NATO STANDARD

AOP-55

ADOPTION OF A STANDARD INDIRECT FIRE FIRING TABLE FORMAT

Edition A Version 1
AUGUST 2019

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED ORDNANCE PUBLICATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

14 August 2019

1. The enclosed Allied Ordnance Publication AOP-55, Edition A, Version 1, ADOPTION OF A STANDARD INDIRECT FIRE FIRING TABLE FORMAT, which has been approved by the nations in the NATO ARMY ARMAMENTS GROUP is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4119.

2. AOP-55, Edition A, Version 1, is effective upon receipt.

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4. This publication shall be handled in accordance with C-M(2002)60.

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
CZE	CZE Armed Forces do not use cluster munitions according to the Act No. 213/2011 Coll., in valid statues at large.
HRV	STANAG 4119 (3) the DRAFT shall be accepted with delay, in a way that the standard shall be applied in units using PzH 2000 HRV and other artillery weapons in accordance with the Joint Ballistic Memorandum of Understanding (JBMoU).

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

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CHAPTER 1 INTRODUCTION

1.1. AIM

1. The aim of this agreement is to describe standardized requirements for the development and publication of tabular firing tables for artillery and appropriate mortar cartridges in both complete and abridged formats.

1.2. AGREEMENT

1. In adopting this agreement, nations agree to develop tabular firing tables for surface to surface weapons as described below and to publish these tables in the formats described in annexes E to Y.

1.3. DETAILS OF AGREEMENT

1.3.1 Background

1. Tabular Firing Tables (TFTs) have been used for at least 100 years to calculate the quadrant elevation (QE), bearing and fuze setting used in firing a projectile to engage targets at a specified range from a gun position. Using a format established by the 1930s, TFTs allow for the standardized calculation of the required gun orders based on the projectile muzzle velocity, projectile weight, projectile ballistic characteristics, atmospheric conditions, and the difference in elevation between gun and target positions. Use of a standardized format allows for the exchange of TFTs between national artillery staffs. TFTs are safety-critical as an error in them can result in a projectile impacting a considerable distance from the intended location.

2. The format of TFTs was established prior to the advent of digital computers and was intended to allow for their use by gunners in carrying out manual calculations of artillery fire-control solutions. With the general use of computer software to determine fire-control solutions, the role of TFTs has changed to one of manual backup for software-based fire-control solutions. TFTs are also employed to support exchanges of weapons, cartridges, and fire-control data between nations.

3. The intent of this AOP is to describe the application of the reference STANAGs to the development of TFTs in both complete and abridged formats, computed using the NATO Modified Point Mass (MPM) trajectory model (STANAG 4355) and Tabular Firing Table (TaFT) S4 software. Included are descriptions of the format of each table and definitions for the terminology employed.

1.3.2 Use and Development of Tabular Firing Tables

1. The intent of TFTs is to provide, through a manual, non-software-based process, accurate fire-control solutions for specified conditions. Use of the full-format tables requires specialist training; the abridged format tables may be used without specialist training. Each table is generated using a stand-alone algorithm and Fire Control Input (FCI) data obtained in accordance with STANAG 4144. It is important to note that the fire-control solutions obtained are accurate for statistical groups of rounds and not for single rounds.

2. Trajectories are computed using the NATO MPM trajectory model (STANAG 4355) with use of the NATO Armament Ballistic Kernel (NABK – AOP-37) being recommended, although not essential. TFTs may be generated for all projectiles whose trajectories may be computed using the MPM model. The formats provided below are, however, only applicable to artillery and mortar weapon systems.

1.3.3 Probable Errors

1. An important component of a fire-control solution is the probable error (PE) associated with it. The term ‘probable error’ is defined in AAP-6 as “the error in range, deflection or in radius, which a weapon may be expected to exceed as often as not”. It is important to note that the PE is a measure of the variance of the fall-of-shot around the mean point of impact, and not of the uncertainty in the impact location of the first round fired. The PE values provided in the tabular firing tables must, for weapon/cartridges included in the NABK, be compatible with the PE terms in the NABK database.

1.3.4 Abridged Format Firing Tables

1. A single abridged-format table (Annex V) may be prepared for standard meteorological conditions (the ICAO Standard Atmosphere), standard muzzle velocity with a propellant at 21 degrees Celsius, and standard projectile weight. For the specified standard conditions, fire-control solutions obtained using this table will have the same accuracy as those obtained using the complete-format tables. Abridged-format tables may be used for safety checks of software-based fire-control solutions, preparation of safety templates, and engineering analyses of gun system ballistics.

1.3.5 Graphical Firing Tables

1. Nations may employ graphical firing tables prepared to national formats. While these tables must be produced using the NATO MPM trajectory model and FCIs obtained using STANAG 4144, fire-control data will not, however, be exchanged using graphical firing tables.

1.3.6 Existing Tabular Firing Tables

1. All TFTs approved for national use prior to promulgation of this agreement may be used for the exchange of fire-control data between nations. Wherever possible, nations shall endeavour to ensure compatibility between these TFTs and cartridge/projectile FCIs in the NABK database.

1.3.7 Language of Tabular Firing Tables

1. Tabular firing tables may be prepared in English, French, or a national language. If prepared in a language other than English or French, a glossary of the Annex D terms shall be prepared providing the English and French equivalents.

1.3.8 Calculation of Solutions for Illuminating Projectiles

1. Corrections for non-standard conditions are not required in obtaining solutions for illuminating projectiles. The ranges to fuze function and projectile functioning, respectively, must be provided if they are different.

1.3.9 Calculation of Fire-Control Solutions for Cargo Projectiles

1. Fire-control solutions for cargo projectiles are generally obtained using one of two table format options described in Annex T or Annex U. The first option requires use of Table F to correct the fire-control solution for non-standard conditions. The second option involves starting with the quadrant elevation obtained using the Part 1 tables for the reference projectile, including corrections for non-standard conditions.

1.3.10 Corrections for the Effects of Surface Winds to Submunition Trajectories

1. Nations may employ the format of Annex U to calculate the trajectories of the ejected submunitions, including the effect of near-surface wind, or use a less precise technique to estimate the mean impact location of the ejected submunitions.

1.3.11 General Requirements for Firing Table Formats

1. Nations may change the fonts and other details of the formats of the firing tables, as presented in annexes to this agreement, so long as procedures for their use, location of rows and columns on the page, and other functional features will not be affected.

1.3.12 Summary of Tables and their Function

1. **Charge Selection Table**. The charge selection table provides the probable error in range when firing single lots of propellant. The purpose of the table is to allow

for selection of the charge providing the lowest probable error in range for the desired range to target (shaded cells).

2. **Table A** lists the meteorological conditions (MET) line numbers of the standard ballistic MET message; and the elevations which give a vertex height from the midpoint of the line below to the midpoint of the line above, at angle of sight zero.

3. **Table B** gives complementary range (non-rigidity) corrections. The entry arguments for the table are map range and difference in altitude between gun and target. The correction must be applied to map range, to give an 'entry range' with which to enter the remaining tables. In addition, the table indicates the MET line in which the vertex of the trajectory will occur. This is the MET line from the standard Ballistic MET message to be used for obtaining all MET corrections for the mission. Low angle data is separated from high angle data by thickened horizontal lines. Thick vertical outside border indicates the remainder of high angle data.

4. **Table C** is a standard table for all guns at all charges. It resolves a one knot vector wind into cross wind and range wind components. These are multiplied by the actual wind speed to get the true cross wind and range wind components with which to enter Table F.

5. **Table D** gives corrections for temperature and density for a difference in height between the battery and the MET station. Two formats are available.

6. **Table E** gives the correction to be applied to muzzle velocity as a result of non-standard charge temperature. Muzzle velocity must be corrected for charge temperature before obtaining the muzzle velocity correction to range from Table F.

6. **Table E.1** is included, if appropriate, to give the correction to range as a result of non-standard rocket-assist motor or base burn unit temperature.

7. **Table F** defines the performance of the gun under standard conditions for every 100 metres of range from zero through maximum, to minimum range high angle, and gives corrections for non-standard conditions. The table is in two parts on facing pages. Table F defines the performance of the weapon in terms of range, elevation, time of flight and fuze setting under standard conditions, and gives basic data which includes corrections to bearing for drift and cross wind. Table F gives corrections to range for non-standard conditions. Low angle data is separated from high angle data by horizontal dotted lines. Thick vertical bars are used to sideline high angle data.

8. **Table G** gives data which supplements that of Table F. The listings are less frequent than in Table F, usually 500 or 1000 metres, and are arranged in such a way as to fit the complete table on a single page. Low angle data is separated from

high angle data by horizontal dotted lines. Thick vertical bars are used to sideline high angle data.

9. **Table H** gives the correction to range to compensate for the rotation of the earth. The entry arguments for the table are range and bearing in order to establish the range correction at the equator (0° latitude). The actual correction required is a function of cosine (latitude). A supplementary table listing cosines every 10 degrees is included below the main table. The correction established from the main table is to be multiplied by the appropriate latitude correction to establish the true correction to range.

10. **Table I** gives the correction to bearing to compensate for the rotation of the earth. There are eight tables of identical layout, one for every ten degrees of latitude from 0° to 70°. The entry arguments for each table are range; bearing, and hemisphere (North or South).

11. **Table J** is included, if appropriate, to give corrections to time fuzes for non-standard conditions. The entry argument for this table is fuze setting.

11. **Table J.1** is included, if appropriate, to give corrections to time fuzes for non-standard rocket-assist motor or base burn unit temperature. The entry arguments for this table are fuze setting and rocket-assist motor or base burn unit temperature.

12. **Table K**, if required, gives the difference in fuze setting for a fuze other than that included in Tables F and J. The entry argument is fuze setting for the standard fuze. The correction from Table K is applied directly to it.

13. **Tables for Cargo Projectile**. The tables are used to produce corrections to the bearing, quadrant elevation and fuze setting for a cargo projectile trajectory that will achieve submunition expulsion from the carrier projectile at the desired height, above and possibly short of the point of graze, which produce optimum target coverage and payload performance.

14. **Tables for Illuminating Projectile**. The tables are used to produce corrections to the bearing, quadrant elevation and fuze setting for an illuminating projectile trajectory which requires the illuminant submunition to perform directly above the target location at a specific height.

15. T**able for Abridged Table, Basic Data**. The information provided within the Abridged Table, Basic Data is the most sought after general data required especially in the planning phases of indirect fires.

16. **Table R,** the MV Table for Bursting Shell. The Abridged MV Tables were developed as an alternative to the Graphical Firing Tables (GFT). Table R was developed for exploding/bursting projectiles. The MV columns, 2 to 7, are at intervals

of 4 metres per second covering the expected MV coverage of the life of a barrel. The 4 m/s intervals allow for the grouping of guns within a battery or fire unit

17. **Table S,** the MV Tables for Carrier Shell. In conjunction with Table R, Table S was developed for cargo projectiles and are used in the same manner as Table R.

18. **Table T,** the Illuminating Carrier MV Supplement Table, Elevation / Range To Impact. Table T was developed as part of the Table R and S package for cargo projectiles with an Altitude Up Correction applied. The Table simplifies the production of the Range to Impact for carrier projectile for Safety Board plotting. The MV columns are used in the same manner as Tables R and S.

ANNEX A PRINCIPLES

A.1. STANDARD CONDITIONS

1. The standard atmospheric conditions for which the firing table is constructed are those of the ICAO Standard Atmosphere as described in the Manual of the ICAO Standard Atmosphere (STANAG 4044; see also STANAG 4061).

2. The earth is a homogeneous sphere. The Coriolis force is zero.

3. Gravity acts along the vertical and has the value given in the Manual of the ICAO Standard Atmosphere. A latitude of 45 degrees is used for all calculations.

4. Unless otherwise stated the reference altitude will be the zero altitude of the map system in use.

5. The motion of a projectile is represented by a mathematical model that utilizes established aerodynamic functions, fitting factors and other parameters associated with the projectile and atmosphere, as described in AOP-4355. The aerodynamic functions for a particular projectile have given tabulated values which, in general, vary with Mach number, as described in AOP-65

6. The parameters used in calculating projectile trajectories are determined from firings conducted in accordance with STANAG 4144 / AOP-65.

7. A pre-assigned standard muzzle velocity is used.

A.2. NON-STANDARD CONDITIONS

1. Allowances are to be given for the following non-standard atmospheric conditions, described in the meteorological message format of STANAG 4061:

   a. Density of the air.

   b. Temperature of the air (the effect due to change in Mach number only to be included; the effect due to change in density is to be included in a.).

   c. Wind.

2. Allowances for these and other non-standard conditions are to be made by means of corrections as described in Annex B.

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ANNEX B DEFINITIONS

1. The terms defined below are based on the concept of a curved earth and are generalized so that they may be used for any artillery weapon. They are derived from gunnery and ballistics procedures and are used in the preparation of tabular firing tables. Figures B-1 to B-4 illustrate the definitions of the trajectory-related terms presented below.

2. The trajectory is the curve described by the centre of gravity of the projectile. It is, in general, a three-dimensional curve. To simplify the description of its elements, the following assumptions are made:

a. The trajectory is a two-dimensional curve lying in a vertical plane.

b. The terms “projectile” and “target” are considered as points.

c. The term “weapon” refers to the trunnions and the term “origin” refers to the muzzle.

Table B-1, Definitions of Lines

(1)	Weapon Axis	The axis of the bore at the breech and taken as a straight line.
(2)	Muzzle Axis	The axis of the bore at the muzzle and taken as a straight line.
(3)	Line of Sight	The straight line passing through the weapon or instrument and the target.
(4)	Line of Departure	The tangent to the trajectory at the commencement of free flight. In general this line should be deduced from elements measured at convenient points on the trajectory.

Table B-2, Definitions of Planes and Surfaces

(5)	Vertical Plane	The plane containing the local gravity vector.
(6)	Horizontal Plane	The plane normal to the local gravity vector.
(7)	Vertical Plane of Sight	The vertical plane containing the line of sight.
(8)	Lateral Plane of Sight	The plane passing through the line of sight, at right angles to the vertical plane of sight.
(9)	Vertical Plane of Fire	The vertical plane containing the muzzle axis before firing.
(10)	Vertical Plane of Departure	The vertical plane containing the line of departure.
(11)	Level Surface	The level surface of a reference point is the surface of a sphere tangential to the horizontal plane through the reference point with a radius equal to the mean radius of the Earth plus the altitude of the reference point. The radius of the Earth is taken to be 6356766 m.

Table B-3, Definitions of Vertical Distances

(12)	Height	The distance measured along the local vertical line between a reference level surface and a given point.
(13)	Altitude	The height of a point with respect to mean sea level, as given by the map system in use.

Table B-4, Definitions of Particular Points of the Trajectory

(14)	Vertex	The point on a trajectory at which the vertical component of velocity is zero.
(15)	Point of Graze (Point of Fall)	The point of intersection between the trajectory and the weapon level surface.
(16)	Point of Impact	The point at which a projectile first strikes an object.
(17)	Zero Target	The vertical projection of a target on the weapon level surface.

Table B-5, Definitions of Distances

(18)	Slant Distance	The distance between two points measured along the straight line joining them.
(19)	Horizontal Distance	The horizontal distance of a point B from a point A is the orthogonal projection of the slant distance between A and B on the horizontal plane through A.
(20)	Level Distance	The level distance of a point B from a point A is the distance, measured along the great circle between A and the orthogonal projection of B on the level surface through A (in particular the level distance from the weapon (A) to a point (B) on the trajectory).
(21)	Range	The level distance from the weapon to the level point or the start point for determining a fire-control solution using tabular firing tables.
(22)	Map Range	The value of the level distance furnished by the map grid in use.
(23)	Range for no Fuze Function	The range from the weapon to the impact location when the fuze fails to function.
(24)	Range for no rocket motor or base-burn function	The range from the weapon to the impact location when the rocket motor or base-burn unit fails to function.
(25)	Range to mean submunition impact location	The range from the weapon to the mean point of impact of the submunitions ejected from a cargo projectile
(26)	Range to canister impact	The range from the weapon to the point of impact of the empty canister.

Table B-6, Definitions of Angles

(27)	Angle of Sight	The vertical acute angle measured from the horizontal plane passing through the weapon or instrument to the line of sight.
(28)	Angular Height Difference	The angular height difference of a point B from a point A is the angle, the tangent of which is the altitude of B minus the altitude of A divided by the level distance of B from A.
(29)	Elevation	The vertical acute angle measured from the horizontal plane passing through a weapon or instrument to its axis.
(30)	Firing Table Elevation	The elevation at which the gun is required to be laid under standard firing table conditions to achieve the objective stated in the firing table.

Table B-6, Definitions of Angles, continued

(31)	Tangent Elevation	The vertical component of the acute angle measured from the line of sight to the weapon axis.
(32)	Angle of Departure	The vertical acute angle measured from the horizontal plane passing through the weapon to the line of departure.
(33)	Angle of Projection	The vertical component of the acute angle measured from the line of sight to the line of departure.
(34)	Jump	The vertical component of the acute angle measured from the muzzle axis before firing to the line of departure.
(35)	Droop	The vertical component of the acute angle measured from the weapon axis to the muzzle axis.
(36)	Lateral Jump or Throw-off.	The lateral component of the acute angle measured in the horizontal plane from the muzzle axis before firing to the line of departure.
(37)	Quadrant Elevation	The elevation at which the gun is required to be laid under the prevailing conditions to achieve the desired objective.
(38)	Correction for Angular Height Difference	The angular value which should be added to the quadrant elevation corresponding to the zero target, to correct for the angular height difference between the target and the weapon.
(39)	Inclination of the Trajectory	The vertical acute angle measured from the local horizontal plane passing through a given point on the trajectory to the orientated tangent to the trajectory at this point.
(40)	Angle of Fall (Angle of Descent)	The inclination of the trajectory at the level point; the sign being positive.
(41)	Angle of Incidence.	The acute angle between the normal to the plane tangential to the surface struck and the tangent to the trajectory at the point of impact.
(42)	Angle of Impact.	The complement of the angle of incidence.
(43)	Projectile Deflection	The horizontal angle measured from the vertical plane of fire to the vertical plane through the weapon and containing a specified point along the trajectory.
(44)	Drift	That part of projectile deflection due to axial spin.

Table B-7, Definitions of Others Terms

(45)	Time of Flight	The time taken by a projectile to travel between the origin and a specified point on a trajectory.
(46)	Muzzle Velocity	A velocity at the muzzle deduced by extrapolation from the velocity of a projectile measured at a convenient point on its trajectory
(47)	Probable Error	The error in range, deflection or in radius, which a weapon may be expected to exceed as often as not (AAP-6).
(48)	Fork	Fork is a change in elevation in mils necessary to move the mean point of impact four times the probable error in range on the level surface.
(49)	Perturbation	Any difference between a non-standard and a standard condition is a perturbation.
(50)	Effect	Any change in the magnitude of a function (elevation, level distance, height, time of flight etc.) due to one or more perturbations (muzzle velocity, wind, density, etc.) with fixed values for two independent variables (level distance and height, elevation and height, etc.), e.g. the change in time of flight due to a perturbation in density for fixed values of elevation and height.
(51)	Corrections.	Any change in the magnitude of a function that is required to compensate for one or more effects in order to achieve a desired objective.
(52)	Standard Trajectory	A trajectory obtained by calculation under standard firing table conditions with given fitting factors and aerodynamic coefficient variations.
(53)	Perturbed Trajectory	A trajectory obtained by calculation under perturbed meteorological and ballistic conditions with given fitting factors and aerodynamic coefficient variations.
(54)	Realized Trajectory	The mean of the trajectories obtained by firing a limited number of rounds with the same firing data on one occasion under effectively the same meteorological and ballistic conditions with a given weapon and given ammunition.
(55)	Ideal Trajectory	The mean trajectory which would be obtained by firing an infinite number of rounds with the same firing data under the same meteorological and ballistic conditions with a given weapon and given ammunition.
(56)	Height of Burst	The height above the ground surface at the start of functioning of a time-fuzed projectile.
(57)	Time to Burst	The time after muzzle exit at the start of functioning of a time fuzed projectile.
(58)	Range to Burst	The range from the muzzle at the start of functioning of a time fuzed projectile.

Table B-8, Miscellaneous

(59)	MET Datum Plane	The reference plane for the meteorological message data.

Notes:

1. In tabular firing tables the terms 'site' and 'sight' are used interchangeably.

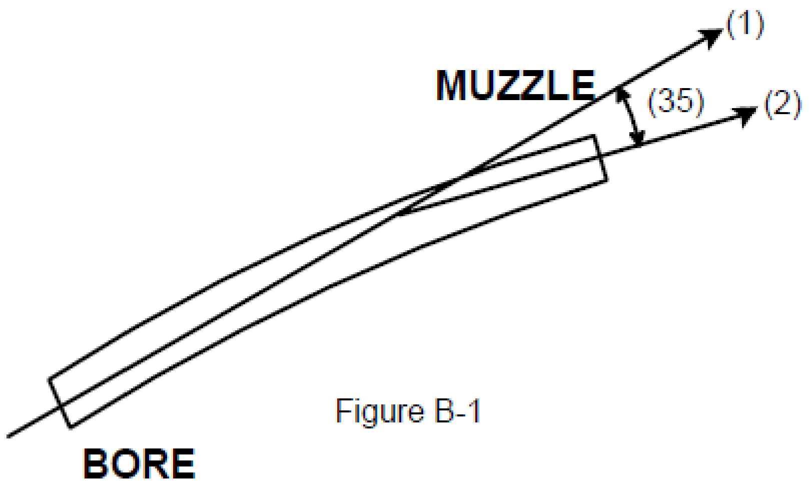

Figure B-1

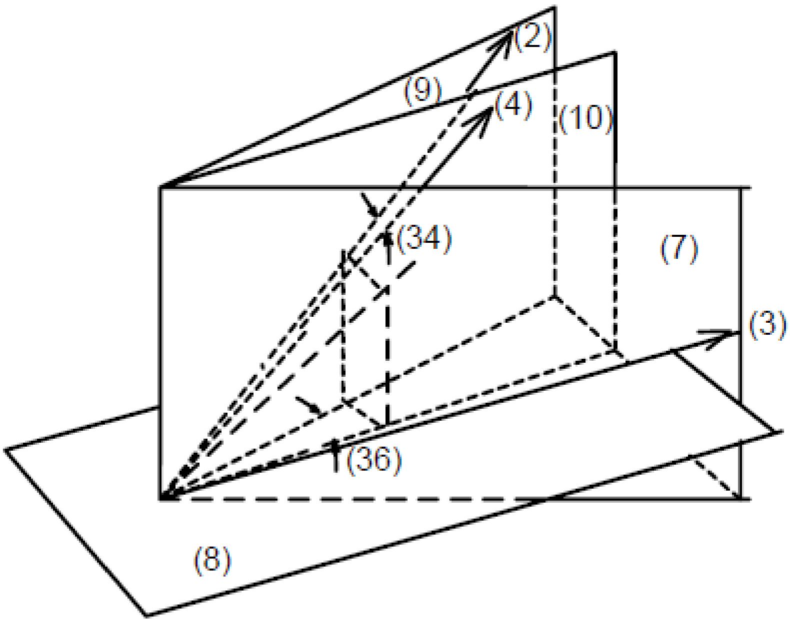

Figure B-2

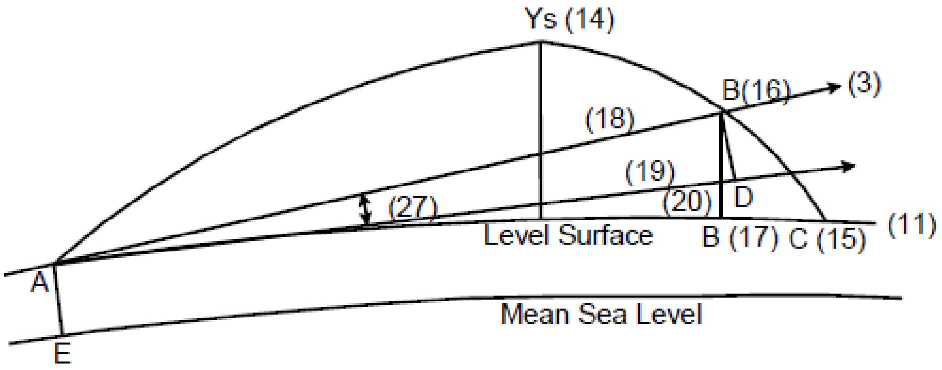

Figure B-3

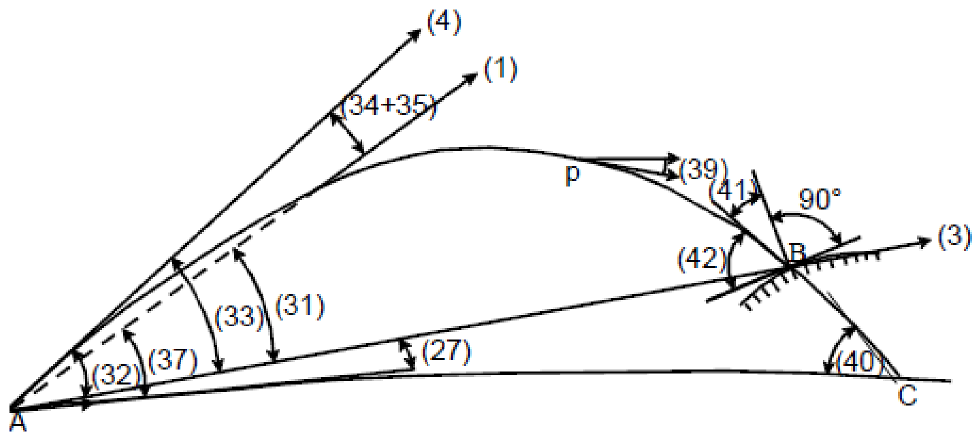

Figure B-4

ANNEX C DESCRIPTION

1. Complete format Tabular Firing Tables shall conform to the conditions specified below. Abridged format firing tables for each charge system shall be prepared in the format of Annex V.

a. **Dimensions** . The overall width and length of the firing table should be approximately that of the international paper size A5 i.e. 148mm × 210mm.

b. **Layout** .

(1) Indexing is to be provided to give easy access to charge and other sections.

(2) Conventional algebraic signs are to be used throughout the tables.

(3) Values with negative signs should be printed in red italics in those tables specified in paragraph c.(3) below.

(4) Shading and distinctive markings are to be used in those tables specified in paragraph c.(3) below.

c. **Contents**

(1) Title page. The title page is to contain the following information:

(a) Nomenclature of the cannon.

(b) List of appropriate ammunition.

(c) Standard conditions on which the data are based.

(d) Table of contents.

(2) Introduction. The introduction is to contain the following information:

(a) A list of symbols and abbreviations used in the firing tables. NATO approved symbols are to be used where possible (see annex D for terminology and symbols).

(b) Details of weapon characteristics (see Annex E).

(c) A table of projectile/fuze combinations and weights, obtained from AOP-29.

(d) A table of equivalent full charge service rounds.

(e) A table of wear data for the cannon.

(f) A charge selection table (see Annex F).

(g) Details of the drag and ballistic coefficients used in the construction of the tables or reference to documents containing such information.

(h) Details of the values of the perturbations used in the calculation of the bilinear corrections given in the tables.

(i) Other information according to national preferences

(3) Part 1 Tables. The Part 1 tables, titled "Tables for the Reference Projectile", contain Tables A to K. These tables give data for each charge for the principal projectile of a family, usually high explosive bursting shells. In some cases, the tables may be generated to reflect air burst solutions for carrier/cargo shells. Alternatively, abridged tables may be provided when only summary information is required.

(a) The title page of each section containing the tables for a given charge should give the standard muzzle velocity for which the tables are constructed, the appropriate jump and any other relevant information such as limitation on elevation.

(b) Part 1 tables may contain the Tables detailed in Table C-1.

Table C – 1, Tables which may be included in Part 1.

TABLE A	MET Line Number as a function of Quadrant Elevation (see Annex G)
TABLE B	Complementary Range (or Complementary Elevation) and MET Line Number (see annex H) Correction to range (or elevation) for difference in altitude of target and gun, and MET Line Number to be used. For the definition of MET Line Number see STANAG 4061. The limits of "Difference in Altitude of Target and Gun" shown in the Annex may be changed according to national preference. Also the number of lines in each block of data in this and other tables shown in the annexes is a matter of national preference. Both the sign and value of negative numbers should be

	printed in red italics. A distinctive marking is to be used to separate MET Line Numbers and a different distinctive marking to separate data for low angle from that for high angle.
TABLE C	Wind Components (see Annex I) Cross and range wind components of a one-knot wind.
TABLE D	Ballistic Air Temperature and Ballistic Air Density Correction (see Annex J). Corrections to ballistic temperature and ballistic density to compensate for the difference in altitude between battery and meteorological datum plane (MDP).
TABLE E	Propellant Temperature (see Annex K). Effects on muzzle velocity due to propellant temperature. Both the sign and value of negative numbers should be printed in red italics.
TABLE E.1	Corrections to Range for Rocket-Assist Motor or Base-Burn Unit Temperature (See Annex L). Corrections to range to compensate for variations in the propellant temperature of the rocket motor or base-burn unit. Both the sign and value of negative numbers should be printed in red italics.
TABLE F	Basic Data and Corrections (see Annex M). Basic data for standard conditions and corrections to bearing are given in Table F (left) and corrections to range for non-standard conditions in Tables F (right). Each page of Table F (right) should appear opposite the corresponding page of Table F (left). Both the sign and value of negative numbers should be printed in red italics. Columns indicated by shading in the example at annex M are to be distinctively marked. A distinctive marking is to be used to separate the data for low angle and high angle fire.
TABLE G	Supplementary Data (see Annex N) Probable errors and other terminal data. Both the sign and value of negative numbers should be printed in red italics. A distinctive marking is to be used to separate data for low angle and high angle fire.
TABLE H	Rotation of the Earth - Range (see Annex O) Correction to range to compensate for the rotation of the earth. A distinctive marking is to be used to separate data for low angle and high angle fire.
TABLE I	Rotation of the Earth - Bearing (see Annex P) Corrections to bearing to compensate for the rotation of the earth. Tables for each 10 degrees of latitude up to 70 degrees are to be given. A distinctive marking is to be used to separate data for low angle and high angle fire.
TABLE J	Corrections to Fuze Setting for Non-Standard Conditions (see Annex Q). Correction for non-standard conditions to be applied to the fuze setting corresponding to the corrected elevation. Both the sign and

	value of negative numbers should, if possible, be printed in red. Columns indicated by shading in the example at Annex R are to be distinctively marked.
TABLE J.1	Corrections to Fuze Setting for Rocket-Assist Motor or Base-Burn Unit Temperature (See Annex R). Corrections to fuze setting to compensate for variations in the propellant temperature of the rocket motor or base-burn unit. Both the sign and value of negative numbers should be printed in red italics.
TABLE K	Data for Alternative Fuzes (see Annex S) Fuze settings or correction for alternative fuzes. Both the sign and value of negative numbers should be printed in red italics.
Abridged Table	Basic Data (See Annex V). The Abridged Table is a summary of ballistic trajectory basic data.
TABLE R	Abridged MV data for Bursting Projectile (See Annex W). Enabling groupings of guns within 4 m/s for bursting projectile, including the correction to range for 1 m/s and the effect of increasing the elevation by 1 mil.

(4) Part 2 Tables. Data for other types of projectile, having ballistics differing from the principal projectiles is included in Part 2 of the tabular tables. Firing data for cargo (submunition) projectiles are to be provided in one of the two format options described in Annex T. Firing Data for illuminating shells, where these are to be included, should be given in Part 2 in the form shown in the example given in Annex U. Columns indicated by shading in the examples at Annexes U and X are to be distinctively marked. Tables S and T may be included within Part 2.

(5) Appendices.

(a) Other information, such as Trajectory Charts and a World Time Zone Map, which may be required according to national preference, should normally be included in appendices but may be added to particular tables where more appropriate.

(b) If, in the case of a radically different weapon or ammunition, it is impracticable to use the standard format described in paragraph 1, the developing country may modify the format as necessary. The modified format should conform, as closely as possible, to the standard.

ANNEX D TERMINOLOGY AND SYMBOLS

English	Français	Symbol
Accuracy	Justesse	j (subscript)
Altitude	Altitude	ALT
Angle	Angle	A
Angle of Bearing	Azimut, Gisement	A_{BG}
Angle of Departure	Angle de projection (départ)	A_o
Angle of Elevation (Firing Table Elevation)	Angle de hausse Hausse des tables	A_E
Angle of Fall (Angle of Descent)	Angle de chute	A_ω
Angle of Jump	Angle de relèvement	A_j
Angle of Projection	Angle de projection	A_p
Angle of Sight (Site)	Angle de site	A_S
Angle of Tangent Elevation	Angle de hausse	A_{TE}
Ballistic	Balistique	B (subscript)
Ballistic Air Temperature	Température balistique (de l'air)	T_B
Ballistic Air Density	Densité balistique (de l'air)	D_B
Ballistic Wind	Vent balistique	W_B
Base Detonating	Fusée de culot	BD
Bearing	Azimut, Gisement	BG (subscript)
Burst	Éclatement	b (subscript)
Change	Variation	Δ
Charge	Charge	CH
Complementary Angle of Site	Angle complémentaire de site	A_{CS}
Complementary Range	Correction complémentaire de site (distance)	$\Delta_C X_{CS}$
Concrete Piercing	Anti-béton	CP
Correction	Correction	C (subscript)
Cross	Latéral	Z (subscript)

English	Français	Symbol
Cross Wind	Vent latéral	W_Z
Decrease	Diminution	DEC
Deflection	Déviation latérale	DEF
Degree Centigrade	Degré centigrade	°C
Degree Fahrenheit	Degré Fahrenheit	°F
Degrees	Degrés	DEG
Density (Air)	Densité (de l'air)	D
Distance at a given level (Range)	Portée	X
Drift	Dérivation	A_d
Effect	Effet (Altération)	EF (subscript)
Following Wind (or Tail Wind)	Vent Arrière	$\underline{W}$
Fork	Fourchette	F
Fuze Setting	Event	FS
Head Wind	Vent debout	$\overline{W}$
Height	Dénivelée	Y
Inches	Not Used (Pouce)	IN
Increase	Augmentation	INC
Jump	Relèvement	A_J
Kilogram	Kilogramme	KG
Knot	Nœud	KT
Latitude	Latitude	La
Left	Gauche	L
Length	Plus	+
Less	Moins	-
Line Number	Numéro de ligne	LN
Loss	Diminution	-

English	Français	Symbol
Low Level Wind	Vent de surface	W_s
Mass	Masse	MASS
Maximum Ordinate (Vertex Height)	Flèche	Y_s
Mechanical Time	Mécanique à temps	MT
Mechanical Time & Super Quick	Mécanique à temps et instantanée	MTSQ
Meteorological	Météorologique	MET
Meteorological Datum Plane	Niveau de la station météorologique	MDP
Meter (metre)	Mètre	M
Meter (metre) per second	Mètre par seconde	M/S
Mil	Millième	MIL
More	Plus	+
Muzzle Velocity	Vitesse initiale	V_o
NATO	OTAN	NATO/OTAN
North	Nord	N
Origin	Origine	o (subscript)
Percent	Pourcent	%
Perturbation	Perturbation	Δ
Pound	Not used (Livre)	LB
Precision (Consistency)	Précision	p (subscript)
Pressure	Pression	P
Probable Error	Écart probable	E
Projectile	Projectile	PROJ
Projectile Deflection	Déviation latérale du projectile	DEF_{PROJ}
Projectile Mass	Masse du projectile	m_{PROJ}
Propellant	Poudre propulsive	pp
Propellant Temperature	Température de la poudre	T_{pp}

English	Français	Symbol
Propellant Mass	Masse de la poudre	m_{pp}
Quadrant Elevation	Angle au Niveau (Angle d'inclinaison)	A_{QE}
Range	Portée	X
Range for no function of rocket motor or base-burn	Portée en cas du non-fonctionnement du moteur roquette ou du culot à réduction de traînée	$X_{NO\text{-}MOT}$
Range for no fuze function	Portée en cas du non-fonctionnement de la fusée	$X_{NO\text{-}FUZE}$
Range Wind	Vent longitudinal	W_X
Right	Droit	R
Rise	Plus	+
Rotation of the Earth	Vitesse de rotation de la terre	ROT
Second	Seconde	S
Shorten	Moins	-
Slant Range	Distance oblique (suivant le site)	SR
South	Sud	S
Square	Carreau	SQ (□)
Standard	Standard	STD
Surface Air Pressure	Pression au Sol	P_o
Tail Wind (or Following Wind)	Vent arrière	$\underline{W}$
Tangent Elevation	Angle de hausse	A_{TE}
Target	Objectif	TGT
Temperature	Température	T
Terminal (fall)	De chute	ω (subscript)
Time of Flight	Durée de trajet (temps de vol)	TOF
Total Angle of Site	Angle de site total	A_{TS}
Travel Time	Temps de passage	TT
Variable Time	de proximité	VT
Variation	Variation	Δ

English	Français	Symbol
Velocity	Vitesse	V
Velocity at Graze (Remaining Velocity)	Vitesse au point de chute (vitesse restante)	V_ω
Vertex	Sommet	s (subscript)
(Vertex Height) Maximum Ordinate	Flèche	Y_s
Wind	Vent	W

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ANNEX E WEAPON CHARACTERISTICS

1. A table is to be provided with essential information on the weapon, the reference projectile and the reference fuze. An example of such a table is shown below.

CANNON	M284
CARRIAGE	Howitzer, M109 Series
CALIBRE	155MM
TWIST AT THE MUZZLE	1 turn in 20 Calibres
LENGTH OF THE RIFLING	6086 MM
TOTAL TRVAERSE	6400 MIL
MAXIMUM ELEVATION	1300 MIL
MINIMUM ELEVATION	-32 MIL
CHANGE IN ELEVATION FOR ONE TURN OF ELEVATING HANDWHEEL	5 MIL
REFERENCE PROJECTILE	HE M107
MASS OF REFERENCE PROJECTILE	43.091 KG
MASS OF ONE SQUARE CORRECTION	0.499 KG
REFERENCE FUZE	PD M557
MASS OF REFERENCE FUZE	0.998 KG

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ANNEX F CHARGE SELECTION TABLE

1. The charge selection table provides the probable error in range when firing single lots of propellant. The purpose of the table is to allow for selection of the charge providing the lowest probable error in range for the desired range to target (shaded cells). An example of a Charge Selection Table is illustrated at Figure F – 1.

Projectile, HE M222 **Charge All**
Fuze, PD M555

Charge Selection Table

Range (X)	Probable Error in Range (E_x) Charge (CH)				
	1	2	3	4	5
m	m	m	m	m	m
1000	7	6	7	9	12
2000	13	8	9	11	12
3000	20	10	11	14	15
4000	26	17	13	16	17
5000	33	22	15	19	20
6000	41	27	17	21	22
7000		32	20	23	24
8000		40	23	25	27
9000			27	27	28
10000				29	28
11000				31	30
12000				35	32
13000					34
14000					37
15000					
16000					
16000					
15000					
14000					40
13000					38
12000				35	36
11000				33	34
10000				31	32
9000			30	29	31
8000		30	26	27	
7000		26	25	26	
6000	43	22	23		
5000	37	22	25		

Figure F – 1, Example of the Charge Selection Table

2. The Charge Selection Table provides a manual means of selecting the optimum charge based upon the Probable Error in Range (PEr).

3. The range column is generally at intervals of 500 M or 1000 M. The Map Range to the target is read down the left side of the table and the optimum charge selected using the highlighted block corresponding to the lowest value of PEr.

ANNEX G TABLE A – LINE NUMBERS OF BALLISTIC METEOROLOGICAL MESSAGE

1. Table A gives the line numbers of the ballistic meteorological message (STANAG 4061) as a function of quadrant elevation. The line numbers correspond to predetermined standard heights. If quadrant elevation is known, or can be reasonably inferred, Table A should be used for line number determination. Otherwise, line numbers may be obtained from Table B as a function of range and height of target above the gun. An example of Table A is illustrated at Figure G –1.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table A

Line Numbers of Ballistic Meteorological Message

Quadrant Elevation (A_{QE})	Line Nr (LN)
mil	
0.0 – 127.3	0
127.4 – 248.2	1
248.3 – 375.7	2
375.8 – 499.8	3
499.9 – 607.3	4
607.4 – 755.1	5
755.2 – 948.5	6
948.6 – 1167.9	7
1168.0 – 1343.9	8

Note - When the projectile must hit the target on the ascending branch of the trajectory, use height of target in meters to enter table B to determine the Line Number.

Figure G – 1, Example of Table A

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ANNEX H TABLE B – COMPLEMENTARY RANGE AND MET LINE NUMBER

1. Table B has the range corrections corresponding to the complementary angle of sight, and line numbers of the meteorological message. The range corrections are tabulated as a function of range and height of target above the gun. For a target at some height other than zero, the complementary range correction is added to the map range to obtain a range to be used for entering Table F. The line number is tabulated in the margin of the table. Each particular line number is applicable to all target points lying between the thick dividing lines containing that number. An example of Table B, Left and Right Pages is illustrated at Figures H – 1 an H - 2.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table B

Complementary Range and Met Line Number

Change in range, in meters, to correct for complementary angle of site
Line numbers of ballistic meteorological message
($\Delta_c X_{CS}$ and LN)

Line Nr (LN)	Range (X)	Difference in altitude of target and gun in meters ΔAlt. Target - Gun								Line Nr (LN)
	m	-400	-300	-200	-100	0	100	200	300	
2	7500	-109	-83	-57	-29	0	30	62	95	3
2	7600	-112	-86	-58	-30	0	31	64	98	3
2	7700	-115	-88	-60	-31	0	32	66	101	3
3	7800	-118	-91	-62	-32	0	33	68	104	3
3	7900	-122	-93	-64	-33	0	34	70	107	3
3	8000	-126	-96	-66	-34	0	35	72	110	4
3	8100	-129	-99	-68	-35	0	36	74	114	4
3	8200	-133	-102	-70	-36	0	37	76	117	4
3	8300	-137	-105	-72	-37	0	38	79	121	4
3	8400	-141	-108	-74	-38	0	40	81	125	4
3	8500	-145	-112	-76	-39	0	41	84	130	4
3	8600	-150	-115	-78	-40	0	42	87	135	4
3	8700	-154	-118	-81	-41	0	44	90	140	4
3	8800	-159	-122	-84	-43	0	45	93	145	4
3	8900	-164	-126	-87	-45	0	47	97	151	5
4	9000	-170	-131	-90	-46	0	49	101	158	5
4	9100	-176	-136	-93	-48	0	51	106	165	5
4	9200	-183	-141	-97	-50	0	53	111	173	5
4	9300	-190	-147	-101	-52	0	56	116	183	5
4	9400	-197	-153	-105	-54	0	59	123	196	5
4	9500	-205	-159	-110	-57	0	62	132	214	5
4	9600	-214	-166	-115	-60	0	67	146		5
4	9700	-224	-175	-122	-64	0	75			5
5	9800	-236	-185	-130	-69	0				6
6	9800	-460	-331	-210	-99	0				6
6	9700	-482	-349	-223	-106	0	91			6
7	9600	-503	-365	-235	-113	0	102	187		6
7	9500	-522	-380	-246	-118	0	109	205	285	6
7	9400	-542	-395	-256	-124	0	115	219	311	6
7	9300	-560	-409	-265	-129	0	120	231	331	6
7	9200	-579	-424	-275	-134	0	125	242	349	6
7	9100	-597	-438	-284	-138	0	130	253	366	7
7	9000	-616	-451	-294	-143	0	135	262	381	7
						7				

Figure H – 1, Example of Table B, Left Page.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table B

Complementary Range and Met Line Number

Change in range, in meters, to correct for complementary angle of site
Line numbers of ballistic meteorological message
($\Delta_c X_{CS}$ and LN)

Line Nr (LN)	Difference in altitude of target and gun in meters ΔAlt. Target - Gun							Range (X)	Line Nr (LN)
	400	500	600	700	800	900	1000	m	
3	130	166	204	244	286	330	377	7500	4
3	134	171	210	251	295	341	389	7600	4
3	138	176	217	259	304	352	402	7700	4
4	142	181	223	267	314	363	416	7800	5
4	146	187	230	276	325	376	430	7900	5
4	150	193	238	285	336	389	446	8000	5
4	155	199	246	295	348	403	463	8100	5
4	160	206	255	306	361	419	482	8200	5
4	166	213	264	317	374	436	502	8300	5
4	172	221	274	330	389	454	524	8400	5
4	178	229	284	343	406	474	549	8500	5
4	185	238	296	357	424	497	578	8600	5
4	192	248	309	373	444	523	613	8700	5
5	200	259	322	391	468	555	659	8800	6
5	208	270	338	412	497	597	733	8900	6
5	218	284	356	438	535	668		9000	6
5	229	299	379	473	605			9100	6
5	242	319	410	541				9200	6
5	258	346	484					9300	6
5	281							9400	6
5								9500	6
5								9600	6
5								9700	6
6								9800	6
6								9800	6
6								9700	6
6								9600	6
6								9500	6
6	386							9400	6
6	419	488	498					9300	6
6	445	528	591	610				9200	6
7	468	560	637	695	711			9100	6
7	490	589	675	747	799	810		9000	6
	7	7	6	6	6	6	6		

Figure H – 2, Example of Table B, Right Page

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ANNEX I TABLE C – WIND COMPONENTS

1. Table C has the components of a one knot wind, blowing from the chart direction, divided into two components: the cross wind, perpendicular to the plane of fire, and the range wind, parallel to the plane of fire. As a calculation, the chart direction is calculated by:

Chart Direction = Wind Direction – Bearing Gun to Target

These components are to be multiplied by the wind speed from the appropriate line of the MET message to obtain the total cross and range wind to be used in a particular fire mission. An example of Table C is illustrated at Figure I - 1.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table C

Wind Components

Components of a One-Knot Wind

Chart Direction of Wind	Cross Wind (W_Z)	Range Wind (W_X)	Chart Direction of Wind	Cross Wind (W_Z)	Range Wind (W_X)
mil	kt	kt	mil	kt	kt
0	0	H1.00	3200	0	T1.00
100	R0.10	H1.00	3300	L0.10	T1.00
200	R0.20	H0.98	3400	L0.20	T0.98
300	R0.29	H0.96	3500	L0.29	T0.96
400	R0.38	H0.92	3600	L0.38	T0.92
500	R0.47	H0.88	3700	L0.47	T0.88
600	R0.56	H0.83	3800	L0.56	T0.83
700	R0.63	H0.77	3900	L0.63	T0.77
800	R0.71	H0.71	4000	L0.71	T0.71
900	R0.77	H0.63	4100	L0.77	T0.63
1000	R0.83	H0.56	4200	L0.83	T0.56
1100	R0.88	H0.47	4300	L0.88	T0.47
1200	R0.92	H0.38	4400	L0.92	T0.38
1300	R0.96	H0.29	4500	L0.96	T0.29
1400	R0.98	H0.20	4600	L0.98	T0.20
1500	R1.00	H0.10	4700	L1.00	T0.10
1600	R1.00	0	4800	L1.00	0
1700	R1.00	T0.10	4900	L1.00	H0.10
1800	R0.98	T0.20	5000	L0.98	H0.20
1900	R0.96	T0.29	5100	L0.96	H0.29
2000	R0.92	T0.38	5200	L0.92	H0.38
2100	R0.88	T0.47	5300	L0.88	H0.47
2200	R0.83	T0.56	5400	L0.83	H0.56
2300	R0.77	T0.63	5500	L0.77	H0.63
2400	R0.71	T0.71	5600	L0.71	H0.71
2500	R0.63	T0.77	5700	L0.63	H0.77
2600	R0.56	T0.83	5800	L0.56	H0.83
2700	R0.47	T0.88	5900	L0.47	H0.88
2800	R0.38	T0.92	6000	L0.38	H0.92
2900	R0.29	T0.96	6100	L0.29	H0.96
3000	R0.20	T0.98	6200	L0.20	H0.98
3100	R0.10	T1.00	6300	L0.10	H1.00
3200	0	T1.00	6400	0	H1.00

Figure I – 1, Table C, Wind Components

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ANNEX J TABLE D – BALLISTIC AIR TEMPERATURE AND BALLISTIC AIR DENSITY CORRECTIONS

1. Table D lists the corrections to be added to the ballistic air temperature and the ballistic air density to compensate for the difference in altitude between the firing battery and the meteorological datum plane (MDP). Examples of Table D, Alternatives 1 and 2 are illustrated at Figures J – 1 and J - 2

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table D

Ballistic Air Temperature And Ballistic Air Density Corrections

Corrections to temperature (T_B) and density (D_B) in percent,
to compensate for the difference in altitude, in meters,
between the gun and the Met Datum Plane (MDP)

ΔAlt (Gun - MDP)		0	+10-	+20-	+30-	+40-	+50-	+60-	+70-	+80-	+90-
0	$\%\Delta_C T_B$	0.0	0.0	0.0	-0.1+	-0.1+	-0.1+	-0.1+	-0.2+	-0.2+	-0.2+
	$\%\Delta_C D_B$	0.0	-0.1+	-0.2+	-0.3+	-0.4+	-0.5+	-0.6+	-0.7+	-0.8+	-0.9+
+100-	$\%\Delta_C T_B$	-0.2+	-0.2+	-0.3+	-0.3+	-0.3+	-0.3+	-0.4+	-0.4+	-0.4+	-0.4+
	$\%\Delta_C D_B$	-1.0+	-1.1+	-1.1+	-1.2+	-1.3+	-1.4+	-1.5+	-1.6+	-1.7+	-1.8+
+200-	$\%\Delta_C T_B$	-0.5+	-0.5+	-0.5+	-0.5+	-0.5+	-0.6+	-0.6+	-0.6+	-0.6+	-0.7+
	$\%\Delta_C D_B$	-1.9+	-2.0+	-2.1+	-2.2+	-2.3+	-2.4+	-2.5+	-2.6+	-2.7+	-2.8+
+300-	$\%\Delta_C T_B$	-0.7+	-0.7+	-0.7+	-0.7+	-0.8+	-0.8+	-0.8+	-0.8+	-0.9+	-0.9+
	$\%\Delta_C D_B$	-2.8+	-2.9+	-3.0+	-3.1+	-3.2+	-3.3+	-3.4+	-3.5+	-3.6+	-3.7+

Figure J-1, Table D, Alternative 1

Projectile, HE M432
Fuze, M455

Charge 4
V_0 = 385 m/s

Table D

Ballistic Air Temperature And Ballistic Air Density Corrections

Corrections to temperature (T_B) and density (D_B) in percent,
to compensate for the difference in altitude, in metres,
between the gun and the Met Datum Plane (MDP)

Difference in Altitude between Gun and Met Datum Plane	Percentage Correction to Temperature	Percentage Correction to Density
Δ_{Alt} (Gun - MDP)	$\%\Delta_C T_B$	$\%\Delta_C D_B$
0	0.0	0.0
+10	0.0	-0.1
+20	0.0	-0.2
+30	-0.1	-0.3
+40	-0.1	-0.4
+50	-0.1	-0.5
+60	-0.1	-0.6
+70	-0.2	-0.7
+80	-0.2	-0.8
+90	-0.2	-0.9
+100	-0.2	-1.0
+110	-0.2	-1.1
+120	-0.3	-1.1
+130	-0.3	-1.2
+140	-0.3	-1.3
+150	-0.3	-1.4
+160	-0.4	-1.5
+170	-0.4	-1.6
+180	-0.4	-1.7
+190	-0.4	-1.8
+200	-0.5	-1.9
+210	-0.5	-2.0
+220	-0.5	-2.1
+230	-0.5	-2.2
+240	-0.5	-2.3
+250	-0.6	-2.4
+260	-0.6	-2.5
+270	-0.6	-2.6
+280	-0.6	-2.7
+290	-0.7	-2.8
+300	-0.7	-2.8
+310	-0.7	-2.9
+320	-0.7	-3.0
+330	-0.7	-3.1
+340	-0.8	-3.2
+350	-0.8	-3.3
+360	-0.8	-3.4
+370	-0.8	-3.5
+380	-0.9	-3.6
+390	-0.9	-3.7
+400	-0.9	-3.8

Figure J-2, Table D, Alternative 2

ANNEX K TABLE E – PROPELLANT TEMPERATURE

1. Table E gives the changes in muzzle velocity produced by variations in the propellant temperature. Whenever possible, the temperature of the propellant itself should be taken, rather than assuming that it is the same as air temperature. The velocity effect obtained from this table is converted to a range correction by use of columns 10 or 11 in Table F. An examples of Table E is illustrated at Figure K – 1.

Table E

Propellant Temperature

Effect of propellant temperature on muzzle velocity

Propellant temperature (T_{pp})	Effect on muzzle velocity (ΔV_0)	Propellant temperature (T_{pp})	Effect on muzzle velocity (ΔV_0)
°C	m/s	°F	m/s
-50	-9.3	-60	-9.5
-45	-8.3	-50	-8.4
-40	-7.4	-40	-7.4
-35	-6.6	-30	-6.5
-30	-5.8	-20	-5.6
-25	-5.1	-10	-4.8
-20	-4.4	0	-4.1
-15	-3.8	10	-3.4
-10	-3.1	20	-2.8
-5	-2.6	30	-2.2
0	-2.0	40	-1.6
5	-1.5	50	-1.0
10	-1.0	60	-0.5
15	-0.6	70	0.0
20	-0.1	80	0.5
25	0.3	90	1.0
30	0.8	100	1.5
35	1.2	110	1.9
40	1.7	120	2.4
45	2.1	130	2.9
50	2.5	140	3.5
55	3.0	150	3.8
60	3.5	160	3.8

Figure K-1, Example of Table E

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ANNEX L TABLE E.1 – CORRECTIONS TO RANGE FOR ROCKET-ASSIST MOTOR OR BASE-BURN UNIT TEMPERATURE

Projectile, HE M888
Fuze, TIME M666

Charge M3A1/5G
V_0 = 374 m/s

Table E.1

Corrections in range, in meters, to compensate for variations in propellant temperature of the motor

($\Delta_C X$)

Range (X)	Propellant temperature (T_{pp})							
	-40°F	*-30°F*	*-20°F*	*-10°F*	0°F	10°F	20°F	30°F
1000	-28	-28	-26	-23	-20	-17	-11	-8
2000	-51	-51	-47	-42	-36	-31	-20	-14
3000	-62	-62	-58	-51	-45	-38	-25	-17
4000	-74	-74	-68	-61	-53	-45	-30	-20
5000	-85	-85	-80	-70	-61	-52	-34	-24
6000	-91	-91	-84	-75	-65	-56	-36	-26
7000	-96	-96	-90	-79	-69	-59	-39	-27
8000	-114	-114	-106	-94	-82	-70	-46	-32
9000	-125	-125	-116	-103	-90	-77	-50	-35
9000	-136	-136	-127	-112	-98	-84	-55	-38
8000	-125	-125	--116	-103	-90	-77	-50	-35
7000	-108	-108	-100	-89	-78	-66	-43	-30
6000	-91	-91	-85	-75	-66	-56	-37	-26
5000	-85	-85	-82	-72	-64	-54	-35	-23
	-40°C	*-34.4°C*	*-28.9°C*	*-23.3°C*	*-17.8°C*	*-12.2°C*	*-6.7°C*	*-1.1°C*

Figure L-1, Example of Table E.1

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ANNEX M TABLE F – BASIC DATA AND CORRECTIONS

1. Table F is a compilation of the data required for the solution of the gunnery problem. The data are arranged in nine and eleven columns in Table F Left and Right Pages, each of which gives values for the various quantities as functions of the range tabulated in the first column of each table. Since these quantities are typically computed for a target at the point of graze, Table F applies primarily to targets at the same altitude as the gun. In it may be found sufficient information to produce a burst on a target at the point of graze. For targets above or below the point of graze, Table F is entered with a range first determined from Table B. In certain circumstances, the calculations and table headings can be adjusted to provide data for carrier / cargo shells that are expected to function above the target. An example of Table F, Left and Right Pages is illustrated at Figures M – 1 and M – 2.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table F

Basic Data And Corrections To Bearing

1	2	3	4	5	6	7	8	9
Range	Quadrant Elevation for standard conditions	Fuze Setting for graze burst	Correction to fuze setting to change height of burst down by 10 m	Effect on range for increase of one mil in elevation	Fork	Time of Flight	Corrections to bearing ($\Delta_c A_{BG}$)	
							Drift (corr. to left)	1 knot crosswind
(X)	(A_{QE})	(FS)	($\Delta_C FS$/ -10 m Y_b)	(ΔX/ 1 mil A_{QE})	(F)	(ToF)	(A_d)	(1 kt W_Z)
m	mil			m	mil	s	mil	mil
7500	415.0	27.0	0.08	12	7	27.0	9.6	0.37
7600	423.4	27.5	0.08	12	7	27.5	9.9	0.37
7700	432.0	28.0	0.08	11	7	28.0	10.1	0.37
7800	440.8	28.5	0.07	11	7	28.5	10.4	0.38
7900	449.8	29.0	0.07	11	8	29.0	10.7	0.38
8000	459.0	29.5	0.07	11	8	29.5	11.0	0.39
8100	468.5	30.1	0.07	10	8	30.1	11.3	0.39
8200	478.2	30.6	0.07	10	9	30.6	11.6	0.39
8300	488.2	31.2	0.07	10	9	31.2	11.9	0.40
8400	498.6	31.8	0.07	10	9	31.8	12.3	0.40
8500	509.2	32.4	0.07	9	10	32.4	12.6	0.41
8600	520.3	33.0	0.06	9	10	33.0	13.0	0.41
8700	531.8	33.7	0.06	9	11	33.7	13.4	0.42
8800	543.8	34.3	0.06	8	12	34.3	13.8	0.43
8900	556.4	35.0	0.06	8	12	35.0	14.3	0.43
9000	569.6	35.7	0.06	7	13	35.7	14.8	0.44
9100	583.7	36.5	0.06	7	14	36.5	15.3	0.45
9200	598.8	37.3	0.06	6	16	37.3	15.9	0.45
9300	615.2	38.2	0.06	6	17	38.2	16.5	0.46
9400	633.1	39.1	0.06	5	20	39.1	17.2	0.47
9500	653.4	40.2	0.05	5	23	40.2	18.1	0.48
9600	677.2	41.4	0.05	4	30	41.4	19.1	0.50
9700	707.4	42.9	0.05	3	45	42.9	20.5	0.52
9800	760.2	45.4	0.05	1	45	45.4	23.0	
9800	818.9	48.2	0.05	*-1*	45	48.2	26.2	
9700	871.1	50.4	0.04	*-3*	45	50.4	29.4	0.57
9600	900.9	51.7	0.04	*-4*	33	51.7	31.4	0.60
9500	924.2	52.6	0.04	*-5*	26	52.6	33.1	0.62
9400	944.1	53.4	0.04	*-5*	22	53.4	34.6	0.64
9300	961.6	54.1	0.04	*-6*	19	54.1	36.1	0.65
9200	977.5	54.7	0.04	*-7*	17	54.7	37.4	0.67
9100	992.2	55.3	0.04	*-7*	16	55.3	38.8	0.68
9000	1005.9	55.8	0.04	*-8*	14	55.8	40.1	0.69

Figure M-1, Example of Table F, Left Page, Basic Data and Corrections to Bearing.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table F

Corrections to range for non-standard conditions

1	10	11	12	13	14	15	16	17	18	19
Range (X)	Range corrections									
	Muzzle velocity		Range wind		Ballistic air temperature		Ballistic air density		Projectile mass	
	(V_0)		(W_X)		(T_B)		(D_B)			
	(1 m/s)		(1 kt)		(1%)		(1%)		(1 square)	
	dec	inc	head	tail	dec	inc	dec	inc	dec	inc
m	m	m	m	m	m	m	m	m	m	m
7500	18.3	-17.9	12.9	-11.5	27.1	-26.7	-14.7	14.6	-21	22
7600	18.5	-18.1	13.1	-11.7	27.5	-27.0	-15.0	15.0	-21	22
7700	18.7	-18.2	13.3	-11.9	27.9	-27.3	-15.3	15.3	-21	22
7800	18.9	-18.4	13.5	-12.0	28.2	-27.7	-15.7	15.6	-21	22
7900	19.1	-18.6	13.7	-12.2	28.6	-28.0	-16.0	16.0	-21	22
8000	19.3	-18.8	14.0	-12.4	28.9	-28.3	-16.4	16.4	-21	22
8100	19.5	-18.9	14.2	-12.5	29.2	-28.7	-16.7	16.7	-20	22
8200	19.7	-19.1	14.4	-12.7	29.6	-29.0	-17.1	17.1	-20	22
8300	19.9	-19.3	14.6	-12.9	29.9	-29.3	-17.4	17.5	-20	22
8400	20.1	-19.5	14.7	-13.0	30.2	-29.6	-17.8	17.8	-20	22
8500	20.3	-19.7	14.9	-13.2	30.5	-29.9	-18.2	18.3	-20	22
8600	20.6	-19.9	15.1	-13.4	30.8	-30.2	-18.5	18.7	-21	22
8700	20.8	-20.1	15.3	-13.5	31.0	-30.4	-18.9	19.1	-20	21
8800	21.1	-20.2	15.4	-13.7	31.2	-30.7	-19.3	19.5	-20	22
8900	21.3	-20.4	15.6	-13.8	31.4	-30.9	-19.7	20.0	-20	22
9000	21.6	-20.7	15.7	-14.0	31.6	-31.1	-20.1	20.4	-20	22
9100	21.8	-20.9	15.3	-14.1	31.7	-31.4	-20.5	20.9	-20	22
9200	22.1	-21.1	15.3	-14.3	31.9	-31.6	-20.9	21.4	-20	22
9300	22.4	-21.3	15.3	-14.4	32.0	-31.8	-21.4	21.9	-20	22
9400	22.7	-21.6	15.3	-14.5	32.0	-32.0	-21.8	22.4	-20	22
9500	23.1	-21.8	15.3	-14.7	32.0	-32.2	-22.3	23.0	-20	22
9600	23.1	-22.0	15.3	-14.8	32.0	-32.3	-22.8	23.0	-20	22
9700	23.1	-22.3	15.3	-14.9	32.0	-32.5	-23.2	23.0	-20	22
9800	23.1	-22.6	15.3	-15.0	32.0	-32.6	-23.7	23.0	-20	22
9800	23.1	-23.3	15.3	-13.4	32.0	-30.5	-25.5	23.0	-20	22
9700	23.1	-23.1	15.3	-13.2	32.0	-30.1	-25.3	23.0	-19	21
9600	23.1	-23.0	15.3	-13.0	32.0	-29.7	-25.0	23.0	-19	21
9500	23.6	-22.8	15.3	-12.8	32.0	-29.3	-24.8	23.9	-19	21
9400	23.5	-22.6	15.3	-12.6	30.8	-29.0	-24.5	23.9	-19	21
9300	23.3	-22.4	15.3	-12.4	30.3	-28.6	-24.3	23.7	-19	20
9200	23.1	-22.2	15.3	-12.2	29.8	-28.3	-24.0	23.5	-18	20
9100	22.9	-22.0	15.3	-12.0	29.4	-27.9	-23.7	23.3	-18	20
9000	22.7	-21.8	15.6	-11.8	29.0	-27.6	-23.4	23.0	-18	20

Figure M-2, Example of Table F, Right Page, Corrections to Range for non-standard conditions

2. Following is an explanation of the contents of each column of Tables F – Left and Right Pages:

Column 1 – Range. The distance measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the point of graze. This column is repeated on both the left and right pages.

Column 2 – Quadrant Elevation. The angle of the gun in the vertical plane required to reach the range tabulated in column 1 in standard conditions. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of meteorology and material. This number varies with non-standard conditions of meteorology and material and is particularly sensitive to changes in range wind.

Column 3 – Fuze Setting for Graze Burst. Numbers to be set on fuzes that will produce a graze burst at the point of graze when firing under standard conditions. This setting will produce a burst at the time of flight listed in column 7. Calculations for air bursting carrier/cargo shells will provide the Fuze Setting to produce fuze function at the location specified to ensure optimum target effects.

Column 4 – Correction to Fuze Setting to Change Height of Burst down by 10 metres. The adjustment to fuze setting required to decrease the height of burst 10 meters. To increase the height of burst 10 meters, change the sign of the value given in the table.

Column 5 – Effect on Range for Increase of 1 MIL in Quadrant Elevation. The change in range corresponding to a one MIL increase in the quadrant elevation.

Column 6 – Fork. The change in the angle of elevation necessary to produce a change in range at the point of graze equivalent to four probable errors in range.

Column 7 – Time of Flight. The projectile travel time, under standard conditions, from the muzzle to the point of graze at the range in column 1.

Columns 8-9 – Corrections to Bearing. The angular changes in the horizontal plane necessary to compensate for a departure of the projectile from the vertical plane of fire. Any deviation of the projectile from the vertical plane of fire is considered a deflection effect. The corrections tabulated in columns 8 and 9 are used in determining the change in the traverse angle needed to offset the effects of drift and cross wind, two of the phenomena which create a deflection effect. Although drift exists in a standard trajectory, it is assumed, for simplicity, to be a deflection effect. The correction for drift is to the left (right) for tubes with clockwise (counterclockwise) rifling. Most tubes have clockwise rifling.

Column 8 – Correction to Bearing for Drift. Because of the right hand twist of the barrel, 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.
Column 9 – Correction to Bearing for One Knot Cross Wind. Ballistic cross wind components may be from either the right or left, and the weapon must be traversed into the cross wind to compensate for the deflection effect (to the right for a cross wind blowing from the right of the plane of fire, to the left for a cross wind blowing from the left). In the wind components (Table C), the directions of the bearing corrections (right and left) are indicated by the letters R and L.

Columns 10-19. Corrections to range to compensate for the effects of non-standard conditions. Although the corrections given in column 10 to 19 are tabulated for a unit decrease and a unit increase in the non-standard conditions, they are actually mean values based on an expected decrease and increase in the non-standard conditions. The columns of corrections for an increase in the non-standard conditions are shaded to aid in identification. A tail wind is considered to be an increase in wind for this purpose.

Columns 10/11 –Range Correction for a Decrease (Increase) of one Metre per Second in Muzzle Velocity. Corrections to range to compensate for variations from the standard muzzle velocity that appears on the title page for each charge.

Columns 12/13 –Range Correction for a Head Wind (Tail Wind) of One Knot.

Column 10-19 – Correction Factors. In computing a standard trajectory it is assumed that no wind is blowing. Columns 12/13 give the corrections to range to compensate for the effect of the longitudinal wind (Head Wind or Tail Wind, denoted H and T, respectively).

Columns 14/15 –Range Correction for a Decrease (Increase) of one Percent in Air Temperature. The drag that a projectile encounters is a function of Mach Number (ratio of the velocity of the projectile to the speed of sound). The drag varies appreciably with Mach Number, particularly for transonic flight. Since the speed of sound is a function of air temperature, it follows that changes in air temperature will change the Mach Number, thereby changing the drag and consequently the range. This effect is sometimes called the elasticity effect. It should not be confused with the distinctly separate effect which air temperature produces through its influence on air density. The elevation tabulated in column 1 is computed in an ICAO standard atmosphere. The real temperature at any given height is recorded and transmitted as a percent of the standard absolute temperature for that height. Columns 14/15 allow to take into account the effect of a decrease (increase) of one percent in air temperature.

Columns 16/17 –Range Correction for a Decrease (Increase) of one Percent in Air Density. Air density affects the drag exerted upon the projectile. Therefore, changes in air density will change the drag and consequently the range. The elevation tabulated in column 1 is computed in an ICAO standard atmosphere. The real air density at any given height, computed from the real air temperature and air pressure recorded at that height, is transmitted as a percent of the standard absolute density for that height. Columns 16/17 allow to take into account the effect of a decrease (increase) of one percent in air density.

Columns 18/19 – Range Correction for a Decrease (Increase) of one Square in Projectile Mass. The elevation tabulated in column 1 is computed for the standard projectile mass. A decrease in projectile mass increases the muzzle velocity, the effect of which is to increase the range. But it also decreases the ballistic coefficient, the effect of which is to decrease the range. The combined effect may be either an increase or a decrease in range depending upon which individual effect is dominant. Under certain conditions these two effects tend to cancel each other.

ANNEX N TABLE G – SUPPLEMENTARY DATA

1. Table G provides probable error values and other trajectory information, respectively, for the ranges and quadrant elevations tabulated in Table F. An example of Table G, Left and Right Pages is illustrated at Figures N – 1 and N – 2.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table G

Supplementary Data - Probable Errors

1	2	3	4	5	6	7
Range	Quadrant Elevation for standard conditions	Probable Errors				
		Range	Deflection	Fuze M767		
				Height of burst	Time to burst	Range to burst
(X)	(A_{QE})	(E_X)	(E_Z)	(E_{Yb})	(E_{Tb})	(E_{Xb})
m	mil	m	m	m	s	m
1000	38.2	7	1	0	0.00	2
1500	59.4	8	1	0	0.00	3
2000	82.0	9	1	1	0.00	4
2500	105.7	10	1	1	0.00	4
3000	130.5	11	2	1	0.00	5
3500	156.4	12	2	1	0.00	5
4000	183.4	13	2	2	0.00	6
4500	211.5	14	3	2	0.00	7
5000	240.8	15	3	2	0.00	7
5500	271.6	16	3	3	0.00	8
6000	304.0	17	4	3	0.00	9
6500	338.3	18	4	4	0.00	10
7000	375.1	20	5	4	0.00	11
7500	415.0	21	5	5	0.00	12
8000	459.0	23	6	6	0.00	13
8500	509.2	25	6	7	0.00	15
9000	569.6	27	7	9	0.00	16
9500	653.4	29	8	11	0.00	18
9500	924.2	31	10	19	0.00	20
9000	1005.9	30	10	21	0.00	19
8500	1064.1	29	10	23	0.00	19
8000	1111.9	27	10	24	0.00	18
7500	1153.2	26	10	25	0.00	17
7000	1189.9	25	10	26	0.00	17
6500	1222.9	24	9	27	0.00	17
6000	1252.6	24	9	27	0.00	17
5500	1279.0	24	8	27	0.00	19
5000	1301.7			26	0.00	22

Figure N-1, Table G, Left Page, Supplementary Data – Probable Error.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table G

Supplementary Data - Trajectory Information

1	8	9	10	11	12	13	14
Range	Angle of descent		Remaining velocity	Max Ord	Complementary angle of site (A_{CS}) for angle of site (A_S) of		Range For No Motor Function
	Angle	Cotangent			+1 mil	-1 mil	
(X)	(A_ω)	(cot A_ω)	(V_ω)	(Y_S)			($X_{No\ Mot}$)
m	mil		m/s	m	mil	mil	m
1000	41	24.8	337	10	0.001	-0.001	1000
1500	66	15.5	325	23	0.003	-0.003	1500
2000	92	11.0	315	43	0.006	-0.005	2000
2500	120	8.4	309	70	0.009	-0.008	2500
3000	150	6.8	303	105	0.013	-0.012	3000
3500	180	5.6	299	147	0.019	-0.016	3500
4000	213	4.7	294	199	0.025	-0.022	4000
4500	246	4.1	291	260	0.034	-0.030	4500
5000	281	3.5	287	331	0.046	-0.040	5000
5500	318	3.1	284	413	0.061	-0.053	5500
6000	357	2.7	281	509	0.081	-0.071	6000
6500	398	2.4	279	619	0.109	-0.093	6500
7000	442	2.2	277	747	0.147	-0.124	7000
7500	489	1.9	275	897	0.201	-0.167	7500
8000	541	1.7	274	1075	0.281	-0.227	8000
8500	599	1.5	274	1291	0.420	-0.320	8500
9000	667	1.3	274	1569	0.727	-0.483	9000
9500	758	1.1	275	1978		-0.882	9500
9500	1024	0.6	285	3377		1.942	9500
9000	1098	0.5	288	3782	-1.777	1.540	9000
8500	1150	0.5	290	4056	-1.467	1.371	8500
8000	1192	0.4	291	4268	-1.322	1.270	8000
7500	1230	0.4	293	4441	-1.234	1.203	7500
7000	1264	0.3	293	4585	-1.174	1.154	7000
6500	1296	0.3	294	4706	-1.129	1.116	6500
6000	1328	0.3	294	4808	-1.095	1.086	6000
5500	1358	0.2	294	4892	-1.066	1.061	5500
5000	1389	0.2	294	4960	-1.043	1.040	5000

Figure N-2, Table G, Right Page, Supplementary Data – Trajectory Information.

2. Following is an explanation of the contents of each column of Tables F – Left and Right Pages:

Column 1 – Range. The distance measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the point of graze. This column is repeated on both the left and right pages.

Column 2 – Quadrant Elevation. The angle of the gun in the vertical plane required to reach the range tabulated in column 1 in standard conditions. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of meteorology and material. This number varies with non-standard conditions of meteorology and material and is particularly sensitive to changes in range wind. The probable errors indicate the round to round variation of a single gun fired on a single occasion and the same propellant lot and do not reflect the variation of the mean of either a single gun fired on different occasions or different guns fired on the same occasion.

Column 3 – Probable Error in Range at Graze. A value which, when added to and subtracted from the expected range, will produce an interval, along the line of fire, that should contain 50 percent of the rounds fired. Variations in muzzle velocity, in angle of departure, and in total drag during flight all contribute to the probable error in range to impact.

Column 4 – Probable Error in Deflection at Graze. A value which, when added both to the right and to the left of the expected impact point, will produce an interval, perpendicular to the line of fire at the expected range, that should contain 50 percent of the rounds fired.

Column 5 – Probable Error in Height of Burst. A value which, when added to and subtracted from the expected height of burst, will produce a vertical interval that should contain 50 percent of the rounds fired. The factors that contribute to the probable error in height of burst are not only those that produce dispersion in range to impact, but also those factors that contribute to variations in the functioning of the time fuze.

Column 6 – Probable Error in Time to Burst. A value which, when added to and subtracted from the expected time to burst, will produce a time interval that should contain 50 percent of the rounds fired.

Column 7 – Probable Error in Range to Burst. A value which, when added to or subtracted from the expected range to burst, will produce and interval, along the line of fire that should contain 50 percent of the rounds fired. The factors that contribute to the probable error in range to burst are not only those that produce dispersion in range to impact, but also those factors that contribute to variations in the functioning of the time fuze.

Column 8 – Angle of Descent. The acute angle measured from the horizontal to a line tangential to the trajectory at the point of graze.

Column 9 – Cotangent of Angle of Descent. The trigonometric cotangent function of the angle of descent given in column 8.

Column 10 – Remaining Velocity. The speed of the projectile at the point of graze.

Column 11 – Max Ord. The maximum height of a trajectory fired under standard conditions by a gun at sea level.

Columns 12/13 – Complementary Angle of Site/Sight for one MIL Angle of Site/Sight. The correction, which must be added algebraically to the actual angle of site to compensate for the non-rigidity of the trajectory. Use column 12 when the target is above the gun in altitude, column 13 when the target is below the gun.

Column 14 – Range for Non-functioning of Rocket Motor or Base Burn Unit. The range that will be achieved if the on-board rocket motor or Base-Burn Unit does not function.

Note. The left and right pages of Table G may be merged with columns 1 to 14 positioned into a single table on a single page for User convenience.

ANNEX O TABLE H – ROTATION OF THE EARTH - RANGE

1. Table H provides the range corrections required to offset the effects on range produced by the rotation of the earth. The entry arguments for the table are range and bearing in order to establish the range correction at the equator (0° latitude). The actual correction required is a function of cosine (latitude). A supplementary table listing cosines every 10 degrees is included below the main table. The correction established from the main table is to be multiplied by the appropriate latitude correction to establish the true correction to range. The simple table of cosines is listed at the foot of the table to provide the correction. A working example of Table H is illustrated at Figure O – 1.

Projectile, HE M222
Fuze, PD M555

Charge M6/ 5
V_0 = 373 m/s

Table H

Rotation of the Earth - Range

Corrections to range for Rotation of the Earth
$(\Delta_C X)$

Range (X)	Bearing of Target $(A_{BG})_{Tgt}$ - mil								
	0 3200	200 3000	400 2800	600 2600	800 2400	1000 2200	1200 2000	1400 1800	1600 1600
m	m	m	m	m	m	m	m	m	m
1000	0	-1+	-2+	-2+	-3+	-4+	-4+	-5+	-5+
2000	0	-2+	-4+	-5+	-7+	-8+	-9+	-9+	-9+
3000	0	-3+	-5+	-7+	-9+	-11+	-12+	-13+	-13+
4000	0	-3+	-6+	-9+	-12+	-14+	-16+	-17+	-17+
5000	0	-4+	-8+	-11+	-14+	-17+	-19+	-20+	-20+
6000	0	-4+	-9+	-13+	-16+	-19+	-22+	-23+	-23+
7000	0	-5+	-10+	-14+	-18+	-21+	-24+	-25+	-26+
8000	0	-5+	-10+	-15+	-19+	-23+	-25+	-27+	-27+
9000	0	-5+	-10+	-15+	-19+	-23+	-25+	-27+	-27+
10000	0	-4+	-9+	-13+	-16+	-19+	-21+	-23+	-23+
10000	0	-3+	-5+	-7+	-9+	-10+	-11+	-11+	-12+
9000	-1+	-1+	-1+	-1+	0	0	0	0	+1-
8000	-2+	0	+1-	+3-	+5-	+6-	+8-	+8-	+9-
7000	-3+	0	+3-	+6-	+9-	+12-	+14-	+16-	+17-
	3200 6400	3400 6200	3600 6000	3800 5800	4000 5600	4200 5400	4400 5200	4600 5000	4800 4800
	Bearing of Target $(A_{BG})_{Tgt}$ - mil								

Notes
1. When entering from the top use the sign before the number.
2. When entering from the bottom use the sign after the number.
3. Corrections are for zero latitude.
For other latitudes, multiply corrections by the following factors:

Latitude (deg)	10	20	30	40	50	60	70
Factor	.98	.94	.87	.77	.64	.50	.34

Figure O – 1, Table H, Rotation of the Earth, Range

2. Extracting Data from Table H. The information required is Bearing and Range to Target and the Latitude of the gun position. In this working example, highlighted in yellow within Figure O – 1 the necessary data is:

Bearing to Target	400 mils
Range to Target	8000 metres
Bty Latitude	50°N

The extracted correction is -10+ metres

Entering the table from the top results in a negative correction, -10 metres.

The correction is then adjusted for latitude by multiplying the correction by the Latitude Factor (cosine latitude), in this case 0.64

The total correction is -10 x 0.64 = - 6.4 metres

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ANNEX P TABLE I – ROTATION OF THE EARTH - AZIMUTH

1. Table H provides the azimuth corrections required to offset the effects on orientation produced by the rotation of the earth. Unlike Table H, there are separate tables for each 10° of Latitude. The entry arguments for the table are the latitude to select the relevant Table, range and bearing in order to establish the bearing correction from the said table. A working example of Table I is illustrated at Figure P – 1.

Projectile, HE M222
Fuze, PD M555

Charge M6/ 5
V_0 = 373 m/s

Table I

Rotation of the Earth - Bearing

Corrections to bearing for Rotation of the Earth
$(\Delta_c A_{BG})$

40 Degree North Latitude

Range (X)	Bearing of Target $(A_{BG})_{Tgt}$ - mil								
	0 6400	400 6000	800 5600	1200 5200	1600 4800	2000 4400	2400 4000	2800 3600	3200 3200
m	mil	mil	mil	mil	mil	mil	mil	mil	mil
1000	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R
2000	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R
3000	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R
4000	L0.5R	L0.5R	L0.5R	L0.6R	L0.6R	L0.6R	L0.6R	L0.6R	L0.6R
5000	L0.7R	L0.7R	L0.7R	L0.7R	L0.7R	L0.8R	L0.8R	L0.8R	L0.8R
6000	L0.8R	L0.8R	L0.8R	L0.9R	L0.9R	L0.9R	L1.0R	L1.0R	L1.0R
7000	L0.9R	L0.9R	L1.0R	L1.0R	L1.1R	L1.2R	L1.2R	L1.2R	L1.2R
8000	L1.1R	L1.1R	L1.1R	L1.2R	L1.3R	L1.4R	L1.5R	L1.5R	L1.5R
9000	L1.2R	L1.2R	L1.3R	L1.4R	L1.6R	L1.7R	L1.8R	L1.9R	L1.9R
10000	L1.3R	L1.4R	L1.5R	L1.7R	L2.0R	L2.2R	L2.4R	L2.5R	L2.6R
10000	L1.2R	L1.3R	L1.6R	L2.0R	L2.4R	L2.8R	L3.1R	L3.4R	L3.4R
9000	L0.9R	L1.1R	L1.5R	L2.0R	L2.7R	L3.3R	L3.9R	L4.2R	L4.3R
8000	L0.5R	L0.8R	L1.3R	L2.1R	L2.9R	L3.8R	L4.4R	L4.9R	L5.0R
7000	L0.1R	L0.4R	L1.2R	L2.2R	L3.3R	L4.3R	L5.1R	L5.6R	L5.6R
	3200 3200	2800 3600	2400 4000	2000 4400	1600 4800	1200 5200	800 5600	400 6000	0 6400
	Bearing of Target $(A_{BG})_{Tgt}$ - mil								

40 Degree South Latitude

Notes
1. When entering from the top use the sign before the number.
2. When entering from the bottom use the sign after the number.

Figure P – 1, Table I, Rotation of the Earth, Correction to Bearing

2. Extracting Data from Table I, Figure P - 1. Information required is Bearing and Range to Target and the Latitude of the gun position. In this working example, highlighted in yellow within Figure P – 1 the necessary data is:

Bearing to Target	400 mils
Range to Target	8000 metres
Bty Latitude	40°N

Select Table I for 40°N

The extracted correction is L1.1R mils

Entering the table from the top results in a Left correction, L1.1 mils.

ANNEX Q TABLE J – CORRECTIONS TO FUZE SETTINGS TO COMPENSATE FOR NON-STANDARD CONDITIONS

1. Table J lists corrections to fuze settings to compensate for the effects of non-standard conditions.

2. **Table J, Fuze Setting Correction Factors.** The data are arranged in eleven columns, each of which gives values for the various quantities as functions of the fuze settings tabulated in the first column. Since all of these quantities have been computed for a target at the point of graze, Table J applies primarily to targets at the same altitude as the gun. In it may be found sufficient information to produce a graze burst on a target at the point of graze. For targets above or below the point of graze, Table J is entered with a fuze setting determined from Table F. Although the corrections given in columns 2 to 11 are tabulated for a unit decrease and a unit increase in the non-standard conditions, they are actually mean values based on an expected decrease and increase in the non-standard conditions. A tail wind is considered to be an increase in wind for this purpose. A working example of Table J is illustrated at Figure Q – 1.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Table J

Fuze Setting Correction Factors

(Δ_cFS)

1	2	3	4	5	6	7	8	9	10	11
Fuze Setting (FS)	Fuze setting correction factors for									
	Muzzle velocity (V_0) (1 m/s)		Range wind (W_X) (1 kt)		Ballistic air temperature (T_B) (1%)		Ballistic air density (D_B) (1%)		Projectile mass (1 square)	
	dec	inc	head	tail	dec	inc	dec	inc	dec	inc
2	-0.005		0.000		0.000			0.000		-0.011
3	-0.007	0.006	0.000	0.000	0.000	0.000	0.000	-0.001	0.013	-0.015
4	-0.010	0.009	0.000	0.000	0.001	0.000	0.001	-0.001	0.019	-0.023
5	-0.012	0.012	0.000	0.001	0.001	0.001	0.002	-0.002	0.023	-0.024
6	-0.015	0.014	0.000	0.001	0.001	0.001	0.002	-0.002	0.027	-0.028
7	-0.017	0.016	0.000	0.001	0.001	0.002	0.003	-0.003	0.031	-0.031
8	-0.018	0.018	-0.001	0.002	0.000	0.004	0.004	-0.004	0.033	-0.034
9	-0.020	0.019	-0.001	0.002	-0.001	0.005	0.005	-0.005	0.036	-0.037
10	-0.021	0.021	-0.002	0.003	-0.002	0.007	0.005	-0.005	0.038	-0.039
11	-0.022	0.022	-0.002	0.004	-0.004	0.009	0.006	-0.006	0.040	-0.041
12	-0.023	0.023	-0.003	0.004	-0.006	0.011	0.007	-0.007	0.042	-0.042
13	-0.025	0.025	-0.004	0.005	-0.008	0.013	0.008	-0.007	0.043	-0.044
14	-0.026	0.026	-0.004	0.006	-0.010	0.015	0.008	-0.008	0.045	-0.046
15	-0.027	0.027	-0.005	0.006	-0.013	0.017	0.009	-0.009	0.046	-0.047
16	-0.028	0.028	-0.006	0.007	-0.015	0.019	0.010	-0.009	0.047	-0.048
17	-0.029	0.029	-0.007	0.007	-0.017	0.021	0.010	-0.010	0.048	-0.050
18	-0.030	0.030	-0.008	0.008	-0.021	0.024	0.011	-0.011	0.050	-0.051
19	-0.031	0.031	-0.009	0.009	-0.023	0.026	0.012	-0.012	0.051	-0.052
20	-0.032	0.032	-0.009	0.010	-0.025	0.028	0.013	-0.012	0.052	-0.054
21	-0.033	0.032	-0.010	0.010	-0.028	0.030	0.013	-0.013	0.053	-0.055
22	-0.034	0.034	-0.011	0.011	-0.031	0.033	0.015	-0.014	0.055	-0.056
23	-0.035	0.035	-0.012	0.012	-0.033	0.035	0.015	-0.015	0.056	-0.057
24	-0.036	0.035	-0.013	0.012	-0.035	0.036	0.016	-0.016	0.057	-0.058
25	-0.037	0.037	-0.014	0.013	-0.039	0.039	0.017	-0.017	0.058	-0.060
26	-0.038	0.037	-0.014	0.014	-0.041	0.041	0.018	-0.018	0.059	-0.061
27	-0.039	0.038	-0.015	0.014	-0.043	0.042	0.019	-0.019	0.060	-0.062
28	-0.041	0.039	-0.016	0.015	-0.045	0.045	0.020	-0.020	0.061	-0.063
29	-0.042	0.040	-0.017	0.015	-0.047	0.046	0.021	-0.021	0.062	-0.064
30	-0.043	0.041	-0.017	0.016	-0.050	0.048	0.022	-0.022	0.064	-0.066
31	-0.044	0.042	-0.018	0.016	-0.051	0.050	0.023	-0.023	0.065	-0.067
32	-0.046	0.043	-0.019	0.017	-0.054	0.052	0.024	-0.025	0.066	-0.068
33	-0.047	0.044	-0.019	0.017	-0.056	0.053	0.025	-0.026	0.067	-0.069
34	-0.048	0.045	-0.020	0.018	-0.058	0.055	0.026	-0.027	0.068	-0.071
35	-0.049	0.046	-0.021	0.018	-0.060	0.056	0.027	-0.028	0.069	-0.072

Figure Q – 1, Example of Table J, Fuze Setting Correction Factors

3. For a detailed explanation of columns 2 to 11 of Table J, see the explanation of columns 2 to 11 in Table F (Left Page). In these explanations, substitute ‘range corrections’ with ‘fuze setting corrections’.

ANNEX R TABLE J.1 - CORRECTIONS TO FUZE SETTING FOR ROCKET-ASSIST MOTOR OR BASE-BURN UNIT TEMPERATURE

1. **Table J.1, Corrections to Fuze Setting for Rocket-Assist Motor or Base-Burn Unit Temperature**. Table J.1 may be produced as an alternative or in addition to Table J and provides corrections to fuze setting to compensate for variations in the propellant temperature of the rocket motor or base-burn unit.

Projectile, HE M431
Fuze, M456

Charge M6/5
V_0 = 534.0 m/s

Table J.1

Corrections to Fuze Setting to Compensate for Variations in Propellant Temperature

(Δ_cFS)

Fuze Setting (FS)	Propellant temperature (T_{pp})										Fuze Setting (FS)
	-40°C	*-30°C*	*-20°C*	*-10°C*	0°C	10°C	20°C	30°C	40°C	50°C	
70	0.754	0.607	0.465	0.331	0.207	0.098	0.008	*-0.060*	*-0.107*	*-0.135*	70
71	0.768	0.619	0.476	0.339	0.213	0.101	0.008	*-0.062*	*-0.109*	*-0.136*	71
72	0.780	0.631	0.486	0.348	0.220	0.105	0.008	*-0.065*	*-0.113*	*-0.139*	72
73	0.791	0.641	0.495	0.356	0.226	0.108	0.009	*-0.068*	*-0.117*	*-0.143*	73
74	0.801	0.650	0.504	0.364	0.232	0.112	0.009	*-0.071*	*-0.122*	*-0.148*	74
75	0.809	0.658	0.511	0.370	0.237	0.115	0.009	*-0.074*	*-0.129*	*-0.154*	75
76	0.816	0.664	0.517	0.375	0.241	0.118	0.009	*-0.077*	*-0.135*	*-0.162*	76
77	0.821	0.669	0.522	0.380	0.245	0.120	0.010	*-0.080*	*-0.142*	*-0.170*	77
78	0.824	0.672	0.525	0.383	0.248	0.122	0.010	*-0.082*	*-0.148*	*-0.179*	78
79	0.825	0.674	0.527	0.386	0.251	0.124	0.010	*-0.085*	*-0.154*	*-0.188*	79
80	0.824	0.674	0.528	0.387	0.252	0.126	0.011	*-0.087*	*-0.159*	*-0.197*	80
81	0.820	0.672	0.527	0.387	0.253	0.126	0.011	*-0.089*	*-0.164*	*-0.206*	81
82	0.815	0.669	0.525	0.386	0.253	0.127	0.011	*-0.090*	*-0.168*	*-0.213*	82
83	0.807	0.663	0.521	0.384	0.252	0.126	0.011	*-0.091*	*-0.171*	*-0.220*	83
84	0.797	0.656	0.516	0.380	0.250	0.126	0.011	*-0.091*	*-0.174*	*-0.226*	84
	-40°F	*-22°F*	*-4°F*	14°F	32°F	50°F	68°F	86°F	104°F	122°F	

Figure R – 1, Example of Table J.1, Correction to Fuze Setting to for Rocket-Assist Motor or Base Burn Unit Temperature

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ANNEX S TABLE K – DATA FOR ALTERNATIVE FUZES

1. Where two fuzes are similar but are not matched, either ballistically or the timer units vary, or two similar projectiles are fitted with the same fuze, Table K provides the means of correcting a computed solution using the 'known' combination.

Projectile, SMK M431 **Charge M6/5**
Fuze, TIME M456 **V_0 = 374.3 m/s**

Table K

Data for Alternative Fuze

Corrections to Fuze Setting ($\Delta_c FS$)

Fuze Setting (FS) for M767		Corrections to Fuze Setting ($\Delta_c FS$)
From	To	
2.1	46.8	0.0
46.8	65.1	0.0

Figure S – 1, Example of Table K, Data for Alternative Fuzes

2. The following is an explanation of the contents of each column of the Firing Table for Data for Alternative Fuze:

Column 1/2 – Fuze Setting for Standard Projectile. The range of fuze settings for the Standard Projectile to be corrected.

Column 3 – Correction to Fuze Setting. The correction to be applied to the standard projectile fuze setting to achieve the ballistic solution for the specified Projectile and Fuze combination.

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ANNEX T TABLES FOR CARGO PROJECTILES

1. The tables for cargo projectiles, which are described in this annex, are in a section of the tabular firing tables titled Part 2, or in a separate addendum.

T.1 Firing Tables for Cargo Projectile Based on Quadrant Elevation

1. The tables below are used to produce corrections to the bearing, quadrant elevation and fuze setting for a cargo projectile trajectory that will achieve submunition expulsion from the carrier projectile at the desired height, above and possibly short of the point of graze, which will give optimum target coverage. The height is variable and quadrant elevation dependent. The solutions are calculated as a correction to the quadrant elevation obtained for the reference projectile using the Part 1 tables. The tables do not include possible fuze function at a specified self-destruct time. Working examples of the Firing Table for Cargo Projectile (Quadrant Elevation) and associated Firing Table for Cargo Projectile (Fuze Setting) are illustrated at Figures T – 1 and T – 2.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Firing Table for Cargo Projectile

(Quadrant Elevation)

1	2	3	4	5	6	7	8
Quadrant Elevation for Projectile M107dc	Correction to Quadrant Elevation for Projectile SMK M431	Change in elevation for an increase of		Corr for low level wind of 1 knot	Travel Time	Range to Impact (No Fuze Function)	Corr to Defl for Proj
		50m in height	100m in range				
(A_{QE})	($\Delta_C A_{QE}$)	($\Delta_C A_{QE}$/50m Y)	($\Delta_C A_{QE}$/100m X)	(Δ_C Def/1 kt W_S)	(Tt)	($X_{No-Fuze}$)	(Δ_C Def)
mil	mil	mil	mil	m	s	m	mil
225	0	11.2	5.9	0.1	15.3	4733	L0.0
230	0	11.0	5.9	0.1	15.7	4818	L0.0
235	0	10.8	6.0	0.1	16.0	4902	L0.0
240	0	10.7	6.0	0.1	16.3	4986	L0.0
245	0	10.5	6.1	0.1	16.6	5069	L0.0
250	0	10.4	6.1	0.1	16.9	5151	L0.0
255	0	10.2	6.2	0.1	17.2	5233	L0.0
260	0	10.1	6.2	0.1	17.6	5314	L0.0
265	0	10.0	6.3	0.1	17.9	5395	L0.0
270	0	9.8	6.3	0.1	18.2	5475	L0.0
275	0	9.7	6.4	0.1	18.5	5554	L0.0
280	0	9.6	6.4	0.1	18.8	5632	L0.0
285	0	9.5	6.5	0.1	19.1	5710	L0.0
290	0	9.4	6.5	0.1	19.4	5787	L0.0
295	0	9.3	6.6	0.1	19.7	5864	L0.0
300	0	9.2	6.7	0.1	20.0	5940	L0.0
305	0	9.1	6.7	0.1	20.3	6015	L0.0
310	0	9.0	6.8	0.1	20.7	6090	L0.0
315	0	9.0	6.8	0.1	21.0	6164	L0.0
320	0	8.9	6.9	0.1	21.3	6237	L0.0
325	0	8.8	7.0	0.1	21.6	6310	L0.0
330	0	8.7	7.0	0.1	21.9	6382	L0.0
335	0	8.7	7.1	0.1	22.2	6453	L0.0
340	0	8.6	7.2	0.1	22.5	6524	L0.0
345	0	8.6	7.2	0.1	22.8	6594	L0.0
350	0	8.5	7.3	0.1	23.1	6663	L0.0
355	0	8.4	7.4	0.1	23.4	6731	L0.0
360	0	8.4	7.5	0.1	23.7	6799	L0.0
365	0	8.4	7.5	0.1	24.0	6867	L0.0
370	0	8.3	7.6	0.1	24.3	6933	L0.0
375	0	8.3	7.7	0.1	24.6	6999	L0.0
380	0	8.2	7.8	0.1	24.9	7064	L0.0
385	0	8.2	7.9	0.1	25.2	7128	L0.0
390	0	8.2	8.0	0.1	25.5	7192	L0.0
395	0	8.1	8.0	0.1	25.8	7255	L0.0
400	0	8.1	8.1	0.1	26.1	7318	L0.0

Figure T – 1, Example of Firing Table for Cargo Projectile (Quadrant Elevation)

2. The following is an explanation of the contents of each column of the Firing Table for Cargo projectile (Quadrant Elevation):

Column 1 – Quadrant Elevation. The elevation obtained through use of the Part 1 tables for the required range.

Column 2 – Correction to Quadrant Elevation for the Cargo Projectile. The correction to the standard projectile quadrant elevation to correct for trajectory and ballistics differences with the cargo projectile.

Column 3 – Correction to Elevation for an increase of 50M in Height of Burst. The change in elevation required to adjust the height of burst of the projectile or the altitude of the target up 50M.

Column 4 – Correction to Elevation for an increase of 100M in Range. The change in elevation required to increase the range to target by 100M.

Column 5 – Correction for Low Level Wind of One Knot. The deflection of the cargo projectile submunitions for each one knot of low-level wind.

Column 6 – Travel Time. The travel time, for the specified conditions, from launch to the impact of the submunitions on the ground.

Column 7 –Range to Impact. The distance, measured on the surface of a sphere concentric with the earth, from the muzzle to a point at the same altitude, at which a projectile, whose fuze has not functioned (and, therefore, not ejected its submunitions) will impact.

Column 8 – Correction to Deflection. The correction for the deflection obtained through use of the Part 1 tables for the required range.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Firing Table for Cargo Projectile

(Fuze Setting)

Fuze Setting for Projectile M107dc		Correction to Fuze Setting for Projectile SMK M431	Correction to Fuze Setting for an increase of	
From	To		50m in height	100m in range
(FS)	(FS)	(Δ_cFS)	(Δ_cFS/50m Y)	(Δ_cFS/100m X)
4.0	46.0	*-2.0*	0.1	0.4
46.1 46.7	46.0	*-1.9* *-1.9*		
47.7	48.1	*-2.1*		
48.2 48.2	48.1 65.2	*-2.1* *-2.0*	*-0.3* *-0.3*	*-0.4* *-0.4*

Figure T – 2, Example of Firing Table for Cargo Projectile (Fuze Setting)

3. The following is an explanation of the contents of each column of the Firing Table for Cargo projectile (Fuze Setting):

Column 1/2 – Fuze Setting for Standard Projectile. The range of fuze settings for the Standard Projectile to be corrected.

Column 3 – Correction to Fuze Setting. The correction to be applied to the standard projectile fuze setting to achieve the ballistic solution for the Cargo Projectile and Fuze combination.

Column 4 – Correction to Fuze Setting for an increase in Height of Burst. The change in fuze setting required to adjust the height of burst of the projectile or the altitude of the target up 50M.

Column 5 – Correction to Fuze Setting for an increase in Range. The change in fuze setting required to increase the range to target by 100M.

T.2 Firing Tables for Cargo Projectile Based on Range to Target

1. The tables below provide an alternative to those found in T.1 (based on Quadrant Elevation). They are used to produce corrections to the bearing, quadrant elevation and fuze setting for a cargo projectile trajectory that will achieve submunition expulsion from the carrier projectile at the desired height, above and possibly short of the point of graze, which will give optimum target coverage. The height is variable and quadrant elevation dependent. The tables do not include

possible fuze function at a specified self-destruct time. A working example of the Firing Table for Cargo Projectile is illustrated at Figures T – 3.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Firing Table For Cargo Projectile

1	2	3	4	5	6	7	8	9
Range	Quadrant Elevation for standard conditions	Fuze Setting	Drift	Corrections for 50m increase in height of burst: Elevation	Corrections for 50m increase in height of burst: Fuze setting	Range to fuze function	Range to impact (no fuze function)	Height of fuze function
(X)	(A_{QE})	(FS)	(A_d)	(ΔA_{QE}/50m Y_b)	(ΔFS/50m Y_b)	(X_{Fuze})	($X_{No\text{-}Fuze}$)	(Y_{Fuze})
m	mil		mil	mil		m	m	m
7500	415.0	25.0	9.6	8.0	2.06	7500	7013	460
7600	423.4	25.5	9.9	8.0	2.06	7600	7117	462
7700	432.0	26.0	10.1	8.0	2.06	7700	7219	465
7800	440.8	26.5	10.4	8.0	2.08	7800	7319	468
7900	449.8	27.0	10.7	8.0	2.11	7900	7417	470
8000	459.0	27.5	11.0	8.0	2.14	8000	7512	472
8100	468.5	28.1	11.3	8.0	2.09	8100	7629	474
8200	478.2	28.6	11.6	8.0	2.16	8200	7719	477
8300	488.2	29.2	11.9	8.1	2.13	8300	7830	480
8400	498.6	29.8	12.3	8.1	2.12	8400	7937	483
8500	509.2	30.4	12.6	8.2	2.13	8500	8041	487
8600	520.3	31.0	13.0	8.3	2.16	8600	8140	492
8700	531.8	31.7	13.4	8.4	2.11	8700	8258	494
8800	543.8	32.3	13.8	8.6	2.18	8800	8348	496
8900	556.4	33.0	14.3	8.7	2.19	8900	8454	498
9000	569.6	33.7	14.8	9.0	2.22	9000	8554	501
9100	583.7	34.5	15.3	9.3	2.20	9100	8667	503
9200	598.8	35.3	15.9	9.7	2.23	9200	8771	505
9300	615.2	36.2	16.5	10.2	2.23	9300	8884	506
9400	633.1	37.1	17.2	11.0	2.31	9400	8981	507
9500	653.4	38.2	18.1	12.1	2.32	9500	9099	508
9600	677.2	39.4	19.1	14.2	2.43	9600	9205	509
9700	707.4	40.9	20.5	19.0	2.67	9700	9313	510
9800	760.2	43.4	23.0			9800	9423	512
9800	818.9	46.2	26.2			9800	9461	540
9700	871.1	48.4	29.4	*-14.1*	1.21	9700	9366	537
9600	900.9	49.7	31.4	*-9.2*	1.39	9600	9286	534
9500	924.2	50.6	33.1	*-7.1*	1.54	9500	9187	529
9400	944.1	51.4	34.6	*-5.9*	1.59	9400	9096	527
9300	961.6	52.1	36.1	*-5.0*	1.61	9300	9006	523
9200	977.5	52.7	37.4	*-4.4*	1.65	9200	8912	521
9100	992.2	53.3	38.8	*-4.0*	1.61	9100	8825	518
9000	1005.9	53.8	40.1	*-3.6*	1.63	9000	8730	517

Figure T – 3, Example of Firing Table for Cargo Projectile

2. The following is an explanation of the contents of each column of the Firing Table for Cargo Projectile:

Column 1 – Range. The distance measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the point directly above the target at a specified height of graze. This column is repeated on both the left and right pages.

Column 2 – Quadrant Elevation. The angle of the gun in the vertical plane required to reach the range tabulated in column 1 in standard conditions and at the specified height. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of meteorology and material. This number varies with non-standard conditions of meteorology and material and is particularly sensitive to changes in range wind. Shading of data boxes within columns 1 and 2 indicates fuze function during the ascending stage of the trajectory.

Column 3 – Fuze Setting. Numbers to be set on fuzes that will produce a function at a specified time to produce optimum functioning of the payload at the specified height above the target location when firing under standard conditions. This setting will produce a burst at the time of flight listed in column 7 of table F.

Column 4 – Correction to Bearing for Drift. Because of the right hand twist of the barrel, 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.

Column 5 – Correction to Elevation for an increase in Height of Burst of 50M. The change in elevation required to adjust the height of burst of the projectile or the altitude of the target up 50M.

Column 6 – Correction to Fuze Setting for an increase in Height of Burst of 50M. The change in fuze setting required to adjust the height of burst of the projectile or the altitude of the target up 50M. Note that the corrections can be positive or negative depending upon range and charge.

Column 7 – Range to Fuze Function. It may be necessary for the fuze to function before reaching the trajectory point directly above the target location at the specified height to ensure optimum performance. The range to fuze function assists in the plotting of fuze function for safety purposes.

Column 8 – Range to Impact. The range at which the projectile will continue until the trajectory reaches the point of graze in the event of fuze failure to function.

Column 9 – Height of Fuze Function. The height of burst at fuze functioning of the carrier projectile above and possibly short of the point of graze. This column is not always included for projectile with a standard height of burst.

ANNEX U TABLES FOR ILLUMINATING PROJECTILES

1. This table should be used when supporting an illumination projectile which requires the illuminant submunition to perform directly above the target location at a specific height and not for a target at the point of graze. This table is based upon the range to the target. A working example of the Illuminating Projectile Table is illustrated at Figure U – 1.

Projectile, SMK M431
Fuze, TIME M456

Charge M6/5
V_0 = 374.3 m/s

Firing Table For Cargo Projectile

1	2	3	4	5	6	7	8
Range to illumination	Quadrant Elevation for standard conditions	Fuze Setting	Drift	Corrections for 50m increase in height of illumination		Range to fuze function	Range to impact (no fuze function)
				Elevation	Fuze setting		
(X)	(A_{QE})	(FS)	(A_d)	(ΔA_{QE}/50m Y_b)	(ΔFS/50m Y_b)	(X_{Fuze})	($X_{No-Fuze}$)
m	mil		mil	mil		m	m
800							
900							
1000							
1100	42.5	1.1	1.0	44.2	0.01	428	1100
1200	47.2	1.4	1.0	42.1	0.01	532	1200
1300	51.3	1.7	1.1	39.2	0.01	629	1300
1400	55.1	2.0	1.2	36.5	0.01	732	1400
1500	59.4	2.3	1.3	34.1	0.01	838	1500
1600	63.8	2.7	1.4	31.9	0.01	943	1600
1700	68.3	3.0	1.5	30.1	0.01	1048	1700
1800	72.8	3.3	1.6	28.4	0.01	1153	1800
1900	77.3	3.6	1.7	26.9	0.01	1257	1900
2000	82.0	3.9	1.8	25.6	0.01	1361	2000
2100	86.6	4.2	1.9	24.4	0.01	1465	2100
2200	91.3	4.6	2.0	23.3	0.01	1569	2200
2300	96.1	4.9	2.0	22.3	0.01	1672	2300
2400	100.9	5.2	2.1	21.4	0.01	1776	2400
2500	105.7	5.5	2.2	20.5	0.01	1879	2500
2600	110.6	5.9	2.3	19.8	0.01	1982	2600
2700	115.5	6.2	2.4	19.1	0.01	2084	2700
2800	120.5	6.5	2.5	18.4	0.01	2187	2800
2900	125.5	6.9	2.6	17.8	0.02	2290	2900
3000	130.5	7.2	2.7	17.2	0.02	2393	3000
3100	135.6	7.5	2.8	16.7	0.02	2495	3100
3200	140.8	7.9	2.9	16.1	0.02	2598	3200
3300	145.9	8.2	3.0	15.7	0.02	2701	3300
3400	151.2	8.6	3.1	15.2	0.02	2803	3400
3500	156.4	8.9	3.2	14.8	0.02	2906	3500
3600	161.7	9.3	3.3	14.4	0.02	3008	3600
3700	167.1	9.6	3.4	14.0	0.02	3110	3700
3800	172.5	10.0	3.5	13.7	0.02	3213	3800
3900	177.9	10.3	3.7	13.4	0.02	3315	3900
4000	183.4	10.7	3.8	13.0	0.02	3418	4000

Figure U – 1, Example of Illuminating Projectile Table

2. The following is an explanation of the contents of each column of the Illuminating Cargo projectile tables:

Column 1 – Range to Illumination. The distance measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the point directly above the target at a specified height of graze. This column is repeated on both the left and right pages.

Column 2 – Quadrant Elevation. The angle of the gun in the vertical plane required to reach the range tabulated in column 1 in standard conditions and at the specified height. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of meteorology and material. This number varies with non-standard conditions of meteorology and material and is particularly sensitive to changes in range wind. Shading of data boxes within columns 1 and 2 indicates fuze function during the ascending stage of the trajectory.

Column 3 – Fuze Setting. Numbers to be set on fuzes that will produce a function at a specified time to produce optimum functioning of the payload at the specified height above the target location when firing under standard conditions. This setting will produce a burst at the time of flight listed in column 7 of table F.

Column 4 – Correction to Bearing for Drift. Because of the right hand twist of the barrel, 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.

Column 5 – Correction to Elevation for an increase in Height of Illumination of 50M. The change in elevation required to adjust the height of burst of the projectile or the altitude of the target up 50M.

Column 6 – Correction to Fuze Setting for an increase in Height of Illumination of 50M. The change in fuze setting required to adjust the height of burst of the projectile or the altitude of the target up 50M. Note that the corrections can be positive or negative depending upon range and charge..

Column 7 – Range to Fuze Function. It may be necessary for the fuze to function before reaching the trajectory point directly above the target location at the specified height to ensure optimum performance. The range to fuze function assists in the plotting of fuze function for safety purposes.

Column 8 – Range to Impact. The range at which the projectile will continue until the trajectory reaches the point of graze in the event of fuze failure to function.

ANNEX V FORMAT FOR ABRIDGED TABLES – BASIC DATA

1. The information provided within the Abridged Table, Basic Data is the most sought after general data required. The data are obtained from Tables F and G.

Projectile, SMK M431 | **Charge M6/5**
Fuze, TIME M456 | V_0 **= 374.3 m/s**

Abridged Table

Basic Data

1	2	3	4	5	6	7	8	9	10
				Probable Errors					
Range	Quadrant Elevation for standard conditions	Time Of Flight	Drift (corr. to left)	Range	Deflection	Angle of descent	Remaining velocity	Vertex height	Range For No Motor Function
(X)	(A_{QE})	(ToF)	(A_d)	(E_X)	(E_Z)	(A_ω)	(V_ω)	(Y_S)	($X_{No\ Mot}$)
m	mil	s	mil	m	m	mil	m/s	m	m
7500	415.0	27.0	9.6	21	5	489	275	897	7500
7600	423.4	27.5	9.9	22	5	499	275	930	7600
7700	432.0	28.0	10.1	22	5	509	275	964	7700
7800	440.8	28.5	10.4	22	6	520	275	1000	7800
7900	449.8	29.0	10.7	23	6	530	274	1037	7900
8000	459.0	29.5	11.0	23	6	541	274	1075	8000
8100	468.5	30.1	11.3	23	6	552	274	1115	8100
8200	478.2	30.6	11.6	24	6	563	274	1156	8200
8300	488.2	31.2	11.9	24	6	575	274	1199	8300
8400	498.6	31.8	12.3	24	6	587	274	1244	8400
8500	509.2	32.4	12.6	25	6	599	274	1291	8500
8600	520.3	33.0	13.0	25	6	612	274	1341	8600
8700	531.8	33.7	13.4	25	7	625	274	1393	8700
8800	543.8	34.3	13.8	26	7	638	274	1448	8800
8900	556.4	35.0	14.3	26	7	652	274	1506	8900
9000	569.6	35.7	14.8	27	7	667	274	1569	9000
9100	583.7	36.5	15.3	27	7	682	274	1636	9100
9200	598.8	37.3	15.9	28	7	699	274	1708	9200
9300	615.2	38.2	16.5	28	7	717	274	1788	9300
9400	633.1	39.1	17.2	29	8	736	275	1877	9400
9500	653.4	40.2	18.1	29	8	758	275	1978	9500
9600	677.2	41.4	19.1	30	8	783	276	2098	9600
9700	707.4	42.9	20.5	30	8	814	276	2253	9700
9800	760.2	45.4	23.0	31	9	868	278	2526	9800
9800	818.9	48.2	26.2	31	9	925	280	2833	9800
9700	871.1	50.4	29.4	31	9	975	282	3104	9700
9600	900.9	51.7	31.4	31	10	1003	284	3258	9600
9500	924.2	52.6	33.1	31	10	1024	285	3377	9500
9400	944.1	53.4	34.6	31	10	1042	285	3478	9400
9300	961.6	54.1	36.1	31	10	1058	286	3565	9300
9200	977.5	54.7	37.4	31	10	1072	287	3644	9200
9100	992.2	55.3	38.8	30	10	1086	287	3716	9100
9000	1005.9	55.8	40.1	30	10	1098	288	3782	9000

Figure V – 1, Example of Abridged Table, Basic Data

2. Following is an explanation of the contents of each column of the Abridged Table, Basic 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 point of graze.

Column 2 – Quadrant Elevation. The angle of the gun in the vertical plane required to reach the range tabulated in column 1 in standard conditions. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of meteorology and material. This number varies with non-standard conditions of meteorology and material and is particularly sensitive to changes in range wind.

Column 3 – Time of Flight. The projectile travel time, under standard conditions, from the muzzle to the point of graze at the range in column 1.

Column 4 – Correction to Bearing for Drift. Because of the right hand twist of the barrel, 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.

Column 5 – Probable Error in Range at Graze. A value which, when added to and subtracted from the expected range, will produce an interval, along the line of fire, that should contain 50 percent of the rounds fired. Variations in muzzle velocity, in angle of departure, and in total drag during flight all contribute to the probable error in range to impact.

Column 6 – Probable Error in Deflection at Graze. A value which, when added both to the right and to the left of the expected impact point, will produce an interval, perpendicular to the line of fire at the expected range, that should contain 50 percent of the rounds fired.

Column 7 – Angle of Descent. The acute angle measured from the horizontal to a line tangential to the trajectory at the point of graze.

Column 8 – Remaining Velocity. The speed of the projectile at the point of graze.

Column 9 – Vertex Height. The maximum height of a trajectory fired under standard conditions by a gun at sea level.

Column 10 – Range for Non-functioning of Rocket Motor or Base Bleed Unit. The range that will be achieved if the on-board rocket motor or Base-Bleed Unit does not function.

ANNEX W TABLE R – ABRIDGED MV TABLE FOR BURSTING PROJECTILE

1. The Abridged MV Tables were developed as an alternative to the Graphical Firing Tables (GFT). Table R was developed for exploding/bursting projectiles. The MV columns, 2 to 7, are at intervals of 4 metres per second covering the expected MV coverage of the life of a barrel. The 4 m/s intervals allow for the grouping of guns within a battery or fire unit. An example of Table R is given at Figure W – 1.

2. Following is an explanation of the contents of each column of the Abridged MV Table for Bursting Projectile:

Column 1 – Range. The distance measured on the surface of a sphere concentric with the earth, from the muzzle to a target at the point of graze. This column is repeated on both the left and right pages.

Column 2/7 – Elevation for Adopted Muzzle Velocity (AMV). The elevation corresponding to the AMV for that column. The AMVs are at 4 metres per second intervals either side of the V_0 covering the expected maximum and minimum bore measurement and allows for 'gun grouping'. An empty box at the head of each column is provided for penciling in the relevant gun number of the battery/fire unit.

Columns 8/9 – Range Correction for a Decrease (Increase) of one Metre per Second in Muzzle Velocity. Corrections to range to compensate for variations from the standard muzzle velocity that appears on the title page for each charge

Column 10 – Effect on Range for Increase of 1 MIL in Quadrant Elevation. The change in range corresponding to a one MIL increase in the quadrant elevation.

Projectile, L888 HE
Fuze, L987

Charge 5
V_0 = 625 m/s

Table R
Abridged MV Table For Bursting Shell

1	2	3	4	5	6	7	8	9	10
Range	Elevation for AMV (Gun No)						Correction to Range for 1 m/s MV (1 m/s V_0)		Effect on Range for Increase of 1 mil in FT Elevation
	625 (m/s)	*625 (m/s)*	*625 (m/s)*	*625 (m/s)*	*625 (m/s)*	*625 (m/s)*	*Decrease*	Increase	
(X)	*(A_E)*	*(A_E)*	*(A_E)*	*(A_E)*	*(A_E)*	*(A_E)*	(-)	(+)	*($\Delta_{EF}X$ /+1 mil A_E)*
m	mil	mil	mil	mil	mil	mil	m	m	m
4000	68	69	70	71	72	73	10.7	-10.7	45
4100	70	71	72	73	74	75	10.9	-10.9	44
4200	72	74	75	76	77	78	11.1	-11.1	43
4300	75	76	77	78	79	80	11.3	-11.3	43
4400	77	78	79	81	82	83	11.5	-11.5	42
4500	80	81	82	83	84	86	11.7	-11.7	41
4600	82	83	84	86	87	88	11.9	-11.9	41
4700	84	86	87	88	89	91	12.1	-12.1	40
4800	87	88	90	91	92	94	12.3	-12.3	39
4900	90	91	92	93	95	96	12.5	-12.5	39
5000	92	93	95	96	98	99	12.7	-12.7	38
5100	95	96	98	99	100	102	12.9	-12.9	38
5200	97	99	100	102	103	105	13.1	-13.1	37
5300	100	102	103	105	106	108	13.3	-13.3	36
5400	103	104	106	108	109	111	13.4	-13.4	36
5500	106	107	109	110	112	114	13.6	-13.6	35
5600	109	110	112	113	115	117	13.8	-13.8	35
5700	111	113	115	116	118	120	14.0	-14.0	34
5800	114	116	118	120	121	123	14.1	-14.1	34
5900	117	119	121	123	125	127	14.3	-14.3	33
6000	120	122	124	126	128	130	14.5	-14.5	32
6100	124	125	127	129	131	133	14.6	-14.6	32
6200	127	129	131	133	135	137	14.8	-14.8	31
6300	130	132	134	136	138	140	15.0	-15.0	31
6400	133	135	137	139	141	144	15.1	-15.1	30
6500	136	139	141	143	145	147	15.3	-15.3	30
6600	140	142	144	146	148	151	15.4	-15.4	29
6700	143	145	148	150	152	154	15.5	-15.5	29
6800	147	149	151	153	156	158	15.7	-15.7	29
6900	150	152	155	157	159	162	15.8	-15.8	28
7000	154	156	158	161	163	166	16.0	-16.0	28
7100	157	160	162	165	167	170	16.1	-16.1	27
7200	161	163	166	168	171	174	16.2	-16.2	27
7300	165	167	170	172	175	178	16.3	-16.4	27
7400	169	171	174	176	179	182	16.5	-16.5	26
7500	172	175	178	180	183	186	16.6	-16.6	26
7600	176	179	181	184	187	190	16.7	-16.7	26
7700	180	183	185	188	191	194	16.8	-16.8	25
7800	184	187	190	192	195	198	16.9	-16.9	25
7900	188	191	194	196	199	202	17.1	-17.1	25
8000	192	195	198	201	204	207	17.2	-17.2	24

Figure W – 1, Example of Abridged MV Table for Bursting Projectile

ANNEX X TABLE S – ABRIDGED MV TABLE FOR CARGO PROJECTILE

1. The Abridged MV Tables were developed as an alternative to the Graphical Firing Tables (GFT). Table S was developed for cargo projectiles. The MV columns, 2 to 7, are at intervals of 4 metres per second covering the expected MV coverage of the life of a barrel. The 4 m/s intervals allow for the grouping of guns within a battery or fire unit. An example of Table S is given at Figure X – 1.

2. Following is an explanation of the contents of each column of the Abridged MV Table for Cargo Projectile:

Column 1 – Range. The distance measured on the surface of a sphere concentric with the earth, from the muzzle to a target.

Column 2/7 – Elevation for Adopted Muzzle Velocity (AMV). The elevation corresponding to the AMV for that column. The AMVs are at 4 metres per second intervals either side of the V_0 covering the expected maximum and minimum bore measurement and allows for 'gun grouping'. An empty box at the head of each column is provided for penciling in the relevant gun number of the battery/fire unit.

Column 8 – Fuze Setting. Numbers to be set on fuzes that will produce a function at a specified time to produce optimum functioning of the payload at the specified height above the target location when firing under standard conditions. This setting will produce a burst at the time of flight listed in column 7 of table F.

Column 9 – Range to Impact. The range at which the projectile will continue until the trajectory reaches the point of graze in the event of fuze failure to function

Projectile, M432 Illum
Fuze, M456

Charge 5
V_0 = 640 m/s

Table S
Abridged MV Table for Illum Carrier Shell

1	2	3	4	5	6	7	8	9
Range	Elevation for AMV (Gun No)						Fuze Setting	Range to Impact
	640 (m/s)	*636* (m/s)	*632* (m/s)	*628* (m/s)	*624* (m/s)	*620* (m/s)		
(X)	*(A_E)*	*(A_E)*	*(A_E)*	*(A_E)*	*(A_E)*	*(A_E)*	(FS)	*($X_{No-Fuze}$)*
m	mil	mil	mil	mil	mil	mil		m
4000	168.2	169.2	170.1	171.1	172.1	173.1	8.0	7300
4100	168.1	169.1	170.0	171.1	172.1	173.1	8.2	7296
4200	168.1	169.1	170.1	171.2	172.2	173.3	8.5	7296
4300	168.2	169.2	170.3	171.4	172.5	173.7	8.7	7299
4400	168.5	169.6	170.7	171.8	173.0	174.1	9.0	7306
4500	168.9	170.0	171.2	172.3	173.5	174.7	9.2	7317
4600	169.5	170.6	171.8	173.0	174.2	175.5	9.5	7331
4700	170.1	171.3	172.6	173.8	175.1	176.4	9.8	7347
4800	170.9	172.2	173.5	174.8	176.1	177.4	10.0	7367
4900	171.9	173.2	174.5	175.8	177.2	178.6	10.3	7390
5000	172.9	174.3	175.6	177.0	178.4	179.8	10.6	7416
5100	174.1	175.5	176.9	178.3	179.7	181.2	10.9	7445
5200	175.4	176.8	178.2	179.7	181.2	182.7	11.2	7476
5300	176.7	178.2	179.7	181.2	182.8	184.4	11.5	7510
5400	178.2	179.8	181.3	182.9	184.5	186.1	11.8	7546
5500	179.8	181.4	183.0	184.6	186.3	188.0	12.1	7585
5600	181.6	183.2	184.8	186.5	188.2	189.9	12.4	7626
5700	183.4	185.0	186.7	188.4	190.2	192.0	12.7	7669
5800	185.3	187.0	188.7	190.5	192.3	194.2	13.0	7714
5900	187.3	189.1	190.9	192.7	194.5	196.4	13.3	7762
6000	189.4	191.2	193.1	194.9	196.9	198.8	13.6	7811
6100	191.6	193.5	195.4	197.3	199.3	201.3	14.0	7863
6200	193.9	195.8	197.8	199.8	201.8	203.8	14.3	7916
6300	196.3	198.3	200.3	202.3	204.4	206.5	14.6	7971
6400	198.8	200.8	202.9	205.0	207.1	209.2	14.9	8028
6500	201.4	203.4	205.5	207.7	209.9	212.1	15.3	8086
6600	204.0	206.2	208.3	210.5	212.7	215.0	15.6	8146
6700	206.8	209.0	211.2	213.4	215.7	218.0	15.9	8208
6800	209.6	211.8	214.1	216.4	218.7	221.1	16.3	8270
6900	212.5	214.8	217.1	219.4	221.8	224.2	16.6	8335
7000	215.5	217.8	220.2	222.6	225.0	227.5	16.9	8400
7100	218.6	221.0	223.4	225.8	228.3	230.8	17.3	8466
7200	221.7	224.2	226.6	229.1	231.7	234.2	17.6	8534
7300	225.0	227.4	230.0	232.5	235.1	237.7	18.0	8603
7400	228.3	230.8	233.4	236.0	238.6	241.3	18.3	8673
7500	231.7	234.2	236.8	239.5	242.2	244.9	18.7	8744
7600	235.1	237.7	240.4	243.1	245.8	248.6	19.0	8815
7700	238.6	241.3	244.0	246.8	249.6	252.4	19.4	8888
7800	242.2	245.0	247.7	250.5	253.4	256.3	19.8	8962
7900	245.9	248.7	251.5	254.4	257.3	260.2	20.1	9036
8000	249.7	252.5	255.4	258.3	261.2	264.2	20.5	9112

Figure X – 1, Example of Abridged MV Table for Cargo Projectile

ANNEX Y TABLE T – ILLUMINATING CARGO PROJECTILE MV SUPPLEMENT, ELEVATION / RANGE TO IMPACT

1. The Illuminating Cargo Projectile MV Supplement, Elevation / Range to Impact were developed as an alternative to the Graphical Firing Tables (GFT). Table T was developed for cargo projectiles to simplify the production of the Range to Impact for carrier projectile for Safety Board plotting. The MV columns, 2 to 7, are at intervals of 4 metres per second covering the expected MV coverage of the life of a barrel. The 4 m/s intervals allow for the grouping of guns within a battery or fire unit. An example of Table T is given at Figure Y – 1.

2. Following is an explanation of the contents of each column of the Illuminating Cargo Projectile MV Supplement, Elevation / Range to Impact:

Column 1 – Quadrant Elevation. The angle of the gun in the vertical plane required to reach the range tabulated in column 1 in standard conditions and at the specified height. The maximum elevation shown represents the highest angle at which predictable projectile flight is possible under standard conditions of meteorology and material. This number varies with non-standard conditions of meteorology and material and is particularly sensitive to changes in range wind. The ballistics is based upon the Standard Projectile contained in Part 1.

Column 2/7 – Range to Impact for Adopted Muzzle Velocity (AMV). The Range to Impact where the projectile will graze in the event of Fuze Failure, corresponding to the AMV for that column and the Elevation. The AMVs are at 4 metres per second intervals either side of the V_0 covering the expected maximum and minimum bore measurement and allows for ‘gun grouping’. An empty box at the head of each column is provided for penciling in the relevant gun number of the battery/fire unit.

Projectile, M485 Illum
Fuze, L163

Charge M4 6W
V_0 = 494 m/s

Table T

Illum Carrier MV Supplement, Elevation / Range to Impact

1	2	3	4	5	6	7
Firing Table Elevation	Range to Impact for AMV (Gun No)					
	***494* (m/s)**	***490* (m/s)**	***486* (m/s)**	***482* (m/s)**	***478* (m/s)**	***474* (m/s)**
(A_E)	*(X)*	*(X)*	*(X)*	*(X)*	*(X)*	*(X)*
mil	m	m	m	m	m	m
20	927	912	898	884	870	856
30	1350	1329	1309	1289	1269	1249
40	1749	1723	1698	1672	1646	1621
50	2127	2096	2065	2035	2004	1974
60	2485	2449	2414	2379	2344	2309
70	2824	2785	2745	2706	2667	2628
80	3146	3103	3060	3017	2974	2931
90	3453	3406	3359	3313	3267	3221
100	3745	3695	3645	3596	3546	3497
110	4024	3972	3919	3867	3815	3763
120	4292	4237	4182	4127	4073	4018
130	4550	4493	4436	4379	4322	4265
140	4799	4740	4681	4622	4563	4505
150	5041	4980	4919	4858	4797	4737
160	5275	5212	5150	5087	5025	4964
170	5503	5439	5375	5311	5248	5184
180	5726	5660	5595	5530	5465	5400
190	5943	5876	5810	5743	5677	5611
200	6156	6088	6020	5952	5885	5818
210	6364	6295	6226	6157	6089	6021
220	6568	6498	6428	6358	6289	6220
230	6768	6697	6626	6556	6485	6415
240	6965	6893	6821	6749	6678	6607
250	7157	7084	7012	6939	6867	6796
260	7347	7273	7199	7126	7053	6981
270	7533	7458	7384	7310	7236	7163
280	7715	7640	7565	7490	7416	7342
290	7895	7819	7743	7668	7593	7518
300	8071	7995	7918	7842	7766	7691
310	8245	8167	8090	8014	7937	7861
320	8415	8337	8259	8182	8105	8028
330	8582	8504	8425	8347	8269	8192
340	8747	8668	8589	8510	8431	8353
350	8908	8828	8749	8669	8590	8511
360	9067	8986	8906	8826	8746	8667
370	9222	9141	9060	8980	8900	8819
380	9375	9293	9212	9131	9050	8969
390	9524	9442	9360	9279	9197	9116
400	9671	9588	9506	9424	9342	9260

Figure Y – 1, Example of Illuminating Cargo Projectile MV Supplement, Elevation / Range to Impact

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