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INSENSITIVE MUNITIONS TECHNICAL REQUIREMENTS

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FOREWORD

The views expressed herein represent the Joint Service Requirements for Insensitive Munitions. These requirements will be applicable to all Departments and Agencies of the Department of Defense.

ABSTRACT

The Navy's efforts to make munitions insensitive to unplanned stimuli is known throughout the ordnance community and coordinated with other services through the Joint Ordnance Commanders Group (JOCG) and with industry and NATO allies.

Standardization test procedures, data requirements, and assessment methods are called out in MIL-STD-2105A (Navy), Draft, dated 19 June 1990, "Hazard Assessment Tests for Non-Nuclear Munitions". This revised document incorporated the U.S. Military Service comments only. This is one milestone that has near and long term impact on weapon and ship design, and safety/vulnerability testing.

INTRODUCTION

The revised MIL-STD-2105A (Navy), Draft, dated 19 June 1990 provides the basic mandatory tests and test requirements to be conducted for the assessment of safety and insensitive munitions characteristics for all non-nuclear munitions, munition subsystems and explosive devices and passing criteria. The tests called out in this document are to characterize the munitions and provide the WSESRB information with which to make a decision. This draft document, applies to all non-nuclear munitions (i.e., all-up missiles, rocket, pyrotechnics), munitions subsystems (e.g., warheads, fuzes, propulsion units, safe and arm devices, pyrotechnic devices, chemical payloads), and other explosive devices. Nuclear systems will be excluded.

MIL-STD-2105A (Navy) lists the passing criteria for all the basic tests. Results will be reviewed by the appropriate service review organization for compliance with safety, operational and insensitive munitions requirements. The lead service will have the responsibility for implementing these requirements.

DEFINITIONS

Explosive. An explosive is a solid or liquid substance (or a mixture of substances) which is in itself capable, by chemical reaction of producing gas at such temperature, pressure and speed, of causing damage to the surroundings. Included are pyrotechnic substances even when they do not evolve gases. The term explosive includes all solid and liquid materials variously known as high explosives, propellants, together with igniter, primer, initiation and pyrotechnic (e.g., illuminant, smoke, delay, decoy flare and incendiary) compositions.

All-up-round (AUR). Refers to the completely assembled munition as intended for delivery to a target or configured to accomplish its intended mission. This term is identical to the term all-up-weapon.

Exudation. A discharge or seepage of material. The material may be either a component of a chemical payload or a component of an explosive/propellant payload.

Detonation Reaction (Type I). The most violent type of explosive event. A supersonic decomposition reaction propagates through the energetic material to produce an intense shock in the surrounding medium (e.g., air or water) and very rapid plastic deformation of metallic cases, followed by extensive fragmentation. All energetic material will be consumed. The effects will include large ground craters for munitions on or close to the ground, holing/plastic flow damage/fragmentation of adjacent metal plates, and blast overpressure damage to nearby structures.

Partial Detonation Reaction (Type II). The second most violent type of explosive event. Some, but not all of the energetic material reacts as in a detonation. An intense shock is formed; some of the case is broken into small fragments; a ground crater can be produced, adjacent metal plates can be damaged as in a detonation, and there will be blast overpressure damage to nearby structures. A partial detonation can also produce large case fragments as in a violent pressure rupture (brittle fracture). The amount of damage, relative to a full detonation, depends on the portion of material that detonates.

Explosion Reaction (Type III). The third most violent type of explosive event. Ignition and rapid burning of the confined energetic material builds up high local pressures leading to violent pressure rupturing of the confining structure. Metal cases are fragmented (brittle fracture) into large pieces that are often thrown long distances.

Unreacted and/or burning energetic material is also thrown about. Fire and smoke hazards will exist. Air shocks are produced that can cause damage to nearby structures. The blast and high velocity fragments can cause minor ground craters and damage (break-up, tearing, gouging) to adjacent metal plates. Blast pressures are lower than that of a detonation reaction.

Deflagration Reaction (Type IV). The fourth most violent type of explosive event. Ignition and burning of the confined energetic materials leads to nonviolent pressure release as a result of a low strength case or venting through case closures (leading port/fuze wells, etc.). The case might rupture but does not fragment; closure covers might be expelled, and unburned or burning energetic material might be thrown about and spread the fire. Pressure venting can propel an unsecured test item, causing an additional hazard. No blast or significant fragmentation damage to the surroundings; only heat and smoke damage from the burning energetic material.

Burning (Type V). The least violent type of explosive event. The energetic material ignites and burns, non-propulsively. The case may open, melt or weaken sufficiently to rupture nonviolently, allowing mild release of combustion gases. Debris stays mainly within the area of the fire. This debris is not expected to cause fatal wounds to personnel or be a hazardous fragment beyond 50 feet.

Propulsion (Type VI). A reaction whereby adequate force is produced to impart flight to the test item in its least restrained configuration as determined by the life cycle analysis.

Service review organization. The organization within the DOA, DOAF or DON which assess the explosives safety and IM characteristics of weapon systems and makes recommendations to the appropriate approval authority.

Weapon Systems Explosive Safety Review Board (WSESRB). A board chartered by the Chief of Naval Operations to assess the explosives safety of weapon systems. The Board is chaired by the Naval Sea Systems Command and its membership is drawn from all the Naval Systems Command.

Weapon system. A munition and those components required for its operation and support.

Munition. An assembled ordnance item that contains explosive material(s) and is configured to accomplish its intended mission.

Munition subsystem. An element of an explosive system that contains explosive material(s) and that, in itself, may constitute a system.

Explosive device. An item that contains explosive material(s) and is configured to provide quantities of gas, heat, or light by a rapid chemical reaction initiated by an energy source usually electrical or mechanical in nature.

Hazardous fragment. For personnel, a hazardous fragment is a piece of the reacting weapon, weapons systems or container having an impact energy of 58 ft-lb (79 joules) or greater.

Sympathetic detonation. The detonation of munition or an explosive charge induced by the detonation of another like munition or explosive charge.

Bare round or configuration. A munition with no external protection or shielding from the environment such as container, barrier or shield.

Threat hazard assessment. An evaluation of the munition life cycle environmental profile to determine the threats and hazards to which the munition may be exposed. The assessment includes threats posed by friendly munitions, enemy munitions, accidents, handling, etc. The assessment shall be based on analytical or empirical data to the extent possible.

GENERAL REQUIREMENTS

The program manager shall be responsible for planning and executing a hazard assessment test program which includes a master test plan based on a realistic life cycle environmental profile. The profile shall establish the environmental conditions and limits the munitions will encounter throughout the life cycle. The program manager shall ensure that the conducted test program uses the minimum of test units required in MIL-STD-2105A (Navy), Figure 1, to complete the basic tests. Safety design goals for the test plan shall be established by the program manager and approved by the service review organization.

Program managers and munition developers shall be aware that additional testing may be required to assess the tactical and logistical vulnerability of the given weapon system against the probable threats to which the system may be subjected. The program manager shall generate and submit a detailed test report to the WSESRB, consistent with the master test plan. The test report shall include rationale for deviations from the test plan, the test item configuration and identification, test date, test results, and safety and vulnerability related conclusions.

The conditions that simulate or duplicate the hazards of credible normal, abnormal, and combat situation(s) identified by the threat assessment shall determine the safety and sensitivity characteristics of the test item. The test parameters shall be selected to reflect maximum stress levels forecast. Unless otherwise specified, all items shall be tested at 77 $\pm$ 18°F.

The test item shall either be production hardware, or equivalent. The test plan shall indicate if the item is different from production hardware.

Test equipment/fixtures shall not interfere with the test stimulus imposed on the test item. The test item configuration shall be the same as the configuration of the item in the life cycle phase being duplicated by the test, and be specified in detail in the test plan and approved by the WSESRB.

Prior to testing, the test item shall be inspected visually and radiographically to assure no existence of unusual conditions. All unit safety mechanisms and devices shall be set or otherwise adjusted to a safe condition. Photographs of the test setup including identification information in the field of view shall be taken.

The test item shall be inspected visually and radiographically after the test is complete to determine its structural integrity and to compare with the pre-test examination results. The following are requirements to be documented whenever the test item is destroyed: a complete description of significant post-test remains of the munition (Figure 2), Post-Test Remains Map (Figure 3) including the distance from the original test positions, dimensions and weight of each recovered part, and Post-Test Remains Tabulation(Figure 4).

DETAILED REQUIREMENTS

The basic safety tests consist of: 28-Day Temperature and Humidity (T&H); Vibration; 4-Day T&H; 40-Foot Drop; Fast Cook-off; Slow Cook-off; Bullet Impact; Fragment Impact; Sympathetic Detonation; Shaped Charge Jet Impact and Spall Impact. Results of each test shall be documented on the appropriate data sheet. The following is a brief description of these tests.

28-Day T&H Test

The test item is exposed to alternating, no less than 24-hour, periods of high and low temperatures at fixed relative humidity levels specified in the environmental profile for 28 days. The test procedures shall reflect the temperature and humidity conditions measured or forecast. Each test item shall be visually examined prior to testing and record the appropriate critical dimensions to determine the material condition. A minimum of three units shall be tested. The passing criteria listed below are based on the final observation:

1. No reaction of the explosive.

2. No exudation of the explosive.

3. Rocket motor propellant and pyrotechnic candles shall not crack or separate from case lining in a manner which would create a hazardous condition in handling or use.

4. All safety devices shall remain in the safe position.

5. The structural integrity of the item shall not be compromised by corrosion, loosening of joints or other physical distortions.

Vibration Test

The test item is exposed to the most severe vibration environment that it normally encounters during the logistic cycle. The test shall be conducted at low and elevated temperatures along the appropriate mutually perpendicular axes, and may consist of one or a combination of the following: random vibration, vibration cycling and resonant dwell. The vibration schedule shall be selected from the environmental profile. Test procedures shall reflect vibration modes and temperatures anticipated in the item's environment. A minimum of three items which have undergone and passed the 28-day T&H test shall be tested. The passing criteria are the same as those listed under the 28-day T&H test.

4-Day T&H Test

This test is a version of the 28-day T&H test. All data relative to the 28-day T&H test are required for the 4-day T&H test. A minimum of three items which have undergone and passed the 28-day T&H and Vibration tests shall be tested. The passing criteria are the same as those listed under the 28-day T&H test.

40-Foot Drop Test

This field test is designed to evaluate the safety response of the test item to the stress loads associated with a free-fall impact onto a striking plate in various attitudes.

The test item is dropped from the lowest point of the item to the point of impact of 40 feet, complying with following orientations:

a. Longitudinal axis horizontal

b. Longitudinal axis vertical (aft-end down)

c. Longitudinal axis vertical (forward-end down)

The test consists of free-fall drops of the environmentally pre-conditioned items (Figure 1) in the configuration of the item in the life cycle phase being duplicated by the test (one drop per item) onto the striking plate. The passing criteria include the following:

1. No reaction of the explosives in the item

2. No rupture of the item resulting in exposed explosives

3. The item shall be safe to handle and be disposed of by normal EOD procedures.

Fast Cook-Off Test

The test item is engulfed in the flame envelope of a liquid fuel fire and the reaction is recorded as a function of time. The item shall be tested in the configuration in the logistic phase being duplicated by the test. Items configured with rocket motors shall be restrained to avoid launching due to a propulsive reaction. The restraining and suspension method shall not interfere with the heating of the item. The test item shall be positioned so that its horizontal center line is 36 inches above the surface of the fuel or in the attitude most probable in the weapons life cycle environment. The test item shall not fall into and being quenched by the fuel. Four thermocouples with time constants of 2 seconds or less shall be located 4 to 8 inches outside the ordnance skin for each item tested. The thermocouples shall be positioned on each end and side of the ordnance skin in a horizontal plane through the center line. A minimum of two tests shall be conducted. The test item shall have no reaction more severe than burning.

Slow Cook-Off Test

This test determines the reaction temperature and measures the overall response of major munition subsystems to a gradually increasing thermal environment at a rate of 6°F per hour until a reaction occurs. The test item is placed in an oven of materials, wall thickness, etc., designed to minimize the confinement of the test item reaction. A minimum of eight inches separation between all outer surfaces of the test item and the inner walls of the oven is required. Figure 5 displays the test configuration. A minimum of two tests shall be conducted. Temperature recording device shall be utilized to record temperatures. Steel witness plates shall be positioned beneath the test item to provide evidence of the item reaction. No reaction more severe than burning shall occur.

Bullet Impact Test

This test is conducted to determine the reaction of the test item when impacted by at least three 0.50 caliber type M2 armor-piercing (AP) bullets at 2800 ± 200 ft/sec. Figure 6 displays the test configuration. The firing interval shall be 50 ± 10 milliseconds (ms). A minimum of two test items shall be tested. In the first test item the bullets impact the largest quantity of explosives. The bullets impact the most sensitive location in the second test item. The airblast overpressure of the test item is measured and steel witness plates are positioned beneath the test item to provide evidence of the test item reaction. No reaction more severe than burning shall occur.

Fragment Impact Test

This test determines the response of the test item to the impact of one-half inch, 250 grain, mild-steel cubes traveling at 8300 ± 300 ft/sec with an impact of at least two but no more than five fragments upon the test item. Figure 7 presents the sample test configuration. A minimum of two items shall be tested with fragments impacting the largest quantity of explosives in one test item and fragments impacting the most shock-sensitive area of the other test item. Steel witness plates positioned beneath the test item shall be used to provide evidence of the test item reaction. The test shall have no reaction more severe than burning.

Sympathetic Detonation

This test evaluates the likelihood a detonation reaction may be propagated from one unit to another within a group or stack of munitions. Generally, one munition (donor) is adjacent to one or more like munitions (acceptors). The test setup should replicate the packaging conditions and stowage arrangement for the logistics life cycle phase deemed to pose the greatest threat of sympathetic detonation. The test setup shall incorporate one or more acceptors positioned (relative to the donor) at location(s) deemed most vulnerable to sympathetic detonation. Where appropriate, the test setup shall also incorporate simulated (or dummy) units to provide additional confinement of the donor and the acceptor(s) as illustrated in Figure 8. The donor may be initiated using an external stimulus that simulates initiation by the threat stimuli most likely to cause detonation of the test item as determined by the threat hazard assessment. Alternatively, if the test item is designed to detonate when functioned, the donor may be initiated using its normal booster system or a booster charge of similar power. For items that are not designed to detonate, the donor may be initiated axisymmetrically using a booster charge of sufficient size/output to ensure sustained, stable detonation of the explosive. The donor may be modified to accommodate the required booster provided the modifications are not expected to have a significant effect on the fragmentation or blast of the item. The test design shall incorporate either high-speed motion picture cameras to record the reaction(s) of the acceptor(s), or steel witness plates beneath the test items to provide rough indications of the shock pressure within each acceptor relative to the shock pressure within the donor. Transducers shall be placed along each of two mutually perpendicular axes illustrated in Figure 9. The transducers shall be mounted flush with the ground surface or in elevated fixtures with the sensing face of each transducer parallel to the direction of flow. Baseline overpressure data shall be obtained by conducting a calibration test firing using either a single test item or an explosive charge of approximately the same yield as the donor test item. The setup for the calibration test shall be identical to the actual test setup with respect to test item mounting, transducer placement, and sensitivity and response of the measurement system. The test shall not have a detonation of any acceptor. For ordnance stored in containers, there shall be no acceptor weapon detonation in any other container.

Shaped Charge Jet Impact Test

This test determines the reaction of the test item when impacted by the jet of a M42/M46 grenade, representative of a top attack or an 81-mm precision shaped charge (or both), representative of a hand-held HEAT attack. Figure 10 provides a schematic of a typical test configuration. The munition shall be tested in the transport/storage or operational use configurations or both, including shielding, which reflect credible threats. The 81-mm shaped charge shall be initiated in a manner that ensures proper formation of the shaped charge jet. The shaped charge shall be aimed to impact the test item so that the jet passes through the greatest possible length of energetic material. A minimum of two test items shall be used. Steel witness plates shall be placed under and on two opposite sides of the test item as witnesses to the degree of reaction. No detonation shall occur as a result of the shaped charge jet impact.

Spall Impact Test

The response of munitions to impact of hot spall fragments is determined in this test. The test setup is illustrated in Figure 11. The spall fragments are produced by impacting a 1-inch thick rolled homogeneous armor (RHA) plate with the shaped charge jet of an 81-mm precision shaped charge. The standoff distance between the shaped charge and the RHA plate shall be 5.8 inches. The placement of the test item behind the RHA plate shall be selected so that it is impacted by spall fragments only. A minimum of 4 spall fragments/10 in^2 of presented area (up to 40 fragments) shall impact the test item. The test item configuration shall be a bare munition subsystem. Closed-circuit video, real time motion picture photography shall be used to document the test events. A minimum of two test items shall be used. No sustained burning shall occur as a result of the spall impact test.

REFERENCES

Government documents. Unless otherwise specified, the following standards form a part of this document to the extent specified herein.

Military

MIL-STD-331 Fuze and Fuze Components, Environmental and Performance Tests for

MIL-STD-453 Inspection, Radiographic

MIL-STD-810 Environmental Test Methods and Engineering Guidelines

MIL-STD-1670 Environmental Criteria and Guidelines for Air-Launched Weapons

FIGURES

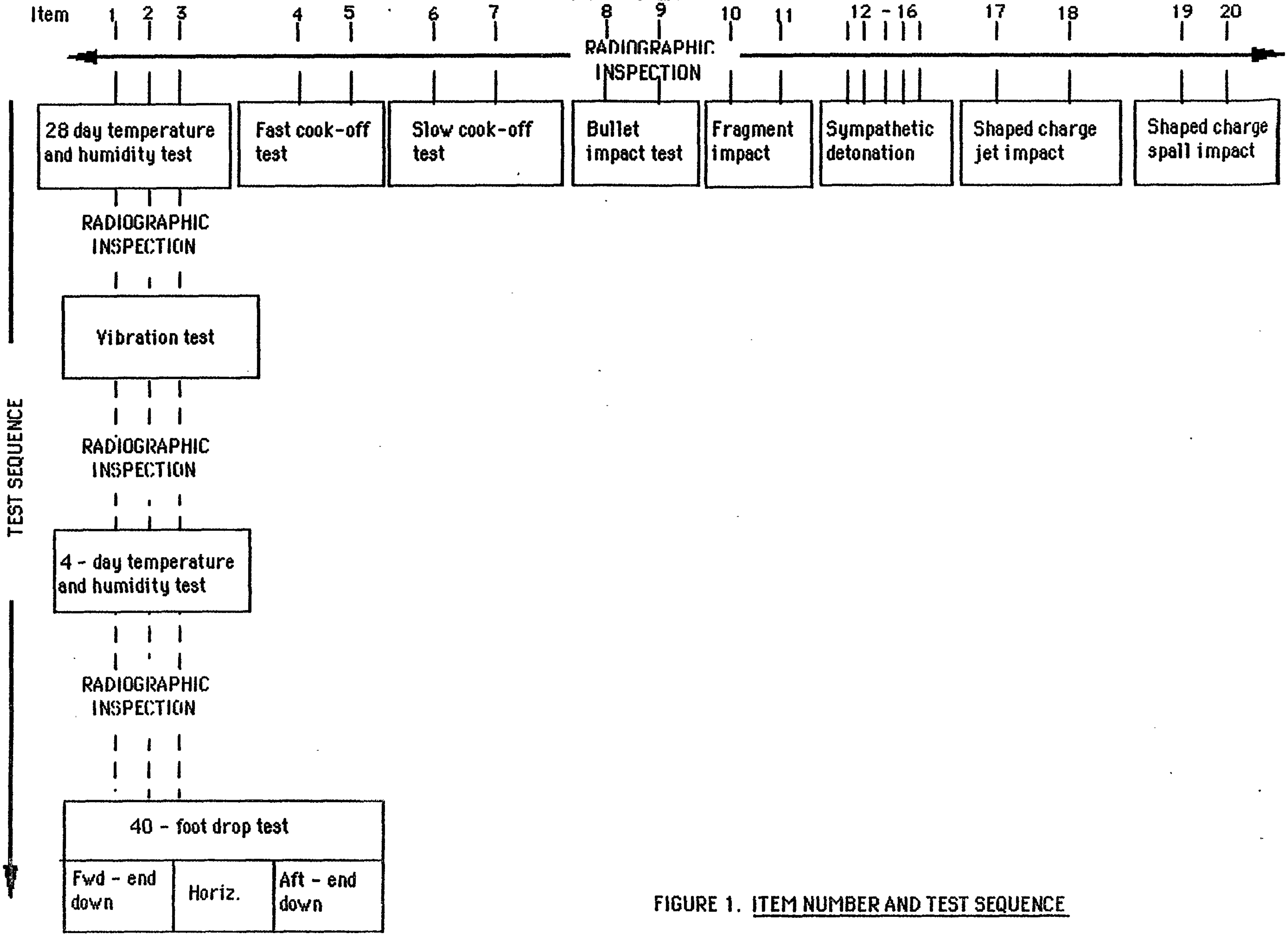


FIGURE 1. ITEM NUMBER AND TEST SEQUENCE

SAMPLE
POST-TEST REMAINS MAP
DATA SHEET

Item Tested: ____________________

Lot # ______________ S/N ______________

Ambient Conditions: ____________________

Test Facility: ____________________ Date: __________

Test Item Description: ____________________

Fragment Projector Description: ____________________

Test Setup (attach sketch): ____________________

____

Test Results

Narrative Description: ____________________

____

Explosive reaction level: __________

Post-Test Description

Number and location of impact fragments: __________ Impact Velocity: ____

* Airblast overpressure _____ psi at _____ ft, time to peak _____ msec

_____ psi at _____ ft, time to peak _____ msec

_____ psi at _____ ft, time to peak _____ msec

* Airblast overpressure data shall be supplied if there is an explosive reaction.

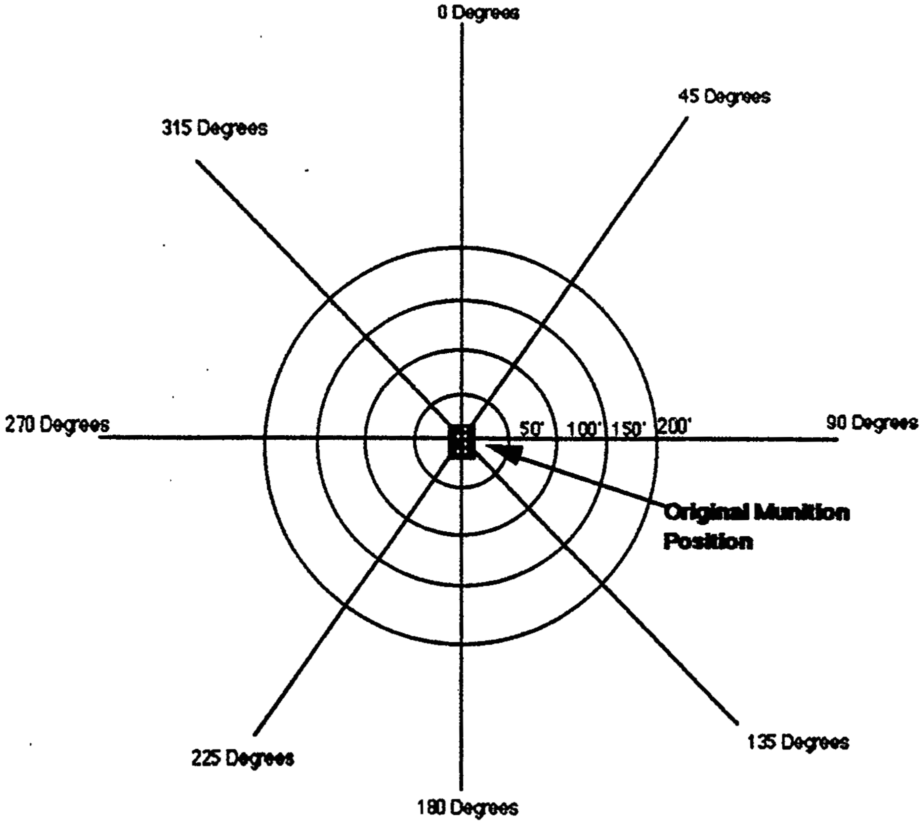
Witness Plate Description: ____________________

Test Engineer: ______________

Signature: ______________

FIGURE 2. Fragment impact test data sheet.

SAMPLE
POST-TEST REMAINS MAP



NOTE: Identify shotline and test item orientation. Identify each fragment numerically (see Figure 3).

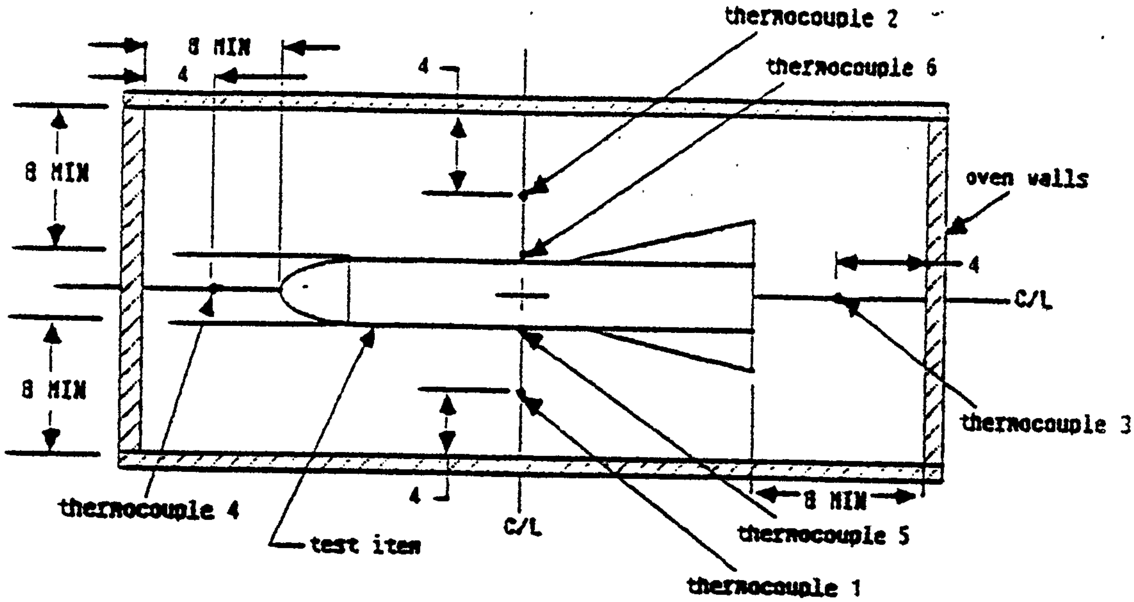
FIGURE 3. Post-test remains map.

SAMPLE

POST-TEST REMAINS TABULATION

DISTANCE	WEIGHT	ANGLE	DESCRIPTION

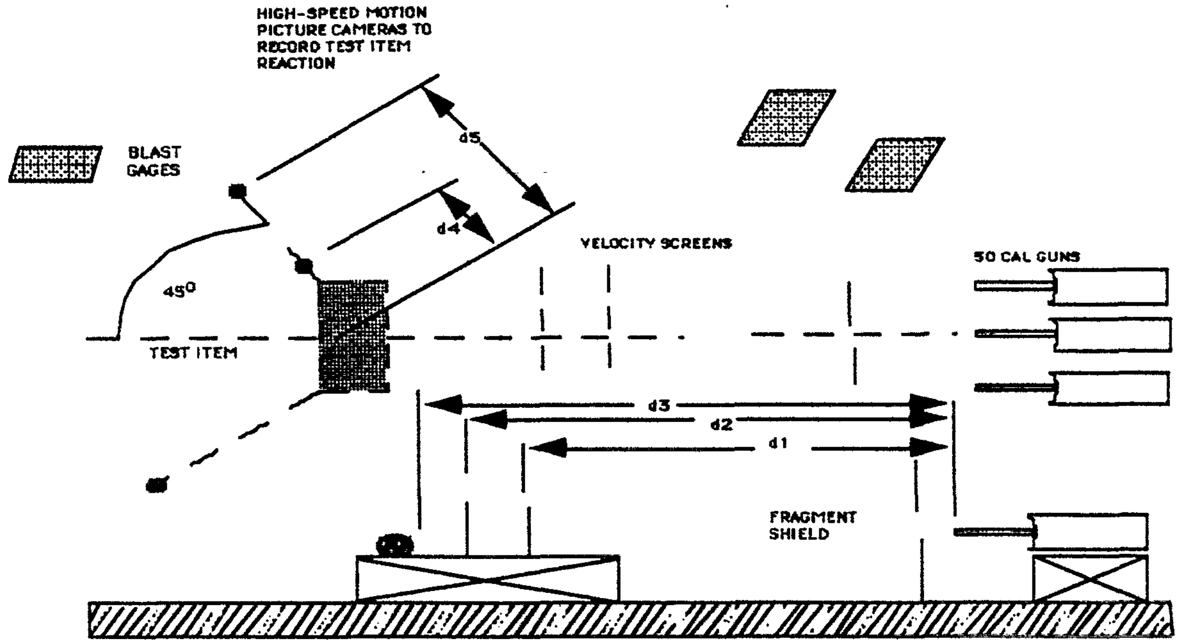
FIGURE 4. Post-test remains tabulation.



Plan View

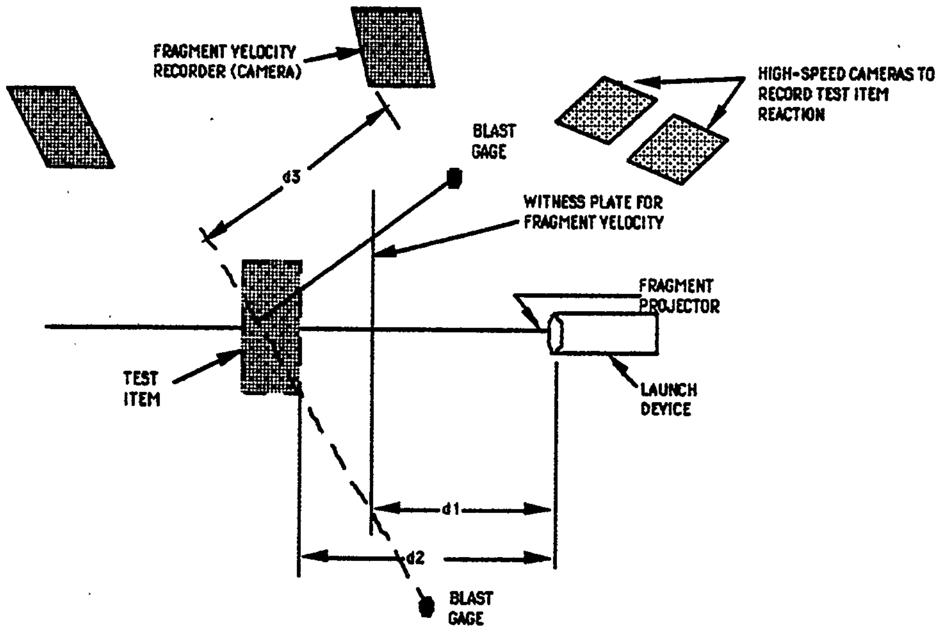
Notes: All dimensions are in inches; all measurements are taken from internal oven walls.

FIGURE 5. "Typical" slow cook-off oven with thermocouple locations.



NOTES d1 = DISTANCE TO FIRST VELOCITY SCREEN
d2 = DISTANCE TO SECOND VELOCITY SCREEN
d3 = DISTANCE TO TEST ITEM
d4 = DISTANCE TO FIRST BLAST GAGE
d5 = DISTANCE TO SECOND BLAST GAGE(S)

FIGURE 6. "Typical" bullet impact test configuration



d1 = DISTANCE FROM FRAGMENT MAT TO WITNESS PLATE
d2 = DISTANCE FROM FRAGMENT MAT TO TEST ITEM
d3 = DISTANCE FROM TEST ITEM TO BLAST GAGE(S)

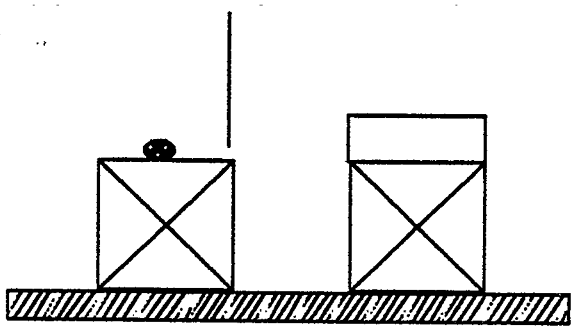
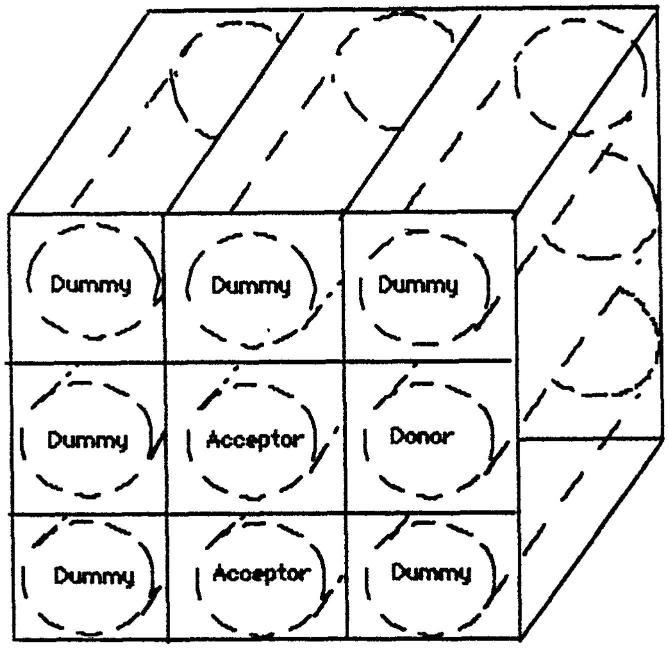
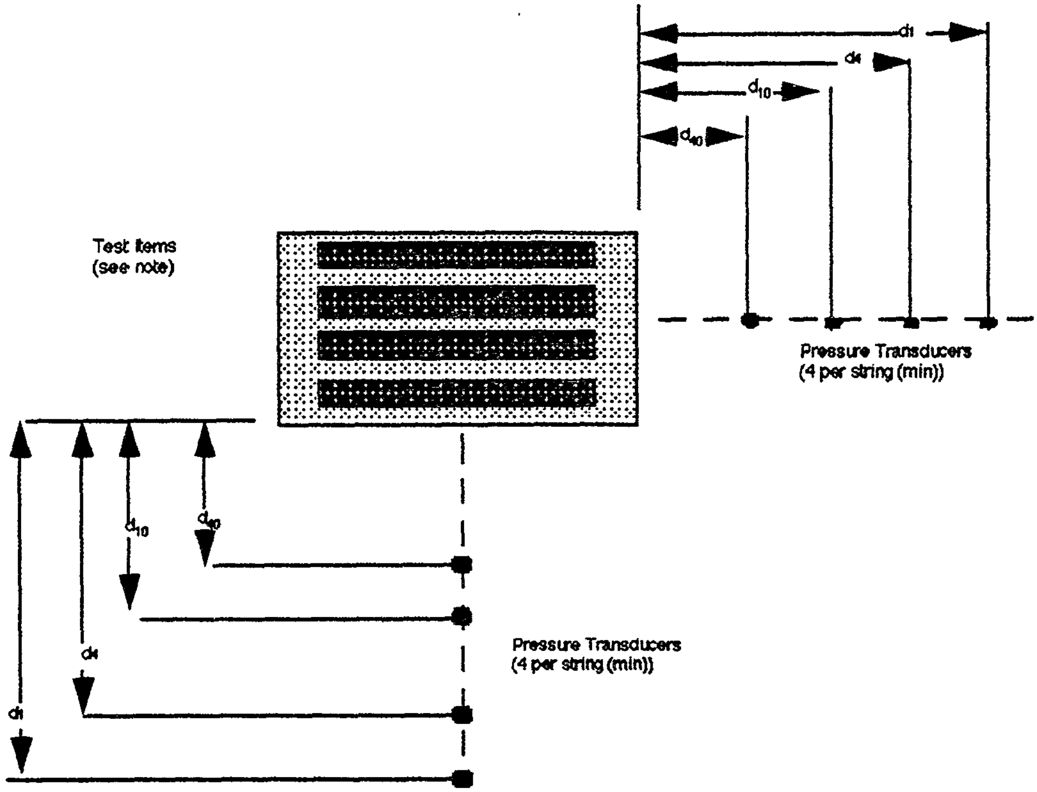


FIGURE 7. "Typical" fragment impact test setup.



NOTE: For illustrative purposes only; packaging, arrangement of test items, and number and placement of acceptors shall be determined based upon the threat hazard assessment.

FIGURE 8. Sample arrangement of test items for sympathetic detonation test.



d40 = **Distance at which peak airblast overpressure is expected to be approximately 40 psig if all test items detonate.**
d10 = **Distance at which peak airblast overpressure is expected to be approximately 10 psig if all test items detonate.**
d4 = **Distance ar which peak airblast over pressure is expected to be approximately 4 psig if all test items detonate.**
d1 = **Distance at which peak airblast over pressure is expected to be approximately 1 psig if all test items detonate.**

Figure 9. Sample placement of pressure transducers for sympathetic detonation test (plan view).

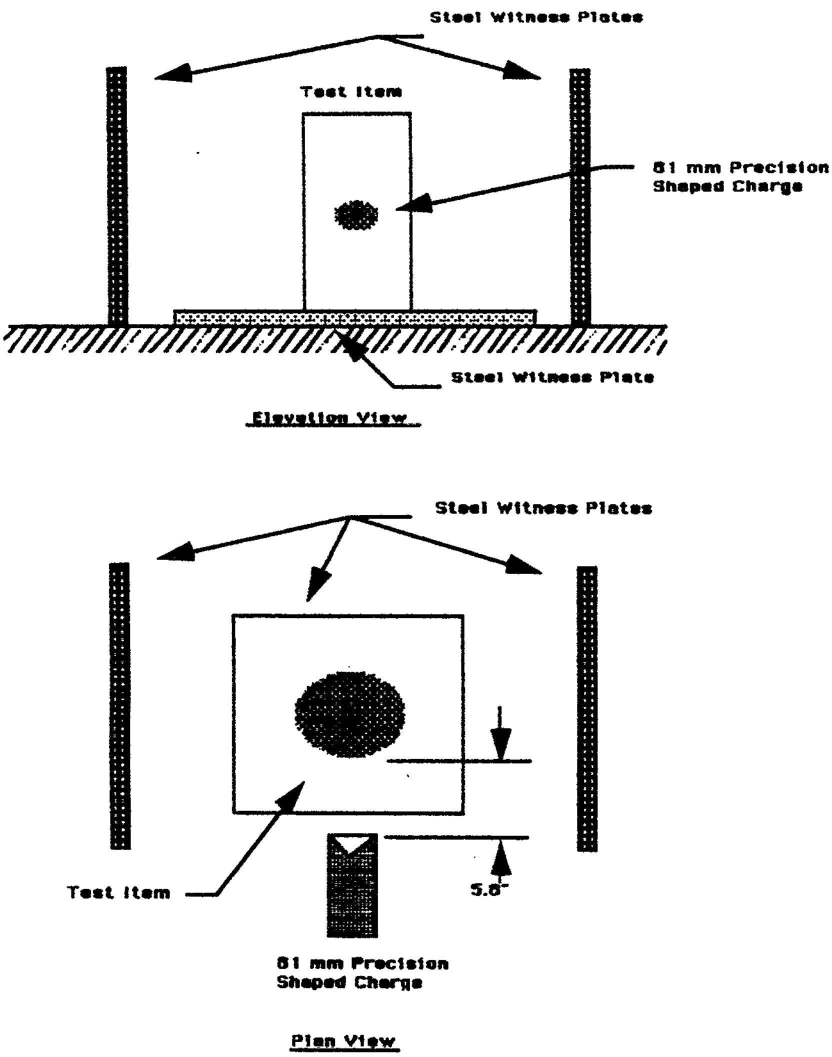


FIGURE 10. "Typical" shaped charge impact test configuration.

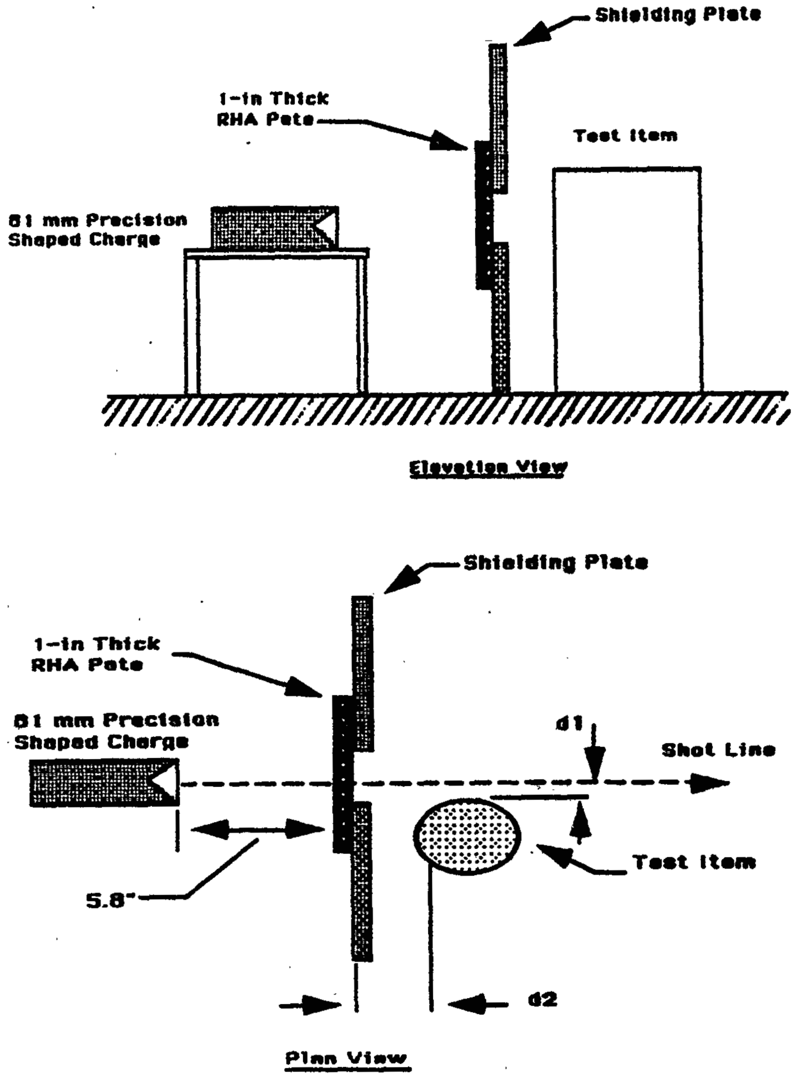


FIGURE 11. "TYPICAL" SPALL IMPACT TEST CONFIGURATION