STANDARDS RELATED DOCUMENT

AOP-39.1

GUIDANCE ON THE ORGANISATION, CONDUCT AND REPORTING OF FULL SCALE TESTS

Edition A, Version 2

MARCH 2022

NORTH ATLANTIC TREATY ORGANIZATION

Published by the
NATO STANDARDIZATION OFFICE (NSO)

INTENTIONALLY BLANK

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

4 March 2022

1. The enclosed Standards Related Document, AOP-39.1, Edition A, Version 2, GUIDANCE ON THE ORGANISATION, CONDUCT AND REPORTING OF FULL SCALE TESTS, which has been approved in conjunction with AOP-39 by the nations in the CNAD AMMUNITION SAFETY GROUP (CASG – AC/326), is promulgated herewith.

2. AOP-39.1, Edition A, Version 2 is effective upon receipt and supersedes AOP-39.1, Edition A, Version 1 which shall be destroyed in accordance with the local procedure for the destruction of documents.

3. This NATO standardization document is issued by NATO. In case of reproduction, NATO is to be acknowledged. NATO does not charge any fee for its standardization documents at any stage, which are not intended to be sold. They can be retrieved from the NATO Standardization Document Database ((https://nso.nato.int/nso/) or through your national standardization authorities.

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

Dimitrios SIGOULAKIS
Major General, GR (A)
Director, NATO Standardization Office

INTENTIONALLY BLANK

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

1.1 ANNEXES

A. Test Framework and Organisation

B. General Full Scale Test Guidance

C. Information to be Included in Test Directive

D. Test Report Template

1.2 RELATED DOCUMENTS

STANAG 4439 / AOP-39	Policy for Introduction and Assessment of Insensitive Munitions (IM)
STANAG / AOP-4240	Fast Heating Test Procedures for Munitions
STANAG / AOP-4241	Bullet Impact Test Procedures for Munitions
STANAG / AOP-4382	Slow Heating Test Procedures for Munitions
STANAG / AOP-4396	Sympathetic Reaction Test Procedures for Munitions
STANAG / AOP-4496	Fragment Impact Test Procedures for Munitions
STANAG / AOP-4526	Shaped Charge Jet Impact Test Procedures for Munitions
STANAG 4123	Determination of the Classification of Military Ammunition and Explosives
AASTP-03	Manual of NATO Safety Principles for the Hazard Classification of Military Ammunition and Explosives
United Nations	Manual of Tests and Criteria (ST/SG/AC.10/11)

1.3 AIM

The aim of this SRD is to provide guidance on the organisation, specification, management, conduct and reporting of full-scale tests in support of Insensitive Munition (IM) and Hazard Classification (HC) assessment. The intent is for all Nations to achieve commonality of approach to full-scale testing, thus ensuring that the evidence which is gathered supports consistent assessment and acceptability of the test results between nations.

1.4 SCOPE

1. This SRD describes:

   a. Test framework, organisation and responsibilities;

   b. Test programme background;

   c. Test specification and planning;

   d. Test conduct, including test-specific considerations;

   e. Test reporting, including recommended format and content.

2. This SRD assumes a generic organisational structure and responsibilities, and gives guidance on the process in a typical chronological sequence.

3. This SRD also provides an overview of the full-scale test assessment process so that those involved in developing, conducting and reporting full-scale tests are aware of the information needed by those who are responsible for the subsequent assessment of the results.

4. This SRD includes a list of the considerations for planning any of the full-scale tests and document templates for specifying and reporting the tests to support the assessment.

1.5 DEFINITIONS

For the purpose of this document, definitions of terms to be used to describe test details and events are given in the NATO Terminology Database (NATOTerm) that is available by reference for all Allied Publications.[1]

1.6 GENERAL

1. The guidance in this SRD concerns the full-scale tests which inform IM and HC assessment in accordance with STANAG 4439 / AOP-39 and STANAG 4123 / AASTP-3. It supports the specific requirements and guidance found within each full-scale test standard, and should be reviewed in conjunction with them.

2. Where there is a contradiction between the full-scale test standard and this SRD, the full-scale test standard will take precedence.

[1] https://nso.nato.int/natoterm/

1.7 APPLICABILITY

This SRD is applicable to those involved in full-scale testing with responsibility for the contracting, specifying, conduct, reporting and assessment of full scale test results to support, amongst other uses, IM and HC assessment, including safety advisors, scientists, technologists and project staff; in test facilities, industry and at research establishments.

INTENTIONALLY BLANK

CHAPTER 2 TEST PROGRAMME ESTABLISHMENT

2.1 GENERAL

1. To correctly and appropriately assess a munition response it is vital to record as much relevant data as possible.

2. When developing the Test Programme the following should be considered in preparation of each Test Directive:

a. Evidence from previous testing

b. Test specific considerations (detailed in the full-scale test standard)

c. Generic guidance (detailed at Annex B)

2.2 BACKGROUND

1. Information relevant to each of the full-scale tests has been widely debated within the NATO forum and, following the 1997 NIMIC Workshops on IM Testing, a NIMIC Report was presented to a joint meeting of AC/258 and AC/310 (now subsumed into AC/326). One of the main recommendations of the workshop was the need for quantitative data – subjective and qualitative data should always play a lesser role.

2. This and other NIMIC and MSIAC reports form the basis for this SRD and the full-scale test APs, which identifies the issues relevant to each of the full-scale tests. It is guidance on what is considered to be best practice rather than mandatory lists, but is intended to assist those responsible for developing Test Directives as well as those witnessing and conducting testing to ensure that all possible issues have been considered. It should always be read in conjunction with the relevant full-scale test AOP.

2.3 USE OF ALLIED PUBLICATIONS

1. The starting point for any full-scale test to support IM and HC assessment is normally the relevant full-scale standard, which should be reviewed in conjunction with the general guidance in this SRD detailed at Annex B. It is important that the latest editions of all documents are used.

2. Where any contract calls up any edition current at the time the contract was placed, but a later edition is issued before testing takes place, wherever possible the testing should be adjusted to take note of any changes reflected in the later edition. The final opportunity to make any adjustment for newer editions is likely to be the Test Readiness Review.

2.4 SPECIFYING TEST PARAMETERS

1. In developing the full-scale test parameters, consideration should be given to all available evidence from earlier development testing and analysis such as modelling, laboratory and small-scale tests, component level tests, characterisation of the energetic materials, and read across of full-scale test results from other munitions with similar design characteristics.

2. This body of evidence should be used both to make an assessment of the likely response from the full-scale test, and to determine specific full-scale test parameters and conditions. Where the appropriate full-scale test standard has different options or supports a choice between a standard and a tailored test, this evidence may also be relevant in providing a supporting justification to the test configuration and parameters to be used.

CHAPTER 3 TEST SPECIFICATION AND PLANNING

3.1 GENERAL

This section outlines how full scale tests are developed and prepared. It also contains guidance on the extent and depth of data required to be gathered to support subsequent assessment. Clear and well-prepared test documentation is essential to a successful test programme and the more effort that is devoted at the planning stage, the greater the likelihood of a successful outcome.

3.2 SPECIFYING TESTS

Processes for documenting full-scale testing will vary between nations, as will the terminology for the associated documents. For the purposes of this SRD the following terms are used:

- **Test Programme** details all testing to be conducted and is normally produced by the Project or Programme Team. This will include requirements for all safety testing including full-scale testing.
- **Test Directive** specifies in detail the requirements for each individual full-scale test.
- **Test Plan** details how the test is to be conducted and is normally produced by the Test Agency.

3.3 TEST REQUIREMENTS

1. **Specific.** In developing the Test Programme and Test Directives the full-scale test specific guidance and requirements in the full-scale test APs should be reviewed for inclusion in the Test Directives. Each of the full-scale test APs may contain test specific requirements on the configuration, set up, instrumentation and conduct of each full-scale test. The requirements and test options in these APs should also be consulted when developing the Test Directives.

2. **General.** For any full-scale test there are considerations that are applicable to most if not all tests. When developing the Test Programme and Test Directives the guidance in this SRD should be considered. Appropriate decisions can be made on test conduct and reporting for inclusion in the Test Directive and so there is no ambiguity with the Test Plan. Generic full-scale test guidance is detailed at Annex B to this SRD. The sections listed in Annex B should be addressed in the Test Directive together with the decision on what is required, to ensure all available evidence is gathered.

3. **Harmonised Testing.** If the test is to be used for more than one purpose, e.g. both IM and HC assessment, an agreement must be reached between all relevant Authorities on what test parameters must be specified in order to make the evidence generated applicable to the needs of all parties. This might include number of test items, their configuration (packaged or unpackaged), the number of tests to be performed, etc.

3.4 TEST DIRECTIVE

1. Development of the Test Programme and each Test Directive should involve the relevant munitions safety, IM and HC National Authorities. It would be normal for the appropriate National Authority to be involved in the development or review of the Test Directive taking into consideration all the requirements and guidance in the full-scale test standard and this SRD respectively.

2. The Test Directive is a key document for the Test Agency. It enables them to prepare the Test Plans and ensure the appropriate data is collected. The Project Team should ensure safety staff, science and technology specialists are consulted in the development of the test plan.

3. A template for the information to be considered for inclusion in the Test Directive is at Annex B. This covers the following areas:

a. Test Item(s) Configuration

b. Test Conditions

c. Baseline Tests

d. Instrumentation and Recording

e. Observation and Records

3.5 TEST PLANS (INSTRUCTIONS)

1. It is normally the responsibility of the munition Design Authority or Test Agency, to produce the Test Plan. This will implement the specification in the Test Directive, which may be subject to variation based on limiting local factors.

2. The test Plan is normally submitted to the Project Team for approval as specified in the contract and should be agreed by the appropriate National Authority before testing takes place. The Test Plans should be reviewed by safety staff and scientists for critical or expensive tests, to ensure any variation in implementing the Test does not unacceptably affect the data gathered.

CHAPTER 4 CONDUCTING THE TEST

4.1 GENERAL

The test should be conducted in accordance with the Test Directive and agreed Test Plan in a methodical and structured manner. Most full-scale tests will result in the destruction of the test item, and due to the expense of both the test and potentially the test item it may not be possible to repeat the test. It is therefore essential that all aspects are completed satisfactorily.

4.2 SITE LAYOUT AND PRE/POST TEST CLEARANCE

1. The layout of the test site and instrumentation should conform with the Test Directive and agreed Test Plan. It is essential that any debris from previous tests is cleared from the site before testing takes place.

2. Consideration should be given before the test to the level of response expected and the likely size and distance that debris will be thrown to ensure that a sufficiently large area is cleared.

3. Ideally, the surface of the test site should be concrete or firm sand, to enable location of debris. Where the test site is grass covered, this should be cut as short as possible.

4.3 INSTRUMENTATION AND RECORDING

1. Instrumentation should be set up as detailed in the Test Directive and agreed Test Plan.

2. It is important that all instrumentation is appropriately tested and calibrated before the test and that all cabling and wiring is adequately protected so that there is no risk of vital connections being cut by the effects of an explosive reaction from the test item, and the subsequent loss of vital data.

4.4 WITNESSING THE TEST

1. The test will normally be witnessed by representatives from the manufacturer, the Project Team and by the Safety Authority. The Project Team may invite appropriate specialists, representatives from the review body, independent safety auditors and individuals from national research establishments, to attend and witness the test.

2. First-hand information from those witnessing the test can prove very valuable to the assessment process, and it is important that all witnesses make appropriate notes and records for subsequent input to the body of evidence which will inform the assessment process.

4.5 VERIFICATION OF COMPLIANCE WITH TEST DIRECTIVE AND TEST OBJECTIVES

1. It is essential that the test is conducted in accordance with the Test Directive; one of the responsibilities of the Project Team is to confirm compliance.

2. Where deviations from the agreed Test Directive and Test Plan or the procedure agreed at the Test Readiness Review prove necessary, these should be approved on behalf of the review body by the appropriate Project Team representative, taking advice as necessary from the safety advisor and technical specialists.

CHAPTER 5 REPORTING THE TEST

5.1 THE TEST REPORT

1. It is usual for the Test Agency to produce a Test Report for each test. This Report may stand on its own or it may form part of a complete report from the Test facility. Where the Test facility produces a report, this should include comments and observations as appropriate on the Test Agency Report and include confirmation that the requirements of the test have been achieved.

2. In making an assessment of the response, the review body will need to review both the Test Agency Report and the Contractor or Test facility's report. An example of a test report layout and the suggested minimum content to be included is at Annex D.

3. Where a test is repeated, the Test Report should report each test separately so that each test result can be assessed separately. This will enable the most violent reaction to be identified and assessed.

5.1.1 Report Writing

1. Once a full-scale test has been completed, the Test Report and the photographic/video records are all that remain from which to assess the level of response. Since some level of explosive response is expected from full-scale tests, unlike most other munitions safety tests where no reaction is expected, it is essential that full details of the reaction of the munition are included in order that an informed assessment of the response can be made.

2. The report is a key element of the audit trail for the IM or HC assessment which is likely to be referred to over the life of the munition and it should therefore contain information which is relevant, adequate, accurate and unambiguous.

5.1.2 Instrumentation Records, Measurements and Observations

All instrumentation records, measurements and observations (including those by witnesses) should be retained after the test as part of the dossier of evidence for review and assessment. This may include information in excess of that which is contained in the test report.

5.2 TEST REPORT SUBMISSION – TIMESCALE, APPROVAL AND ACCEPTANCE

1. The test report should be submitted to the project team as soon as practicable. It is important that the formal assessment takes place whilst all those involved in the testing are still members of the staff and available and whilst the events of the test remain fresh in the minds of those attending.

2. The project team will confirm that the test report meets the required standard and formally accept the report from the contractor. Where there are shortcomings in the report, the project team may require the report to be re-written, which will delay the acceptance and assessment process; it is in the interests of all concerned that the report should of a satisfactory standard from the outset.

5.3 TEST REPORT CONFIGURATION CONTROL AND ARCHIVING

1. It is important that each test report can be clearly identified and referenced. There have been examples of programmes where extensive development testing has taken place and it has proved difficult to identify whether individual reports refer to the same or different tests.

2. If a report is changed or updated, it is important to identify the revised report accordingly. It is essential to retain all information relating to a full-scale test in a dossier; this will include the test report(s), photographs, video records and any additional instrumentation records not included in the test report.

3. This dossier of evidence should be retained by and archived appropriately by the project team so that it can be accessed as necessary throughout the in-service life of the munition.

ANNEX A TEST FRAMEWORK AND ORGANISATION

A.1 INTRODUCTION

Clear objectives and responsibilities are essential to provide the basis for a successful full-scale test programme and should be established before proceeding to the detailed work of developing the Test Programme and individual Tests within the Programme.

A.2 DETERMINING TEST OBJECTIVES

1. The first step in developing a Test Programme is to clearly define the test objectives. Normally there will be two overall objectives:

- To support application of a Nation’s assessment processes, in particular IM and HC Policy.
- To determine the response of the munition(s) to the test stimuli.

2. These objectives are not necessarily the same. It is important to establish the response of the munition(s) to the stimuli, even if for IM assessment they are assessed as non-compliant. This information is needed for safety, risk and vulnerability assessment, and to inform any mitigation measures which may be needed to reduce risks to the lowest level required by national policy or legislation.

3. There may also be a variety of additional reasons for undertaking full-scale testing. Examples include:

- To determine time to response.
- To determine the effectiveness of different types of packaging and mitigation schemes.
- To determine the response of alternative filling and fuzing compositions.
- To determine the response using different munition design characteristics such as case material, case thickness, coatings and barriers, initiating devices, venting devices.
- To determine and potentially mitigate, the munitions hazards.

4. The Test Objectives should clearly state how the results are to be assessed, who by, and reference the appropriate national policy or procedure.

A.3 FORMATION AND DUTIES OF TESTS PLANNING GROUP

1. A project-based Tests Planning Group (TPG) should normally be established at the outset of each munition programme. This should include representation from the Project Team, the relevant National Safety Authorities and, where appropriate, relevant specialists from research establishments and the test facility. The TPG will provide a collective overview of, and input to, all tests including those relevant to full-scale testing and will contribute to ensuring that a full body of evidence is obtained. This will support compliance with a Nation's IM and HC Policy requirements (if different) for assessment and which will demonstrate achievement of the agreed upon (contracted) levels of IM compliance.

2. The responsibilities of the TPG should extend to ensuring a Tests Readiness Review is held, ideally for each test, to ensure that all aspects of the testing are sufficiently established to the satisfaction of all stakeholders and the tasking to the Test Agency has been effective in communicating the detailed test requirements.

3. A Tests Compliance Check Sheet (TCCS) is a useful document for all concerned at the Tests Readiness Review. This gives satisfaction to all involved that the tests and data collection are to be conducted as agreed, including allowing any waivers or amendments to original requirements to be recorded. The TCCS should be prepared at the same time as the tests are being developed and could be included with the Test Directive.

A.4 NATIONAL AUTHORITY RESPONSIBILITIES

1. The relevant National Authorities are normally responsible for ensuring that the test requirements are correctly and fully specified to support their subsequent assessment. This may be achieved in a number of ways depending upon national processes. The National Authority may be responsible for preparation or supporting preparation of the Test Directive and may also be responsible for reviewing the details of the test as part of the Tests Readiness Review.

2. The costs and in some instances the availability of resource for the conduct of full-scale testing limits opportunities to repeat the test. Whatever the national process the National Authority responsible for assessing the test results should have the opportunity within the process to ensure the evidence being gathered from the test is sufficient to support its assessment. This should be specifically applicable for IM and HC assessment especially where they are separate Authorities.

A.5 PROJECT TEAM RESPONSIBILITIES

1. The Project Team has overall responsibility for developing the Test Programme including full-scale tests. This is done either directly or jointly with the relevant Safety Authorities. The Project Team is also responsible for ensuring the relevant National Authorities are consulted before full-scale testing takes place.

2. The Project Team is responsible for ensuring that the Test Agency's full-scale Test Plan will provide sufficient evidence from which assessment can be made in support of national policy and contracted requirements.

3. They are also responsible for ensuring the test results are presented for formal assessment on completion of testing. In addition to the test results, the National Authority will require additional information on the munition's design, energetic materials and function. The Project Team is therefore responsible for ensuring guidance to the relevant agencies on the application of this SRD and full-scale test APs.

A.6 TEST AGENCY RESPONSIBILITIES

1. The Test Agency is responsible for carrying out the programme of tests in accordance with the Test Programme or Test Directives. If it becomes necessary to deviate from the conditions/parameters stated in the Directive or Plan, the Test Agency should seek the agreement through the Project Team who will seek specialist advice from the relevant National Authority as necessary.

2. The Test Agency is normally responsible for writing the Test Report. Since the Test Report is the permanent record of what occurred and plays a vital role in the assessment of the result, it is essential that the Test Report is comprehensive and contains all the information necessary to make an objective assessment. Guidance on how to construct a Test Report is in Annex D of this SRD.

INTENTIONALLY BLANK

ANNEX B GENERAL FULL SCALE TEST GUIDANCE

B.1 GENERAL

Guidance on the various aspects of a full-scale test specification for inclusion in the Test Directive is structured in this Annex as follows:

a. Test Item Configuration

b. Test Conditions

c. Baseline Tests

d. Instrumentation and Recording

e. Observations and Records

B.2 TEST ITEM CONFIGURATION

1. The test item configuration should be determined by the Threat Hazards Assessment (THA). It should represent the configuration of the item appropriate to the Life Cycle Phase represented by the test. Depending on the specific details of the test item and its Life Cycle Phase, it may be necessary to test a particular item in several different configurations.

2. For small munitions, the test will be more likely conducted packaged. If this is to be combined for IM and Hazard Classification purposes, a test of the packaged configuration is required consisting of three packages or a volume of packaged test items not less than 0.15 cubic meters (whichever is greater). This is currently a requirement for the following UN Hazard Classification Tests and should be specified in the comparable IM test:

- UN 6(b) Stack test
- UN 6(c) External fire (bonfire) test
- UN 7(g) 1.6 article (or component level) external fire test

3. Guidance on other considerations which may affect the choice of configuration for full-scale testing are considered in the following paragraphs.

B.2.1 Design Standard

1. Full-scale testing is usually undertaken at the end of the development cycle of a munition and on a test item which is either to the Final Production Standard or a standard that is acceptably representative to the National Authority. Guidance on acceptable variations to the build standard is detailed below. Preliminary assessments of responses may be undertaken on items during development and should follow the guidance in this SRD.

2. For a test to be as representative as possible, energetic items tested should be to the Final Production Standard. Non-energetic components in the firing line (shot line) should also be to the Final Production Standard or at least physically representative as discussed in more detail further in this SRD. Any changes from the Final Production Standard should be shown not to affect the test result.

3. Any packaging and logistic support items under test should always be fully representative of the final design standard as any subsequent changes may alter the response of the item to the defined test stimulus.

B.2.2 Live and Inert Components

1. The munition under test should be the complete item. For example, the various components of the energetic train may have a significant effect on the response of the munition and omitting one or more may result in an unrepresentative response.

2. However, it is not necessary to destroy expensive electronic components if these will not have any influence on the test response. Thus, such components can be replaced by thermally, mechanically, geometrically and physically representative inert components, provided that the thermal characteristics of the test munition and the mechanical confinement of the energetic components remain unchanged.

3. Non-energetic sections or structures may also be replaced by thermal and geometric representations. They should, throughout the test, exhibit closely comparable mechanical and thermal behaviour to the Final Production Standard non-energetic items.

4. Components may be substituted only if there is no potential for that component to lead to an initiation of the test item as a result of the test environment or stimulus. For some components, e.g. complex electronic units, independent confirmation may be required. It is recommended that components that store energy such as thermal batteries and gas bottles be included in the test.

5. Where a munition has a removable fuze (e.g. artillery shell), the decision to test with or without the fuze fitted will depend on the configuration appropriate to the THA and Life Cycle Phase represented by the test. For munitions with a non-removable fuze, it is not normally acceptable to test with an inert fuze.

B.2.3 Use of Pre-test Conditioned Munitions

1. There is no specific rule regarding whether the munition under test should be factory-fresh, un-aged and in pristine condition or whether the munition should have been subjected to some degree of accelerated ageing. Both are acceptable.

2. Use of new munitions can provide a useful baseline whilst use of aged/environmentally conditioned munitions may provide closer representation of the munition condition when more likely to be exposed to the IM threats in-service. Guidance should always be sought from the National Authority.

3. Guidance on thermal pre-test conditioning is discussed at B.3.5.

B.2.4 Packaged vs. Unpackaged

1. The THA will determine the required test configuration; in some instances, it may be necessary to conduct a particular test in both the packaged and unpackaged configurations (logistic or tactical configurations). For some munitions, the logistical and tactical configurations are the same.

2. When tested in the tactical configuration, the item should not be restrained with packaging / unitization (pallet) straps.

3. For items tested in the packaged configuration, whether multiple items or a single item, the response descriptors will be applied to the entire package.

B.2.5 Component Level or All-Up Round (AUR)

1. The decision whether to test at AUR or component level will depend on a variety of factors. The first is the size of the munition. Small munitions will invariably be tested as an AUR, usually packaged. It is only munitions such as missiles, incorporating more than one major energetic component such as a separate warhead and rocket motor(s), where the option to test at component level arises.

2. For the thermal tests (Fast and Slow Heating), it can be useful to conduct tests at component level so that the response of each major component can be clearly determined in isolation. However, there may be interaction between the components which would lead to a different response and therefore it is recommended to conduct an AUR test as well. Additionally, the test item (component or AUR) should not differ from the thermal profile (heat transfer) of the actual component or AUR.

3. For the impact tests (Bullet, Fragment and Shaped Charge Jet), it is standard practice to conduct the tests at component level and the most violent response is then ascribed to the AUR. However, there may be interaction between the components which would lead to a different response and therefore it is recommended to conduct an AUR test as well.

4. Sympathetic Reaction tests may be conducted at component level to determine the response and inform mitigation, for example to determine the need for mitigating barriers between missile warheads or between missile motors. However, AUR tests will normally also be required in the packaged configuration unless the response can be assessed with confidence from the component level tests. There are examples in which detonation of a donor rocket motor has caused the warhead of an adjacent munition to detonate and vice versa.

5. Additionally, it is always necessary to consider the effect of the energetic or mechanical reaction from the component which reacts first onto the other components in the item, e.g. from warhead reaction causing motor initiation; or from functioning/arming resulting from flight or propulsion of the munition, etc.

6. Where it is decided to test at component level, it is important to ensure that the component is in a configuration representative of the AUR. For example, if a thermal test is to be conducted on a rocket motor, omitting the external structure around the nozzle and blast pipe may reduce mechanical confinement and allow the nozzle assembly to be ejected from the motor with a consequently less violent explosive reaction than if the nozzle assembly had remained in place.

B.3 TEST CONDITIONS

B.3.1 Safety

1. Munitions tested in accordance with the test requirements of the respective standards and the guidance in this SRD may react with violence varying from detonation, fragmentation, burning, or become propulsive (see AOP-39). Consequently, it is the responsibility of the facility conducting the test to ensure the safety of personnel and equipment during preparation of the test, during and after conduct of the test.

2. If the test item must be restrained for reasons of safety, refer to guidance in B.3.4 ‘Restraints and Tethering’. It is recommended to test missiles and rockets inside a cage or use suitable clamps to prevent them from moving if they become propulsive. Some means of measuring test item propulsion and fragmentation should be utilized, documented, and agreed with the National Authority.

3. Where safety reasons will affect test conduct the National Authority should be informed.

B.3.2 Positioning and Orientation

1. The test item is normally positioned and orientated consistent with the position and orientation in the Life Cycle Phase being tested. Where the requirements for aim/impact point and shotline cannot be met, the test item may be reoriented if necessary and agreed upon by the National Authority. Deviations can be made during testing for development, engineering tests or information purposes but to be considered a valid test for assessment purposes the position and orientation should follow the guidance given in this SRD and be agreed with the National Authority.

2. If necessary and agreed by the National Authority, the item may be strapped or restrained by suitable means (e.g. cords, straps, chains, etc.) to prevent it from accidental movement (e.g. wind). If possible, fixing points on the test item (e.g. attachment points, lash rings, hooks, etc.) should be used.

3. The test fixtures positioning and orientating the test item should not interfere with the test stimulus (e.g. heating rate) imposed on the test item. Any method of mounting the test item (e.g. clamps or tethers) to retain it in the correct position and orientation should not interfere with the conduct of the test (e.g. affect bullet or fragment flight) or affect the ability of the test item to rupture or fragment. Similar considerations as for restraints or tethers discussed in B.3.4 below are appropriate.

4. Test munitions and over-pressure measurements should be elevated to minimise blast effects such as Mach Stem and ground reflection.

B.3.3 Impact Test Guidance

1. **Aim/Impact point**

   a. For the impact tests (bullet, fragment and shaped charge jet), it is important to select appropriate aiming points. For each relevant configuration, impact tests are normally carried out against both the most sensitive sub-component/energetic material (e.g. motor igniter, warhead booster) and against the main charge filling. "Most sensitive sub-component" should be taken to mean the component which, if exposed to the threat, is likely to lead to the most violent response of the munition and which is not separated from the main energetic component by barriers or other safety devices.

   b. When selecting the aim point, it is important to be realistic about the probability of a sub-component being struck, either by the real-world threat, or by the test stimulus: for a very small booster or initiator buried deep within the munition, the probability of this being struck may be so remote as to not be a credible target; similarly, the accuracy of the test method may mean that the probability of successfully hitting this target during testing is very low. In such cases, it is far more relevant to attack the main charge filling or where the most violent reaction is expected.

c. Every test should be evaluated separately, using advice from specialists, to ensure that appropriate aiming points are selected, with appropriate tolerances to reflect the difficulty of achieving absolute precision in aiming.

2. **Shotline (Firing Line)**

a. The shotline (or firing line) should be perpendicular to the surface of the test item to ensure penetration. However, as far as possible, no structures or non-explosive components should be in the shotline that could influence the path, integrity or velocity of the projectile/jet. The likelihood of achieving a violent response will normally be maximized by choosing a shotline which provides the longest possible path length through the energetic material. However, unlikely shotlines should be avoided, which are aimed at components that are quite small when compared to the bulk of the energetic material, or aimed at unlikely angles.

b. Prior to testing, shotlines should be agreed by the appropriate authorities. In this regard, the following considerations may apply: if the energetic material contains a cavity of significant size (such as the bore of a rocket motor), aim the projectile/jet to pass perpendicularly through the cavity. It has been observed that such cavities can promote the occurrence of violent reactions. If small items stored in a box are to be tested, the shotline should be chosen as to impact as many items as possible.

3. **Accuracy at impact:**

a. Fulfilment of the accuracy requirement can be proven with pre-shots, or during the live test with suitable means (e.g. holes in the test item or high-speed video). If the accuracy is proven with pre-shots, it is independent of potential movement or destruction of the test item. It is up to the test facility to choose the most suitable means according to their set up.

b. To prove accuracy with pre-shots, a provisional target can replace the test item on the test rig. A provisional target might consist of a card showing the aim point and the target area. Example drawings of provisional target can be found below. All lines and the target area should be in a different color than the background. To prove accuracy it is recommended to follow the steps listed below:

(1) Place a provisional target on the test rig and perform pre-shots to adjust the gun(s). Repeat this step until all parameters (accuracy, velocity, rate of fire) are within the required limits. Replace the provisional target after each round if needed.

(2) If the gun(s) are adjusted, place the test item right behind the provisional target. Take care that the desired region of impact on the test item is placed behind the projectile hole(s) in the provisional target (see Figure B-1 below).

(3) Remove the provisional target and perform the live test.

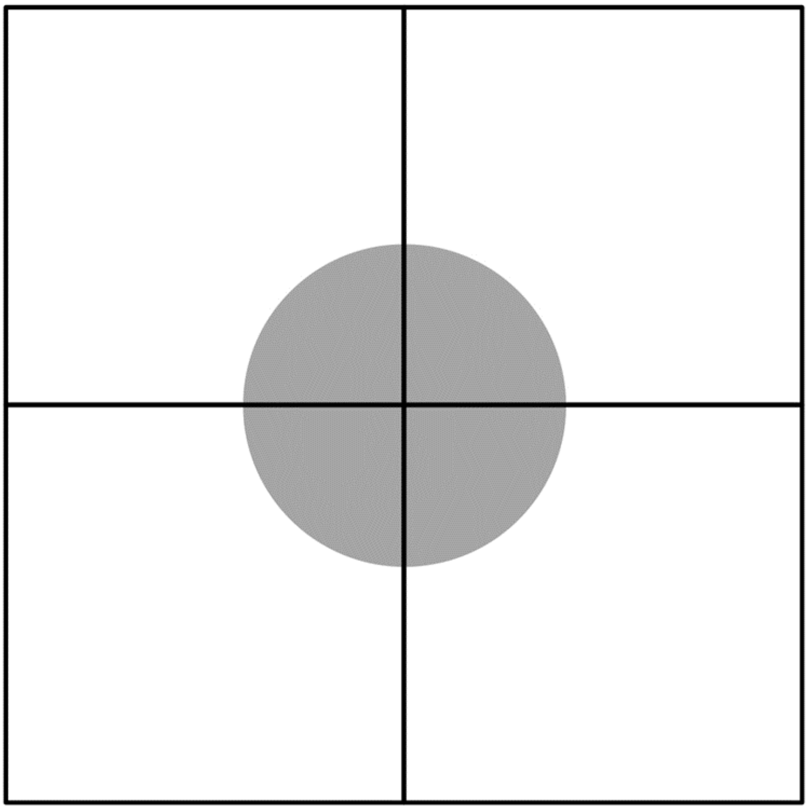

Figure B-1: Example drawing of provisional target (not to scale)

4. **Additional Factors**

a. For the fragment and bullet impact tests, additional measures may be necessary to meet the requirements, depending on local conditions, including:

(1) Warming up the barrel

(2) Warming or cooling of propellant

(3) Adjusting the amount of propellant

(4) Considering the length and the wear of the barrel

(5) Adjusting the distance to the target

B.3.4 Restraint and Tethering

1. Where it is expected that a munition may become propulsive as a result of the test stimulus, it may be necessary to restrain the munition to minimise hazards. There are various ways in which this can be achieved, for example:

- Contained within a cage
- Contained within a concrete block enclosure
- Clamped to the test stand
- Restrained by some additional tethering device such as a steel chain or cable

2. Cages, barriers and restraints can influence the effect of the test stimulus and should be positioned so as not to mitigate thermal or mechanical stimuli. Whatever method is used, it is essential that the restraint and fixing points do not influence the response of the munition in any way. Their positioning should avoid attenuating:

- Blast overpressure readings
- Accurate measurement of debris throw
- Mitigation devices
- The ability of the test item to rupture or fragment
- Heating or exposure to flame

3. Restraints and tethers must not impact the ability to evaluate whether the test item would have gone propulsive nor alter the kind of reaction or the projection of fragments and debris.

4. For missiles, rockets and rocket motors it will normally be important to establish whether propulsion occurred and some assessment of thrust will be required; the method of restraining the test item should not prevent assessment of thrust and confirmation of propulsion. Note that any component containing energetic material can become propulsive.

B.3.5 Thermal Preconditioning

1. Full-scale tests are normally undertaken on test items at ambient temperature. There may be specific reasons for thermal preconditioning of test items at either a higher or lower temperature. Testing a preconditioned item may result in a different response, for example due to embrittlement at low temperature and softening of the energetics and weakening of the case at high temperature.

2. However, if the THA shows that a particular threat is most likely to occur at a high or low temperature, then it may be appropriate to test at this temperature. The test item should be stabilised at the required temperature before conducting the test, and should only be removed from the conditioning chamber immediately before the test.

3. The thermal tests (Fast and Slow Heating) should always commence with the test item at ambient, noting that the slow heating test includes thermal preconditioning as part of the test procedure. In this latter case, it is often most useful and effective to precondition the munition and the oven together.

4. Environmental preconditioning of test items (e.g. accelerated ageing) is discussed at B.2.3.

B.3.6 Marking and Colouring

1. Where multiple items are to be included in a test, consideration should be given to individually marking items to facilitate post-test identification of any munition reactions. This is important in impact tests where reaction of adjacent munitions to those being aimed at can better inform understanding of sympathetic reaction or successively targeted munitions. Marking and colouring of munitions involved in thermal tests may also be of similar benefit.

2. In some instances colour alone is not sufficient, particularly in a confined test. Consideration should be given to stamping, etching or other more indelible methods of marking test items.

B.3.7 Meteorology

Extreme meteorological conditions (e.g. wind, rain, temperature) that might influence the test outcome should be avoided. Any meteorological limits in the Test Directive should be monitored and recorded for compliance.

B.3.8 Re-use of Test Item if No Reaction

If after a test a test item has not reacted, consideration may be given to re-using the test item in a subsequent test if it can be shown that the response of the munition will not be altered, and that there are no other safety concerns. This is at the discretion of the national authority.

B.4 BASELINE TESTS

The conduct of baseline testing should be considered if there are any concerns about interpretation of full scale test results. Testing suitably representative inert or live item(s) may be considered necessary in order to discriminate the response of the test item from test induced or test mitigated evidence (e.g. overpressure, fragmentation etc.). The full-scale tests should be conducted under roughly the same conditions (e.g. environmental, calibration of test equipment etc.) as the baseline tests to ensure that the results stay comparable. There are three types of baseline tests:

B.4.1 Inert Baseline Test

1. A test conducted to characterise the mechanical behaviour of an inert test item, subjected to the threat in a defined environment.

2. Inert baseline tests may be considered necessary in order to better discriminate the response of the test item from test induced evidence (e.g. overpressure, fragmentation, etc.). An example would be the scattering of debris caused by the mechanical momentum transfer from a bullet or fragment impact.

3. Inert test items should be to the same build standard as the live test item to the extent possible. Non-energetic sections of the test item need to be geometrically, physically and thermally representative. The inert materials replacing the energetic materials should have appropriate density, shock impedance, thermal properties, mechanical properties and strength.

B.4.2 Live Baseline Test

1. A test conducted to characterize the response of the test item (e.g. overpressure, fragmentation etc.) when initiated in the design mode.

2. Live baseline tests may be considered necessary to determine the full reaction (e.g., detonation) of a test item for comparison with the IM test reaction; in addition, they may also be used to factor out the output of the donor in a Sympathetic Reaction Test.

3. Test items should be to the same build standard as the full scale test item whether it is to the Final Production Standard or includes inert sections or components that are thermally, physically, mechanically, and geometrically representative.

B.4.3 Calibration Test

A test of the equipment and measurement gauges for the purpose of verifying test parameters such as aiming accuracy, impact velocity or thermal flux and to calibrate the recording equipment.

B.5 INSTRUMENTATION AND RECORDING

B.5.1 General

1. The instrumentation used should provide sufficient data to demonstrate correct test conduct, and to allow the munition response to be accurately assessed. Such instrumentation and recordings could include the following:

- Thermal Flux.
- Blast pressure measurements.
- Time Of Arrival (TOA) Probes.
- Witness Plates.
- Fragment Velocity Screens.
- Imagery including still photography of the pre and post-test conditions, high-speed and normal speed video coverage of the test item and the surrounding area.
- Recording of sound via a microphone.
- Any other instrumentation as determined by the test plan and/or other requirement

2. Despite the detailed guidance on data collection in this SRD, consideration should be given to maximizing collection of other data whether currently of direct relevance or not. Additional instrumentation is allowed as long as they do not affect reaction measurements (such as fragment projection) nor significantly affect the applied threat (such as thermal radiation or impact velocity) to the test item.

B.5.2 Impact Stimulus

1. For impact tests a measurement method should permit assessment of the impact point, regardless of the type and promptness of the response. This might require measuring the fragment trajectory a short distance up-range from the test item, with spatial reference to the intended shotline.

2. For Fragment/Bullet Impact tests, the method for measuring impact velocity should include compensation for the effects of drag. Additionally, the reported value should include the estimated measurement uncertainty. Guidance for estimating measurement uncertainties may be found in JCGM 100:2008 and JCGM 101:2008. Compensation for drag effects may assume a drag coefficient value of 1.65 with an uncertainty range of ± 0.05.

B.5.3 Temperature

1. Additional external thermocouples should be positioned at the discretion of the Test Authority when testing large items to ensure the uniformity of the thermal threat.

2. Additional internal thermocouples may also be placed at the discretion of the Test Authority if it is assured that this will not affect the structural integrity of the test item, nor allowing internally built-up pressure to be released.

B.5.4 Thermal Flux

Using thermal flux measurement as a response discriminator is problematic as heat flux depends on the size of the munition and its shape and is likely to be directional. Therefore, it is not included in the primary or secondary evidence for any reaction level and is not mandated by the full-scale test AOPs. However, it is a very useful metric in establishing the collateral damage from the reaction of a munition, as long as measurement device does not affect test item reaction (such as fragment projection or time to reaction). It may also be necessary to support the HC assessment.

B.5.5 Blast Overpressure

1. Although not mandated as a primary evidence descriptor for all reaction levels, blast overpressure is a key parameter in assessing response type, and should be measured in all full-scale tests.

2. It is important to estimate before the test the likely response of the munition and the associated blast overpressure so that gauges of appropriate scale can be used. It can also be useful to calibrate blast overpressure measurement by measuring the output of the design mode initiation of a single munition; this will provide a baseline for comparison in subsequent IM tests and will identify the contribution of the donor munition in Sympathetic Reaction.

3. Blast overpressure gauges should normally be sited at 5, 10 and 15 m unless either a low order response is expected or the munition under test has a small NEQ, in which case the distances can be reduced to 2.5 m, 5 m and 10 m. It is important to maintain these standard distances for siting the pressure gauges to provide a basis for comparison between tests and munitions.

4. At least two rows of blast overpressure gauges, sited orthogonally, should be used in every test. Gauges should be sited in the same position for different tests and in the same orientation relative to the test item to better inform the assessment of response between different tests for a comparative assessment.

B.5.6 Time of Arrival Probes

1. Time of Arrival (TOA) probes can be used to quantify the velocity of propagation of the reaction in a munition, which in turn can give an indication of whether a munition has detonated. This can also be useful in confirming that the donor munition in a Sympathetic Reaction test has achieved full detonation.

2. However, the use of TOA probes has limitations. For example, they are only effective in estimating the velocity of propagation when the reaction starts at a single point in a munition. In sympathetic reaction, for example, the acceptor munition will normally be impacted along its length by the shock, blast and fragmentation from the donor and it is unlikely to be possible to obtain any meaningful information about the velocity of propagation.

3. The utility of TOA probes in discriminating between lower order reactions is also less clear, and on their own it is unlikely that the probes will provide sufficient information to make any assessment.

B.5.7 Witness Plates and Screens

1. Witness plates are commonly positioned beneath the test item whereas witness screens are sited on 2 or 3 sides with a suitable stand-off distance. Both can be extremely valuable in discriminating between reaction types. The amount of pitting, marking and indentation can show quite clearly whether a munition has detonated (many witness marks from the fragmentation of the munition case and deformation due to blast) or has experienced a lower order reaction (fewer witness marks, minimal deformation, through to no marking at all).

2. Furthermore, when a sympathetic reaction may be anticipated, it may provide additional evidence if both are placed around the donor as well as the acceptors, so that the witness damage from the full detonation of the donor can be compared with that of any acceptor.

3. They also have the benefit of providing a permanent record which can be examined in detail after the test, and should be strong enough to withstand detonation of the test item. For this, special attention should be paid to the materials to be used:

   a. For a witness plate, the optimum material to use depends on the type and velocity of the expected fragments. For heavy munitions with steel walls, a steel witness plate with a thickness of at least 25 mm is recommended. However, for munitions with aluminium skins or very thin steel skins, an aluminium witness plate may provide better results. For munitions with plastic or composite skins, witness plates may not be useful.

b. For a witness screen, the material to use is often chosen not to impede fragment throw. It should be noted that certain test standards may have specific requirements for witness screen construction: for example, the UN Manual of Tests and Criteria requires the use of three 2 m square witness screens made of 1100-0 grade aluminium.

4. It is important not to screen other instrumentation such as blast overpressure gauges or to restrict the throw of debris, whilst at the same time being close enough to the test item to obtain a meaningful record of fragmentation and blast damage.

B.5.8 Fragment Throw, Velocity and Mass

1. One of the key determinants in assessing response type is the size and mass of the debris (fragments, casings and any other items generated by the tested munition) and the distance it has been thrown from the site of the test. In a detonation reaction, the case of the munition will be shattered into very small pieces and projected considerable distances, and all energetic material will be consumed; as the response type reduces in severity, so the munition fragments will increase in size, the amount of unconsumed energetic material will increase and the distances over which debris is projected will reduce.

2. A detailed debris map is an essential element of the report of any full-scale test. The map should show the location of each significant item of debris, recording its identity, mass and distance thrown. In order to achieve this, it is essential that the test arena is cleared of all debris from previous tests before any test is performed. The surface of the arena should ideally be smooth and hard, such as concrete or rolled sand; if the arena is grass covered, it should be cut as short as possible. Access to all areas of the arena is essential for debris plotting and identification.

3. Once debris mapping is complete, the debris should be photographed in situ (which can help determine the fragment energy, as described in AOP-39), collected and photographed again; where more than one munition has been tested, debris should be separated and grouped by individual munition. The total weight of debris recovered per individual munition should be recorded, so that it can be compared with the original weight of the test item. All fragments possible should be collected for insensitive munitions tests, not just those in specific quadrants or at certain distances.

4. Fragment size and velocity can also be measured using absorbent material, such as strawboards, fibreboards or soft plaster panels to catch the fragments without breaking them. It is usual to have a number of layers which can be separated after the test. The fragments can be recovered, identified and weighed and the depth of penetration can be used to calculate fragment velocity.

5. Such fragment recovery blocks/panels should be sited at set distances from the test item; 5 m and 15 m are recommended, to provide a standard. They should be sited on opposite sides of the test item along the axis representing the line of greatest fragmentation. For a bursting munition such as an artillery shell, this will be at right angles to the body of the shell but for a munition that has a directional fragmentation pattern, it will be necessary to select an appropriate worst-case axis.

6. Fragments should be examined by a subject matter expert to determine the type of fracture as this can be essential in differentiating among all reaction type during IM or HC assessment.

B.5.9 Imagery

1. Photographic and video evidence is vital to assessment of response. High speed photography/video should be used for all tests so that the test can be played back for analysis after the test.

2. Photographs of the test setup and the method used to mount the test item, any restraints and enclosure.

3. In siting the camera(s), it is important to ensure that the field of view will not be obstructed by any of the test facilities or instrumentation and that the field of view will include all necessary information. For example, if it is expected that a rocket motor under test will exhibit propulsion, it is important that the field of view includes an area to the rear of the motor nozzle so that it can be determined whether a plume with shock waves has formed.

4. Ideally, there should be one high speed video giving an overall view of the test arena, which will include capture of debris throw and a view of any fireball that forms, and a second video giving a close up view of the test item. Video for the duration of each test with time and audio correlation should also be considered. Care should be taken in siting the camera(s) to ensure the best view of the test item and to minimise the likelihood of masking by smoke and flame.

5. Still photography should be used to record the test set up before the test. This should include general shots of the test arena and test stand, close ups of the test item including, for packaged items, a shot of the contents of the container with the lid removed to show packing method and orientation of test items, and close ups of the test item(s) on the stand. For impact tests, include shots showing the aiming point.

6. Post-test, still photography should be used to show the test stand and remains of the test item, close ups of the witness plates/screens, any craters formed and of all significant items of debris including unreacted energetic material. It is important that the debris in each photograph is clearly identified in the subsequent report with a dimensional reference (link with the debris plot).

B.5.10 Audio

1. It is important to record the sound throughout the test. All events will be accompanied by sound and these can help to differentiate between the sharp crack of a detonation and the more prolonged sound of an explosion.

2. Sound is particularly valuable when the test item is obscured from view, for example by the smoke and flame from the fast heating hearth or by the slow heating oven, or when the item is being tested packaged and multiple events are occurring within the package. A microphone should therefore be placed at an appropriate distance from each test item to record the sounds of any reaction.

3. Any audio recordings should be correlated with the video recording (as a sound track on the recording or by some other means).

B.5.11 Thrust Measurement (for Propulsive Reactions)

1. Measurement of thrust has rarely been attempted in past full-scale tests. However, as munitions become increasingly insensitive and burning reactions rather than explosive reactions become the norm, so the likelihood of a propulsive reaction from a rocket motor under test becomes greater.

2. It is important for assessment of safety to determine whether a motor does become propulsive and whilst the formation of a plume and shock waves is perhaps the clearest indication, measurement of thrust is important for those occasions when the visual indication is inconclusive. Examples of techniques to measure thrust include the installation of a pressure transducer in the motor suspension arrangement on the test stand or between the nose of the motor and the wall of the test chamber.

ANNEX C INFORMATION TO BE INCLUDED IN TEST DIRECTIVE

The information that should be specified in the Test Directive is detailed below. This needs to take account of:

a. The selected test method of the full-scale Test AOP.

b. Other more generic aspects of test conduct detailed in this SRD.

c. The test procedure to follow (from the Test AOP).

d. The number of times the test is to be repeated and any variation in test procedure.

e. Test Item Build standard and acceptable variation(s) (see Generic and Test Specific Guidance below).

f. The number of items to be tested.

g. Whether an item is to be tested in its normal packaging, unpackaged or other configuration. Generic guidance is given in this SRD and Test Specific requirements in the relevant AOP.

h. The preconditioning required, if any.

i. Test specific requirements (see relevant AOP).

j. Additional generic test specific guidance from this SRD (see generic guidance in this SRD and Test Specific requirements in the relevant AOP).

k. Any additional observations and recordings to that specified in the full-scale Test Standards.

l. The number and positions of any video cameras to be used.

m. Any permitted deviations from the test method.

INTENTIONALLY BLANK

ANNEX D TEST REPORT TEMPLATE

The essential elements of the IM Test Report are described below. The precise format may vary depending upon the requirements of the customer and the standard procedures of the test facility.

While reports should be as concise as practical, it is better to include information which may not be relevant than to omit information which may be relevant. Thus, where there is doubt, the author of the report should include information rather than omit it.

D.1 EXECUTIVE SUMMARY

A one-page summary describing the test and concluding with an initial assessment of the response.

D.2 INTRODUCTION

Including:

a. Background giving reason(s) for test, test sponsor, place and date of test, test procedure.

b. Aim and Objectives of test.

c. Test Officials.

d. List of those attending the test.

D.3 TEST MATERIEL

Identify all materiel used for the test. This will typically include:

a. Energetic components, design standard, details of any inert components and packaging with diagrams and photographs of the test items before test.

b. Exploded diagram of the packaged munition (for packaged tests, to show packaging configuration and internal furniture).

c. Ancillary equipment (e.g. firing device for bullet and fragment impact).

d. Firing/Initiation System (e.g. detonator or shaped charge jet warhead to initiate donor in Sympathetic Reaction).

e. Instrumentation - list of all instrumentation used.

D.4 TEST PROCEDURE

Identify the test procedure employed, including the specific test method, and deviations from the standard (if any).

D.5 TEST CONFIGURATION

Describe the test site and layout of test item, including test stand and method of fixing test item to the stand, and instrumentation. It is essential to include a diagram showing test arena, and the location and position of (including but not limited to): test item, witness plates / screens, blast overpressure gauges and similar devices, and all instrumentation with relevant distances. Include colour photographs of the test set up to show both general arrangement and close up details of the test item and how it is mounted.

D.6 CALIBRATION

Include details of any calibration tests, for example to be used as comparative evidence, to achieve correct impact velocity and impact location for bullet and fragment impact.

D.7 TEST CONDITIONS

D.7.1 Safety Measures

If the safety measures employed necessitate changes to the agreed test procedure, detail these changes and their impact on the outcome of the test.

D.7.2 Meteorological conditions

Record the relevant prevailing meteorological conditions throughout the test (e.g. wind speed, temperature, etc.) and identify any deviations outside defined limits.

D.8 RESULTS

The results should include observations and records specified in the full-scale test AOP. The Test report should also include:

a. A detailed description of the test, including a diary or time log of events where appropriate (e.g. for Fast and Slow Heating). In particular, describe the reaction of test item.

b. Details of all instrumentation measurements, temperature records and blast overpressure records.

c. A detailed written description of how the test item reacted.

d. A debris map identifying all ejected debris, location and distance from test position.

e. Photographs of the test item post-test and photographs of debris, the test site (to show damage and cratering) and of witness plates and screens. Label each photograph to clearly identify the subject, in particular the precise nature of the debris. Where the test has been conducted packaged and the lid of the container has remained in situ, include internal photographs with the lid removed but indicate that the lid was removed post-test. Include any post-test X-ray photography to determine condition of test items.

D.9 CONCLUSIONS

A short summary of the results of the test and an initial assessment of the response type, including rationale for the assessment such as all data used as comparative evidence (e.g. blast over pressure from the detonation of a single munition calibration, etc.).

D.10 REFERENCES

References should always include Test Directive and Test Procedure (e.g. Test Standards, AOP etc.).

AOP-39.1(A)(2)