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AUTHORITY

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U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

FLASH RANGING EQUIPMENT

1. OBJECTIVE

The objective of this Materiel Test Procedure is to describe engineering test procedures required to determine the technical performance characteristics of equipments employed in the flash ranging procedure by artillery target acquisition units relative to requirements as expressed in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other applicable documents, and to determine their suitability for their intended use.

2. BACKGROUND

Flash ranging is the procedure employed to locate points in a target area by visual or infrared observation and intersection of direction measurements from two or more observation posts (OP's). The principal missions of a target acquisition flash ranging unit are:

a. Location of hostile artillery.
b. Registration and adjustment of friendly artillery fire.
c. Collection of battlefield activity information.
d. Fall-of-shot comparative calibration data for friendly artillery.
e. Burst location of nuclear rounds delivered by friendly forces.

A review of the tactics and techniques of flash ranging operations is beyond the scope of this document; comprehensive coverage of the subject is given in FM 6-122 and related publications listed in Section 4.

Flash ranging equipments comprising an operational installation are described in general terms, by function, as follows:

a. An optical or infrared surveillance and angle-measuring instrument at each observation post (OP) for detecting gun flashes, shell bursts or other target evidence and measuring the horizontal and vertical line-of-sight angles from known references.
b. A plotting board or equivalent means located at a rearward flash command post (CP) for graphically recording and computing target location from the directional data reported by the OP's.
c. A discrete communication system linking the OP's with the CP and the CP with higher headquarters or supported unit for rapid dissemination of target data and related information.

New or improved equipment items developed to increase flash ranging capabilities, for example: accuracy, range, detection, or data processing speed, must be tested by engineering-type methods to determine compliance with the stipulated requirements. STATEMENT #2 UNCLASSIFIED

3. REQUIRED EQUIPMENT

a. Surveyed field test areas.
b. Military topographic maps of the above.
c. Control sighting/measuring instruments, e.g. T2 Theodolite (mil).
d. Passive visual targets.
e. Photo-flash lamps or equivalent and firing control system.
f. Explosive charges (flash and smoke) and firing control system.
g. Vehicles for transporting or mounting the test item, as required.
h. Plotting and computing items, e.g. military slide rule, range deflection protractor, coordinate scale.
i. Field radio sets for test coordination net.
j. Photographic equipment, motion and still, and film, (black and white or color.
k. Maintenance support facilities.
l. Sound recording equipment.

4. REFERENCES

A. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
B. USATECOM Regulation 700-4, Reliability Program for USAMC Materiel.
C. USATECOM Regulation 705-2, Research and Development of Materiel, Documenting Test Plans and Reports.
D. USATECOM Regulation 705-4, Equipment Performance Reports.
E. USATECOM Regulation 705-12, Preliminary Operating and Maintenance Manual.
F. AMCR 385-12, Verification of Safety of Materiel from Development Through Testing, Production, and Supply to Disposition.
G. FM 6-2, Artillery Survey.
H. FM 6-10, Field Artillery Communications.
I. FM 6-121, Field Artillery Target Acquisition.
J. FM 6-122, Field Artillery Sound Ranging and Flash Ranging.
K. TM 9-6109, Plotting Boards.
L. TM 11-5516, Flash Ranging Set, AN/GTC-1.
M. MTP 3-1-002, Confidence Intervals and Sample Size.
N. MTP 6-2-110, Handset, Telephone.
O. MTP 6-2-115, Headsets.
P. MTP 6-2-135, Infrared Equipment.
Q. MTP 6-2-230, Radio Control Equipment.
R. MTP 6-2-242, Radio Receiver-Transmitter, General.
S. MTP 6-2-265, Switchboards.
T. MTP 6-2-507, Safety.
U. MTP 10-2-110, Theodolites.

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

This MTP describes the engineering test procedures required to determine the technical performance characteristics of equipments intended for flash ranging operations.

The test procedures are segregated on the basis of equipment function within an operating system, i.e. (1) target detection and measurement, (2) communication, and (3) computation of target location. The test objectives are as follows:

a. Observation Instruments Test - The objective of this subtest is to determine the ability of the test item component to detect and measure simulated targets under controlled conditions. Determination is done for:

1) Orientation accuracy.
2) Angle-measurement accuracy.
3) Accuracy of target position location (multiple test items).

NOTE: All test sites, targets, and reference points are located/positioned by fourth-order survey (one order of accuracy higher than normal flash ranging requirements) and correlated with the applicable military topographic map (third-order).

b. Communication Systems/Equipments Test - The objective of this subtest is to determine the ability of this test item component to transfer data with accuracy and speed between the observations posts and the flash command post (plotting center).

c. Flash Ranging Plotting Boards Test - The objective of this subtest is to determine the ability of this test item component to plot accurately target position using the survey data of the observation instruments test as test problems or test problems evolved from map data of comparable hypothetical situations.

5.1.2 Common Engineering Tests

Not included in this MTP are the following common engineering tests which are applicable to these commodities:

a. MTP 6-2-500, Physical Characteristics.
b. MTP 6-2-502, Human Factors Engineering.
c. MTP 6-2-503, Reliability.
d. MTP 6-2-504, Design for Maintainability.
e. MTP 6-2-514, Electrical Power Requirements.
f. MTP 6-2-520, Transportability of Communication, Surveillance, and Electronic Equipment.
g. MTP 6-2-530 through 541, Environmental Tests.

5.2 LIMITATIONS

The procedures herein are limited to manually operated equipments

generally comparable to current standard items. The advent of flash ranging equipments incorporating new concepts or techniques will necessitate some modification of the procedures as described.

NOTE: Units of measurement used throughout the procedure are in consonance with current target acquisition practices, i.e. distance/length is expressed in meters or kilometers and angles in mils. Map references are in UTM 1000-meter grid coordinates.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Orient all test personnel on the test objectives and requirements as stipulated in the applicable QMR, SDR, or test directive and on information derived from test item instructional material and reports of comparable tests.

b. Establish a coordinated test schedule to ensure test continuity and timely cooperation of support agencies.

c. Ensure that test equipment and instrumentation/control items are available and have an accuracy at least ten times greater than that of the function to be measured, that is in keeping with the state of the art, and with calibrations traceable to the National Bureau of Standards.

d. Prepare and/or provide record forms and equivalent material suitable for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

e. Upon establishing the scheduled availability of the test item, coordinate the availability of the following:

1) Engineering Safety release or other safety statement.
2) Maintenance support facilities, spare parts, and personnel.
3) Equipment, special facilities and instrumentation with special attention to timely provision of additional supplies or special equipment not readily available at the test site.

f. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous tests conducted on the same types of equipment, and familiarize all test personnel with the contents of such documents. These documents shall be kept readily available for reference.

g. Record the following information:

1) Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

h. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed

throughout the test and that the item has successfully completed MTP 6-2-507.

i. Prepare a test item sample plan sufficient to ensure that enough samples of all measurements are taken to provide statistical confidence of final data in accordance with MTP 3-1-002. Provisions shall be made for modification of test plan during test progress as may be indicated by monitored test results.

j. Ensure that arrangements for supporting and participating agencies, activities, and facilities have been made, and that authorization for electromagnetic radiation at specific frequencies, power levels, and modulations for required periods as necessary has been obtained.

k. Ensure that appropriate security measures are instituted as required to safeguard classified materiel and data.

l. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent critical parts, and corroded plugs or jacks. Check for continuity of wire terminations to ensure that wiring is connected to the proper terminals, and that no damage will result when power is applied. All defects shall be noted and corrected before proceeding with the test.

6.2 TEST CONDUCT

6.2.1 Observation (spotting) Instruments

6.2.1.1 Test Conditions and Provisions

NOTE: These tests are generally adaptable to observation equipments of both the optical (visual) type and the thermal sensing (infrared) type using passive targets and appropriate active devices simulating artillery fire. Infrared (IR) test items shall be tested in daylight as well as at night if filters and/or aperture-control features are incorporated for ambient light reduction.

a. Evaluate technical performance of test items in accordance with the subtests of this section in conjunction with the following, as appropriate:

1) Optical instruments shall be tested in accordance with the applicable provisions of MTP 10-2-110.
2) Infrared features/devices of test items shall be tested in accordance with MTP 6-2-135.
3) Features which are peculiar to a specific test item shall be covered by additional subtests to determine conformance with the applicable QMR/SDR specifications.

b. Establish the positions of observation posts (test item), targets, and reference points by fourth-order survey (1:3000) or as otherwise directed. Positions shall be spotted on a military topographic map of the area and a record made of the position and height data.

c. Use a T2 Theodolite (mil) or equivalent instrument as a control

instrument to provide the reference measurements for corresponding test item measurements.

d. Test targets shall include, as appropriate, prepared visible objects, incandescent lamps, photo flash lamps, flares, and explosive charges (flash-and smoke-producing) suitably emplaced and controlled to simulate single and multiple real targets.

6.2.1.2 Orientation Accuracy

a. Level and plumb a test item over a surveyed observation post (OP). Inspect and functionally check the positioned item for any transit damage.

b. Orient the test item to grid north using the magnetic needle or compass and the current magnetic declination as computed from the topographic map.

c. Measure and record the grid azimuths to 10 passive targets, repeating the series a minimum of 12 times and alternating the direction of approach each time.

d. After each group of 10 readings, verify the orientation of the test item and record errors.

e. Displace the magnetic needle and re-center it a minimum of 20 times to determine the reliability in seeking magnetic north. Record magnitude and direction of errors.

f. If the test item is so designed, determine and record the capability to perform celestial observations as an orientation method, using both daytime solar and nighttime stellar methods at three separate OP stations.

6.2.1.3 Angle-measurement Accuracy

a. Emplace the test item and 15-20 momentary - type targets (flash/smoke) approximately as shown in Figure 1. at an initial range of 1000 meters.

b. Level and align the test item telescope or boresighting telescope on the reference aiming point and lock the horizontal and vertical scales on 0 mils.

c. Fire the targets individually in random order at time intervals sufficient to allow test item measurements. Record the time and target number in firing order.

d. With test items having a single optical axis and a mil-graduated crosshair reticle -

1) Measure and record the azimuth and vertical angle (positive or negative) to each fired target by means of the reticle, i.e. without moving the telescope.
2) If target persistence, e.g. smoke, is sufficient, slew the telescope to place the reticle center on target (center at base) and record the horizontal and vertical circle readings. Realign the telescope as in step (b) above after each such measurement.

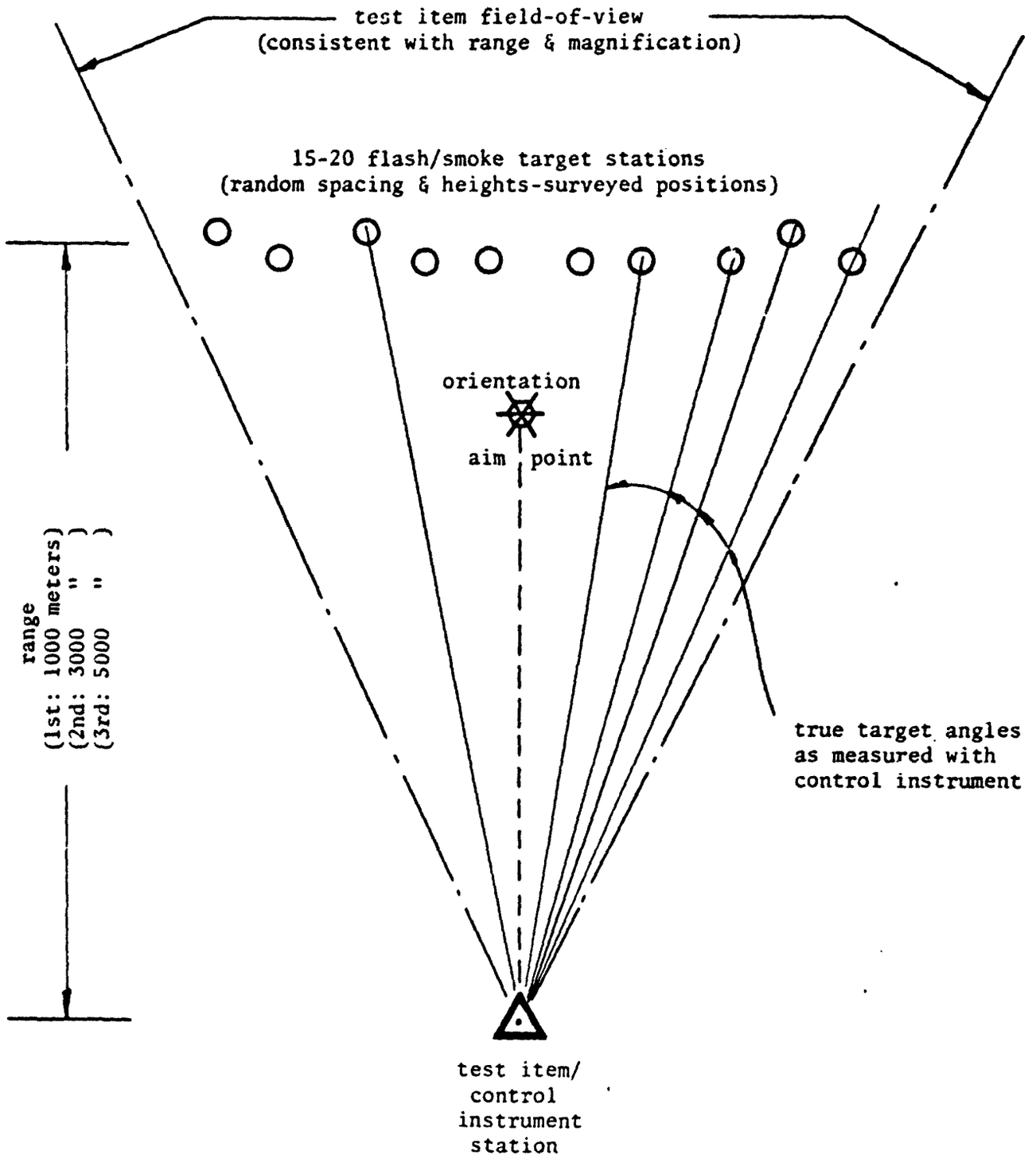

Figure 1. Field Test Layout for Angle Measurements

e. With test items incorporating multiple viewing/sensing and automatic data display features, record the data resulting from each fired target.

f. Repeat steps (b) and (c) a minimum of 3 times, rotating and reorienting the traversing head as in step (b) between each target series. Record any reorientation errors.

g. Repeat steps (b) through (f) at OP-target ranges of 3000 and 5000 meters or as otherwise directed, increasing target spacing as required to maintain the same general angle relationship though providing test azimuths different from other ranges.

6.2.1.4 Accuracy of Target Position Location

NOTE: This subtest is based, in part, on the following factors:
Two or more (preferably four) identical test items shall be available to establish a representative flash ranging OP base.
Controlled target simulation shall be employed since the test item service test will employ real weapons fire representative of hostile and friendly artillery operations (reference MTP 6-3-331).
Test coordination shall be effected by radio nets linking OP's and target control stations as required.

a. Emplace test items and test targets in representative tactical deployments consistent with applicable flash ranging principles as set forth in FM 6-122. Establish the test setups successively to provide nominal OP base-target area ranges of 5, 10, 15, and 20 kilometers or as otherwise directed and perform the steps listed below.

NOTE: 1. Explosive charges and equivalent target simulators shall produce effects which are characteristic of a variety of actual weapons and missile bursts.

2. OP and target positions shall be located by survey and recorded as prescribed in paragraphs 6.2.1.1 (b) and 6.2.1.1 (c).

b. Orient the test items to grid north by compass or celestial observation, ensuring that the measurement axes of all test items are parallel. Record details.

c. Fire or activate the targets individually in random order at time intervals adequate for OP measurements. Record the time and target numbers in firing order.

d. At each OP, measure and record the grid azimuth and vertical angle to each fired target. Record the time of detection, visibility conditions, and remarks pertinent to accuracy or method of measurement.

e. Repeat steps (b) through (d) a sufficient number of times to ensure statistically valid test data as required in MTP 3-1-002.

f. Conduct all or selected test phases, as directed, under various conditions of visibility in daylight and darkness.

g. Record difficulties or discrepancies encountered in test item operation.

6.2.2 Communication Equipment

NOTE: 1. These tests are described in general terms to provide adaptability to systems of various types which may be intended for flash ranging use.
2. System components such as radio sets, telephones, switchboards, data sets, and signaling devices shall be tested individually in accordance with applicable procedures and specific requirements as given in MTP's 6-2-110, 6-2-115, 6-2-230, 6-2-242, and 6-2-265. The communication system shall be tested as an operational entity in accordance with the following paragraphs.

6.2.2.1 Preparation

Establish the communication system (test item) in a representative flash ranging configuration consisting of several observation posts (OP's), the flash command post (CP), and compatible communication equipment to simulate a fire direction center (FDC), e.g. telephone.

6.2.2.2 Operation

a. Perform conventional two-way transmission and/or intelligibility tests between all elements and record results in the applicable form.

NOTE: For wire systems, the test shall include a conference-type connection, i.e. the CP (switchboard) operator connected to all OP's and the FDC simultaneously.

b. Perform the applicable signaling functions in both directions on each line and trunk of the net. Measure and record the time interval between initiation and response. Repeat a sufficient number of times to obtain valid data on which to evaluate reliability and response time.

c. Perform other tests as required to obtain technical performance data on characteristics peculiar to the test item, for example: accuracy of target information transfer in a digital data type system.

6.2.3 Plotting Boards

NOTE: These tests are applicable to a class of manual plotting boards which incorporate the trigonometric sine law of oblique triangles in mechanical features to rapidly determine target position by the intersection method from plotted data.

a. Determine technical performance characteristics of the test item by utilizing control (survey) data derived from paragraph 6.2.1.4 as test

problems, or comparable test problems developed from map data as hypothetical situations. Reference is made to TM 9-6109 and FM 6-122 for description and method of operation of a typical flash ranging plotting board.

6.2.3.1 Preparation

a. Assemble and adjust the test item in accordance with the applicable instructions.

b. Orient the test item so that when the graduated edge of the plotting arm is on or parallel to any north-south grid line on the plotting disk, the disk azimuth scale zero mark and the vernier scale zero mark are in coincidence. Ensure that the arm maintains parallelism to grid lines when the disk is set at any cardinal point (0, 1600, 3200, or 4800 mils).

c. Number the plotting disk grid lines to correspond to the grid system of the topographic map area utilized in the instrument tests of paragraph 6.2.1.3, assuming the same scale relationship.

d. The use of tracing paper taped to the plotting disk for each test problem is recommended in order to retain a record of data and for use as a map overlay in the analysis of results.

6.2.3.2 Plotting Accuracy

a. Using the surveyed coordinates, plot the positions of all OP's for one deployment selected from the instrument test.

b. Plot the survey azimuth from each OP to one selected target by means of the plotting arm and determine and record the disk grid coordinates of the intersection point of the rays, i.e. the plotted target location.

NOTE: "Survey azimuth" is the azimuth from an OP to a target station as measured by the control instrument, e.g. T2 Theodolite, and verified by map plot.

c. If the rays fail to intersect at a point, resulting in a "polygon of error," replot the entire problem. If the error remains, determine the center of the polygon by computation (FM 6-122) and record the coordinates as target loaction.

d. Using the graduated scale of the plotting arm, measure and record the distance in meters from each OP to the plotted target position.

e. Repeat steps (b) through (d), plotting the azimuths in reverse order and with reverse disk rotation.

f. Repeat steps (a) through (e) for each selected/prepared test problem. Problems shall be varied with respect to:

1) Number and location of OP's.
2) OP base-target distance and azimuthal relationship.

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited to:

a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
b. Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.
c. Damages to the test item incurred during transit and/or manufacturing.

6.3.2 Test Conduct

6.3.2.1 Observation Instruments

6.3.2.1.1 Test Conditions and Provisions-

Record the following:

a. Test item identification and results of initial inspection and checkout.
b. Test data in accordance with MTP 10-2-110 or MTP 6-2-135 as applicable.
c. Coordinates and heights of surveyed observation posts, target positions, and reference points for all subtests in tabular form and marked map.
d. Target types correlated with position and fire plan information.

6.3.2.1.2 Orientation Accuracy-

Record the following:

a. Test item position (coordinate) and computed magnetic declination of grid north.
b. Grid azimuths of targets as measured from test site with control instrument (theodolite).
c. Grid azimuths of targets as measured by test item; each series suitably identified.
d. Magnitude and direction of orientation errors, each series.
e. Magnitude and direction of magnetic needle/compass errors.

6.3.2.1.3 Angle-measurement Accuracy -

Record the following:
(For each item, target series,and range; each subtest appropriately identified).

a. Test item position (coordinates) and control azimuths to aim point and target positions (pretest measurements).
b. Nominal range.
c. Test item measurements as each target is fired and detected,

to include:

1) Horizontal and vertical angles relative to aiming point.
2) Time.
3) Description of target evidence (flash/smoke).
4) Method of measurement, i.e. reticle reference, reticle centering, or other.

d. Target series number and firing order by target number and real time.

e. Results of reorientation actions.

6.3.2.1.4 Accuracy of Target Position Location -

Record the following:
(For each test deployment and range).

a. Observation post and target positions by coordinates in tabular form and map overlay.

b. Control grid azimuths as measured from each OP to each target position with control instrument.

c. Test item orientation method and data.

d. Nominal OP base-target area range.

e. Test item measurements at each OP as each target is fired to include:

1) Grid azimuth and vertical angle (positive or negative).
2) Time.
3) Description of target evidence (flash/smoke).
4) Measurement method and accuracy estimate as applicable.
5) Visibility conditions.

f. Target series number and firing order by target number and time.

6.3.2.2 Communication Equipment

a. Prepare a narrative and graphic description of the test item and test setup.

b. Record the transmission and signaling test data in tabular form and tape recorded form, where applicable.

c. Record data resulting from unique feature tests in a form dictated by the test characteristics.

d. Record test data collected under other applicable MTP's.

6.3.2.3 Plotting Boards - Preparation

a. Record discrepancies and difficulties encountered in orientation.

b. List data for each test problem as follows:

1) Coordinates of each OP.

2) Target grid azimuth from each OP.
3) Range to target from each OP.
4) Target point coordinates.

6.3.2.4 Plotting Accuracy

a. Index and annotate each test problem overlay, associate it with the originating information and retain for data reduction.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general, consist of organizing, marking for correlation and identification, and grouping the test data according to subtest title. Test criteria or test item specifications shall be noted on the test data presentation to facilitate analysis and comparison.

Specific instructions for the reduction and presentation of individual subtest data are outlined in the succeeding paragraphs.

6.4.1 Observation Instruments

a. Presentation of final results of each subtest shall include diagrams of layouts of test item(s) and test descriptions in addition to detailed data on each test item.

b. Individual test item data obtained in the orientation and angle accuracy subtests shall be reduced to show mean error, average deviation and percent of total number of observations in error in each phase (e.g. range) and presented in tabular and/or graphic form with the control data included for comparison as appropriate.

c. Target location test data shall be reduced and presented in tabular and/or graphic form for each test deployment and range, clearly identifying the specific test item used at each OP. Both formats shall be prepared in a manner featuring the comparison of plotted/computed target locations with the respective surveyed location relative to mean error, dispersion of plotted locations, and the error contribution of each test item.

6.4.2 Communication Equipment

Test data from all sources and subtests shall be combined and presented in a manner suitable for an analysis of the test item technical performance as given in the referenced MTP's.

6.4.3 Plotting Boards

a. Test problem overlays shall be measured by independent means (coordinate scale and protractor) and the data tabulated for direct comparison with the given data. Each overlay shall be marked with the correct target location.

b. All problem data shall be compiled, reduced, and presented in a manner showing the percent accuracy and the error characteristics.

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13. ABSTRACT

This Engineering Test Procedure describes test methods and techniques for evaluating the technical performance and characteristics of Flash Ranging Equipments used by Artillery Target Acquisition organizations, and for determining their suitability for their intended employment. The evaluation is related to criteria expressed in appropriate Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate design requirements and specifications.

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