NATO STANDARD

AOP-4157

SAFETY, ARMING AND FUNCTIONING SYSTEMS (SAF SYSTEMS) TESTING REQUIREMENTS

Edition A Version 1
FEBRUARY 2017

NORTH ATLANTIC TREATY ORGANIZATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

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NATO LETTER OF PROMULGATION

27 February 2017

1. The enclosed Allied Ordnance Publication AOP-4157, Edition A, Version 1, SAFETY, ARMING AND FUNCTIONING SYSTEMS (SAF SYSTEMS) TESTING REQUIREMENTS, which has been approved by the nations in the CNAD AMMUNITION SAFETY GROUP (CASG - AC/326), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4157.

2. AOP-4157, Edition A, Version 1 is effective upon receipt.

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

Edvardas MAŽEIKIS
Major General, LTUAF
Director, NATO Standardization Office

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RESERVED FOR NATIONAL LETTER OF PROMULGATION

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RECORD OF RESERVATIONS

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

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RECORD OF SPECIFIC RESERVATIONS

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

Summary of Changes

AOP-4157 (A)(1) has been created to ensure compliance with AAP-03(J), Directive for the Production, Maintenance and Management of NATO Standardization Documents. To ensure the Interoperability Requirements are still valid, the requirements of the old STANAG 4157 have been updated and moved into this document.

This standard incorporates the new term “Safety, Arming and Functioning Systems (SAF Systems). It should be noted that every time the word SAF Systems is used, it includes Fuzes, Fuzing Systems, Ignition Systems, as well as components of weapon systems serving a Fuzing or Ignition function.

Annex B has been amended to indicate that, even though the tests may not be mandatory, it is mandatory to address the list of test. This means that the developer of SAF Systems may not have to perform the tests, however, justification must be provided to the National Safety Approving Authority (NSAA) as to why tests were not performed or deviation from the standard procedures has occurred.

A list of nationally approved tests has been included at Annex C.

A list of mandatory test for Pyrotechnic Initiated Explosives (PIE) projectiles has been included at Annex D.

Annex E has been introduced to illustrate the concept of sequential environmental testing as part of the qualification process. It must be noted that it is just an example, therefore not mandatory to follow.

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CHAPTER 1 INTRODUCTION

1.1. AIM

The aim of this allied publication is to standardize the test requirements for the safety and suitability for service assessment of Safety, Arming and Functioning Systems (SAF Systems), to which the design requirements of STANAGs 4187, 4368, or 4497 are applicable. SAF Systems include Fuzes, Fuzing Systems, and Ignition Systems. Within this document the terms SAF System and “Fuze” or “Fuzing System” may be used interchangeably. These tests are intended to support and contribute to the qualification of SAF systems for application in munitions, and safety and suitability for service assessments of munitions as prescribed by STANAG 4297 and AOP-15.

1.2. GENERAL REQUIREMENTS

This standard is employed to:

a. Assess the safety and suitability for service (S3) of SAF systems to which the design requirements of STANAGs 4187, 4368, or 4497 are applicable, in accordance with the requirements of this standard and the test procedures specified in Annexes B and C.

b. The development and acquisition of SAF systems commenced after promulgation of this Standard.

c. Provide, upon a justified request submitted through the proper channels, information regarding the safety and suitability for service of specified SAF systems.

d. Provide to the Custodian of this Standard, the National Point(s) of Contact for S3 Assessments, upon promulgation of this Standard, for incorporation into Annex A.

e. Assess the safety and suitability for service (S3) of Pyrotechnic Initiated Explosive (PIE) projectiles to which the design requirements of STANAG 4187/AOP-4187 are applicable, in accordance with the requirements of this standard and the additional test procedures specified in Annex D.

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CHAPTER 2 GENERAL

2.1. GENERAL

2.1.1. SAF systems provide the control and initiation required to correctly function a munition. For this reason, SAF systems are among the most important assemblies in munitions. They determine the safety of the complete weapon system to a considerable degree.

2.1.2. The accidental, premature or incorrect operation of a SAF system could result in a hazard to personnel either close to the weapon system itself or under the warhead/projectile trajectory, and/or damage to the launch platform and nearby equipment. It may also generate Unexploded Ordnance (UXO) in case of failure. Therefore testing of the SAF system is essential to provide evidence to support the overall safety and suitability for service assessment of the munition.

2.1.3. In addition, the suitability for service of the munition is dependent on its SAF system's capability to operate under various environmental conditions. Therefore there is a need to subject the SAF systems to tests, which characterize their ability to operate in the life cycle environments encountered.

2.1.4. Considering the potential safety consequences of failures, SAF systems should be tested to more severe environments than the expected life cycles, which is reflected by the environmental test levels provided in AOP-20.

2.1.5. It is a mandatory requirement to address all the tests in Annex B. The tests shall be performed or evidence shall be provided that compliance is met by analysis, analogy, or other means. If any test is not applicable or was not carried out, justification shall be provided to the satisfaction of the NSAA. That justification shall become part of the S^3 assessment report. The SAF system tests need not be limited to the test requirements specified in this Standard. Annex C provides additional national test procedures for information purposes. For PIE projectiles the additional tests in Annex D shall be performed. Specific pass/fail criteria for the tests in Annex D shall be established and/or approved by the NSAA.

2.1.6. Definitions for munition-specific terms used in this Standard are provided in the NATO terminology database and/or AOP-38. Descriptions of the required test procedures are provided in AOP-20 and additional documents specified herein.

2.2. DETAILED REQUIREMENTS

2.2.1. Assessment

Assessment shall adhere to the following:

a. Formal S3 assessments by NSAA of all SAF systems developed or procured by nations shall be performed, documented and maintained;

b. The S3 assessment shall take into account user requirements and include:

(1) A design safety and hazard assessment conducted in accordance with STANAG 4187, 4368, or 4497;

(2) The results of the tests listed in Annex B conducted in accordance with the test procedures specified in this Standard or the respective analysis; in addition, for PIE projectiles the results of tests listed in Annex D;

(3) Justification for any tests listed in Annex B or D which were not performed; and

(4) The results of the test listed in Annex C if chosen.

c. Test plans, including the selection of tests and their justifications, quantities, parameters, facilities, and acceptance criteria shall be approved by the NSAA;

d. As part of the assessment test program, sequential environmental testing of the SAF system shall be conducted. The sequential environmental test program shall be based on the life cycle environment and any particular user requirements for the munition into which the SAF system will be incorporated. A sample sequential environmental test plan can be found at Annex E;

e. For each new application, the SAF system shall be reappraised, retested as appropriate, and approved by the NSAA.

2.2.2. Requirements

The following requirements shall be adhered to:

a. Tailoring of test procedures is not encouraged. If necessary, the

standardized tests shall only be tailored in accordance with the following general principles:

(1) Tailoring shall be approved by the NSAA prior to testing and documented in the Test Plan;

(2) The tailored environment shall be at least as severe as the expected life cycle environment for the SAF system; and

(3) The tailored test procedures and tailoring rationale shall be documented and retained as part of the S3 assessment report;

b. Electromagnetic environment testing of SAF systems shall be conducted with two primary objectives:

(1) Confirming that the SAF system's electronics will remain suitable for service; and

(2) Confirming that safety is not degraded for SAF systems employing Electrically Initiated Devices (EID), or electronic circuits controlling the safety of the SAF system.

c. Unless they are specified in the test procedures, quantities shall be selected so as to provide meaningful results and should reflect the quantities used in previous assessments of similar SAF systems which subsequently entered into service. The overall objective shall be to both meet national requirements and provide a convincing demonstration of the SAF system's safety and suitability for service.

d. Pass/fail criteria are provided in the test procedures, where appropriate. Otherwise the general criterion for passing any test is that no unsafe condition be observed during the test or upon examination of the SAF system after the test. One observed unsafe condition constitutes a failure. Depending upon the SAF system or munition design requirements, a small decrease in SAF system performance may be acceptable, if safety is not affected. Any such decrease shall be approved by the proper national authorities, or by the NSAA as appropriate and mentioned in the S3 assessment report. Large degradations in SAF system performance may indicate that it is not suitable for service use.

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ANNEX A National Points of Contact for S3 Assessments

A.1. BELGIUM

Directorate General Material Resources
Section Management – Risk – Ammunition
Queen Elisabeth Barracks
Eversestraat 1
1140 Brussels
Belgium

A.2. CANADA

Directorate Ammunition Explosive Management and Engineering
National Defence Headquarters
101 Colonel By Drive
Ottawa, Ontario, Canada
K1A 0K2

A.3. DENMARK

Danish Defence Acquisition and Logistics Organisation
Lautrupbjerg 1-5
DK-2750 Ballerup
Denmark

A.4. FRANCE

DGA/INSP/IPE
60, boulevard du général Martial Valin
75509 Paris Cedex 15
France

DGA Techniques terrestre
Rocade Est - échangeur de guerry
18021 Bourges Cedex
France

A.5. GERMANY

Bundesamt für Ausruestung, Informationstechnologie und Nutzung der Bundeswehr
K1.3
Ferdinand-Sauerbruch-Str. 1
56073 Koblenz
Germany

A.6. NETHERLANDS

The Chairman of the Defence Safety board on Dangerous Goods
Attn: The secretary
PO Box 20702
2500 ES The Hague
Netherlands

A.7. NORWAY

Norwegian Defence Logistics Organisation
Ammunition division
P.O. Box 800, Postmottak
N-2617 Lillehammer, Norway

A.8. UNITED KINGDOM OF GREAT BRITIAN

Defence Ordnance Safety Group (DOSG)
Fir 3a, #4304
MOD Abbey Wood, Bristol
United Kingdom, BS34 8JH

A.9. UNITED STATES OF AMERICA

Army
Chairman, US Army Fuze Safety Review Board.
Attn: RDAR-EIZ
Picatinny Arsenal, NJ 07806-5000
United States of America

Navy & Marine Corps
Weapon System Explosives Safety Review Board (WSESRB) Chair
Naval Ordnance Safety & Security Activity
3817 Strauss Ave, Suite 108
Indian Head, MD 20640
United States of America

Air Force
USAF, Non-Nuclear Munitions Safety Board
Attn: AAC/SES
1001 N 2nd Street, Suite 366
Eglin Air Force Base
FL 32542 - 6838
United States of America

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ANNEX B List of Tests that are Mandatory to address

Mechanical Shock

1. Jolt
Reference: AOP-20, Test A1

2. Jumble
Reference: AOP-20, Test A2

3. 12 m Drop
Reference: AOP-20, Test A3

4. 1.5 m Drop
Reference: AOP-20, Test A4

5. Transportation Handling (Packaged Fuzes)
Reference: AOP-20, Test A5

6. Ramming Forces (Power/Flick)
Safety and performance test for fuzes that are used on power or flick rammed projectiles.
Reference: No agreed test procedure, Use national test procedures

Vibration

1. Transportation Vibration (Unpackaged and Packaged SAF systems)
Reference: AOP-20, Test B1

2. Tactical Vibration
Reference: AOP-20, Test B3

Climatic

1. Temperature and Humidity
Reference: AOP-20, Test C1

2. Vacuum-Steam-Pressure
Reference: AOP-20, Test C2

3. Salt Fog
Reference: AOP-20, Test C3

4. Waterproofness
Reference: AOP-20, Test C4

5. Fungus
Reference: AOP-20, Test C5

6. Extreme Temperature
Reference: AOP-20, Test C6

7. Thermal Shock
Reference: AOP-20, Test C7

8. Leak Detection
Reference: AOP-20, Test C8

9. Dust
Reference: AOP-20, Test C9

10. Solar radiation
Reference: AOP-20, Test C10

Safety, Arming and Functioning

1. **Primary Explosive Component Safety:**
Reference: AOP-20, Test D1

2. SAF System Arming Distance
Reference: AOP-20, Test D2

3. Time to Air Burst
Reference: AOP-20, Test D3

4. Explosive Component output
Reference: AOP-20 Test D-4

5. Explosive component water gap test
Test for all SAF systems containing detonating explosive components
Reference: STANAG 4363, AOP-21

6. Rain Impact
Reference: AOP-20, Test D5

7. No-Fire Threshold
Test for SAF systems with electro-explosive devices.
Reference: STANAG 4560

8. Brush impact no fire test
Reference: AOP-20, Test D6

9. Mortar Ammunition Fuze Double-Loading Test
Reference: AOP-20, Test D7

10. Progressive arming test
Reference: AOP-20, Test D8

11. Sequential Environmental Test Programme
Safety and performance test for all SAF systems.
See Para 2.2.1.d of this standard and annex E

Aircraft Munitions

1. Jettison
Reference: AOP-20 Test E1

2. Low-Altitude Accidental Release
Reference: AOP-20, Test E2

3. Arrested Landing Munition Pull-Off
Reference: AOP-20, Test E3

4. Catapult and Arrested Landing
Reference: AOP-20, Test E4

5. Simulated Parachute Air Delivery
Reference: AOP-20, Test E5

Electrical and Electromagnetic Influence

1. Electrostatic Discharge (ESD)
Reference: AOP-20, Test F1

2. Nuclear Electromagnetic Pulse (NEMP)
Reference: AOP-20, Test F2

3. Hazards of Electromagnetic Radiation to Ordnance (HERO)
Reference: AOP-20, Test F3

4. Ordnance Electromagnetic Vulnerability
Reference: AOP-20, Test F4

5. Lightning Munition Assessment.
Reference: AOP-20 Test F5

ANNEX C List of Additional National Test Procedures

For information purposes only

Safety, Arming and Functioning Tests

1. Explosive Train Transfer Reliability Testing
Reference: AOP-20, Test D9

Electric and Magnetic Influence Tests

1. Electrical Stress Test (EST)
Reference: AOP-20, Test F6

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ANNEX D List of Mandatory Tests for PIE Projectiles

1. Double Ram Feed Test
Reference: No agreed test procedure, use national test procedures

2. 12m Drop (with unpackaged round and onto the nose)
Reference: AOP-20, Test A3

3. Shock (crash safety test)
Reference: MIL-STD-810C, Method 516, Procedure III

4. Explosive Decompression
Reference: AECTP-300, Method 312, Procedure IV

5. Acoustic Noise
Reference: AECTP-400, Method 402

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ANNEX E Sample Sequential Environmental Test Plan

1 Scope

This annex provides guidance on a proposed sequential environmental test plan of SAF Systems. The primary purpose of this guideline is to standardize a minimally acceptable test series, addressing safety and basic suitability for service use. It is expected that other tests and test items would be added, as required, based on unique program specifications and munition lifecycle to further support suitability for service use.

2 Requirements

2.1 General. As part of test program, all SAF Systems shall be subjected to Sequential Environment Testing, Miscellaneous Tests, Safety Tests and Electromagnetic Environmental Effects (E3) tests. These requirements do not constitute an entire qualification program. Rather, they must be included as part of the qualification program

2.2 Test Basis. In general, AOP-20 should be used as the test basis for qualification of SAF systems. In the case where the life cycle environments are greater than those of AOP-20, the life cycle environments must be employed. Tests from other standards (i.e., AECTP) may be employed when there is no similar AOP-20 test or such standards pose more severe test parameters

2.3 Sequential Environmental Testing

2.3.1 Sequential environment testing representative of SAF systems life cycle will consist of Transportation Vibration (Trans Vib), Temperature and Humidity (T&H), Extreme Temperature (ET), Thermal Shock (TS) and Tactical Vibration (Tac Vib) as a minimum. Non-operating environments should occur prior to operating environments in test series. The NSAA should be consulted on the need for 1.5m drop testing to be conducted as part of the Sequential Environmental Test Series.

2.3.2 There are two methods for conducting Sequential Environment Testing. One of the two test methods shall be employed as part of a SAF system test program. A minimum of thirty test items are required to be subject to all environments in prescribed sequence for either Method

2.3.2.1 Method I. Method I is intended to be the baseline test series and includes full duration tests outlined in 2.3.1. Figure 1a depicts the sequential environmental

test plan for Method I. Figure 1b depicts an expanded notional example of the sequential test flow for Method I

2.3.2.2 Method II. Method II requires the same sequential environment tests as in Method I, but allows for lesser T&H and ET test duration in the sequential path. However, additional, full duration T&H and ET tests must be conducted in parallel to the sequential tests. This allows for a reduced test schedule, but an increase in test items in comparison to Method I. Figures 2a and 2b depict the environmental test sequence for Method II. Figure 2c depicts an expanded notional example of the test flow for Method II. A minimum of three test items are required for each full duration ET and T&H tests conducted in parallel with the sequential environment tests in Method II.

2.4 Miscellaneous Tests

2.4.1 As part of the test program, the following safety tests shall be conducted on the SAF systems: Primary Explosive Component Safety, Jolt, Jumble, One-and-a-half Meter (5 foot) Drop, Transportation Handling, Transportation Vibration and Twelve Meter (Forty Foot) Drop. (One-and-a-half Meter Drop test not required here if conducted as part of Sequential Environment Tests.)

2.4.2 Miscellaneous Tests shall be conducted as described in Figure 3

2.4.3 Additional Miscellaneous Tests shall be conducted as described in Figure 4.

2.5 Safety Tests

2.5.1 As part of the test program for SAF systems, the following safety tests shall be conducted: Progressive Arm, Subverted Jolt (two configurations), Subverted Jumble (two configurations), Subverted 1.5m (5 ft) Drop (two configurations) and Arm, All-fire, No-fire Tactical Performance.

2.5.2 The subverted Jolt, Jumble and 1.5m Drop tests require two configurations to be tested. One configuration has the first safety feature intact, with the second safety feature subverted. The other configuration has the second safety feature intact with the first safety feature subverted. Each of these tests will be conducted with the required quantities of each configuration.

2.5.3 Safety Tests shall be conducted as described in Figure 5.

2.6 Electromagnetic Environmental Effects (E3) Tests

2.6.1 The following E3 tests shall be conducted as part of the test program for SAF systems: Personnel-Borne ESD, Helicopter-Borne ESD, Power Supply Transients,

Lightning Effects, Electromagnetic Radiation (EMR), Electromagnetic Pulse (EMP) and Electromagnetic Interference (EMI).

2.6.2 E3 Tests shall be conducted as described in Figure 6.

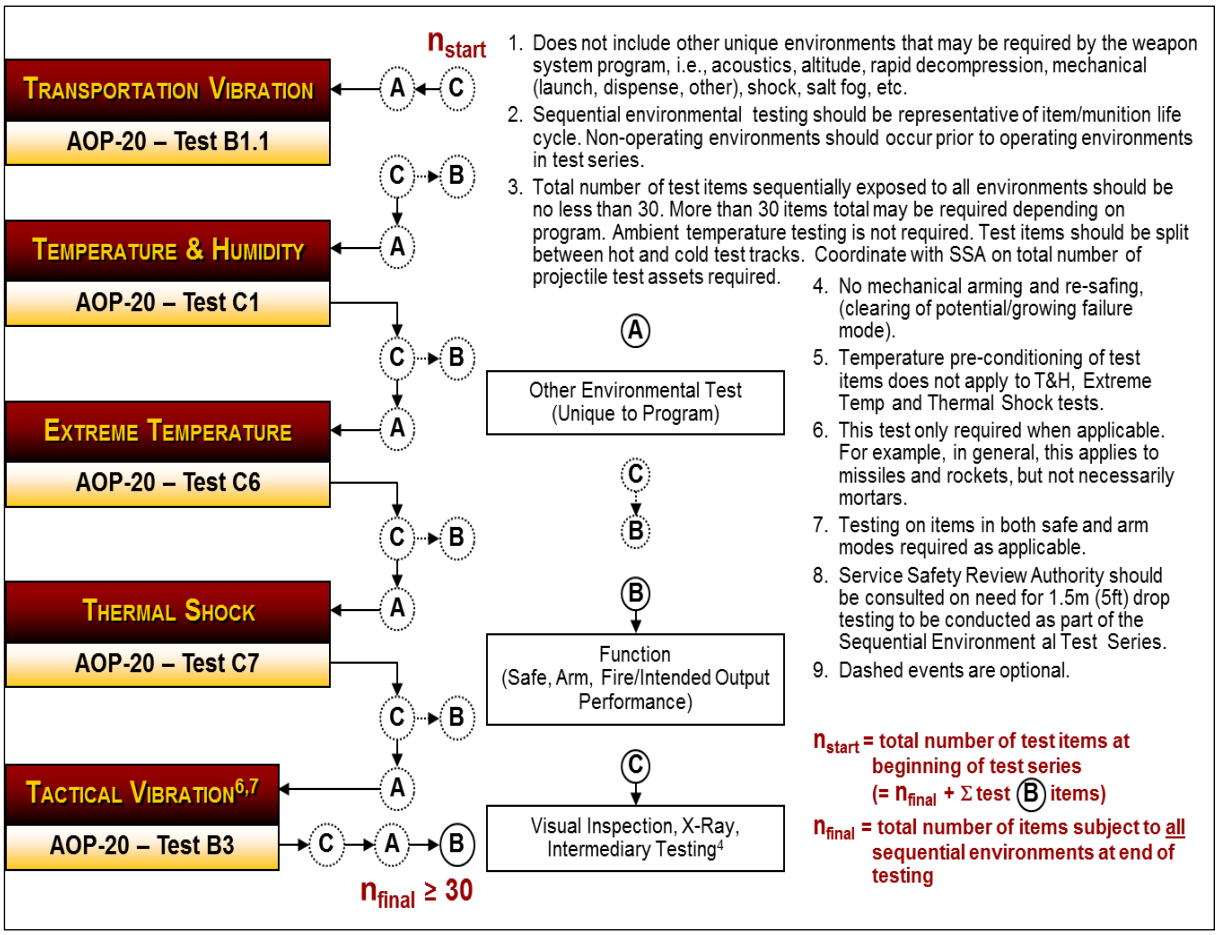


Figure 1a. Sequential Environment Testing Method 1

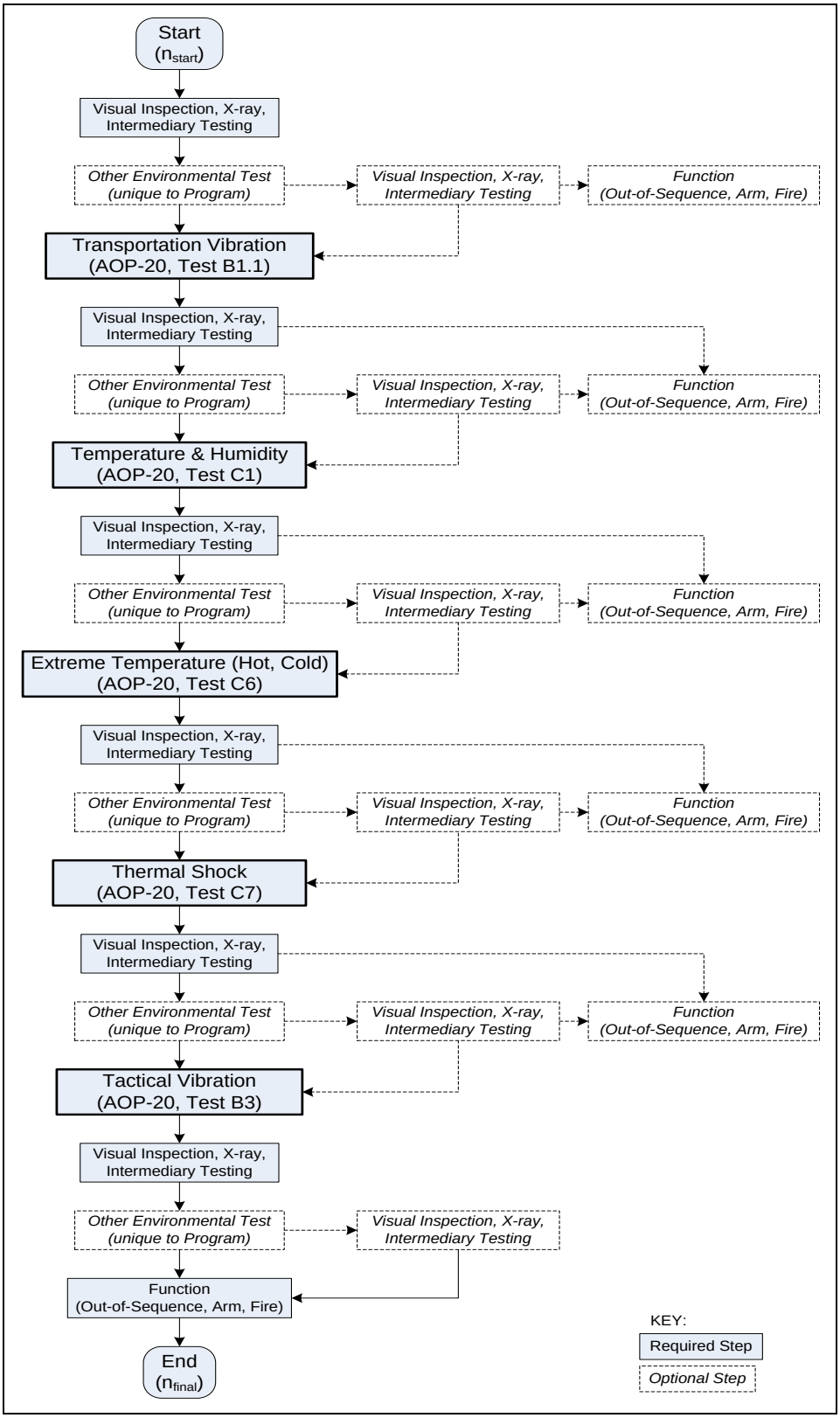


Figure 1b. Method I Test Flow – Expanded

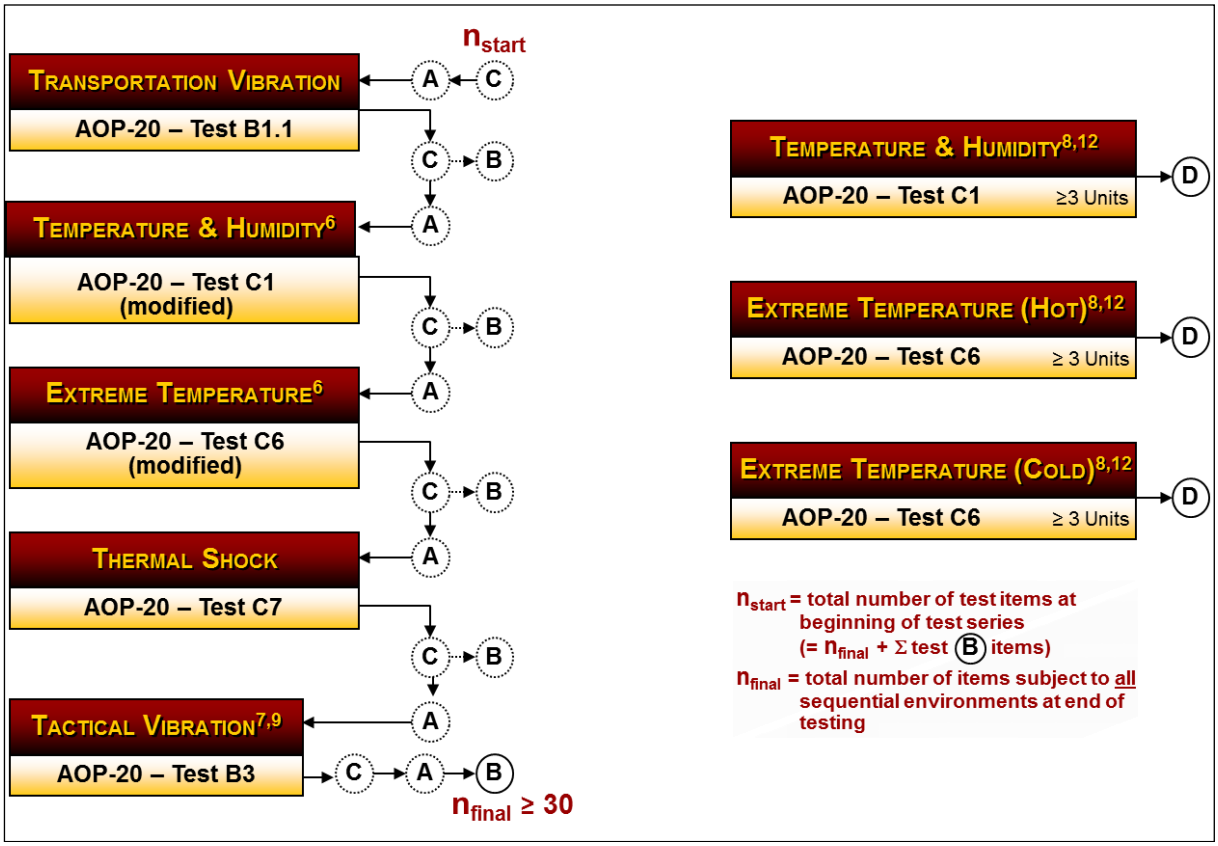
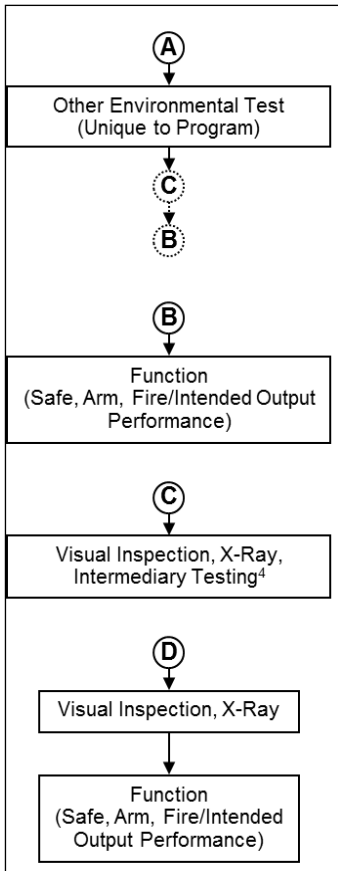


Figure 2a. Sequential Environment Testing Method II



Notes:

1. Does not include other unique environments that may be required by the weapon system program, i.e., acoustics, altitude, rapid decompression, mechanical (launch, dispense, other), shock, salt fog, etc.
2. Sequential environmental testing should be representative of item/munition life cycle. Non-operating environments should occur prior to operating environments in test series.
3. Total number of test items sequentially exposed to all environments should be no less than 30. More than 30 items total may be required depending on program. Ambient temperature testing is not required. Test items should be split between hot and cold test tracks. Coordinate with SSA on total number of projectile test assets required.
4. No mechanical arming and re-safing, (clearing of potential/growing failure mode).
5. Temperature pre-conditioning of test items does not apply to T&H, Extreme Temp and Thermal Shock tests.
6. These tests can be of decreased duration (14 day duration each test, each test temperature).
7. This test only required when applicable. For example, in general, this applies to missiles and rockets, but not necessarily mortars.
8. Full 28-day duration tests.
9. Testing on items in both safe and arm modes required as applicable.
10. Service Safety Review Authority should be consulted on need for 1.5m (5ft) drop testing to be conducted as part of the Sequential Environment al Test Series.
11. Dashed events are optional.
12. Test quantities for these “parallel” tests should be no less than three for each test.

Figure 2b. Sequential Environment Testing Method II - Notes

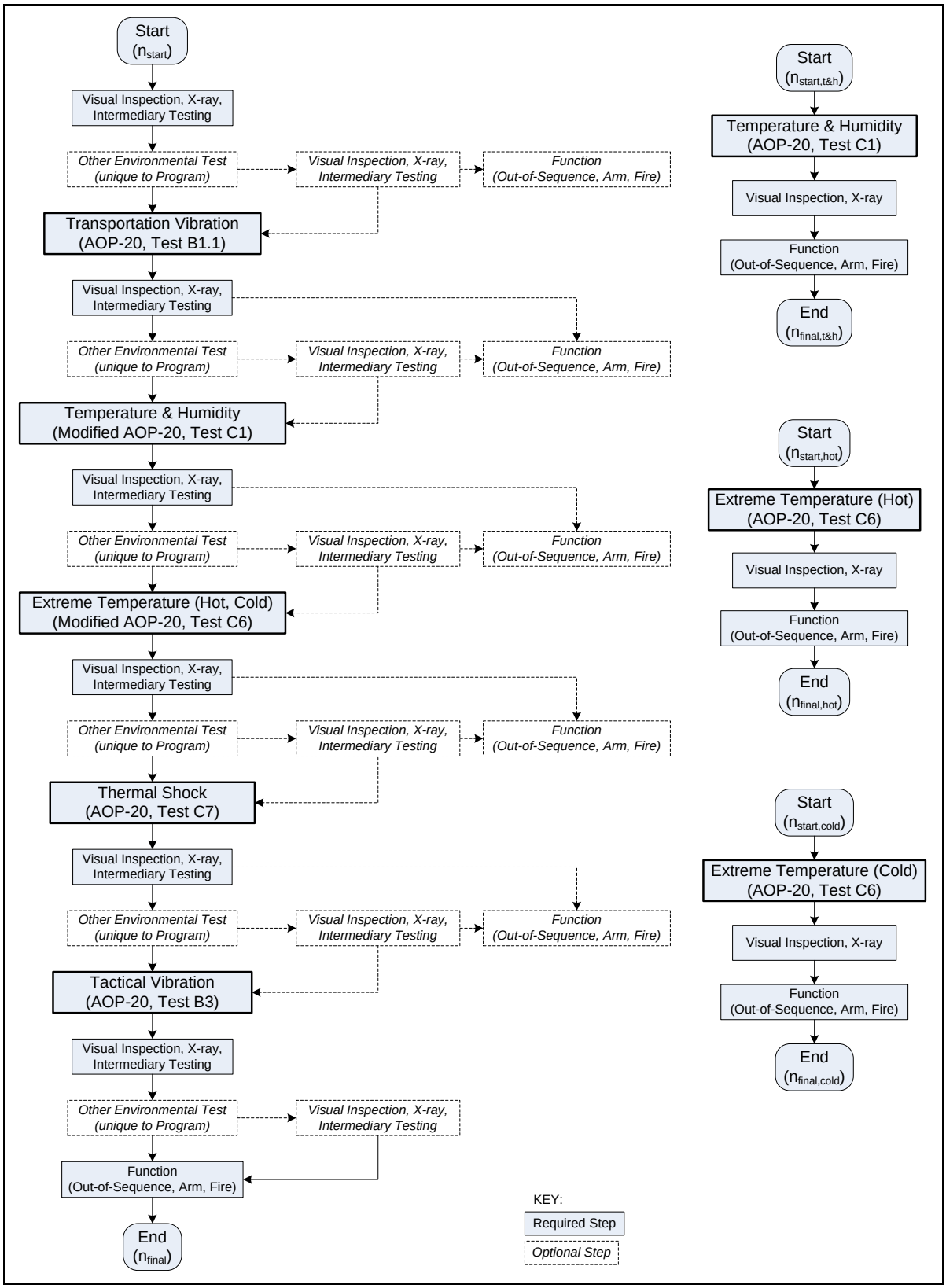


Figure 2c. Method II Test Flow - Expanded

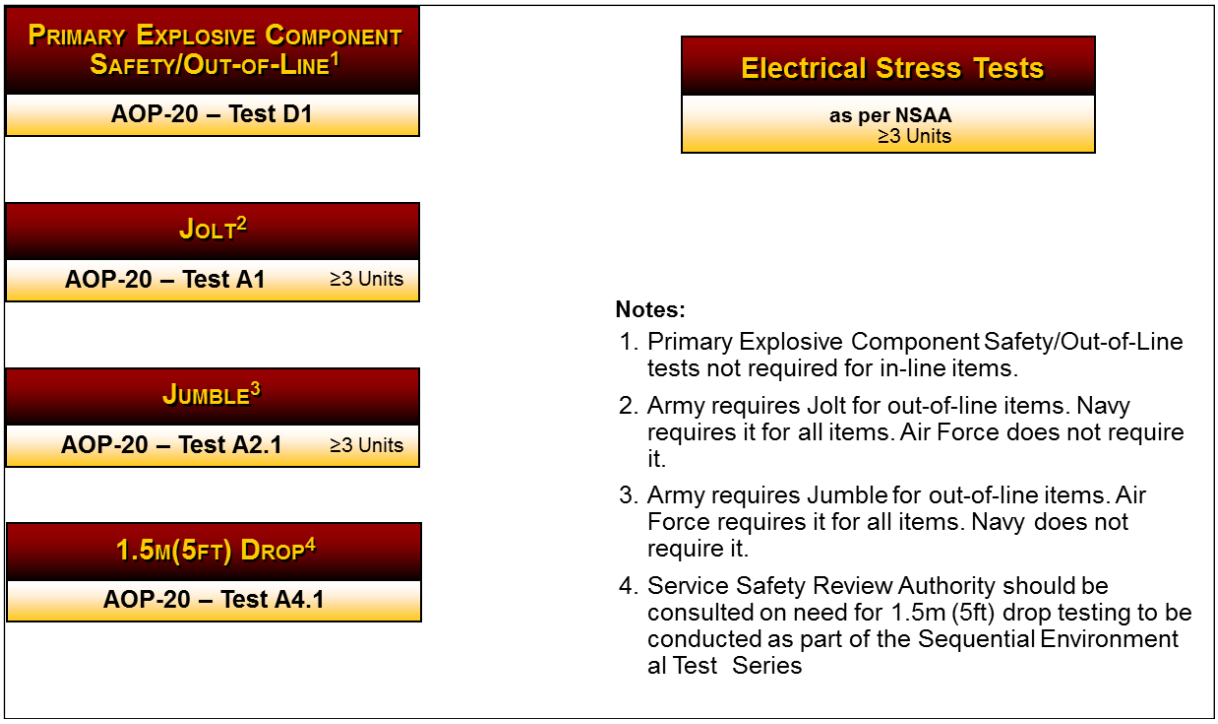


Figure 3. Miscellaneous Tests

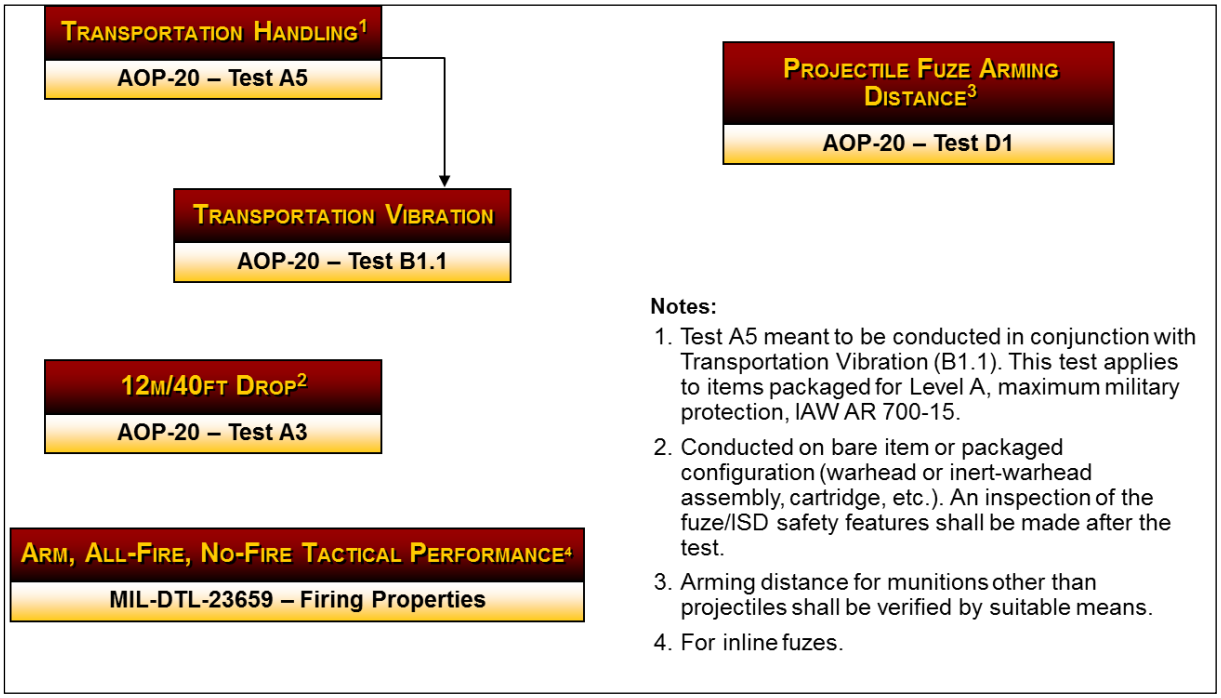


Figure 4. Additional Miscellaneous Tests

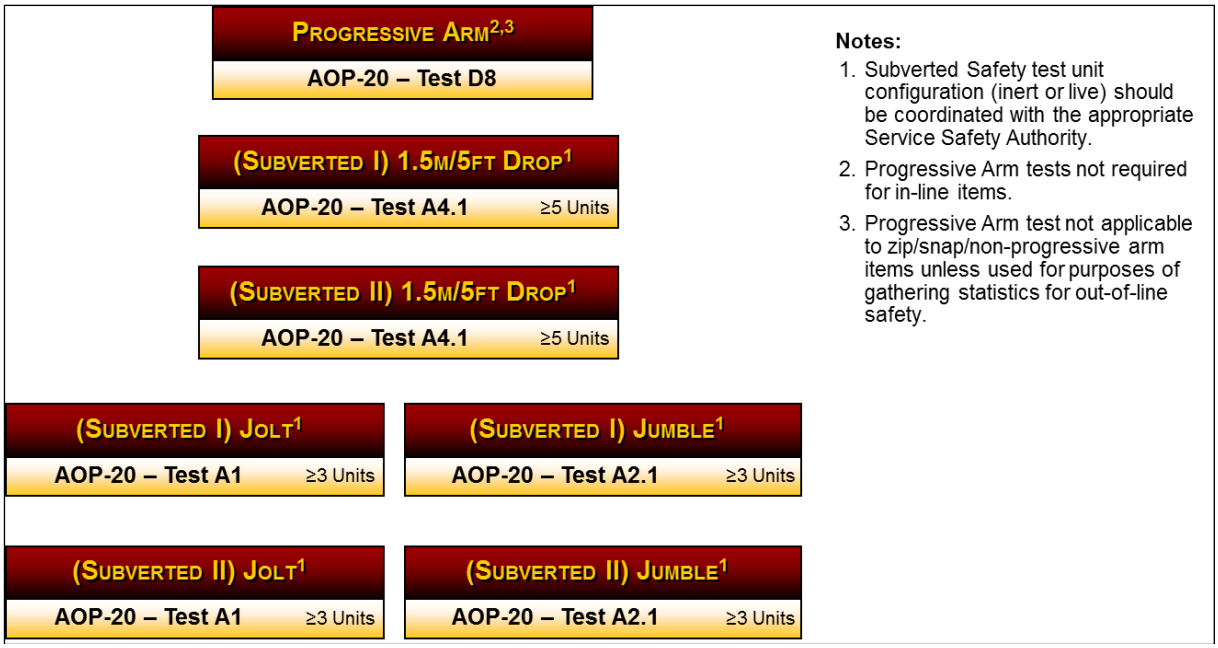


Figure 5. Safety Tests

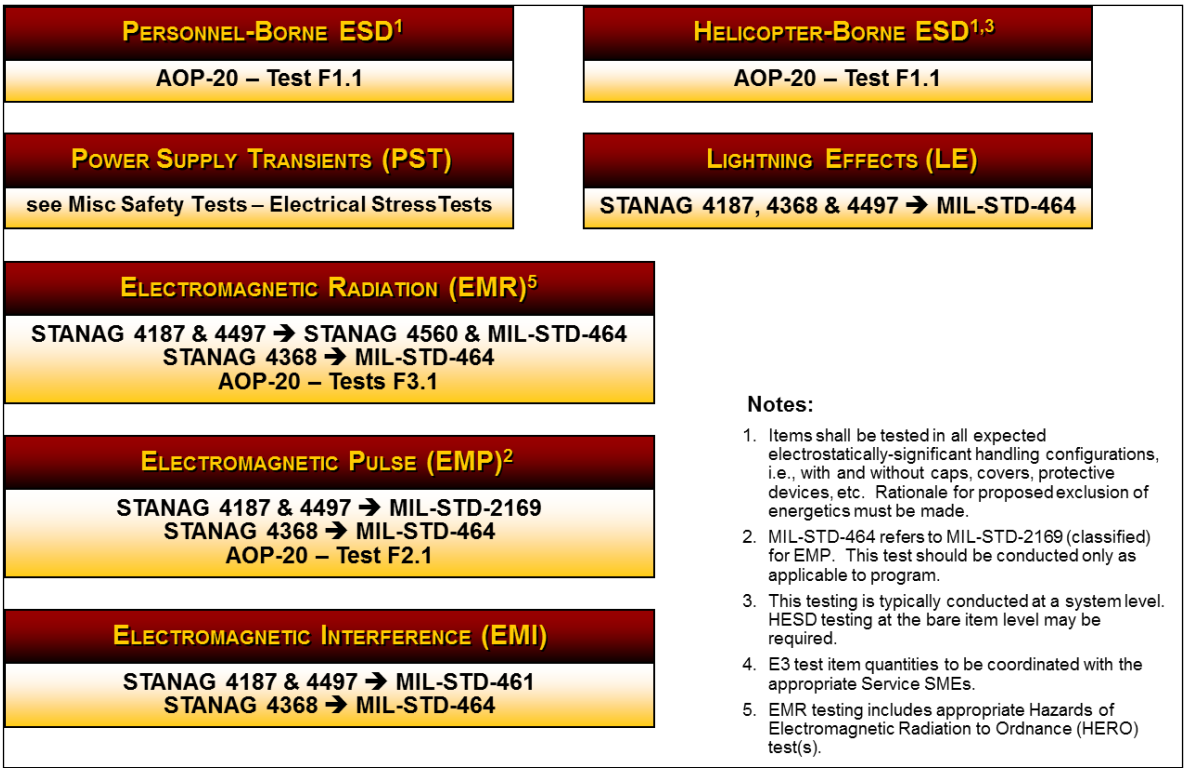


Figure 6 Electromagnetic Environmental Effects (E3) Tests

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