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 o f 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

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JOEL B. HUDSON
Administrative Assistant to the
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0011015

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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 # AA72Ø1 **RECORD OF FIRE** SADARM FT 155 ADD-W-0 BTRY ALT 4Ø5

CALL FOR FIRE Observer: H42 AF/(FFE)/IS/S Tgt	TGT ALT 445		FS
Grid: 442 783	-BTRT ALT 4Ø5		100/R 23
Polar: Dir Dis U/D VA	VI +4Ø		/R
Shift Dir L/R +/- U/D			20/R 5
T-72 Platoon i/o, SADARM	∠T Si ÷ 10	10m Si	HOB Corr
FIRE ORDER (2)		Df Corr	Si + 9
INITIAL FIRE COMMANDS (FM) MF BTRY (2)	Rg 45ØØ	Cht Df 327Ø	El 232
Sp Instr Sh SAD Lot S/G Chg 5 Fz	Ti	Df	QE (241)
MTO K, (2) TGT # AA72Ø2 ∠T (2ØØ)	PE R (< 38) TF (15)	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 (+9)	El	QE	Exp	Type
AN-2 AIMPOINT DATA						(15.3)	326Ø	L9	(3269)	464Ø		+9	241	(250)		
DRIFT (L4) + GFT (L5) =																
SADARM AIMPOINT DATA					-2Ø	(13.3)		LØ	(3269)				+ 129	(379)		
ADD-W-Ø, TBL B, COL 2						TBL A, COL 8				TBL A, COL 2						
HOB CORRECTION DATA (U1ØØ/5Ø =2 INC)					+Ø.2	13.5			3269				+32	411	(12)	SAD
ADD-W- Ø TBL B, COL 3 X INC (Ø.1 X 2) =									TBL A COL 3 X INC (16.1 X 2) =							
			EOM	**EOM**												

MET MSG LINE Ø3 19 KTS (From Met Msg) AN-2 GFT SETTING: GFT B, CHG5, LOT D/G, RG 5ØØØ, EL 264, TI 16.7 (M577)
Wind Dir 24ØØ Mils X 9.9 M/KT (TBL A, Col 5) GFT DF CORR L5
Wind Speed 19 Knots = 188.1~19Ø Meter Aimpt shift

Btry	DTG	Tgt	Replot Grid	Replot Alt
B	241022SFEB98	AA72Ø2		

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 # AA72Ø1 **RECORD OF FIRE** SADARM FT 155 ADD-W-1 METHOD BTRY ALT 4Ø5

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 4Ø5
VI +4Ø

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

∠ Si ÷ 10 | 10m Si

FIRE ORDER (2) | Df Corr

INITIAL FIRE COMMANDS	(FM)	MF BTRY (2)
Rg 45ØØ	Cht Df 327Ø	
Sp Instr	Sh SAD	Lot S/G
Chg 5	Fz	Ti
Df		

MTO K, (2) TGT # AA72Ø2 | ∠T (2ØØ) | PE$_R$ (< 38) | TF (15) | In Eff

SUBSEQUENT FIRE COMMANDS

Tgt / Dir, MF Sh, Fz	Location / Dev	Priority ✓ / Rg	Firing Unit / 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)	326Ø	L9	(3269)	464Ø		+9	241	(250)		
				DRIFT (L4) + GFT (L5) =												
SADARM AIMPOINT DATA					-1.8	13.5		LØ	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 Ø3 19 KTS (From Met Msg) AN-2 GFT SETTING: GFT B, CHG5, LOT D/G, RG 5ØØØ, EL 264, TI 16.7 (M577)
Wind Dir 24ØØ Mils X 9.9 M/KT (TBL A, Col 5) GFT DF CORR L5
Wind Speed 19 Knots = 188.1~19Ø Meter Aimpt shift

Btry	DTG	Tgt	Replot Grid	Replot Alt
B	241022SFEB98	AA72Ø2		

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 **Ø5/30/98** ScheduledDate Out **Ø5/30/98**
TimeIn **Ø7:ØØ** TimeOut **23:59**

Firing Point 185 (6Ø26 411Ø) HT 37Ø.Ø Impact Area S. CARLTON AREA
Weapon M198 (155) Ammunition M1Ø7, M11Ø, 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 134Ø MILS Right 19ØØ MILS
Low Angle PD Minimum Range 39ØØ METERS Min Charge 3GB
Fuze TI and High Angle Minimum Range 4ØØØ 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 62ØØ METERS Max Charge 4GB

COMMENTS

From AZ 134Ø TO AZ 15ØØ MAXIMUM RANGE IS 57ØØ

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.

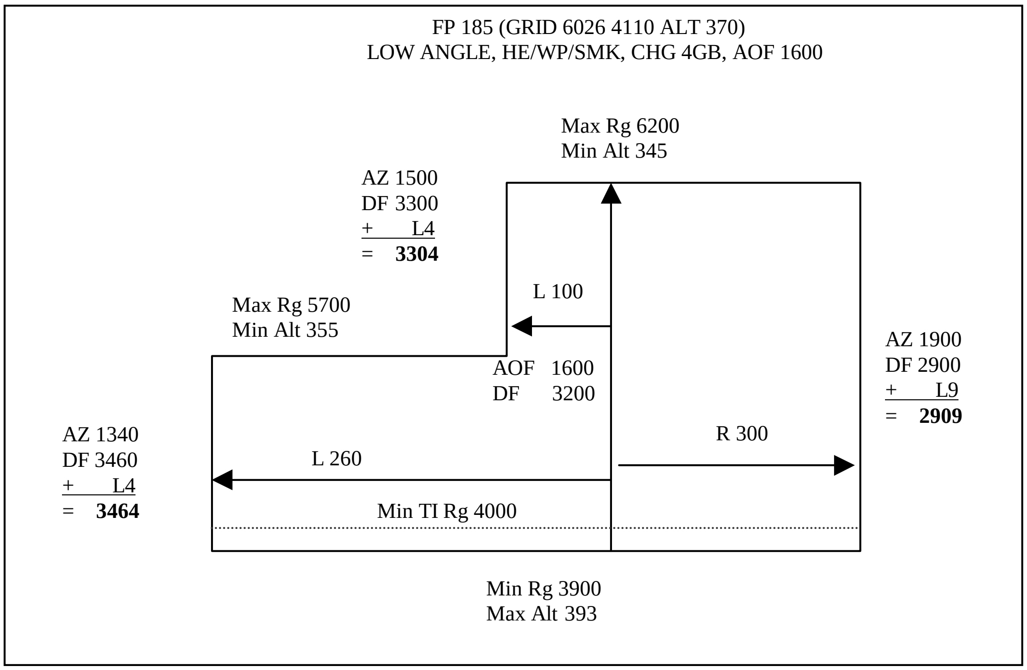


Figure 15-2. Example of a Completed Safety Diagram, HE/WP/SMK

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.

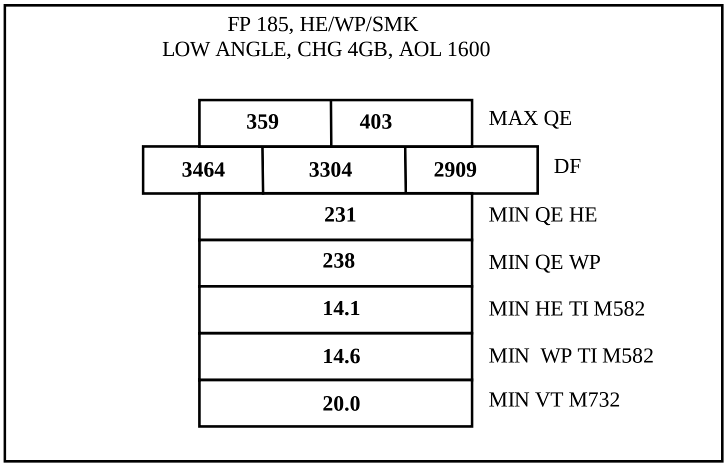


Figure 15-5. Example of a Completed Safety T.

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/	M314	HE	105-AS-3	N/A
M119	M444	HE	105-AS-3	ADD-F-1
M198 or	M485	HE	155-AM-2	N/A
M109A3/A5/A6	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.

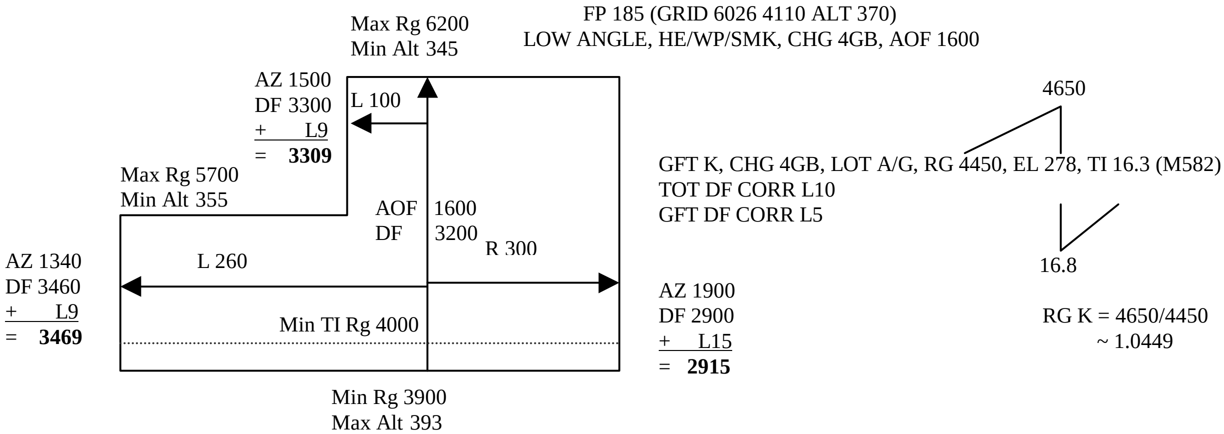
(1) Determining Minimum Fuze Setting with a GFT with a GFT Setting Applied: When a GFT setting is applied and a fuze setting is to be determined, it is extracted opposite the Time Gage Line (if it is the fuze listed on the GFT setting) or as a function of elevation (for all others). Use the procedures 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 <u>*Diagram Ranges*</u> from the basic safety diagram.
4	Record the <u>*Charge*</u> from the range safety card.
5	Enter the <u>*Range Correction*</u>, 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.



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

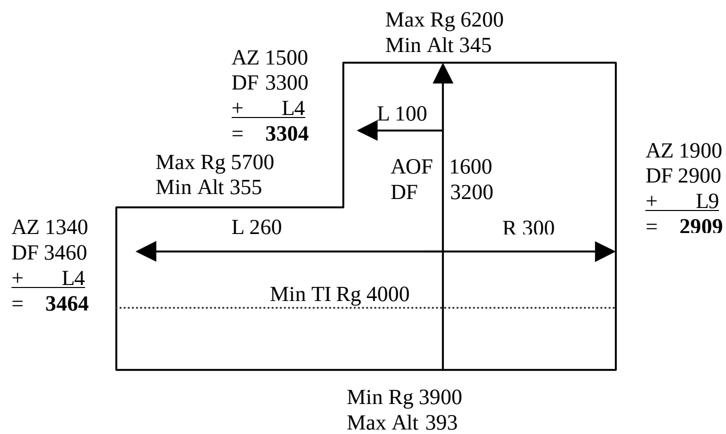
DIAGRAM RG	+	RG CORR	= TOT RG	x	RG K	= ENTRY RG	CHG	VI	SI	+ EL	= QE	M564/ M565	M582 M577	TOF	+ 5.5	= M728/ M732	DFT
3900	+	(+110)	= 4010	x	1.0449	= 4190	4GB	+23	(+6)	+ 245	= **251**	--	--	--		--	--
4000	+	(+110)	= 4110	x	1.0449	= 4290	4GB	--	--	--	--	--	**15.3**	--		--	--

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

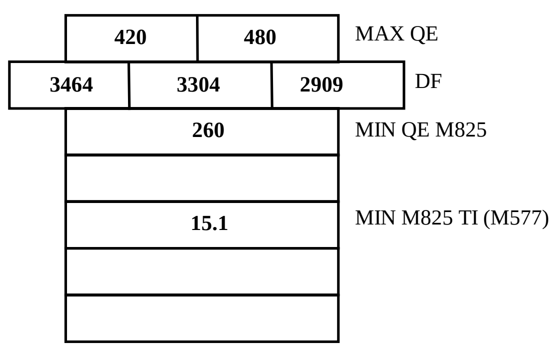


Figure 15-7. Example of Low Angle Safety Shell M825

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

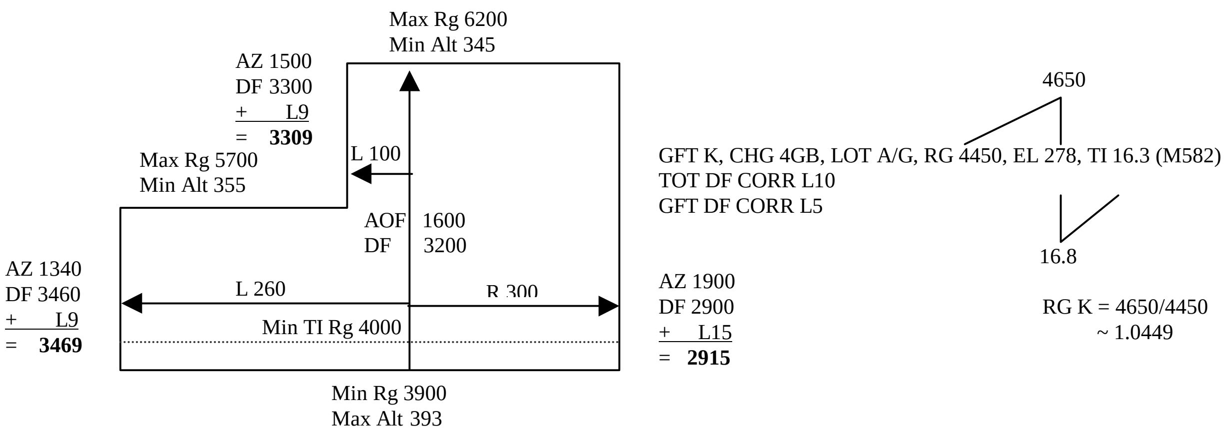
Figure 15-8. Safety Table Data for M825 Example (Cont'd)

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

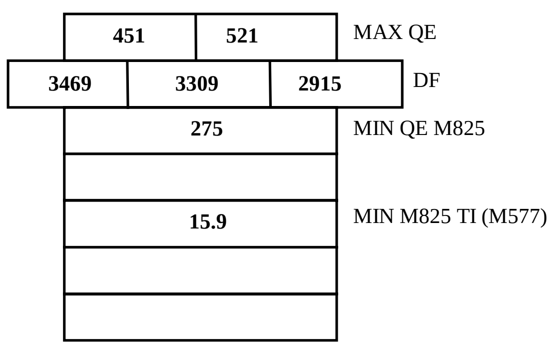
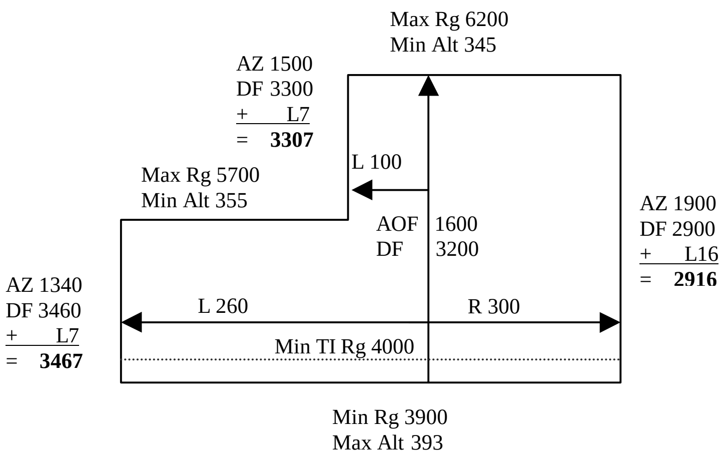


Figure 15-9. Example of Post Occupation Low Angle Safety with Range K applied, Shell M825

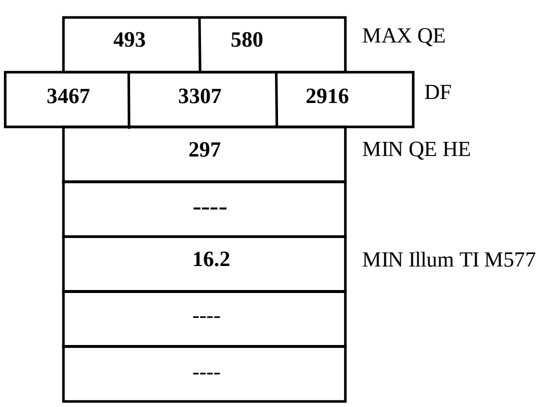
FP 185 (GRID 6026 4110 ALT 370)
LOW ANGLE, ILLUM, CHG 3GB, AOF 1600



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



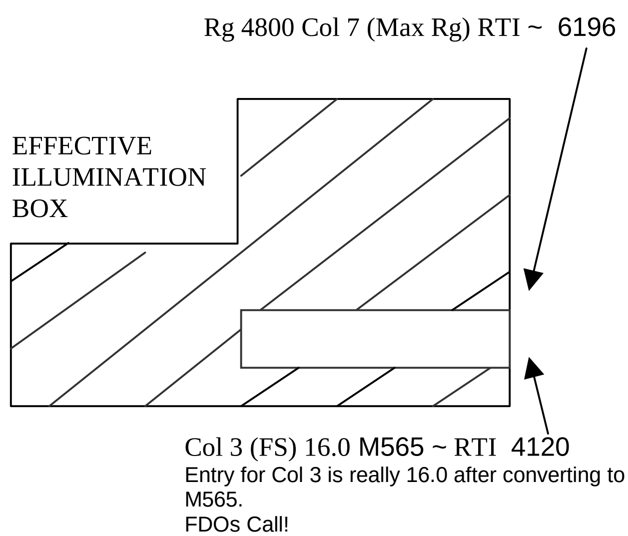


Figure 15-10. Example of Low Angle Safety, Shell Illum

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: $\frac{\text{Range} \sim \text{Adjusted Elevation}}{\text{Achieved Range}}$ = 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 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	RG + CORR	TOT = RG x	RG K =	ENTRY 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). *

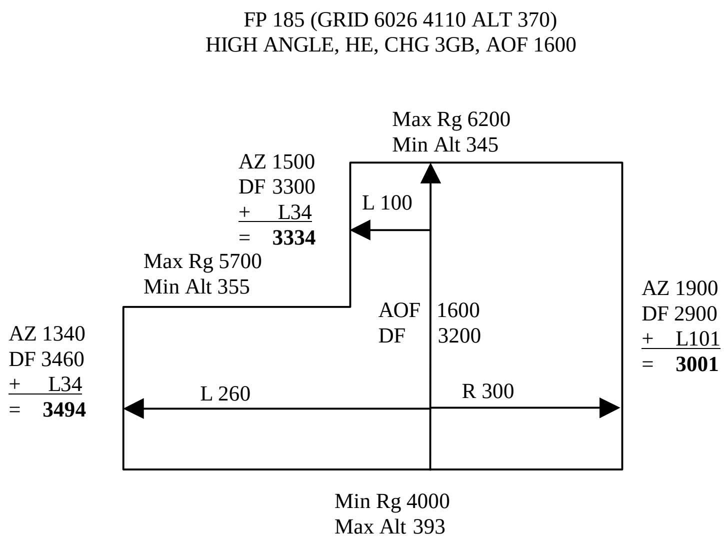
(k). This is the elevation to impact from Table C (base ejecting), or GFT/TFT (bursting). *

(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



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

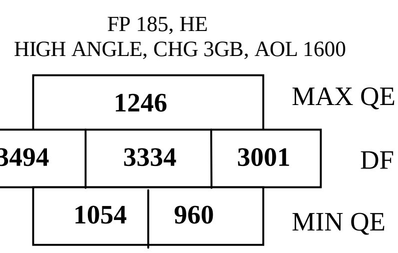
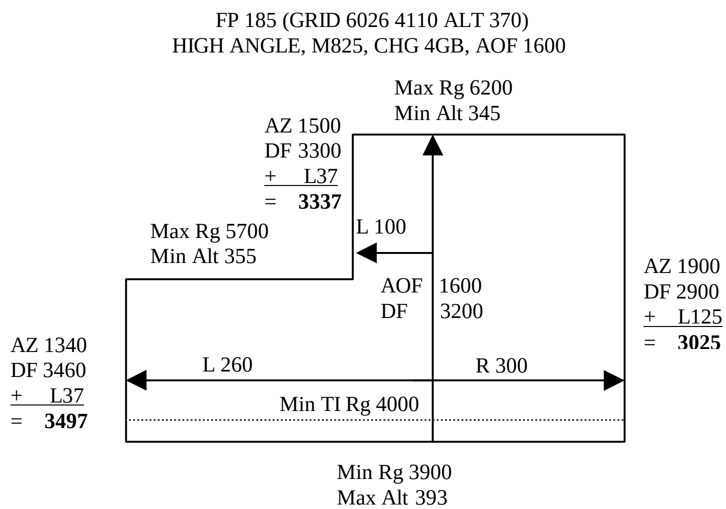


Figure 15-13. Example of High Angle Safety, Shell HE



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

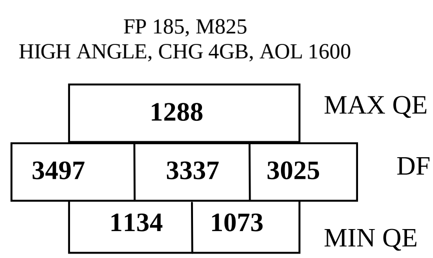
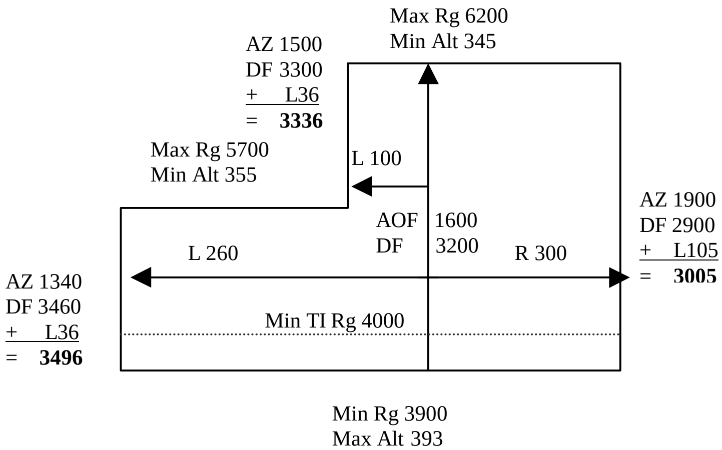


Figure 15-14. Example of High Angle Safety, Shell M825

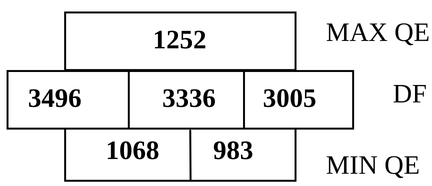
FP 185 (GRID 6026 4110 ALT 370)
HIGH ANGLE, ILLUM, CHG 3GB, AOF 1600



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



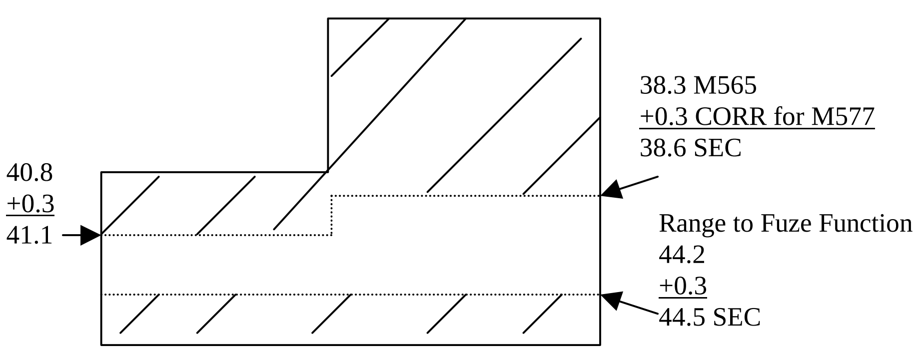
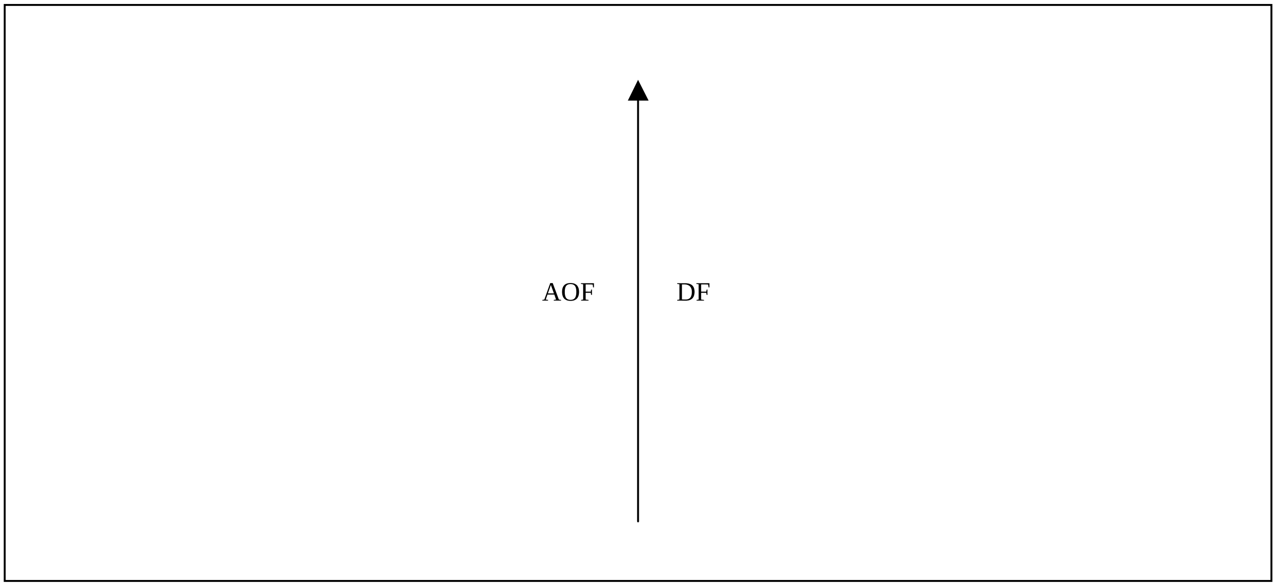


Figure 15-15. Example of High Angle Safety, Shell Illum

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: ____

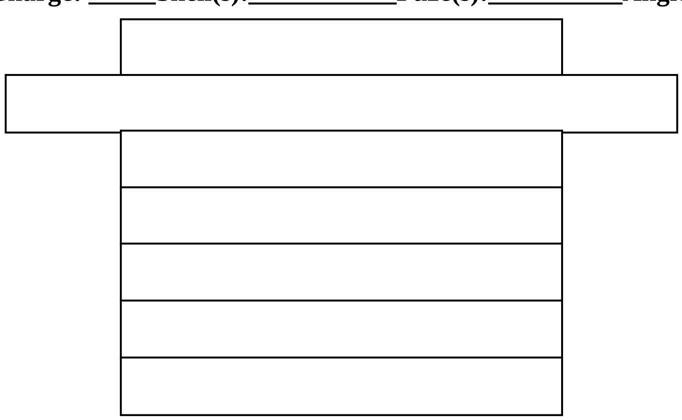
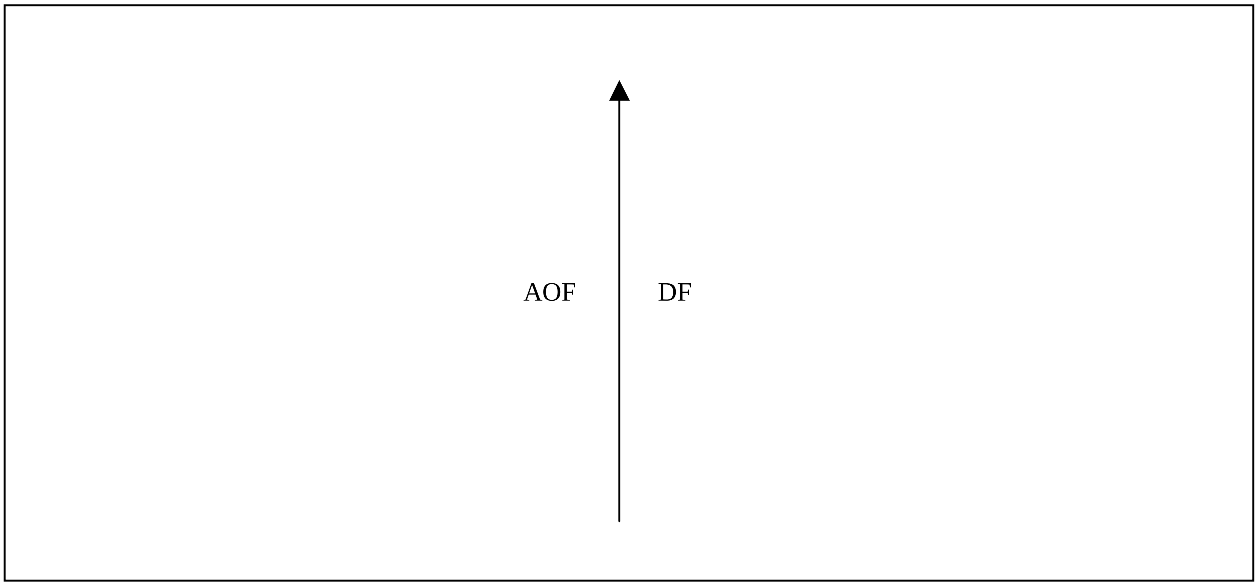


FIGURE 15-17: HIGH ANGLE SAFETY COMPUTATIONS

Safety Diagram

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

AOL:



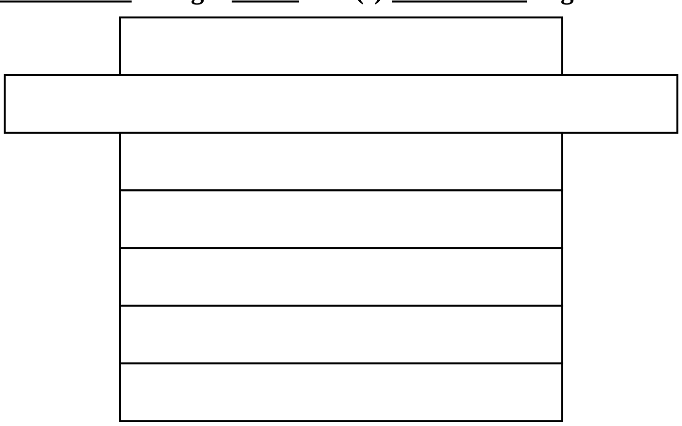
High Angle Safety Matrix

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

DIAGRAM RG	+	RG CORR	=	TOT RG	x	RG K	=	ENTRY 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.

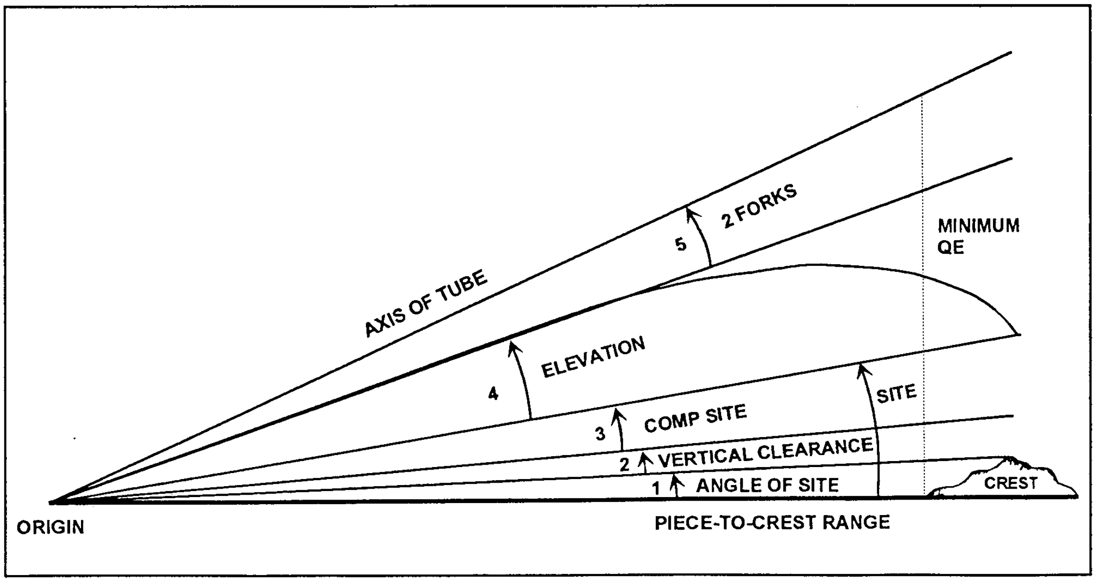


Figure 15-18. Angles of Minimum QE

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. 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.

15-18. 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 **(϶1 + ϶2 [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 **(϶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 15-11 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.

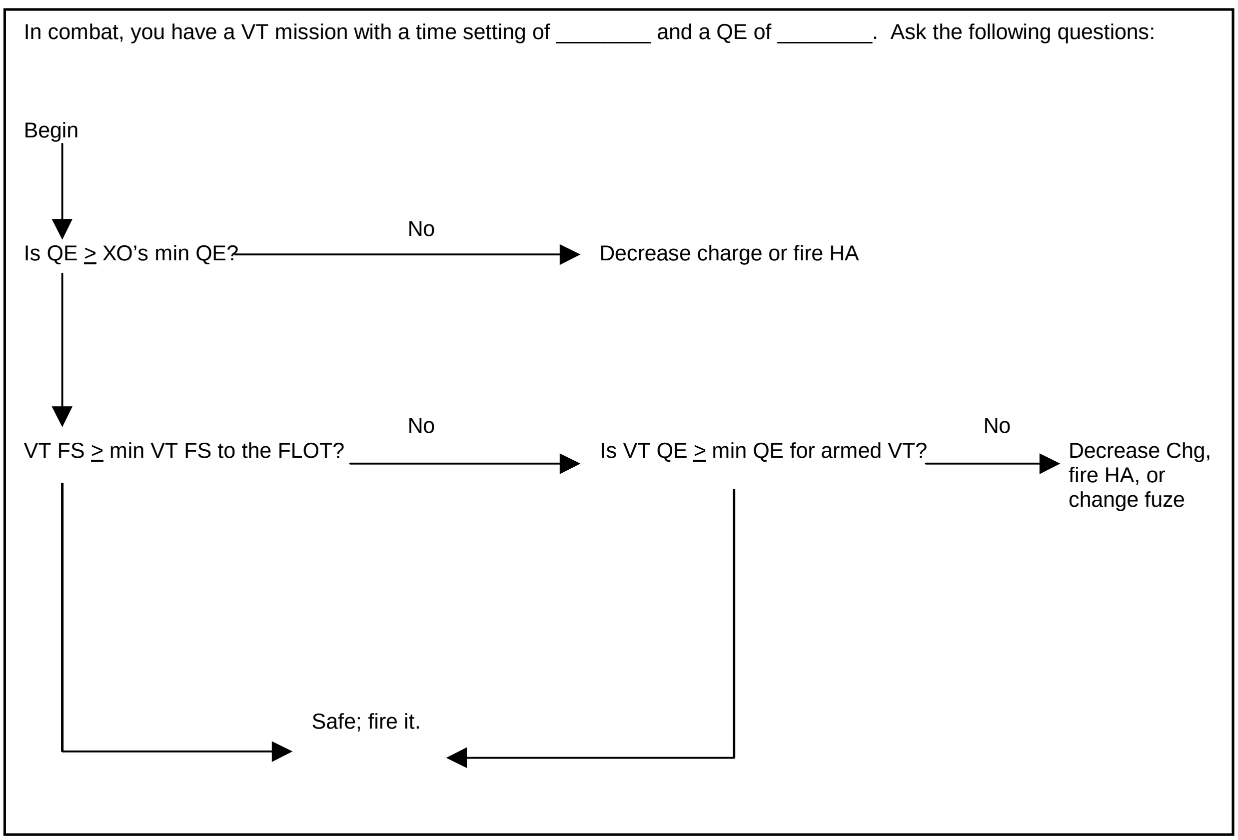


Figure 15-19. Armed VT Decision Tree.

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.**