEN WIDTH (METERS)		100			200			300			400			600			
SCREEN TIME (MINUTES)		5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	
PASQUILL CATEGORY	WIND SPEED (KNOTS)	ROUNDS REQUIRED TO ESTABLISH AND/OR SUSTAIN SMOKE SCREEN[1]															FIRE INTERVAL (MINUTES)
A	2-5	14			*			*			*			*			40
B	3-6	11			16			*			*			*			40
	6-10	11			16			*			*			*			
C	0-8	8			11			14			*			*			40
	9-10	8			11			14			*			*			
	11-15	8			11			14			*			*			
D	6-10	6			8			10			12			16			40
	12	6			8			10			12			16			
	16	6			8			10			12			16			
E	4-5	4			6			7			8			11			30
	6-9	5			6			7			8			11			
F	1-3	4			4			5			6			8			30
	4-5	4			5			5			6			8			

[1] 10 and 15 minute screens not shown require the same number of initial and/or sustaining rounds as a 5 minute screen requires.

* Exceeds 16 rounds.

Appendix J

EXTRACT FROM AN-2 TABULAR FIRING TABLE

Table J-1. Column 3, M577 Graze Burst Fuze Setting.

RANGE	3GB	4GB	5GB	3WB	4WB
2200	9.0	7.8	6.8	8.1	7.2
2300	9.4	8.2	7.1	8.5	7.6
2400	9.8	8.6	7.5	8.9	7.9
2500	10.3	8.9	7.8	9.3	8.3
2600	10.7	9.3	8.1	9.7	8.7
2700	11.2	9.7	8.5	10.1	9.0
2800	11.7	10.1	8.8	10.5	9.4
2900	12.1	10.5	9.2	10.9	9.7
3000	12.6	10.9	9.5	11.3	10.1
3100	13.1	11.3	9.8	11.7	10.5
3200	13.6	11.7	10.2	12.2	10.8
3300	14.1	12.1	10.6	12.6	11.2
3400	14.6	12.5	10.9	13.0	11.6
3500	15.1	12.9	11.3	13.5	12.0
3600	15.6	13.4	11.6	13.9	12.4
3700	16.1	13.8	12.0	14.3	12.7
3800	16.7	14.2	12.3	14.8	13.1
3900	17.2	14.6	12.7	15.3	13.5
4000	17.7	15.1	13.1	15.7	13.9
4100	18.3	15.5	13.4	16.2	14.3
4200	18.9	16.0	13.8	16.7	14.7
4300	19.5	16.4	14.2	17.1	15.1
4400	20.1	16.9	14.6	17.6	15.5
4500	20.7	17.3	14.9	18.1	15.9
4600	21.3	17.8	15.3	18.6	16.4
4700	22.0	18.3	15.7	19.1	16.8
4800	22.7	18.8	16.1	19.7	17.2
4900	23.4	19.3	16.5	20.2	17.6
5000	24.1	19.8	16.9	20.7	18.1
5100	24.9	20.3	17.3	21.3	18.5
5200	25.7	20.8	17.7	21.8	19.0
5300	26.6	21.3	18.1	22.4	19.4
5400	27.6	21.8	18.5	23.0	19.9
5500	28.6	22.4	18.9	23.6	20.3
5600	29.8	22.9	19.4	24.2	20.8
5700	31.3	23.5	19.8	24.9	21.3
5800	33.7	24.1	20.2	25.5	21.7
5900		24.7	20.6	26.2	22.2
6000		25.3	21.1	27.0	22.7
6100		25.9	21.5	27.7	23.2
6200		26.6	22.0	28.5	23.7
6300		27.3	22.4	29.4	24.3
6400		28.0	22.9	30.3	24.8
6500		28.7	23.3	31.3	25.4
6600		29.5	23.8	32.4	25.9
6700		30.4	24.3	33.7	26.5
6800		31.2	24.8	35.5	27.1
6900		32.2	25.3		27.7
7000		33.3	25.8		28.3
7100		34.6	26.3		28.9
7200		36.2	26.8		29.6
7300			27.3		30.3
7400			27.9		31.0
7500			28.4		31.7
7600			29.0		32.5
7700			29.6		33.4
7800			30.2		34.3
7900			30.8		35.3
8000			31.4		36.4
8100			32.1		37.7
8200			32.8		39.5
8300			33.5		
8400			34.3		
8500			35.0		
8600			35.9		
8700			36.8		
8800			37.8		
8900			38.9		
9000			40.3		
9100			42.1		

RANGE	5WB	6WB	7WB	7R
3000	9.1	7.7	6.3	5.1
3100	9.4	8.0	6.6	5.3
3200	9.7	8.3	6.8	5.5
3300	10.1	8.6	7.1	5.7
3400	10.4	8.9	7.3	5.9
3500	10.8	9.2	7.6	6.1
3600	11.1	9.5	7.8	6.3
3700	11.4	9.8	8.1	6.5
3800	11.8	10.2	8.3	6.7
3900	12.1	10.5	8.6	6.9
4000	12.5	10.8	8.9	7.1
4100	12.9	11.1	9.1	7.3
4200	13.2	11.4	9.4	7.5
4300	13.6	11.8	9.7	7.8
4400	13.9	12.1	10.0	8.0
4500	14.3	12.4	10.2	8.2
4600	14.7	12.8	10.5	8.4
4700	15.0	13.1	10.8	8.6
4800	15.4	13.4	11.1	8.8
4900	15.8	13.8	11.4	9.1
5000	16.2	14.1	11.7	9.3
5100	16.5	14.4	12.0	9.5
5200	16.9	14.8	12.3	9.8
5300	17.3	15.1	12.6	10.0
5400	17.7	15.5	12.9	10.2
5500	18.1	15.8	13.2	10.5
5600	18.5	16.2	13.5	10.7
5700	18.9	16.5	13.8	11.0
5800	19.3	16.9	14.1	11.2
5900	19.7	17.2	14.4	11.4
6000	20.1	17.6	14.8	11.7
6100	20.5	18.0	15.1	11.9
6200	20.9	18.3	15.4	12.2
6300	21.4	18.7	15.7	12.5
6400	21.8	19.1	16.1	12.7
6500	22.2	19.4	16.4	13.0
6600	22.7	19.8	16.7	13.2
6700	23.1	20.2	17.0	13.5
6800	23.5	20.6	17.4	13.8
6900	24.0	20.9	17.7	14.1
7000	24.4	21.3	18.1	14.3
7100	24.9	21.7	18.4	14.6
7200	25.4	22.1	18.7	14.9
7300	25.9	22.5	19.1	15.2
7400	26.3	22.9	19.4	15.5
7500	26.8	23.3	19.8	15.8
7600	27.3	23.7	20.1	16.0
7700	27.8	24.1	20.5	16.3
7800	28.4	24.5	20.8	16.6
7900	28.9	24.9	21.2	16.9
8000	29.4	25.3	21.6	17.2
8100	30.0	25.7	21.9	17.5
8200	30.5	26.1	22.3	17.8
8300	31.1	26.6	22.6	18.2
8400	31.7	27.0	23.0	18.5
8500	32.3	27.4	23.4	18.8
8600	32.9	27.9	23.8	19.1
8700	33.6	28.3	24.1	19.4
8800	34.3	28.8	24.5	19.7
8900	35.0	29.2	24.9	20.1
9000	35.7	29.7	25.3	20.4
9100	36.5	30.1	25.7	20.7
9200	37.3	30.6	26.0	21.0
9300	38.2	31.1	26.4	21.4
9400	39.1	31.6	26.8	21.7
9500	40.1	32.1	27.2	22.0
9600	41.4	32.6	27.6	22.4
9700	42.8	33.1	28.0	22.7
9800	45.1	33.6	28.4	23.0
9900		34.1	28.8	23.4
10000		34.6	29.2	23.7
10100		35.2	29.6	24.1
10200		35.8	30.0	24.4
10300		36.3	30.5	24.8
10400		36.9	30.9	25.1

RANGE	6WB	7WB	7R
10500	37.5	31.3	25.5
10600	38.1	31.7	25.8
10700	38.8	32.2	26.2
10800	39.5	32.6	26.6
10900	40.1	33.0	26.9
11000	40.9	33.5	27.3
11100	41.6	33.9	27.7
11200	42.4	34.4	28.0
11300	43.3	34.8	28.4
11400	44.2	35.3	28.8
11500	45.2	35.8	29.1
11600	46.4	36.3	29.5
11700	47.7	36.7	29.9
11800	49.6	37.2	30.3
11900		37.7	30.7
12000		38.2	31.1
12100		38.7	31.4
12200		39.2	31.8
12300		39.8	32.2
12400		40.3	32.6
12500		40.8	33.0
12600		41.4	33.4
12700		42.0	33.8
12800		42.5	34.2
12900		43.1	34.6
13000		43.7	35.1
13100		44.4	35.5
13200		45.0	35.9
13300		45.7	36.3
13400		46.4	36.7
13500		47.1	37.2
13600		47.9	37.6
13700		48.7	38.0
13800		49.5	38.5
13900		50.5	38.9
14000		51.5	39.3
14100		52.6	39.8
14200		53.9	40.2
14300		55.7	40.7
14400			41.2
14500			41.6
14600			42.1
14700			42.6
14800			43.1
14900			43.5
15000			44.0
15100			44.5
15200			45.0
15300			45.5
15400			46.1
15500			46.6
15600			47.1
15700			47.7
15800			48.2
15900			48.8
16000			49.3
16100			49.9
16200			50.5
16300			51.1
16400			51.7
16500			52.3
16600			53.0
16700			53.7
16800			54.4
16900			55.1
17000			55.8
17100			56.6
17200			57.4
17300			58.3
17400			59.2
17500			60.2
17600			61.4
17700			62.7
17800			64.4
17900			67.2

FM 6-40/MCWP 3-1.6.19
23 APRIL 1996

By Order of the Secretary of the Army:

DENNIS J. REIMER
General, United States Army
Chief of Staff

Official:

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By Direction of the Commandant of the Marine Corps:

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DISTRIBUTION:

Active Army, USAR, and ARNG: To be distributed in accordance with DA Form 12-11E, requirements for FM 6-40/MCWP 3-1.6.19, *Tactics, Techniques, and Procedures for Field Artillery Manual Cannon Gunnery* (Qty rqr. block no. 0044).

GLOSSARY

A

A as acquired (attack guidance matrix)

AA artillery airburst (Firefinder mission type)

AC aiming circle

AD artillery datum plane (Firefinder mission type)

ADA air defense artillery

ADAM area denial artillery munitions

add a correction used by an observer or spotter to indicate that an increase in range along the observer-target line is desired.

adj adjust

adjust fire command that specifies all howitzer sections to follow the adjusting phase of a fire mission.

adjusted deflection a deflection based on firing and computed to place the center of impact of a round on target. This deflection can differ from chart deflection because of nonstandard conditions.

adjusted elevation an elevation based on firing and computed to place the center of impact of a round on target. This elevation can differ from TFT elevation because of nonstandard condtions.

adjust fire (1) An order or request to initiate an adjustment. (2) A method of control transmitted in the call for fire by the observer or spotter that indicates he will control the adjustment of the rounds to the target.

adjustment (1) A process used in artillery and naval gunfire to obtain correct direction, range, and height of burst (if time fuzes are used) in engaging a target with observed fire. (2) The actual subsequent correction sent by the forward observer or spotter that is expressed in a LEFT/RIGHT, ADD/DROP, or UP/DOWN format in relation to the actual impact versus the desired impact of a round versus the target.

admin administrative

AF adjust fire

AFDO-AXO assistant fire direction ofiicer-assistant executive officer

AI artillery impact prediction (Firefinder mission type)

aimpoint (1) A point or points on the ground in relation to the target that firing data for munitions are calculated for in order to achieve the desired effects on target. (2) A point on the ground where employment of nuclear weapon(s) achieves the desired target effects without violating the commander's guidance. (3) A point on the ground where FASCAM projectiles are delivered.

aimpt aimpoint

air a spotting or observation by an observer or spotter indicating that a burst or group of bursts occurred before impact.

airburst (1) An explosion of a bomb or projectile above the surface as distinguished from an explosion on impact or after penetration of the surface. (2) A nuclear detonation in the air at a height of burst greater than the maximum radius of the fireball.

alt altitude

AMC at my command

ammo ammuniton

ammunition lot number the code number that identifies a particular quantity of ammunition from one manufacturer. The number is assigned to each lot when it is manufactured.

∢ SI angle of site

angle of departure the vertical angle between the tangent to the trajectory at the origin and the horizontal or base of the trajectory.

angle of elevation the smaller angle at the origin in a vertical plane from the line of site to the line of elevation.

angle of fall the vertical angle at the level point between the line of fall and the base of the trajectory.

angle of site the vertical angle between the level base of the trajectory anchor horizontal and the line of site.

angle T the interior angle formed at the target by the intersection of the observer-target and the gun-target lines.

ANGLICO air and naval gunfire liaison company

AO aerial observer

AOL azimuth of lay

APERS antipersonnel

APICM antipersonnel improved conventional munitions

approx approximate

arg argument

ARTEP Army training and evaluation program

ATACMS Army tactical missile system

AT MY COMMAND (1) Restrictive command used to control time of delivery of fire that prohibits the battery or battalion from firing until directed to do so by the fire direction center. (2) Restrictive method of control used by the observer that prohibits the battery or battalion from firing until directed to do so by the observer.

avg average

axis of tube an imaginary straight line through the center of the bore at the breech end and the center of the bore at the muzzle end.

AZIMUTH a command announced to alert the sections to a large shift in the direction of fire.

B

B behind (DA Form 4757)

ballistic density the computed constant air density that would have the same total effect on a projectile during its flight as the varying densities actually encountered.

ballistics the science or art that deals with the motion, behavior, appearance, or modification of missiles or other vehicles acted upon by propellants, wind, gravity, temperature, or any other modifying substance, condition, or force.

barrel a metal tube through which ammunition is fired, which controls the initial direction of the projectile.

base of trajectory a line extending from the muzzle of the tube that intersects the trajectory at the same altitude as the muzzle.

BATTERY (PLATOON) ADJUST a fire command given to alert all elements of a fire unit to follow the mission to participate in the FFE phase of an adjust-fire mission.

battery center a point materialized on the ground at the approximate geometric center of the battery position; the chart location of the battery.

BATTERY (PLATOON or TROOP) LEFT (RIGHT) a method of fire in which weapons are discharged from the flank designated in a 5-second interval.

BATTERY (BATTALION or PLATOON) 1 (or more) ROUND(S) a fire order command indicating an FFE mission and directing all pieces to fire the designated number of rounds at the data announced in the initial fire command.

BB base bum

BCS battery computer system

BE base ejection (fuze), Belgium

beehive (ammunition) a type of antipersonnel ammunition designed for use in defending a position against massed personnel attack.

BMA battery-minefield angle

boattail the conical section of a ballistic body that progressively decreases in diameter toward the tail to reduce overall aerodynamic drag through increasing its ballistic coefficient.

BOC battery operations center

bourrelet the widest part of the projectile located immediately to the rear of the ogive.

BP base piece

BPAMC by piece at my command

BPBRAMC by piece, by round, at my command

bracketing a method of adjusting fire in which a bracket is established by obtaining an **OVER** and a **SHORT** along the spotting line and then successively splitting this bracket until a target **HIT** or desired bracket is obtained.

BRAMC by round at my command

breechblock a movable steel block that doses the breech of a cannon.

breach ring the breechblock housing that is screwed or shrunk onto the rear of a cannon tube in which the breechblock engages.

btry battery

burster an explosive charge used to break open and spread the contents of chemical projectiles, bombs, or mines.

BUCS backup computer system

C

C^3 command, control, and communications

CA Canada

caliber (1) The inside diameter of the tube as measured between opposite lands. A .45 caliber pistol has a barrel with a diameter of 45/100 of an inch. (2) The diamater of a projectile. (3) An expression of the length of the tube obtained by dividing the length from the breach face to the muzzle by the inside diameter of its bore. A gun tube with a bore 40 feet long (480 inches) and 12 inches in diameter is 40 calibers long.

calibration measuring the muzzle velocity of a weapon and then performing a comparison between the muzzle velocity achieved by a given piece and accepted standard performance.

call for fire a request for fire containing data necessary for obtaining the required fire on a target.

cancel when coupled with an order other than quantity or type of ammunition, rescinds that order.

cannon a complete assembly consisting of an artillery tube, a breech mechanism, a firing mechanism, and a sighting system mounted on a carriage.

cannoneer a member of an artillery gun or howitzer crew whose primary duty is servicing the piece.

CANNOT OBSERVE a method of control in the call for fire from the observer in which the observer or spotter believes a target exists at the given location that is important enough to engage; however, the observer is unable to adjust fire onto the target because of obscuration, mask, and soon.

CAS complementary angle of site

CD compact disk

CDNL cancel do not load

centrifugal force the force acting on a rotating body that forces its parts outward and away from the center of rotation.

CEOI communications-electronics operation instructions

CF command/fire direction (redo net)

CFF call for fire

chap chapter

charge the propellant of semifixed and separate-loading ammunition.

charge group the charges within the propellant type associated with a projectile family, within which MVVs can be transferred.

check firing a command used to cause a temporary halt in firing.

chemical agent a chemical compound which produces incapacitating, lethal, or damaging affects on man, animals, plants, or materials.

chg charge

cld cloud

CLGP cannon-launched guided projectile

COB center of battery

col column

cold stick firing data computed from a graphical firing table with no GFT setting applied.

COLT combat observation/lasing team

comp comparative, complementary

complementary angle of site the correction to compensate for the error made in assuming rigidity of trajectory.

complementary range range confections corresponding to the complementary angle of site. These corrections are tabulated in the TFT and are a function of chart range and height above or below the gun.

complete round a term applied to an assemblage of components designed to perform a specific function at the time and conditions desired to complete the firing chain. Examples of these rounds are *separate loading,* consisting of a primer, a propelling charge, a projectile, and a fuze; and *fixed* or *semifixed,* consisting of a primer, a propelling charge, a cartridge case, a projectile, and a fuze.

computer (1) A mechanical or electromechanical device for solving mathematical problems associated with the development of the gunnery solution (for example, BCS). (2) A fire direction center operator who operates an FDC computer or manually computes data for laying and firing artiliery.

concurrent met a concurrent mat is solved to separate the total corrections determined from a registration into two parts: met corrections and position constants.

CONTINUOUS FIRE a command causing the howitzer crew to continue firing as rapidly as possible, consistent with accuracy and the prescribed rate of fire for the weapon, until the commands **CHECK FIRING, CEASE LOADING,** or **END OF MISSION** are given.

continuous illumination (1) A method of fire in which illumination rounds are fired at specific time intervals to provide uninterrupted lighting of the target. (2) A request from the observer in the call for fire for continuous illumination.

CONVERGED (1) A request from the observer for all rounds to impact at the center of the target. (2) A command in the fire order specifying a special sheaf in which all planes of fire intersect at the same point on the ground (see converged sheaf).

converged sheaf a special sheaf in which each piece fires a unique time, deflection, and quadrant elevation to cause the rounds to impact at the same point on the ground.

cook off the functioning of a chambered round initiated by the heat of the weapon.

coordinated fire line a line beyond which conventional fire support means (FA, mortars, naval gunfire) may fire at any time without additional coordination within the zone of the establishing headquarters. A CFL is designated to expedite fires across boundaries and speed fire support reaction to targets in those areas.

coordinated illumination (1) The firing of illumination rounds to illuminate a target only at the time required for spiting and adjusting HE fires. (2) A request from the observer in the call for fire for continuous illumination.

coppering metal fouling left in the bore of a weapon by the rotating band or jacket of a projectile.

Coriolis effect the change in range or azimuth caused by the rotational effects of the earth.

corr correction

correcton (1) Any change in firing data to bring the mean point of impact of a round closer to the target. (2) A communications proword announcing that an error in data has been announced and that corrected data will follow.

cos cosine

COS center of sector

cot cotangent

COT center of target

CP concrete-piercing (fuze)

Cphd Copperhead

crest a terrain feature of such altitude that it restricts observation of an area or fires into an area on either the ascending or descending branch of the trajectory, resulting in dead space or limitation to the minimum elevation, or both.

CRESTED a report indicating engagement, or observation, of a target is not possible because of an obstacle or intervening crest.

CS chlorobenzaimalononitrile (riot control agent)

CSF complementary site factor

CSR controlled supply rate

CTGPC cancel terrain gun position correction

D

D decrease, down (ROF), destroy (attack guidance matrix)

DA Denmark

dec decrease

defection (1) The setting on the scale of a weapon sight to place the line of fire in the desired direction. (2) The horizontal clockwise angle between the axis of the tube and the line of sight.

deflection index a fine line constructed on a firing chart and used to measure deflection with the range-deflection protractor.

deflection limits the right and left traverse limits that establish the lateral limits of a designated impact area.

deflection probable error the directional error caused by dispersion that will be exceeded as often as not by an infinite number of rounds fired at the same deflection. This value is given in the TFT.

delay action the predetermined delayed explosion of ammunition after the activation of the fuze.

description of target an element in the call for fire in which the observer describes the personnel, equipment, activity, or installation to be taken under fire.

destruction fire (1) An element of the method of engagement potion of the call for fire requesting destruction fire. (2) Fire delivered for the sole purpse of destroying materiel.

deviation (1) The distance by which the burst misses the target. (2) The angular difference between the magnetic and compass headings.

df deflection

DHD did hit data

did hit data are data fired under nonstandard conditions that will cause the round to impact at a point of known location.

diff difference

direction a term used by the observer to indicate the bearing of the observer-target line.

dispersion pattern the dispersion of a series of rounds fired from one weapon or group of weapons under conditions as nearly identical as possible. The points of bursts or impacts are distributed around a point called the mean point of impact.

dispersion rectangle a table that shows the probable distribution of a series of shots fired with the same firing data. This table is a rectangle made into 64 zones. The table shows the percentage of shots expected to fall within each zone.

displ displacement

div arty division artillery

DNL do not load

DOWN (1) A term used in a call for fire to indicate that the target is at a lower altitude than the observation post or reference point used in locating the target. (2) A correction used by the observer to indicate a decrease in the height of burst of a round is needed.

DPICM dual-purpose improved conventional munitions

drag the resistance of the atmosphere to a projectile moving through it. It is directly proportional to the diameter and velocity of the projectile and air density.

drift the lateral deviation of the trajectory from the plane of departure as caused by the rotation of the earth. As a result, the horizontal projection of trajectory is a curved, rather than a straight line. The deviation is always to the right with a projectile having a right-hand spin.

DROP a correction used by an observer to indicate that a decrease in range along the observer-target line is needed.

droop the algebraic sum of barrel curvature, untrueness of the breech quadrant seats, and untrueness in assembling the tube to the breach.

DS direct support

DTG date-time group

E

E east, easting

ed edition

EFC equivalent full charge

EGL elevatiom gauge line

elevate to raise the muzzle or warhead end of the weapon.

elevation the vertical angle between horizontal and the axis of the bore or rail of the weapon required for a projectile to reach a prescribed range.

emplacement (1) A prepared position for one or more weapons or pieces of equipment for protection from hostile fire and from which they can execute their tasks. (2) The act of fixing a gun in a prepared position from which it may be fired.

END OF MISSION an order given to terminate firing on a specific target.

engr engineer

EOL end of orienting line

EOM end of mission

ERDPICM extended range dual-purpose improved conventional munitions

erosion the wear in a howitzer tube which is the result of firing rounds.

ET electronic time (fuze)

ETI elevation to impact

exterior ballistics the study of the phenomena associated with the aerodynamic performance of missiles or projectiles.

F

F Fahrenheit, forward (DA Form 4757)

FA field artillery

fac factor

FASCAM family of scatterable mines

FCI fire control information

FCT firepower control team

FDC fire direction center

FDO fire direction officer

FFE fire for effect

final protective fire an immediately available, prearranged barrier of fire designed to impede enemy movement across defensive lines.

fins aerodynamic surfaces that are attached to missiles or projectiles and are designed to provide stability and control during flight (for example, Copperhead).

FIRE the fire command given to discharge a weapon.

fire control all operations connected with the planning, preparation, and actual application of fire on a target.

fire direction (1) The tactical employment of firepower exercising the tactical command of one or more units in the selection of targets, the concentration and distribution of fire, and the allocation of ammunition for each mission. (2) The methods and techniques used to convert target information into the appropriate fire commands.

fire direction center the element of a commend post consisting of gunnery and/or communications personnel and equipment which receives target Intelligence and requests for fire and converts it into appropriate fire direction and by which the commander exercises fire direction or fire control.

FIRE FOR EFFECT (1) A command to indicate that fire for effect is desired. (2) Fire that is intended to achieve the desired result on target.

FIRE MISSION (1) An order used to sled the weapon or battery area that the message following is firing data. (2) A specific assignment given to a fire unit as part of a definite plan.

fire support coordination line a line beyond which all targets may be attacked by any weapon systems (including aircraft or special weapons) without additional coordination with the establishing headquarters or endangering friendly troops.

fire support team a group of FA observers with the required equipment to plan, request, coordinate, and direct fire support efforts for a company-sized maneuver force.

firing data all data necessary for firing an artillery piece eta given objectve.

firing table a table or chart giving the data needed firing a particular weapon and ammunition accurately on a target under standard conditions. It also gives the corrections needed to compensate for the existence of nonstandard conditions or special conditions such as variations in temperature.

FIST fire support team

fixed ammunition ammunition in which the cartridge case is permanently attached to the projectile.

FLOT forward line of own troops

FM field manual

FO fire order

FO forward observer

fork the change in the angle of elevation necessary to produce a change in range at the level point equivalent to four probable errors in range.

forward line of own troops a line that indicates the most forward location of friendly maneuver forces. The line is designated from left to right, facing the enemy.

forward observer an observer who can observe targets or the burst of attillery shells.

FP firing point

FPF final protective fire

FR France

free fire area an area into which any fire support means may deliver fires or aircraft can jettison munitions without additional coordination with the establishing headquarters. It can be used for an area where neutralization of the enemy by fire support is preferred over the use of maneuver forces.

FS fuze setting

FS fire support

FSCM fire support coordinating measure

FSO fire support officer

FT firing tables

fuze a device used in munitions to initiate detonation.

fuze delay a fuze that has a delay element incorporated into the fuze train.

fuze superquick a fuze that functions immediately upon impact of the projectile with the target.

fuze time (fuze mechanical time superquick) a fuze containing a graduated time element which regulates the time interval after which the fuze will function.

fuze VT see proximity fuze.

fz fuze

G

G/VLLD ground / vehicular laser locator designator

gas check seat on weapons firing separate-loading ammunition, the tapered surface in the rear interior of the tube.

GB green bag

GE Germany

geometry the control lines, boundaries, and other areas used to coordinate fire and maneuver (battlefield graphics are sometimes called battlefield geometry).

GFT graphical firing table

gm/m^3 grams per cubic meter

GMET graphical munitions effectiveness table

GMT Greenwich mean time

graphical munitions effectiveness table provides guidance for determining the expected fraction of casualities to personnel targets or damage to material targets in a graphical format.

graze a spotting by an observer that indicates that a round or group of rounds detonated upon impact versus in the air.

grid (1) Two sets of parallel lines intersecting at right angles and forming squares. The grid is accurately superimposed on maps, charts, and other similar representations of the surface of the earth to permit identification of ground locations and permit the computation of direction and distance to other points. (2) A term used in giving the location of a geographic point by grid coordinates. (3) A fire mission in which target location is sent in grid coordinates.

grid convergence the angular difference in direction between grid north and true north measured from east to west from true north.

grid coordinates numbers and letters of a coordinate system that designate a point on a gridded map, photograph, or chart.

grid line one of the lines in the grid system used to divide the map into squares. East-west lines are X lines and north-south lines are Y lines.

grid magnetic angle (GM angle) the angular difference in direction between grid north and magnetic north measured east to west from grid north. This is sometimes called the gravitation grid variation.

grid north the northerly or zero direction indicated by the grid datum of directional reference.

grid system imaginary lines dividing the earth into sectors to aid in the location of points.

grooves the spiral channels cut in the bore of a gun making up part of the rifling.

GSR general support reinforcing

GST graphical site table

GT gun to target

gun-target line (GT line) an imaginary straight line from the gun to the target.

H

H blister agent (mustard)

HA high angle

HB high burst

HB/MPI high burst / mean point of impact

HC hexachlorothane (smoke)

HCO horizontal control operator

HD blister agent (distilled mustard)

HE high explosive

height of burst (1) The vertical distance from the surface of the earth to the point of burst for a round. (2) The optimum height of burst for a particular target where a nuclear weapon of a specific yield will produce the estimated energy needed to achieve the desired affects on target over the maximum possible area.

HEP-T high-explosive plastic-tracer

high-angle fire fire delivered at elevations greater then the elevation of maximum range of the gun and ammunition concerned. Range decreases as the angle of elevation increases.

high-burst (mean-point-of-impact) registration a registration technique used to determine the mean burnt location of a group of rounds fired with a single set of firing data.

high-order detonation complete and instantaneous explosion.

HIP howitzer improvement program

HMMWV high-mobility multipurpose wheeled vehicle

HOB height of burst

HQ headquarters

ht height

I

I increase (DA Form 4200), immediate (attack guidance matrix)

I/E in effect

IAW in accordance with

ICAO International Civil Aviation Organization

ICM improved conventional munitions

IFSAS initial fire support automated system

illum illumination

inc increase

index a scribed mark on an instrument indicating the number to read.

indirect fire (1) Fire delivered at a target not visible to the firing unit. (2) Fire delivered to a target that is not used as the point of aim for the weapon or director.

interior ballistics the study of the phenomena associated with imparting kinetic energy to missiles.

intervening crest a crest tying between the firing point and the FLOT that is not visible from the firing point that has the capability of affecting target engagement on either the ascending or descending branches of the trajectory. The minimum quadrant elevation needed to dear this crest is the intermediate or intervening crest quadrant elevation.

IS immediate suppression

IT Italy

J

JMEM joint munitions effectiveness manual

joint munitions effectiveness manuals these tables provide guidance for determining the expected fraction of casualties to personnel targets or damage to materiel targets.

jump the displacement of the line of departure from the line of elevation that exists at the instant the projectile leaves the tube.

K

K Kelvin

km kilometer

kn pt known point

L

L left

lands the raised portion between grooves in the bore of a gun making up part of the rifling.

lateral spread (1) An element of the fire order directing that firing data be calculated to place the mean point of impact of two or more guns 1,000 (155 mm) meters apart on a line perpendicular to the gun-target line. (This technique is used with illumination.) (2) An element of the call for fire requesting that the target be engaged with a lateral spread sheaf.

lay (1) To direct or adjust the aim of a weapon. (2) Setting of a weapon for a given range, deflection, or both.

level point point on the descending branch of the trajectory which is at the same altitude as the origin. This is sometimes referred to as the point of fall.

lb pound

LCU lightweight computer unit

LIN line item number

LINE a spotting used to indicate that the burst occurred along the observer-target line.

line of departure a line designated to coordinate the jump-off point for an attack or for scouting elements.

line of elevation the axis of the bore prolonged.

line of sight (1) A straight line joining the origin and a point, usually the target. (2) Line of vision. (3) A straight line between two radio antennas.

link general term used to indicate the existence of communications facilities between two points.

LLHC lower left-hand corner

LMDIRT length (of smokescreen), maneuver target line direction, direction (of wind), time smoke is required (duration) (memory aid)

log logarithm

log logistics

LOS line of site

LOST a spotting used to indicate that the round(s) fired was not observed.

low-angle fire fire delivered at or below the elevation of maximum range for the gun and ammunition concerned.

LTD laser target designator

M

m/s meters per second

man maneuver (attack guidance matrix)

maximum ordinate the difference in altitude between the origin and the summit.

maximum quadrant elevation the greatest vertical angle of the tube for a specific charge which, when fired, will ensure that the rounds impact within the physical boundaries of a predesignated impact area for safety reasons. This angle is generally limited by the mechanical structure of the piece.

MBL mean burst location

MCRES Marine Corps combat readiness evaluation system

MD mortar datum plane (Firefinder mission type)

MDP meteorological datum plane

mean height of burst the average of the heights of burst of a group of rounds fired with the same data.

mean point of impact the arithmetic average of the point of impact of a group of rounds fired with the same data under a given set of conditions.

mechanical time fuze a fuze with a clocklike mechanism controlling the time the fuze will function.

met meteorological, meteorology

met corrections all measurable nonstandard conditions for which we can account

meteorological data meteorlogical facts pertaining to the atmosphere, such as wind, temperature, air density, and so on, that affect military operations.

METL mission-essential task list

METT-T mission, enemy, terrain, troops, and time available

MGP M gauge point

MHL manufacturer's hairline

MI mortar impact prediction (Firefinder mission type)

mil a unit of measure for angles that is based on the angle subtended by l/6400 of the circumference of a circle.

mil relation a gunnery formula expressed as mils = W/R in which roils is the angular measurement in roils between two points, W is the lateral distance (width) in meters between two points, and R is the mean distance in thousands of meters to the points. This relation is approximately true for angular measurements of less than 600 mils.

min minute, minimum

minimum quadrant elevation the minimum vertical angle of the tube for a specific charge which, when fired, ensures the round impacts within the physical boundaries of a predesignated impact area for safety reasons.

minimum range (1) The least range setting of a gun at which the projectile will dear friendly troops or obstacles between if and the target. (2) The shortest distance a gun can fire from a given position with a given charge.

misfire (1) Failure of the propellant to ignite when the firing circuit is complete. (2) Failure to fire or explode properly. (3) Failure of the primer or the propelling charge to function wholly or in part.

mixed a spotting used to indicate that a group of rounds equally detonated both in the air and upon impact.

mixed air a spotting used to indicate that the majority of a group of rounds detonated in the air versus upon impact.

mixed graze a spotting used to indicate that the majority of a group of rounds detonated upon impact versus in the air.

MO maximum ordinate

MOF method of fire

MOS military occupational specialty

mph miles per hour

MPI mean point of impact

msg message

MT maneuver target, mechanical time (fuze)

MTL maneuver target line

MTO message to observer

MTOE modification tables of organization and equipment

MTSQ mechanical time superquick (fuze)

MULE modular universal laser equipment

muzzle velocity the velocity of a projectile at the instant the projectile leaves the muzzle of the weapon.

muzzle velocity variation the change in muzzle velocity from the standard muzzle velocity expressed in meters per second.

MV muzzle velocity

MVCT muzzle velocity correction tables

MVV muzzle velocity variation

N

N north, northing, neutralize (attack guidance matrix)

N/CH nuclear and chemical (attack guidance matrix)

NATO North Atlantic Treaty Organization

NBC nuclear, biological, chemical

NCO noncommissioned officer

NE northeast

neutralization this knocks the target out of the baffle temporarily.

NL Netherlands

NLT not later than

NO Norway

no-fire area restrictive FSCM in which neither fires or the effects of fires are permitted.

northing the northward reading of grid values on a map.

NSN national stock number

number of rounds the part of the fire order or fire command that indicates the number of rounds per tube to fire at a specific target.

NW northwest

O

observation post a position which possesses the appropriate communications and other equipment to make military observations and from which fire is directed and adjusted onto targets.

observed firing chart a chart on which the relative locations must be established by the adjustment of fire.

observer-target line an imaginary straight line from the observer to the target.

observer-target range the measured distance of the OT line.

obsr observer

obturating band a nylon band located below the rotating band that assists in forward obturation. Current projectiles include the illumination, rocket-assisted, and Copperhead projectiles.

obturation any process that prevents the escape of gases from the tube of the weapon during the firing of the projectile.

OF observed fire

offset registration a registration that is conducted by one gun from a position away from the rest of the platoon or battery.

ogive the curved forward part up to and including the tip of the projectile; also called the head.

OIC officer in charge

OL orienting line

on-call targets planned targets, other than scheduled targets, on which fire is delivered when requested.

OP observation post

open sheaf (1) A type of sheaf in which each gun fires a unique time, deflection, and quadrant to cause the rounds to impact in a straight line, perpendicular to the GT line and centered on the target, with bursts spaced one effective burst width apart. (2) A fire order commanding that the target be attacked with an open sheaf.

OPORD operation order

origin of the trajectory the center of the muzzle of a gun at the instant the projectile leaves it.

OT observer to target

OUT (1) In conduct-of-fire procedure, a proword indicating the end of a read back or the end of transmission with the same station expected to transmit. (2) In normal RATELO procedures, a proword indicating the end of transmission with no answer required.

OVER (1) A spotting used to indicate that the burnt has occurred beyond the target along the OT line. (2) In normal RATELO procedures, a proword that indicates the end of a transmission with an answer being expected.

P

PAD provisional aiming data

PADS position azimuth determining system

pantel panoramic telescope

PC personal computer

PCR piece-to-crest range

PD point-detonating (fuze)

PE probable error

PE$_{D}$ probable error in deflection

PE$_{HB}$ probable error in height of burst

PE$_{R}$ probable error in range

PE$_{RB}$ probable error in range to burnt

PE$_{TB}$ probable error in time to burst

plt platoon

PMCS preventive maintenance checks and services

POC platoon operations center

point-detonating fuze a fuze that functions immediately upon impact.

POL petroleum, oils and lubricants

polar coordinates (1) The direction, distance, and vertical shift from a known point to another point. (2) The direction, distance, and vertical shift from an observer's location to the target.

polar plot the method of locating a target or point by means of polar coordinates.

pos position, positive

position constants all nonstandard conditions that are difficult to identify, relatively small in magnitude, and remain relatively constant for which we cannot account. The purpose of solving a concurrent met is to isolate the positiom constants.

pract practice

precision registration the determination, by adjustment, of firing data that will place the MPI of a group of rounds on a point of known location.

predicted fire the delivery technique of applying accurately computed corrections (not determined by firing) to standard firing data for all nonstandard conditions (weather, weapon, ammunition, rotation of the earth) to deliver accurate, surprise, nuclear, or nonnuclear fire on any known target in any direction from any weapon limited only by the characteristics of the weapon and ammunition used.

preferred charges the charges that are preferred for measuring and transferring muzzle velocities because of the consistent muzzle velocities produced by these charges.

PRF pulse repetition frequency

probable error (1) An error that is exceeded as often as it is not. (2) The measurement of the impact distribution in the dispersion pattern around the mean point of impact resulting in the development of units of measure (PROBABLE ERROR RANGE, PROBABLE ERROR DEFLECTION) used in the solution of the gunnery problem.

projectile an object projected by the application of exterior force and continuing in motion by virtue of its own inertia such as a bullet, shell, or grenade.

projectile family a group of projectiles that have exactor very similar ballistic characteristics.

propellant that which provides the energy required to place a projectile into motion. Some examples are powder charges and rocket fuel.

propelling charge a powder charge that is set off in a weapon to propel a projectile from the weapon through the action of expanding gases in a confined space produced by the burning of the powder.

propelling increment a distinct portion of a propelling charge designed to permit separation of the charge for range adjustment purposes.

prox proximity

proximity fuze a fuze designed to function when activated by an external influence such as the dose vicinity of the target.

Q

Q quick (fuze)

QE quadrant elevation

QSTAG quadripartite agreement

quadrant elevation the angle between the level base of the trajectory and the axis of the bore when laid. It is the algebraic sum of the elevation, angle of site, and the complementary angle of site.

R

R reinforcing, right (ROF)

RAAMS remote antiarmor mine system

range (1) The distance between any given point and an object or target. (2) The extent or distance limiting the operation of the gun.

range correction a change in firing data necessary to allow for deviation because of nonstandard conditions.

range-deflection protractor a device used to measure chart range and deflection.

range K a correction expressed in meters per 1,000 meters of range to correct for nonstandard conditions.

range probable error the range error caused by dispersion that is exceeded as often as not in an infinite number of rounds fired at the same elevation and is a numerical value given in the TFT. It is one-eighth the greatest length of the dispersion pattern.

range spread (1) An element of the fire order directing that firing data be calculated to place the mean point of impact of two or more weapons 1,000(155 mm) meters apart along the gun-target line (This technique is used with illumination). (2) An element in the call for fire requesting the target be engaged with a range spread sheaf.

RAP rocket-assisted projectile

RATELO radiotelephone operator

RATT record, apply, transfer, tables (rule)

RDP range-deflection protractor

REC radio electronic combat

repeat an order or request to fire the same number of rounds again with the same method of fire.

restrictive fire area a restrictive FSCM in which specific restrictions may not be exceeded or no fires delivered into this area without prior coordination with the establishing headquarters.

restrictive fire line a restrictive FSCM which prohibits fires across it without prior coordination with the establishing headquarters.

restricted charges those charges within a charge group for which it is not preferred to transfer measured MVVs to or from or for which it is not authorized to fire.

RFT rapid fire table

rg range

ROF record of fire

rotating band the soft metal band around a projectile that makes it tit tightly in the bore by centering it, thus preventing the escape of gases and giving the projectile its spin.

round (1) All parts that make up the ammunition necessary to fire one shot (see complete round). (2) One shot expended by a weapon.

rounds complete a term used to report that the number of specified FFE rounds have been fired.

RSTA reconnaissance, surveillance, and target acquisition

RTI range to impact

S

S south, southing, suppression (ROF), suppress (attack guidance matrix)

SDZ surface danger zone

SE southeast

sh shell

SHD should hit data

sheaf planned planes of fire that produce a desired pattern of bursts with rounds fired by two or more weapons.

SHELL (1) Afire command specifying the type of projectile to be used in a fire mission. (2) A request for a specific type of round to be used in a fire mission. (3) A hollow projectile filled with explosives, chemicals, or other material as opposed to shot, a solid projectile. (4) To bombard or fire a certain number of rounds on a target.

shift (1) To transfer fire from one target to another. (2) The deflection difference from one designated point to another designated point used in opening or dosing the sheaf of artillery or mortar units.

SHORT (1) A spotting used to indicate that the round burst short of the target in relation to the OT line. (2) A round that strikes or bursts on the nearside of the target. (3) Around that is fired without sufficient range to reach the target.

SHOT a report that indicates a gun or guns have been fired.

should hit data are data fired under standard conditions that will cause the round to impact at a point of known location.

si site

side spray fragments from a bursting shell that are thrown sideways from the line of sight.

sin sine

smk smoke

SOP standing operating procedures

SP self-propelled

special corrections individual piece corrections applied to time, deflection, and quadrant to place the FFE bursts in a precise pattern on the target.

special sheaf a type of sheaf in which each weapon fires a unique time, deflection, and quadrant to cause the rounds to impact in a specific geometric pattern.

SPLASH a proword transmitted to the observer 5 seconds before the estimated impact of a volley or round of artillery, mortar, or naval gunfire.

spotting the process to determine either visually or electronically the deviations of artillery or naval gunfire from the target in relation to the OT line and supplying this information to the FDC for the purpose of adjustment or analysis of the effects of fire.

spotting line: sea observer-target line.

square a mark or measurement on projectiles used to denote standard weight or deviation from standard weight.

■'wt square weight

SR self-registration

ST special text

STANAG standardization agreement

std standard

subcal subcaliber

subsequent met a subsequent met is solved to determine new met corrections that are applied to the position constants from a previous met to determine new total corrections.

supplemental charge a TNT-filled cylindrical container usually used in deep cavity projectiles to fill the void between the fuze, booster combination, and the booster charge.

suppression this limits the ability of enemy personnel to perform their mission.

surveyed firing chart a chart on which the location of all required points are plotted.

sustained rate of fire the actual rate of fire that a weapon can continue to deliver for an indefinite length of time without seriously overheating.

SW southwest

sw switch

sweep fire a method of fire where weapons fire a constant quadrant elevation with several deflections in direct relation to the direction of fire.

T

TA target acquisition

TAB target acquisition battery

TAG target above gun

tan tangent

target analysis the examination and evaluation of an enemy target situation to determine the most suitable weapon, ammunition, and method required to defeat, neutralize, of otherwise disrupt, delay, or limit the enemy.

target grid a device for convecting the observer's target locations and corrections in respect to the OT line to corrections and target locations in respect to the GT line.

TBG target below gun

terrain gun position corrections precomputed individual piece corrections applied to the gunner's aid on the panoramic telescope and the correction counter on the range quadrant of each piece.

TF time of fight (GFT scale)

TFT tabular firing tables

TGL time gauge line

TGPC terrain gun position correction

tgt target

ti time

time of flight the time in seconds from the time a projectile leaves the muzzle until it bursts.

time on target a restrictive command that allows the FDO or FDC to control the time the rounds will impact at the target.

TLE target location error

tml vel terminal velocity

TNT trinitrotoluene

TOC tactical operations center

TOE tables of organization and equipment

TOF time of fight

TOT time on target

TRADOC US Army Training and Doctrine Command

trajectory the path traced by a projectile in fight.

transfer limit the maximum difference in direction and range from a location or checkpoint within which corrections for the checkpoint are assumed to be sufficiently accurate to warrant application to any target justifying its attack by a transfer of fire.

transitional ballistics the study of the transition from interior to exterior ballistics.

TU Turkey

tube wear wearing away of the interface of the bore as a result of the combined effects of gas, washing, scoring, and mechanical abrasion, which causes a reduction in muzzle velocity.

U

U up (ROF)

UBL unit basic load

UCARET unit (that fired registration), charge (fired during the registration and for which GFT setting applies), ammo lot (used in registration), range ([chart or achieved] from the howitzer to point of known location), elevation (adjusted or did hit), time (adjusted or did hit fuze setting) (memory aid)

UK United Kingdom

UP (1) A term used to indicate that the target is higher in attitude than the OP or reference point used to locate it. (2) A correction used to indicate that an increase in the height of burst is required.

US United States

USAFAS US Army Field Artillery School

USDA up, subtract; down, add (memory aid)

USMC United States Marine Corps

UTM universal transverse mercator

V

VCO vertical control operator

VE velocity error

vertical angle the angle measured vertically, up or down, from a horizontal plane of reference and expressed in plus or minus in roils depending on whether the position is above or below the horizontal plane.

vertical clearance the vertical distance by which a projectile must dear an intervening crest.

vertical interval (1) The difference in altitude between two specified points or locations, such as the battery and a target. (2) The difference between the height of the weapon and the desired burst point.

VI vertical interval

VT variable time

VX nerve agent (persistent)

W

W west, westing

WB white bag

WP white phosphorus

WR when ready

Y

yaw the angle between the direction of motion of the projectile and the axis of the projectile-right, down, left, and up.

Z

zone fire a method of fire where the weapons fire constant deflections with several different quadrants in direct relation to the direction of fire.

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TM 43-0001-28-6. *Artillery Ammunition: Authorized Projectile, Fuze, and Propelling Charge Combinations for Howitzer, Medium, Self-Propelled: 155mm, M109A1, M109A2, M109A3 With Cannon M185*. 30 June 1993.

TM 43-0001-28-7. *Artillery Ammunition: Authorized Projectile, Fuze, and Propelling Charge Combinations for Howitzer, Medium, Towed: 155mm, M198 With Cannon M199*. 30 June 1993.

TM 43-0001-28-10. *Artillery Ammunition: Authorized Projectile, Fuze, and Propelling Charge Combinations for Howitzer, Light, Towed: 105mm, M101, M101A1, and M102*. 31 August 1988.

DOCUMENTS NEEDED

These documents must be available to the intended users of this publication.

DA Pam 25-30. *Consolidated Index of Army Publications and Blank Forms*. 1 October 1994.

FM 6-20-1. *Tactics, Techniques, and Procedures for Field Artillery Cannon Battalions*. 29 November 1990.

FM 101-60-25. *Joint Munitions Effectiveness Manual/Surface-to-Surface (JMEM/SS) Effectiveness Data for Howitzer, 155-mm, M198 and M109/A2/A3*. 1 September 1984.

FM 101-60-28. *Joint Munitions Effectiveness Manual/Surface-to-Surface (MLRS), 227-mm, M270*. 1 December 1993.

FM 101-60-35. *Effectiveness Data for the Army Tactical Missile System: M39 (Army-TACMS Block I)(S)*. 18 November 1994.

FM 6-300. *Army Ephemeris, 1988-1997*. 23 July 1992.

TC 6-20-5. *Field Artillery Delivered Scatterable Mines*. 8 January 1982.

TM 6-230. *Logarithmic and Mathematical Tables*. 26 June 1956.

READINGS RECOMMENDED

These readings contain relevant supplemental information.

DA Form 581. *Request for Issue and Turn-In of Ammunition*. August 1989.

DA Form 581-1. *Request for Issue and Turn-In of Ammunition Continuation Sheet*. August 1989.

DA Form 2028. *Recommended Changes to Publications and Blank Forms*. February 1974.

DA Form 5338-R. *Computer Checklist*. September 1984.

ARTEP 6-037-30-MTP. *Mission Training Plan for the Cannon Firing Battery, 155 mm Self-Propelled.* 28 March 1989.

ARTEP 6-127-30-MTP. *Mission Training Plan for the Cannon Firing Battery, 105 mm Towed.* 24 January 1990.

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FM 3-10-1. *Chemical Weapons Employment (U).* April 1988.

FM 6-2. *Field Artillery Survey.* 23 September 1993.

FM 6-20. *Fire Support in the AirLand Battle.* 17 May 1988.

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FM 6-121. *Field Artillery Target Acquisition.* 7 January 1993.

FM 100-2-1. *The Soviet Army: Operations and Tactics.* 16 July 1984.

FM 100-2-2. *The Soviet Army: Specialized Warfare and Rear Area Support.* 16 July 1984.

FM 100-2-3. *The Soviet Army: Troops, Organization, and Equipment.* 16 July 1984.

ST 6-40-16. *Operation of M90 Radar Chronograph and Muzzle Velocity Management.* January 1991. (Can be obtained by contacting: Commandant, US Army Field Artillery School, ATTN: ATSF-GD, Fort Sill, OK 73503-5600.)

ST 6-50-20. *Battery Executive Officer's/Platoon Leader's Handbook.* 30 October 1992. (Can be obtained by contacting: Commandant, US Army Field Artillery School, ATTN: ATSF-GD, Fort Sill, OK 73503-5600.)

STP 6-13E14. *Soldier's Manual and Trainer's Guide MOS 13E, Cannon Fire Direction SM-TG Specialist Skill Levels 1/2/3/4.* 31 July 1992.

STP 21-1. *Soldier's Manual of Common Tasks (Skill Level 1).* 1 October 1994.

STP 21-24. *Soldier's Manual of Common Tasks (Skill Level 2,3,&,4).* 1 October 1992.

TM 9-1260-477-12. *Operator's and Organizational Maintenance Manual for Target Designator Set, AN/TSQ-2 G/VLLD and Vehicular Adapter Kit.* 23 January 1982.

TM 9-6920-361-13&P. *Operator, Organizational, and Direct Support Maintenance Manual (Including Repair Parts and Special Tools List): Field Artillery Trainer Kits (With Field Artillery Trainer M31).* 22 September 1976.

TM 11-5820-477-12. *Operator's and Organizational Maintenance Manual Groups AN/GRA-39, AN/GRA-39A, AND AN/GRA-39B.* 10 July 1995.

TM 11-5830-340-12. *Operator's and Organizational Maintenance Manual for Intercommunication Set, AN/VIC-1(V), Control, Intercommunication Set, C-10456/VRC, C-10680/VRC, and Amplifier, Audio Frequency, AM-7046/VRC.* 15 January 1986.

TM 11-5860-201-10. *Operator's Manual: Laser Infrared Observation Set, AN/GVS-5.* 2 February 1982.

TM 11-5985-357-13. *Operator's, Organizational, and Direct Support Maintenance Manual for Antenna Group OE-254/GRC.* 1 February 1991.

INDEX

REGISTRATION/SPECIAL CORRECTION WORKSHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

SECTION I. REGISTRATION COMPUTATION

	ACHIEVED RANGE			DEFLECTION CORRECTION	
1	CHART RANGE	____ (10 METERS)	7	CORRECTED DEFLECTION (REGISTRATION)	____ (1 MIL)
2	REGISTERING PIECE DISPLACEMENT (F-/B+)	____ (10 METERS)	8	REGISTERING PIECE DISPLACEMENT CORRECTION $\boxed{6}$ (L+/R-)	____ (1 MIL)
3	ACHIEVED RANGE ($\boxed{1}$ + $\boxed{2}$)	____ (10 METERS)	9	ADJUSTED DEFLECTION ($\boxed{7}$ + $\boxed{8}$)	____ (1 MIL)
	REGISTERING PIECE DISPLACEMENT CORRECTION		10	CHART DEFLECTION	____ (1 MIL)
4	LATERAL DISPLACEMENT (L/R)	____ (5 METERS)	11	TOTAL DEFLECTION CORRECTION ($\boxed{9}$ - $\boxed{10}$) (+L/-R)	____ (1 MIL)
5	ACHIEVED RANGE (3) ÷ 1000	____ (10 METERS)	12	DRIFT CORRECTION (-ADJUSTED ELEVATION) (L)	____ (1 MIL)
6	REGISTERING PIECE DISPLACEMENT CORRECTION ($\boxed{4}$ ÷ $\boxed{5}$) L+/R-	____ (1 MIL)	13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION ($\boxed{11}$ - $\boxed{12}$)	____ (1 MIL)

GFT SETTING (MANUAL METHOD)							DEFLECTION CORRECTION	
14	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	TOTAL	GFT
15	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME		
16	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME		

GFT SETTING (COMPUTER METHOD)						
17	AFU;REG	LOT	RANGE	RANGE CORRECTION	TIME CORRECTION	DEFLECTION CORRECTION
18	BUCS RESIDUALS	LOT	DEFLECTION CORRECTION L R	FUZE K + / -	RANGE K + / -	

TERRAIN GUN POSITION / SPECIAL CORRECTION

REMARKS

L / P / R SECTOR	TRANSFER LIMITS					CHG ____
		LEFT	CENTER	RIGHT		
CEN DF + 400 ₥	DF				DF	CEN DF - 400 ₥
CEN RG - 2000 M	RG	(MIN)		(MAX)	RG	CEN RG + 2000 M

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
GUN	POS LATERAL CORR (L/R)	100/R GFT* (____) CEN RG	POS DF CORR (L/R) $\frac{①\times②}{100}$	BTRY COMP VE (I/D)	MV Unit Corr Fac (Tbl F) D+ ____ I+ ____	MV RG Corr ④X⑤	POS RG CORR (F= —) (B= +)	TOTAL RG Corr ⑥+⑦	POS EL CORR ⑧ ÷ DR PER 1m D EL (TBL F) (____)	CORR RG ⑧ ≈ 10M Plus CEN RG* (____)	FS ~ ⑩	POS TI CORR ⑪ MINUS FS ~ CEN RG (____)	GUN
#	5M		1 ₥	0.1 M/S	0.1 M	1 M	5 M	1 M	1 ₥	10 M	0.1	0.1	#
1													1
2													2
3													3
4													4
5													5
6													6
7													7
8													8

SECTION II. HASTY TGPC

CHARGE ____

INITIAL CHART DATA

RANGE ____

DEFLECTION ____

	POSITION LATERAL CORRECTION (LEFT/RIGHT)	HASTY POSITION DEFLECTION CORRECTION ~ ⓐ	COMPARATIVE MUZZLE VELOCITY	HASTY MUZZLE VELOCITY CORRECTION ~ ⓒ	POSITION RANGE CORRECTION (FORWARD - BACK +)	HASTY POSITION QUADRANT ELEVATION CORRECTION	TOTAL QUADRANT ELEVATION CORRECTION ⓓ + ⓕ
	a	b	c	d	e	f	g
GUN	5 METERS	AS LISTED	0.1 METER PER SECOND	AS LISTED	5 METERS	AS LISTED	1 MIL
1							
2							
3							
4							
5							
6							
7							
8							

TGT	BTRY	DTG	* FOR SPECIAL CORR USE CHART RANGE TO TARGET

DA FORM 4757-R, 1 JULY 93

FOR USE OF THIS FORM, SEE FM 6-40;
THE PROPONENT AGENCY IS TRADOC

MUZZLE VELOCITY RECORD For use of this form, see FM 6-40; the proponent agency is TRADOC.	DATE
	POWDER MODEL

FIRST-LOT CALIBRATION

SHELL/FAMILY	FIRST POWDER LOT NUMBER	GUN NUMBER/CHARGE FIRED							
ITEMS		1/	2/	3/	4/	5/	6/	7/	8/
1. WEAPON BUMPER NUMBER									
2. WEAPON TUBE NUMBER									
3. FIRST-LOT CHARGE STANDARD MUZZLE VELOCITY (FROM TABULAR FIRING TABLE (TFT)									
4. CALIBRATED MUZZLE VELOCITY (BATTERY COMPUTER SYSTEM (BCS) ENTRY)									
5. FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 4 - LINE 3 = LINE 5)									

SECOND-LOT CALIBRATION

SHELL/FAMILY	POWDER GROUP	GUN NUMBER/CHARGE FIRED							
ITEMS		1/	2/	3/	4/	5/	6/	7/	8/
6. SECOND-LOT CHARGE STANDARD MUZZLE VELOCITY (FROM TFT)									
7. SECOND-LOT CALIBRATED MUZZLE VELOCITY									
8. SECOND-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 7 - LINE 6 = LINE 8)									
9. FIRST-LOT PIECE MUZZLE VELOCITY VARIATION (LINE 5)									
10. CHANGE IN MUZZLE VELOCITY VARIATION (LINE 8 - LINE 9 = LINE 10)									

SECOND-LOT INFERENCE

11. SECOND-LOT STANDARD MUZZLE VELOCITY (FROM TFT)								
12. CHANGE IN MUZZLE VELOCITY VARIATION (LINE 10)								
13. FIRST-LOT MUZZLE VELOCITY VARIATION (LINE 5)								
14. SECOND-LOT CALIBRATED MUZZLE VELOCITY VARIATION (LINE 12 + LINE 13 = LINE 14)								
15. CALIBRATED MUZZLE VELOCITY (BCS ENTRY) (LINE 11 + LINE 14 = LINE 15)								

REMARKS

DA FORM 4982-R, NOV 88

EDITION OF SEPTEMBER 1984 IS OBSOLETE.

M90 VELOCIMETER WORK SHEET

For use of this form, see FM 6-40; the proponent is TRADOC.

CHARGE GROUP	DATE AND TIME	PROJECTILE FAMILY
PROJECTILE MODEL	POWDER LOT NUMBER	PROJECTILE WEIGHT

CALIBRATION DATA

ITEMS a	GUN 1 CHARGE	GUN 2 CHARGE	GUN 3 CHARGE	GUN 4 CHARGE	GUN 5 CHARGE	GUN 6 CHARGE	GUN 7 CHARGE	GUN 8 CHARGE
1. WEAPON BUMPER NUMBER								
2. WEAPON TUBE NUMBER								
3. STARTING POWDER TEMPERATURE								
4. ENDING POWDER TEMPERATURE								
5. AVERAGE POWDER TEMPERATURE								
M90 VELOCIMETER READOUT								
ROUND 1								
ROUND 2								
ROUND 3								
ROUND 4								
ROUND 5								
ROUND 6								
ROUND 7								
ROUND 8								
READOUT AVERAGE								
M90 VELOCITY COMPUTATION								
6. MUZZLE VELOCITY CORRECTION FOR NONSTANDARD CONDITIONS								
7. CALIBRATED MUZZLE VELOCITY								
8. NUMBER OF WARMUP ROUNDS FIRED								

REMARKS

DA FORM 4982-1-R, NOV 88

EDITION OF SEPTEMBER 1984 IS OBSOLETE.

FIELD ARTILLERY DELIVERED MINEFIELD PLANNING SHEET

For use of this form see FM 6-20-40 or FM 6-20-50; the proponent agency is TRADOC.

SECTION A-MINEFIELD DATA

1 TARGET NUMBER	2 PRIORITY	3 REQUESTER

4 MINEFIELD END POINTS (COORDINATES)
FROM TO

5 MINEFIELD DEPTH	6 MINEFIELD WIDTH
7 ADAM (APERS) DENSITY	8 RAAMS (AT) DENSITY
9 SELF DESTRUCT TIME SHORT ☐ LONG ☐	10 SCHEDULED MINEFIELD ______ HRS ______ MIN ON-CALL ☐

11 CAUTION NLT EMPLACEMENT TIME	12 APPROVAL AUTHORITY	13 DATE TIME GROUP (DTG)

14 REMARKS

SECTION B-G3/S3/ENGR

15 DTG RECEIVED	16 DTG SAFETY ZONE DISSEMINATED

17 REMARKS

SECTION C-FSE/FSO

18 DTG TO UNIT	19 DTG FROM UNIT	20 DTG TO G3 S3 ENGR

21 REMARKS

SECTION D-FDC DATA

22 TARGET NUMBER	23 FIRING UNIT	24 RANGE TO MINEFIELD CENTER

25 TRAJECTORY ADAM ☐ HIGH ☐ LOW RAAMS ☐ HIGH ☐ LOW	26 DELIVERY TECHNIQUE MET + VE TRANSFER ☐ OBSERVER ADJUST ☐

27 AIMPOINT COORDINATE(S) (LEFT AND RIGHT OR SINGLE)

ADAM FROM ______ TO ______ RAAMS FROM ______ TO ______

28 DTG MISSION COMPLETED

29 REMARKS

DA Form 5032-R, Jan 82

SECTION E-MINEFIELD SKETCH WORK SHEET (SCALE 1:50,000)

REVERSE OF DA FORM 5032-R

COMPUTER CHECKLIST

For use of this form, see FM 6-40. The proponent agency is TRADOC.

FIRE ORDER STANDARDS	ADJUST FIRE	FIRE FOR EFFECT
1. UNIT TO FIRE		
2. ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT		
3. BASIS FOR CORRECTION		
4. DISTRIBUTION		
5. PROJECTILE		
6. AMMUNITION LOT/CHARGE		
7. FUZE		
8. NUMBER OF ROUNDS		
9. RANGE SPREAD, LATERAL SPREAD, ZONE OR SWEEP		
10. TIME OF OPENING FIRE		
11. TARGET NUMBER		

PIECE DISPLACEMENT DATA			
GUN NUMBER	GRID	DISPLACEMENT	
		LATERAL	RANGE
1			
2			
3			
4			
5			
6			
7			
8			
AIMING CIRCLE			

FIRE COMMAND STANDARDS	ADJUST FIRE	FIRE FOR EFFECT
12. WARNING ORDER		
13. PIECE TO FOLLOW/PIECE TO FIRE/METHOD OF FIRE		
14. SPECIAL INSTRUCTIONS		
15. PROJECTILE		
16. AMMUNITION LOT		
17. FUZE/FUZE SETTING		
18. DEFLECTION		
19. QUADRANT		
20. METHOD OF FIRE		

PRIORITY TARGET INFORMATION FINAL PROTECTIVE FIRE/ COPPERHEAD	
GRID	TARGET NUMBER

BATTERY AMMUNITION COUNT	BATTERY DATA	GRID/ALTITUDE	AZIMUTH	CALL SIGN

24. FIRE PLAN

KNOWN POINT/ TARGET	LOCATION	TIME ON TARGET	UNIT OF FIRE

BATTERY GFT SETTING

21. HIGH EXPLOSIVE

22. DUAL-PURPOSE IMPROVED CONVENTIONAL MUNITIONS

23. ROCKET-ASSISTED PROJECTILES

REMARKS

DA FORM 5338-R SEP 84

COPPERHEAD PLANNED TARGET LIST WORK SHEET

For use of this form, see FM 6-40. The proponent agency is TRADOC.

TARGET NUMBER *(a)*	TARGET LOCATION *(b)*	OBSERVER *(c)*	PRIORITY (√ IF YES) *(d)*	FIRED (√ IF YES) *(e)*	PLATOON TO FIRE *(f)*	NUMBER OF ROUNDS PLANNED *(g)*	CHARGE *(h)*	TRAJECTORY *(i)*	SWITCH SETTING *(j)*	DEFLECTION *(k)*	QUADRANT ELEVATION *(l)*	TIME OF FLIGHT *(m)*	DESIGNATED TIME *(n)*

REMARKS

DA FORM 5711-R, NOV 88

UNIVERSAL SAFETY T

For use of this form, see FM 6-40. The proponent agency is TRADOC.

FP:	**GRID:**	**ALT:**
AOL:	**DATE:**	**CHARGE AND TYPE:**
ANGLE OF FIRE:	**SHELL(s):**	

MAX QE

DF LIMITS

MIN QE (_______)

MIN QE (_______)

MIN TI (_______)
(_______)

MIN TI (_______)
(_______)

MIN VT (_______)

PLT: _______________

PREREGISTRATION SAFETY: _______________

POSTREGISTRATION SAFETY: _______________

NOTE: Enter inside the parentheses following "MIN QE" and "MIN TI" the type of shell(s) for which safety was computed. Enter inside the parentheses under "MIN TI" and next to "MIN VT" the type of fuzes for which safety was computed.

DA FORM 7353-R, JAN 96

M712 COPPERHEAD MET + VE WORK SHEET

For use of this form, see FM 6-40. The proponent agency is TRADOC.

NOTE: Use FT 155-AS-1

STEP	ACTION	VALUE	STEP	ACTION	VALUE
1	Record the Chart Rg to Tgt		26	Record Dir of Fire [25] (100)	
2	Record the Chart Df to Tgt		27	Record 6400 (If [26] > 6400)	
3	Record Obsr Visibility		28	Compute Dir of Fire [26] - [27]	
4	Record Obsr Cld Ht		29	Record Wind Direction [17]	
5	Record Tgt Altitude		30	Record 6400 (If [29] < [28])	
6	Record Obsr Altitude		31	Compute Wind Direction [29] + [30]	
7	Compute OT VI [5] - [6]		32	Record Dir of Fire [28] (100)	
8	Compute Tgt Cld Ht [4] - [7]		33	Compute Chart Dir Wind [31] - [32]	
9	Enter Chg, Visibility, Cld Ceiling Tbl With [1], [3], [8]; Extract Change and Mode		34	Enter Tbl C With [33]; Record the Range Wind Component	
10	Record Tgt Altitude [5]		35	Record Wind Speed [18]	
11	Record Btry Altitude		36	Compute Rg Wind [34] X [35] (1 knot)	
12	Compute VI [10] - [11]		37	Enter Tbl C With [33]; Record the Crosswind Component	
13	Compute ∢ Si (GST) [12], [1]		38	Record Wind Speed [18]	
14	Enter Tbl F With [1]; Record El From Col 3		39	Compute Crosswind [37] X [38] (1 knot)	
15	Compute Trial QE VI [13] + [14]		40	Enter Tbl F With [1]; Record the Crosswind Correction	
16	Enter Tbl A With [15]; Record Met Message Line Number		41	Compute Tot Df Corr [39] X [40] (1 mil)	
17	Record Wind Dir		42	Record Chart Df [2]	
18	Record Wind Speed		43	Compute Df to Fire [41] + [42]	
19	Record Air Temp		44	Record Btry Altitude [11] (10 meters)	
20	Record Air Density		45	Record MDP Altitude From Met Msg	
21	Record Common Df		46	Compute Δh [44] - [45]	
22	Record Chart Df [2]		47	Enter Tbl D With [46]; Record the Temp Correction	
23	Compute Difference [21] - [22] (+/-)		48	Record Air Temp [19]	
24	Record AOL		49	Compute Corr Air Temp [47] + [48]	
25	Compute Dir of Fire [23] + [24] (1 mil)			DTG	Tgt Number

DA FORM 7352-R, JAN 96

M712 COPPERHEAD MET + VE WORK SHEET

STEP	ACTION	VALUE
50	Enter Tbl D With [46]; Record the Density Corr	
51	Record Air Density [20]	
52	Compute Corr Air Density [50] + [51]	
53	Record Propellant Temp	
54	Enter Tbl E With [53]; Record the Change in MV (0.1 m/s)	
55	Record MVV; Go to [62]; If Unknown, Enter 0; Go to [56]	
56	Record Pullover Gauge Reading	
57	Enter Approx Loss in MV Tbl With [56], EFCs Equal to [56]	
58	Record the Erosion EFCs Since Last Pullover Gauge Reading	
59	Compute Total EFCs [57] + [58]	
60	Enter Approx Loss in MV Tbl With [59], Record Loss in MV	
61	Record Propellant Efficiency	
62	Compute ΔV [54] + [55] or [54] + [60] + [61] (I/D) (If no MVV available)	
63	Enter Tbl F With [1]; Record the MV Unit Correction	
64	Compute ΔV Rg Corr [62] X [63]	
65	Record Range Wind [36]	
66	Enter Tbl F With [1] ; Record the Rg Wind Correction	
67	Compute Rg Wind Corr [65] X [66] (0.1)	
68	Record Corr Air Temp [49]	
69	Enter 100	
70	Compute Variation From Std [68] - [69]	
71	Enter Tbl F With [1] ; Record the Air Temp Rg Unit Corr	
72	Compute Air Temp Rg Corr [70] X [71] (0.1 meter)	
73	Compute Corr Air Density [52]	
74	Enter 100	
75	Compute Variation From Std [73] - [74]	
76	Enter Tbl F With [1] ; Record the Density	
77	Compute Density Rg Corr [75] X [76] (0.1)	
78	Record ΔV Rg Corr [64]	
79	Compute Rg Wind Corr [67]	
80	Record Air Temp Corr [72]	
81	Compute Tot Rg Corr [77] + [78] + [79] + [80] (10 meters)	
82	Record Chart Rg [1]	
83	Compute Corr Rg [81] + [82]	
84	Enter Tbl F With [83]; Interpolate the El From Col 3 (1 mil)	
85	Record ∡ Si [13]	
86	Enter Tbl G With [82]; Record the CSF for 1 mil Angle of Site	
87	Compute CAS [85] X [86] Same Sign as [86] (0.1 mil)	
88	Record ∡ Si [85]	
89	Compute Si [87] + [88]	
90	Record El [84] (1 mil)	
91	Compute QE to Fire [89] + [90]	
92	Enter Tbl F With [83]; Record the Time Setting	
93	Record Switch Setting [92] Followed by Obsr PRF Code	
94	Enter Tbl F With [83]; Record the Designate Time	

Firing Data

Chg [9] _______ Switch Setting [93] _________
Df [43] _______ QE [91] _________

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