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SAFETY AND SUITABILITY FOR SERVICE ASSESSMENT TESTING FOR SMALL CALIBRE AMMUNITION LESS THAN 20MM

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NORTH ATLANTIC TREATY ORGANIZATION

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20 December 2019

1. The enclosed Allied S3 Publication AAS3P-22, Edition A, Version 1, SAFETY AND SUITABILITY FOR SERVICE ASSESSMENT TESTING FOR SMALL CALIBRE AMMUNITION LESS THAN 20MM, which has been approved by the nations in the CNAD AMMUNITION SAFETY GROUP (CASG – AC/326), is promulgated herewith. The agreements of the nations to use this publication is recorded in STANAG 4763.

2. AAS3P-22, Edition A, Version 1, is effective upon receipt.

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for

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RECORD OF RESERVATIONS

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RECORD OF SPECIFIC RESERVATIONS

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SAFETY AND SUITABILITY FOR SERVICE ASSESSMENT TESTING FOR SMALL CALIBRE AMMUNITION LESS THAN 20MM

CHAPTER 1 INTRODUCTION

This Allied Publication (AP) is aimed at the Safety and Suitability for Service (S3) Assessment Testing for SMALL CALIBRE AMMUNITION LESS THAN 20MM as agreed under North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 4629 and Allied Ammunition Safety and Suitability for Service Procedures (AAS3P)-1. AAS3P-1 provides general discussion of Safety and Suitability for Service Assessment Testing. AAS3P-22 is intended to act as an ammunition type specific document dealing specifically with the necessary safety testing and assessments for SMALL CALIBRE AMMUNITION LESS THAN 20MM to enter service within the NATO community.

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CHAPTER 2 SCOPE

2.1. PURPOSE

The purpose of this AP is to guide personnel involved in the planning and implementation of S3 assessment testing of ammunition to enable appropriate evidence to be collected covering the entire life cycle. The objective of the safety test programme defined by this AP is to provide data to demonstrate that the ammunition will be “safe for use”, as defined in AAS3P-1, throughout the potential deployment possibilities in NATO service.

2.2. APPLICATION

The guidance provided in this AP is applicable to SMALL CALIBRE AMMUNITION LESS THAN 20MM projects in NATO Nations; multi-national ammunition projects as well as for national ammunition projects.

The categories of ammunition covered by this AP are ball, tracer, armour piercing (and variants), frangible, incendiary, high explosive (HE) and variants, training (such as blanks, reduced range and target practice), shotgun and less than lethal ammunition. This list is not intended to be exhaustive. If there is a change in configuration or use, then the S3 programme should be reviewed and the validity of prior testing reassessed.

This AP is applicable for ammunition used with weapons as personal defence weapons, individual combat weapons (all rifles, sniper, anti-materiel, shot guns, light machine guns), crew served weapons (medium/heavy machine guns, vehicle mounted machine guns, Remote Controlled Weapon Stations), and anti-riot weapons.

In addition there are a range of miscellaneous systems that use this category of ammunition such as sub-calibre systems, spotting rifles, line throwers, explosively-operated tools (bolt guns) or devices (such as nail guns) to which the requirements of this AAS3P may be applicable. This should be confirmed during the Preliminary Design Assessment and Hazard Analysis.

This AP assumes that there has been considerable engineering design and development conducted prior to S3 qualification, and that there is a high expectation of successful safety qualification. This body of evidence should be used during the Preliminary Design Assessment and Hazard Analysis to determine if tailoring of the testing recommended within this standard is necessary. The tailoring shall be carried out as described in paragraph 6.5.

2.3. LIMITATIONS

This AP does not cover the ammunition categories observing/spotter, smoke, illuminating, and rifle/gun launched grenades.

This AP does not address fuze qualification. Guidance should be sought from Allied Ordnance Publication (AOP)-20 or national fuze standards.

This AP is not applicable for ammunition used with weapons of 20 mm and above such as cannons, automatic grenade launchers, underslung systems for rifles, and miscellaneous.

This AP does not address the aspect of interchangeability as stated in the MULTI CALIBRE MANUAL OF PROOF AND INSPECTION (MC-MOPI) FOR 5.56 MM, 7.62 MM, 9 MM AND 12.7 MM AMMUNITION (AEP-97). The purpose of the MC-MOPI is to prescribe uniform test and inspection procedures for NATO 5.56 mm x 45, 7.62 mm x 51, 9 mm x 19 and 12.7 mm x 99 (calibre 0.50”) ammunition, to ensure functional interchangeability on the battlefield as laid down in relevant STANAGs.

This AP is not intended to be used in the assessment of effectiveness, reliability or performance of ammunition unless failure to be reliable or to perform effectively is deemed to represent a direct and immediate safety hazard to the user or other personnel. However, the data may be used in support of effectiveness, reliability, or performance assessment.

Furthermore there are performance tests that may indicate safety issues that require further testing. Examples are ammunition – weapon kinematics, ballistic match, terminal effects (projectile lethality and armor penetration), and repeated chambering, among others. The national authority can add tests not described in this AP to the test schedule based on national requirements or the nature of the ammunition.

CHAPTER 3 TERMINOLOGY

Definitions in this AP take precedence over those in AAS3P-1, which in turn take precedence over those in AOP-38. Refer to AAS3P-1 for definitions related to Safety and Suitability for Service test procedures.

3.1. CARTRIDGE

Ammunition, ready for firing, wherein the propelling charge(s), its primer, with or without the projectile with its fuze are assembled in one unit for handling and firing.

3.2. CARTRIDGE CASE

Cylindrical casing and its function is to contain the primer, propelling charge and projectile if applicable.

3.3. ELECTRONIC PRESSURE VELOCITY ACTION TIME (EPVAT)

EPVAT equipment makes it is possible to measure several internal ballistic parameters of firing a single round.

Note: Measurements sensors like pressure gauges can be placed in the barrel of this dedicated weapon.

3.4. LOWER CONDITIONING TEMPERATURE (LCT)

The temperature to which test items are stabilized for cold non-firing tests.

Note: This temperature is based on the climatic region defined later in this document as being the worst case that the item will encounter during storage and transportation**.**

3.5. LOWER FIRING TEMPERATURE (LFT)

The temperature to which test items are stabilized for cold test firing.

Note: This temperature is based on the climatic region defined later in this document as being the worst case that the item will encounter during operations or that are identified in the requirements document.

3.6. PRE-STRESS

Exposure of ammunition to a sequence of one or more environmental stresses (i.e., temperature, humidity, shock, vibration, etc.) prior to conducting a particular test event.

3.7. PRIMER

Cap containing a primary explosive and a booster and its function consists of transforming an external action normally mechanical or electrical in sufficient explosive energy to ignite the propelling charge.

3.8. PROJECTILE

An object, projected by an applied external force and continuing in motion by virtue of its own inertia, as a bullet, shell or grenade.

3.9. PROPELLING CHARGE

A component of ammunition that contains the energetic material that when ignited, the gases produced propel the projectile out the gun barrel.

3.10. SOLAR RADIATION EQUIVALENT (SRE) TEMPERATURE

In environmental testing, the maximum temperature achieved by energetic material when exposed to cycles of high temperatures in combination with solar radiation during a laboratory test.

Note: The SRE is defined as the maximum temperature value experienced by the energetic material (e.g., motor propellant, warhead, fuze) during the solar test. Determination of this value will require exposure of an inert, internally instrumented munition, with similar thermal characteristics to the complete round, to the full solar test requirement defined in Allied Environmental Conditions and Test Publication (AECTP) 200, Category A1. The SRE temperature should be determined for the packaged and unpackaged state. In the absence of these data, a value of +71 °Celsius (C) should be used for the SRE temperature.

3.11. TEMPERATURE CONDITIONING

Exposure of ammunition to a thermal environment in preparation for a test event at a specified test temperature.

3.12. TEMPERATURE STABILIZATION

Temperature stabilization is achieved when the part of the item considered to have the longest thermal lag is changing no more than 2 °Celsius (C) per hour.

Note: Since it may not be practical to monitor the part of a live round with the longest thermal lag during test without damaging seals, the stabilization time may be determined prior to live round testing using an inert, internally instrumented round, with similar thermal characteristics to the ammunition. The stabilization time will typically be required for the round in both the unpackaged and the transport configurations and at the hot and cold temperature extremes.

3.13. UPPER CONDITIONING TEMPERATURE (UCT)

The temperature to which test items are stabilized for hot non-firing tests.

Note: This temperature is based on the climatic region defined later in this document as being the worst case that the item will encounter during storage and transportation.

3.14. UPPER FIRING TEMPERATURE (UFT)

The temperature to which the test items are stabilized for hot test firing.

Note: This temperature is based on the climatic region defined later in this document as being the worst case that the item will encounter during operations or that are identified in the requirements document.

3.15. WEAPON SYSTEM

A weapon and those components required for its operation, comprising the aggregate of the weapon, the associated launching vehicle or platform launching the ammunition, the available ammunition and the ancillary equipment necessary to test, aim, launch, and guide the ammunition, as applicable.

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CHAPTER 4 FACILITIES AND INSTRUMENTATION

4.1. FACILITIES

All test facilities utilized must suit specific test requirements and provide adequate protection for personnel and equipment in accordance with local and national regulations for testing of hazardous material. Note that although it is not necessary for all the facilities to be co-located, consideration should be given to the safe transport of potentially degraded test articles between test facilities. In addition to the requirements provided in Annex F, Table F-1, test facilities shall be prepared for the handling and possible disposal of explosive items.

4.2. INSTRUMENTATION, ACCURACY, AND CALIBRATION

The instrumentation and test equipment used to control or monitor the test parameters shall have an accuracy at least equal to 1/3 the tolerance of the variable to be measured. Recommended tolerances are provided in Annex F, Table F-2. In the event of conflict between this accuracy and guidelines for accuracy in any one of the test procedure or methods referenced in this document, the more stringent accuracy requirement takes precedence. The instrumentation and test equipment shall be calibrated periodically to laboratory standards whose calibration is traceable to national laboratory standards. The test facility shall maintain the calibration records.

4.3. TEMPERATURE CONTROLS

Conduct all firing tests with the test items uniformly conditioned to the appropriate temperatures. All temperature conditioning shall be monitored by at least two independent measuring devices (i.e., conditioning-box measuring equipment, and separate thermocouples).

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CHAPTER 5 LIFE CYCLE ENVIRONMENTAL PROFILE

5.1. LIFE CYCLE ENVIRONMENTAL PROFILE

A representative Life Cycle Environmental Profile (LCEP) for small calibre ammunition is illustrated in Annex B of this document as part of a S3 test programme flow chart with rationale provided in Annex A and test descriptions provided in Annex C. The representative LCEP has two primary sequential streams, one hot stream and one cold stream and is considered as the standard for this AP.

The representative LCEP is based upon the applicable environmental factors for storage, transportation, and deployment selected from Allied Environmental Conditions Testing Publication (AECTP) 100, Annex A along with the generic usage profiles from AECTP 100. Testing in accordance with this life cycle sequence and combining environments (i.e., vibration with temperature) is required to determine if the interaction (synergistic effect) and/or the sequence in which environments are experienced may result in a safety hazard.

5.2. DEVIATIONS

The safety tests recommended in this document are intentionally conservative to account for a wide range of deployment possibilities in NATO service. Test tailoring may be necessary for a variety of reasons including test conduct safety considerations, variation of deployment requirements and/or LCEP, the need to address nation specific requirements and/or factors that affect test sample sizes. The tailoring shall be carried out as described in paragraph 6.5.

When nation specific requirements conflict with requirements in this document, the reference tables in Annex H, Appendix 2, Table H2-1 may be used to assist in the process of cross-referencing the national and international documents.

All deviations from the representative LCEP contained in this document shall be approved by national S3 authority(ies) or other appropriate authorities prior to the start of testing. The rationale used in tailoring shall be documented and retained as part of the S3 assessment file.

During sequential testing, test levels and/or test configurations may require tailoring such that non-safety hazard related damage in any one particular test does not affect the validity of subsequent test data.

If a safety related hazard is identified during any part of the test then a failure analysis shall be conducted and corrective action taken. This may include redesign or additional testing. Significant hazard or design changes may require a repeat of the full test sequence.

It should be noted that the elimination of tests, reduction of sample quantities, or reduction of severities may result in reduced evidence to fully support the required safety certification of the ammunition.

CHAPTER 6 SAFETY TEST PLANNING

6.1. OVERALL TEST OBJECTIVES

The objectives of the safety tests are to provide data to demonstrate that risks associated with the ammunition are sufficiently low that they meet the criteria of "safe for use" as defined in AAS3P-1. To achieve this, the safety tests must provide data to determine the following:

a. Existence and nature of actual and potential ammunition hazards to personnel and equipment.

b. Safety of the ammunition throughout the planned LCEP including storage, transport, maintenance, training, operations, firing, and disposal.

c. Safety arguments developed by National subject matter experts that may lead to limitations or restrictions on service usage.

6.2. GENERAL

Safety assessment of ammunition is an evolutionary process, which begins in the early design phase of the ammunition and continues after deployment of the ammunition. The data gathered during the S3 tests described in this document should not be considered the exclusive source of data to support the safety assessment. Evidence shall be provided by the developing agency that the energetic materials used in the ammunition have been assessed and qualified. Other sources of safety data such as the ones described below shall be considered.

6.3. PRELIMINARY DESIGN ASSESSMENT & HAZARD ANALYSIS

Review of existing safety, design, and test data is strongly advised prior to development of the safety test plan. Review documentation concerning ammunition requirements, design, safety and prior tests in order to identify potential hazards and their causes. The degree to which this AP is followed and the degree to which other data are accepted in place of these AP tests depend on the characteristics of the ammunition and on the credibility and completeness of existing safety data. These reviews and this AP must be used to develop the detailed safety test plan and shall be in accordance with national health and safety standards and regulations. Thoroughly review all data related to the ammunition under test. This should also include any data that can be used by analogy from previously qualified designs. This review should include test data from component and ammunition level performance and safety testing (engineering-design or component-development tests). Evaluate the safe operating temperatures of the energetic materials, as LCEP temperatures may exceed the safe operating conditions of these energetic materials. Figure 1 gives an overview of possible data.

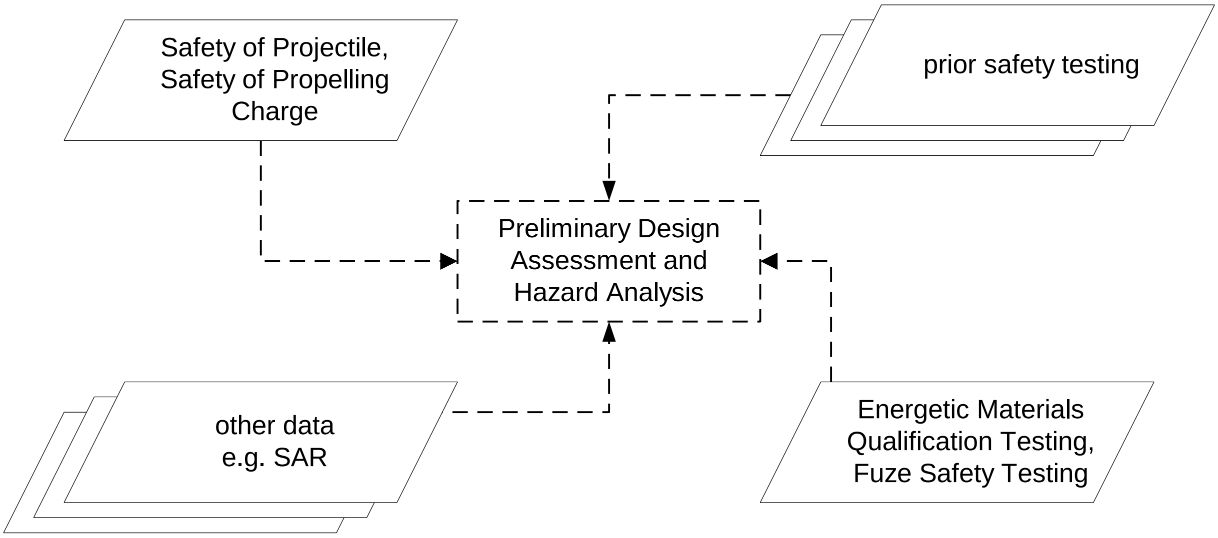


Figure 1: Preliminary Design Assessment and Hazard Analysis

6.3.1. Safety of Projectile

The projectile shall be designed such that it will be able to withstand the forces generated by the pressure of the propelling charge and the weapon during firing. Annex A, Appendix 5 provides the rationale/background for and Annex C, Appendix 5 provides the description of the Safety of Projectile Test.

6.3.2. Safety of Propelling Charge

The pressure generated by the propelling charges during firing shall be in accordance with both the weapon and the projectile safe operating limits to ensure safe firing. Annex A, Appendix 5 provides the rationale/background for and Annex C, Appendix 5 provides the description of the Safety of Propelling Charge Test.

6.3.3. Energetic Materials Qualification Testing

All energetic materials in ammunition shall undergo appropriate testing and assessment per STANAG 4170 and AOP-7 to determine whether each possesses properties which make it safe for consideration for use in its intended role.

6.3.4. Fuze Safety Testing

AAS3P-22 assumes that the fuze, if applicable, is already qualified and that no further testing is required. The design safety requirements standard is STANAG

4187 and the fuze procedures document is AOP-20. Test Requirements for S3 Assessment is STANAG 4157, which is based on the principles of AOP-15. The results of fuze qualification shall be provided within the S3 assessment report, as described in Chapter 9, if the fuze is integral to the projectile.

6.3.5. Prior Safety Testing

Available data from prior safety tests for the ammunition design or comparable designs can give insight and therefore indicate the need for additional and/or adjusted testing.

6.3.6. Other Data

The Safety Assessment Report (SAR) is a formal document that summarizes potential hazards to developmental testers that shall be submitted by the material developer to the tester prior to commencement of testing. The SAR shall describe the safety related characteristics of the ammunition, identify potential hazards, assess severity and probability of the mishap risk of each identified hazard, and recommend procedures and precautions to mitigate hazards to an acceptable level of risk. Other sources of data are to be considered.

6.4. S3 TEST OUTLINE

S3 assessment testing of small calibre ammunition requires a series of functional/firing tests, LCEP tests and standalone (non-sequential) tests, as defined in Annex B. The test types and combination of environments for the different ammunition types vary.

6.5. TEST TAILORING

The safety tests recommended in this document are intentionally conservative to account for a wide range of deployment possibilities in NATO service. Test tailoring may be necessary for a variety of reasons including test conduct safety considerations, variation of deployment requirements and/or LCEP, the need to address nation specific requirements and/or factors that affect test sample sizes, see also paragraphs 6.6, 6.7, 6.8 and 6.9 for guidance. When nation specific requirements conflict with requirements in this document, the reference table in Annex H, Appendix 2 may be used to assist in the process of cross-referencing the national and international documents. During sequential testing, test levels and/or test configurations may require tailoring such that non-safety hazard related damage in any one particular test does not affect the validity of subsequent test data. If tailoring is determined to be necessary, the tailoring may be carried out in accordance with the following general principles:

a. The tailored environment shall be at least as severe as the expected life cycle environment.

b. Any alternative test standards / methods that are utilized shall be technically equivalent or superior to the referenced standards / methods.

c. The tailored test procedures and severities, along with full justification / rationale shall be documented as part of the S3 assessment report.

d. Tailoring shall be approved by the relevant national authority prior to testing.

Particularly, document the elimination of tests, reduction of sample quantities, or reduction of severities, any of which may result in reduced evidence to fully support the required safety assessment of the ammunition.

6.6. ENVIRONMENTAL TEST LEVELS

The environmental test levels specified in this document are based on the anticipated extreme conditions for storage, transportation, handling, maintenance, and firing of the ammunition. Natural and induced environmental factors for storage, transportation, and deployment were selected from AECTP 100, Annex A. Climatic test levels are based upon climatic categories defined in AECTP 230 and 300; Dynamic test levels are based on AECTP 240 and 400; and Electromagnetic Environmental Effects (E3) test levels are based on AECTP 250 and 500. National test specifications may be employed to meet the environmental test requirements if it can be demonstrated that the national specification is technically equivalent or superior to the AECTP. Rationale for the specific test levels in this document is provided in Annex A. Test levels or specification deviations for ammunition designated to be deployed to specific areas of the world or on specific transport or tactical vehicles may result in limitations on service use or require use of special procedures. Test time compression in accordance with AECTP 240 may be acceptable, however the risk of introducing false failure modes should be considered.

6.7. TEST SAFETY CONSIDERATIONS

Explosive materials can often become less stable with age. This ageing is exacerbated by the presence of increased temperature, humidity and vibration/mechanical stressing. It is therefore necessary to review the projected test sequence and determine whether the sequence, including any temperature conditioning and storage, result in an unacceptable hazard. As a minimum this will require an assessment of explosive material stability with respect to extreme temperature exposure durations. It might be necessary to divide the overall test time (shock, vibration, and bounce in particular) into smaller portions to prevent heat build-up within the ammunition and subsequent unintended energetic reaction potential. It is essential and mandatory to have a log for each test article (batch, lot, ammunition container, or wirebound box) indicating the amount of time that has been spent at extreme temperature for the entire test sequence, including all periods of temperature conditioning.

6.8. TEST SAMPLE QUANTITIES

The test sample quantities are largely dictated by the minimum number of tests required to provide sufficient evidence of ammunition safety. Specific rationale for the tests in each of the test categories is provided in Annex A. The following general notes should be considered when assessing the test sample quantities required for an S3 test programme:

a. Existing safety data may be reviewed for acceptability with the goal of reducing sample sizes and the number of tests. The degree to which this data can be used depends upon ammunition characteristics, reliability and completeness of the existing safety data, and the adequacy with which it treats hardware configuration, input stress, potential synergistic effects, types and severity of hazards, and the probability of hazard occurrences. However, tests which may interact with each other in a synergistic fashion (e.g., vibration/shock or vibration/climate) must not be removed from the sequence.

b. Additional ammunition beyond those recommended in this document may be needed in the test programme for further investigation, including inspections, and to replace items that become damaged during testing.

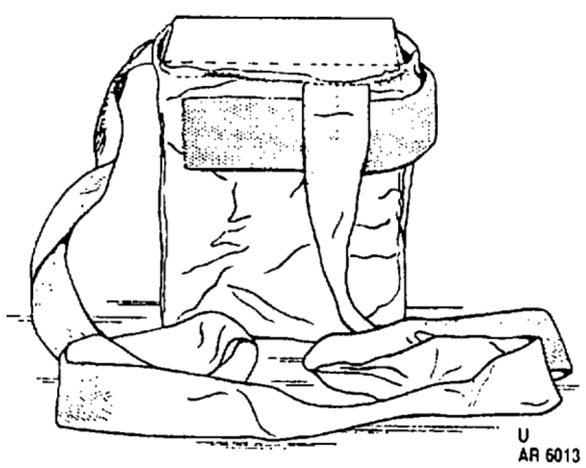
c. The total number of test items required for S3 assessment varies according to the type of ammunition and its packaging configuration. The minimum total required numbers for each ammunition type shall be declared in the S3 test programme. The round allocation table presented in Annex B, Table B-1 illustrates a recommended approach to determining test quantities and typical test design for the Sequential Environmental Testing for a single deployment.

6.9. WEAPON

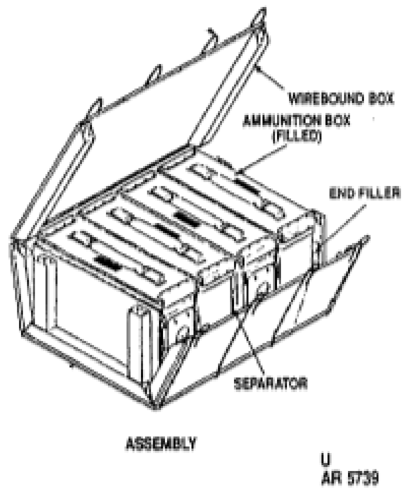
If the ammunition is intended for use in more than one type of weapon, including different configurations of the same weapon design, distribute the firings across a representative subset of these weapons. This may be necessary where it is not feasible to conduct all ammunition tests with each intended weapon due to the sample size of ammunition required.

6.10. AMMUNITION PACKAGING

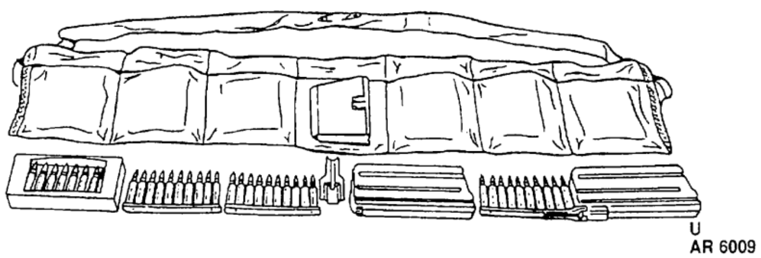
Ammunition can be loose, linked or clipped and is normally packed in an ammunition container or box including bandoleers, spacers, padding, etc. Containers and boxes may be in an overpack and configured palletized. The ammunition packaging during the test should be the appropriate shipping, handling, storage, and operational deployment configuration that the ammunition will experience during its service life. Ammunition packaging used for S3 testing should have completed sufficient testing to ensure safe conduct of ammunition testing specified in this document. Figure 2 presents possible test item configuration examples.



Bandolier 7.62 mm x 51



Wirebound box with 4 metal containers



Bandolier 5.56 mm x 45 with possible contents

Figure 2: Packaging Illustrations

CHAPTER 7 TEST INSPECTIONS

Ammunition, packaging and ancillary items (links, magazines, etc.) shall be inspected at different moments throughout the sequential environmental trials. Inspections should be conducted in accordance with the following inspection levels:

Initial Inspection	(Baseline)
Level 1 Inspection	(Basic)
Level 2 Inspection	(Intermediate)
Level 3 Inspection	(Full)
Sealing Check	

Appropriate inspection methodologies combine visual assessment and detailed chemical and physical tests to fully understand degradation of the ammunition.

The flowchart in Annex B shows an Initial Inspection and several Level 1 Inspections as a minimum within the sequential environmental trials. A Level 3 Inspection is optional before (baseline data) and after finishing the sequential environmental trials. The Level 3 Inspection is also known as Breakdown, Test and Critical Analysis (BTCA).

It is recommended that extra inspections are added when test exposure is considered likely to have adversely affected the ammunition, packaging or ancillary items. For these additional inspections the appropriate inspection level (1, 2 or 3) must be chosen. The exact inspection tests need to be determined on a case-by-case basis. Failure modes and life limiting factors identified for comparable ammunition may assist. Non-destructive techniques utilized shall have the capability to accurately assess condition of the safety critical characteristics.

Note that extra inspections can also be added throughout the complete test scheme as shown in the flowchart in Annex B, also including the non-sequential and firing tests.

The inspection levels are described in paragraphs 7.1 to 7.5 below. In Annex E additional information can be found concerning tests on Level 3 Inspection.

7.1. INITIAL (BASELINE) INSPECTION

An initial inspection using a random sample of the test items is conducted before the start of the sequential environmental trials. It is conducted to verify conformance of the ammunition, packaging and ancillary items to build standards (see AAS3P-1) against the production drawings and to provide an assessment of the baseline condition for subsequent test inspections.

The list given below is not intended to be exhaustive, but to indicate the typical aspects to be inspected and reported. However, the specific criteria should be selected on a case-by-case basis depending upon the ammunition type, construction, its packaging and ancillary items.

a. Physical characteristics such as weight and all critical dimensions (e.g., overall length, case head bevel, chamfer, neck taper, etc.) – for both ammunition and packaging.

b. Type of projectile (i.e., ball, tracer, armour piercing, high explosive, etc.).

c. Manufacturer, manufacturer's markings (e.g., head stamp) and manufacturer's lot/batch number – for both ammunition and packaging (including clips/links/bandoliers as applicable).

d. Energetic materials (e.g., propellant, primer, tracer element) manufacturer, lot/batch number, type, size and charge weight.

e. Materials of construction (e.g., cartridge case material).

f. Packaged configuration (e.g., linked, bandolier, cardboard boxes, etc.), type of container, overpack (if any), and number of rounds per container.

7.2. LEVEL 1 (BASIC) INSPECTION

A Level 1 Inspection using a random sample is conducted before, during and after the sequential environmental trials. It is conducted to detect possible degradation due to test exposure. It consists of visual examination of all test ammunition, packaging and ancillary items.

The list given below is not intended to be exhaustive, but to indicate the typical aspects to be inspected and reported. However, the specific criteria should be selected on a case-by-case basis depending upon the ammunition type, construction, its packaging and ancillary items.

a. Overall condition of ammunition and packaging, noting damage/degradation (e.g., abrasion, indentations, splits, scratches, corrosion, etc.).

b. Condition of links, bandoliers and/or clips as applicable, specifically damage/degradation, alignment (including position of rounds) and freedom of movement (including hinging and torsion).

c. Identification markings on ammunition, containers (e.g., batch/lot numbers).

d. Inspect interior of packaging for foreign material, loose propellant, evidence of moisture and general cleanliness.

e. Primer condition (e.g., ‘cocked’, loose, etc.).

f. Looseness of projectile in cartridge case.

7.3. LEVEL 2 (INTERMEDIATE) INSPECTION

A Level 2 Inspection using a random sample can be conducted before, during and after the sequential environmental trials if necessary. It is conducted to detect possible degradation due to test exposure. It consists of the visual inspection according to Level 1 Inspection and additional tests.

The list given below is not intended to be exhaustive, but to indicate the typical aspects to be inspected and reported. However, the specific criteria should be selected on a case-by-case basis depending upon the ammunition type, construction, its packaging and ancillary items.

a. Adequacy of sealing at component interfaces, paying particular attention to primer pocket and case mouth. This may be achieved via immersion testing.

b. Radiography of hazardous fillings within the projectile (e.g., HE), if applicable, to determine the presence of voids, cracks and/or other defects. Consideration should be given to preconditioning at LCT prior to radiography (avoiding thermal shock) where the presence of voids, cracks and/or other defects are a concern.

c. Continuity and resistance checks of electrically initiated primers, if fitted.

d. Measure full length of round.

e. Assess ability of round to be chambered using chamber gauge.

7.4. LEVEL 3 (FULL) INSPECTION

A Level 3 Inspection using a random sample can be conducted before, during and after the sequential environmental trials if necessary. It is conducted to detect possible degradation due to test exposure. It consists of Level 2 Inspection and additional tests.

The list given below is not intended to be exhaustive, but to indicate the typical aspects to be inspected and reported. However, the specific criteria should be selected on a case-by-case basis depending upon the ammunition type, construction, its packaging and ancillary items.

It is necessary to disassemble the ammunition for Level 3 Inspection in order to analyse the ammunition and its components. Annex E provides additional information concerning the disassembly and the additional tests.

a. Chemical properties (energetic materials).

- Chemical composition.
- Chemical stability.
- Chemical compatibility.
- Pyrotechnic composition.

b. Physical properties (energetic materials).

- Flow properties.
- Particle size distribution.
- Thermal analysis.

c. Hazard properties (energetic materials).

d. Mechanical properties (ammunition).

- Cartridge case residual stress.
- Cartridge case hardness profile.
- Projectile extraction force (‘bullet pull’).
- Compressive force resistance.

e. Electrical components.

f. Primer Sensitivity.

7.5. SEALING CHECK

A Sealing Check is conducted before and after the sequential environmental testing using a random sample. The checks shall be conducted on the same ammunition. It consists of the following check:

- Adequacy of sealing at component interfaces, paying particular attention to primer pocket and case mouth. This may be achieved via immersion testing of individual rounds.

CHAPTER 8 S3 TEST PROGRAMME OVERVIEW

8.1. S3 TEST PROGRAMME

The S3 test programme based on the representative LCEP for SMALL CALIBRE AMMUNITION LESS THEN 20MM consists of non-sequential and sequential tests and assessments. Test sequences are given in Annex B. An attempt has been made to address all environments described in AECTP 100, Annex A, based on the representative LCEP for SMALL CALIBRE AMMUNITION LESS THEN 20MM. Figure 3 illustrates the total test outline consisting of the Preliminary Design Assessment and Hazard Analysis as described in Chapter 6 and the S3 test programme itself.

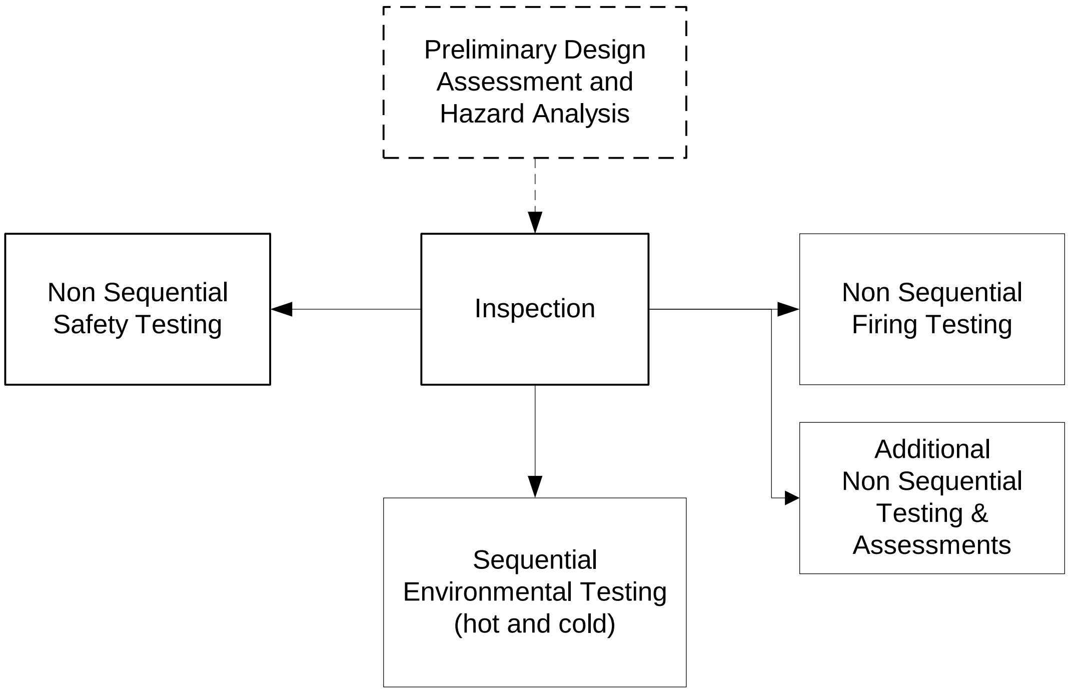


Figure 3: S3 Test Programme Outline

Test description details are deferred to STANAG or AP documents referenced in the test descriptions whenever possible. Test methods which are not currently covered by STANAG or AP documents are referred to the appropriate national document or International Test Operating Procedure (ITOP). Conflicts between the referenced test methods and the procedures described in this document should defer to the referenced test method. Background and rationale for these tests are provided in Annex A. Below the different parts of the S3 test programme are briefly described.

8.2. SEQUENTIAL ENVIRONMENTAL TESTING

Sequential Environmental Testing involves the climatic and dynamic tests associated with the life cycle of the ammunition as part of the S3 package. Sequential Environmental Testing has a hot and cold stream. The exposed ammunition will be used in a firing test after completion of sequential tests. Annex A, Appendix 1 provides the rationale/background for and Annex C, Appendix 1 provides the description of the Sequential Environmental Tests and Annex C, Appendix 3 provides the description of the firing test of the exposed ammunition. Test sequences are given in Annex B (see Figure B-1).

8.3. NON SEQUENTIAL SAFETY TESTING

Non Sequential Safety Testing is required as part of the S3 test programme. Some of the exposed ammunition will be used in a firing test after completion of the following non sequential tests, of which not all are mandatory (see Figure B-1):

- Insensitive Munitions
- Safety Drop 12 m
- Hazard Classification
- Fluid Contamination
- Electromagnetic Environmental Effects
- Altitude
- UNDEX Shock
- Corrosion (Salt Fog)
- Immersion
- Parachute Resupply
- Ageing

Annex A, Appendix 2 provides the rationale/background for and Annex C, Appendix 2 provides descriptions of the Non Sequential Safety Tests on ammunition. Annex C, Appendix 3 provides description of the firing test of the exposed ammunition.

8.4. NON SEQUENTIAL FIRING TESTING

Non Sequential Firing Testing is required as part of the S3 test programme. Unexposed ammunition will be used in the following firing tests, of which not all are mandatory (see Figure B-1):

- Baseline Firings
- System Interface Firings
- Component Security
- Bore Safety Firings

Annex A, Appendix 3 provides the rationale/background for and Annex C, Appendix 3 provides the description of the Non Sequential Firing Tests on ammunition.

8.5. ADDITIONAL NON SEQUENTIAL TESTING & ASSESSMENTS

Additional Non Sequential Testing and Assessments are required as part of the S3 programme (see Figure B-1). The following Additional Non Sequential Tests and Assessments are mandatory (if applicable):

- Operational & Maintenance
- Health Hazards
- Range Safety and Sustainability
- Demilitarisation and Disposal
- EOD procedures
- Software Safety

Annex A, Appendix 4 provides the rationale/background for and Annex C, Appendix 4 provides the description of the Additional Non Sequential Tests and Assessments.

8.6. INSPECTION

Ammunition, packaging and ancillary items (links, magazines, etc.) shall be inspected at different moments throughout the sequential environmental trials. Inspections should be conducted in accordance with the inspection levels as described in paragraphs 7.1 to 7.5.

Figure B-1 shows an Initial Inspection, two Sealing Checks and several Level 1 Inspections as a minimum within the sequential environmental trials. A Level 3 Inspection (Full) is optional before (baseline data) and after finishing the sequential environmental trials.

It is recommended that extra inspections are added when test exposure is considered likely to have adversely affected the ammunition, packaging or ancillary items. For these additional inspections the appropriate inspection level (1, 2 or 3) must be chosen. The exact inspection tests need to be determined on a case-by-case basis. Failure modes and life limiting factors identified for comparable ammunition may assist. Non-destructive techniques utilized shall have the capability to accurately assess condition of the safety critical characteristics.

Note that extra inspections can also be added throughout the complete test scheme as shown Figure B-1.

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CHAPTER 9 AMMUNITION SAFETY DATA PACKAGE

As stated in AAS3P-1 and AOP-15 Annex C, the results of the testing and assessments required in this document will be compiled into an S3 assessment report for use by the appropriate S3 approving authority in determining the overall S3 for small calibre ammunition.

If test procedures and severities have been tailored, see paragraph 6.5, the full justification / rationale shall be documented as part of the S3 assessment report.

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ANNEX A BACKGROUND/RATIONALE

A.1. GENERAL

This document was developed within the international community and is written primarily with references to NATO test procedures. Annex H, Appendix 2, Table H2-1 provides cross reference of similar national and international test standards.

A.2. INTRODUCTION

This Annex provides background information and rationale for the sample quantities and test environments recommended by this document. Formal safety testing is required to establish test data, which supports the issuance of the safety certification. The tests may indicate that limitations or restrictions must be imposed when the safety certification is issued. These restrictions may be imposed to limit exposure to certain environments (climatic, dynamic, electromagnetic, etc.), to restrict methods of transportation, or to define special handling and operating procedures. Generally, because of increased severity associated with safety testing, satisfactory performance of the test item is not required. Poor performance after exposure to test environments may indicate a need for further investigation.

A.3. LIFE CYCLE ENVIRONMENTAL PROFILE

During its expected life cycle, ammunition will experience transportation from its place of manufacture to a storage facility, transportation to a place of temporary storage in an Operational Theatre, before tactical transportation within that Operational Theatre and finally function or return to storage. At each stage it will experience exposure to various environments resulting from the local climate, general rough handling and transportation by numerous platforms. It may also experience abnormal environments such as being accidentally dropped.

A.3.1. Test Levels

This Appendix gives rationale for the specific test procedures and test severities recommended in this document. The test levels are credible extreme environments, to which the ammunition may be exposed as part of the LCEP. Conflicts between the recommended test levels and ammunition specific LCEP environments should be addressed through test tailoring and/or safety release restrictions.

A.3.2. Temperatures

Ammunition is required to remain safe and suitable for service at extreme temperatures where personnel are expected to be capable of military operations, namely within NATO climate categories C2 to A1. It would be expected for the ammunition to remain S3 during and following storage and transportation by various platforms within these climate categories. The extreme temperatures of these climate categories (or the SRE for hot stream ammunition) form the basis for the conditioning temperatures for all mechanical environment tests intended to address logistic movements. Ammunition is also expected to remain S3 following storage at extreme cold conditions of a C3 climate category, but would not necessarily be expected to be moved during the coldest period within this climate zone due to difficulties with vehicles and the temperatures being outside the human comfort zone (i.e., survival as opposed to capable of military operations). For this reason, the cold temperature extreme for mechanical environmental tests has been based on the C2 climate category. Default steady state conditioning temperatures to be used for each climate category if no additional data is readily available are shown in Table A-1.

Table A-1: Climatic Category Temperatures [1, 2]

Climatic Category	Storage Temperature Conditioning Limits (ºC) [3]	Firing Temperature (ºC) [4, 5]
A1/B3/M1	71	71
A2/B2/M2	63	56
A3	58	52
C0	-21	-19
C1/M3	-33	-32
C2	-46	-46
C3	-51	-51
M1	69	49
M2	63	Not Known
M3	-32	-18

NOTE 1: Prior to using this table, evaluate the safe operating temperatures of the energetic materials, as table temperatures may exceed the safe operating conditions of these energetic materials.

NOTE 2: Some nations may require temperatures that differ from those in the table (e.g., -54 °C for low temperature storage).

NOTE 3: Temperatures listed are for steady state conditioning.

NOTE 4: Firing Temperature relates to firing ammunition that has been protected from direct solar exposure. If it has been determined that a potential exists for direct exposure to solar radiation, then it is highly recommended that a solar radiation test be conducted to establish the maximum response temperature. This value should be used as the UFT.

NOTE 5: The moderating effects of shipboard storage vary widely depending on position within the ship, type of ship, and climate control, therefore, the firing temperatures given above for M1, M2, and M3 are merely an example of what may be expected at the extremes on board ship.

A.3.3. Temperature Stabilisation

For environmental tests that require temperature conditioning, temperature stabilisation is achieved when the part of the ammunition considered to have the longest thermal lag is changing no more than 2 °C per hour. Since it may not be practical to monitor the interior parts of live ammunition without damaging seals, the stabilisation time may be determined from temperature measurement inside the package. The stabilisation time will typically be required for the ammunition in the transport configuration and at the hot and cold temperature extremes. As an alternative, a default duration of 12 hours for unpackaged, 24 hours for packaged, or up to a maximum of 48 hours for palletised ammunition may be applied after the chamber air around the test article has stabilised to the test temperature. Care should be taken that no ammunition exceeds the safe life of the energetic material when subjected to multiple exposures to high temperature conditioning.

A.3.4. Solar Radiation Equivalent Temperature

As an alternative to installing solar lamps in a test chamber, the SRE temperature is specified in most mechanical environment tests in order to facilitate testing. The SRE is the maximum temperature value experienced by the energetic material after exposure to direct or indirect solar radiation. Determination of this value will require temperature measurement inside the package, and conduct of the full solar test requirement defined in Annex C, Appendix 1. The SRE temperature should be determined for the packaged state and applied for all mechanical environment tests. In the absence of this data, a value of +71 °C should be used in lieu of the SRE temperature since this reflects the maximum value of the A1 Storage and Transit diurnal cycle defined in AECTP 230 Leaflet 2311/1.

A.3.5. Ammunition Movements and Handling

A list of typical Commercial and Military movements and Rough Handling components is shown in Table A-2. In particular, Military movements can be subdivided to address Military Logistic movements by land, sea or air, and deployment of ammunition on combat platforms (Tactical Operational movements). The former addresses logistic movement into and from a point of entry into Theatre of Operations (such as an airfield or naval vessel) to a bulk storage site. The latter addresses logistic movement beyond a bulk storage site in either a palletised configuration, or as ‘issued equipment’.

Table A-2: Typical LCEP Movements and Handling

Mode	Paragraph	Restrained / Unrestrained Cargo	Packaging configuration
Commercial Logistic Dynamics	A1.3.		
Packaged Transit Drop 2.1 m	A.1.3.1.	Restrained	Packaged / Palletised Packaged
Land	A.1.3.2.		
Wheeled Vehicle	A.1.3.2.1.		
Rail	A.1.3.2.2.		
Sea	A.1.3.3.		
Air	A.1.3.4.		
Safety Drop 12 m	A.2.3.		
Military Logistic Dynamics	A.1.5.		
Air	A.1.5.1.	Restrained	Packaged / Palletised Packaged
Fixed Wing - Jet Aircraft	A.1.5.1.1.		
Fixed Wing - Turboprop Aircraft	A.1.5.1.2.		
Helicopter	A.1.5.1.3.		
Internal			
Underslung & VERTREP			
Sea	A.1.5.2.		
Land	A.1.5.3.		
Wheeled Vehicle			
Common Carrier	A.1.5.3.1.		
All Terrain	A.1.5.3.2.		
Shock	A.1.5.3.3.		
Trailer	A.1.5.3.4.		
Parachute Resupply	A.2.11.		
Rough Handling	A.1.6.		
Loose Cargo	A.1.6.1.	Unrestrained	Packaged / Unpackaged
Unpacked Deployment Drop 1.5 m	A.1.6.2.		
Tactical Operational Dynamics	A.1.8.		
Land	A.1.8.1.	Restrained	Packaged
Sea	A.1.8.2.		
Air	A.1.8.3.		
Dismounted / Man-Portable	A.1.8.4.		

A.4. SAMPLE QUANTITIES AND STATISTICAL CONSIDERATIONS

Due to the broad scope of small calibre ammunition, definitive sample sizes are not recommended in this document. The objectives of the safety tests are to provide data to demonstrate a high degree of confidence that risks associated with the ammunition are sufficiently low. Statistical methods and other methodologies such as analogy may be used to derive sample quantities. The sample size must be sufficient to provide reasonable assurance that comparison of test results against safety requirements will be meaningful, and are to be approved by appropriate authorities.

A.4.1. Performance Test Data

Data from additional performance tests (outside the scope of S3 testing) may be used to build the ammunition safety case.

A.4.2. Increased-Severity Testing

In order to yield acceptable confidence in safety test results with a relatively small sample size, increased-severity testing is prescribed in this document. The probability of ammunition failure resulting in a hazardous condition is increased by testing under conditions, which are representative of credible extremes or slightly above the environments to be encountered in actual ammunition use. These extreme environments are low-probability environments. Therefore, the test levels recommended in this document are at credible extremes.

A.4.3. Sequential and Combined Environments

Ammunition is subjected to environmental testing in a sequential manner, which is representative of the probable LCEP scenario. Testing in accordance with this life cycle sequence and combining environments (e.g., vibration with temperature) is recommended to determine if the interaction (synergistic effect) and/or the sequence in which environments are experienced may result in a safety hazard.

A.4.4. Inspection for Incipient Failure

For each test item which fails during test, there may be many items that have not failed, but are approaching the failure threshold. Inspection of the test ammunition before, during, and after test adds significantly to the confidence of the test data. Radiographic inspections provide particularly useful insight into the condition of the ammunition including early detection of displaced components as well as cracking or de-bonding of energetic materials if applicable. If the inspections indicate that failure is likely to occur, further investigation or testing may be required. If the inspections indicate that a margin of safety exists and that no safety hazard is likely to occur, additional confidence in the data is gained.

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ANNEX A BACKGROUND/RATIONALE
APPENDIX 1 SEQUENTIAL ENVIRONMENTAL TESTS

A.1.1. GENERAL

Provided below are the rationale for the Sequential Environmental Tests related to normal usage in typical environmental conditions, or from plausible mishandling during logistic and field operations. The ammunition should be tested following temperature conditioning at either UCT or the LCT.

If only one test configuration is to be used this must be the most severe configuration, packaged or unpackaged, for the ammunition. In most, but not all, cases this is more likely to be the unpackaged configuration.

A.1.2. SOLAR RADIATION

The solar radiation test is intended to aggravate those thermally induced degradation mechanisms associated with elevated skin temperatures and thermal gradients within the ammunition that are induced due to solar radiation. Since most nations' solar test chambers do not incorporate the ultraviolet element of the spectrum they tend not to aggravate the photo-chemical (actinic) degradation modes associated with solar radiation. If this is of concern (as may be the case for some paints, adhesives and polymers) then a separate ultra-violet exposure test will also be required. A minimum of seven A1 climate category cycles (meteorological temperature and solar radiation) is recommended in order to attain the maximum elevated temperatures throughout the test ammunition. The solar radiation level of 1120 W/m^2 is derived from AECTP 200.

A.1.3. COMMERCIAL LOGISTIC DYNAMICS

A.1.3.1. Packaged Transit Drop 2.1 m

The Transit Drop test (AECTP 400, Method 414) simulates accidental drops encountered in logistical (packaged) handling of the ammunition such as a hovering helicopter dropping the ammunition from a sling or the unloading of ammunition stacked on a truck. The recommended drop height of 2.1 metres is based on the likelihood of ammunition being dropped from the bed of a transport vehicle. Tailoring may be carried out in accordance with the LCEP requirements.

A.1.3.2. Land

A.1.3.2.1. Wheeled Vehicle

The movement of palletised ammunition from the point of manufacture to the storage location is usually accomplished by commercial logistic vehicles over improved or paved highways. This can be addressed by the 'Ground Wheeled Common Carrier' vibration profiles in AECTP 400, Method 401. No factors of safety need to be applied to the amplitude to AECTP 400 vibration schedules as specified. These vibration schedules have been developed from field data and have conservatism factors built into them.

A transportation distance of 20,000 km is suggested in AECTP 100-4. This can be represented by 'Ground Wheeled Common Carrier' vibration testing.

However both the Commercial Logistic Dynamics and the Military Logistic Dynamics by Wheeled Vehicle requirement can be represented by the 'Ground Wheeled Common Carrier' vibration test.

In Table A1-3 distances are given for only a single deployment of small calibre ammunition. The distance for Military Logistic Dynamics by Wheeled Vehicle requirement, for a single deployment, would therefore be assumed to cover any Commercial Logistic Dynamics by Wheeled Vehicle requirement as well.

This environment can degrade the shipping container and ammunition seals prior to climatic exposure and is therefore required to be the first test performed in the life cycle test sequences of Annex B.

A.1.3.2.2. Rail

Based on an assessment that this environment is relatively benign compared to other S3 test environments, testing for this environment is generally excluded. If testing Commercial Logistic Dynamics by Rail is considered necessary, this should be conducted in accordance with AECTP 400, Method 401, Annex E.

Additionally rail vibration and impact testing (in accordance with AECTP 400, Method 416) could also be a requirement for military transportation certification in the US.

A.1.3.3. Sea

Based on an assessment that this environment is relatively benign compared to other S3 test environments, testing for this environment is generally excluded. If testing Commercial Logistic Dynamics by Sea is considered necessary, this should be conducted in accordance with AECTP 400, Method 401.

A.1.3.4. Air

Often there is little information on the vibration environment suggested by Commercial Logistic Dynamics by Air. The nature of Military Logistic Dynamics by Air suggests it is more severe than the Commercial alternative. Therefore it is not normal to test small calibre ammunition for Commercial Logistic Dynamics by Air.

A.1.4. LOGISTIC AND TACTICAL STORAGE

High and low temperature testing is carried out as part of the sequential environmental trial to simulate the thermal exposure, and aggravate associated degradation mechanisms likely to be encountered during logistic and tactical storage.

Throughout their lifecycle, ammunition will be exposed to hot and/or cold thermal environments during storage, transportation and deployment. Periods of deep storage will most likely assume relatively stable (quasi-static) temperature conditions due to the protection offered by most storage facilities, and may be simulated by constant temperature testing. Periods of transportation, deployment and/or field storage typically follow the daily cyclic temperature variation (diurnal cycles) of the local climate since the level of protection is reduced, and may be simulated by cyclic temperature testing. Note that the temperature cycles likely to occur during transportation, deployment and/or field storage will most probably differ from the prevailing meteorological conditions due to a number of localised factors (e.g., packaging construction, transportation/storage mode, climatic factors such as solar radiation, etc.), and induced temperature cycles are recommended on this basis. Further guidance relating to the climate categories, and their derivation, as used by NATO can be found in AECTP 200 Leaflets 2310, 2311/1, 2311/2 and 2311/3.

High temperature exposure (cyclic and constant) tends to aggravate chemical degradation (e.g., stabiliser depletion in nitrate-ester propellants) and/or physical processes (e.g., diffusion of chemical substances, such as plasticisers). Cyclic high temperature exposure also aggravates thermo-mechanical degradation (e.g., thermally induced fatigue) due to differential expansion and contraction of materials and interactions between different materials. Little appreciable chemical ageing occurs at cold temperatures, and thermo-mechanical effects predominate – for example, cold strain cracking due to long periods at constant cold temperatures or thermal fatigue for cyclic exposure.

The specific tests that should be applied depend upon the LCEP (e.g., climate category, and protected vs. unprotected storage/ transportation) and the outcome of the Preliminary Design Safety Assessment and Hazard Analysis. Whatever ageing tests are conducted as part of the sequential trials programme, the resulting life predictions must be compared with the results of surveillance to determine how accurate they were and whether any potential failure modes were missed.

It should be noted that laboratory based ageing studies using small samples of material do not take account of the geometry of the component, so some potential degradation mechanisms could be missed. Furthermore, it should be noted that conditioning time for mechanical environmental tests should not be counted towards life estimates since this is effectively a thermal ramp and it can prove difficult to determine the amount of thermal energy imparted to the ammunition. Therefore, it is difficult to model the equivalent ageing likely to have occurred within the ammunition.

A.1.5. LOGISTIC STORAGE

Logistic Storage is different for the hot and cold stream within the sequential part of the S3 Test Programme, see Figure B-1. Cold Logistic Storage consists of Low Temperature Storage and Thermal Shock, Hot Logistic Storage consists of High Temperature Storage and Thermal Shock.

A.1.5.1. Low Temperature Storage

Ammunition may be exposed to Climate Category C3 conditions during deep storage, although exposure to such extreme conditions is unlikely during transportation and deployment. In Climate Category C3, a constant low temperature of -51 °C is likely to predominate for a significant duration due to a lack of sunlight and solar radiation during the coldest period of the year (AECTP 200 Leaflet 2311/1), with both meteorological and induced conditions becoming aligned. Category C3 applies to the coldest area of the North American continent and the areas surrounding the coldest parts of Siberia and Greenland. A minimum of 72 hours is recommended since this is considered sufficient duration to thermally stabilise the ammunition and has proven sufficient to demonstrate short-term safety in cold climates. Note that this duration is unlikely to aggravate degradation mechanisms associated with constant strain during long term storage at cold temperatures, and longer durations may be required (it is recommended that specific guidance should be sought from the ammunition Design Authority). If it is identified during the Preliminary Design Safety Assessment & Hazard Analysis that the ammunition under test could be susceptible to thermo-mechanical stresses due to low temperature fluctuations, the C2 low temperature cycle or that defined in the LCEP is recommended.

A.1.5.2. High Temperature Storage

If testing at constant elevated temperature is required, +71 °C is the maximum temperature that should be considered since this reflects the induced temperature that is likely to be exceeded for only 1% of the time during ‘field’ storage or deployment in Climate Category A1.

Note that care must be exercised if applying constant temperature testing since this may induce unrepresentative failure modes, or may not adequately exercise all potential failure modes, such that consideration must be given to the design of the ammunition and any known design limitations. For example, gas cracking, phase changes (e.g., melting and exudation) or changes in the chemical reaction mechanism may occur during constant temperature ageing which might not occur during service use. This test should not be conducted instead of high temperature cycling, but may be used to supplement the chemical and physical ageing effects of cyclic temperature testing. If the ammunition under test could be susceptible to high temperature fluctuations, then the A1 storage and transit (induced) cycle or that defined in the LCEP should be used.

A.1.5.3. Thermal Shock

This test is intended to simulate the rapid temperature transitions that are possible during logistic movements of ammunition. The most commonly used approach is to perform three complete cycles that consist of a low temperature profile followed by a high temperature profile. Experience has shown that three cycles (three exposures to each of the two temperatures) is sufficient.

The small calibre ammunition is exposed to a low temperature of -51 °C and sequentially exposed to a high temperature of +71 °C. These temperatures are the low extreme and high induced extremes as presented in AECTP 200, for Climate Category C3 / A1. In most applications, the ammunition will be exposed to the temperature shock environment in its logistic container. If feasible, all testing should be carried out on unpackaged items to provide worst case thermal stress conditions.

A.1.6. MILITARY LOGISTIC DYNAMICS

A.1.6.1. Air

Ammunition may be subjected to transportation by jet and/or propeller fixed wing aircraft or helicopter. Cumulative flight durations for both aircraft types are specified in AECTP 100-4. Each of these environments must be addressed as applicable. Additionally, ammunition may occasionally be subjected to parachute resupply.

A.1.6.1.1. Fixed Wing – Jet Aircraft

For Jet aircraft, the vibration environment associated with cruise is relatively benign and addressed by other vibration environments within the LCEP, and need not necessarily be tested. The take-off vibration environment is significantly more severe than that for cruise, and can be addressed by the vibration profiles in AECTP 400, Method 401 for ‘Jet Aircraft Cargo – Takeoff’. The duration of this test is determined based on the number of takeoff events. The number of takeoff events in the life of the ammunition may be estimated from the total flight duration defined in AECTP 100-4, Annex E, Appendix 1, for each commodity type transported by ‘Jet Aircraft’ divided by an assumed average flight duration of 10 hours per flight.

A.1.6.1.2. Fixed Wing – Turboprop Aircraft

For propeller driven aircraft, the most commonly used aircraft throughout NATO is the C130, of which the four and six bladed propeller variants are most typical (4-blade, f_0=68 Hz and 6-blade, f_0=102 Hz). The vibration severities for these aircraft are defined in AECTP 400, Method 401 for ‘Propeller Aircraft’. If other cargo aircraft are identified as part of the LCEP, then the blade frequencies (f_0) for these shall also require consideration. Since it is not always possible to predetermine the specific aircraft types that will be used during transportation, the total test duration based on the total flight duration defined in AECTP 100-4, Annex E, Appendix 1 for each commodity type transported by ‘Propeller Aircraft’ should be split between the different blade frequencies (f_0) identified. For C130, this will require the test to be divided equally between the two blade frequencies (f_0=68 Hz & 102 Hz) as a minimum.

A.1.6.1.3. Helicopter

Ammunition may be subjected to transportation within a variety of helicopters as part of its LCEP, either internally or as an under-slung load (particularly in a tactical scenario). Some of the more common helicopter types used throughout NATO with a cargo capacity can be grouped according to their fundamental blade frequencies as per Table A1-1.

The vibration environment for these cargo helicopters can be addressed by the vibration profiles in AECTP 400, Method 401 for ‘Helicopter Cargo’. If other cargo helicopters are identified as part of the LCEP, then the blade frequencies (f_0) for these shall also require consideration but only if they are sufficiently different to the 11 Hz, 17 Hz, and 22 Hz already identified.

Table A1-1: Main Rotor Parameters

Helicopter	Main Rotor			
	Rotation Speed, Hz	Number of Blades	Test Frequency (f_1, Hz)	S3 Test Frequency (f_1, Hz)
CH-47D (Chinook)	3.75	3	11.25	11
OH-58A/C (Kiowa)	5.90	2	11.80	
CH-46 (Sea Knight)	4.40	3	13.20	
NH-90	4.26	4	17.04	17
UH-60 (Black Hawk)	4.30	4	17.20	
Sea King / Commando	3.48	5	17.40	
Puma	4.42	4	17.68	
EH101 (Merlin)	3.57	5	17.85	
Gazelle	6.30	3	18.90	
UH-1 (Huey)	5.40	4	21.60	22
CH-53E (Super Stallion)	3.00	7	21.00	
Lynx Mk 1, Mk 2 Mk 3	5.51	4	22.04	
Lynx 3	5.51	4	22.04	
OH-58D (K. Warrior)	6.60	4	26.40	

NOTE 1: This list is not exhaustive. Additional helicopter types may be considered based on the LCEP

NOTE 2: Ref AECTP 400-3

Since it is not always possible to predetermine the specific aircraft types that will be used during transportation, the total test duration based on the total flight duration defined in AECTP 100-4, Annex E, Appendix 1 for each commodity type transported by 'Helicopter' should be split between the different helicopter types identified. For those identified in Table A1-1, this will require the test to be divided equally between the stated blade frequencies (f_1=11 Hz, 17 Hz, and 22 Hz). In AECTP 100-4, small calibre ammunition is expected to be transported up to 50 hours.

For a single deployment, 10 hours as internal cargo by helicopter is expected. Based on this guidance and a test equivalence of 1 hour vibration for 6 hours of flight, helicopter cargo transportation testing would be conducted for 0.5 hours per axis at each of the three blade frequencies for a total of 1.5 hours per axis.

Ammunition may be moved as an under-slung load by helicopter over land and/or subjected to Vertical Replenishment at Sea (or VERTREP). The vibration environment associated with under-slung movement is less severe than internal carriage and can be addressed by other tests in the environmental sequence. In the case of over land movement, the shock associated with set-down will typically be addressed by other tests in the environmental sequence.

For VERTREP, the ship's motion affects the impact velocity and therefore impact is related to sea-state. The AECTPs currently do not provide guidance for suitable test levels for VERTREP, but the values provided in Table A1-2 are based on those from Def-Stan 00-035, Part 3, Issue 5. The impacts at lower sea-states may be addressed by other tests in the environmental sequence so there will be no requirement to specifically test for these, but at sea-states 5 and 6 consideration should be given to addressing these impacts through additional testing. VERTREP is commonly replicated by a freefall impact in accordance with AECTP 400, Method 414 and should be conducted as a sequential test if required.

Table A1-2: Impact Test Severities for VERTREP

Sea State	Total Impact Velocity (m/s)	Equivalent Drop Height (m)
3	3.3	0.6
4	4.0	0.8
5	5.6	1.6
6	6.9	2.4

A.1.6.2. Sea

Based on an assessment that this environment is relatively benign compared to other S3 test environments, testing for this environment is generally excluded. If testing Military Logistic Dynamics by Sea is considered necessary, this should be conducted in accordance with AECTP 400, Method 401, Annex E using the distances specified in AECTP 100-4 for Cargo Ships in the Transportation Mode.

If the ammunition has HE filling, non-contact underwater explosion (UNDEX) must be considered. UNDEX events cause significant shock amplitudes that exceed those from normal handling. UNDEX shock testing in accordance with AECTP 400, Method 419 or appropriate National Standards is a mandatory requirement prior to ship embarkation for some NATO Nations. The overall basis for UNDEX shock is addressed in Allied Navy Engineering Publication (ANEP) 43. Additional guidance may be found in STANAGs 4549 and 4150. The temperature in the ship's hold would be expected to be relatively benign, so testing may be performed under standard ambient conditions (+21 °C). The typical requirement would be for the ammunition to remain 'Safe for Disposal' so testing may be conducted non-sequentially. If, however, the requirement is for the ammunition to remain 'Safe for Use' (as may be necessary for Naval ammunition) UNDEX shock testing must be conducted within the sequence.

A.1.6.3. Land

Transportation as restrained cargo from a point of arrival into the Theatre of Operations (e.g., friendly port or airfield) up to a bulk storage area may be by military transport vehicles and towed trailers travelling over a variety of terrain such as improved or paved highways, and/or degraded roads.

This mechanical environment is defined by both vibration and shock elements. In particular, a shock element to address minor obstacle negotiation for vehicles travelling in an off-road role is necessary. Wheeled Vehicle testing requires separate vibration and shock elements to fully simulate the environment, and as such neither element can be tailored out.

A transportation distance of 20,000 km is suggested in AECTP 100-4 for the lifetime requirement. Table A1-3 summarises the military vehicle transportation distances assumed for only a single deployment of small calibre ammunition.

A.1.6.3.1. Wheeled Vehicle – Common Carrier

Military Logistic Dynamics by Wheeled Vehicle on paved roads and improved highways is comparable to Commercial Logistic Dynamics by Wheeled Vehicle. Testing to the 'Ground Wheeled Common Carrier' vibration profiles in AECTP 400, Method 401 covering the distance given for Tactical Wheeled Vehicle – Common Carrier in Table A1-3 is considered sufficient to cover Commercial and Military wheeled vehicles for a single deployment.

A.1.6.3.2. Wheeled Vehicle – All Terrain

The vibration element for variable terrain such as degraded roads may be addressed by the vibration profiles in AECTP 400, Method 401 for 'Tactical Wheeled Vehicle – All Terrain'. Testing using the distance given in Table A1-3 is considered sufficient.

A.1.6.3.3. Wheeled Vehicle – Shock

The Restrained Cargo Transport Shock levels in Edition 3 of AECTP 400, Method 403, are not currently considered sufficient to satisfy the intent of this test. The levels specified in Table C1-1 are based on Def-Stan 00-035, Part 3, Issue 5 and are considered to be more representative of the actual field levels. The number of shocks specified in Table C1-1 represents those typical for 850 km of transportation and match the distance to be covered by the vibration test for Wheeled Vehicle All Terrain and Trailer.

A.1.6.3.4. Trailer

The vibration element for trailers may be addressed by the vibration profiles in AECTP 400, Method 401 for 'Two Wheeled Trailer'.

A.1.7. ROUGH HANDLING

A.1.7.1. Loose Cargo

Irrespective of the deployment mode, ammunition may be subjected to unrestrained packaged and unrestrained unpackaged sliding or rolling within a tracked or wheeled vehicle. This may be simulated by Loose Cargo testing according to AECTP 400, Method 406.

A.1.7.2. Unpacked Deployment Drop 1.5 m

Irrespective of the deployment mode, ammunition may be subjected to accidental drops during handling, such as during resupply and/or loading into a weapon. This may be simulated by free-fall impact testing according to AECTP 400, Method 414.

The drop heights used will be LCEP specific. The minimum recommended drop height is 1.5 m for all ammunition (to represent manual handling), and the ammunition should remain safe to fire after being dropped.

Additional drop heights should be considered to verify that the ammunition will be safe to dispose if dropped from a greater height (e.g., during loading into the Combat Platform). If ammunition subjected to this test at greater heights is damaged to such an extent that it cannot be fired, and the damage does not create a hazardous condition, subsequent drop tests may be carried out at a reduced drop height to determine the height for all drop orientations at which there is no evidence of physical damage.

A.1.8. TACTICAL STORAGE

Tactical Storage is different for the hot and cold stream within the sequential part of the S3 Test Programme, see Figure B-1. Cold Tactical Storage consists of Low

Temperature Cycling, Hot Tactical Storage consists of High Humidity Cycling and High Temperature Cycling.

A.1.8.1. Low Temperature Cycling

Ammunition may be exposed to Climate Category C2 during storage, transportation and deployment. The induced air temperature diurnal cycle for Category C2 storage and transit conditions given in AECTP 200 Leaflet 2311/1, Annex A, Table 4 is considered to adequately encompass most conceivable situations that may occur during transportation and 'field' storage. Note that at these extreme cold conditions, the meteorological and induced diurnal cycles become aligned. Historically, 14 cold C2 induced temperature diurnal cycles has proven sufficient to demonstrate short-term safety in cold climates. If it is identified during the Design Safety Assessment that the ammunition under test could be susceptible to cold strain effects due to constant low temperature (such as during storage), C3 constant low temperature exposure or that defined in the LCEP is recommended.

A.1.8.2. High Humidity Cycling

The humid heat cycling test is performed to determine the resistance of ammunition to the effects of a warm humid atmosphere. Moisture can alter burning characteristics of propellants. High humidity may promote corrosion degradation. Ammunition may be exposed to this environment year-round in tropical areas and seasonally in mid-latitude areas. The procedure recommended by this document is an aggravated test. It does not reproduce naturally occurring or service-induced temperature-humidity scenarios. In order to reduce the time and cost of testing, the test ammunition is exposed to higher temperature and humidity levels than those found in nature; however, the exposure duration is shorter. A minimum of ten test cycles has proven to be effective at inducing degradation/failures that are indicative of long-term effects. Consideration must be taken for the type of seals to ensure that the duration is adequate and therefore longer test durations may be required to obtain a higher degree of confidence that the ammunition will remain S3 in warm-humid conditions. Annex C, Appendix 1 provides the description of this test.

A.1.8.3. High Temperature Cycling

The induced air temperature diurnal cycle for Category A1 (or Category B3) storage and transit conditions given in AECTP 200 Leaflet 2311/1, Annex A, Table 1 is considered to adequately encompass most conceivable situations that may occur during transportation and 'field' storage. For other environments, such as naval controlled environments, other storage categories may be considered and are LCEP dependent. Historically, 28 hot A1 (or B3) induced temperature diurnal cycles is considered sufficient to aggravate any likely degradation mechanisms expected for an initial deployment. For some nations this may limit field storage life to 3-6 months due to their stockpile management policies and the robustness of the surveillance programmes. Note that 28 diurnal cycles is insufficient to simulate the degradation mechanisms arising during longer term storage, and additional testing may be required within the test sequence. Such testing may take the form of additional diurnal cycles (e.g., 56 diurnal cycles), and/or periods of constant elevated temperature conditioning (note, constant temperature conditioning primarily aggravates chemical and physical processes).

For more advanced propellants (e.g., double or triple-base) it may not be appropriate to dwell at elevated temperatures. Therefore, a constant temperature of +58 °C (associated with the induced temperature likely to be exceeded for only 1% of the time in Climate Zone A3) may be more appropriate where the use of +71 °C is thought to generate unrealistic degradation. This should be considered the minimum for temperate climates unless material characteristics dictate otherwise. Using the Arrhenius kinetic model discussed in AECTP 300 Method 306, Paragraph 2.4.2 'Test Duration', and an activation energy of 70 kJ/mol; constant temperature stressing applied for 216 hours (9 days) at +71 °C, or 528 hours (22 days) at +58 °C, may be taken as being equivalent to 28 A1 induced temperature cycles.

Additional data beneficial to support analysis of the 'safe life' may be gained through exposure to fixed temperature conditioning at different temperatures, or for different durations, followed by ballistic and chemical tests to establish the effects of temperature on these safety parameters – such testing may be conducted non-sequentially on previously unstressed ammunition.

A.1.9. TACTICAL OPERATIONAL DYNAMICS

Ammunition may be deployed on numerous land, sea and/or air platforms or in a man-portable configuration (e.g., for use within a personal weapon). When deployed on platforms, the ammunition may be stowed or in a ready-for-immediate-use configuration (i.e., affixed to a weapon) on either a crew served weapon, remote weapon station or as a secondary armament on an armoured combat vehicle. These multiple configurations make it difficult to set-predetermined test schedules for the final elements of the LCEP. Furthermore, the dynamic environment associated with the combat platform is highly specific to that particular platform. Therefore, 'typical' test requirements are recommended below to address stowed ammunition since this is likely to be the configuration that will be most prevalent before the ammunition is consumed.

A.1.9.1. Land

Ammunition may be deployed on wheeled and/or tracked vehicles; either in a stowed and restrained configuration (i.e., still boxed), stowed but unrestrained, or loaded in weapons magazines in a ready-to-fire configuration. Such platform mounted weapons might include crew-served weapons, remote weapon stations, and/or secondary armaments; each of which might be fired when the platform is static or moving ('fire-on-the-move'). The ready-to-fire and/or fire-on-the-move configuration, if applicable, is assumed to account for at least 20% of the distance travelled on the combat platform. Ammunition may also be stowed within trailers when travelling between locations.

Due to these many variables, tailoring of the vibration and shock environments is recommended based on measured data. Such data and test tailoring should account for the worst case vehicles, stowage configurations and weapon mount configurations wherever possible. AECTP 240 Leaflet 2410 Method 247 provides guidance regarding deriving tailored vibration test severities.

Vibration testing should be conducted in accordance with AECTP 400 Method 401. Shock testing should be conducted in accordance with AECTP 400 Method 403. Where platform specific data is not available, then default severities for wheeled and tracked vehicles may be used.

Deployment on wheeled vehicles may be addressed by the vibration profiles in AECTP 400, Method 401 for ‘Tactical Wheeled Vehicle’ and ‘Restrained Cargo Transport Shock’ to AECTP 400, Method 403.

Deployment on tracked vehicles may be addressed by the vibration profiles in AECTP 400, Method 401 for ‘Light Vehicle – Materiel On Sponson or Installed in Hull’.

As an absolute minimum, testing should address the most severe deployment environment, which are generally considered to be tracked vehicle vibration and loose cargo ‘bounce’. Loose cargo ‘bounce’ is already part of Rough Handling (see paragraph A1.7.1.) and does not to be repeated for Tactical Operational Dynamics.

A.1.9.2. Sea

Ammunition may be deployed on surface ships and small boats either in a stowed and restrained configuration (i.e., still boxed), or mounted to weapons in a ready-to-fire configuration. Such platform mounted weapons might include crew-served weapons, and/or remote weapon stations. Ammunition may be carried on submarines for crew served weapons but is likely to remain stowed for extended periods and spend very little time mounted. Ammunition may also be stowed on Naval vessels for subsequent use by an embarked military force (see paragraph A.1.9.4 for dismounted/man-portable deployment).

The vibration environment associated with larger surface ships and submarines tends to be relatively benign and is likely to have been addressed by other testing within the LCEP so specific testing is unlikely to be required.

Larger surface ships may be subject to relatively severe shock loadings in rough seas, and tailored testing is recommended. Smaller boats tend to demonstrate quite severe vibration and shock loadings due to their size and mass, and tailoring is recommended.

A.1.9.3. Air

Ammunition deployed from aircraft would typically be expected to be mounted to crew-served weapons firing out of doors, but may on occasion be remotely fired from mounts directly affixed to the aircraft structure. General small calibre ammunition may also be loaded into stowed aircrew personal protection weapons.

A.1.9.4. Dismounted/Man-Portable

Ammunition deployed in a dismounted/man-portable role will experience a broad range of service platforms typically employed for movement of personnel (wheeled vehicles, tracked vehicles, helicopters, etc.). The mechanical environment associated with such movement is variable in nature and not easily replicated for testing.

Dismounted/Man-Portable requirements are likely to be largely covered by testing for deployment by other means, transportation and general rough handling, so no specific testing is considered necessary in most cases.

A.1.10. DEFAULT DISTANCES LAND – SINGLE DEPLOYMENT

Table A-2 in Annex A describes the typical LCEP components for the mechanical environment tests. The AECTP 100 distances are considered being the lifetime requirements for the Commercial Logistic Dynamics, Military Logistic Dynamics, Rough Handling and the Tactical Operational Dynamics. Testing using these lifetime distances is not realistic as ammunition will not experience all of these LCEP components to the maximum extent. Table A1-3 shows default distances for a single deployment on land.

Table A1-3: Default Distances Land for a Single Deployment

Lifetime Requirement [1]	Transport Mode [2, 3]	Single Deployment [4]		
		packaged	unpackaged	Total
Commercial Logistic Land Dynamics				
20,000 km Commercial Vehicle	Ground Wheeled Vehicle – Common Carrier	Addressed by Military Logistic Land Dynamics - Tactical Wheeled Vehicle – Common Carrier [5]		
Military Logistic Land Dynamics				
20,000 km Military Vehicle	Tactical Wheeled Vehicle – Common Carrier	1,600 km (palletized)	n/a	1,600 km minimum
	Tactical Wheeled Vehicle – All Terrain	800 km (palletized)	n/a	800 km minimum
	Tactical Wheeled Vehicle – Shock	800 km (palletized)	n/a	800 km minimum
	Two Wheeled Trailer	50 km (palletized)	n/a	50 km minimum
Rough Handling / Tactical Operational Land Dynamics				
5,000 km Military Vehicle	Unrestrained / Loose Cargo	200 km	50 km	250 km minimum
	Tracked Vehicle [6]	800 km	200 km	1000 km minimum

NOTE 1: The Lifetime Requirements are taken from AECTP 100 and are provided as an example only. The most current AECTP 100 value should be considered as the default Lifetime Requirement.

NOTE 2: Table A1-3 summarises the distances assumed for a single deployment of small calibre ammunition on land combat platforms. This only considers deployment by land platforms and does not address the requirements for deployment on sea and air platforms.

NOTE 3: Table A1-3 provides a set of assumptions regarding the subdivision of distances across multiple land platforms, including deployment on military combat vehicles and the dismounted/man-portable configuration for a single deployment.

NOTE 4: The stated distances are assumed to represent the worst case likely to be experienced during one single deployment cycle. For multiple deployments, additional distance may be added as determined by the ammunition LCEP to give the Lifetime Requirement. In some cases, a follow-on surveillance programme will address a multiple deployment scenario.

NOTE 5: For the single deployment scenario it is assumed that the Military Logistic Dynamics by Wheeled Vehicle requirement is sufficient to cover the Commercial Logistic Dynamics by Wheeled Vehicle requirement. See Paragraph A1.3.1 for further explanation of this assumption.

NOTE 6: The combat platform is a complex environment. It is the most likely to require a tailored test approach for the Tactical Operational Dynamics. Where there is no opportunity to tailor then it is considered that the Tracked Vehicle (Light Vehicle – Material on Sponson or installed in Hull) is the most appropriate test levels from the AECTP to use as a default.

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ANNEX A BACKGROUND/RATIONALE
APPENDIX 2 NON SEQUENTIAL SAFETY TESTS

A.2.1. GENERAL

Provided below are the rationale for the Non Sequential Safety Tests related to normal usage in typical environmental conditions, or from plausible mishandling during logistic and field operations.

If only one test configuration is to be used this must be the most severe configuration, packaged or unpackaged, for the ammunition. In most, but not all, cases this is more likely to be the unpackaged configuration.

A.2.2. INSENSITIVE MUNITIONS

For ammunition expected to have significant changes to its vulnerability with age/use, using environmentally stressed ammunition within IM vulnerability test and assessment should be considered.

A.2.3. SAFETY 12 M DROP TEST

This mandatory logistic safety drop test assesses the safety of the ammunition when exposed to a free-fall drop which may be encountered during ship loading operations. This test is conducted as a non-sequential test since it is representing an accident scenario.

A.2.4. HAZARD CLASSIFICATION

For storage and transport purposes, the appropriate ammunition hazard classification shall be determined.

A.2.5. CONTAMINATION BY FLUIDS

Small calibre weapons are exposed to a variety of chemical compounds during storage, cleaning and use. Some exposures are deliberate (such as decontamination efforts) and some are inadvertent (such as contact with insect repellent used by Soldiers).

Select the fluids most commonly encountered throughout the ammunition's life cycle and apply to the unpackaged ammunition per AECTP 300, Method 314 using the intermittent exposure method. Contamination effects must be analysed for their immediate or potential (long term) effects on the safety of the ammunition. A list of typical contaminants can be found in AC/225(LG/3-SG/1)D/14, Table 2.20.

A.2.6. ELECTROMAGNETIC ENVIRONMENTAL EFFECTS

Evidence of Safety to electromagnetic environmental effects is required if the ammunition has components that are sensitive to this environment such as electrical primers and fuzes. Testing must address Hazards of Electromagnetic Radiation to Ordnance (HERO), e.g., high power radio, radar and jamming systems, Electrostatic Discharge (ESD), and Lightning Tests to demonstrate electrical safety.

A.2.7. ALTITUDE

A.2.7.1 Low Pressure (Altitude)

Transportation within cargo aircraft may be within pressurised or unpressurised cargo bays depending upon aircraft type. In the case of pressurised cargo bays, most pressurisation systems replicate external atmospheric pressure up to a particular altitude, and then maintain a stabilised internal pressure at greater altitudes. This stabilised pressure is known as the ‘cabin altitude’. The most common aircraft in NATO service is the C130, for which the cabin altitude may be assumed to be 4570 m with a corresponding pressure of 56.8 kPa, unless otherwise identified. Other values may be substituted based upon LCEP requirements for transportation by other aircraft. The default test parameters provided in AECTP 300, Method 312 are considered appropriate.

A.2.7.2. Cargo Aircraft Decompression

Rapid decompression can result when cabin pressurization is lost during an accident scenario in a transport aircraft. Rapid decompression may result in bursting of the ammunition container and this test is required to verify that the packaging does not present a secondary hazard to the ammunition or aircraft crew. This test should be conducted as part of packaging certification for air transportation and is not necessarily required for ammunition safety testing. However, some ammunition components (e.g., seals) may be susceptible to sudden changes in pressure if the container fails to regulate the pressure in a rapid decompression scenario. If the results of the container rapid decompression test or the ammunition altitude test indicate a potential vulnerability, this test should be conducted on the packaged ammunition. The default test parameters provided in AECTP 300, Method 312 are considered appropriate.

A.2.8. UNDEX SHOCK

If the ammunition has HE filling, non-contact underwater explosion (UNDEX) must be considered.

A.2.9. CORROSION (SALT FOG)

The salt fog test (AECTP 300, Method 309) provides a set of repeatable conditions to determine the relative resistance of the ammunition to the effects of an aqueous salt atmosphere. This test helps to identify potential degradation mechanisms within a relatively short period of time, and is required for ammunition / components that will experience exposure to high levels of salt in the atmosphere. It should be noted that testing at the component level will not address galvanic corrosion.

As a minimum, this AP requires alternating wet-dry-wet-dry conditions of 24 hours each to be imposed. Alternating periods of salt fog exposure and drying conditions provides a higher damage potential than does continuous exposure to a salt atmosphere. The ammunition should be tested in the most severe configuration; that is, outside its shipping/storage container. The number of cycles may be increased if a higher degree of confidence is required to assess the ability of the materials involved to withstand a corrosive environment (e.g., naval-specific environment). Note, there is no relationship between this test and any real world exposure duration but it does provide an indication of potential degradation mechanisms associated with the salt (maritime) environment, nearby water sources, and from salted roads during winter operations.

A.2.10. IMMERSION

The immersion test (AECTP 300, Method 307) determines whether (fresh or salt) water is likely to penetrate the cartridge, affect materials, and/or affect performance of the ammunition during temporary immersion. Temperature conditioning the ammunition to 27 °C above the water temperature represents exposure to solar heating immediately prior to immersion, and induces a slight negative pressure differential within the ammunition (on cooling) to aggravate potential water ingress. Thirty minutes of immersion at a depth of one metre is required for routine fording operations/manoeuvres. There may be a non-routine operational requirement to assess immersion in deep water, such as for combat swimmers, which necessitates immersion testing at higher pressures and for longer durations.

A.2.11. PARACHUTE RESUPPLY DYNAMICS

Ammunition are likely to be resupplied by parachutes, whereupon the ammunition will be expected to remain S3. Parachutes may also fail, resulting in more severe impact velocities whereupon the ammunition is only expected to remain safe for disposal.

A.2.11.1. Low Velocity Parachute Drop

Small calibre ammunition are likely to be resupplied by parachute delivery and are expected to remain S3 following such an event. Low velocity parachute delivery typically results in impact velocities of 9.2 m/s (30 ft/s). If it can be demonstrated that the shock loads to the ammunition in parachute drop are less severe in terms of velocity and spectral content to the 2.1 m transit drop, the parachute drop may be eliminated as a S3 test requirement.

A.2.11.2. High Velocity Parachute Drop

Small calibre ammunition are likely to be resupplied by parachute delivery and are expected to remain S3 following such an event. High velocity parachute delivery typically results in impact velocities of 27.4 m/s (90 ft/s).

A.2.11.3. Malfunctioning Parachute Drop

Small calibre ammunition are likely to be resupplied by parachute delivery and are expected to remain S3 to remain safe such an event, but in the case of a malfunctioning parachute the ammunition is expected to be remain safe for disposal. Malfunctioning parachute typically results in impact velocities of 45.7 m/s (150 ft/sec).

A.2.12. AGEING

Small calibre ammunition will be used in different climate zones. Effects on the propellant will change as temperature rises. In order to investigate this relation between propellant and temperature, ammunition can be subjected to an ageing test in which small quantities are stored at different constant temperatures for 30 days followed by EPVAT testing. The test gives insight into the temperature ageing effects on the propellant.

ANNEX A BACKGROUND/RATIONALE
APPENDIX 3 NON SEQUENTIAL FIRING TESTS

A.3.1. GENERAL

Provided below are the rationale for the Non Sequential Firing Test as part of the S3 package.

A.3.2. BASELINE FIRINGS

Data from firing unstressed ammunition sets a baseline to determine possible effects of the sequential and non-sequential tests. The ammunition should be tested following temperature conditioning at LFT, ambient and UFT.

A.3.3. SYSTEM INTERFACE FIRINGS

The System Interface Firings are intended to provide evidence related to interactions between the weapon and ammunition. Additional testing should be considered to address extreme internal pressures that may result from weapon heating caused by a series of engagements at sustained high rates of fire.

A.3.3.1. Hot Gun Cook Off

The purpose of Hot Gun Cook Off test / assessment is to determine the temperature and time at which ammunition is likely to cook-off when loaded into a hot chamber. Firing ammunition for prolonged periods, or after a series of engagements at high rates of fire may result in sufficient weapon heating to cause ammunition to cook-off if left in the chamber for extended periods (such as during a misfire). A projectile filled with HE may cook-off with a low order detonation if left in a hot gun, destroying the gun and possibly killing the gunner. Additionally, the explosive filling may melt, with the potential for exudation or other effects. A propelling charge loaded into a hot gun may cook-off depending upon the temperature of the chamber wall, heat dissipation, and the construction of the charge. In extreme occasions, a combustible case could ignite as it is being loaded and before the chamber is closed. At a given temperature, the time required for a projectile to cook-off is far greater than that for a propelling charge – although this may not necessarily be the case for novel energetic materials and/or thin walled projectiles. The time to initiate propelling charge cook-off may be within the order of a few minutes. Hot gun cook-off is typically assessed based on the results of gun heating trials and small-scale tests to determine the temperature of ignition of the energetic material(s) used within the ammunition. A trial may be conducted if considered necessary.

A.3.3.2. Double Feed

The purpose of this test is to identify any safety hazard associated with attempting to chamber a live cartridge with a fired case or live cartridge already in the chamber.

This situation can occur due to a weapon fault (a broken extractor, for example) or due to a cartridge fault such as a sheared extractor rim. The double feed test is only required if the Preliminary Design Safety Assessment and Hazard Analysis identifies such an event to be credible.

A.3.3.3. Recoil

Firing a small calibre weapon produces a rearward force that must be absorbed by the gunner or by the weapon system. Excessive recoil can injure the firer and damage the weapon. The purpose of recoil tests is to demonstrate that the recoil energy of fired small calibre ammunition that is transmitted to the firer does not cause injury. The recoil energy of fired small calibre ammunition transmitted to the firer should be below that level which could cause injury to a firer, or prejudice efficient or sustained operation of the weapon.

A.3.4. COMPONENT SECURITY

For safety down range no unintended and unexpected components, especially metal parts, shall have its own trajectory down range. An example is the possible separation of the tracer cup. This test is in addition to determining the debris coming from firing which is expected like sabots.

A.3.5. BORE SAFETY FIRINGS

In addition to the basic safety tests there are additional tests that are required to demonstrate safety of ammunition during firing. Determining the barrel wear by firing and firing through a worn barrel or with a fouled weapon can be unsafe as internal ballistics (pressures) and interaction with the weapon are altered. Although barrel wear is a general issue, it is mainly related to firing with machineguns or automatic weapons due to the high number of rounds fired during their lifetime.

A.3.5.1. Barrel Wear

A barrel wear test may be required for specific firing scenarios such as overhead firing or training scenarios because of the potential hazard to downrange personnel due to increased projectile dispersion or fragmentation. Testing of barrel wear may be required to evaluate the safety of changes in the design of the barrels with a given ammunition. The reverse is also the case. The safety effects of a new or redesigned cartridge with a given barrel must also be evaluated.
In general, barrel wear of machine guns and automatic weapons is of a concern from both a safety, and operational viewpoint. The receiver life of most automatic weapons is multiples of the barrel life. The user needs barrel wear information to determine operational requirements such as the need to carry spare barrels or how many to have readily available. Data from barrel wear testing is also used to develop barrel wear gauges.

A.3.5.2. Worn Barrel

Firing through a worn barrel can result in pressure leakage, but also in physical contact with muzzle attachments like flash hiders. A projectile out of the center line while still in the barrel (balloting), causing a stoppage, is an extreme but likely example. The worn barrel test can be combined with a barrel wear test in which the barrel wear is tested causing a worn barrel.

A.3.5.3. Fouling

Fouling can result in the weapon not being able to fire, but can also result in high stresses while the projectile moves within the barrel. During fouling testing, the effects of combustion residue buildup on weapon system safety are examined.

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ANNEX A BACKGROUND/RATIONALE
APPENDIX 4 NON-SEQUENTIAL TESTS & ASSESSMENTS

A.4.1 GENERAL

Provided below are the rationale for the Non Sequential Test and Assessments as part of the S3 package.

A.4.2. OPERATIONAL AND MAINTENANCE

Operational tests assess the safety of operational and maintenance procedures and equipment during field handling exercises. Human factors engineers (HFE) shall be involved in the planning, conduct, and evaluation of the following tests.

A.4.3. HEALTH HAZARDS

Blast Overpressure, Impulse Noise and Toxicity Tests are primarily tests aimed at examining the level of noise, pressure and toxic gasses produced during firing. The exact conduct of the tests will vary dependent upon the ammunition, weapon, and operational requirement (e.g., proximity of crew and other personnel). The tests can be conducted individually but it is typical to combine them and conduct them concurrently with other tests.

A.4.3.1. Acoustic Energy (Blast Overpressure and Impulse Noise)

Blast Overpressure and Impulse Noise are usually measured when firing at maximum service pressure. If the results with Impulse Noise gauges are at their maximum limit, this test should be repeated using instrumentation with a greater range of measurement. Pressure and Noise are measured at standard crew positions; at predetermined distances from the muzzle and breach; and with the weapon or platform in all standard firing configurations. Usually the ammunition are fired with the gun barrel at prone, kneeling, and standing positions. Special attention should be paid to the directional effects of the backpressure of suppressed weapons. International Standard ISO 10843: 1997 Acoustics - Methods provides further information regarding the description and physical measurement of single, or series of impulses.

A.4.3.2. Toxic Chemical Substances

Toxicity is usually measured at standard service pressure, although cold and low pressure charges may also need examination due to the different obturation that may be achieved at low temperatures and pressures. Propellant gases contain harmful chemical substances such as CO, CO_2, SO_2, NO_x, and HCN, as well as other toxic particulates (e.g., Pb, Cr) that may be hazardous to personnel. These toxic substances are usually modeled based upon the charge composition and then, if necessary, the most hazardous substances are measured during firing. These measurements should be taken at standard crew positions; at predetermined distances from the muzzle and breech; and with the weapon or platform in all standard firing configurations. Toxicity may be assessed using a measured rate of fire or multiple round rapid fire depending on the weapon or platform and analysis technique (Note: there may be a build-up of gases following multiple round rapid fire). Special attention should be paid to the directional effects of the backpressure of suppressed weapons.

A.4.4. RANGE SAFETY AND SUSTAINABILITY

Appropriate testing and analysis shall be conducted to assess range safety and sustainability. The potential for individual and cumulative environmental effects of ammunition use on operational ranges, e.g., the expected deposition of hazardous substances, pollutants and contaminants, or emerging contaminants should be assessed.

A.4.4.1. Weapon Danger Areas / Zones

Appropriate testing and analysis shall be performed to assess the Weapon Danger Areas / Zones (WDA/Z).

A.4.4.2. Debris Field

In addition to the WDA/Z the field of debris shall be assessed. This test is done to determine the spatial distribution of ammunition debris projected from the weapon. Sabot debris is the most common, but items such as shot shell wads, pusher plates, and other components must also be considered. The debris distribution has safety implications, such as when firing over the heads of friendly troops, and is also needed for the determination of range safety fans and training scenarios. If applicable, appropriate testing and analysis shall be performed to assess the Weapon Danger Area / Zone.

A.4.5. DEMILITARISATION AND DISPOSAL

If required, ensure that a verified Demilitarisation and Disposal Plan is prepared for the ammunition.

A.4.6. EOD PROCEDURES

Ensure that verified Explosive Ordnance Disposal (EOD) procedures are developed for new ammunition entering the inventory.

A.4.7. SOFTWARE SAFETY

If applicable, the ammunition software shall be designed, assessed and tested to assure its safety and suitability for service.

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ANNEX A BACKGROUND/RATIONALE
APPENDIX 5 SAFETY OF PROJECTILE,
SAFETY OF PROPELLING CHARGE

A.5.1. GENERAL

Every weapon is essentially a pressure vessel. As such it is necessary to demonstrate that the weapon can hold and vent the pressurised propelling charge gasses, and launch the projectile, as intended, without presenting a hazard to personnel or platform. This is demonstrated through a number of firing tests conducted under various conditions to establish the safe operating pressures for the system. It is important to keep a distinction between the gun system pressure limits and the ammunition system pressure limits. In all cases the ammunition limits must be at or preferably below the gun limits.

A.5.1.1. Weapon Pressure Limits

This AP is only concerned with the ammunition and therefore assumes that the gun barrel, breech and other system components already have established safety and suitability criteria. In order to carry out a safety and suitability for service evaluation for the ammunition during launch there must already be Weapon System Design Pressure (DP) and Weapon System Permissible Maximum Pressure (PMP) limits available. The Weapon System pressure limits may have been determined in parallel with a particular ammunition design. However, in many cases several ammunition types may be developed for a single gun.

A.5.1.2. Projectile Pressure Limits

It is necessary to establish similar pressure limits for the projectile to those established for the weapon. The values for Projectile Design Pressure (PDP) and Projectile Permissible Maximum Pressure (PPMP) will have been established during design and development.

A.5.2. SAFETY OF PROJECTILE

The Strength of Design Test and the Projectile Safety in Gun Test, outlined in Annex C, Appendix 5 have been developed to provide the minimum required evidence that the design actually meets the established values.

A.5.2.1. Strength of Design Test

The Strength of Design Test has been developed to demonstrate that component casings and structures will not permanently deform or break up under the stresses induced between PPMP and PDP. For the purpose of this test, projectiles developed with energetic or hazardous fill shall be tested with inert fills.

The trial is to determine the strength of the projectile at maximum firing stresses. Therefore, it is important to avoid firing rounds that are inherently stronger than the average population. It is recommended that effort is made to select weak projectiles (e.g., minimum metal). However, the critical requirement for the projectiles is that they represent the whole population of manufactured projectiles and that sufficient measurements are taken to ensure they represent that population.

Most conventional ammunition below 20 mm caliber has no obturator band. But, in those rare occasions where the ammunition has an obturator band, this should be considered during the Strength of Design Test, paying particular attention to fragmentation from the obturator and/or excessive gas leakage.

Charge pressure and pressure rise are critical. The maximum stresses must be represented, without exceeding the weapon system Design Pressure (DP). If insufficient pressures are achieved the trial may need to be repeated or a lower Weapon System PMP declared.

The trial is to determine deformation therefore as many rounds as possible should be recovered with as little deceleration and impact damage as possible. This may require overwater recovery or other soft recovery methods.

A.5.2.2. Projectile Safety in Gun Test

The Projectile Safety in Gun Test was developed to demonstrate for any projectile containing energetic or hazardous materials that those materials will not escape or react in bore, or just forward of the muzzle, under the stresses induced at PPMP.

THIS TEST IS ONLY APPLICABLE TO PROJECTILES WITH ENERGETIC MATERIALS.

If sufficient data were obtained during the conduct of the Strength of Design Test or other trial, including the hazardous material, then this specific trial may not be necessary.

Projectiles must be as representative of the overall production population as possible (not specially selected for a particular property).

This trial requires an element of pre-stressing of the hazardous materials. This pre-stressing is to induce as quickly as possible any cracking, de-bonding, separation or powdering that the materials may be prone to. Although environmental test procedures are used to provide the stressing it is not an environmental assessment. Unrepresentative material failure should be avoided but some form of both thermal and mechanical shock needs to be applied. Vibration, Bounce or other cyclic stress testing will also be required if powdering or separation of materials could increase the hazard.

The charges for this trial should produce PMP. If the mean pressure falls below PMP then the declared PMP should become this lower mean, or rounds should be added until a mean of PMP is achieved.

A.5.3. SAFETY OF PROPELLING CHARGE

In order to complete any assessment of the safety and suitability of small calibre ammunition evidence for the following elements of Propelling (Charge) System safety must be provided:

a. Regular ignition (acceptable ignition delay).

b. No signs of pressure-time irregularities.

c. Predictable performance across the required temperature range.

d. Remote chance of exceeding the PMP.

e. Improbable chance of exceeding the System DP.

The above evidence can be collected across all gun firing trials during development and qualification of the ammunition. However, the Preliminary and Final Propelling System Safety Tests, outlined in Annex C of this document, have been developed to provide a systematic and unbiased source for the required evidence.

A.5.3.1. Preliminary Propelling System Safety Test

The Preliminary Propelling System Safety Test is aimed at providing evidence of regular and acceptable Propelling System performance across the required temperature range (addressing paragraphs A.5.3.a. to d. above). If sufficient data are available from an alternate test, then this specific test may not be necessary.

The trial requires propellant from two manufacturing runs (lots). This addresses the possibility of changes in performance between manufacturing runs. The trial also requires a single gun barrel. This is usually a new barrel just after proof to give expected maximum pressure. For conventional (non-chromed) gun barrels, this may be expressed as a barrel with a minimum of 95% wear life remaining.

The gun barrel is drilled to accommodate dynamic recording of the pressure within the gun chamber to provide a record of pressure versus time for each round. If possible pressure is measured at the breech face and just behind the base of the seated projectile. If required the gun barrel could be drilled for pressure measurement along its length to add pressure versus distance data. However, this is rarely specified and only considered necessary for guns with an unusual barrel profile or particularly small predicted safety margin.

The pressure versus time traces and the data for time to pressure maximum and time to shot exit should be examined for any irregularities. Large time delays which could be classified as a hang-fire (nominally in excess of 300 ms for indirect fire and 100 ms for direct fire) or irregular times to pressure maximum or shot exit are considered unacceptable and will require further investigation and possible redesign.

Differential pressures are obtained from simultaneous time-pressure measurements taken at the breech face and just behind the base of the seated projectile. A negative differential pressure occurs whenever the chamber pressure of a weapon at the forward end of the chamber is higher than the pressure at the breech end of the chamber at some time during the pressure-time history. This is a potentially hazardous condition which is indicative of an oscillating pressure wave in the chamber. In firing a round, the initial occurrence of negative-differential pressure will be observed on a pressure-time trace at a time prior to reaching peak pressure. This may be followed by swings to positive, negative, and then positive differential pressures. The peak of the initial negative differential pressure is usually the most significant because it occurs prior to the movement of the projectile. Projectile movement will permit expansion of the gases and a lessening of any negative differential pressure that may exist.

Rounds are fired conditioned at sufficient temperatures to plot the temperature versus pressure profile. As a minimum this should be UFT, LFT and a nominal ambient (usually 21 °C). These data can be used to calculate temperature corrections for the ammunition. The Final Propelling System Safety Test will be fired with rounds conditioned to the temperature which consistently gives the highest pressure. If no temperature consistently gives the highest pressure then the Final Propelling System Safety Test may need to be fired with rounds conditioned at UFT, LFT and nominal ambient.

A.5.3.2. Maximum Operating Pressure Assessment

The Maximum Operating Pressure Assessment is specifically designed to allow Analysis of Variance (ANOVA) techniques to be used to estimate the mean and distribution for the Extreme Service Condition Pressure (ESCP). For a relatively easily calculated, unbiased estimate the data set must consist of rounds split evenly between a minimum of two gun barrels, two propelling charge lots and two separate occasions. Other conditions such as temperature can be introduced but this will complicate the calculations and require additional rounds.

Alternatively a gross mean pressure and variance, assuming a normal distribution, can be estimated. However, statistical confidence cannot be accurately calculated with this alternative method and the effects of the various conditions, particularly propellant lot variation, are harder to detect. Therefore this alternative calculation requires considerably more rounds to achieve a reliable estimate and could still underestimate variance without well-defined manufacturing controls on lot to lot variability.

The primary function of the estimate of ESCP mean and distribution is to determine if the chance of exceeding PMP is remote and the chance of exceeding System DP is improbable. In terms of risk to the gun and ammunition system this equates to; there should be a probability of no more than 1 charge in 1000 exceeding PMP at extreme service conditions; and there should be a probability of no more than 1 charge in 1,000,000 exceeding System DP at extreme service conditions.

The pressures associated with these probabilities are termed the Maximum Operating Pressure (MOP) and Extreme Maximum Operating Pressure (EMOP). Therefore:

$$MOP \leq PMP$$
$$EMOP \leq SDP$$

For the simplistic normal distribution approach the remote estimate for MOP is considered to be mean ESCP plus 3 standard deviations (which is approximately 1 in 1000) and the improbable estimate for EMOP is considered to be mean ESCP plus 4.75 standard deviations (which is approximately 1 in 1,000,000).

The Maximum Operating Pressure Assessment requires the recorded pressures to represent the Extreme Service Conditions. The charges should be conditioned to the temperature that produces the highest pressure.

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ANNEX B S3 TEST PROGRAMME FOR SMALL CALIBRE AMMUNITION

B.1. GENERAL

This document was developed within the international community and is written with primarily references to NATO test procedures. Annex H, Appendix 2, Table H2-1 provides cross reference of similar national and international test standards.

S3 assessment testing of SMALL CALIBRE AMMUNITON LESS THAN 20MM requires a series of sequential environmental tests, operating/firing tests, and non-sequential (standalone) environmental and additional tests.

It should be noted that several non-sequential test requirements (e.g., hazard classification and IM tests) are considered part of the overall S3 programme, but are not governed by this document. For these tests, references are provided for determination of test requirements and quantities.

This annex provides the overall representative S3 test programme presented in the form of test flowchart and an example test asset quantities table for the sequential testing. Figure B-1 is the test flowchart with details of a representative S3 test programme.

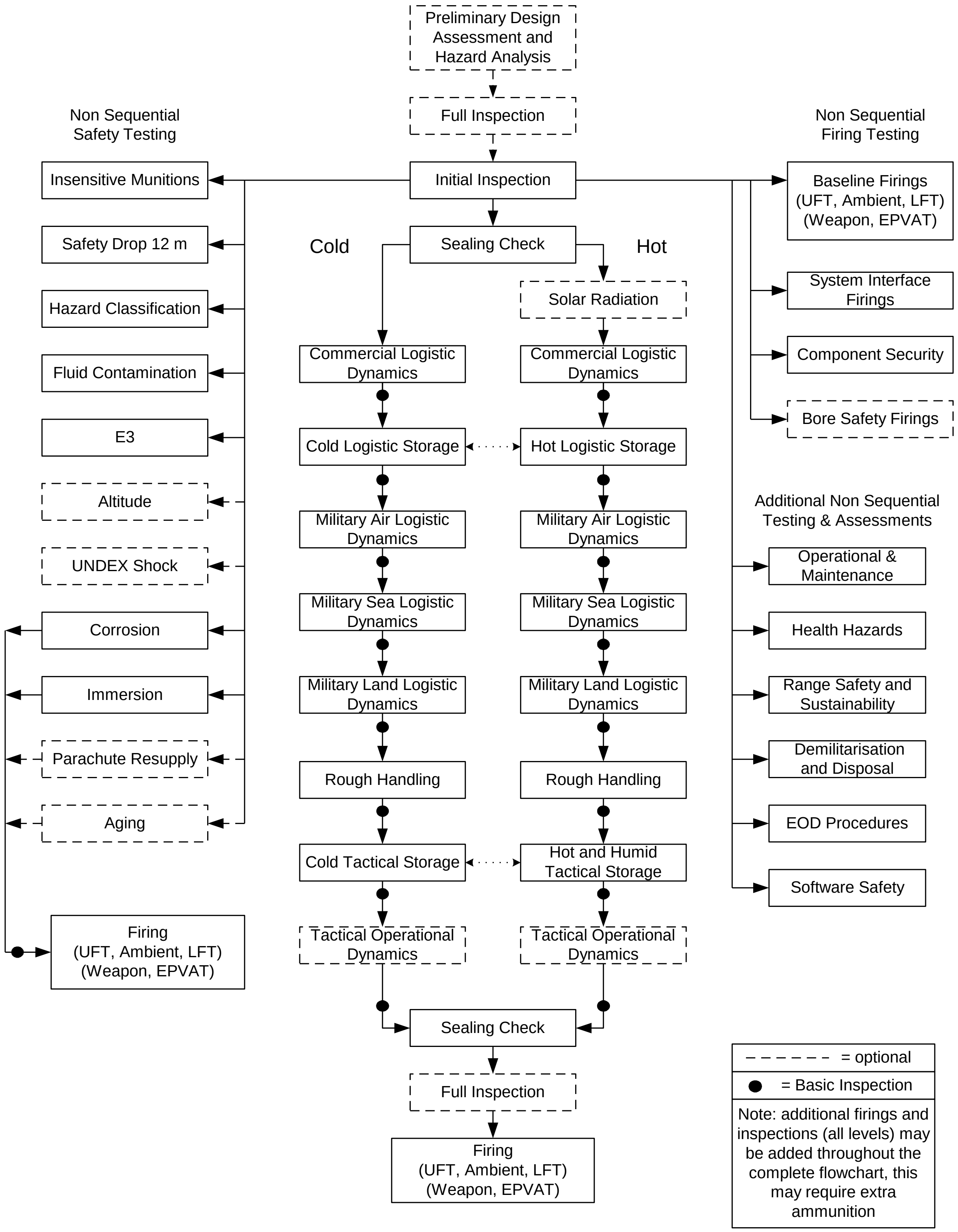

Figure B-1: Representative S3 Test Programme

B.2. SAMPLE QUANTITIES FOR SEQUENTIAL ENVIRONMENTAL TESTING

An example allocation table with recommended sample quantities for Sequential Environmental Testing is given in Table B-1. This example of a total of 26 boxes describes a single deployment with Military Sea Logistics Dynamics and completely separated cold and hot stream.

These quantities correspond to the sequential test flows given in Figure B-1. These quantities can be tailored based upon the logistics unit load or multiples thereof. Care should be taken not to significantly reduce the total quantity. Justification for the test environments and associated test severities can be found in Annex A. The test methods and severities can be found in Annex C.

Upon completion of the sequential environmental tests, ammunition are subjected to a firing test with the ammunition conditioned at LFT, ambient and UFT (in accordance with the guidance given in Annex C). Before the firing test a Full Inspection (in accordance with the guidance given in Annex E) can be performed.

During sequential testing, rounds may become unsafe. If this occurs, remove them from the sequence, set them aside and document the damage for subsequent assessment. Damaged rounds may be replaced but would not count as a full sequential round (i.e., not been subjected to the full sequence). Furthermore, some rounds might become damaged to such extent that they could not be fired but do not present a direct safety hazard. In such cases, these rounds could complete the environmental sequence and may be used for a Full Inspection.

Table B-1: Example Allocation Table

		Cold												Hot												Other / Spare	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	21	23	24	25	26
Initial Inspection		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Baseline Firings																										x	
Sequential Enviromental Testing																											
Sealing Check		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Solar Radiation																											x
Commercial Logistic Dynamics	Packaged Transit Drop 2.1 m	x		x			x	x			x		x	x		x			x	x			x		x		
Cold Logistic Storage	Low Temperature Storage	x	x	x	x	x	x	x	x	x	x	x	x														
	Thermal Shock	x	x	x	x	x	x	x	x	x	x	x	x														
Hot Logistic Storage	High Temperature Storage													x	x	x	x	x	x	x	x	x	x	x	x		
	Thermal Shock													x	x	x	x	x	x	x	x	x	x	x	x		
Military Air Logistic Dynamics	Jet Aircraft	x	x	x		x			x		x	x	x	x	x	x		x			x		x	x	x		
	Turboprop Aircraft	x	x	x	x					x	x	x	x	x	x	x	x					x	x	x	x		
	Helicopter Underslung	x	x		x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x		x	x		
	Helicopter Vertex	x	x		x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x		x	x		
Military Land Logistic Dynamics	Common Carrier	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
	All Terrain	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
	Shock	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
	Two Wheeled Trailer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Rough Handling	Loose Cargo	x			x		x	x		x				x			x		x	x		x					
	Unpacked Deployment Drop 1.5 m	x		x		x			x		x			x		x		x			x		x				
Cold Tactical Storage	Low Temperature Cycling	x	x	x	x	x	x	x	x	x	x	x	x														
Hot and Humid Tactical Storage	High Humid Cycling													x	x	x	x					x	x	x	x		
	High Temperature Cycling													x	x			x	x	x	x			x	x		
Tactical Operational Dynamics	Tracked Vehicle	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Sealing Check		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Full Inspection		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Firing		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		

- Sequential Enviromental Testing only
- Cold and Hot streams completely separated

B.3. SAMPLE QUANTITIES FOR NON-SEQUENTIAL SAFETY TESTS

The sample quantities of ammunition recommended for the non-sequential safety tests depend on different test standards. These tests are Life Cycle dependent and may not necessarily be required. Justification for the test and associated test severities can be found in Annex A. The test methods and severities to use for the non-sequential safety tests can be found in Annex C. Upon completion of the non-sequential safety tests, ammunition are subjected to level 1 inspection, and depending on the subtest results may be subjected to level 2 inspection, level 3 inspection, or be fired.

B.4. SAMPLE QUANTITIES FOR NON SEQUENTIAL FIRING TESTING

The sample quantities of ammunition recommended for the Non Sequential Firing Testing depend on different test standards. The justification and sample quantities for these tests depend upon national policies and design data available. The test methods and severities to use for the safe functioning and weapon interface assessment tests can be found in Annex C.

B.5. SAMPLE QUANTITIES FOR ADDITIONAL NON SEQUENTIAL TESTING AND ASSESSMENTS

The sample quantities of ammunition recommended for the Additional Non Sequential Firing Testing and Assessments depend on different test standards. The justification and sample quantities for these tests depend upon national policies and design data available. The test methods and severities to use for the safe functioning and weapon interface assessment tests can be found in Annex C.

B.6. PRELIMINARY DESIGN ASSESSMENT AND HAZARD ANALYSIS

A minimum of 126 rounds per test is required to perform the Projectile Safety and Propelling Charge Safety Tests as part of the Preliminary Design Assessment and Hazard Analysis (see Chapter 6). Those are not necessary if the design authority / manufacturer has provided reliable data.

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ANNEX C TEST DESCRIPTIONS

This document was developed within the international community and is written with primarily references to NATO test procedures. Test methods which are not currently covered by STANAG or AP are referred to the appropriate national document or International Test Operating Procedure (ITOP).

Annex H, Appendix 2, Table H2-1 provides cross reference of similar national and international test standards. Conflicts between the referenced test methods and the procedures described in this document should defer to the referenced test method.

This Annex provides descriptions of all the tests required in the S3 Test Programme as shown in Figure 3 and Figure B-1. Background and rationale for these tests are provided in Annex A.

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ANNEX C TEST DESCRIPTIONS
APPENDIX 1 SEQUENTIAL ENVIRONMENTAL TEST DESCRIPTIONS

C.1.1. GENERAL

Appendix 1 gives test descriptions for the Sequential Environmental Tests, see Figure 3 and Figure B-1.

C.1.2. SOLAR RADIATION

Perform Solar Radiation testing in accordance with AECTP 300, Method 305, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged and/or unpackaged ammunition.

b. Test Level: AECTP 300, Method 305, Figure 1 'Cycling Test' Category A1. (Temperatures: +32 °C to +49 °C. Irradiance: 0 W/m^2 to 1120 W/m^2).

c. Test Duration: Minimum of three to maximum of seven 24-hour solar cycles to be applied.

C.1.3. COMMERCIAL LOGISTIC DYNAMICS

C.1.3.1. Packaged Transit Drop 2.1 m

Perform drop testing in accordance with AECTP 400, Method 414, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: 2.1 m onto a concrete supported steel surface.

c. Drop Orientation: Each package is to be dropped twice to impact in the following orientations (Note sample size should be sufficient to ensure that all orientations are addressed):

Drop 1: A A A A B B B C C D
Drop 2: B C D E C D E D E E
A - Major axis horizontal
B - Major axis vertical, nose up / base down
C - Major axis vertical, nose down / base up
D - Major axis 45°, nose up / base down
E - Major axis 45°, nose down / base up

d. Test Temperature: Temperature condition the test ammunitions prior to testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT. The drop tests should be conducted within the shortest duration possible upon removal from the conditioned environment. The maximum duration should be no longer than 30 minutes. During transport from the conditioned environment to the test site, it is good practice to minimise heat transfer effects through the use of thermal mitigation measures (e.g., insulated transport box or insulating blanket).

C.1.4. STORAGE

Simulated thermal exposure during logistic and tactical storage is carried out by high and low temperature testing to accelerate any associated degradation mechanisms.

C.1.5. LOGISTIC STORAGE

Logistic Storage is different for the hot and cold stream within the sequential part of the S3 Test Programme, see Figure B-1. Cold Logistic Storage consists of Low Temperature Storage and Thermal Shock, Hot Logistic Storage consists of High Temperature Storage and Thermal Shock. Below descriptions are given for both streams.

C.1.5.1. Low Temperature Storage

Perform Low Temperature testing in accordance with AECTP 300, Method 303, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: Constant temperature of -51 °C.

c. Test Duration: 72 hours (3 days) continuous.

C.1.5.2. High Temperature Storage

Perform High Temperature testing in accordance with AECTP 300, Method 302, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Levels:

(1) Small calibre ammunition that does not contain energetic materials that are temperature sensitive: Constant temperature of +71 °C for 216 hours (9 days).

(2) Small calibre ammunition that contains energetic materials that are temperature sensitive: Constant temperature of +58 °C for 528 hours (22 days).

C.1.5.3. Thermal Shock

Perform Thermal Shock testing in accordance with AECTP 300, Method 304, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged and/or unpackaged ammunition.

b. Test Level:

(1) Low temperature chamber: -51 °C.

(2) High temperature chamber: +71 °C.

c. Test Duration: Three cycles of both the low and high temperature shock tests (6 shocks in total).

d. The ammunition are to remain in each test chamber until temperature stabilisation is achieved (24 hours maximum for unpackaged ammunition).

C.1.6. MILITARY LOGISTIC DYNAMICS

C.1.6.1 Air

These tests address the mechanical environments that may be encountered during military transportation by fixed wing aircraft (propeller and jet) and helicopters. The shocks associated with parachute resupply are tested non-sequentially.

C.1.6.1.1 Fixed Wing Aircraft – Jet Aircraft

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 400, Method 401, Figure C-2 ‘Jet Aircraft Cargo – Takeoff’.

c. Test Duration: Equivalent to 10 % of the total flight duration specified in AECTP 100-4, Annex E, Appendix 1 for transportation by ‘Jet Aircraft’. Assume a minimum test duration of 20 minutes per axis.

d. Test Temperature: Temperature condition the test ammunitions prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.6.1.2. Fixed Wing Aircraft – Turboprop Aircraft

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 400, Method 401, Figure C-1 ‘Propeller Aircraft’ for C130K (4-blade, f_0=68 Hz) and C130J (6 blade, f_0=102 Hz), with L_0 = 1.2 g^2/Hz for f_0. Other aircraft types may be added if their blade passing frequencies (f_0 component) are known.

c. Test Duration: Equivalent to the flight duration specified in AECTP 100-4, Annex E, Appendix 1 for transportation by ‘Turboprop Aircraft’. The total test duration for a stated axis should be split such that each set of blade passing frequencies are addressed equally. (For C130 only, this would require the total test duration to be divided equally between the two blade passing frequencies of 86 Hz and 102 Hz).

d. Test Temperature: Temperature condition the test ammunitions prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.6.1.3. Helicopter

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 400, Method 401, Figure D-1 ‘Helicopter Cargo’. Default blade passing frequencies (f_1 component) of 11 Hz, 17 Hz, and 22 Hz should be used to address most transport helicopter types. Other aircraft types may be added if their blade passing frequencies (f_1 component) are known.

c. Test Duration: Equivalent to a flight duration of 10 hours. The total test duration for a stated axis should be split such that each set of blade passing frequencies (as stated above) are addressed equally. Assume a minimum test duration of 30 minutes per f_1 component per axis.

d. Test Temperature: Temperature condition the test ammunitions prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

Note: This test does not consider the shocks associated with VERTREP to/from ships. If this is a LCEP requirement, refer to Annex A, Appendix 1, Paragraph A.1.3.2.4. for guidance regarding applicable testing.

C.1.6.2. Sea

Based on an assessment that this environment is relatively benign compared to other S3 test environments, testing for this environment is generally excluded, see Annex A. If testing Military Logistics Dynamics by Sea testing is considered necessary, this should be conducted in accordance with AECTP 400, Method 401, Annex E using the distances specified in AECTP 100-4 for Cargo Ships in the Transportation Mode.

C.1.6.3. Land

C.1.6.3.1. Wheeled Vehicle – Common Carrier

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Munition Configuration: Packaged and/or Palletised (depending upon the LCEP).

b. Test Level: AECTP 400, Method 401, Figure A-1 'Ground Wheeled Common Carrier'.

c. Test Duration: Equivalent to 1600 km transportation (Note, this simulates a single deployment).

d. Test Temperature: Temperature condition the test ammunition prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.6.3.2. Wheeled Vehicle – All Terrain

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 400, Method 401, Figure A-2 'Tactical Wheeled Vehicle – All Terrain'.

c. Test Duration: Equivalent to 800 km transportation (Note, this simulates a single deployment).

d. Test Temperature: Temperature condition the test ammunitions prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.6.3.3. Wheeled Vehicle - Shock

Perform shock testing in accordance with AECTP 400, Method 403 using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: All shocks stated in Table C1-1, applied in each sense of each orthogonal axis. The shocks may be applied as either half-sine pulses or a single decaying sinusoidal pulse encompassing both senses in each axis. Terminal peak saw-tooth pulses or Shock Response Spectrum (SRS) methods may be substituted for the levels specified in Table C1-1 if it can be shown to produce equivalent velocities. AECTP 400, Method 417 provides guidance for SRS methods.

c. Test Temperature: Temperature condition the test ammunitions prior to, and during shock testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

Table C1-1: Restrained Cargo Transport Shock Levels

Half Sine Pulse		OR	Decaying Sinusoid	
Duration 5 ms			Frequency (F): 100 Hz Duration (T): 0.37 s (Number of Complete Cycles (N): 37) Damping Factor: 3% of critical	
Amplitude (g pk)	Number of Shocks		Amplitude of First Peak (g pk)	Number of Repetitions
8.0	34		8.0	34
10.0	17		10.0	17
12.0	3		12.0	3

C.1.6.3.4. Two Wheeled Trailer - Vibration.

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 400, Method 401, Figure A-3 'Two Wheel Trailer'.

c. Test Duration: Equivalent to 50 km transportation (Note, this simulates a single deployment).

d. Test Temperature: Temperature condition the test ammunitions prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.7. ROUGH HANDLING

C.1.7.1. Loose Cargo

Either Procedure I or II of AECTP 400, Method 406 'Loose Cargo' should be applied depending upon whether the ammunition in its tactical packaging is likely to slide or roll. The default duration of 20 minutes is considered adequate to address most circumstances.

Perform loose cargo (bounce) testing in accordance with AECTP 400, Method 406, Procedure I or II depending upon packaging, using the following test parameters:

a. Ammunition Configuration: Packaged

b. Test Level: Default values stated in AECTP 400, Method 406, Annex A: 300 rpm circular synchronous motion for 20 minutes. Where possible test in two orientations (horizontal and vertical) dividing total test duration between each.

c. Test Temperature: Temperature condition the test ammunitions prior to, and during testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.7.2. Unpacked Deployment Drop 1.5 m

Perform drop testing in accordance with AECTP 400, Method 414, Procedure I using the following test parameters:

a. Ammunition Configuration: Unpackaged

b. Test Level: Single drop of 1.5 m onto a concrete supported steel surface.

c. Drop Orientation: Each test ammunition is to be dropped once to impact in one of the following orientations. (Note sample size should be sufficient to ensure that all orientations are addressed):

A - Major axis horizontal
B - Major axis vertical, nose up / base down
C - Major axis vertical, nose down / base up
D - Major axis 45°, nose up / base down
E - Major axis 45°, nose down / base up

d. Test Temperature: Temperature condition the test ammunitions prior to testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT. The drop tests should be conducted within the shortest duration possible upon removal from the conditioned environment. The maximum duration should be no longer than 5 minutes. During transport from the conditioned environment to the test site, it is good practice to minimise heat transfer effects through the use of thermal mitigation measures (i.e., insulated transport box or insulating blanket).

C.1.8. TACTICAL STORAGE

Tactical Storage is different for the hot and cold stream within the sequential part of the S3 Test Programme, see Figure B-1. Cold Tactical Storage consists of Low Temperature Cycling, Hot Tactical Storage consists of High Humidity Cycling and High Temperature Cycling. Below descriptions are given for both streams.

C.1.8.1. Low Temperature Cycling

This test may be performed in addition to or as an alternative to the Low Temperature Storage Test at the discretion of the National Safety Authority. Perform Low Temperature testing in accordance with AECTP 300, Method 303, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 230, Leaflet 2311/2, Table 14 ‘C2 Cycles’ (Temperatures: - 37 °C to - 46 °C).

c. Test Duration: 14 diurnal (24-hour) cycles to be applied.

C.1.8.2. High Humidity Cycling

Perform Aggravated Humidity testing in accordance with AECTP 300, Method 306, Procedure I using the following test parameters:

a. Ammunition Configuration: Unpackaged ammunition.

b. Test Level: AECTP 300, Method 306, Figure 1 ‘Aggravated Cycle (cycle 3)’.

c. Test Duration: Ten 24-hour cycles to be applied.

C.1.8.3. High Temperature Cycling

Perform High Temperature testing in accordance with AECTP 300, Method 302, Procedure I using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 300, Method 302, Table 1 ‘High Temperature Diurnal Cycles’ Category A1 Induced Conditions (Temperatures: +33 °C to +71 °C).

c. Test Duration: 28 diurnal (24-hour) cycles to be applied.

C.1.9. TACTICAL OPERATIONAL DYNAMICS

In most instances the mechanical environment is highly specific to the method of deployment and the weapon platform. Therefore, it is recommended that actual environments be measured and used to develop bespoke test criteria whenever possible. The default test severities stated in the following paragraphs are intended to represent minimum test requirements in lieu of actual measured data.

C.1.9.1. Land - Tracked Vehicle

Perform vibration testing in accordance with AECTP 400, Method 401, Procedure III using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: AECTP 400, Method 401, Figure B-4 ‘Light Vehicle – Materiel on Sponson or Installed in Hull’.

c. Test Duration: Equivalent to 1000 km transportation. (Note, this simulates a single deployment).

d. Test Temperature: Temperature condition the test ammunitions prior to, and during vibration testing. Stabilise all cold ammunitions to LCT, and all hot ammunitions to UCT.

C.1.9.2. Sea

Tailoring of the vibration environments is recommended based on measured data. Such data and test tailoring should account for the worst case ship or boat ammunition stowage and weapon mount configurations wherever possible.

AECTP 240 Leaflet 2410 Method 247 provides guidance regarding deriving tailored vibration test severities. Vibration testing should be conducted in accordance with AECTP 400 Method 401.

C.1.9.3. Air

Tailoring of the vibration environments is recommended based on measured data. Such data and test tailoring should account for the worst case aircraft and/or helicopters, stowage configurations and weapon mount configurations wherever possible.

AECTP 240 Leaflet 2410 Method 247 provides guidance regarding deriving tailored vibration test severities. Vibration testing should be conducted in accordance with AECTP 400 Method 401.

ANNEX C TEST DESCRIPTIONS
APPENDIX 2 NON SEQUENTIAL SAFETY TEST DESCRIPTIONS

C.2.1. GENERAL

Appendix 2 gives test descriptions for the Non Sequential Safety Tests, see Figure 3 and Figure B-1.

C.2.2. INSENSITIVE MUNITIONS

The IM test programme shall be conducted in accordance with STANAG 4439 and AOP-39. For a system expected to have significant changes to its vulnerability with age/use, using environmentally stressed ammunition within IM vulnerability test and assessment should be considered.

C.2.3. SAFETY DROP 12 M

This mandatory logistic drop test, as described in STANAG 4375, assesses the safety of the ammunition when exposed to a free-fall drop which may be encountered during ship loading operations.

a. Ammunition Configuration: Packaged or palletised (depending upon the LCEP).

b. Test Level: One freefall drop from a height of 12 m onto a concrete supported steel surface.

c. Drop Orientation: The test ammunition is to be released such that it will approximate an initial impact in one of the following orientations:

(1) major axis vertical, nose up

(2) major axis vertical, nose down

(3) major axis horizontal

d. Test Temperature: Ambient.

C.2.4. HAZARD CLASSIFICATION

Appropriate ammunition hazard classification testing shall be conducted in accordance with STANAG 4123 and AASTP-3.

C.2.5. CONTAMINATION BY FLUIDS

Perform Fluid Contamination testing in accordance with AECTP 300, Method 314, using the following test parameters:

a. Ammunition Configuration: Unpackaged ammunition.

b. Test Requirements: To be tailored according to the LCEP.

C.2.6. ELECTROMAGNETIC ENVIRONMENTAL EFFECTS

If applicable, E3 test programme shall be conducted in accordance with STANAG 4370, AECTP 250 and 500. This testing must address Hazards of Electromagnetic Radiation to Ordnance (HERO), e.g., high power radio, radar and jamming systems, Electrostatic Discharge (ESD), and Lightning Tests that are required to demonstrate electrical safety. Evidence of Safety to electromagnetic environmental effects is required if the ammunition has components that are sensitive to this environment.

C.2.7. ALTITUDE

C.2.7.1. Low Pressure

Perform Low Pressure testing in accordance with AECTP 300, Method 312, Procedure I ‘Storage/Air Transport’ using the following parameters:

a. Ammunition Configuration: Packaged.

b. Test Pressure: 56.8 kPa (4,570 m equivalent altitude).

c. Rate of Pressure Change: 10.3 kPa/s (equivalent to 10 m/s rate of altitude change).

d. Pressure Stabilisation Duration: One hour.

e. Test Temperature: Ambient.

C.2.7.2. Cargo Aircraft Decompression

Perform Rapid Decompression testing in accordance with AECTP 300, Method 312, Procedure III ‘Rapid Decompression’ using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Pressures: Initial pressure = 56.8 kPa.
Final (decompression) pressure = 18.8 kPa.

c. Duration of Pressure Change: 10 ± 5 seconds.

d. Decompression Pressure Stabilisation Duration: 10 minutes.

e. Rate of Pressure Change to Ambient: 10.3 kPa/s (equivalent to 10 m/s rate of altitude change)

f. Test Temperature: Ambient.

C.2.8. UNDEX SHOCK

If national procedures require UNDEX testing, this should be done in accordance with AECTP 400, Method 419 using the following test parameters:

a. Ammunition Configuration: Packaged.

b. Test Level: Test parameters are to be determined by National Authority to ensure Safe for Disposal requirements are met. Guidance can be found in NATO publications ANEP-43, STANAG 4549 and STANAG 4150.

c. Test Temperature: Temperature condition the test ammunitions prior to, and during testing. Stabilise all ammunitions to +21 °C.

Note: This should be conducted as a non-sequential test on a single tactical transportation package if the criteria is ‘safe for disposal’, or during the LCEP life cycle test sequence on selected ammunitions if the criteria is ‘safe for use’.

C.2.9. CORROSION (SALT FOG)

Perform Salt Fog testing in accordance with AECTP 300, Method 309 using the following test parameters:

a. Ammunition Configuration: Unpackaged ammunition ready for operational use.

b. Test Levels: Use default parameters as specified in AECTP 300, Method 309.

c. Test Duration: Minimum of two wet-dry cycles to maximum of four cycles.

C.2.10. IMMERSION

Perform Immersion testing in accordance with AECTP 300, Method 307, Procedure I using the following test parameters:

a. Ammunition Configuration: Unpackaged ammunition.

b. Conditioning Temperature: Ammunition are to be preconditioned to a temperature of 27 °C above the water temperature to represent exposure to solar heating.

c. Depth of Immersion: Complete immersion to a depth of one metre, or equivalent pressure, for routine fording operations/manoeuvres. Depths greater than one metre may be required based on the LCEP.

d. Test Duration: 30 minutes immersion, for routine fording operations / manoeuvres. Durations greater than 30 minutes may be required based on the LCEP.

e. Other: Weigh the test ammunition prior to testing, immediately after testing once surface moisture has been removed, and after drying at laboratory ambient temperature for 24 hours. Alternatively, the ammunition(s) may be disassembled to determine presence of moisture and ingress path(s) or may be fired to determine the internal ballistics.

C.2.11. PARACHUTE RESUPPLY

C.2.11.1 Parachute Drop Shock – Low Velocity

Ammunition may be resupplied by low-velocity parachute delivery and are expected to remain S3 following such an event. Low velocity parachute systems may result in impact velocities of 9.2 m/s (30 ft/sec).

If parachute is an expected mode of deployment, this test should be conducted on a minimum of three ammunition items. This test is normally required for airdrop certification and specific test requirements are subject to approval by the airdrop certifying agency.

a. Ammunition Configuration: Conduct this test on individual packaged or palletized ammunitions with appropriate parachute drop specific padding/crushable material.

b. Test Procedure: This environment may be replicated by either an aircraft drop per ITOP 07-2-509 and ITOP 04-2-601 or may be simulated with a freefall drop. For the simulated drop, conduct one drop in accordance with AECTP 400, Method 414, Procedure I, from a height of 4.3 m onto a hard surface, such as steel or concrete, to simulate a Low Velocity Air Drop. The test item is to be released such that it will approximate an initial impact drop orientation of base down. A laboratory shock test may also be applied if it can be demonstrated to produce an equivalent velocity and loading on the ammunition.

c. Test Temperature: Ambient.

C.2.11.2. Parachute Drop Shock - High Velocity

Ammunition may be resupplied by high-velocity parachute delivery and are expected to remain S3 following such an event. High velocity parachute systems may result in impact velocities of 27.4 m/s (90 ft/sec).

a. Test Configuration: High velocity parachute drops occur in bulk ammunition (palletized) configuration with appropriate supplemental shock isolation commonly used for parachute drop operations.

b. Drop Height: This environment may be replicated by either an aircraft drop per ITOP 07-2-509 and ITOP 04-2-601 or may be simulated with a freefall drop. For the simulated drop, conduct one drop in accordance with AECTP 400, Method 414, Procedure I, from a height of 38 m onto a hard surface, such as steel or concrete, to simulate a Low Velocity Air Drop. The test item is to be released such that it will approximate an initial impact drop orientation of base down.

c. Test Temperature: Ambient.

C.2.11.3. Malfunctioning Parachute Drop

Ammunitions that may be resupplied by parachute delivery are at risk of a malfunctioning parachute drop scenario and are expected to remain safe for disposal. Malfunctioning parachute systems may result in impact velocities of 45.7 m/s (150 ft/sec).

a. Test Configuration: Malfunctioning parachute drops occur in bulk ammunition (palletized) configuration with appropriate supplemental shock isolation commonly used for parachute drop operations.

b. Drop Height: This environment may be replicated by either an aircraft drop per ITOP 07-2-509 and ITOP 04-2-601 or may be simulated with a freefall drop. For the simulated drop, conduct one drop in accordance with AECTP 400, Method 414, Procedure I, from a height of 106 m onto a hard surface, such as steel or concrete, to simulate a Low Velocity Air Drop. The test item is to be released such that it will approximate an initial impact drop orientation of base down.

c. Number of Drops: It is not expected that an ammunition would be dropped more than once from this extreme height during its service life; thus, only one drop is required.

d. Test Temperature: Ambient.

C.2.12. AGEING: 30-DAY CONSTANT TEMPERATURE STORAGE TEST

Perform High Temperature testing in accordance with AECTP 300, Method 302, Procedure I using the following test parameters:

a. Ammunition Configuration: Unpackaged or in cardboard carton.

b. Test Level: Constant temperature conditioning for 30 days at each of the following temperatures.

   i. 40 rounds at -54 °C,
   ii. 40 rounds at +21 °C,
   iii. 40 rounds at +54 °C,
   iv. 40 rounds at +60 °C,
   v. 40 rounds at +65 °C (for information),
   vi. 40 rounds at +71 °C (for information).

c. Post Firing Test: Immediately perform EPVAT firings for ten rounds reconditioned for a minimum of 24 hours at -54 °C and for ten rounds reconditioned for a minimum of 24 hours at +21 °C from each 'storage' regime (i.e., i to vi). If the ballistics data are as expected, continue with EPVAT firings reconditioned for a minimum of 24 hours at +54 °C of ten of the remaining rounds from each 'storage' regime. If the ballistic data are anomalous (e.g., pressure peaks, high pressures, etc.) the propellant from ten of the remaining rounds should be extracted for chemical analysis, and/or additional EPVAT firings should be performed at -54 °C.

ANNEX C TEST DESCRIPTIONS
APPENDIX 3 FIRING TEST DESCRIPTIONS

C.3.1. GENERAL

Appendix 3 gives test descriptions for the firing tests with both stressed and/or unstressed ammunition, see Figure 3 and Figure B-1.

C.3.1.2. Weapons

If the ammunition is intended for use in more than one type of weapon, distribute the firings across a representative subset of these weapons. This may be necessary where it is not feasible to conduct all ammunition testing with each intended weapon due to the sample size of ammunition required.

Firing tests might be undertaken using barrels with different wear life remaining, for example less than 25%, 50% and more than 75%.

Inspect the weapon(s) periodically in accordance with national procedures throughout testing, and whenever there are unexpected occurrences such as projectile breakup, cartridge case rupture, or unexpectedly high chamber pressure.

C.3.2. BASELINE FIRINGS

Fire unstressed ammunition at LFT, ambient and UFT in both single shot and burst (if applicable) to establish a baseline (reference) for comparison with environmentally stressed ammunition using standard weapons and EPVAT equipment. Burst firings (if applicable) should establish correct functioning of the weapon and determine the rate of fire at each temperature (except externally driven weapons). Dispersion of rounds on a target shall be determined. Single shot firing should be through an EPVAT barrel to establish correct internal ballistic parameters (pressure), action times and muzzle velocities for each temperature.

C.3.3. SYSTEM INTERFACE FIRINGS

C.3.3.1. Hot Gun Cook Off Test

This test determines the maximum number of rounds that can be fired semi-automatically or automatically from the weapon before the chamber becomes hot enough to cause the propellant to cook-off, i.e., ignite spontaneously, if a cartridge is resting in the chamber. Guidance can be found in NATO Manual AC/225(LG/3-SG/1)D/14 section 2.14.

C.3.3.2. Double Feed

A cartridge case with a live primer (or live cartridge, depending on national requirements) is loaded into the chamber and a live round is then loaded with the goal to impact the primer of the chambered cartridge case. Guidance can be found in NATO Manual AC/225(LG/3-SG/1)D/14 section 2.10.

C.3.3.3. Recoil

Firing a small calibre weapon produces a rearward force that must be absorbed by the shooter or by the weapon mount. Excessive recoil can degrade training, injure the shooter, and damage weapon mounts. Guidance can be found in AC/225(LG/3-SG/1)D/14 section 2.11.

C.3.4. COMPONENT SECURITY

This test can be combined with other firings, for example Debris Field. The setup consists of multiple witness screens to determine possible unintended and unexpected components, especially metal parts, having its own trajectory.

C.3.5. BORE SAFETY FIRINGS

C.3.5.1. Barrel Wear

The nature of this test requires firing an unusually large number of rounds per day using one or more barrels using machineguns or automatic weapons. Personnel should be provided with suitable protective equipment such as heavy gloves and attire for protection from hot gun barrels and expended cartridge cases. The large number of rounds fired may also increase toxic fumes to levels above those more typically encountered. Since weapon barrels are fired to, or past, the limits of serviceability, personnel must consider the possibility of erratic bullet flight and deviations from the established line of fire:

a. Thoroughly inspect the test barrel(s). Record the bore dimensions at 25 mm intervals for the entire length of the barrel. Inspect the bore with a borescope; photograph or make video recordings of any defects, discontinuities, or areas of concern. Determine the chamber dimensions by chamber casts. If possible, check the inspection results for compliance with barrel drawings and specifications.

b. Determine the specific firing schedule to be used for the test. The firing schedule may be specified in the requirements documents or may be determined by the user, usually based on a tactical situation. Use the firing cycles detailed in the reliability test if no other information is available. All planned test schedules should be conducted with one lot of ammunition. If additional ammunition lots are required, they should be of the same type as the first lot.

c. Initiate the test by firing three targets (one 10-round burst per target). Muzzle velocities and cyclic rates are recorded for each burst. The targets should be set at 100 m from the weapon, unless otherwise specified. Targets must be capable of recording the X and Y coordinates of the bullet impacts and must facilitate inspection of the impacts to determine bullet yaw. A common technique is to determine X and Y coordinates with an electronic target and to determine bullet yaw with a paper target placed in the line of fire at 25 m.

d. Fire the barrels using the predetermined firing schedule. Repeat the barrel inspections and target firings at 2,000-round intervals unless otherwise specified.

e. Terminate the test when the barrels become unserviceable or when a predetermined round count is reached. Use the following criteria to determine unserviceability if no other information is available:

(1) A barrel wear gauge designed for the specific barrel under test indicates that the barrel is unserviceable.

(2) Twenty percent or more of rounds fired at the targets, or 20 percent of any group of rounds or more, exhibit yaw of 15° or more.

(3) The mean velocity of any 30 consecutive rounds drops 6 percent or more below the mean velocity of the first 30 rounds fired.

(4) The average dispersion of three consecutive 10-round targets is double that of the initial three targets

f. Degradation happens very rapidly near the end of the barrel life; therefore, the 2,000-round inspection interval should be reduced if it is evident that the barrel is near the end of its life. Test personnel must always be alert for indications of imminent barrel failure. These indications may include an increase in muzzle flash, erratic flight of bullets, an increase in the malfunction rate, or any other significant change in weapon performance.

g. Firing schedule interruptions during barrel wear tests must be avoided in order to produce the best quality data. Therefore, weapons must be maintained to a high standard. Inspect the ammunition prior to starting each firing cycle to assure its proper condition. Also, periodically inspect weapon mounts and instrumentation. If an operator clearable malfunction occurs, and is cleared in less than 10 seconds, testing may continue.

h. Recordings:

(1) Barrel bore measurements;

(2) Chamber dimensions;

(3) Details of the firing cycle;

(4) Identification of the ammunition;

(5) Velocities and cyclic rates from the target firings;

(6) Target dispersion statistics;

(7) Target yaw measurements;

(8) Weapon maintenance actions;

(9) Weapon stoppages and malfunctions;

(10) Observations of any adverse weapon effects due to the firing schedule.

C.3.5.2. Worn Barrel

This subtest determines the effects of firing through a worn barrel and is likely to be combined with the barrel wear test as described in C3.5.1. Since worn barrel(s) are past the limits of serviceability (see C3.5.1.e.), personnel must consider the possibility of erratic bullet flight and deviations from the established LOF when firing through:

a. Thoroughly inspect the test barrel(s). Record the bore dimensions at 25 mm intervals for the entire length of the barrel. Inspect the bore with a borescope; photograph or make video recordings of any defects, discontinuities, or areas of concern. Determine the chamber dimensions by chamber casts. If possible, check the inspection results for compliance with barrel drawings and specifications.

b. All planned test schedules should be conducted with one lot of ammunition. Foreseen total amount of ammunition is 100 rounds.

c. Test personnel must always be alert for indications of imminent barrel failure during execution of the test. These indications may include an increase in muzzle flash, erratic flight of bullets, an increase in the malfunction rate, or any other significant change in weapon performance.

d. Execute the test by firing on targets (10 single shots or one 10-round burst per target). Muzzle velocities and cyclic rates if applicable are recorded. The targets should be set at 100 m from the weapon, unless otherwise specified. Targets must be capable of recording the X and Y coordinates of the bullet impacts and must facilitate inspection of the impacts to determine bullet yaw. A common technique is to determine X and Y coordinates with an electronic target and to determine bullet yaw with a paper target placed in the LOF at 25 m.

e. Thoroughly inspect the test barrel(s) after the test. Record the bore dimensions at 25 mm intervals for the entire length of the barrel. Inspect the bore with a borescope; photograph or make video recordings of any defects, discontinuities, or areas of concern. Determine the chamber dimensions by chamber casts.

f. Recordings:

(1) Barrel bore measurements;

(2) Chamber dimensions;

(3) Details of the firing cycle;

(4) Identification of the ammunition;

(5) Velocities and cyclic rates from the target firings;

(6) Target dispersion statistics;

(7) Target yaw measurements;

(8) Weapon maintenance actions;

(9) Weapon stoppages and malfunctions;

(10) Observations of any adverse weapon effects due to the firing schedule.

C.3.5.3. Fouling

This subtest determines the effects of combustion residue buildup on weapon system safety. The test is done at cool ambient temperatures to encourage condensation and the accumulation of residue. A relatively small number of rounds are fired at large time intervals to prevent weapon heating that would tend to evaporate residue deposits:

a. Maintain three test weapons in accordance with the maintenance literature for a temperature of -7 °C (20 ± 5 °F). Condition the weapons, ammunition (300 rounds per hand or shoulder weapon, 500 rounds per machine gun), and magazines in an environmental facility at -7 °C (20 °F) for at least 12 hours before initiating firing.

b. Two firings are done each day for five days. The daily firings are separated by a minimum of 4 hours. For hand and shoulder weapons, each firing consists of 30 rounds fired semi-automatically at a rate of approximately one round per second. For machine guns, each firing consists of 50 rounds fired in three- to five-round bursts. Firings should be done from within the conditioning chamber. If this is not possible, remove the weapons for firing and replace them into the conditioning chamber as quickly as possible.

c. Weapons are not maintained during this test unless a weapon is rendered inoperable by the test environment. If this occurs, perform minimum restorative maintenance, and continue testing until completed. Do not remove the weapon from the test environment to perform maintenance.

d. Recordings:

(1) Chamber dimensions;

(2) Details of the firing cycle;

(3) Identification of the ammunition;

(4) Velocities and cyclic rates from the target firings;

(5) Weapon maintenance actions;

(6) Weapon malfunctions;

(7) Observations of any adverse weapon effects due to the firing schedule.

C.3.6. FIRING AFTER SEQUENTIAL ENVIROMENTAL TESTS

The environmentally stressed ammunition shall be fired in accordance to the Baseline Firings, see paragraph C.3.2. Firings should also be considered to collect data to assess Safe and Arming Distances, Debris Field and Component Security as applicable.

C.3.7. FIRING AFTER NON SEQUENTIAL SAFETY TESTS

C.3.7.1. Firing After Corrosion Stressing

The environmentally stressed ammunition shall be fired in accordance to the Baseline Firings, see paragraph C.3.2. Firings should also be considered to collect data to assess Safe and Arming Distances, Debris Field and Component Security as applicable.

C.3.7.2. Firing After Immersion Stressing

As Baseline Firings, but with stressed ammunition through an EPVAT barrel only, see paragraph C.3.3.1.

C.3.7.3. Firing After Parachute Resupply Stressing

As Baseline Firings, but with stressed ammunition, see paragraph C.3.2.

C.3.7.4. Firing After Ageing Stressing

Single shot firing shall be through an EPVAT barrel to establish correct internal ballistic parameters (pressure), action times and muzzle velocities as described in paragraph C.2.12.

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ANNEX C TEST DESCRIPTIONS
APPENDIX 4 ADDITIONAL NON SEQUENTIAL TESTS AND ASSESSMENTS

C.4.1. GENERAL

Appendix 4 gives test descriptions for the Additional Non Sequential Tests and Assessments, see Figure 3 and Figure B-1.

C.4.2. OPERATIONAL AND MAINTENANCE

Operational tests assess the safety of operational and maintenance procedures and equipment during field handling exercises. Human factors engineers (HFE) shall be involved in the planning, conduct, and evaluation of the following tests.

C.4.2.1. Operation and Maintenance Simulation

Soldiers using inert ammunition and non-maintenance support items perform tactical transportation, system handling, and firing operations tests under simulated battlefield conditions. Human factors engineering tests during simulated firing missions include setup, ammunition loading, and simulated firings. Training exercises are performed with the complete training package. The operator manuals are reviewed and followed during the above. Operators wear temperate weather and arctic clothing and nuclear, biological, chemical (NBC) masks and clothing. The tester will consider performing a low-temperature (cold room) operational test to assess the soldier's ability to operate the weapon with protective gear. Live ammunition may be used once enough testing has been completed to satisfy the safety authorities that the system is safe for use. Review and exercise the system support package. Assess the safety of preventive and corrective maintenance operations up to depot level. Simulated system faults may be used to exercise test sets and other test, measurement, and diagnostic equipment. Use maintenance manuals for these exercises and evaluate them in terms of safety.

C.4.2.2. Human Error Checklist

Develop a checklist of "Common Sources of Human Error" to categorize human errors that occur during operational tests and to suggest potentially hazardous human errors that apply to the system. Develop additional safety checklists to address electrical, mechanical, and miscellaneous safety items. Information for developing this checklist is specified in STANAG 7201.

C.4.2.3. Operational and Maintenance Report

Record, describe, and score actual and potential unsafe operations and maintenance practices by using observations, video records, checklists, measurements, and operator and maintainer debriefings. Note, the experience and impressions gained by the test persons during handling of the equipment should be recorded during and/or immediately after the tests. This could be done best in the form of standardized interviews made by persons who are experienced in social sciences (e.g., HFEs) using a catalog of previously determined questions. The interview results shall be evaluated based on social science criteria (statistical evaluation, etc.).

C.4.3. HEALTH HAZARDS

Health hazard data are to be collected during the Firing Tests (see Annex C, Appendix 3). The hazards to be assessed for small calibre ammunition are described below.

C.4.3.1. Acoustic Energy (Impulse Noise and Blast Overpressure)

During Firing tests, measure blast overpressure and acoustic noise to determine if the shock wave damages structures and/or injures personnel (especially hearing). Test in accordance with ITOP 04-2-822.

C.4.3.2. Toxic Chemical Substances

Collect and analyze toxic chemical data during firing tests. Pretest analysis is recommend to determine most likely combustion products (gaseous and particulate) and their concentrations. The test design should encompass configurations most likely to produce the greatest toxic fume hazards. Gas concentrations (for example CO, CO_2, SO_2, NO_x, and HCN) shall be measured at the operator's face and at other strategic locations. The resulting values should be presented in the form of concentration versus time curves and integrated over time to produce the equivalent exposure. The toxic substances under review must be examined by toxicologists, human factors engineers, physicians and/or ecologists for potential human (exposure time and dose) health hazards. These hazards shall be evaluated with respect to the envisaged operational environment and on the basis of pertinent national laws and regulations.

C.4.4. RANGE SAFETY AND SUSTAINABILITY

In accordance with AOP-15, appropriate testing and analysis shall be conducted to assess range safety and sustainability. The potential for individual and cumulative environmental effects of ammunition use on operational ranges, e.g., the expected deposition of hazardous substances, pollutants and contaminants, or emerging contaminants should be assessed.

C.4.4.1. Weapon Danger Areas / Zones

Appropriate testing and analysis shall be performed to assess the Weapon Danger Areas / Zones in accordance with STANAG 2401, STANAG 2240, and Allied Range Safety Publication (ARSP)-1 VOL II.

In addition to the Weapon Danger Areas / Zones the field of debris shall be assessed. This test is done to determine the spatial distribution of ammunition debris projected from the weapon. Sabot debris is the most common, but items such as shot shell wads, pusher plates, and other components must also be considered. The debris distribution has safety implications, such as when firing over the heads of friendly troops, and is also needed for the determination of range safety fans and training scenarios.

C.4.4.2. Debris Field

This test can be combined with other firings, for example Component Security. The setup consists of multiple witness screens to determine to spatial distribution in width and length of debris seen from the muzzle. The number and position of witness screens depends on the nature of the ammunition. A range with a horizontal surface without any form of debris already present is preferred for the test.

C.4.5. DEMILITARISATION AND DISPOSAL

Ensure a verified Demilitarisation and Disposal Plan is prepared for the ammunition in accordance with STANAG 4518 or respective national requirements.

C.4.6. EOD PROCEDURES

Ensure that verified Explosive Ordnance Disposal (EOD) render safe procedures are developed for new ammunition entering the inventory in accordance with national requirements.

C.4.7. SOFTWARE SYSTEM SAFETY

If applicable, ammunition software shall be designed, assessed and tested to assure its safety and suitability for service in accordance with AOP-52.

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ANNEX C TEST DESCRIPTIONS
APPENDIX 5 SAFETY OF PROJECTILE, SAFETY OF PROPELLING CHARGE

C.5.1. GENERAL

The projectile shall be designed such that it will be able to withstand the forces generated by the pressure of the propelling charge and the weapon during firing and the pressure generated by the propelling charges during firing shall be in accordance with both the weapon and the projectile safe operating limits to ensure safe firing.

C.5.2. SAFETY OF PROJECTILE

C.5.2.1. Strength of Design Test

Strength-of-design tests are conducted to verify that projectile and cartridge case structural components can withstand the maximum firing stresses at LFT and UFT. In the case of projectiles containing a hazardous filling (e.g., those containing high explosive), these should be filled with an inert stimulant material during preliminary firings.

The test is done by firing through an overpressure barrel (representative of standard in-service weapons) such as that used for Electronic Pressure, Velocity, & Action Time (EPVAT). Vertical witness screens are used to detect parts or fragments that may separate from the projectile while it is in bore or in the early part of its flight.

C.5.2.1.1. Method

a. The weapon used for this test shall have a minimum of 75% wear life remaining. Thoroughly inspect the test barrel(s). Record the bore dimensions at 25 mm intervals for the entire length of the barrel. Inspect the bore with a borescope; photograph or make video recordings of any defects, discontinuities, or areas of concern. If possible, check the inspection results for compliance with barrel drawings and specifications.

b. Witness screens may be constructed of any convenient material; fiberboard and light plywood are commonly used. The surface of the screens is smooth, clean, and light colored (white paint may be required) to facilitate inspection. A hole is cut in the centre of each screen so that the projectiles may pass through unimpeded. One screen should be placed as close to the muzzle as feasible, usually at 5 m for calibres less than 20 mm. A screen should be erected at the maximum practicable distance, usually at 50 m. At least two screens should be placed at intermediate distances.

c. Either:

(1) Fire a minimum of 459 rounds, divided in three equal groups, at LFT, +21 °C and UFT. This will indicate 99% reliability at 99% confidence if there are no failures.

Or:

(2) Fire 10 rounds preconditioned at LFT and 10 rounds preconditioned at UFT with propelling charges that will yield an overpressure as close as possible to DP for the ammunition (for guidance, DP may be approximated as 105 % PMP, and PMP may be approximated as at least 130 % of the mean pressure at +21 °C). This can be achieved either by further temperature conditioning and/or by providing a special propelling system to develop the required chamber pressure.

C.5.2.1.2. Data Required

a. General Test Data:

(1) Date of test and location;

(2) Weapon configuration and component serial numbers;

(3) Weapon inspection results before and after testing;

(4) Meteorological conditions of wind and air temperature.

b. Round by Round:

(1) Time of firing;

(2) Ammunition configuration and lot numbers;

(3) Muzzle velocity;

(4) Chamber / case-mouth pressure (Option 2);

(5) High speed video / still imagery of projectile exiting the weapon (Option 2);

(6) Ammunition temperature;

(7) Description of witness screen material and size;

(8) Location of witness screens;

(9) Location of marks relative to the line of fire and weapon position;

(10) Inspect the witness screens after each shot. Look for imbedded debris, perforations, smudges, and any other markings on the screen. Measure and photograph any perforations and marks;

(11) Inspect the cartridge case for splits, buckling, primer damage or any other damage.

C.5.2.2. Projectile Safety In Gun Test

Safety in gun tests are conducted to give assurance that fully live ammunition can safely be fired at extremes of service conditions. THIS TEST IS ONLY APPLICABLE TO PROJECTILES WITH ENERGETIC MATERIALS. The ammunition is subjected to pre-firing environmental stressing, that simulates the extreme temperature environments and severe shocks, bumps and drops that ammunition may receive during operational use.

C.5.2.2.1. Method

Make pre-fire dimensional measurements (diameters, hardness weight) on projectiles to be fired. Compare with drawing requirements. If satisfactory, proceed with the test.

The weapon used for this test shall have a minimum of 75% wear life remaining. Examine the weapon bore with a borescope and record its condition; measure the bore at intervals of 25 mm for its complete length. The weapon should be equipped the same as it will be used in service; flash hiders, muzzle brakes, noise suppressors, etc. must be installed.

The number of test samples needed depends heavily on the type of test and what the test results are expected to accomplish or support. The number of rounds to be fired depends on the required reliability and confidence level. If no guidance is given a sample of twenty rounds is usually taken.

Subject the test sample in sequence to:

a. High temperature storage test.

(1) Ammunition Configuration: Bare.

(2) Test Level: 7-day temperature cycle using the Climatic Category A1 of AECTP 200.

b. Low temperature storage test.

(1) Ammunition Configuration: Bare.

(2) Test Level: 7-day temperature cycle using the Climatic Category C3 of AECTP 200.

c. Level I inspection.

d. Loose cargo test.

(1) Ammunition Configuration: Bare.

(2) Test Level: Default values stated in AECTP 400, Method 406, Annex A, 300 rpm circular synchronous motion for 20 minutes.

(3) Test Temperature: Ambient temperature.

e. Level I inspection.

f. Drop test.

(1) Ammunition Configuration: Bare.

(2) Test Level: One drop in accordance with AECTP 400, Method 414, Procedure I for each round of 1.22 m onto a concrete supported steel surface.

(3) Drop orientation: Major axis horizontal, nose down/bottom up.

(4) Test Temperature: Ambient temperature.

g. Level I inspection.

h. The rounds will be fired at LFT and UFT.

C.5.2.2.2. Data Required

a. Identification of ammunition and support weapon;

b. Meteorological conditions of wind and air temperature;

c. Ammunition temperature;

d. Velocity versus time as recorded by the Doppler radar;

e. Target impact coordinates, if appropriate;

f. Observation of any abnormalities in target impact markings;

g. Examine the weapon bore with a borescope and record its condition; measure the bore at intervals of 25 mm for its complete length;

h. Description and location of target screen material and size;

i. Thoroughly inspect the target screens after firing at each temperature for any abnormal marks.

C.5.3. SAFETY OF PROPELLING CHARGE

C.5.3.1. Preliminary Internal Ballistics Assessment

Preliminary Internal Ballistics Assessment testing is conducted to establish the ammunition temperature coefficient, and to verify correct internal and external ballistics for the ammunition.

Ammunition used in this test should use the projectile that gives rise to the highest chamber pressure (if the propelling charge is used with multiple different projectiles).

This test is done by firing production build-standard ammunition, preconditioned to different temperatures, through an overpressure barrel (representative of standard in-service weapons) such as that used for EPVAT. If alternative projectiles are used, they must possess identical internal ballistics characteristics, volume intrusion into the propellant bed / cartridge case and crimp geometry to the service projectile.

Note that Parts 1 and 2 of the Propelling Charge Safety Tests may be combined but the sample quantities will necessarily be greater than those quoted in the methods to gain sufficient statistical confidence. Guidance should be sought from the appropriate National Authority.

C.5.3.1.1. Method

a. The weapon used for this test shall have a minimum of 75% wear life remaining. Examine the weapon bore with a borescope and record its condition; measure the bore at intervals of 25mm for its complete length.

b. Fire at least 10 rounds preconditioned at LFT, 10 rounds preconditioned to laboratory ambient +21 °C, and 10 rounds preconditioned at UFT. Further intermediate firing temperatures are recommended to develop greater understanding of temperature effects.

c. For each of the firing temperatures, assess the data for peak chamber / case-mouth pressure and muzzle velocity trends (mean and standard deviation of each) with temperature. Chamber pressure may be plotted against firing temperature to establish the temperature coefficient (change in pressure per degree change in temperature) for the propelling charge.

C.5.3.1.2. Data Required

a. General Test Data:

(1) Date of test and location;

(2) Weapon configuration and component serial numbers;

(3) Weapon inspection results before and after testing;

(4) Meteorological conditions of wind and air temperature.

b. Round by Round:

(1) Time of firing;

(2) Ammunition configuration and lot numbers;

(3) Ammunition temperature;

(4) Chamber/case-mouth pressure;

(5) Muzzle velocity;

(6) High speed video / still imagery of projectile exiting the weapon.

C.5.3.2. Maximum Operating Pressure Assessment

Maximum Operating Pressure Assessment testing is conducted to obtain a maximum chamber pressure and muzzle velocity standard deviation, and to demonstrate that the ammunition maximum operating pressure is lower than the weapon permissible maximum pressure. The values shall be compared with the Extreme Service Conditions Pressure (ESCP) and Life Cycle Standard Deviation (LCSD) from the LCEP test. If the results are not significantly different, the data may be combined. If the results are significantly different further testing may be required in accordance with national practices.

This test is done by firing production build-standard ammunition, preconditioned to the temperature that produces the ESCP, containing propellant from two different production lots, though two different overpressure barrels (representative of standard in-service weapons) and on two different occasions. If alternative projectiles are used, they must possess identical internal ballistics characteristics, volume intrusion into the propellant bed / cartridge case and crimp geometry to the service projectile.

Statistically, a two-lot-test provides the best data. However, the statistical analysis of the data (for example, from Annex A of STANAG 4110) can also be applied to the analysis of the results from a One Lot Test, but the ESCP and LCSD should be recalculated based on data from subsequent propellant lots.

Note that Parts 1 and 2 of the Propelling Charge Safety Tests may be combined but the sample quantities will necessarily be greater than those quoted in the methods to gain sufficient statistical confidence. Guidance should be sought from the appropriate National Authority.

C.5.3.2.1. Method

a. This test is based upon the experimental design methods recommended for ANOVA. It is assumed that data for the analysis will be collected from a single test, although the analysis is still possible using data from a number of separate tests.

b. The test requires the use of two EPVAT barrels and that they are fired concurrently in sequence and hence the weapons are required at the same firing point at the same time. Statistically, a two lot test provides the best data. However, the statistical analysis of the data can also be applied to the analysis of the results from a one lot test but the ESCP and LCSD should be recalculated based on data for subsequent propellant lots (guidance in Annex A of STANAG 4110).

c. Fire preconditioned ammunition to the sequences provided in Table C5-1 for two propellant lots (or alternatively to Table C5-2 for a single propellant lot).

d. Analyse data according to STANAG 4110 Annex A.

Table C5-1: Two-Lot Test Propelling System Safety Test

OCCASION 1				OCCASION 2			
Weapon 1		Weapon 2		Weapon 1		Weapon 2	
Lot 1	Lot 2	Lot 2	Lot 1	Lot 1	Lot 2	Lot 2	Lot 1
rd 1	rd 2	rd 3	rd 4	rd 29	rd 30	rd 31	rd 32
rd 5	rd 6	rd 7	rd 8	rd 33	rd 34	rd 35	rd 36
rd 9	rd 10	rd 11	rd 12	rd 37	rd 38	rd 39	rd 40
rd 13	rd 14	rd 15	rd 16	rd 41	rd 42	rd 43	rd 44
rd 17	rd 18	rd 19	rd 20	rd 45	rd 46	rd 47	rd 48
rd 21	rd 22	rd 23	rd 24	rd 49	rd 50	rd 51	rd 52
rd 25	rd 26	rd 27	rd 28	rd 53	rd 54	rd 55	rd 56

Table C5-2: One-Lot Test Propelling System Safety Test

OCCASION 1		OCCASION 2		OCCASION 3		OCCASION 4	
Wpn 1	Wpn 2	Wpn 1	Wpn 2	Wpn 1	Wpn 2	Wpn 1	Wpn 2
rd 1	rd 2	rd 15	rd 16	rd 29	rd 30	rd 43	rd 44
rd 3	rd 4	rd 17	rd 18	rd 31	rd 32	rd 45	rd 46
rd 5	rd 6	rd 19	rd 20	rd 33	rd 34	rd 47	rd 48
rd 7	rd 8	rd 21	rd 22	rd 35	rd 36	rd 49	rd 50
rd 9	rd 10	rd 23	rd 24	rd 37	rd 38	rd 51	rd 52
rd 11	rd 12	rd 25	rd 26	rd 39	rd 40	rd 53	rd 54
rd 13	rd 14	rd 27	rd 28	rd 41	rd 42	rd 55	rd 56

C.5.3.2.2. Data Required

a. General Test Data:

(1) Date of test and location;

(2) Weapon configuration and component serial numbers;

(3) Weapon inspection results before and after testing;

(4) Meteorological conditions of wind and air temperature.

b. Round by Round:

(1) Time of firing;

(2) Ammunition configuration and lot numbers;

(3) Ammunition temperature;

(4) Chamber/case-mouth pressure;

(5) Muzzle velocity;

(6) High speed video / still imagery of projectile exiting the weapon;

(7) Action time (t_4);

(8) Precision at 550 m including horizontal / vertical standard deviations.

ANNEX D
Reserved For Future Use

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ANNEX E BASIC DATA AND INSPECTIONS

E.1. GENERAL INSPECTION GUIDANCE

Ammunition, packaging and ancillary items (links, magazines, etc.) shall be inspected at different moments throughout the sequential environmental trials. Inspections should be conducted in accordance with the following inspection levels:

- Initial Inspection (Baseline)
- Level 1 Inspection (Basic)
- Level 2 Inspection (Intermediate)
- Level 3 Inspection (Full)
- Sealing Check

Appropriate inspection methodologies combine visual assessment and detailed chemical and physical tests to fully understand degradation of the ammunition. The structure of the inspections is such that each higher level incorporates the lower levels. This Annex gives guidance regarding the disassembly and the additional tests of the Level 3 Inspection.

E.1.1. BASELINE DATA

The Level 3 Inspection before the start of the sequential environmental trials can be used to identify potential failure modes. Together with the Initial and Level 1 Inspection, it forms baseline data for both treated ammunition and ammunition for the firing tests. For the Level 3 Inspection, the ammunition needs to be disassembled.

It may also be possible to use manufacturer's development or acceptance test data provided these ammunition are of the same build standard and the data it gives is equivalent to that required above for baseline purposes. However, it should be noted that these latter options may not permit comparison against the physical condition of the complete ammunition following the sequential environmental trial.

E.1.2. DISASSEMBLY

Prior to the disassembly, perform physical integrity checks on the ammunition, sub-systems, energetic materials and structural materials. This can be achieved through visual examination (including photography as required), radiography, Computerized Tomography Scan, Dye Penetrant, Bore-scope (for base bleed conduits and other cavities), Ultrasonic inspection and/or Fluoroscopy both prior to, and following disassembly. Some techniques may be more applicable to structural materials which must also be assessed.

During disassembly and material extraction, care must be taken to ensure that the extracted samples do not become contaminated (by structural materials or other matter) and/or physically damaged/changed (e.g., compressed, cracked, abraded, etc.). Furthermore, caution must be exercised when unscrewing threaded joints where explosive crystals may be present as a result of environmental exposure, leading to the potential for their initiation from pinching and/or friction. Processing (unpacking and disassembly) should only be undertaken in well ventilated areas using appropriate personal protective equipment (respirators, etc.). Pyrotechnic compositions containing metal fuels (e.g., Magnesium) are prone to oxidation resulting in the production of Hydrogen gas, which if present in sufficient quantity is explosive. Therefore relevant safety procedures must be implemented when processing ammunition containing these compositions.

Small items such as igniters, initiators, etc. pose particular difficulties during disassembly, and it may not be possible to extract sufficient material without damaging the material contained within. In such cases it is acceptable to perform just visual and radiographic examination followed by functioning tests (at extremes of service temperature). In some cases it may be possible to extract sufficient material to perform small scale tests such as volatile matter content determination and/or appropriate thermal analysis techniques (e.g., Heat-flow Calorimetry or Differential Scanning Calorimetry).

During disassembly, pay particular attention to signs of cracking, surface crystallization / dusting, exudation, corrosion, discolouration, wear, missing components, dislodged components, and other damage (e.g., splits in combustible cases). Furthermore, examine specifically: plastics, rubbers, foams, seals, etc., for signs of degradation or uptake of plasticiser. 'O' rings should be examined for compression set and that they still meet their specification requirements.

After disassembly of the ammunition, tests should be done for the baseline analyses.

E.1.3. TESTS – EXPLOSIVE MATERIALS

The following tests are applicable to explosives, propellants, pyrotechnics and primers.

E.1.3.1. Chemical Tests

Chemical composition, including total volatile matter and moisture content, must be assessed to demonstrate compliance with specifications/drawings.

Chemical stability must be assessed for all energetic materials, although the tests used will be material dependent. The vacuum stability test is particularly applicable for main charge explosives. Chemical stabiliser depletion testing (to AOP-48) is applicable for nitrate-ester propellants, with a preference for multi-temperature ageing since this gives both stabiliser content and chemical kinetics.

Pyrotechnic compositions having a metal fuel are prone to oxidation (e.g., tracer compositions). This is brought about by the reaction of the metal fuel with moisture which results in the production of metal corrosion products and Hydrogen. To assess levels of the fuel degradation it is recommended that the Active, or Free Metal (i.e., un-reacted, or un-oxidised) and Total Metal (i.e., oxidised and un-oxidised combined) contents of compositions should be determined using suitable analytical techniques.

Chemical/explosive compatibility (per STANAG 4147) between all components with the energetic materials they will be in contact with (both in physical contact and by gas/vapour path) should have been assessed during material qualification and/or design of the ammunition. This compatibility data shall be presented as a matrix that lists the materials, and for each explosive declares whether there is contact or not with evidence to support the claim of compatibility where contact is expected.

Any material incompatibilities and/or migration of explosive species are likely to become evident during the Level 1 visual inspection. Any such anomalies observed shall be noted and assessed further to address whether the ammunition remains safe as defined in AAS3P-1. An example is the migration of species from one energetic material to another (e.g., burn-rate modifiers from one propellant to another).

E.1.3.2. Physical Properties

Assessment of flow properties and particle size distribution for granular materials (such as granular propellants and some pyrotechnic compositions), checking for coagulation of granular materials, bulk cracking and surface cracking/crazing. Optical microscopy is particularly applicable for gunpowders to assess crystal morphology and for Potassium Nitrate leeching. Thermal analysis methods, especially Differential Scanning Calorimetry, are useful tools that may indicate changes in the material over time and are particularly suited to subsequent comparison during In-Service Surveillance. They are applicable to most explosive materials, especially pyrotechnics, since they can be performed on small samples of material.

E.1.3.3. Hazard Properties

Conduct STANAG 4170/AOP-7 small scale material qualification and hazard tests to assess hazard properties for comparison to baseline measurements. These may include, but are not limited to, methods to determine ease of initiation by impact, friction and electrical spark, along with temperature of ignition.

Normally the small scale tests will be sufficient but larger scale tests may also be required if an issue is identified. The exact methods used would depend upon the type and quantity of material available for the tests but may include ‘gap tests’ and tests to assess Velocity of Detonation. However, they may ultimately require full scale (i.e., All Up Round) tests to assess the IM properties of the ammunition following environmental exposure.

E.1.4. MECHANICAL PROPERTIES

Mechanical Properties of explosive materials must be assessed at the full range of working temperatures for the ammunition. It will also be necessary to test structural materials at temperature extremes for safety critical items, such as cartridge cases or shell bodies, in order to verify design safety margins. Typical methods will include uniaxial tensile test to STANAG 4506 and differential thermal mechanical analysis to STANAG 4540. It may also be necessary to assess fatigue crack growth for some structural materials. The types of testing will ultimately be determined by the type of material being tested.

E.1.4.1. Cartridge Case Residual Stress

This test predominantly applies to brass cartridge cases, although other engineering materials (including polymers) may also be susceptible. Cartridge cases (brass in particular) possess residual internal stresses caused by the case drawing process, bullet crimping and other forces. These residual stresses may cause the case to split or otherwise fail, particularly after periods of long storage and/or exposure to other conditions conducive to aggravating environmental stress cracking (e.g., exposure to certain chemicals).

Residual stresses in the cartridge case are assessed on assembled ammunition. The ammunition is exposed to an active chemical (or environmental stress cracking agent) for a prescribed duration, possibly stored at pre-defined conditions (temperature and duration), and finally inspected for cracking, crazing, discolouration or other defects. The specific test requirements are usually given in the ammunition specifications. If no specification is available, the procedure given in Section 23 of the Draft AEP-97 Edition A, Version 1, may be applied for brass cartridge cases, where the active chemical is usually ammoniacal copper sulphate or mercurous nitrate. Due to toxicity and environmental concerns the former is preferred, although either chemical is acceptable; but note that both give differing results. Report the procedure and active chemical used, along with the results (time of observation, and presence of cracking, crazing, discolouration or other defects).

E.1.4.2. Cartridge Case Hardness Profile

The test procedure must correspond to the ammunition specifications. The procedure and equipment used should be reported along with the results and observations.

E.1.4.3. Bullet Pull

The purpose of this test is to determine, and/or confirm, the force required to extract (pull) a projectile from its case. It is a measure of security of the projectile within the case so that it will not separate during handling or feeding. Correct (and consistent) bullet pull force affects consistency of propellant burning and resulting velocity consistency. Ammunition specifications usually state a minimum extraction force that the projectile must resist.

Hold the cartridge case to be tested in a test fixture and apply a tensile load to the bullet at a rate of travel of the loading head given in the ammunition specifications. The procedure and equipment used should be reported along with the results and observations. Record the force (average, range & standard deviation) required to extract the projectile from the case, the rate of travel of the loading head, and the test apparatus used.

E.1.5. PRIMER SENSITIVITY

The primers of small calibre ammunition must be sensitive enough to function reliably in the weapons in which they are used; yet they must also be sufficiently insensitive to allow safe handling and loading. The majority of small calibre primers ammunition uses percussion primers that function upon physical impact, although some may use electrical primers that function when the correct voltage and current are applied. This test determines, and/or confirms, the sensitivity of the primer to the correct stimulus.

E.1.5.1. Percussion Primers

There is no single specific test procedure that covers all percussion primers, although the test equipment and methods required, along with the “go/no go” threshold are usually stated in the ammunition and/or primer specifications. The procedure and equipment used should be reported along with the results and observations.

E.1.5.2. Electrical Primers

Each type of electrical primer is designed to function by specific conditions of voltage and current. There is no single specific test procedure that covers all electrical primers, although the test equipment and methods required, along with the “go/no go” threshold are usually stated in the ammunition and/or primer specifications. The procedure and equipment used should be reported along with the results and observations. Electrical resistance should also be measured and recorded using a safety ohm meter.

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ANNEX F FACILITIES AND INSTRUMENTATION REQUIREMENTS

This document was developed within the international community and is written with primarily references to NATO test procedures.

Table F-1: Facility Requirements

ITEM	REQUIREMENT
Inspection and Non-Destructive Test Facility	Material inspection equipment such as video borescope, ultrasonic, and radiographic must be available to determine the condition of the ammunition and its components before and after exposure to environmental tests. Facility should have the capability to conduct radiographic inspection of ammunitions at low temperature extremes or within 15 minutes of removal from a conditioning chamber.
Climatic Test Facility	• Climatic chamber equipment capable of temperature conditioning live ammunitions to the extremes of -55 to 75 °C and relative humidity from 5 to 95%. • High temperature chamber equipped with solar lamps capable of at least 1120 W/m^2 output. • Combined environments chamber capable of conducting combined temperature, altitude, and humidity of live ammunitions. • Equipment capable of conducting Sand and Dust, Salt Fog, and Rain tests on live ammunitions.
Rapid Decompression Test Facility	Chamber capable of pressure change from 60 kPa to 18.8 kPa within 15 seconds. Must be suitable for packaged, live ammunitions.
Dynamic Test Facility	Equipment suitable for simulating the full range of dynamic environments (e.g., transportation shock and vibration, tactical shock and vibration, drop test) expected during the ammunition's lifetime. Facility should have the capability to conduct shock and vibration tests at temperature extremes and drop tests within 15 minutes of removal from a conditioning chamber.
Firing Range	Selected to suit ammunition test requirements and to provide adequate protection for personnel and equipment. Facility should have the capability to conduct firing tests at temperature extremes or within 30 minutes of removal from a conditioning chamber.
Ammunition Disassembly	Facility suitable for disassembly of live ammunitions for detailed inspection and component level testing.
Energetic Material Extraction (if required)	Equipment suitable for the extraction of energetic material samples for chemical analysis.

Table F-1: Facility Requirements (continued)

ITEM	REQUIREMENT
Chemistry Laboratory (if required)	Equipment suitable for the conduct of the chemical analysis tests set out in STANAG 4170, AOP-7, and paragraph D.1.4.1 of Appendix D (Level III Inspection).
Electromagnetic Radiation Test Facility	Facility suitable for the generation of the specified field intensities with an adequate test volume for the test of the ammunition and launcher as required by the stockpile to launch configuration.
Electrostatic Discharge Test Facility	Facility suitable for the generation of the required ESD environments and large enough for the ammunition and launcher as required by the stockpile to launch configuration.
Lightning Test Facility	Facility capable of conducting the required lightning strike test on live ammunitions.
Data Collection/Processing Facility	Test data shall be recorded on Digital Recorders for post-test processing. The data processing system shall edit, display, and print out the desired data plot for analysis and reporting purposes.
Video/Photographic	Closed circuit video is required for personnel safety to permit observation of ammunition tests. Video Camera/Recording Systems having a sufficient frame rate to record and playback desired events. High speed digital cameras and/or UV/IR cameras may also be required.

Table F-2: Measurement Tolerances

DEVICES FOR MEASURING	MEASUREMENT TOLERANCE
Pressure	± 5 percent of the value or ± 200 Pa, whichever is greater.
Strain	± 1 percent of highest expected value
Firing Pulse (Automatic Fire Control System)	As required for the initiation of remote firing systems and the automatic sequencing of the data collection systems.
Time	± 1 percent
Temperature Climatic Temperature Measurements	 ± 2 °C
Relative Humidity	± 5 percent
Solar Radiation	± 20 W/m^2
Vibration Acceleration	See AECTP 400 Method 401
Acoustic Sound Pressure Level	See AECTP 400 Method 402
Mechanical Shock	See AECTP 400 Method 403
Toxic Gas (NO, NO_2, NO_x, CO, CO_2, SO_2)	2 percent of full scale
Particulates (0.5-15 microns)	2 percent of full scale
Pyrolysis products (fluoride, chloride, bromide, cyanide, aldehydes)	2 percent of full scale
Length	± 1 percent
Weight	± 1 percent
Meteorological Conditions Temperature Relative Humidity Barometric Pressure UV Radiation Potential Lightning/Severe Weather Wind	 ± 2 °C ± 3 percent ± 0.25 mm of Hg ± 20 W/m^2 > 2 km ± 3 km/hr

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ANNEX H ABBREVIATIONS / REFERENCES AND RELATED DOCUMENTS

This document was developed within the international community and is written with primarily references to NATO test procedures to provide a framework for international procurement and test programmes. Table H2-1 (Annex H, Appendix 2) provides detailed comparison of similar national and international test standards. Whilst each test standard often has unique requirements, the table does not imply the standards are the same or interchangeable.

If tailoring is determined to be necessary, the tailoring may be carried out in accordance with the following general principles:

a. The tailored environment shall be at least as severe as the expected life cycle environment.

b. Any alternative test standards / methods that are utilized shall be technically equivalent or superior to the referenced standards / methods.

c. The tailored test procedures and severities, along with full justification / rationale shall be documented as part of the S3 assessment report.

d. Tailoring shall be approved by the relevant national authority prior to testing.

Particularly, document the elimination of tests, reduction of sample quantities, or reduction of severities, any of which may result in reduced evidence to fully support the required safety assessment of the ammunition.

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ANNEX H ABBREVIATIONS AND RELATED DOCUMENTS
APPENDIX 1 ABBREVIATIONS

TABLE H1-1: Abbreviations

AAS3P	Allied Safety and Suitability for Service Publication
AECTP	Allied Environmental Conditions Test Publication
ANEP	Allied Navy Engineering Publication
ANOVA	Analysis of Variance
AOP	Allied Ordnance Publication
AP	Allied Publication
ºC	Degrees Celsius
DP	Design Pressure
E3	Electromagnetic Environmental Effects
EID	Electrically Initiated Devices
EMOP	Extreme Maximum Operating Pressure
EMRH	Electromagnetic Radiation Hazards
EOD	Explosive Ordnance Disposal
EPVAT	Electronic Pressure, Velocity, & Action Time
ESCP	Extreme Service Condition Pressure
ESD	Electrostatic discharge
HE	High Explosive
HERO	Hazards of Electromagnetic Radiation to Ordnance
HFE	Human Factors Engineering
Hz	Hertz
IM	Insensitive Munitions
ITOP	International Test Operating Procedure
kJ/mol	Kilojoule per Mole
km	Kilometer
LCEP	Life Cycle Environmental Profile
LCSD	Life Cycle Standard Deviation
LCT	Lower Conditioning Temperature
LFT	Lower Firing Temperature
m	Metre
m/s	Metre per Second
MIL-STD	Military Standard
mm	Millimetre
MOP	Maximum Operating Pressure

MOPI	Manual of Proof and Inspection Procedures
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological, and Chemical
Pa	Pascals
PDP	Projectile Design Pressure
PMP	Permissible Maximum Pressure
PPMP	Projectile Permissible Maximum Pressure
S3	Safety and Suitability for Service
SAR	Safety Assessment Report
SET	Sequential Environmental Test
SRE	Solar Radiation Equivalent
SRS	Shock Response Spectrum
STANAG	NATO Standardization Agreement
UCT	Upper Conditioning Temperature
UFT	Upper Firing Temperature
UNDEX	Underwater explosion
W/m^2	Watts per Metre Square
VERTREP	Vertical Replenishment

ANNEX H ABBREVIATIONS / REFERENCES AND RELATED DOCUMENTS
APPENDIX 2 REFERENCES AND RELATED DOCUMENTS

Note: It should not be assumed that the various methods are exactly equivalent or that methods other than the NATO documents can be necessarily deemed acceptable by the relevant national authorities. Further advice should be sought from these national authorities before alternates to the NATO methods are used. National test method specifications may be employed to meet the environmental test requirements if it can be demonstrated that the national specification is technically equivalent or superior to the referenced methods. Revision identifiers have been intentionally removed, the latest version of the above referenced documents should be utilized.

Table H2-1: Cross-Reference Table

	SHORT TITLE	NATO	US	UK	FR	GE
1	Ammunitions Safety Testing	STANAG 4629	ITOP 05-2-619 MIL-STD-2105 MIL-STD-882		ITOP 05-2-619	ITOP 05-2-619
2	System Safety	AOP-15	MIL-STD-882 MIL-HDBK-764 ITOP 05-1-060	Def Stan 00-56	AOP-15	VG 95373, DIN EN 61508 ITOP 05-1-060
3	Safety Assessment	AOP-15	MIL-STD-882	AOP-15 Joint Services Publication-520		
4	Hazardous Material Classification	STANAG 4123, AASTP-3	TB 700-2 UN ST/SG/AC.10/11	Joint Services Publication 482 Chapter 4 UN ST/SG/AC.10/11	UN ST/SG/AC.10/11	STANAG 4123, AASTP-3
5	Hazardous Material Classification (Thermal Stability)	UN ST/SC/AC.10/11	TB 700-2 UN ST/SG/AC.10/11	Joint Services Publication 482 UN ST/SG/AC.10/11	UN ST/SG/AC.10/11	
6	Insensitive Munitions Tests	STANAG's 4240, 4241, 4382, 4396, 4496	MIL-STD-2105	STANAG's 4240, 4241, 4382, 4396, 4496; UN ST/SG/AC.10/11	STANAG's 4240, 4241, 4382, 4396, 4496	STANAG's 4240, 4241, 4382, 4396, 4496
7	Insensitive Munitions Assessment	AOP-39, STANAG 4439	AOP-39, STANAG 4439	AOP-39, STANAG 4439	AOP-39, STANAG 4439	AOP-39 STANAG 4439
8	Software Safety	AOP-52	ITOP 01-1-057 QAP-268 Joint Software Systems Safety Engineering Handbook	Def Stan 00-56,	AOP-52	VG 95373, DIN EN 61508 ITOP 01-1-057

Table H2-1: Cross-Reference Table (continued)

	SHORT TITLE	NATO	US	UK	FR	GE
9	Fuze Safety Tests	STANAG 4157, AOP-20; STANAG 4363, AOP-21; STANAG 4187	MIL-STD-331 MIL-STD 1316	STANAG 4157, AOP-20; STANAG 4363, AOP-21;	Tailored Test Methods + AOP-20	STANAG 4157, AOP-20; STANAG 4363, AOP-21; STANAG 4187
10	Explosive Material Qualification	STANAG 4170, AOP-7	STANAG 4170, AOP-7 NAVSEAINST 8020.5C	STANAG 4170, AOP-7	STANAG 4170 AOP-7 S-CAT 17500	STANAG 4170 AOP-7
11	Human Factors	STANAG 7201	MIL-STD-1472 TOP 01-1-015 TOP 01-2-610 MIL-HDBK-46855A	Def Stan 00-25; HSE Regulations	DGA/NO/FHG/913	VG 95115 ZDv 90/20 HdE, MIL-STD-1472
12	Environmental Testing	STANAG 4370, AECTPs 100, 200, 230, 240, 300, 400	MIL-STD-810 MIL-STD-2105	Def Stan 00-035	STANAG 4370 AECTPs 100, 200, 230, 240, 300, 400; GAM EG-13	STANAG 4370, AECTPs 100, 200, 230, 240, 300, 400; MIL-STD-810
12a	Global Climatic Data	STANAG 4370, AECTP 230 Leaflet 2311	MIL-HDBK-310 AR 70-38	Def Stan 00-035, Part 4	STANAG 4370	STANAG 4370
12b	Humid Heat	AECTP 300, Method 306	MIL-STD-810, Method 507	Def Stan 00-035, Part 3, Test CL6 Severity from Def Stan 00-035 Part 4 Ch2-01	AECTP 300, Method 306	AECTP 300, Method 306
12c	Low Temperature Storage	AECTP 300, Method 303	MIL-STD-810, Method 502	Def Stan 00-035, Part 3, Test CL5 Severity from Def Stan 00-035 Part 4 Ch2-01	AECTP 300, Method 303	AECTP 300, Method 303
12d	High Temperature Storage	AECTP 300, Method 302	MIL-STD-810, Method 501	Def Stan 00-035, Part 3, Test CL6 (for high humidity) & CL2 (for low humidity) Severity from Def Stan 00-035 Part 4 Ch2-01 if cyclic.	AECTP 300, Method 302	AECTP 300, Method 302
12e	High Temperature Cycle	AECTP 300, Method 302	MIL-STD-810, Method 501	Def Stan 00-035, Part 3, Test CL6 (for high humidity) & CL2 (for low humidity) Severity from Def Stan 00-035 Part 4 Ch2-01	AECTP 300, Method 302	AECTP 300, Method 302
12f	Solar Radiation	AECTP 300, Method 305	MIL-STD-810, Method 505	Def Stan 00-035, Part 3, Test CL3	AECTP 300, Method 305	AECTP 300, Method 305
12g	Thermal Shock	AECTP 300, Method 304	MIL-STD-810, Method 503	Def Stan 00-035, Part 3, Test CL14	AECTP 300, Method 304	AECTP 300, Method 304

Table H2-1: Cross-Reference Table (continued)

	SHORT TITLE	NATO	US	UK	FR	GE
12h	Temperature-Altitude-Humidity	AECTP 300, Method 317	MIL-STD-810, Method 520	Def Stan 00-035, Part 3, Test CL13	AECTP 300, Method 317	AECTP 300, Method 317
12i	Salt Fog	AECTP 300, Method 309	MIL-STD-810, Method 509	Def Stan 00-035, Part 3, Test CN2	AECTP 300, Method 309	AECTP 300, Method 309
12j	Sand and Dust	AECTP 300, Method 313	MIL-STD-810, Method 510	Def Stan 00-035, Part 3, Test CL25	AECTP 300, Method 313	AECTP 300, Method 313
12k	Immersion	AECTP 300, Method 307	MIL-STD-810, Method 512	Def Stan 00-035, Part 3,Test CL29	AECTP 300, Method 307	AECTP 300, Method 307
12l	Rain/ Watertightness	AECTP 300, Method 310	MIL-STD-810, Method 506	Def Stan 00-035, Part 3, Test CL27	AECTP 300, Method 310	AECTP 300, Method 310
12m	Icing	AECTP 300, Method 311	MIL-STD-810, Method 521	Def Stan 00-035, Part 3, Test CL10	AECTP 300, Method 311	AECTP 300, Method 311
12n	Mould Growth	AECTP 300, Method 308	MIL-STD-810, Method 508	Def Stan 00-035, Part 3, Test CN1	AECTP 300, Method 308	AECTP 300, Method 308
12o	Contamination by Fluids	AECTP 300, Method 314	MIL-STD-810, Method 504	Def Stan 00-035, Part 3, Test CN4	AECTP 300, Method 314	AECTP 300, Method 314
12p	Aircraft Cargo Decompression	AECTP 300, Method 312	MIL-STD-810, Method 500	Def Stan 00-035, Part 3, Test CL9	AECTP 300, Method 312	AECTP 300, Method 312
12q	Vibration Test	STANAG 4370, AECTP 400	MIL-STD-810, Method 514	Def Stan 00-035, Part 3, Test M1	STANAG 4370, AECTP 400	STANAG 4370, AECTP 400
12r	Vibration Test Schedule Development	STANAG 4370, AECTP 240, Leaflet 2410	MIL-STD-810, Methods 514, 527	Def Stan 00-035, Part 5	STANAG 4370, AECTP 240, Leaflet 2410	STANAG 4370, AECTP 240; ITOP 01-01-050
12s	Commercial (Common Carrier) Transportation Vibration	AECTP 400, Methods 401, 421	MIL-STD-810, Methods 514, 527	Def Stan 00-035, Part 3, Test M1, Annex A and M2	AECTP 400, Method 401	AECTP 400, Method 401
12t	Military Wheeled Vehicle Transportation Vibration	AECTP 400, Methods 401, 421	MIL-STD-810, Methods 514, 527	Def Stan 00-035, Part 3, Test M1, Annex A and M2	AECTP 400, Method 401	AECTP 400, Method 401
12u	Restrained Cargo Transport Shock	AECTP 400, Method 403	MIL-STD-810, Methods 516, 527	Def Stan 00-035, Part 3, Test M3	AECTP 400, Method 417	AECTP 400, Method 417
12v	Fixed Wing Aircraft Cargo Transportation Vibration	AECTP 400, Methods 401, 421	MIL-STD-810, Methods 514, 527	Def Stan 00-035, Part 3, Test M1, Annex A and M2	AECTP 400, Method 401	AECTP 400, Method 401
12w	Helicopter Cargo Transportation Vibration	AECTP 400, Methods 401, 421	MIL-STD-810, Methods 514, 527	Def Stan 00-035, Part 3, Test M1, Annex A and M2	AECTP 400, Method 401	AECTP 400, Method 401
12x	Under Water Explosion (UNDEX)	STANAG 4549 STANAG 4150 ANEP 43	MIL-DTL-901 ANEP 43	Def Stan 00-035, Part 3, Test M7 (or Test M3).		STANAG 4150
12y	Shipboard Vibration	AECTP 400, Methods 401, 421	MIL-STD-810, Methods 528, 527; MIL-STD-167	Def Stan 00-035, Part 3, Test M1, Annex A and M2	AECTP 400, Method 401	AECTP 400, Method 401

Table H2-1: Cross-Reference Table (continued)

	SHORT TITLE	NATO	US	UK	FR	GE
12z	Fixed and Rotary Wing Captive Carriage Vibration	AECTP 400, Method 401,420, 421 and AECTP 240 Leaflet 2410	MIL-STD-810, Methods 514, 527	Def Stan 00-035, Part 5 (test spec development) Def Stan 00-035, Part 3, Test M1and M2 (tailored severities)	AECTP 400, Method 401 and AECTP 240 Leaflet 2410	AECTP 400, Method 401 and AECTP 240 Leaflet 2410
12aa	Gunfire Shock (Time Waveform Replication)	AECTP 400, Methods 405, 417, 421	MIL-STD-810, Methods 519, 525, and 527	Def Stan 00-035, Part 3, Test M19 (tailored severities)	AECTP 400, Methods 405, 417, and 421	AECTP 400, Methods 405, 417, and 421
12ab	Packaged Transit Drop	AECTP 400, Method 414	MIL-STD-810, Method 516	Def Stan 00-035, Part 3, Test M5	AECTP 400, Method 414	AECTP 400, Method 414
12ac	Catapult Launch and Arrested Landing		MIL-STD-810 Methods 513, 516, and 525			
13	Unpackaged Handling Drop	STANAG 4375	MIL-STD-810, Method 516	Def Stan 00-035, Part 3, Test M5	STANAG 4375	STANAG 4375
14	Packaged and Unpackaged Safety Drops	STANAG 4375	MIL-STD-810, Method 516	Def Stan 00-035, Part 3, Test M5	STANAG 4375	STANAG 4375
15	Logistic Drop Test (12 m drop)	STANAG 4375	MIL-STD-2105 ITOP 04-2-601	STANAG 4375	STANAG 4375	STANAG 4375 ITOP 04-2-601
16	Parachute Drop	AOP-20	MIL-STD-331 ITOP 07-2-509 TOP 04-2-509 ITOP 04-2-601	Def Stan 00-035, Part 3, Test M5 AP101A 1102-1		ITOP 04-2-601
17	Dynamic Firing	STANAG 4157, AOP-20; STANAG 4363, AOP-21	ITOP 04-2-806	STANAG 4157, AOP-20; STANAG 4363, AOP-21	STANAG 4157, AOP-20	STANAG 4157, AOP-20; STANAG 4363, AOP-21
18	Weapon Danger Area / Zone	STANAGs 2240, 2401, ARSP-1 Vol I and II STANAG 2470, ARSP-2, Vol. 1	ITOP 05-2-505	STANAGs 2240, 2401, ARSP-1 Vol I and II STANAG 2470, ARSP-2, Vol. 1	TTA206 STANAG 2921	STANAGs 2240, 2401, ARSP-1 Vol I and II STANAG 2470, ARSP-2, Vol. 1; A2-2090/0-0-1, ITOP 05-2-505
19	Health Hazards		TOP 06-2-507 TOP 10-2-508 OPNAVINST 5100.19E OPNAVINST 5100.23G	HSE Regulations		
20	Toxic Gas / Materials		ITOP 05-2-502	HSE Regulations		Erl. BMVg InSan I4-42-19-01 ITOP 05-2-502

Table H2-1: Cross-Reference Table (continued)

	SHORT TITLE	NATO	US	UK	FR	GE
21	Acoustic Noise	ISO 10843: 1997	MIL-STD-1474 ISO 10843: 1997	Def Stan 00-27 HSE Regulations	AT-83/27/28	ZDv 90/20 VM Blatt 1993
22	Blast Overpressure	STANAG 4569 with references. Final Report RTO-HFM-089, -090, -148	ITOP 04-2-822 DOD 6055.9-STD		Consignes et instructions relatives à l'enregistrement et à l'exploitation des bruits d'armes et des bruits de détonation	Vorschriften und Richtlinien zur Registrierung und Auswertung von Waffen und Detonationsknallen and STANAG 4569 with references. Final Report RTO-HFM-089, -090, -148
23	Electromagnetic Environmental Effects (tests)	STANAG 4370, AECTP 500	MIL-STD-464 TOP 01-2-511 MIL-STD-461	Def Stan 59-411	GAM DRAM 02	STANAG 4370, AECTP 500, VG 95370, VG 95373, VG 95379
24	Electromagnetic Environmental Effects (environment description)	STANAG 4370, AECTP 250, Leaflet 258	MIL-STD-464 MIL-HDBK-235	Def Stan 59-411	GAM DRAM 01	STANAG 4370, AECTP 250, Leaflet 258 VG 95370, VG 95373, VG 95379
25	Electromagnetic Environmental Effects (HERO)	STANAG 4370, AECTP 508 Leaflet 3	MIL-STD-464 MIL-HDBK-240 JOTP-61 OP3565 Vol. 2	Def Stan 59-114 Def Stan 59-411	GAM DRAM 02	STANAG 4370, AECTP 508, Leaflet 3 VG 95378, VG 95379
26	Electrostatic Discharge (ESD) Environmental Test	STANAG 4370, AECTP 250, Leaflet 253; AECTP 508, Leaflet 2	MIL-STD-464 JOTP-62	Def Stan 59-411	GAM DRAM 01 GAM DRAM 02	STANAG 4370, AECTP 250, Leaflet 253
27	Lightning Environmental Test	STANAG 4370, AECTP 508, Leaflet 4; AECTP 250, Leaflet 254	MIL-STD-464	Def Stan 59-411	GAM DRAM 01 GAM DRAM 02	STANAG 4370, AECTP 508, Leaflet 4; AECTP 250, Leaflet 254 VG 95379
28	Electromagnetic Interference	STANAG 4370, AECTP 501	MIL-STD-461 MIL-STD-464	Def Stan 59-411	STANAG 4370, AECTP 501	STANAG 4370, AECTP 501, VG 95370, VG 95373
29	Electromagnetic Compatibility	STANAG 4370, AECTP-250 and 500; IEC 61000 4-2	MIL-STD-461 MIL-STD-464 MIL-HDBK-237	Def Stan 59-411 IEC 61000 4-2		IEC 61000 4-2, VG 95370, VG 95373

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