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NORTH ATLANTIC TREATY ORGANIZATION

MANUAL OF DATA REQUIREMENTS AND TESTS FOR THE QUALIFICATION OF EXPLOSIVE MATERIALS FOR MILITARY USE

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NORTH ATLANTIC TREATY ORGANIZATION

NATO STANDARDIZATION AGENCY (NSA)

NATO LETTER OF PROMULGATION

1. AOP-7 (Edition 2) - MANUAL OF DATA REQUIREMENTS AND TESTS FOR THE QUALIFICATION OF EXPLOSIVE MATERIALS FOR MILITARY USE is a NATO/PfP UNCLASSIFIED publication.

2. AOP-7 (Edition 2) is effective upon receipt.

3. AOP-7 (Edition 2) contains only factual information. Changes to these are not subject to the national ratification procedures; they will be promulgated on receipt by the nations concerned.

Jan H ERIKSEN
Rear Admiral, NONA
Director, NSA

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RESERVATIONS

NATION	RESERVATIONS

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RECORD OF AMENDMENTS

Identification of Amendment/Change – Section No.	Date Entered	By whom Entered	Remarks

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CHAPTER 1

1.0 INTRODUCTION

1.1 Explosive materials such as high explosives, propellants and pyrotechnics are used in weapon systems to perform a variety of functions. They provide the energy required to deliver the payload to the target and to obtain the desired terminal effect. Because of their high energy content, these materials are sensitive and can be initiated by stimuli such as heat, shock, friction, impact, and electrostatic discharge. All of these stimuli may be encountered in development programs, and later in the manufacture, transport, storage, and operational or training use of explosive materials.

1.2 The careful and judicious selection of explosives is important since it will affect the sensitivity and safety of munitions and the vulnerability of weapon platforms. Trade-off with performance can be made, but in general, the more powerful the explosive used, the more sensitive it is to stimuli, and the more protection must be provided to shield munitions in hazardous areas. Since in many applications space is limited, it is often impossible or unfeasible to provide the increased protection. Therefore, in qualifying explosives, National Authorities must exercise caution and concern for the sensitivity and the suitability for service of the explosive materials being considered for all military applications. Further, munition designers should select the least sensitive explosive material that meets the operational requirements defined for their application.

1.3 In the past, the tests, and criteria used by each North Atlantic Treaty Organization (NATO) country to accept explosives for military use have not been readily available nor, in general, well documented. This has delayed the NATO-wide acceptance of explosives, hindered munitions interoperability programs, caused unnecessary testing redundancy, and wasted the valuable material and financial resources of countries in the Alliance.

1.4 The use of modeling to assess the behavior of explosive materials under a wide range of stimuli and scenarios is important. The Qualification phase lends itself to the determination of the intrinsic properties of the explosive materials and allows for the generation of a range of modeling parameters. This then will allow those nations wishing to model small and intermediate-scale testing the opportunity to develop appropriate models and computer codes. In addition, it will facilitate the development of generic test vehicles and test methods that will underpin and support weapons safety and suitability for service activities. The AC/310 Subgroup 1 will consider further development along these lines in the future.

1.5 The recognition of the differences in weapon sensitivity evaluations and in the explosives selection processes among NATO nations, led to the establishment of the AC/310 Cadre Group and four Subgroups. This organization operates under the aegis of the Conference of National Armament Directors (CNAD). Since 1997 the AC/310 group has admitted non-aligned, Partnership for Peace (PfP), nations who wish to participate in these activities. The four Subgroups in AC/310 address, respectively, Explosive Materials, Fuzing Systems, Environment, and Generic Classes of Munitions.

1.6 Subgroup 1 (Explosive Materials) has developed an approach and is standardizing the tests used to acquire the data deemed necessary for the Qualification of military explosives. The Subgroup recognizes that substantial continuing efforts must be directed toward the following:

1.6.1 The development of Standardization Agreements, STANAGs, on test equipment, and test procedures used to acquire the data to satisfy national requirements for the Qualification of explosives used by the military.

1.6.2 The formation and identification of central repositories of data on qualified explosives in each member country to facilitate the exchange of information used in munitions co-development or cross-procurement programs.

1.6.3 The documentation of tests and acceptance criteria which may be unique to one nation to permit other NATO members to understand and interpret the data exchanged in terms of the specific test apparatus, procedures, and criteria employed.

1.6.4 The development of STANAGs to assure that the explosives used by the NATO forces are produced to the same or equivalent material specification and to the same or equivalent quality assurance principles.

1.7 STANAG 4170, "Principles and Methodology for the Qualification of Explosive Materials for Military Use," documents the agreement to standardize the assessment principles and methodology. This manual supplements STANAG 4170 and presents the specific requirements, techniques, and tests used by the participating nations to implement the STANAG.

1.8 This document is officially designated Allied Ordnance Publication No. 7, "Manual of Data Requirements and Tests for the Qualification of Explosive Materials for Military Use." The abbreviated designation "AOP-7" is used throughout this manual.

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CHAPTER 2

2.0 OBJECTIVES

2.1 The primary objectives of this document are as follows:

2.1.1 To promote standardization and interoperability of munitions among the NATO countries. This can be achieved by documenting the policies established by the participating countries to implement the explosive materials Qualification process established by STANAG 4170.

2.1.2 To supplement STANAG 4170 by identifying the organizational elements and unique national requirements involved in the explosive materials development and Qualification process for each participating country.

2.1.3 To identify the National Authorities responsible for the Qualification of military explosives in each nation.

2.1.4 To identify the minimum explosives safety data that must be reported to the National Authority to satisfy STANAG 4170 Qualification requirements.

2.1.5 To provide both summaries and references to complete descriptions of tests used by member nations to evaluate the properties of explosive materials and, within the limits of national regulations, standardize methods for recording and exchanging data on explosive materials.

2.1.6 To provide the recipients of data with the information necessary to assess the experimental and theoretical basis used by each nation in qualifying military explosives.

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CHAPTER 3

3.0 SCOPE

3.1 This manual documents Qualification procedures and tests used by the National Authorities of each participating nation to assess the safety and suitability of explosives used in their intended role, e.g. high explosive, booster, etc. The Qualification of a new explosive in accordance with STANAG 4170 and this AOP does not imply Final (or Type) Qualification for use in a specific hardware application.

3.2 This document is not a substitute for legislative and regulatory requirements (e.g. UN tests, hazard classification tests, etc.) relating to the manufacture, transportation, storage, and disposal of explosive substances. These requirements are, in general, the responsibility of other government organizations. However, many of the tests included in this manual may also be used to satisfy those legislative or regulatory requirements.

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CHAPTER 4

4.0 DEFINITIONS AND REFERENCED POLICY DOCUMENTS

4.1 The participating countries have agreed on the following definitions:

4.1.1 ASSESSMENT. This is an evaluation of the properties of an explosive material, including the results of appropriate tests, to determine its relationship, with particular regard to safety, to other explosive materials already in service use.

4.1.2 COMPARISON EXPLOSIVE. This is an in-service explosive with proven safety characteristics whose properties are used to assess the relative safety and suitability of a new explosive intended for use in a similar role.

4.1.3 EXPLOSIVE MATERIAL. An explosive material is a substance (or a mixture of substances) capable by chemical reaction of producing gas at such temperature and pressure as to cause damage to the surroundings. Included are pyrotechnic substances even though they may not evolve gases as they react. This document refers only to those explosive materials whose application requires that they react reliably on demand. The term "explosive" thus includes all solid and liquid materials variously known as high explosives and propellants, together with igniter, primer, initiatory and pyrotechnic (e.g., illuminant, smoke, delay, decoy, flare, and incendiary) compositions.

4.1.4 MAIN CHARGE EXPLOSIVE. An explosive material (high explosive, propellant, or pyrotechnic) used as the final charge and functioned to obtain the desired effect in the end item application.

4.1.5 FINAL (OR TYPE) QUALIFICATION. This relates to the use of the explosive material in a specific application or munition. Final Qualification is given when the explosive has been assessed as part of the design of the specific munition, and predicted to be safe and suitable for military operational or training use in that role. The database of results provides a means of undertaking “Risk Assessments”.

4.1.6 INTENDED ROLE. The main roles are as follows. Nations may define other roles or add the specific information for the intended application of a particular explosive material.

a. Primary Explosive: A substance or mixture of substances used to initiate a detonation or a burning reaction. In their intended role these materials are sensitive to a range of thermal, mechanical and electrical stimuli.

b. Booster Explosive: An explosive material used to augment and transmit the reaction (initiated by the primary explosive) with sufficient energy to initiate a detonation reaction in the main charge high explosive.

c. High Explosive: A material that is used as a detonating final charge.

d. Solid Gun Propellant: This is a substance (or a mixture of substances) that is required to burn in a controlled manner within a gun combustion chamber producing hot gases capable of propelling a projectile at high velocity. Combustible cases may also be included as they contribute to the overall energy of the propellant.

e. Solid Rocket Propellant: This is a substance (or a mixture of substances) that is required to burn in a controlled manner within a rocket motor producing hot gases that are vented through a nozzle to propel the munition. Propellants used in cartridge activated or other non-propulsive devices are also included in this category.

f. Liquid Propellant: This is a substance (or a mixture of substances) that is required to react in a combustion chamber in controllable manner in order to generate propulsive force. These may be monopropellants, bi-propellants or hybrids comprised of liquids and solids.

g. Pyrotechnic Compositions: These are substances (or a mixture of substances) that when ignited, undergo an energetic chemical reaction at a controlled rate intended to produce on demand and in various combinations, specific time delays or quantities of heat, noise, smoke, light or infrared (IR) radiation. Pyrotechnic compositions may be used to initiate burning reactions such as in igniters.

4.1.7 MANDATORY DATA. These are the results of mandatory tests that provide a basis for a decision concerning the military application of the explosive.

4.1.8 MANDATORY TESTS. These are tests that should always be required by a National Authority to produce data for assessing the safety and suitability of an explosive material. The tests compiled in chapter 7 of this document are considered to be the minimum safety, performance, and application-oriented tests required. Each nation reserves the right to use additional or supplementary (optional) tests for Qualification. Where this is the case, the specific national requirements are documented and the tests are identified in Chapter 10 of this manual.

4.1.9 NEW EXPLOSIVE. The term "new explosive" encompasses the following:

a. An explosive material not previously qualified.

b. An explosive material for which the existing specification defining its composition, its material constituents or process by which the composition is prepared has been modified.

c. An explosive material resulting from a change in manufacturer or manufacturing location.

d. An explosive material used in a role (See 4.1.5) for which it has not already been Qualified.

4.1.10 OPTIONAL DATA. Test results introduced to supplement data acquired in the mandatory tests or to provide additional information where mandatory test results may be inconclusive.

4.1.11 OPTIONAL TESTS. Tests that may be required by a National Authority to produce data for assessing the safety and suitability of an explosive material being considered for military application. Optional tests are compiled by each nation in Chapter 10 of this manual.

4.1.12 QUALIFICATION. The assessment of an explosive by the National Authority according to STANAG 4170 and this document to determine whether it possesses properties that makes it safe and suitable for consideration for use in the intended role.

4.1.13 QUALIFIED EXPLOSIVE MATERIAL. This is an explosive material that has successfully completed the Qualification process of a National Authority. This is an intermediate risk reduction stage prior to Final (or Type) Qualification.

4.1.14 REFERENCE STANDARD EXPLOSIVE. This is an explosive whose properties are consistent and sufficiently well defined to enable its use for the calibration of test apparatus. The explosive nominated as a reference standard, together with its lot number when appropriate, must be identified on the relevant national test information sheet.

4.2 The following policy documents are referenced in this manual:

a. STANAG 4123 - "Methods to Determine and Classify the Hazards of Ammunition".

b. STANAG 4170 - "Principles and Methodology for the Qualification of Explosive Materials for Military Use".

c. STANAG 4297 – Implementation of Allied Publication N^o 15 (AOP-15).

d. STANAG 4397 – Explosives, NATO Catalogue of, Implementation of Allied Ordnance Publication N^o 26 (AOP-26).

e. STANAG 4439 - Policy for Introduction, Assessment, and Testing for Insensitive Munitions (MURAT).

f. AOP-15 - "Guidance on the Assessment of the Safety and Suitability for Service of Munitions for the NATO Armed Forces".

g. AOP-26 - "NATO Catalogue of Explosives".

h. AOP-39 - Guidance on the Development, Assessment, and Testing of Insensitive Munitions (MURAT)

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CHAPTER 5

5.0 METHODS TO RECORD AND ISSUE DATA

5.1 The participating countries have agreed on the following ways to record and issue data:

5.1.1 A formal Qualification report will be issued by the National Authority or by a National Authority approved organization for each explosive Qualified. This report must include, in so far as possible, all the information required to enable other participating countries to accept the explosive with minimal or no additional testing. In general, the information reported must comply with Tables 1 to 3 of STANAG 4170.

5.1.2 The technical report issued must identify the developer and manufacturer of the explosive, the organization that conducted the tests and the qualifying National Authority. It will also include the following:

5.1.3 Background information on the development of the explosive and the advantages expected from its use.

5.1.4 The data required in Chapter 7 of this document. In addition, sensitivity and stability data acquired during the development program, including any other pertinent information acquired in the development and pre-production phases.

5.1.5 The description of the properties of the explosive that are relevant to its nature and intended use.

5.1.6 Information on tests performed to provide data relating to any unique characteristic.

5.1.7 An Assessment of the properties by comparing test data with that of comparison explosives of known and proven satisfactory use in similar applications.

5.1.8 An evaluation of the physical, chemical, and aging properties of the explosive.

5.2 The formal Qualification Certificate issued by the National Authority (Annex B of STANAG 4170 Edition 2) and the reports issued to support Qualification will be released to requesting nations in accordance with paragraph 3 of STANAG 4170.

5.3 For ease of reference and simplicity, a data sheet consistent with the format used in AOP-26 shall be prepared by the National Authority or by a National Authority approved organization for each explosive Qualified by a NATO country. These data sheets shall be forwarded to the custodian nation for inclusion in AOP-26, “NATO Catalogue of Explosives”.

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CHAPTER 6

6.0 REVIEWS AND REVISIONS OF THIS MANUAL

6.1 This manual and the tests included herein will be reviewed upon the request of a participating nation. If any changes are proposed the national delegate of the submitting country shall request that the Chairman of AC/310 Subgroup 1 include this as an agenda item for the next meeting of the Subgroup.

6.2 Requests to revise AOP-7 must be accompanied by supporting documentation and should be presented to the Chairman of AC/310 Subgroup 1 for inclusion on the agenda of the next meeting of the Subgroup. Subgroup 1 will rewrite and approve the revisions of Chapters 1 through 9 and the leading section of Chapter 10 of this manual. Such revisions will be provided to the Custodian Nation and to the International Staff secretary for publication. The United States is the Custodian Nation for this document.

6.3 National Authorities shall perform regular reviews of their respective sections of Chapter 10 of this document to verify that the information is still applicable. Subgroup 1 will review proposed revisions of Chapter 10 of this manual and provide comments as appropriate. The Subgroup has no authority to change the content of the National sections of Chapter 10 of this manual. This authority resides solely within the purview of the National Authority of the submitting country.

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CHAPTER 7

7.0 ASSESSMENT PRINCIPLES AND COMMON REQUIREMENTS FOR THE QUALIFICATION OF EXPLOSIVES

7.1 This chapter sets forth the minimum data requirements and assessment principles agreed upon and used by the NATO and participating PfP countries for qualifying explosive materials in accordance with STANAG 4170. National Authorities may require additional data in order to qualify explosives for potential applications by their forces.

7.1.1 Unique requirements such as mandatory data, tests, criteria, etc., which may be imposed by a country are included in the respective national sections of Chapter 10 of this manual. For example, some nations have pass and fail criteria for booster explosives.

7.1.2 For each requirement, the information provided must be accompanied with data on comparison explosives as defined in section 4.1.2. The selection of comparison explosives should be such that each explosive selected is familiar to the nations participating in the collaborative weapons development or procurement program.

7.1.3 In general, Qualification decisions made by the National Authority must be based on an assessment of the relative safety of the new explosive compared to that of an explosive material with proven safety characteristics that has been used in a similar role.

7.1.4 It is very important to determine whether the safety and performance characteristics of an explosive will change during its life cycle. Accelerated aging studies shall be considered during the explosives Qualification process. Basic information on aging is obtained during the Qualification phase; however, the results of a more complete study of the aging characteristics of the explosive material should be available before the Final (or Type) Qualification process is completed. Example aging protocols are presented in Chapter 8 of this document.

7.1.5 Toxicity data on the explosive material, its components, and its reaction products shall, in-so-far-as possible, be determined and included in the Qualification report.

7.1.6 Information on the ability of the explosive material to be reused, recycled or destroyed with minimum effect on health and environment is required.

7.1.7 The condition of having been assessed as satisfactory on the basis of the information and tests described herein is necessary but not sufficient for an explosive material to be Final (Type) Qualified for a specific application in an operational or training device. Final (Type) Qualification is subject to the demonstration of safety and suitability of the explosive in that specific application with testing performed in accordance with STANAG 4297 and AOP-15. A general discussion on Final (or Type) Qualification is provided in Chapter 9 of this document.

7.1.8 For ready reference, the STANAGs on agreed tests that are used by participating nations to obtain data to support the Qualification of explosive materials in accordance with STANAG 4170 are listed in Chapter 10 of this document.

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7.2.0 PRIMARY EXPLOSIVES

7.2.1 Primary explosives are sensitive materials used to initiate a detonation or a burning reaction. By nature, these materials are sensitive to thermal, mechanical and electrical stimuli. In general, they are not used beyond the safety and arming device. The information required for Qualification is used to make an assessment of the safety of the explosive in comparison with in-service explosives for which adequate safety has been demonstrated. Materials used in initial and intermediary charges for primers, igniters, detonators, caps, relays, electric matches, fuze heads, delays, explosive bolts, explosive switches, explosive valves, explosive cutters, and explosive pistons are included when these do not qualify for evaluation and assessment under other sections of this chapter.

7.2.2 The following data and information are necessary for the Qualification of primary explosives. However, because of the sensitive nature of these explosives the tests identified below may not always be appropriate. Thus on a case-by-case basis, the National Authority may substitute other tests when the test apparatus or the test procedures required by the STANAGS listed in this section are not appropriate.

7.2.2.1 General Characteristics.

a. Composition. A specification for the explosive material with its ingredients and, if applicable, their permissible ranges specified shall be provided. The samples used for the Qualification tests must comply with the specification and must be made by the approved method of manufacture.

b. Intended Application. Information on the intended application (i.e., detonator, igniter, etc.) shall be provided.

c. Loading. Information on the final state of the material in its intended application (i.e., pressed, cast, etc.) and, as appropriate, its nominal loading density in the anticipated applications shall be provided.

d. Related Service Applications and Compositions. Information on existing service applications of the explosive or closely related explosives shall be provided if available.

e. Hazard Classification. Information on transportation and storage hazard classification per STANAG 4123, UN, or national regulations shall be provided.

7.2.2.2 Chemical, Physical and Mechanical Properties.

a. Stability. Data acquired in accordance with STANAG 4515 to support a determination of how the explosive reacts to elevated temperatures over a period of time shall be provided.

b. Compatibility. Data acquired in accordance with STANAG 4147 to determine the compatibility of the explosive with materials used in its manufacture and in its intended application shall be provided.

c. Aging. Data acquired following accelerated aging to determine whether the material characteristics will change with time shall be provided. Any change that could affect safety and reliable performance is of particular concern. Example aging protocols are presented in Chapter 8 of this document.

7.2.2.3 Hazard Assessment.

a. Sensitivity/Sensitiveness. Data shall be provided on the sensitivity/sensitiveness of the explosive to credible stimuli including:

b. Ignition Temperature. Data acquired in accordance with STANAG 4491 or 4515 as appropriate shall be provided.

c. Electrostatic Discharge. Data acquired in accordance with Annex A of STANAG 4490 shall be provided. Ease of ignition is presented in terms of the minimum energy required for initiation.

d. Impact. Drop-weight impact data acquired in accordance with appropriate national test procedures which may include those of STANAG 4489 shall be provided. National Authorities may require information on the degree of sensitization by grit on a case-by-case basis.

e. Friction. Data acquired in accordance with appropriate national test procedures which may include those of STANAG 4487 shall be provided.

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7.3.0 BOOSTER EXPLOSIVES

7.3.1 Booster explosives are used to transmit and augment the reaction initiated by the primary explosive with sufficient energy to initiate a detonation reaction in the high-explosive charge. A detonation reaction of the booster explosive would normally be communicated to the high-explosive charge when the fuze is in both the armed or unarmed condition. Booster explosives need to be relatively sensitive materials, but to be Qualified, they must have been shown to be sufficiently safe to be used beyond the safety and arming device or in-line fuze systems.

7.3.2 Explosives used in leads, relays, detonating cords, boosters, or in any other element used in direct line (uninterrupted) with the high-explosive charge of an end item application are included under the booster explosive requirements. The Qualification documents issued by the National Authority should specify any restrictions in the role for which the booster explosive is qualified.

7.3.3 Historically, tetryl was deemed to be an acceptable comparison explosive and often used to assess the sensitivity of new booster materials. It was used successfully in fuzes for many years but many countries no longer produce it. Also, tetryl is not acceptable for operational use in munitions designed to meet the Insensitive Munitions (MURAT) requirements per STANAG 4439 and AOP-39. Thermal heating of tetryl loaded items such as occurs in fast and slow cook-off tests often leads to a detonation reaction that can transmit to the high-explosive charge in a weapon.

7.3.4 The data and other information obtained during the Qualification process are used by the National Authority to assess the safety and suitability for service of the explosive material used in a particular role. The following table provides the minimum criteria that should be considered by National Authorities to judge the suitability for service of a booster explosive. The thresholds established are based on test results obtained with tetryl; however, the values shown therein are not necessarily the values obtained with all tetryl batches. A material that does not meet the requirements set forth in table 1 should not be considered for use as a booster explosive. The pass-fail criteria may be waived by the National Authority depending on the use of an explosive in a specific application such as, for example, detonating cords.

7.3.5 In addition to table 1 (shown below), the following data and information are necessary for the Qualification of booster explosives:

TABLE 1
MINIMUM REQUIREMENTS FOR BOOSTER EXPLOSIVES

TEST STANAG/PARAMETER MEASURED	TEST PERFORMED	CRITERIA
4556 VACUUM THERMAL STABILITY	MANOMETER/ TRANSDUCER	NO MORE THAN 1.0 cm^3/g AT 100°C FOR 40 HOURS
4515 THERMAL PROPERTIES OR 4491 THERMAL PROPERTIES	DTA/DSC	DECOMPOSITION EXOTHERM PEAK > 180°C AT 5°C/min
	TEMPERATURE OF IGNITION	TEMPERATURE OF IGNITION T of I > 180°C AT 5°C/min
4487 FRICTION	BAM	NO EVIDENCE OF REACTION AT 80 N FOR 10 OUT OF 10 TRIALS
	ROTARY FRICTION	FIGURE OF FRICTION F of F > 3.0
4488 SHOCK	SMALL SCALE GAP TEST	NO EVIDENCE OF DETONATION AT 1 GPa AT DENSITY OF APPLICATION FOR 10 OUT OF 10 TRIALS
	INTERMEDIATE SCALE GAP TEST	NO EVIDENCE OF DETONATION AT 1.4 GPa AT DENSITY OF APPLICATION FOR 10 OUT OF 10 TRIALS
4490 ELECTROSTATIC DISCHARGE	SMALL-SCALE SPARK TEST	SEE NATIONAL SECTIONS IN CHAPTER 10
4489 IMPACT	ERL-BRUCETON TEST	NO DETONATION AT 12 cm FOR 10 OUT OF 10 TRIALS
	ROTTER IMPACT TEST	FIGURE OF INSENSITIVENESS F of I > 60
	BAM IMPACT TEST	NO REACTION AT 3 JOULE LEVEL FOR 10 OUT OF 10 TRIALS

7.3.5.1 General Characteristics.

a. Composition. A specification for the explosive material with its ingredients and, if applicable, their permissible ranges specified shall be provided. The samples used for the Qualification tests must comply with the specification and must be made by the approved method of manufacture.

b. Intended Application. Information shall be provided on the intended application (i.e. booster, detonating cord, lead, etc.).

c. Loading. Information on the final state (i.e., pressed, cast, etc.) and the density of the material in its intended application shall be provided.

d. Related Service Applications and Compositions. Information on existing service applications of closely related explosives shall be provided, if available.

e. Hazard Classification. Information on transportation and storage hazard classification per STANAG 4123, UN, or national regulations shall be provided.

7.3.5.2 Chemical, Physical and Mechanical Properties.

a. Stability & Thermal Characterization. Data acquired in accordance with STANAG 4515 and 4556, as appropriate, to support a determination of how the explosive reacts to elevated temperatures over a period of time shall be provided.

b. Aging. Data acquired following accelerated aging to determine whether the material characteristics will change with time shall be provided. Any change that could affect safety and reliable performance is of particular concern. Example aging protocols are presented in Chapter 8 of this document.

c. Compatibility. Data acquired in accordance with STANAG 4147 to determine the compatibility of the explosive with materials used in its manufacture or in its intended application shall be provided.

d. Density. Data on theoretical maximum density and acceptable loading density reported in accordance with National procedures shall be provided.

e. Melting Point. When applicable. Data acquired in accordance with STANAG 4515 or other methods found acceptable for use in explosive materials STANAGs, i.e., STANAG 4284 (HMX) shall be provided.

f. Glass Transition Point. Data acquired in accordance with STANAG 4540 shall be provided for explosives made with polymeric binders.

g. Mechanical/Rheological Properties: Data per STANAG 4443, 4506, 4507, and 4525 may be required for boosters made with polymeric binders.

7.3.5.3 Hazard Assessment.

a. Sensitivity/Sensitiveness. Data shall be provided on the sensitivity/sensitiveness of the explosive to credible stimuli including:

(1) Ignition Temperature. Data acquired in accordance with STANAG 4491 or 4515, as appropriate.

(2) Explosive Response when Ignited (Confined and Unconfined). Data acquired in accordance with STANAG 4491.

(3) Electrostatic Discharge. Data acquired in accordance with STANAG 4490.

(4) Impact. Drop-weight impact data acquired in accordance with STANAG 4489.

(5) Friction. Data acquired in accordance with STANAG 4487.

(6) Shock. Data acquired in accordance with STANAG 4488.

7.3.5.4 Performance Assessment.

a. Detonation Velocity. Detonation velocity measured by high-speed photography, ionization probes, or any other method accepted by the National Authority shall be provided.

b. Critical diameter. Minimum size required to sustain a steady state detonation shall be provided. This may be estimated or measured by any method accepted by the National Authority.

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7.4.0 HIGH EXPLOSIVES

7.4.1 High explosives are compounds or formulations that are used as the final charge and detonated to obtain the desired effect for the end-item application. The information acquired for Qualification is used to assess the safety of the new explosive in comparison with in-service high explosives for which adequate safety has been demonstrated. Materials demonstrated to be in the same range of sensitivity in the hazard tests as in-service booster explosives, such as CH-6, should be classed as booster rather than high explosives. National Authorities may allow a booster explosive to be used as a main charge high explosive in certain instances. However before a booster explosive is considered for a main charge application a safety assessment must be performed and the potential application approved by the National Authority. The following data and information are necessary for the Qualification of high explosives:

7.4.1.1 General Characteristics

a. Composition. A specification for the explosive material with its ingredients and, if applicable, their permissible ranges specified shall be provided. The samples used for the Qualification tests must comply with the specification and must be made by the approved method of manufacture.

b. Intended Application. Information shall be provided on the intended application (i.e. warhead, demolition charge, etc.).

c. Loading. Information on the final state (i.e., pressed, cast, etc.) and the density of the material in its intended application shall be provided.

d. Related Service Applications and Compositions. Information on existing service applications of the explosive or closely related explosives shall be provided, if available.

e. Hazard Classification. Information on transportation and storage hazard classification per STANAG 4123, United Nations, or national regulations shall be provided.

7.4.1.2 Chemical, Physical and Mechanical Properties.

a. Stability & Thermal Characterization. Data acquired in accordance with STANAG 4515 and 4556, as appropriate, to support a determination of how the explosive reacts to elevated temperatures over a period of time shall be provided.

b. Aging. Data acquired following accelerated aging to determine whether the material characteristics will change with time shall be provided. Any change that could affect safety and reliable performance is of particular concern. Example aging protocols are presented in Chapter 8 of this document.

c. Compatibility. Data acquired in accordance with STANAG 4147 to determine the compatibility of the explosive with materials used in its manufacture or in its intended application shall be provided.

d. Density. Data shall be provided on the theoretical maximum density and the acceptable loading density. The data shall be acquired in accordance with National procedures.

e. Melting Point. When applicable. Data acquired in accordance with STANAG 4515 or other methods found acceptable for use in explosive materials STANAGs, i.e., STANAG 4284 (HMX) shall be provided.

f. Glass Transition Point. Data acquired in accordance with STANAG 4540 shall be provided for explosives that are made with polymeric binders.

g. Mechanical/Rheological Properties: Data per STANAG 4443, 4506, 4507, and 4525 may be required for high explosives made with polymeric binders.

7.4.1.3 Hazard Assessment.

a. Sensitivity/Sensitiveness. Data shall be provided on the sensitivity/sensitiveness of the explosive to credible stimuli including:

(1) Ignition Temperature. Data acquired in accordance with STANAG 4491 or 4515, as appropriate.

(2) Explosive Response When Ignited (Confined and Unconfined). Data acquired in accordance with STANAG 4491.

(3) Electrostatic Discharge. Data acquired in accordance with STANAG 4490.

(4) Impact. Drop-weight impact data acquired in accordance with STANAG 4489.

(5) Friction. Data acquired in accordance with STANAG 4487.

(6) Shock. Data acquired in accordance with STANAG 4488.

7.4.1.4 Performance Assessment.

a. Detonation Velocity. Detonation velocity measured by high-speed photography, ionization probes, or any other method accepted by the National Authority shall be provided.

b. Critical Diameter. Minimum size required to sustain a steady state detonation shall be provided. This may be estimated or measured by any method accepted by the National Authority.

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7.5.0 SOLID GUN AND ROCKET PROPELLANTS

7.5.1 Solid gun and rocket propellants are substances or mixtures of substances that are required to burn in a controlled manner in devices such as guns, rocket motors, or gas generators. Propellants comprise a wide range of formulations each of which is tailored to a specific application. It is thus difficult to define a concise list of data requirements for Qualification common to all propellants. It is possible, however, to establish basic requirements and indicate, where appropriate, the types of propellants that apply. Because final adjustments to the formulations must be made throughout the propulsion or gas generator unit development period, the Qualification of solid propellants may be concurrent with Final (or Type) Qualification of the propellant for use in a specific application. The following data and information are necessary for the Qualification of solid propellants:

7.5.1.1 General Characteristics.

a. Composition. A specification for the explosive material with its ingredients and, if applicable, their permissible ranges specified shall be provided. The samples used for the Qualification tests must comply with the specification and must be made by the approved method of manufacture.

b. Intended Application. Information on the intended application (i.e. gun, rocket motor, gas generator, etc.) shall be provided.

c. Loading. Information on final state of the material (i.e. cast, pressed, extruded, etc.) and the density of the material in its intended application shall be provided.

d. Related Service Applications and Compositions. Information on existing service applications of the propellant or closely related propellants shall be provided, if available.

e. Hazard Classification. Information on transportation and storage hazard classification per STANAG 4123, UN, or national regulations shall be provided.

7.5.1.2 Chemical, Physical and Mechanical Properties.

a. Stability & Thermal Characterization. Data acquired in accordance with STANAG 4515 and 4556 to support a determination of how the propellant reacts to elevated temperatures over a period of time shall be provided. Also, data on stabilizer depletion shall be provided. Depending on the formulation, stabilizer depletion shall be measured in accordance with either STANAG 4117, 4527, 4541, or 4542. (see NOTE at chapter 8, section 8.4)

b. Aging. Data acquired following accelerated aging to determine whether the material characteristics will change with time shall be provided. Any change that could affect safety and reliable performance is of particular concern. Example aging protocols are presented in Chapter 8 of this document.

c. Compatibility. Data acquired in accordance with STANAG 4147 to determine the compatibility of the propellant with materials used in its manufacture or in its intended application shall be provided.

d. Density. Data on theoretical maximum density and acceptable loading density acquired in accordance with National procedures shall be provided.

e. Glass Transition Point. Data acquired in accordance with STANAG 4540 shall be provided for solid propellants that use a polymeric binder.

f. Tensile Strength. Data on uni-axial tensile properties acquired in accordance with STANAG 4506 and data on stress relaxation in tension in accordance with STANAG 4507 shall be provided for solid rocket propellants.

g. Compressive Strength. Data acquired in accordance with STANAG 4443 shall be provided for gun and rocket propellants.

h. Thermomechanical Analysis. Data in accordance with STANAG 4525 shall be provided for rocket and gun propellants.

7.5.1.3 Hazard Assessment.

a. Sensitivity/Sensitiveness. Data shall be provided on the sensitivity/sensitiveness of the propellant to credible stimuli including:

(1) Ignition Temperature. Data acquired in accordance with STANAG 4491 or 4515, as appropriate.

(2) Explosive Response When Ignited (Confined and Unconfined). Data acquired in accordance with STANAG 4491.

(3) Electrostatic Discharge. Data acquired in accordance with STANAG 4490.

(4) Impact. Drop-weight impact data acquired in accordance with STANAG 4489.

(5) Friction. Data acquired in accordance with STANAG 4487.

(6) Shock. Shock sensitivity data acquired in accordance with STANAG 4488 shall be provided. For gun propellants, tests are performed with propellant grains loaded into the gap-test tube.

7.5.1.4 Performance Assessment.

a. Critical Diameter. Minimum size required to sustain a steady state detonation shall be provided. This may be estimated using data on similar compositions or measured by any method accepted by the National Authority. This is not required for compositions that do not detonate in the shock sensitivity test performed in accordance with STANAG 4488.

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7.6.0 LIQUID PROPELLANTS

7.6.1 Liquid propellants are substances or mixtures of substances that are required to react in a combustion chamber in a controllable and predictable manner. Liquid propellants are as varied as the uses in which one finds them. These may be mono-propellants, bi-propellants, or hybrids comprised of liquids and solids. Mono-propellants are generally single substances or mixtures of pre-mixed substances that burn when ignited. Bi-propellants are generally comprised of separately stored fuels and oxidizer materials that are mixed and ignited in a combustion chamber. The fuel and oxidizer components may be hypergolic and ignite spontaneously on contact or may require an ignition source to initiate the reaction. The hybrids are generally comprised of solid fuels, which are reacted with liquid oxidizers. The following data and information are required for the Qualification of liquid propellants:

7.6.1.1 General Characteristics.

a. Composition. A specification for the explosive material with its ingredients and, if applicable, their permissible ranges specified shall be provided. The samples used for the Qualification tests must comply with the specification and must be made by the approved method of manufacture.

b. Propellant Type and Intended Application. Information on the type of propellant and its intended application, e.g. gun propellant, rocket propellant, naval torpedo propellant etc. shall be provided.

c. Loading. Information shall be provided on the proposed mixing and handling procedures and on any unusually hazardous conditions in these operations.

d. Related Service Applications and Compositions. Information shall be provided on existing service applications of the propellant or closely related propellants, if available.

e. Hazard Classification. Information on transportation and storage hazard classification in accordance with STANAG 4123, UN or national regulations shall be provided.

7.6.1.2 Chemical, Physical and Mechanical Properties.

a. Stability & Thermal Characterization. Data acquired in accordance with STANAG 4515 to determine if its properties change with time shall be provided. Also, where appropriate data on stabilizer depletion shall be provided. Analytical techniques used to determine stabilizer depletion must be approved by the National Authority.

b. Aging. Data acquired following accelerated aging shall be provided to determine whether the material characteristics will change with time shall be provided. Any change that could affect safety and reliable performance is of particular concern.

c. Compatibility. Data acquired in accordance with STANAG 4147 to determine the compatibility of the propellant with materials used in its manufacture and intended application shall be provided.

d. Toxicity. Information shall be provided on the toxicity hazards of the explosive and on its component materials in accordance with national procedures.

e. Boiling Point. Information in accordance with national procedures shall be provided.

f. Flash Point. Information in accordance with UN or national procedures shall be provided.

g. Vapor Pressure. Information in accordance with national procedures shall be provided.

h. Specific Gravity. Data on specific gravity reported in accordance with national procedures shall be provided.

i. Freezing/Melting Point. Information in accordance with UN or national procedure shall be provided.

7.6.1.3 Hazard Assessment.

a. Sensitivity/Sensitiveness. Data shall be provided on the sensitivity/sensitiveness of the propellant and, as applicable, its component parts to credible stimuli including:

(1) Ignition Temperature. Data acquired in accordance with STANAG 4491 or 4515 as appropriate.

(2) Explosive Response when Ignited (Confined and Unconfined). Data acquired in accordance with STANAG 4491.

(3) Impact. Drop-weight impact sensitivity data acquired in accordance with STANAG 4489 or accepted national procedures.

(4) Shock. Shock sensitivity data acquired in accordance with STANAG 4488.

(5) Critical Film Thickness. For materials that detonate in the shock sensitivity test, data on the critical diameter or critical liquid film thickness for detonation propagation is required. Test procedures must be documented and approved by the National Authority.

(6) Electrostatic Discharge. Data acquired in accordance with STANAG 4490.

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7.7.0 PYROTECHNIC COMPOSITIONS

7.7.1 Pyrotechnic compositions undergo an energetic chemical reaction at a controlled rate intended to produce, on demand, time delays or quantities of heat, noise, smoke, light, or IR radiation. In general, pyrotechnic compositions can be readily ignited, burn rapidly, and are very hot when they burn. Because final adjustments to the formulations must be made throughout the end-item development phase, Qualification of pyrotechnic materials may be concurrent with Final (or Type) Qualification. The following data and information are required for their Qualification:

7.7.1.1 General Characteristics.

a. Composition. A specification with the ingredients and, if applicable, their permissible ranges specified shall be provided. The samples used for the Qualification tests must comply with the specification and must be made by the approved method of manufacture.

b. Intended Application. Information shall be provided on the intended application (i.e. flare, smoke, etc.).

c. Loading. Information shall be provided on the final state of the material (i.e. granular, cast, pressed, extruded, etc.), and the density of the material in its intended application.

d. Related Service Applications and Compositions. Information shall be provided on existing service applications of the pyrotechnic composition or related compositions, if available.

e. Hazard Classification. Information shall be provided on transportation and storage hazard classification per STANAG 4123, UN, or national regulations.

7.7.1.2 Chemical, Physical and Mechanical Properties.

a. Stability & Thermal Characterization. Data acquired in accordance with STANAG 4515 to support a determination of how the pyrotechnic material reacts to elevated temperatures over an extended period of time shall be provided.

b. Aging. Data acquired following accelerated aging to determine whether the material characteristics will change with time shall be provided. Any change that could affect safety and reliable performance is of particular concern. Chapter 8 of this document provides examples of aging protocols.

c. Compatibility. Data acquired in accordance with STANAG 4147 to determine the compatibility of the pyrotechnic composition with materials used in its manufacture or in its intended application shall be provided.

d. Density. Data shall be provided on theoretical maximum density and acceptable loading density reported in accordance with national procedures.

e. Glass Transition Point. Data acquired in accordance with STANAG 4540 shall be provided for pyrotechnics that use a polymeric material as the binder shall be provided.

f. Mechanical/Rheological Properties: Data per STANAG 4506, 4507, and 4443 may be required for pyrotechnics made with polymeric binders.

7.7.1.3 Hazard Assessment.

a. Sensitivity/Sensitiveness. Data shall be provided on the sensitivity/sensitiveness of the explosive to credible stimuli including:

(1) Ignition Temperature. Data acquired in accordance with STANAG 4491 or 4515 as appropriate.

(2) Explosive Response When Ignited (Confined and Unconfined). Data acquired in accordance with STANAG 4491.

(3) Electrostatic Discharge. Data acquired in accordance with Annex A of STANAG 4490.

(4) Impact. Drop-weight impact data acquired in accordance with STANAG 4489.

(5) Friction. Data acquired in accordance with STANAG 4487.

(6) Shock. Shock sensitivity data acquired in accordance with STANAG 4488, if appropriate.

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CHAPTER 8

8.0 AGING PROTOCOLS

8.1 Accelerated aging studies on new explosives are recommended and should begin early during the qualification-testing phase. Aging studies should be started shortly after the physical and chemical characteristics of the new explosive have been defined. It may often be desirable to request Qualification by the National Authority before the accelerated aging studies are completed. But in any case, these studies should be in progress and continue until there is reasonable assurance that no unanticipated aging problems exist. The objective of beginning an aging protocol before Qualification is to determine, early, if characteristics of the explosive material are apt to change with time and if any of the changes are likely to affect the safety and suitability for service of the material in an end-item application.

8.2 The decision to grant or deny Qualification before the accelerated aging studies are completed is left to the National Authority. In so far as possible, the data acquired along with safe-life and service-life predictions based on changes in the explosive properties, if any, should be submitted to the National Authority with the Qualification request package. Based on the data available at the time and, if it is deemed appropriate, the Qualification request submission should contain a recommendation concerning the need to conduct additional aging studies before or after Final (type) Qualification of the explosive material for the end-item application.

8.3 Tables 2 through 7, provided on the following pages, are examples of aging protocols used by some of the participating countries. These can serve as examples that can be used by other countries to develop their own aging protocols.

8.4 NOTE: STANAGs 4117, 4527, 4541, and 4542 referred to in the tables below will be replaced by AOP-48 – “Explosives, Nitrocellulose Based Propellants, Stability Test Procedures and Requirements Using Stabilizer Depletion” and its covering document, STANAG 4620.

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TABLE 2
AGING PROTOCOLS – PRIMARY EXPLOSIVES

PROCEDURE	FRANCE	GERMANY	NETHERLANDS	SWITZERLAND	UNITED KINGDOM	USA (NAVY)
Aging conditions: a. Without nitrate esters present	60 ºC for 2 months	71°C for 4 weeks in sealed containers[1] [80°C/4 weeks[2]] 23 °C for 4 weeks at 30, 50, 65, & 83% RH	No criteria given	60 ºC for 6, 12 months in sealed containers	National Authority to decide if aging is appropriate on a case by case basis	70 ºC for 6, 12 months in sealed containers and 25ºC at 30%RH until Final (Type) Qualification.
b. With nitrate esters	As above	As above	As above	As above	As above	As above
Impact sensitivity	AOP-7	Yes				Yes
Friction sensitivity	AOP-7	Yes		Yes		Yes
Priming ability				Yes		Yes
ESD sensitivity		Yes				
Chemical analysis		Yes				
Hot wire ignitability						Yes
Temperature of ignition				Yes		
Thermal stability						
DSC/DTA/TG	STANAG 4515 DSC	Yes				
Closed vessel test		Yes[3]				
Heat of explosion		Yes[3]				

Notes:
Note 1. HFC glass ampoules
Note 2. If extreme thermal stress within service lifetime can be predicted
Note 3. Only for non-detonating mixtures

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TABLE 3
AGING PROTOCOLS - BOOSTER EXPLOSIVES

PROCEDURE	FRANCE	GERMANY	NETHERLANDS	SWITZERLAND	UNITED KINGDOM	USA (NAVY)
Aging conditions: a. Without nitrate esters present	60°C for 6 months	90°C for 1 month; sealed containers[1] (65°C for 2 months[2]) Temperature cycle program: -40°C [3hr] to +63°C [3hr]. (Max. 100 cycles) Temperature change within 1 hr sealed containers[1]	No criteria given	60°C for 1,2 & 4 months 70°C for 1,2 & 4 months sealed containers[3] (polyester binders also at 30%RH)	60°C for 3 & 6 months at ambient and 40% relative humidity[4]	60°C for 1,2,4,6,8 months 70°C for 1,2,4,6 months sealed containers (polyester binders also at 30%RH)
Aging conditions: b. With nitrate esters	60°C for 6 months	As above		50°C for 1,3,6,9 & 12 months; 60°C for 1,2,4,6 & 8 months[5]	60°C for 1,2, & 3 months at ambient and 40% relative humidity[4]	50°C for 1,3, 6, 9 & 12 months 60°C for 1,2,4,6,8 months 25°C at 30%RH until final (type) qualification sealed containers (polyester binders also at 30%RH)
Impact sensitivity	STANAG 4489C			Yes	STANAG 4489B[8]	Yes
Friction sensitivity	STANAG 4487A			Yes	STANAG 4487B[8]	Yes
Uniaxial tensile test	STANAG 4506 20°C			Yes	Yes	Yes (3 temp's)
Uniaxial compression test	STANAG 4443 20°C	Yes		Yes	Yes	
DMA glass transition temp.		Yes (if relevant)			STANAG 4540	
Shock sensitivity	STANAG 4488B					Yes[11]
Friability	AOP-7					
Temperature of ignition				Yes	STANAG 4491[8]	Yes
Thermal stability					STANAG 4491[8]	Yes
Vacuum thermal stability					STANAG 4556	
DTA/DTG or DSC		Yes		Yes		Yes[10]
X-ray						Yes[12]
Cube crack test				Yes (cylinder)[6]	Yes 30 d/ 80°C[9]	Yes[13]
Heat flow calorimetry				Yes[7]		
Projectile impact		Yes				
Safe life or service prediction				Yes (if applicable)		Yes
Sol/gel level					Yes (if applicable)	
Weight and volume change					Yes	
Stabilizer/antioxidant content				Yes (if applicable)	Yes (if applicable)	Yes (if applicable)

See Notes on following page.

NOTES ON TABLE 3, AGING PROTOCOLS FOR BOOSTER EXPLOSIVES

Note 1. Welded aluminum bags
Note 2. Explosives containing wax or low melting explosives like TNT
Note 3. Glass, welded aluminum bags or silicone cured thick aluminum foil
Note 4. National Authority to decide if storage at 40% relative humidity is necessary
Note 5. These conditions also apply if acetates are in the HE composition
Note 6. Cylinder geometry 30/60 days at 60°C (where applicable)
Note 7. HFC test at 70°C for 30 days and 60°C for 90 days
Note 8. Test conducted after maximum storage interval only
Note 9. Not after accelerated aging
Note 10. DTA 2 grams, 1°C/minute. Performed on baseline and after completion of accelerated aging
Note 11. Without nitrate esters or other energetic plasticizers 60°C/8 months; 70°C/6 months.
With nitrate esters or other energetic plasticizers 50°C/12 months; 60°C/8 months.
Note 12. X-ray for compositions with nitrate esters or other energetic plasticizers
Note 13. 30/60 days at 60°C; 6” cubes, where applicable on compositions with nitrate esters or other energetic plasticizers

TABLE 4
AGING PROTOCOLS - HIGH EXPLOSIVES

PROCEDURE	FRANCE	GERMANY	NETHERLANDS	SWITZERLAND	UNITED KINGDOM	USA (NAVY)
Aging conditions: a. Without nitrate esters present	60°C for 6 months	90°C for 1 month; sealed containers[1] (65°C for 2 months[2]) Temperature cycle program: -40°C [3hr] to +63°C [3hr] (Max. 100 cycles). Temperature change within 1 hr sealed containers[1]	Time and temperature dependant on specific composition	60°C for 1,2 & 4 months 70°C for 1,2 & 4 months sealed containers[3] (polyester binders also at 30%RH)	60°C for 3 & 6 months at ambient and 40% relative humidity[4]	60°C for 1,2,4,6,8 months 70°C for 1,2,4,6 months sealed containers (polyester binders also at 30%RH)
b. With nitrate esters	60°C for 6 months	As above	As above	50°C for 1,3,6,9 & 12 months; 60°C for 1,2,4,6 & 8 months[5]	60°C for 1,2, & 3 months at ambient and 40% relative humidity[4]	50°C for 1,3, 6, 9 & 12 months 60°C for 1,2,4,6,8 months 25°C at 30%RH until final (type) qualification sealed containers (polyester binders also at 30%RH)
Impact sensitivity	STANAG 4489C		Yes	Yes	STANAG 4489B[8]	Yes
Friction sensitivity	STANAG 4487A		Yes	Yes	STANAG 4487B[8]	Yes
Uniaxial tensile	STANAG 4506 20°C		Yes	Yes	Yes	Yes (3 temp's)
Uniaxial compression	STANAG 4443 20°C	Yes	Yes	Yes	Yes	
Stress relaxation			Yes			
DMA glass transition temp.		Yes (if relevant)			STANAG 4540	
Shock sensitivity	STANAG 4488B					Yes[11]
Friability	AOP-7					
Hardness Shore A			Yes			
Temperature of ignition				Yes	STANAG 4491[8]	Yes
Thermal stability			Yes		STANAG 4491[8]	Yes
Vacuum thermal stability					STANAG 4556	
DTA/DTG or DSC		Yes		Yes		Yes[10]
X-ray						Yes[12]
Cube crack				Yes (cylinder)[6]	Yes 30 d/ 80°C[9]	Yes[13]
Heat flow calorimetry				Yes[7]		
Projectile impact		Yes				
Exudation			Yes			
Safe life or service prediction				Yes (if applicable)		Yes
Sol/gel level					Yes (if applicable)	
Weight and volume change					Yes	
Stabilizer/antioxidant content			Yes (if applicable)	Yes (if applicable)	Yes (if applicable)	Yes (if applicable)

See Notes on following page.

NOTES ON TABLE 4, AGING PROTOCOLS FOR HIGH EXPLOSIVES

Note 1. Welded aluminum bags
Note 2. Explosives containing wax or low melting explosives like TNT
Note 3. Glass, welded aluminum bags or silicone cured thick aluminum foil
Note 4. National Authority to decide if storage at 40% relative humidity is necessary
Note 5. These conditions also apply if acetates are in the HE composition
Note 6. Cylinder geometry 30/60 days at 60°C (where applicable)
Note 7. HFC test at 70°C for 30 days and 60°C for 90 days
Note 8. Test conducted after maximum storage interval only
Note 9. Not after accelerated aging
Note 10. DTA 2 grams 1°C/minute. Performed on baseline and after completion of accelerated aging
Note 11. Without nitrate esters or other energetic plasticizers 60°C/8 months; 70°C/6 months
With nitrate esters or other energetic plasticizers 50°C/12 months; 60°C/8 months
Note 12. X-ray for compositions with nitrate esters or other energetic plasticizers
Note 13. 30/60 days at 60°C; 6" cubes, where applicable on compositions with nitrate esters or other energetic plasticizers

TABLE 5
AGING PROTOCOLS – SOLID GUN PROPELLANTS

PROCEDURE	FRANCE	GERMANY	NETHERLANDS	SWITZERLAND	UNITED KINGDOM	USA (NAVY)
Aging conditions: a. Without nitrate esters present	50°C for 3,6,12,24 weeks and 12, 24 months	60°C for 3 months in sealed containers[2]	Time and temperature dependant on specific composition	60°C for 1, 2, 4 months 70°C for 1,2,4 months in sealed containers (if polyester binder present also at 30%RH)	60°C for 1,2,4,8 months at ambient and 40%RH[6]	60°C for 1,2,4,6,8 months 70°C for 1,2,4,6 months sealed containers (if polyester binder present use 30%RH)
b. With nitrate esters	As above	As above	As above	50°C for 3, 6, 9 months 60°C for 1,2, 3, 6 months 70°C for 2,4,8 **weeks**[5]	60°C for 1,2,3,6 months at ambient and 40%RH[6]	50°C for 1,3,6,9, 12 months 60°C for 1,2,4,6,8 months sealed containers 25°C at 30%RH until final (type) qualification
Impact sensitivity			Yes		Yes[7]	Yes
Friction sensitivity			Yes		Yes[7]	Yes
Shock sensitivity						Yes[8]
Ignition temperature			Yes (DTA)	Yes	Yes[7]	Yes
DSC/DTA				Yes		Yes[9]
HFC		STANAG 4582	Yes[3]	STANAG 4582		
Stabilizer/Antioxidant content	Yes	Yes	Yes (if applicable)	Yes	Yes	Yes (if applicable)
Safe life prediction			Yes	Yes		Yes (chem & ser.)
Compressive strength	Yes[1]	Yes	Yes			Yes
DMA					STANAG 4540	
Closed vessel		Yes	Yes[4]			
Thermal stability					STANAG 4491[7]	Yes
Vacuum stability					STANAG 4556	
X-ray						Yes[10]
Sol-gel determination					Yes (if applicable)	
GPC			Yes			

See Notes on following page.

NOTES ON TABLE 5, AGING PROTOCOLS FOR SOLID GUN PROPELLANTS

Note 1. After 6 and 24 months aging
Note 2. Welded aluminum bags
Note 3. One week at 85°C, 3 weeks at 75°C and 9 weeks at 65°C as a minimum
Note 4. Closed vessel test after applying quasi-static compression
Note 5. These conditions also apply where acetates are present in the composition
Note 6. National Authority to decide if storage at 40% relative humidity is necessary
Note 7. Test to be conducted only after maximum storage interval
Note 8. Without nitrate esters or other energetic plasticizers; 60°C/8 months, 70°C/6 months
With nitrate esters or other energetic plasticizers; 50°/12 months, 60°C/8 months
Note 9. DTA 2g at 1°C/minute. Performed on baseline and after accelerated aging
Note 10. Compositions with nitrate esters or other energetic plasticizers

TABLE 6
AGING PROTOCOLS – SOLID ROCKET PROPELLANTS

PROCEDURE	FRANCE	GERMANY	NETHERLANDS	SWITZERLAND	UNITED KINGDOM	USA (NAVY)
Aging conditions: a. Composite propellants	60°C for 6 months	60°C for 3 months in sealed containers[1] Temp program -46°C [2hr] to 23°C [2hr] to 63°C [2hr] up to 100 cycles; ΔT 5 secs	50°C for 4,8,16, 32 weeks 60°C for 2,4,8,16 weeks sealed bags, low RH. [40°C and 70°C may also be used]	63°C for 1, 2, 4, 8 months 74°C for 1,2,4, 6 months in sealed containers[3] (if polyester binder present also at 30%RH)	60°C for 1,2,4,8 months at ambient and 40%RH[7]	60°C for 1,2,4,6,8 months 70°C for 1,2,4,6 months sealed containers (if polyester binder present use 30%RH)
b. Nitrate ester propellants	50°C for 6 months	As above	As above	50°C for 1,3, 6, 9 (12) months 60°C for 1,2, 4, 6 8 months	60°C for 1,2,3,6 months at ambient and 40%RH[7]	50°C for 1,3,6,9, 12 months 60°C for 1,2,4,6,8 months sealed containers 25°C at 30%RH until final (type) qualification
Impact sensitivity	STANAG 4489C		Yes		Yes[8]	Yes
Friction sensitivity	STANAG 4487A		Yes		Yes[8]	Yes
Shock sensitivity						Yes
Ignition temperature				Yes	Yes[8]	Yes[10]
DSC/DTA				Yes		Yes[11]
HFC						
Stabilizer/Antioxidant content	Nitrate ester only		Yes	Yes (if applicable)	Yes	Yes
Chemical analysis	Nitrate ester only		Yes (plasticizer)	Notes 4 & 5		
Safe life prediction			Yes (safe & serv)[2]	Yes (safe & serv)		Yes (safe & serv)
Uniaxial tensile test	STANAG 4506 20°C	Yes	Yes	Yes	Yes	Yes (3 temp's)
Compressive strength						
Stress relaxation test			Yes	Yes		
Shore A hardness			Yes			
DMA					Yes	
Closed vessel test						
Linear burning rate		Yes				
Thermal stability			Yes	Yes	Yes[8]	Yes
Vacuum stability					STANAG 4556	
Microscopy	Control of aspect					
Cube crack test				Yes[6](if applicable)	Yes[9](if applicable)	Yes[12](if applicable)
X-ray						Yes[13]
Density	Composite only					
Sol-gel determination			Yes		Yes (if applicable)	

See Notes on following page.

NOTES ON TABLE 6, AGING PROTOCOLS FOR SOLID ROCKET PROPELLANTS

Note 1. Welded aluminum bags
Note 2. Service life prediction is done at system level
Note 3. Glass, welded aluminum bags or silicone cured thick aluminum foil
Note 4. Ammonium nitrate containing propellants, humidity test (?)
Note 5. Plasticizer migration
Note 6. Cube crack performed on cylinder of diameter as cube edge 30/60 days at 60°C
Note 7. National Authority to decide if storage at 40% humidity is necessary
Note 8. Test to be conducted only after maximum storage interval
Note 9. Thirty days at 80°C *but not after accelerated aging*
Note 10. Without nitrate esters or other energetic plasticizers; 60°C/8 months, 70°C/6 months
With nitrate esters or other energetic plasticizers; 50°/12 months, 60°C/8 months
Note 11. DTA 2g at 1°C/minute. Performed on baseline and after accelerated aging
Note 12. Compositions with nitrate esters or other energetic plasticizers, 6" cubes 30/60 days at 60°C
Note 13. Compositions with nitrate esters or other energetic plasticizers

TABLE 7
AGING PROTOCOLS - PYROTECHNICS

PROCEDURE	FRANCE	GERMANY	NETHERLANDS	SWITZERLAND	UNITED KINGDOM	USA (NAVY)
Aging conditions:	60°C for 2 months	23°C for 4 weeks at 30, 50, 65, & 83% RH Temp program -35°C [3hr] to 63°C [3hr] 4 weeks sealed containers[1]	Time, temperature and humidity vary depending on specific composition	70°C for 3, 6, 12 months sealed containers under controlled humidity	National Authority to decide if aging is appropriate on a case by case basis	70°C for 6, 12 months in sealed containers and 25°C at 30%RH until final (Type) qual.
Impact sensitivity	STANAG 4489C					
Friction sensitivity	STANAG 4487A					
Chemical life prediction			Yes			
Ignitability		Yes (by black p'r)				Yes
Temperature of ignition				Yes		Yes
Thermal stability				Yes		
DSC/DTA/TG	STANAG 4515 DSC	Yes	Yes (DSC/TG)	Yes (DSC/TG)		Yes
HFC			Yes (3-4 temps)	Yes[2]		

Notes:
Note 1. Welded aluminum bags
Note 2. 60% relative humidity; 70°C/30 days, 60°C/90 days

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CHAPTER 9

9.0 FINAL (or TYPE) QUALIFICATION

9.1 This chapter provides information about Final (or Type) Qualification of an explosive material. A national or a military service authority generally reviews the safety and suitability data and grants this approval level. This is generally the final approval level and it allows an explosive to be used operationally by the military forces. Some call this step “Final Qualification” while others call it “Type Qualification”. Whatever name is given to this level of approval however, this final review and assessment should be executed, in some way, by all countries before an item loaded with this explosive is released for operational or training use. Final (or Type) Qualification was the name agreed by the NATO AC/310 for this approval level for military explosive materials.

9.2 The Final (or Type) Qualification process provides the explosive materials scientists and safety experts an opportunity to perform a final review of the safety and the suitability for service data acquired on the material. This generally includes a review of the stability, compatibility, aging, mechanical and physical properties, and sensitivity data acquired during both the explosive Qualification program and the end-item application research, development, and sensitivity test programs. After reviewing this information, the safety authorities are in a better position to provide the national approval authority a complete evaluation and a recommendation on the safety and suitability for service of the explosive in the intended application.

9.3 The Final (or Type) Qualification process requires that tests and assessments be performed in accordance with STANAG 4297 and AOP-15. In some cases, Qualification (as required by STANAG 4170) and Final Qualification evaluations are performed at the same time. This is especially true for solid propellants and pyrotechnics because formulations are often modified until the desired end-item performance is achieved.

9.4 Data submitted to the National Authority for Final (or Type) Qualification of an explosive should be sufficient to show that the explosive is safe and suitable for operational or training use in the intended application. Tests to acquire the data may be performed on the complete ordnance package or on subsystems, e.g., warhead, rocket motor, etc., as long as extrapolation of vulnerability characteristics to all-up ordnance item can be justified.

9.5 In some instances assessments may be used to satisfy some of the testing requirements. This is particularly true where data from generic tests conducted on the explosive material in simulated application-type containers are available. Justification for such assessments, with supporting data, should be included in the Final (or Type) Qualification data package. Computer modeling may be used in conjunction with generic tests results and data from the Qualification phase (see chapter 7) as a tool to assess the behavior of explosive materials under a wide range of stimuli and scenarios. Qualification data define many of the intrinsic properties of the energetic material and allow for the generation of a range of modeling parameters that can be used in the assessment.

9.6 For Final (or Type) Qualification, chemical compatibility with materials the explosive is likely to be in contact with and accelerated aging data should be available. The chemical compatibility data should include information obtained with the explosive in contact with all materials (both energetic and inert) with which it will come in contact in production and in the specific end item in which it will be used.

9.7 The following are some of the sensitivity test STANAGS that relate to Final (or type) Qualification and are used in conjunction with STANAG 4297 and AOP-15:

a. Liquid Fuel Fire: This test is performed in accordance with STANAG 4240

b. Bullet Attack: This test is performed in accordance with STANAG 4241

c. Safety Drop: This test is performed in accordance with STANAG 4375

d. Slow Heating: This test is performed in accordance with STANAG 4382

e. Sympathetic Reaction: This test is performed in accordance with STANAG 4396

f. Fragment Impact: This test is performed in accordance with STANAG 4496

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CHAPTER 10

10.0 NATIONAL QUALIFICATION PROCEDURES AND TEST INFORMATION SHEETS

10.1 This chapter identifies the National Authorities and provides information on the procedures used to Qualify explosive materials in each participating nation. In addition, it contains a list of NATO STANAGs used to describe Qualification tests and brief descriptions of tests that are used by member nations to satisfy the Qualification requirements but are not detailed by NATO STANAGs.

10.2 Countries that have not provided information to include in this chapter are invited to send their contribution to the Chairman of AC/310 Subgroup 1 (Explosive Materials) and to the Custodian Nation. Even if a country does not have a formal qualification procedure per STANAG 4170 in place, it is important to note that fact along with a description of the process used to accept an explosive material for use by its military in this chapter. The Custodian Nation will add new inputs to this chapter upon receipt.

10.3 All nations accept, as a minimum, the information and data requirements documented in Chapter 7 of this manual. Some nations have unique tests and passing criteria for certain types or classes of explosives. Where these exist, they are documented in the national sections of this chapter.

10.4 QUALIFICATION TESTS STANAGS

a. STANAG 4117 - Explosives, Stability Test Procedures for Propellants Stabilized with Diphenylamine, Ethyl Centralite, or Mixtures of Both. (See Note below)

b. STANAG 4147 – Explosives, Chemical Compatibility of Ammunition Components with Explosives and Propellants (Non-Nuclear Applications).

c. STANAG 4443 - Explosives, Uniaxial Compressive Test.

d. STANAG 4487 - Explosives, Friction Sensitivity Test(s).

e. STANAG 4488 - Explosives, Shock Sensitivity Test(s).

f. STANAG 4489 - Explosives, Impact Sensitivity Test(s).

g. STANAG 4490 - Explosives, Electrostatic Discharge Sensitivity Test(s).

h. STANAG 4491 - Explosives, Thermal Sensitivitness and Explosiveness Test(s).

i. STANAG 4506 – Explosive Materials, Physical/Mechanical Properties, Uniaxial Tensile Test.

j. STANAG 4507 - Explosives, Physical/Mechanical Properties, Stress Relaxation Test.

k. STANAG 4515 - Explosives, Thermal Characterization by Differential Thermal Analysis, Differential Scanning Calorimetry, and Thermogravimetric Analysis.

l. STANAG 4525 - Explosives, Physical/Mechanical Properties, Thermomechanical Analysis for Determining the Coefficient of Linear Thermal Expansion (TMA).

m. STANAG 4527 - Explosives, Chemical Stability, Nitrocellulose Based Propellants, Procedure for the Assessment of Chemical Life and the Temperature Dependence of Stabilizer Consumption Rates. (See Note below)

n. STANAG 4540 - Explosives, Procedures for Dynamic Mechanical Analysis (DMA) and Determination of Glass Transition Temperature.

o. STANAG 4541 - Explosives, Nitrocellulose Based Propellants Containing Nitroglycerin and Stabilized with Diphenylamine, Stability Test Procedures and Requirements. (See Note below)

p. STANAG 4542 – Explosives, Nitrocellulose Based Propellants Containing Nitroglycerin and Stabilized with 2-Nitrodiphenylamine, Stability Test Procedures and Requirements. (See Note below)

q. STANAG 4556 - Explosives, Vacuum Stability Test(s).

10.4.1 NOTE: STANAGs 4117, 4527, 4541, and 4542 referred to above will be replaced by AOP-48 – "Explosives, Nitrocellulose Based Propellants, Stability Test Procedures and Requirements Using Stabilizer Depletion" and its covering document, STANAG 4620.

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10.5.0 TEST INFORMATION SHEETS

10.5.1 Test information sheets are used to provide summaries of the national tests used to supplement the STANAGs referenced in this document.

10.5.2 For consistency among nations and ease of reference, each test information sheet is assigned an AOP-7 registry number. The qualification test categories and sub-categories for each explosive material are identified under "Type of Test" in the Test Information Sheets. The tests are divided into three major categories: (a) Chemical, Mechanical, and Physical properties; (b) Hazard Assessment; and (c) Performance. Each category and sub-category is assigned a number as shown below:

10.5.3 CATALOGUE OF TESTS

Category 100	Chemical, Physical and Mechanical Properties
101.01.XXX	Analytical Tests
101.02.XXX	Other Tests
102.01.XXX	Mechanical Properties
102.01.XXX	Uniaxial Tensile Creep
102.01.XXX	Uniaxial Tensile Relaxation
	Tensile & Volumetric Dilatation (Farris)
102.01.XXX	Shear
102.01.XXX	Torsion
102.01.XXX	Bi-axial Tensile
102.01.XXX	Tri-axial (Poker Chip)
102.01.XXX	Charpy V
102.01.XXX	Hardness
102.01.XXX	Penetrometry
102.01.XXX	Fracture Susceptibility (Critical Stress Intensity Factor)
102.01.XXX	Shotgun
102.01.XXX	Bond in Tension
102.01.XXX	Bond in Shear
102.01.XXX	Bond in Peel
102.02.XXX	Physical Properties
102.02.XXX	Thermal Conductivity
102.02.XXX	Specific Heat (Other than DSC)
102.02.XXX	Heat of Explosion
102.02.XXX	Thermal Calorimetry
102.02.XXX	Pycnometry
102.02.XXX	Density
102.02.XXX	Wave Propagation Velocity
102.02.XXX	Hygroscopicity

Category 200	Hazard Assessment
201.XX.XXX	Sensitivity/Sensitiveness & Explosiveness
201.01.XXX	Impact
201.02.XXX	Friction
201.03.XXX	Electrical Discharge
201.04.XXX	Shock
201.05.XXX	Projectile Impact
201.06.XXX	Fragment Impact
201.07.XXX	Shaped Charge Jet Impact
201.08.XXX	Other
202.XX.XXX	Stability & Thermal Behavior
202.01.XXX	Thermal
202.02.XXX	Other
203.XX.XXX	Compatibility
203.01.XXX	Reactivity
203.02.XXX	Other
204.XX.XXX	Toxicity and Environmental Impact
204.01.XXX	Toxicity Evaluation
204.02.XXX	Environmental Impact Assessment
205.XX.XXX	Dimensional Effects
205.01.XXX	Critical Diameter
205.02.XXX	DDT
205.03.XXX	Other
Category 300	Performance Assessment
301.XX.XXX	Theoretical Methods
301.01.XXX	Thermodynamic Models
301.02.XXX	Other Models
302.XX.XXX	Experimental Methods
302.01.XXX	Detonation Velocity
302.02.XXX	Burning Rate/Time
302.03.XXX	Other

10.6 Results from reference standard explosives are included in "typical results" on the Test Information Sheets.

10.7 NATIONAL QUALIFICATION PROCEDURES

NOTE: The information in this section is as approved by the National Authority in each participating nation. Any changes made to the national sections must comply with the methods outlined in Chapter 6 of this manual.

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10.7.1 QUALIFICATION PROCEDURES OF CANADA

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10.7.1.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.7.1.1.1 The National Authority has established an Explosive Qualification Advisory Committee to advise on all matters pertaining to the qualification of explosives. This committee decides on the tests, reviews results, and recommends whether an explosive satisfies the criteria for qualification.

10.7.1.1.2 The committee is chaired by the Director of Ammunition Procurement and Maintenance (DAPM) of the Department of National Defense. He reports directly to the National Authority. Members of the committee consist of a Secretary from the DAPM staff and experienced personnel from the following Government organizations:

a. The Defense Research Establishments;

b. The Headquarters of the Chief, Research and Development, Department of National Defense; and

c. The Canadian Explosives Research Laboratory (CERL), Department of Energy, Mines and Resources**.**

10.7.1.1.3 The Explosives Qualification Advisory Committee selects expertise from other departments of Government or private industry, when necessary.

10.7.1.1.4 The Canadian Explosives Research Laboratory provides a source of independent information and judgment. The department of natural resources is responsible for the safety in manufacture of all military and industrial explosives, **and** for the safety of industrial explosives used in mining, quarrying, construction, demolition and related uses.

10.7.1.2 NATIONAL AUTHORITY(IES)

10.7.1.2.1 The National Authority for Military Explosives is the Director Ammunition Procurement and Maintenance (DAPM) of the Department of National Defense. This office is responsible for the design of all munitions for the Canadian Armed Forces.

10.7.1.2.2 The National Authority performs the following functions:

a. Coordinates the implementation of STANAG 4170 in Canada;

b. Prepares, publishes and maintains the Canadian sections of Allied Ordnance Publication No. 7 (AOP-7);

c. Provides a Canadian point-of-contact to other NATO countries for the exchange of information on the safety of explosives and the qualification of explosive materials; and

d. Maintains a data bank of qualified explosive materials used by the Canadian Armed Forces.

10.7.1.2.3 The address for the Custodian National Authority is as follows:

Director Ammunition Procurement and Maintenance
National Defense Headquarters
Louis St-Laurent Building
Hull, Canada
KlA 0K2

10.7.1.3 QUALIFICATION PROCEDURES

10.7.1.3.1 Requests for qualification are submitted to the National Authority who normally refers the request to the Explosives Qualification Advisory Committee for consideration and appropriate actions.

10.7.1.3.2 In Canada most of the research on military explosives of all types is performed in the following two defense research establishments of the Department of National Defense:

a. Defense Research Establishment Valcartier (DREV) -concerned with pyrotechnics, high explosives, solid rocket propellants and gun propellants; and

b. b. Defense Research Establishment Suffield (DRES) - concerned with research into fuel-air and foam explosives.

Some research, development and evaluation of military explosives and propellants is done in private industry such as SNC TEC, Bristol Aerospace Limited, Expro Chemical Products/Energetic Materials and Mining Resources Engineering Limited.

10.7.1.3.3 Most of the qualification tests used by Canada are identical to or based on tests developed and used by the United Kingdom and United States. Although the reasons for this are historical, there is a present-day advantage in terms of standardization and interoperability. US MIL-STDs and NATO STANAGs are extensively used for specifying Canadian military items.

10.7.1.3.4 In general, formal qualification testing is not done until an explosive has successfully passed all stages of research and development including pilot-scale production. The explosive also must have been produced in pre-production lots using full scale production equipment, conditions and methods. However, it is customary to use appropriate qualification tests during the research and development phases to ensure that when an explosive finally reaches production it will be unlikely to encounter unforeseen problems.

10.7.1.3.5 Before qualification it is necessary for an explosive to have its transportation and storage hazard classification determined in accordance with NATO STANAG 4123, "Methods to Determine and Classify Hazards of Ammunition." This action is the responsibility of the Department of National Defense for Military Explosives and of the Department of Natural Resources.

10.7.1.4 QUALIFICATION METHODS AND TESTS

10.7.1.4.1 DAPM has no test facilities. Therefore tests are normally done by the Defense Research Establishments, the Canadian Explosives Research Laboratory or other Government agencies. In some cases tests may be conducted in the test laboratories of industry with DAPM providing an observer or test supervisor. The establishment or agency which has conducted the tests must report to the Secretary of the Explosives Qualification Advisory Committee the results and any observations. The Secretary is then responsible for arranging a review meeting of the Advisory Committee to decide the following:

a. Whether results are sufficient to qualify the explosive;

b. Whether further tests are needed; or

c. Whether the explosive should be considered unsuitable for qualification.

10.7.1.4.2 When the Advisory Committee is satisfied that the explosive warrants qualification, the Secretary prepares the appropriate papers and data sheets for approval and issuance by the National Authority.

10.7.1.4.3 High Explosives:

a. Mandatory Data for Primary Explosives:

Test	Registry/STANAG Number
(1) Impact Sensitivity (BAM)	STANAG 4489C
(2) Friction Sensitivity (BAM)	STANAG 4487A
(3) Electric Spark	STANAG 4490A
(4) Vacuum Thermal Stability	STANAG 4556
(5) Compatibility - Vacuum Stability-Reactivity	STANAG 4147

b. Mandatory Data for Booster Explosives:

Test	Registry/STANAG Number
(1) Impact Sensitivity (BAM)	STANAG 4489C
(2) Friction Sensitivity (BAM)	STANAG 4487A
(3) Electric Spark	STANAG 4490A
(4) Shock (Card Gap)	201.04.001/STANAG 4488
(5) Vacuum Thermal Stability	STANAG 4556
(6) Woods Metal Bath	STANAG 4491 B2
(7) Toxicity	204.01.001
(8) Detonation Velocity	302.01.001

c. Mandatory Data for Main Charge High-Explosives

Test	Registry/STANAG Number
(1) Impact Sensitivity (BAM)	STANAG 4489C
(2) Friction Sensitivity (BAM)	STANAG 4487A
(3) Electric Spark	STANAG 4490A
(4) Shock Sensitivity (Card Gap)	201.040001/STANAG 4488
(5) Vacuum Thermal Stability	STANAG 4556
(6) Woods Metal Bath	STANAG 4491 B2
(7) Ease of Ignition (Safety Fuze)	202.01.007
(8) Exudation Characteristics	202.01.009
(9) Growth Characteristics	202.01.010
(10) Toxicity	204.01.001
(11) Detonation Velocity	302.01.001

d. Optional Data for Main-ChargeHigh Explosives: Some of these and other tests may be required to augment the data derived from mandatory tests:

Test	Registry/STANAG Number
(1) Calibrated Shock Wave	201.01.003
(2) AWRE Charge Oblique Impact	201.01.004
(3) Adiabatic Sensitivity (DREV Set-Back)	201.01.005
(4) Cap Test/Lead Block Comparison	201.04.004
(5) Differential Thermal Analysis	STANAG 4515 B2
(6) Trough (Train) Test	202.01.008
(7) Differential Scanning Calorimeter	STANAG 4515 B2

10.7.1.4.4 PROPELLANTS:

a. Mandatory Data for Solid Rocket Propellants:

Test	Registry/STANAG Number
(1) Uniaxial Mechanical Properties (Constant Strain Rate)	STANAG 4507
(2) Specific Gravity	102.01.071
(3) Impact Sensitivity (BAM)	STANAG 4489C
(4) Friction Sensitivity 9BAM)	STANAG 4487A
(5) Electric Spark	STANAG 4490A
(6) Vacuum Thermal Stability	STANAG 4556
(7) Ease of Ignition (Safety Fuse)	202.01.007
(8) Trough (Train) Test	202.01.008
(9) Compatibility with Materials	STANAG 4147
(10) Toxicity	204.01.001
(11) Theoretical Performance Calculations	301.01.001
(12) Sub-scale Motor	302.03.001

b. Optional Data for Solid Rocket Propellants:

Test	Registry/STANAG Number
(1) Shock Sensitivity (Card Gap)	STANAG 4488
(2) Cap Test/Lead Block Compression	201.04.004
(3) Woods Metal Bath (100°C/Min.)	STANAG 4491
(4) Differential Thermal Analysis	STANAG 4515 B2
(5) Burning Rate - Closed Vessel	STANAG 4115
(6) Burning Rate - Strand Burner	302.02.002

c. Solid propellants are tested in two stages, as formulations and in specific motors:

(1) As formulations the following data are obtained and evaluated:

(a) compatibility
(b) chemical, physical properties including mechanical properties,
(c) sensitivity
(d) ballistic properties

(2) In specific rocket motors, the following data are obtained and evaluated:

(a) ballistic properties
(b) performance

d. Mandatory Data for Solid Gun Propellants:

NOTE: Most Canadian gun propellants are developed in other countries and adapted to Canadian needs when required. Manufacturing processes and equipment are usually based on those used in other countries. The qualification tests are either identical or similar to tests used in other countries.

Test	Registry/STANAG Number
(1) Specific Gravity	102.02.001
(2) Impact Sensitivity (BAM)	STANAG 4489C
(3) Friction Sensitivity (BAM)	STANAG 4487A
(4) Electric Spark	STANAG 4490A
(5) Vacuum Thermal Stability	STANAG 4556
(6) Differential Thermal Analysis	STANAG 4515 B2
(7) Ease of Ignition (Safety Fuse)	202.01.007
(8) Trough (Train)	202.01.008
(9) Stability	STANAG 4117
(10) Compatibility with Materials	STANAG 4147
(11) Theoretical Performance Calculations	301.01.002
(12) Burning Rate - Closed Vessel	STANAG 4115

e. Optional Data for Solid Gun Propellants:

Test	Registry/STANAG Number
(1) Shock Sensitivity	201.04.003
(2) Cap Test/Lead Block Compression	201.04.004
(3) Woods Metal Bath	STANAG 4491 B2

f. Mandatory Data for Liquid Propellants:

NOTE: The liquid propellants used by the Canadian forces in naval torpedoes or other uses are generally procured from other countries. The data required for these materials is as documented in Chapter for liquid propellants.

10.7.1.4.5 PYROTECHNICS

a. Mandatory Data for Pyrotechnics:

Test	Registry/STANAG Number
(1) Thermal Gravimetric Analysis	STANAG 4515 B3
(2) Impact Sensitivity (BAM)	STANAG 4489C
(3) Friction Sensitivity (BAM)	STANAG 4487A
(4) Electric Spark	STANAG 4490 A
(5) Woods Metal Bath	STANAG 4491
(6) Ease of Ignition (Safety Fuse Test)	202.01.007
(7) Trough Test (Train Test)	202.01.008
(8) Compatibility with Materials	STANAG 4147
(9) Burning Characteristics (loose)	302.02.003

b. Optional Tests for Pyrotechnics:

Test	Registry/STANAG Number
(1) Specific Gravity (Density)	102.01.070
(2) Impact (Ball and Disk Test)	201.01.002
(3) Shock Sensitivity (Card Gap)	STANAG 4488
(4) Cap Test/Lead Block Compression	201.04.004
(5) Vacuum Thermal Stability	STANAG 4556
(6) Differential Thermal Analysis	STANAG 4515 B2
(7) Toxicity	204.01.001
(8) Effect of Moisture	302.02.004

10.7.1.5 LIST OF CANADA'S TEST INFORMATION SHEETS

Category 100	Chemical ,Physical & Mechanical Properties
102.01.003	Uniaxial Tensile Stress Relaxation
102.01.010	Uniaxial Compression (Gun Propellants)
102.01.023	Hardness Measurement
102.01.051	Thermal Conductivity
102.01.060	Dilatometer
102.01.070	Density (Helium Gas Pycnometer)
102.01.071	Specific Gravity (Density)
102.01.340	Bond in Tension
Category 200	Hazards Assessment Sensitiveness/Sensitivity/ Explosiveness
201.01.001	CERL Impact - Modified NOL
201.01.002	Ball and Disc
201.01.003	Calibrated Shock Wave
201.01.004	AWRE Charge Oblique Impact
201.01.005	Adiabatic Sensitivity (DREV Setback)
201.03.001	CERL Electric Spark
201.04.001	Shock Sensitivity - DREV
201.04.003	Shock Sensitivity - Propellant
201.04.004	Cap Test/Lead Block Compression
202.01.008	Trough Test (Train)
202.01.009	Exudation Characteristics
202.01.010	Growth Characteristics
202.01.011	Methyl-Violet
203.01.003	Pyrotechnics - Compatibility with Materials
204.01.001	Toxicity Evaluation
Category 300	Performance Assessment Theoretical/ Experimental Methods
301.01.001	Theoretical Performance Calculations (Solid Rocket Propellants)
301.01.002	Theoretical Performance Calculations (Solid Gun Propellants)
302.01.001	Detonation Velocity - Camera Technique
302.02.002	Burning Rate (Linear) Strand Burner
302.02.002	Burning Characteristics (Loose)
302.02.004	Effect of Moisture Content on Burning
302.03.001	Sub-Scale Motor

10.7.1.5 CATALOGUE OF TEST INFORMATION SHEETS FOR CANADA

NOTE: The Test Information Sheets are listed consecutively in accordance with the Registry number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Uniaxial Tensile Stress Relaxation Modulus

   a. Type of Test: Viscoelastic Properties in Tension

   b. Description: 0.4 X 0.4 X 4.0 in (10 X 10 X 10 mm) specimen is cut from block with band saw. Wooden tabs are bonded to specimen with 5-minute epoxy. A 5% strain is applied by a spring-actuated relaxation testing machine equipped with a temperature/humidity conditioning box. After conditioning at the specified test temperature (from -82°C to 72°C), the spring mechanism is actuated and the decay of force is measured as time progresses. Four replicates at each test temperature are tested. Test duration of the order of 1000 minutes is required to define the relaxation curve. Time duration of aging and humidity are important. A master curve in the form of a Prony series as a function of reduced time using a non-linear curve fitting technique or the original WLF equation is reported.

   c. Information Requirements for Assessment:

      (1) Application: Characterization of rocket propellants. The master curve Prony-series is used as input into VISTA, a Canadian developed, 3D, thermoviscoelastic FE code.
      (2) Significance: Used to determine the constitutive equation of the material.
      (3) Limitations: Assumes that the material is thermorheologically simple and linear viscoelastic.

   d. Typical Results: A master curve of the relaxation modulus as a function of shifted time often presented in the form of a Prony series.

   e. Repeatability and Reproducibility: High repeatability among specimens. Fair reproducibility among test facilities (affected by process related parameters).

3. NATIONAL REFERENCES: N/A

Canada/102.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Uniaxial Compression Test of Gun Propellants

   a. Type of Test: Drop-Weight Compression

   b. Description:

      (1) Apparatus: Drop-weight mechanical property tester.
      (2) Specimen: Right circular cylinder L/D= 1 0, 1, 7 or 19 perforations.
      (3) Strain-Rate: On the order of 100 s^{-1}.
      (4) Temperature: Can be varied between -5O°C and 70°C.
      (5) Data: Load and displacement determined independently.

   c. Information Requirements for Assessment:

      (1) Application: Mechanical property characterization.
      (2) Significance: Mechanical property parameters, failure characteristics assessment.
      (3) Limitations: Specimen age and deviations from right circular cylinder geometry may affect the results. Machining of each sample is highly recommended.
      (4) Properties: Elastic modulus (E_o), strain rate (er), stress at failure (s_f), strain failure (e_f).

   d. Typical Results:

      (1) M30 (19°C):
      E_o = 3.81 $\pm$ 0.18 GPa
      s_f = 112 $\pm$ 5MPa
      e = 287 $\pm$ s-1
      e_f = 5.0 $\pm$ 0.1 %

   e. Repeatability and Reproducibility:
      (1) Repeatability - very easy.
      (2) Reproducibility - fluctuations up to 15% may occur specially is samples have not been machined to assure perfectly parallel surfaces.

3. NATIONAL REFERENCES: To be supplied

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Hardness Measurement

   a. Type of Test: Shore-A Hardness

   b. Description: Sample is normally 4-in. diameter by 0.7-in. thick, but any smooth surface is suitable. There are two possibilities: tester applied by hand or mounted on a "CONVE LOADER". When applied by hand, a light pressure must be applied and the reading is taken after 15 sec. The reading varies with time, pressure, surface quality and homogeneity of the sample.

      A CONVE LOADER is a stand that holds the tester and depresses it on the sample with constant pressure. More repetitive results are obtained. Three readings are taken at various locations on the sample and a mean value is given.

   c. Information Requirements for Assessment: The test gives the hardness of a rubbery (composite) material in the Shore "A" range. Hardness is used with curable materials to monitor the curing reaction of polymers or polymer bounded composites. Readings are taken with time (from day to day) and when the hardness ceases to increase the curing is considered complete.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: Repeatability and reproducibility are good, but depend on the operator unless the "conveloader" is used.

3. NATIONAL REFERENCES:

   (1) The Shore Instrument & Mfg. Co.

Canada/102.01.051

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Thermal Conductivity, Hot Plate Method

   a. Type of Test: Physical Testing

   b. Description: See ASTM Standard Test Method C1045

   c. Information Requirements for Assessment:

      (1) Application: Thermal conductivity is required to carry out transient thermal stress analysis of rocket propellant grains.
      (2) Significance: Essential.
      (3) Limitations:
      (4) Properties: Density.

   d. Typical Results:

      (1) Typical HTPB/AP/Al propellant: k = 75 W/mm °C.

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES: N/A

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Explosives/Propellants

2. TEST TITLE: Dilatometer Testing

a. Type of Test: Physical Properties

b. Description: Specimen: 12.7 mm x 12.7 mm x 5O.8 mm. Experimental Method: The apparatus consists of a Dilatometer, a bell jar, a controlled heating system, a recorder and a thermocouple. The specimen is cooled to -l30°C, then heated to 80°C at a rate of 1°C/min. The elongation is recorded as a function of temperature. The independent variables are temperature and heating rate. Results: Tg, the glass transition temperature and alpha, the coefficient of linear thermal expansion.

c. Information Requirements for Assessment:

(1) Application: The CTE is required for thermal stress analysis of rocket propellant grains and explosive charges. Tg, is used to assess the lowest operating temperature limit of a propellant or explosive.
(2) Significance: Essential.
(3) Limitations: The measured Tg is often different from the one measured with TMA or DMA.
(4) 4. Properties:

d. Typical Results:

(1) For a HTPB propellant, T_g = -81.5°C and a = 12.4×10^{-6} /°C.

e. Repeatability and Reproducibility

(1) $T_g = \pm 2\%$ a = $\pm$ 4.5%

3. NATIONAL REFERENCES:

(1) Bedford, F. and Ouellet, A., “A linear Dilatometer for use with polymeric materials", DREV TN-1977/71, 1971.

Canada/102.01.070

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/Pyrotechnic Compositions

2. TEST TITLE: Density Measurement with Helium Gas Pycnometer

a. Type of Test: Physical properties

b. Description: The specimen must be small enough to fit into a 156 ml test cell (50 mm in diameter). The specimen is placed in the test cell and the Pycnometer is purged with helium gas. The volume of the test cell is then increased by a known volume and the volume of the specimen is calculated from the pressure difference resulting from the change in volume of the test cell. The density is obtained by dividing the weight of the specimen by the volume measured with the Pycnometer.

d. Information Requirements for Assessment:

(1) Application: Density measurement of any solid of any shape; very useful for perforated gun propellant grains.
(2) Significance: Essential.
(3) Limitations: Not recommended for liquids.
(4) Properties: To be supplied

d. Typical Results:

(1) 1.560 g/ml for Canadian PBX CX-84A

e. Repeatability and Reproducibility:

(1) Error on the volume is not greater than 0.5 ml (0.32%).

3. NATIONAL REFERENCES: N/A

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Specific Gravity (Density)

a. Type of Test: Physical Property - Mandatory for gun and rocket solid propellants and Optional for high explosives.

b. Description: This test is the same as US/Propellant/ 102.02.001. It is used to determine the specific gravity of gun and rocket solid propellants by immersing a sample of the material in a liquid of known specific gravity and volume and measuring the volume and weight change of the combined materials.

c. Information Requirements for Assessment: Specific gravity/density data is necessary for rocket motor design and for determining the output characteristics of propellants.

d. Typical Results: Densities of gun propellants are about 1.6 g/cc and about 1.8 g/cc for solid rocket propellants.

e. Repeatability and Reproducibility:

(1) Specific gravity/density values are very precise and reproducible if good equipment and normal care are used.

3. NATIONAL REFERENCES:

(1) U.S. MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of, 30 March 1979, Method 5.4.21.
(2) U.S. MIL-STD-286B Methods 510.1.1 and 510.2.1,1 December 1967.

Canada/102.01.340

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Bond in Tension

   a. Type of Test: Uniaxial Bond Test

   b. Description: To accomplish this test, the material of interest, punched into a 3.75 cm diameter disc, is placed between two cylindrical aluminum anvils having a diameter of 6 cm. Then, the sample-to-anvils bond is achieved by pressing the assembly at 900 KPa for 1 hour at 60°C. The test is carried out at a crosshead speed of 5 mm/min using an Instron machine. The bond strength and the strain of the samples are measured at peak load and rupture. Even though this test is designed for self- adhesive materials, it could apply to other assemblies.

   c. Information Requirements for Assessment: Results of this test allow the characterization of the bond strength of components related to the insulation of rocket motors. The resulting interfaces can be made up of insulants, liners, restrictors, and propellants.

   d. Typical Results: To be supplied.

   e. Repeatability and Reproducibility:

      (1) This test produces fluctuations in results, and the coefficient of variation can be as high as 10-15%.

3. NATIONAL REFERENCES: N/A

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: CERL Impact Test - (NOL Test with Modified Type 12 Tools)

a. Type of Test: Impact - Mandatory for primary, booster, and main charge high explosives, solid rocket and gun propellants, and pyrotechnics.

b. Description: An unconfined sample is subjected to a compression wave by the impact of a falling weight. The sample is placed on a piece of fine sandpaper which helps create hot spots in the explosive and acts as a "witness". In some cases, tests are done without the sandpaper. Type 12 intermediate striker pins were altered to have the same mass as that of falling weights. The usual configuration consists of a 2.5 Kg drop weight and a 2.5 Kg striker with a 30 mg sample placed on "extra-fine" sandpaper resting on the anvil. The arrangement is coded "M2525 sp". Shock pressure waves in the anvil during the drop may be monitored for size and duration.

c. Information Requirements for Assessment: Results are compared with suitable standards.

d. Typical Results:

(1)

Explosive	50% Point CM (M2525 sp)
Lead Styphnate	3.5
PETN (fine)	5.0
Lead Azide	13.0
Black Powder	20.1
TNT (200 Mesh)	24.8
Smokeless Powder	25.2
Nitrostarch	63.0

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

(1) Canadian Explosives Research Laboratory Explosives Test Manual.
(2) U.N. Group of Experts on Explosives - 24th Session, 27January 1984: Draft Manual of Tests. Test Para 24, pp 114-188.

Canada/201.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Pyrotechnics

2. TEST TITLE: Ball and Disc Test for Sensitive Explosives

   a. Type of Test: Safety/Impact - Mandatory for primary explosives - Optional for sensitive pyrotechnics.

   b. Description: This test is the same as AOP-7 Registry No. U.K./High Explosives/201.01.002. Energy is transmitted from a falling steel ball to a small sample of explosive through a striker which has a small replaceable steel ball attached to its lower end. The small ball rests on a brass disc which in turn covers the explosive sample that has been placed on a steel roller bearing anvil.

   c. Information Requirements for Assessment: This test is a better measure for impact sensitivity of sensitive explosives and pyrotechnics than the CERL Impact Test (Canada/High Explosives/Propellants/Pyrotechnics/201.01.001).

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Sensitiveness Collaboration Committee: Manual of Tests, Test No. 14/66, RARDE, Oct.. 1988.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Calibrated Shock Wave Test

   a. Type of Test: Safety/Impact - Optional for main charge high explosives.

   b. Description: This test measures the initiation sensitivity of an explosive by using shock waves of a given intensity and duration. An explosively driven metal flyer plate is caused to impact simultaneously across the plane face of a receptor explosive. The strength of the incident shock will be a function of the velocity of the flyer plate, its material and its thickness. The energy transferred to the receptor explosive is calculated and a curve of critical initiation pressure as a function of shock duration is obtained.

   c. Information Requirement for Assessment: To determine the critical initiation pressure of an explosive.

   d. Typical Results:

      (1) Threshold Initiation Energy
      Composition B: 142 J/cm^2 (from 0.17ms to 1.80ms)

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Report of the Twelfth Annual Meeting of TTCP WTP-1, Quebec, Canada, October 1984.

Canada/201.01.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: AWRE Charge Oblique Impact Test

   a. Type of Test: Safety-Impact/Friction

   b. Description: This test is the same as AOP-7 Registry No. U.K./High Explosive/201.01.003. It is used to assess the combined impact/friction hazard associated with the handling of bare explosives charges. In the test a 355 mm (14-inch) diameter hemisphere is caused to strike a standard surface, simulating concrete, at an oblique angle. A variation of the test uses a 127 mm (5-inch) diameter cylinder with a hemispherical end. The comparative sensitiveness of explosives is judged from the heights of fall necessary to cause an observable reaction. Explosiveness is indicated by the severity of the damage resulting from a reaction.

   c. Information Requirements for Assessment: To be supplied

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Sensitiveness Collaboration Committee: Manual of Tests,Test No. 16/66, RARDE, Oct. 1988.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Adiabatic Sensitivity (DREV Setback Simulator)

a. Type of Test: Safety-Adiabatic Compression - Optional for main charge high explosives.

b. Description: The purpose of this test is to assess the sensitiveness of an explosive to adiabatic heating induced by setback forces from gun firing of filled shell. A realistic simulation of these forces is achieved by using a square-wave force applied to a specific piston which reproduces most of the launch conditions for a cylindrical explosive specimen.

c. Information Requirements for Assessment: To be supplied

d. Typical Results: (105 M1 Shell)

Explosive	Base separation (mm)	Acceleration (g_n)	Results (Frequency)	(Type)
Comp B	0.50	25,000	3/5	E
	0.50	20,000	0/5	N
	0.33	25,000	0/5	N
TNT	0.50	25,000	1/5	P
	0.50	20,000	0/5	N
	0.33	25,000	0/5	N

E = Explosion; P = Heavy partial; N = No reaction

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Report of the Twelfth Annual Meeting of TTCP WTP-1 Quebec, Canada, October 1983.

Canada/201.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: CERL Electric Spark Test

   a. Type of Test: Electrostatic Discharge Susceptibility - Mandatory for high explosives, propellants, and pyrotechnics.

   b. Description: Small samples of explosive are subjected to discharge of static electricity up to 25 kv through metal-to-metal or metal-to-conductive-rubber in a positive to negative direction. Polarities may be reversed. The electrical value of 1.0 microfarad is selected so that anticipated accidental energy levels of sparks from humans are attained at the relatively low level of 5000 volts.

   c. Information Requirements for Assessment: Compositions are rated according to determined 0% firing levels as follows:

      (1) Levels above 0.025 joules - routine precautions required,
      (2) levels between 0.012 and 0.025 Joules - antistatic precautions required, and
      (3) levels below 0.012 Joules - substances may beprocessed under special license only.

   d. Typical Results:

      (1)

Explosive	Energy Levels 0% Ignitions
TNT	0.025+
RDX	0.025+
PETN (Commercial)	0.025+
$KClO_3$/Acaroid	0.012
$BaClO_3$/Acaroid	0.012
$BaNO_3$/Aluminum	0.012

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

      (1) Canadian Explosives Research Laboratory-Explosives Test Manual.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Explosive Shock Sensitivity Test - DREV

   a. Type of Test: Shock Initiation- Mandatory for booster and main charge high explosives.

   b. Description: The sensitivity of an explosive to the shock induced by another explosive is measured by the thickness of an inert "gap" across which the explosive under test (the acceptor) is initiated with a probability of 50% by a specified explosive charge (the donor). The inert material used in the "gap" is aluminum plus laminated shim aluminum. The donor consists of two pressed tetryl pellets each of 15.7 mm diameter x 16.8 mm length, initiated by a REYNOLDS RP-83 Exploding bridgewire detonator.

   c. Information Requirements for Assessment:This test provides a measure of the sensitivity of an explosive to initiation in high order by an explosive induced shock.

   d. Typical Results:

      Composition B (r=1.68): 11.48 $\pm$ 0.07 mm

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Report of the Twelfth Annual Meeting of TTCP WTP-1, Quebec, Canada, October 1984.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/Pyrotechnics

2. TEST TITLE: Explosive Shock Sensitivity Test/Propellant

   a. Type of Test: Shock Initiation - Optional for solid rocket and gun propellants and pyrotechnics.

   b. Description: This test is the same as AOP-7 Registry No. 11 US/Propellant/201.04.002. It measures the sensitivity of a material to the shock from a detonating high explosive. The sample as granular, cast or machined is placed in a seamless steel tube 1-7/16-inch ID x 1-7/8-inch OD x 5 inches long. This rests vertically on a mild steel witness plate 3/5-inch thick with plastic spacers creating an air gap of 1/16 inch between the bottom of the sample and the witness plate. The donor consists of two pentolite pellets each 2-inches diameter by 1-inch in length. The shock from the donor is attenuated by placing disks of cellulose acetate 0.01 inches thick between the donor and acceptor. The donor is initiated by a No. 13 or Engineer's Special electric blasting cap held in a wood centering block. Tests are done by varying the number of cellulose acetate disks in a prescribed manner until a thickness of disks is reached at which detonation of the sample will occur 50 percent of the time. Detonation is indicated when a clean hole is punched in the witness plate.

   c. Information Requirement for Assessment:This test provides data on the sensitivity of the propellant or composite pyrotechnic to explosive induced shock.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3I. NATIONAL REFERENCES:

   (1) U.S. MIL-STD-2100(0S), Method 5.4.5.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Cap Test/Lead Block Compression

   a. Type of Test: Shock Initiation – Optional.

   b. Description: This test is similar to US/High Explosives/ 201.04.009. The purpose is to determine if the material can be initiated by a No. 8 electric blasting cap with shaped charge indent. For insensitive materials in powder, granular or liquid form, the cap may be inserted in the sample. For more sensitive materials the cap is held in a centered block so that its bottom end is flush with the top of the sample. The lower end of the sample "sits" on a solid lead cylinder. The criterion of propagation of detonation of the sample is the compression or deformation of the lead cylinder.

   c. Information Requirements for Assessment: The test determines the ability of an explosive material to be initiated from a small detonating source.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Canadian Explosives Research Laboratory - Explosives Test, Manual.
(2) U.S. MIL-STD-2100 (OS), "Military Standard Propellant, Solid, Characterization of", 30 March 1979, Test 5.4.6.3. United Nations Group of Experts on Explosives, ST/SG/AC.IO/C.l/R.lll/Rev. 1. Draft Manual of Tests, 27 January 1984.

Canada/202.01.007

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Ease of Ignition (Safety Fuse) Test

a. Type of Test: Thermal - Ignition - Mandatory for main charge high explosives, solid propellants and pyrotechnics.

b. Description: This test is similar to U.K./High Explosive/Propellant/Pyrotechnic 202.01.001. A sample of the explosive, confined in a test tube, is subjected to short bursts of flame from the end of a length of safety fuze. The behavior of the sample is characterized by the following:

(1) - failure to ignite
(2) - ignites and burns quietly
(3) - ignites and burns vigorously
(4) - explodes

c. Information Requirements for Assessment:The test is used to evaluate the behavior of the material when subjected to a short flame pulse or non-electric spark.

d. Typical Results:

(1) SR 399 - Exploded
(2) SR 371B - Violent ignition
(3) SR 372B - Ignited
(4) SR 524 - Violent ignition

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Canadian Explosives Research Laboratory - ExplosivesTest Manual.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Trough Test (Train Test)

a. Type of Test: Thermal Ignition/Burning - Mandatory for pyrotechnics and solid propellants - Optional for booster and main charge high explosives.

b. Description: This test is similar to U.K./202.01.003. An iron trough 30 cm long x 1.58 cm inside diameter is filled with loose sample material. One end is ignited with a tightly coiled igniter cord.

c. Information Requirements for Assessment: The response of the explosive material. The following information is reported:

(1) - burning rate (cm/sec)
(2) - type of burning
(3) - fails to ignite
(4) - ignites but supports train fitfully
(5) - ignites and supports train steadily throughout
(6) - ignites and supports train vigorously throughout
(7) - explodes

d. Typical Results:

(1) SR 44 - burns vigorously throughout
(2) RDX - burns steadily throughout
(3) Smokeless Powder - burns steadily throughout

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Canadian Explosives Research Laboratory – Explosives Test Manual.
(2) U.K. Sensitiveness Collaboration Committee; Explosives Hazard Assessment Manual of Tests, SCC No. 3, Test No. 5/66.

Canada/202.01.009

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Exudation Characteristics

   a. Type of Test: Thermal - Mandatory test for all main charge high explosives containing TNT.

   b. Description: This test is the same as US/High Explosives/202.01.011. Exudation can cause degradation of the quality of TNT based shell fillings. The test simulates the conditions in a filled HE shell subject to hot storage. A paper wrapped cylinder of the explosive is placed upright into a heavy walled metal cylinder which is heated in an oven to 70°C (158°F) for a specified time. The paper wrapping absorbs the exudate. At the end of the test the paper is removed and weighed. The increase in weight is a measure of the exudation behavior of the explosive.

   c. Information Requirements for Assessment: To determine the exudation behavior of a TNT based main charge filling on being subjected to storage at elevated temperature.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Voigt, H.W., "Exudation Test for TNT Explosives Under Confinement: Exudation Control and Proposed Standards", ARRADCOM Technical Report ARLCD-TR-83004, 3 February 1983.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Growth Characteristics

   a. Type of Test: Thermal - Mandatory for main charge high explosives.

   b. Description: This test is the same as US/High Explosives/ 202.01.012. The test measures irreversible growth in main charge fillings caused by such factors as liquid impurities or additive in the solid explosive.

   c. Information Requirements for Assessment:To determine if temperature cycling of an explosive causes irreversible dimensional changes or exudation.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

   (1) NAVORD OD 44811 of 8 September 1971, Chapter V, Method 5.6.

Canada/204.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Toxicity Evaluation

   a. Type of Test: Toxicity - Mandatory for booster and main charge high explosives, and for solid rocket propellants - Optional for pyrotechnics.

   b. Description: No one test will cover all concerns with respect to toxicity of ingredients and products during manufacture, storage and use. Decisions on tests to be done are made in consultation with the Canadian Department of Health and Welfare.

   c. Information Requirements for Assessment:Tests will be concerned with possible health hazards from contact, breathing or ingestion of ingredients and products. Tests are determined on a case by case basis from many available sources.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES: N/A

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Theoretical Performance Calculations - Solid Rocket Propellants

a. Type of Test: Performance - Mandatory for solid rocket propellants.

b. Description: To calculate thermodynamic properties and performance characteristics of solid rocket propellants. The methods used are from a NASA computer program SP-273, "Computer Equilibrium Compositions, Rocket Performance, Incident and Reflected Shocks and Chapman Jouget Detonations". Some of the parameters which can be calculated are the adiabatic flame temperature, products of combustion, enthalpy, entropy, ratio of specific heats, characteristic velocity, specific impulse and thrust coefficients for equilibrium and frozen flow.

c. Information Requirements for Assessment: The data generated by this program are used in the design and characterization of the propellants and rocket motors and for the prediction of performance.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) NASA Computer Program SP-273 by Sanford Gordon and Bonnie J. McBride.

Canada/301.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Theoretical Performance Calculations - Solid Gun Propellants

   a. Type of Test: Performance

   b. Description: Theoretical performance calculations for solid gun propellants are made by using one of the followings: BLAKE general thermodynamic code or BAGHEERA which is a NATO standard.

   c. Information Requirements for Assessment: To be supplied

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) U.S. Army Ballistic Research Laboratory Technical Report ARBRL-TR-02411, July 1982., "BLAKE - A Thermodynamic Code Based on TIGER: Users' Guide and Manual".

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Detonation Velocity - Camera Technique (DREV)

   a. Type of Test: Performance - Mandatory for booster and main charge high explosives.

   b. Description: This test is similar to U.S. High Explosives/302.01.004. The detonation velocity of an explosive will depend on its diameter, density and on the degree of any confinement of the explosive. For most booster and main charge explosives the critical diameter (the diameter below which the explosive will not maintain a stable high order detonation) and the infinite diameter (the diameter beyond which the detonation velocity does not increase) are both relatively small. In this test the detonation velocity is usually measured with little or no confinement. The length of the explosive charge is never less than 4 times its diameter, which is usually 5 cm. The explosive charge is initiated by a plane wave generator and a suitable detonator and booster arrangement. Near the end of the cage a scribe mark 20 cm long is made. A Model 150A Cordin camera operated in the streak mode is used to determine the detonation velocity by being aligned on the scribe mark. Variants of the test may be used to determine detonation velocities at other diameters. A detailed test description based on methods used at the Canadian Defense Research Establishment Valcartier will be prepared.

   c. Information Requirements for Assessment: To be supplied

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES: N/A

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

. TEST TITLE: Burning Rate (Linear) - Strand Burner

a. Type of Test: Performance - Optional for rocket propellants.

b. Description: This test is the same as AOP-7 Registry No. U.S./Propellants/3O2.02.001. The linear burning rates of propellants are measured at designated temperatures and pressures using a Crawford type Strand Burning Rate vessel. The vessel has a volume of about 980 cm^3(60 $in.^3$) and is operated at pressures up to 35 MP (5000 psi). The vessel with the propellant is conditioned at specified temperatures as low as -65°C (-85°F) and as high as about 99°C (210°F).

c. Information Requirements for Assessment: Data are used to determine burning rate and performance characteristics.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility:

These are good at burning rates less than 7.5 cm (3 in) per second.

3. NATIONAL REFERENCES:

(1) U.S. MIL-STD-286B, method T803.1, 1 December 1967.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Burning Characteristics (Loose)

   a. Type of Test: Performance - Mandatory test for pyrotechnics.

   b. Description: This test may be varied to suit different circumstances. It is used to observe the burning behavior of loose pyrotechnic compositions in quantities and conditions relevant to manufacturing conditions. The material is ignited by a suitable squib on tables, trays or containers. When tested in the Trough Test (Canada/ High Explosives/Propellants/Pyrotechnics/2O2.01.008) the explosive exhibited "Vigorous Burning".

   c. Information Requirements for Assessment: For safety in manufacture, handling, storing of pyrotechnics.

   d. Typical Results: Pyrotechnics may undergo a wide range of behaviors, from very slow burning to rapid burning with extensive flame to fast deflagration.

   e. Repeatability and Reproducibility: Under the same conditions of test a pyrotechnic composition will in general exhibit similar combustion behavior from test to test.

3. NATIONAL REFERENCES:

(1) McLain, Joseph H., Lectures on "Pyrotechnics and Solid State Chemistry", Philadelphia, PA, 14-18 August 1978.
(2) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).
(3) Ellern, Herbert, "Military and Civilian Pyrotechnics", Chemical Publishing Co. Inc., New York, NY (1968).

NOTE: The Pyrotechnic Hazard Classification proposed by McLain in his above noted lectures is a useful guide.

Canada/302.02.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Effect of Moisture Content on Burning

   a. Type of Test: Performance – Optional

   b. Description: Many of the ingredients of the pyrotechnic compositions are affected by moisture or react with moisture, e.g., metal powders are hygroscopic. Small amounts of moisture thus may have a large effect on the performance of a pyrotechnic formulation. Tests are needed to determine the acceptable range of moisture content for each composition based on performance. Standard analytical methods may be used for measuring moisture content. Tests such as the Trough Test may be used to determine performance. Performance should be studied for the composition used as either a donor or acceptor.

   c. Information Requirements for Assessment: To determine the range of moisture content within which the performance of the pyrotechnic is acceptable.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) McLain, J. H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Rocket Propellants

2. TEST TITLE: Sub-Scale Motor Test

a. Type of Test: Performance - Mandatory for new rocket motor propellants.

b. Description: Static testing of new rocket motor propellants in sub-scale motors is a step in the development process. The conditions for individual tests will vary according to the type of propellant, its proposed end use, etc. But in general, the motors are designed for average pressures of 1000 to 4000 psi and firings are carried out with the motors conditioned to selected temperatures between -55°C and +70°C.

c. Information Requirements for Assessment: Data on the burning rate with temperature and pressure, burning uniformity, and thrust are essential for the development of propellants for full-scale motors.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) There is no fixed test or series of tests. However,U.S. MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979, is used for guidance.

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10.7.2 QUALIFICATION PROCEDURES OF THE CZECH REPUBLIC

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10.7.2.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

Military Institute for Weapon and Ammunition Technology Slavicin (Vojensky technicky ustav vyzbroje a munice Slavicin - VTUVM) has full responsibility for qualification of explosives for military use.

10.7.2.2 NATIONAL AUTHORITY (IES)

10.7.2.2.1 Military Institute for Weapon and Ammunition Technology Slavicin (Vojensky technicky ustav vyzbroje a munice Slavicin – VTUVM) is the appointed National Authority for the Czech Republic and is responsible for the following functions in accordance with STANAG 4170:

a. Initiation of the qualification procedure, assessment of preliminary data and selection of tests necessary for qualification of explosive materials used by the military services of the Czech Republic;

b. Conduct of the tests and preparation of the qualification reports;

c. Assessment of the explosive in accordance with STANAG 4170 and determination of the qualification status;

d. Decision on the application of the qualified explosive in a specific role;

e. Creation and maintenance of Czech data bank of qualified explosive materials used by the Czech military services;

f. Maintenance of Czech repository for NATO Standardization Agreements and Czech Defence Standards relating to explosive materials;

g. Coordination of the implementation of STANAG 4170 within the Czech Republic;

h. Serve as a Point of Contact within the Czech Republic for inputs to AOP-7 and AOP-26;

i. Serve as a Point of Contact to other NATO countries for the exchange of information;

j. Release the qualification data to other NATO nations in accordance with STANAG 4170.

10.7.2.3 QUALIFICATION PROCEDURES

10.7.2.3.1 The basis for the Czech assessment for the qualification of an explosive composition is laid down in the Czech Defence Standard 137601 ”Organization and Methods for the Qualification of Explosives for Military Use“. This defence standard is in line with requirements of STANAG 4170 and STANAGs for explosives testing quoted in STANAG 4170. This qualification procedure does not include the assessment of the explosive in a particular ammunition system (final or type qualification) or legal provisions for storage and transportation.

10.7.2.3.2 In the Czech Republic, research and development of new explosives intended for military use are mainly carried out by private firms - e.g. Aliachem - division Explosia Pardubice-

Semtin (high explosives and propellants), Sellier & Bellot Vlasim (primary explosives), ZEVETA Bojkovice (pyrotechnics). Additionally, research may also be carried out in certain state institutes sponsored by the Czech MOD (e.g. Military Institute for Weapon and Ammunition Technology Slavicin, Military Technical Institute of Protection Brno).

10.7.2.3.3 In general, research and development of new military explosives are usually carried out under contracts awarded by Czech Ministry of Defence or Czech Ministry of Industry and Commerce. However, they may also result from a private firm's initiative. Import of explosives or munitions with explosives not qualified according to STANAG 4170 is also a subject for the qualification procedure. In this context a new explosive is an explosive which has not yet been qualified, whose composition, nature, manufacturing procedure, manufacturer or manufacturing location has been changed, or which is intended for a role for which it has not been qualified. Existing in-service explosives with unchanged material specification may be regarded as being qualified by sufficient long experience representative for its expected service life and intended use.

10.7.2.3.4 Written requests for qualification of a new explosive are to be submitted to the National Authority. Requests may be submitted by the military services (Army, Air Force), developers, manufacturers or importers or explosives and ammunition.

10.7.2.3.5 Before the start of the qualification procedure, an applicant requesting the assessment of the new explosive must identify some basic characteristics of the explosive, according to Table 1 to STANAG 4170 and must present results of tests obtained in the development project. The information is evaluated by the National Authority and can be returned for revision if unsatisfactory or incomplete. A producer of the new explosive also has to prove that the explosive can be manufactured and processed in a full production scale and the quality levels required can be met consistently. The National Authority can refuse further qualification testing if it is clear from the preliminary results that the new explosive will not satisfy general requirements for safety and suitability in the intended role.

10.7.2.3.6 In case of positive results of the preliminary assessment, the National Authority prepares a list of tests for qualification of the explosive. The tests listed in STANAG 4170 are always taken as mandatory for this purpose, the national tests listed in AOP-7 are usually taken as optional (except those referred by STANAG 4170 to AOP-7, such as electric spark test, detonation velocity and critical diameter test). Other tests not included in STANAG 4170 or AOP-7, but which are suitable to obtain the required information, may also be used in the qualification testing. Results of the optional tests can be taken from the development project of a new explosive.

10.7.2.3.7 The National Authority is responsible for the conduct of the qualification tests in its testing laboratories and the subsequent assessment of the new explosives regarding their safety and basic suitability for military purposes. If any particular test cannot be conducted by the facilities of the National Authority, the National Authority will delegate other testing laboratory for conducting the test under supervision of a representative of the National Authority.

10.7.2.3.8 Results of the qualification tests, together with other observations and recommendations are considered by an expert committee of the National Authority, consisted of explosives and ammunition specialists of VTUVM, other Czech military technical institutes, General Staff and Ministry of Defence. The results are evaluated in relation to the results of the same tests carried out on materials of a similar type and role that have proven history of safety and satisfactory use in service. After completion of the investigation, the National Authority prepares a qualification report in accordance with STANAG 4170 and the qualification certificate with resulting qualification status: (a) qualified, (b) not qualified, (c) qualified with certain restrictions.

10.7.2.3.9 If the National Authority determines that a new explosive is suitable for military use, an organization developing, manufacturing or importing the explosive will prepare a technical specification for this qualified explosive. The technical specification stipulates characteristics of the explosives such as composition, nature, manufacturing process, type and source of raw materials and use, as far as these ensure reproducible manufacture and delivery. The quality requirements for the explosive, the testing methods, provisions on quality assurance, packaging, storage and transportation conditions are also reflected in this document. The final version of this document is ratified by organizations participating on production, processing or use of the explosive (a developer, a manufacturer, a processing company, military authority representatives to these companies, the national authority, military standardization office, end user etc.).

10.7.2.3.10 In case of ammunition system developments requiring the new explosives, these explosives must be qualified before the system design is finalized. The introduction of the explosive for a particular role before conclusion of the qualification procedure and before completion of the technical specification is prohibited in general.

10.7.2.4 QUALIFICATION METHODS AND TESTS

10.7.2.4.1 List of Tests for Primary explosives:

10.7.2.4.1.1 Mandatory Tests

Test	Registry/STANAG No.
a. Thermal characterization by DTA	STANAG 4515
b. Thermal characterization by DSC	STANAG 4515
c. Thermal characterization by TGA	STANAG 4515
d. Chemical compatibility with materials by dynamic TGA*	STANAG 4147
e. Chemical compatibility with materials by DSC*	STANAG 4147
f. Chemical compatibility of azides with materials by chemical analysis*	STANAG 4147
g. Temperature of ignition	STANAG 4491 (B1)
h. Impact sensitivity test	STANAG 4489 (C)
i. Friction sensitivity test	STANAG 4487 (A)
j. Electric spark test	201.03.001

10.7.2.4.1.2 Optional Tests

Test	Registry/STANAG No.
a. Pycnometry	102.02.001
b. Small scale BAM friction sensitivity test	201.02.001
c. Large scale differential thermal analysis	202.01.003

10.7.2.4.2 List of Tests for Booster and Main Charge High Explosives:

10.7.2.4.2.1 Mandatory Tests

Test	Registry/STANAG No.

a. Thermal characterization by DTA	STANAG 4515
b. Thermal characterization by DSC	STANAG 4515
c. Thermal characterization by TGA	STANAG 4515
d. Vacuum stability test	STANAG 4556 (2B)
e. Chemical compatibility with materials by vacuum stability test*	STANAG 4147
f. Chemical compatibility with materials by dynamic TGA*	STANAG 4147
g. Chemical compatibility with materials by DSC*	STANAG 4147
h. Temperature of ignition	STANAG 4491 (B1)
i. Slow cook-off	STANAG 4491 (C3)
j. Fast cook-off	STANAG 4491 (C3)
k. Impact sensitivity test	STANAG 4489 (C)
l. Friction sensitivity test	STANAG 4487 (A)
m. Electric spark test	201.03.001
n. Large scale electrostatic discharge sensitivity test	STANAG 4490 (B)
o. Shock sensitivity tests (small, intermediate and superlarge scale gap test)	STANAG 4488 (ABD)
p. Large scale gap test	201.04.001
q. Critical diameter test	202.05.001
r. Detonation velocity test	302.01.001
s. Uniaxial compressive test	STANAG 4443
t. Uniaxial tensile test (only for PBX)	STANAG 4506
u. Stress relaxation test in tension (only for PBX)	STANAG 4507
v. Thermomechanical analysis	STANAG 4525
x. Dynamic mechanical analysis (only for PBX)	STANAG 4540

10.7.2.4.2.2 Optional Tests

Test	Registry/STANAG No.
a. Pycnometry	102.02.001
b. Large scale differential thermal analysis	202.01.003
c. Lead block compression test	302.03.001
d. Ballistic mortar test	302.03.002
e. Lead block expansion test	302.03.003

10.7.2.4.3 List of Tests for Solid gun propellants

10.7.2.4.3.1 Mandatory Tests

Test	Registry/STANAG No.
a. Thermal characterization by DTA	STANAG 4515
b. Thermal characterization by DSC	STANAG 4515
c. Thermal characterization by TGA	STANAG 4515
d. Vacuum stability test	STANAG 4556 (2B)
e. Chemical stability tests by stabilizer depletion+	STANAG 4117 (B) STANAG 4527 STANAG 4541
f. Chemical compatibility with materials by vacuum stability test*	STANAG 4147
g. Chemical compatibility with materials by dynamic TGA*	STANAG 4147
h. Chemical compatibility with materials by DSC*	STANAG 4147
i. Chemical compatibility with materials by stabilizer depletion*	STANAG 4147
j. Temperature of ignition	STANAG 4491 (B1)
k. Slow cook-off	STANAG 4491 (C3)
l. Fast cook-off	STANAG 4491 (C3)

m. Impact sensitivity test	STANAG 4489 (C)
n. Friction sensitivity test	STANAG 4487 (A)
o. Electric spark test	201.03.001
p. Large scale electrostatic discharge sensitivity test	STANAG 4490 (B)
q. Shock sensitivity tests (intermediate and super large scale gap test)	STANAG 4488 (BD)
r. Large scale gap test	201.04.001
s. Critical diameter test	202.05.001
t. Uniaxial compressive test[#]	STANAG 4443
u. Stress relaxation test in tension[#]	STANAG 4507
v. Thermomechanical analysis[#]	STANAG 4525
x. Dynamic mechanical analysis[#]	STANAG 4540

10.7.2.4.3.2 Optional Tests

Test	Registry/STANAG No.
a. Pycnometry	102.02.001
b. Deflagration to detonation transition test	202.05.002
c. 100°C heat test	202.01.001
d. Czech vacuum stability test	202.01.002
e. Large scale differential thermal analysis	202.01.003
f. Closed vessel test	302.02.001
g. Heat of explosion	302.03.004

10.7.2.4.4 List of Tests for Solid rocket propellants

10.7.2.4.4.1 Mandatory Tests

Test	Registry/STANAG No.
a. Thermal characterization by DTA	STANAG 4515
b. Thermal characterization by DSC	STANAG 4515
c. Thermal characterization by TGA	STANAG 4515
d. Vacuum stability test	STANAG 4556 (2B)
e. Chemical stability tests by stabilizer depletion[+] (only for nitrocellulose based propellants)	STANAG 4117 (B) STANAG 4527 STANAG 4541
f. Chemical compatibility with materials by vacuum stability test*	STANAG 4147
g. Chemical compatibility with materials by dynamic TGA*	STANAG 4147
h. Chemical compatibility with materials by DSC*	STANAG 4147
i. Chemical compatibility with materials by stabilizer depletion* (only for nitrocellulose based propellants)	STANAG 4147
j. Temperature of ignition	STANAG 4491 (B1)
k. Slow cook-off	STANAG 4491 (C3)
l. Fast cook-off	STANAG 4491 (C3)
m. Impact sensitivity test	STANAG 4489 (C)
n. Friction sensitivity test	STANAG 4487 (A)
o. Electric spark test	201.03.001
p. Large scale electrostatic discharge sensitivity test	STANAG 4490 (B)
q. Shock sensitivity tests (intermediate and superlarge scale gap test)	STANAG 4488 (BD)
r. Large scale gap test	201.04.001
s. Critical diameter test	202.05.001

t. Uniaxial compressive test	STANAG 4443
u. Uniaxial tensile test	STANAG 4506
v. Stress relaxation test in tension	STANAG 4507
x. Thermomechanical analysis	STANAG 4525
y. Dynamic mechanical analysis	STANAG 4540

10.7.2.4.4.2 Optional Tests

Test	Registry/STANAG No.
a. Pycnometry	102.02.001
b. 100°C heat test (only for nitrocellulose propellants)	202.01.001
c. Czech vacuum stability test (only for nitrocellulose based propellants)	202.01.002
d. Large scale differential thermal analysis	202.01.003
e. Heat of explosion	302.03.004

10.7.2.4.5 List of Tests for Liquid Propellants

The tests required for liquid propellants are listed in Chapter 7 of this document.

10.7.2.4.6 List of Tests for Pyrotechnics

10.7.2.4.6.1 Mandatory Tests

Test	Registry/STANAG No.
a. Thermal characterization by DTA	STANAG 4515
b. Thermal characterization by DSC	STANAG 4515
c. Thermal characterization by TGA	STANAG 4515
d. Vacuum stability test	STANAG 4556 (2B)
e. Chemical compatibility with materials by dynamic TGA*	STANAG 4147
f. Chemical compatibility with materials by DSC*	STANAG 4147
g. Temperature of ignition	STANAG 4491 (B1)
h. Slow cook-off	STANAG 4491 (C3)
i. Fast cook-off	STANAG 4491 (C3)
j. Impact sensitivity test	STANAG 4489 (C)
k. Friction sensitivity test	STANAG 4487 (A)
l. Electric spark test	201.03.001
m. Shock sensitivity tests#	STANAG 4488 (BD)
n. Large scale gap test#	201.04.001
o. Critical diameter test#	202.05.001
p. Uniaxial compressive test#	STANAG 4443
q. Thermomechanical analysis#	STANAG 4525
p. Dynamic mechanical analysis#	STANAG 4540

10.7.2.4.6.2 Optional Tests

Test	Registry/STANAG No.
a. Pycnometry	102.02.001
b. Small scale BAM friction sensitivity test	201.02.001
c. Large scale differential thermal analysis	202.01.003
d. Heat of explosion	302.03.004

10.7.2.4.7 Remarks :

* two compatibility tests are usually chosen from the lists

+ selection of a suitable chemical stability test depends on composition of a propellant under test

applicability of the test depends on a resolution of the national authority

10.7.2.4.8 Ageing Characterization

10.7.2.4.8.1 Determination of the influence of ageing on a new explosive's properties is an important part of the qualification process. The ageing characterization is mostly based on artificial ageing at higher temperatures (50-70^{o}C) for several months with packaging corresponding to the final application of the explosive and following determination of changes in selected properties. Some types of explosive materials (especially rocket propellants and main charge high explosives) can also be aged using temperature cycling and shocks. The final version of the ageing protocol for different types of explosives is established by case-by-case basis in such a manner allowing to determine the important properties of the explosive after artificial ageing corresponding to at least the end of its guaranteed service life (with some safety reserve).

10.7.2.4.8.2 Determination of change in properties of a new explosive before and after the artificial ageing is done by the following methods, in general:

Methods	Types of explosives
Impact, friction and electrostatic discharge sensitivity	All types of explosives
Shock wave sensitivity	Booster and main charge high explosives
Thermal stability (DTA, TGA, DSC, temperature of ignition, cook-off)	All types of explosives (except primary explosives for cook-off tests)
Vacuum stability test	All types of explosives
Stabilizer or antioxidant depletion	Propellants
Mechanical properties (in tension, pressure, relaxation, DMA, TMA, hardness)	Propellants, plastic bonded high explosives
Chemical properties (plasticizer migration, active metal degradation)	Propellants, pyrotechnics
Performance properties (heat of explosion, closed vessel test, live firings from ballistic weapons)	Propellants, pyrotechnics

10.7.2.5 LIST OF TEST INFORMATION SHEETS

10.7.2.6 CATALOGUE OF TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with the Registry Number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Pycnometry

a. Type of Test: Physical Property

b. Description: The density is calculated as a quotient of mass and volume of a sample. The mass is measured with an analytical balance (resolution 0.0001 g) and the volume is measured with a pycnometer by a liquid displacement method at 20 ^{o}C. Liquid that does not dissolve the sample is used as a medium for the pycnometric measurements (e.g. water for high explosives, parafinic oil for propellants and pyrotechnics). A solid sample is used in a form of small pieces that will pass through the pycnometer neck, with smooth surfaces free from crevices and dust.

c. Information Requirements for Assessment: This test is used for material characterization and quality control before some qualification tests.

d. Typical Results:

Cast TNT loading density: 1.58 $g.cm^{-3}$

e. Repeatability and Reproducibility:

Good (± 0.005 $g.cm^{-3}$)

3. NATIONAL REFERENCES:

(1) CSN 66 8102

Czech Republic/201.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Pyrotechnics

2. TEST TITLE: Small Scale BAM Friction Sensitivity Test

a. Type of Test: Safety/Friction - Used for Primary Explosives and Pyrotechnics

b. Description: The sensitivity of primary explosives and some sensitive pyrotechnics is tested by means of the scale-down version of standard BAM friction test apparatus (described in Annex A to STANAG 4487). The applied friction load ranges from 0.1 N to 18 N. Sensitivity of an explosive is usually expressed as a down level (the maximum load giving 0 ignitions of 6 trials) and an upper level (the minimum load giving 6 ignitions of 6 trials).

c. Information Requirements for Assessment: This test is used to determine the sensitivity of primary explosives and sensitive pyrotechnics at very low loads that can produce incorrect results using the standard type of BAM friction test apparatus.

d. Typical Results: Results are quoted as minimum loads for obtaining 6 ignitions or explosions of 6 trials (upper level)

(1) Potassium Chlorate + Red Phosphorous 75/25: 0.4 N (explosion)
(2) Lead Trinitroresorcinate: 5 N (explosion)

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

(1) ON 66 8093

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Electric Spark Test

   a. Type of Test: Safety/Electric Spark - used for all types of explosives.

   b. Description: An explosive sample of volume of 5 mm^3 is placed between two electrodes (usually fixed discs). Electrostatic energy stored on a charged variable capacitor (capacity 100 pF - 350 nF, charged with 4 - 10 kV potential) is discharged to the sample. The standard test interval ranges from 0.01 mJ to 16 J. Using an oscilloscope and high voltage sensors, voltage vs. time dependence is measured on the electrodes and the software determines the real energy transferred into the sample. Two values of electrostatic discharge sensitivity of explosives are obtained from this test – E_{50} and E_{min}. E_{50} is a total energy given to the sample with 50 % probability level of initiation (E_{50}) determined by an „up and down“ Bruceton method. E_{min} is a minimum energy for initiation of the sample calculated from the oscilloscopic measurements. The test should be more representative than usual spark tests owing to direct measurement of spark energy transferred to the sample.

   c. Information Requirements for Assessment: To determine the electrostatic charge required for ignition of an explosive material.

   d. Typical Results (E_{50}):

      (1) RDX: 55 mJ
      (2) PETN: 30 mJ
      (3) Tetryl: 83 mJ (criterion for booster explosives)
      (4) TNT: 116 mJ

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

Czech Defence Standard 137601 “Organization and Methods for the Qualification of Explosives for Military Use”, chapter 6.16

Czech Republic/201.04.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Large Scale Gap Test

a. Type of Test: Safety/Detonative Shock

b. Description: A flat shock wave from a conical donor charge of cast TNT (density 1.58 $g.cm^{-3}$, diameter at the bottom of the charge of 68 mm) with a coating layer of PETN/TNT 50/50 and a small booster charge of PETN/wax 90/10 is attenuated by layers of PMMA discs (diameter of 68 mm). The occurrence of detonation of the acceptor charge in a steel tube (internal diameter of 60 mm, wall thickness of 5 mm, length of 200 mm) is assessed by the degree of damage to a 15 mm thick steel witness plate under a 3 mm air gap. Thickness of the attenuator giving a 50% probability of detonation is determined by a simplified Bruceton method.

c. Information Requirements for Assessment: This test determines the sensitivity to shock initiation of explosives that will propagate detonation in confined charges with diameters of 60 mm.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

Czech Defence Standard 137601 “Organization and Methods for the Qualification of Explosives for Military Use”, chapter 6.18

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: 100 ^{o}C Heat Test

   a. Type of Test: Stability/Thermal - Used for Gun Propellants and Nitrocellulose Based Rocket Propellants

   b. Description: 10 g samples of propellants, enclosed in standardised glass test tubes, are heated at 100 ^{o}C in a heating block. The number of days required to cause clearly visible yellow or red fumes of nitrogen oxides is recorded.

   c. Information Requirements for Assessment: This test determines the stability level of nitrocellulose based propellants.

   d. Typical Results:

      (1) Double based propellants: 2 - 10 days
      (2) Single based propellants: 6 - 14 days

   e. Repeatability and Reproducibility: within ± 6 hours

3. NATIONAL REFERENCES

   (1) Czech Mining Office Promulgation 246/1996 Sb., Test No.23B

Czech Republic/202.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Czech Vacuum Stability Test

a. Type of Test: Stability/Thermal - Used for Nitrocellulose Based Gun and Rocket Propellants.

b. Description: Samples of propellants (2 grams) enclosed in standardised glass test tubes (volume of 20 ±1 cm^3) with adapters for connection of electronic pressure transducers and a vacuum pump are heated at initial vacuum for a specified period of time at a specified temperature in a heating block. Single based propellants are heated for 5 hours at 125^oC, double based propellants for 5 hours at 115^oC. The volume of gases evolved during the test is recorded from the transducers by computer in regular intervals (5 - 30 minutes) and volume of gases vs. time graph is finally plotted for every sample. Together with total volume of gases evolved in the test, rate of steady gas evolution is determined from the curve. The rate (extrapolated to 20 hours) is usually taken as a value for stability evaluation.

c. Information Requirements for Assessment: This test determines a stability level of the nitrocellulose based propellants.

d. Typical Results:

(1) Nitroglycerine propellants: 6 - 16 $cm^3.g^{-1}$.20hours (115^oC)
(2) Single based propellants: 10 - 25 $cm^3.g^{-1}$.20hours (125^oC)

e. Repeatability and Reproducibility: Within 0.2 $cm^3.ml.g^{-1}$.20hours.

3. NATIONAL REFERENCES

(1) CSVN 26 910

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Large Scale Differential Thermal Analysis

a. Type of Test: Stability/Thermal - Used for all types of explosives.

b. Description: Commercially available DTA equipment with reinforced design is utilised. The apparatus is capable to withstand explosion of up to 50 mg of primary explosives. Sample weight of 50 - 500 mg of non-primary explosives can be used. In this apparatus, endothermic and exothermic changes of the sample in a small glass test tube are observed and recorded during heating at a constant rate (usually 5 - 20 $^{o}C.min^{-1}$) under air atmosphere. The apparatus is very suitable for measurement of highly heterogeneous samples (esp. pyrotechnics) that can produce unrepeatable results with low sample weights. The equipment is also suitable for preliminary assessment of thermal reactivity of an unknown explosive before measurement at more sensitive apparatuses.

c. Information Requirements for Assessment: This test determines the thermal stability of an explosive - start, onset and peak of exothermal decomposition.

d. Typical Results (peaks of decomposition at 50 mg sample weight and 5 $^{o}C.min^{-1}$ heating rate):
(1) TNT: 295^{o}C
(2) RDX: 220^{o}C

(3) PETN: 190^{o}C
(4) Double Based Propellants: 165 - 170^{o}C
(5) Black Powder: 320^{o}C

e. Repeatability and Reproducibility: ± 2^{o}C of peak temperatures

3. NATIONAL REFERENCES

Czech Republic/202.05.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Critical Diameter Test

   a. Type of Test: Safety/Critical Diameter - Used for Booster and Main Charge High Explosives, Propellants and Pyrotechnics

   b. Description: The explosive under test contained in 100 cm long steel tube with a selected internal diameter and wall thickness of 10 % of internal diameter, is subjected to an explosive shock known to be sufficient to initiate detonation (using detonator or a plastic explosive booster). The remains of the tube are examined to determine whether the detonation has propagated through the whole length of the charge. If detonation propagates, internal diameter of the next steel tube is reduced to its half. If detonation fails, internal diameter of the next steel tube is doubled. Using this procedure, critical diameter of the explosive at given loading density is determined as a minimum diameter of the tube at which complete detonation occurs.

   c. Information Requirements for Assessment: This test determines the critical diameter of an explosive material for sustaining a detonation through a long confined explosive charge.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

   Czech Defence Standard 137601 "Organization and Methods for the Qualification of Explosives for Military Use", chapter 6.19

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Deflagration to Detonation Transition Test

   a. Type of Test: Safety - Used for Gun Propellants

   b. Description: The explosive under test is contained in a steel tube (inside diameter of 32 mm, wall thickness of 3 mm, length of 500 mm), which is closed at one end with a welded steel disc 3 mm thick. Initiation occurs by means of electric squib at the open end of the tube. The lengths of deflagration and detonation zones are determined by means of a mechanical sensor made of 3.15 mm thick steel wire wrapped with 0.6 mm thick copper wire. The mechanical sensor is located inside the tube along all its length. After explosion, the mechanical sensor is collected. The first cut of the copper wire into the steel wire corresponds to the transition point from deflagration to detonation.

   c. Information Requirements for Assessment: This test determines tendency of a propellant charge to transition from burning to detonation.

   d. Typical Results:

      (1) A porous nitrocellulose sheet propellant: 250 mm

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

   (1) Czech Mining Office Promulgation 246/1996 Sb., Test No.24

CZ/302.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Detonation Velocity

a. Type of Test: Performance/Experimental - Used for Booster and Main Charge High Explosives.

b. Description: Two measurement probes (insulated copper foils or wires wrapped round or pressed to each other) are inserted into the explosive charge of the selected diameter, length and confinement. The explosive charge is initiated by means of a detonator or a booster charge and the two probes are short-circuited by the passing detonation wave that removes insulation from the probes. The time between the two generated pulses is determined by an electronic counter. Knowing the distance between the two probes, the average detonation velocity is calculated.

c. Information Requirements for Assessment: This test determines the detonation velocity of an explosive charge - one of important performance parameters.

d. Typical Results:
(1) TNT (pressed 1.62 $g.cm^{-3}$): 6800 $m.s^{-1}$
(2) RDX/wax 95/5 (pressed 1.62 $g.cm^{-3}$): 8150 $m.s^{-1}$

e. Repeatability and Reproducibility: Precision ± 2%

3. NATIONAL REFERENCES

Czech Defence Standard 137601 “Organization and Methods for the Qualification of Explosives for Military Use”, chapter 6.19

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Closed Vessel Test

a. Type of Test: Performance/Experimental - Used for Gun and Rocket Propellants

b. Description: Basic ballistic properties of a propellant are determined in a closed high-pressure combustion chamber of constant volume (5 - 200 cm^3). The propellant charge is ignited by a small black powder charge. Loading density of a propellant in the bomb should be 0.19 - 0.22 $g.cm^{-3}$. The pressure rise is measured by a piezoelectric pressure transducer, with computer evaluation of the pressure-time curve. The force, covolume, quickness, vivacity, form and other ballistic parameters of the propellant are calculated from the curve.

c. Information Requirements for Assessment: The results of the test are used for a ballistic assessment of the propellant.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

U.S. MIL-STD-286C, „Military Standard: Propellant, Solid, Sampling, Examination and Testing“, Method 801.1

CZ/302.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Lead Block Compression Test

a. Type of Test: Performance/Brisance - Used for Booster and Main Charge High Explosives

b. Description: 50 g explosive charge with diameter of 40 mm is placed on steel plates 10 - 30 mm thick situated on the top of a lead cylinder with diameter of 40 mm and height of 60 mm. The charge is initiated by means of a detonator. After explosion, resulting compression of the lead cylinder is measured.

c. Information Requirements for Assessment: The value of the lead cylinder compression corresponds to a brisance of the explosive.

d. Typical Results: (with steel plates of 30 mm thickness)
(1) TNT (pressed, 1.60 $g.cm^{-3}$): 22 mm
(2) RDX/TNT 75/25 (cast, 1.71 $g.cm^{-3}$): 28.5 mm (130% TNT)

e. Repeatability and Reproducibility: within ± 0,5 mm

3. NATIONAL REFERENCES

(1) Czech Mining Office Promulgation 246/1996 Sb., Test No.8

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Ballistic Mortar Test

   a. Type of Test: Performance/Explosive power - Used for Booster and Main Charge High Explosives

   b. Description: 10 g explosive charge is detonated in a heavy (300 kg) steel mortar, damped with a steel projectile (15 kg). The mortar is attached to a pendulum bar and suspended on knife edges. After explosion of the charge, resulting degree of swing is compared to that produced on detonation of a specific amount of TNT. The result is expressed as percentage of TNT.

   c. Information Requirements for Assessment: The value corresponds to an explosive power (working ability) of the explosive.

   d. Typical Results:
      (1) RDX/TNT 75/25: 144% TNT

   e. Repeatability and Reproducibility: ± 2% TNT

3. NATIONAL REFERENCES

   Czech Mining Office Promulgation 246/1996 Sb., Test No.7

Czech Republic/302.03.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Lead Block Expansion Test

a. Type of Test: Performance/Explosives - Used for Booster and Main Charge High Explosives

b. Description: 10 g sample is placed into a tube with diameter of 25 mm made of tin sheet and a standard detonator is inserted. The charge is then put into a hole in a lead block of diameter and length of 200 mm. Volume produced by the explosion of the charge is measured.

c. Information Requirements for Assessment: The value corresponds to an explosive power (working ability) of the explosive.

d. Typical Results:
(1) TNT (powder): 300 cm^3 (100% TNT)
(2) RDX/Al/wax 76/20/4: 471 cm^3 (157% TNT)

e. Repeatability and Reproducibility: within ± 1% TNT

3. NATIONAL REFERENCES

Czech Mining Office Promulgation 246/1996 Sb., Test No.6

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/Pyrotechnics

2. TEST TITLE: Heat of Explosion

a. Type of Test: Performance - Used for Propellants and Pyrotechnics

b. Description: The heat of explosion of an explosive is determined in a gas-tight stainless steel container. This container is placed in an adiabatic water-bath calorimeter and the heat of explosion of the sample is determined from the temperature raise of the water-bath. Knowing the heat capacity of the calorimeter obtained by combustion of a reference material, the heat of explosion of the explosive can be calculated.

c. Information Requirements for Assessment: Determination of an energetic content of explosives.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

(1) Czech Mining Office Promulgation 246/1996 Sb., Test No.22

10.7.3 QUALIFICATION PROCEDURES OF DENMARK

PARAGRAPH | PAGE

[1] Not Applicable since Denmark does not perform tests.

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10.7.3.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.7.3.1.1 Denmark does not qualify new military explosives since no new explosives are developed in this country.

10.7.3.1.2 Denmark procures explosives from foreign producers as part of a complete munition or weapon system design or bulk explosives for production or rework of ammunition.

10.7.3.1.3 The approval of explosives, in Denmark, is done as part of the approval of the specifications of the complete ammunition or weapon system as procured from either Danish or foreign contractors.

10.7.3.2 NATIONAL AUTHORITY(IES)

10.7.3.1.1 The following authorities within the Danish Defense Organization are responsible for approving the specifications for explosives contained in munitions:

a.	Haerens Materielkommando	(Army Materiel Command)
b.	Sovaernets Materielkommando	(Naval Materiel Command)
c.	Flyvematerielkommandoen	(Air Materiel Command)

10.7.3.2.2 The Danish National Authority does not approve explosives for military use. This is done by the Materiel Commands. The Danish National Authority serves as point of contact for STANAG 4170 and for specific explosive material STANAGs.

10.7.3.3 QUALIFICATION PROCEDURES

10.7.3.3.1 Approval of new explosives for military use is done by the above mentioned Materiel Commands. If necessary the Materiel Commands may forward safety questions concerning the introduction of new explosives to the Ministry of Defense Explosives Safety Commission (the Danish National Authority) for further evaluation. The Danish Defense authorities procure only ammunition and weapon systems containing explosives approved by the military authorities in the country of origin. Normally, procurement takes place from other NATO countries.

10.7.3.4 QUALIFICATION METHODS AND TESTS

10.7.3.4.1 The basis for the approval of new explosives is the specifications with related test-methods and requirements given in NATO-STANAGs used for approval in other NATO countries. Specific Danish test methods for explosives do not exist. Consequently Test Information Sheets are not relevant. The tests which the Danish authorities consider mandatory for assessing the safety of an explosive material are listed below.

10.7.3.4.2 High Explosives

a. Mandatory Data for Primary Explosives

(1) Impact Sensitivity
(2) Friction Sensitivity
(3) Electrostatic Sensitivity
(4) Heat Test/Temperature of Ignition
(5) Vacuum Thermal Stability
(6) Compatibility
(7) Toxicity

b. Mandatory Data for Booster Explosives

(1) Impact Sensitivity
(2) Friction Sensitivity
(3) Electrostatic Sensitivity
(4) Heat Test/Temperature of Ignition
(5) Shock Sensitivity
(6) Vacuum Thermal Stability
(7) Compatibility
(8) Detonation Velocity
(9) Toxicity

c. Mandatory Data for Main Charge High Explosives

(1) Impact Sensitivity
(2) Friction Sensitivity
(3) Electrostatic Sensitivity
(4) Heat Test/Temperature of Ignition
(5) Shock Sensitivity
(6) Vacuum Thermal Stability
(7) Exudation
(8) Detonation Velocity
(9) Toxicity

10.7.3.4.3. Propellants

a. Mandatory Data for Solid Propellants

(1) Impact Sensitivity
(2) Friction Sensitivity
(3) Electrostatic Sensitivity
(4) Temperature of Ignition
(5) Stability
(6) Bergmann-Junk Test 132°C/120°C
(7) Weight Loss Test (Holland Test) 110°C/105°C
(8) Methyl-Violet Test 134,5°C/120°C
(9) Abel Test 80°C
(10) Chemical Analysis (Stabilizer Content)
(11) Compatibility
(12) Burning Rate
(13) Toxicity

b. Mandatory Data for Liquid Propellants

NOTE; The liquid propellants used by the Danish forces in naval torpedoes or other uses are generally procured from other countries. The data required for these materials are as documented in Chapter 7 for liquid propellants.

10.7.3.4.4 PYROTECHNICS

a. Mandatory Data for Pyrotechnics

(1) Thermal Gravimetric Analysis
(2) Impact Sensitivity
(3) Friction Sensitivity
(4) Electric Spark
(5) Woods Metal Bath
(6) Ease of Ignition (Safety Fuse Test)
(7) Trough Test (Train Test)
(8) Compatibility with Materials
(9) Burning Characteristics (loose)

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10.7.4 QUALIFICATION PROCEDURES OF FINLAND

To be provided

10.7.6 QUALIFICATION PROCEDURES OF FRANCE

PARAGRAPH PAGE

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10.7.6.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION
(cf. STANAG 4170 Ed2 §3)

10.7.6.1.1 The procurement of all weapon systems for the armed forces is under the responsibility of DGA (Délégation Générale pour l'Armement). According to DGA instruction 11500 - which is the national STANAG 4170 implementation document - Qualification is mandatory for all explosive material to be used in munitions intended for the 4 Services: Army, Navy, Air Force and "Gendarmerie" (*state police force*). So DGA has the full responsibility of qualifying all explosive materials to be used by the French forces.

10.7.6.2 NATIONAL AUTHORITY
(cf. STANAG 4170 Ed2 § 4(a) & Annex A)

10.7.6.2.1 Within DGA, the office appointed as National Authority for the Qualification of explosive materials is the "bureau de la sécurité pyrotechnique" (*explosive safety office*) part of the "Inspection de l'armement pour les poudres et explosifs" (Armament Inspectorate for Propellants and Explosives):

INSP/IPE/SM
8 Boulevard Victor – Paris
00303 ARMEES

10.7.6.3 QUALIFICATION PROCEDURES

10.7.6.3.1 General: (cf. STANAG 4170 Ed2 §3 & 4(c))
According to STANAG 4170, the Qualification of an explosive material is a process whereby it is officially acknowledged that:

a. this well specified explosive material has the necessary properties to provide an expectation of an adequate level of safety and suitability for service in military use, for a given intended role,

b. the manufacture and quality of the explosive material are adequately controlled.

10.7.6.3.2 Qualification request:

a. Generally, and especially for a new composition, the official request for qualifying an explosive has to come from the designer of this explosive.

b. In some cases, the request could come from the manufacturer of the explosive, or even from the munition or munition-component designer, which then acts as the explosive designer by proxy. This request is sent directly to the National Authority.

10.7.6.3.3 Approach: (cf. STANAG 4170 Ed2 §4 & 5)

a. In order to make the Qualification decision, the following information has to be brought to INSP/IPE/SM:

(1) the precise identification/specification of the explosive material to be qualified (which include the manufacturing process**), [type A information],**

(2) the assessment data (from tests performed on material coming from industrial production batches) on which the judgement of safety and suitability for service use will be based, **[type B information],**

(3) the information justifying that the manufacturing process and quality are adequately controlled, [type C information].

b. According to STANAG 4170 (and DGA instruction 11500), all this information is collated in the Qualification report upon which is based the Qualification decision.

10.7.6.3.4 DGA offices involved:

a. The validity and quality of the information produced are ensured by involving two "intervening parties" of DGA, DPM/SQ and DCE/ETBS:

(1) DPM/SQ - the quality assurance office for all armament programmes - mainly involved in verifying that both the designer and the manufacturer of the explosive have a good quality assurance system, and that the manufacturer has the capability of producing it in conformity with the designer specifications,

(2) DCE/ETBS - the Bourges establishment of the directorate for technical expertise and testing – in participating in the design of the Qualification programme as well as giving advice on the Qualification report. (Generally, but this is not always the case, ETBS is also involved for the performing of some of the tests of the qualification programme).

10.7.6.3.5 The steps of the qualification procedure:
(cf. STANAG 4170 Ed2 §4 & 5)

a. The following table provides the different steps of the qualification procedure and the parties involved in them:

	Step	Participants
1	Request for Qualification	**From** Explosive Designer (or other requester) **To** INSP/IPE/SM
2	Definition of the Qualification programme	**By** INSP/IPE/SM **With** DCE/ETBS (issue of the *"Qualification document"*)
3	Performing of the Qualification programme	**By** Explosive Designer (or other requester) Under the control of DPM/SQ
4	Production of the *"Qualification report"*	**By** INSP/IPE/SM or Explosive Designer (or other requester)
5	Advice on this report	**By** INSP/IPE/SM **With** DPM/SQ and DCE/ETBS
6	Qualification decision	**By** INSP/IPE/SM (issue of the *"Qualification certificate"*)

10.7.6.3.6 The different types of Qualification decisions:

a. **“Qualification” as defined in STANAG 4170.** When it is possible to completely follow the process as described under §5 of STANAG 4170 Ed2 and particularly to provide type A, B (as described hereafter under §10.7.6.4) and C information as defined here above under § 10.7.6.3.3 “Approach” of this document, INSP/IPE/SM is making the actual “Qualification” decision of the explosive material.

b. **“In principle Qualification” (cf. STANAG 4170 Ed2 § 4(e)).** A decision can be taken to qualify an explosive material, even if there is no immediate application envisaged for it. In that case, because, most of the time, there is not yet an industrial production of this material, and so just type A and B (limited to a lab scale preparation of the necessary samples) information is available, INSP/IPE/SM is just making an “In principle Qualification” (*Homologation de definition*) decision of the explosive material which will have to be completed with a confirmation of type B information (to be performed on production batches of the material) and type C information prior to any military use in a munition, this in order to verify that the manufacturer is producing it according to its defined specifications.

c. **“Qualification de facto” (cf. STANAG 4170 Ed2 § 3 & 6).** Explosives already in service for which there is a well-established history of safe and satisfactory use **[type B’ information]**, providing the original material specifications remains the same, may be qualified for use in the same role. Without further testing, or with a very limited testing programme, and so just on the basis of type A, B’ (instead of type B) and C information, INSP/IPE/SM is making a “Qualification de facto” (*Homologation de fait*) decision with possible restrictions of the role.

d. **“Recognition of Qualification” (cf. STANAG 4170 Ed2 § 3).** According to DGA instruction 11500, Qualification by the French authority is mandatory for all explosive material to be used in munitions intended for the French services. If an explosive material was already qualified according to STANAG 4170 by a foreign National Authority, INSP/IPE/SM is just making a “recognition of the Qualification” - given by this foreign National Authority - decision. This is done on the basis of the Qualification certificate produced by this Authority and, if necessary, of the Qualification report (which should include type A, B -or eventually B’- and C information on this explosive material). Most of the time, INSP/IPE/SM is also asking for additional data according to the methods and tests described at §10.7.6.4.

10.7.6.4 QUALIFICATION (HOMOLOGATION) METHODS AND TESTS

10.7.6.4.1. List of Tests for Primary Explosives

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Impact (small BAM apparatus)	201.01.005
(2) Friction (small BAM apparatus)	201.02.002
(3) Spark sensitivity (small-scale)	STANAG 4490A
(4) Differential thermal analysis (DSC)	STANAG 4515B2
(5) Thermal stability at 60 °C or lower	202.01.009

b. Optional Tests:

Test	Registry/STANAG Number
(1) Heat of combustion under oxygen	102.02.001
(2) Potential calorimeter	102.01.002
(3) Density	102.02.011
(4) Particle size by laser diffraction	102.02.020
(5) Particle size by microscopic examination	102.01.021
(6) Crushing impact	201.01.006
(7) Stab initiation	201.01.007
(8) Hot wire sensitivity	201.08.007
(9) Temperature of ignition	STANAG 4491B1
(10) Thermogravimetric analysis	STANAG 4515B3
(11) Compatibility with materials	STANAG 4147
(12l) Initiation power (primary explosives)	302.03.004

10.7.6.4.2 List of Tests for Booster Explosives:

a. Mandatory Tests

Test	Registry/STANAG Number
(1) Uniaxial tensile	STANAG 4506
or Uniaxial compression	STANAG 4443
(2) Impact sensitivity (BAM)	STANAG 4489C
(3 Friction sensitivity (BAM))	STANAG 4487A
(4) Spark sensitivity (small-scale)	STANAG 4490A
(5) Shock sensitivity (plastic barrier)	STANAG 4488B
or Initiability by a primer	201.04.002
(6) Temperature of ignition	STANAG 4491B1
(7) Differential scanning calorimeter (DSC)	STANAG 4515B2
(8) Thermogravimetric analysis	STANAG 4515B3
(9) Vacuum stability	STANAG 4556
(10) Thermal stability at 60 °C or lower	202.01.009
(11) Critical temperature of self-ignition	202.01.012

b. Optional Tests:

Test	Registry/STANAG Number
(1) Dynamic mechanical analysis (DMA)	STANAG 4540
(2) Density (Gravimeter)	102.02.012
(3) Particle size by laser diffraction	102.02.021
(4) Particle size by underwater screening	102.02.022
(5) Impact sensitivity (Bourges apparatus)	201.01.002
(6) Impact sensitivity (30kg apparatus)	201.01.004
(7) Electrostatic discharge (small-scale)	STANAG 4490B
(8) Initiability by a booster	201.04.003
(9) Water Gap Test	STANAG 4488A
(10) Friability	201.08.004
(11) Fast cook-off under confinement	202.02.002
(12) Critical diameter	205.01.001
(13) Compatibility with materials	STANAG 4147
(14) Detonation velocity	302.01.001
(15) Initiability by a primer	302.03.001
(16) Initiability by a booster	302.03.002
(17) Initiating power of a booster	302.03.003
(18) Critical diameter	302.03.005

c. For booster explosive, France uses the table I in chapter 7 but some criteria are more severe or some additional tests can be conducted:

(1) Friction test : STANAG 4487A: ISF (Bruceton) ≥ 170 N
(2) Shock sensitivity : 201.04.002: e_{50} at ≤ 5.7 mm
(3) Impact test: STANAG 4489C: ISI (Bruceton) ≥ 5 J (or ≥ 14J with test 201.01.002)

d. Tetryl from the reference lot M35 DNAG 82 meets the above criteria. If these criteria are not met, supplementary tests are necessary. These are selected based on the particular end item use and are addressed in the ammunition safety report in accordance with AOP-15.

10.7.6.4. 3 List of Tests for Main Charge High Explosives:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Uniaxial tensile	STANAG 4506
or Uniaxial compression	STANAG 4443
(2) Impact sensitivity (BAM)	STANAG 4489C
(3) Impact sensitivity (Bourges apparatus)	201.01.002
(4) Friction sensitivity (BAM)	STANAG 4487A
(5) Electrostatic discharge (small-scale)	STANAG 4490B
(6) Shock sensitivity (plastic barrier Ø40)	STANAG 4488B
or Initiability by a booster	201.04.003
(7) Friability	201.08.004
(8) Critical diameter	205.01.001
(9) Temperature of ignition	STANAG 4491B1
(10) Differential scanning calorimeter (DSC)	STANAG 4515B2
(11) Thermogravimetric analysis	STANAG 4515B3
(12) Vacuum stability	STANAG 4556
(13) Thermal stability at 60 °C or lower	202.01.009
(14) Critical temperature of self-ignition	202.01.012
(15) Detonation velocity	302.01.001

b. Optional Tests:

Test	Registry/STANAG Number
(1) Relaxation	STANAG 4507
(2) Dynamic mechanical analysis (DMA)	STANAG 4540
(3) Linear dilatation coefficient	102.01.060
(4) Shore Hardness	102.01.065
(5) Density	102.02.012
(6) Impact sensitivity (30kg apparatus)	201.01.004
(7) Spigot intrusion	201.01.008
(8) Spark sensitivity (small scale)	STANAG 4490A
(9) Shock sensitivity (plastic barrier Ø75)	STANAG 4488C
(10) 12.7 mm bullet impact in vehicle	201.05.002
(11) Heavy spherical fragment impact (250 g) in vehicle	201.06.002
(12) Light fragment impact (16 g) in vehicle	201.06.003
(13) 62 mm shaped charge in vehicle	201.07.001
(14) Fast cook-off in vehicle	201.09.001
(15) Fast cook-off under confinement	201.09.002
(16) Slow heating (3.3°C/min) in vehicle	201.09.003
(17) Compatibility with materials	STANAG 4147
(18) Initiability by a booster	302.03.002
(19) Critical diameter	302.03.005

10.7.6.4.4 List of Tests for Solid Gun Propellants:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Content of particular ingredients	101.01.002
(2) Volatile matter (CPG)	101.01.003
(3) Moisture content (Fisher)	101.01.004
(4) Potential calorimeter	102.02.002
(5) Density (gas pycnometer)	102.02.010
(6) Impact sensitivity (30kg apparatus)	201.01.004
(7) Friction sensitivity (BAM)	STANAG 4487A
(8) Temperature of ignition	STANAG 4491B1
(9) Differential scanning calorimeter (DSC)	STANAG 4515B2
(10) Thermal stability at 60 °C or lower	202.01.009
(11) Closed bomb	302.02.002

b. Optional Tests:

Test	Registry/STANAG Number
(1) Hygroscopicity	101.02.001
(2) Radial compression	102.01.011
(3) Dynamic mechanical analysis (DMA)	STANAG 4540
(4) Density (gravimetry)	102.02.011
(5) Free surface (B.E.T.)	102.01.030
(6) Impact sensitivity (BAM)	STANAG 4489C
(7) Spark sensitivity (small scale)	STANAG 4490B
(8) Shock sensitivity (plastic barrier)	STANAG 4488B
(9) 12.7 mm bullet impact in vehicle	201.05.002
(10) Light fragment impact (16 g) in vehicle	201.06.003
(11) 62 mm shaped charge in vehicle	201.07.001
(12) Fast cook-off in vehicle	202.02.001
(13) Fast cook-off under confinement	202.02.002
(14) Slow heating (3.3°C/min) in vehicle	202.02.003
(15) Vacuum stability	STANAG 4556
(16) Critical temperature of self-ignition	202.01.012
(17) Compatibility with materials	STANAG 4147
(18) Critical height for detonation	205.02.001
(19) Train propagation (trough test)	302.02.001

10.7.6.4. 5 List of Tests for Solid Rocket Propellants:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Uniaxial tensile	STANAG 4506
or Uniaxial compression	STANAG 4443
(2) Density (gas pycnometer)	102.02.010
(3) Impact sensitivity (BAM)	STANAG 4489C
(4) Friction sensitivity (BAM)	STANAG 4487A
(5) Electrostatic discharge (large scale)	STANAG 4490B
(6) Friability	201.08.004
(7) Temperature of ignition	STANAG 4491
(8) Differential scanning calorimeter (DSC)	STANAG 4515B2
(9) Thermogravimetric analysis	STANAG 4515B3
(10) Vacuum stability	STANAG 4556
(11) Thermal stability at 60 °C or lower	202.01.009

b. Optional Tests:

Test	Registry/STANAG Number
(1) Content of particular ingredients	101.01.002
(2) Moisture content (Fisher)	101.01.004
(3) Relaxation	STANAG 4507
(4) Dynamic mechanical analysis (DMA)	STANAG 4540
(5) Density	102.02.012
(6) Impact sensitivity (30 kg apparatus)	201.01.004
(7) Spigot intrusion	201.01.008
(8) Shock sensitivity (plastic barrier)	STANAG 4488B
(9) 12.7 mm bullet impact in vehicle	201.05.002
(10) Heavy spherical fragment impact (250 g) in vehicle	201.06.002
(11) Light fragment impact (16 g) in vehicle	201.06.003
(12) 62 mm shaped charge in vehicle	201.07.001
(13) Fast cook-off in vehicle	202.02.001
(14) Fast cook-off under confinement	202.02.002
(15) Slow heating (3.3°C/min) in vehicle	202.02.003
(16) Compatibility with materials	STANAG 4147
(17) Burning rate (strand burner)	302.02.003
(18) Standard motor firing	302.02.004

10.7.6.4.6 List of Tests for Liquid Propellants:

a. The Tests required for liquid propellants is as documented in Chapter 7 of this document.

10.7.6.4.7 List of Tests for Pyrotechnics:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Potential calorimeter	102.02.001
(2) Impact sensitivity (BAM)	STANAG 4489C
or Impact sensitivity (small BAM)	201.01.005
(3) Friction sensitivity (large BAM)	STANAG 4487A
or Friction sensitivity (small BAM)	201.02.002
(4) Spark sensitivity (small scale)	STANAG 4490A
(5) Temperature of ignition	STANAG 4491B1
(6) Differential scanning calorimeter (DSC)	STANAG 4515B2
(7) Thermogravimetric analysis	STANAG 4515B3
(8) Vacuum stability	STANAG 4556
(9) Thermal stability at 60 °C or lower	202.01.009

b. Optional Tests:

Test	Registry/STANAG Number
(1) Content of particular ingredients	101.01.002
(2) Density (gas pycnometer)	102.02.010
(3) Density (gravimetry)	102.02.011
(4) Particle size laser diffraction	102.02.020
(5) Compatibility with materials	STANAG 4147
(6) Train propagation (trough test)	302.02.001

10.7.6.5 LIST OF FRANCE'S TEST INFORMATION SHEETS

Category100	Chemical, Physical & Mechanical Properties
101.01.XXX	Analytical tests
101.01.002	Content of particular ingredients
101.01 003	Volatile matters by CPG
101.01.004	Moisture content (Fisher)
101.02.XXX	Other tests
101.02.001	Hygroscopicity
102.01.XXX	Mechanical properties
STANAG 4443	Uniaxial compression
STANAG 4506	Uniaxial tensile
STANAG 4507	Stress relaxation
STANAG 4540	Dynamic mechanical analysis (DMA)
102.01.011	Radial compression
102.01.060	Linear dilatation coefficient
102.01.065	Shore hardness
102.02.XXX	Physical properties
102.02.001	Heat of combustion in oxygen
102.02.002	Potential calorimeter
102.02.010	Density (gas pycnometer)
102.02.011	Density (gravimetry)
102.02.012	Density
102.02.020	Particle size laser diffraction
102.02.021	Particle size by microscopic examination
102.02.022	Particle size by underscreening
102.02.030	Free surface (B.E.T.)
Category 200	Hazard Assessment Sensitiveness/Sensitivity/ Explosiveness
201.01.XXX	Impact
STANAG 4489C	Impact sensitivity (BAM)
201.01.002	Impact - Bourges apparatus
201.01.004	Impact - 30 kg apparatus
201.01.005	Impact - small BAM apparatus
201.01.006	Crushing impact
201.01.007	Stab initiation
201.01.008	Spigot intrusion

201.02.XXX	Friction
STANAG 4487A	Friction sensitivity (BAM)
201.02.002	Friction -Small BAM apparatus
201.03.XXX	Electric discharge
STANAG 4490A	Spark sensitivity (small scale)
STANAG 4490B	Electrostatic discharge (large scale)
201.04.XXX	Shock
STANAG 4488A	Water gap test
STANAG 4488B	Shock sensitivity (plastic barrier Ø 40)
STANAG 4488C	Shock sensitivity (plastic barrier Ø 75)
201.04.002	Initiability by a primer
201.04.003	Initiability by a booster
201.05.XXX	Projectile impact
201.05.002	12.7 mm bullet impact in vehicle
201.06.XXX	Fragment impacts
201.06.002	Heavy spherical fragment- (250 g) impact in vehicle
201.06.003	Light fragment impact (16 g) in vehicle
201.07.XXX	Shaped charge jet impact
201.07.001	62 mm shaped charge in vehicle
201.08.XXX	Other tests
201.08.004	Friability
201.08.007	Hot wire sensitivity
202.01.XXX	Thermal tests
STANAG 4491B	Temperature of ignition
STANAG 4515B2	Thermal characterization by DSC
STANAG 4515B3	Thermal characterization by TGA
STANAG 4556	Vacuum stability
202.01.009	Thermal stability at 60 °C or lower
202.01.012	Critical temperature of self-ignition
202.02.XXX	Other tests
202.02.001	Fast cook-off in vehicle
202.02.002	Fast cook-off under confinement
202.02.003	Slow heating (3.3°C/min) in vehicle

203.01.XXX	Compatibility/Reactivity
STANAG 4147	Compatibility
205.01.XXX	Critical diameter evaluation
205.01.001	Critical diameter for detonation
205.01.XXX	Other tests
205.02.001	Critical height for detonation
Category 300	Performance Evaluation Theoretical/Experimental methods
302.01.XXX	Detonation velocity
302.01.001	Detonation velocity
302.02.XXX	Burning rate
302.02.001	Train propagation (trough test)
302.02.002	Closed bomb
302.02.003	Strand burner
302.02.004	Standard motor firing
302.03.XXX	Other tests
302.03.001	Initiability by a primer
302.03.002	Initiability by a booster
302.03.003	Initiating power (booster explosive)
302.03.004	Initiation power (primary explosives)
302.03.005	Critical diameter

10.7.6.6 CATALOGUE OF TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with their Registry Number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Levels of certain components

   a. Type of Test: Chemical test

   b. Description: The method involves determination of the full composition of the powder using appropriate techniques

      (1) The organic components are identified and measured by the following methods: gas chromatography, liquid chromatography etc

      (2) The levels of nitroguanidine, nitroglycerine and perchlorate are measured specifically.

      (3) Mineral salts are measured by atomic absorption after mineralization.

      (4) The combustion ashes are analysed using X-rays to make sure that all the minerals present have been noted. The composition is checked by comparing the measured potential with the potential calculated from the different levels of materials found.

   c. Information Requirements for Assessment: This trial is applicable to all propellants.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FP-101-A-1	NF T 70-303	NF T 70-310
FP-102-B-1	NF T 70-304	FP-211-A-1
FP-106-A-1	NF T 70-305	FP-212-A-1
NF T 70-306	FP-202-I-1	FP-302-A-2
NF T 70-301	FP-202-J-1	
FP-202-C-5	FP-203-C-2	
FP-306-A-1	FP-204-A-1	

France/101.01.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Levels of volatile materials by Gas Chromatography

   a. Type of Test: Chemical test

   b. Description: The method consists in separating the solvents by gas chromatography using a column filled with a Porapak Q-type polymer or a Megabore column. A flame ionization detector is used. Measurement is by internal calibration.

      The current method of preparation is dissolution of 1.5 to 3 g of powder in ethyl acetate, then precipitation of the nitrocellulose and injection of the supernatant liquid after centrifuging.

   c. Information Requirements for Assessment: This trial is applicable to grain propellants.

   d. Typical Results:

   d. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FP-105-D-1
   FP-105-E-1
   FP-105-G-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Moisture content (Fischer)

   a. Type of Test: Chemical trial

   b. Description: 1.5 to 3 g of the sample to be analysed is dissolved in anhydrous ethyl acetate.
   The water in the collodion formed is measured by the Karl Fischer method. This involves the reduction of iodine by sulphurous acid in the presence of water. The consumption of a mole of water causes the reduction of a mole of iodine which plays the role of titrant.

   The method may be volumetric (direct or indirect), or coulometric with the generation of iodine in situ by electrolysis.

   c. Information Requirements for Assessment: Propellants, including those containing lead salts or less than 5% acetone.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FP-103-D-1

France/101.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Hygroscopic characteristic

a. Type of Test: Other trials

b. Description: The loss or gain in mass is measured as a function of the time spent in hermetic enclosures in which there are relative humidities of 33, 52, 65, 76 and 93%. The powder is first treated by holding it in an enclosure with 65% relative humidity.

The degree of humidity is measured before and after the test. The curve of equilibrium humidity levels as a function of the relative humidity is deduced from these figures.

c. Information Requirements for Assessment:

d. Typical Results:

(1)	Powder B	B.19T (1.34)	1.30%		50% RH
		1.90%	at		70% RH
(2)	Powder LB	LB.Tu.72 (0.4)	0.55%	at	50% RH
		0.85%	at		70% RH
(3)	Powder				
	(double base)	GB.Pa (0.075)	0.40%	at	50% RH
		0.60%	at		70% RH

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FP-801-A-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Radial compression

a. Type of Test: Mechanical trial

b. Description: The test piece, which is a grain of powder machined at the ends (with a length/diameter ratio close to 1), is compressed radially in a machine at a constant rate of movement.

The curve which plots the force as a function of the movement allows deduction of:

(1) the point where rupture or cracking of the test piece begins;
(2) the radial stress;
(3) the deformation relative to the shattering force.

c. Information Requirements for Assessment: This trial is applicable to propellants in grains with diameters greater than or equal to 5 mm.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

Nil

France/102.01.060

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Linear expansion coefficient

   a. Type of Test: Mechanical trial

   b. Description: A test piece whose length lies between 5 and 25 mm and whose length/transverse dimension ratio is greater than 1 is subjected to a temperature increase of 0.5 to 2°C/min under a very small constant load.

      Measurement of the elongation of the test piece as a function of temperature permits determination of the linear expansion coefficient.

      This method can also be used to estimate the glass transition temperature.

   c. Information Requirements for Assessment: This trial is applicable to shaped solid materials.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   NF T 70-313

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Shore hardness

   a. Type of Test: Mechanical trial

   b. Description: The hardness of the material is estimated from the degree of indentation caused by a penetrator under a constant force exerted by a calibrated spring for a determined period.

      The measurement is made using a test piece of minimum thickness 4 mm and a Shore type A or D hardness tester.

   c. Information Requirements for Assessment: This trial is applicable to shaped solid materials with hardness ranging from the least measured by the Shore A test to the hardest measured by the Shore D test.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   NF T 70-316

France/102.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Heat of combustion in oxygen

a. Type of Test: Physical trial

b. Description: The quantity of heat liberated by the combustion of 1.5 g of primary explosive is determined.

The measurement is carried out at constant volume in an oxygen bomb calorimeter.

The quantity of heat liberated is determined by measuring the increase in the temperature of the water in the calorimeter by a thermometer or a temperature probe.

c. Information Requirements for Assessment: This trial is applicable to all primary explosives.

d. Typical Results:

(1)	Lead styphnate:	1250 cal/g
(2)	Lead azide:	590 cal/g

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FA-600-A-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Calorimetric potential

   a. Type of Test: Physical trial

   b. Description: The potential of an explosive substance is the heat of combustion at constant volume in the absence of oxygen. It is calculated by measuring the water temperature reached in an adiabatic calorimeter

      Stainless steel calorimeters containing 340 to 500 cm^3 are used; ignition is by a hot wire which may be complemented by a certain quantity of powder with a potential of about 1200 cal/g. The mass of the powder under analysis and the added powder corresponds to a charging density of 15 g/dm^3, i.e. 5.1 g for the usual volume of 340 cm^3.

   c. Information Requirements for Assessment:

   d. Typical Results:

(1)	GB.Pa (0.075)	1198 cal/g
(2)	LB.Tu.72 (0.4)	720 cal/g

   e. Repeatability and Reproducibility:

      ± 2 cal/g

3. NATIONAL REFERENCES:

   FP 807-A-1
   FP 807-A-2
   FP 807-A-3
   FP 807-A-4
   FC 705-A-1

France/102.02.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/Pyrotechnics

2. TEST TITLE: Absolute density by gas pycnometer

a. Type of Test: Physical trial

b. Description: The volume of a known mass of sample is measured, using a gas pycnometer based on the following principle:

Two cylinders are connected by a differential-pressure gauge, and the container holding the sample communicates with one of the cylinders. Each cylinder has a piston which allows slow compression of the gas in it. The compression is stopped when the piston of the reference cylinder reaches its end stop, and the other piston is moved until the pressure is the same in both cylinders. The sample cylinder is graduated so that the position indicates the volume of the sample. This trial is carried out under either air or helium.

c. Information Requirements for Assessment: This trial is applicable to all materials.

d. Typical Results:

(1)	Double-base powder GB.Pa (0.075)	=	1670 kg/m^3
(2)	Ignition powder TB A1	=	3000 kg/m^3

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FE 203-C-1
FP 803-C-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Apparent density by gravimetric method

a. Type of Test: Physical trial

b. Description: The method is to measure the mass of a certain quantity of the material which, loose in bulk, exactly fills a container of a given volume.

The bulk state is obtained by filling the container with the material flowing freely from the orifice of a funnel located a specified distance above the said container, without compaction.

The ratio of the mass to the volume represents the apparent density of the material (in kg/m^3).

c. Information Requirements for Assessment:

d. Typical Results:

(1)	Lead styphnate:	1300 kg/m^3
(2)	Lead azide:	1600 kg/m^3
(3)	Grain propellant B.19T (0.34)C:	950 kg/m^3

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FA 303-A-1
FC 402-A-1
FP 819-A-1
FP 819-B-1
FP 819-B-2

France/102.02.012

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Overall density

a. Type of Test: Physical trial

b. Description: The overall density is determined by applying Archimedes' principle to 2 to 20 g of the material.

The piece of explosive is suspended below the pan of a set of scales weighing to within 1/10th mg, and is immersed in a suitable liquid (generally water plus a wetting agent).

If the material is porous, it should be very lightly coated with Vaseline oil.

The overall density is expressed in kg/m^3.

c. Information Requirements for Assessment: This trial is applicable to materials in the form of blocks, grain or plates.

d. Typical Results:

(1) Hexabu: 1620 kg/m^3
(2) Compressed Hexal: 1850 kg/m^3

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FE 203-A-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Pyrotechnics

2. TEST TITLE: Granulometry by laser diffraction

a. Type of Test: Physical trial

b. Description: A specimen of material representative of the entire sample is held in suspension in a dispersing agent which does not dissolve the material.

The laser diffractometer measures the angle of the diffraction caused by particles in suspension which pass across a fine laser beam. Small fixed detectors (concentric diodes) measure the diffracted luminous intensities.
Their positions correspond to particle sizes. A calculation programme transforms the particle size into a volume corresponding to the sphere.

Particle counting gives us the differential and cumulative particle-size distribution curves. From this we can deduce the mean diameter at 50% of the cumulative curve.

c. Information Requirements for Assessment: Counting of particles with sizes between 0.1 and 600 microns.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FA-302-C-1
PPH-400

France/102.02.021

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Granulometry by microscopic examination

   a. Type of Test: Physical trial

   b. Description: A representative fraction of the sample to be analysed is placed on and glued to the electron microscope plate.

      The enlargement is adapted to the material under examination in order to determine the shape and size of the crystals or particles

   c. Information Requirements for Assessment: This trial is applicable to all materials.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   Nil

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Granulometry by screening with water

   a. Type of Test: Physical trial

   b. Description: The method uses a screening machine vibrating at 50 Hz with variable amplitude. 50 g of the material which has previously been homogenized is placed on the upper screen with the largest mesh. A cover with a water feed allows a continuous flow of water throughout the screening process (generally 1 hour).

   c. Information Requirements for Assessment: This trial is applicable to materials in powder form which are insoluble in water.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   NF T 70-332
   NF T 70-333

France/102.02.030

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/High Explosives/Pyrotechnics

2. TEST TITLE: B.E.T. specific surface ratio

a. Type of Test: Physical trial

b Description: The method relies on the fixation of a layer of gas to the surface and within each open pore of the sample by Van der Waals bonding. Krypton gas is used for specific surfaces of less than 5 m^2/g and nitrogen for those of more than 5 m^2/g.

The method is to plot the gas adsorption curve at the temperature of liquid nitrogen for different adsorbed gas pressures. Processing of the results by the B.E.T. method allows calculation of the volume of gas adsorbed corresponding to a monolayer.

The specific surface obtained is divided by the apparent surface per unit mass calculated for the material.

The result is a dimensionless figure indicating the ratio of the real surface to the apparent surface of the propellant.

c. Information Requirements for Assessment: This trial is applicable to propellants.

d. Typical Results:

(1) LB.Tu.72 (0.4): 4 m^2/g
(2) B.19T (0.36)C: 15 m^2/g
(3) GB.Se (0.3): 3 m^2/g

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FR 901-B-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Bourges drop-hammer impact

a. Type of Test: Impact

b. Description: The method of Bruceton is used to determine the energy bringing a 0.5 probability of a pyrotechnic event with an explosive placed in a capsule on which a variable mass is dropped from an adjustable height.

The energies applied vary from 5 J to 200 J in discrete steps. A minimum of 50 tests are carried out. The result is considered satisfactory if the mean energy converges towards an asymptotic value.

The tests are carried out on 25 mg of liquid or powder explosive.

c. Information Requirements for Assessment: This trial is applicable to all explosive materials.

d. Typical Results:

(1)	Tetryl:	18 J
(2)	Hexocire [RDX/wax]:	28 J

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FMD 410-B-1

France/201.01.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: 30 kg drop-hammer impact

a. Type of Test: Impact

b. Description: The method is to determine the pyrotechnic behaviour of an explosive material subject to the impact of a mass of 30 kg falling from a height which varies from 0.25 m to 4 m.

The mass is dropped on one end of a test piece of thickness 8 mm placed in a tank of mild steel 0.4 mm thick of dimensions 8 mm x 50 mm x 150 mm. Charging may be by insertion of a machined plate, by direct casting, or by charging at gravimetric density where powder materials are concerned.

The aim is to find the drop height at which 3 negative tests occur (that is tests where the reaction is not a violent pyrotechnic event) provided that at the height which is one step of 0.25 m greater there is at least one positive test (violent decomposition with propagation).

The drop height for non-reaction is determined in the same way.

c. Information Requirements for Assessment: This trial is applicable to all explosive materials except primary explosives.

d. Typical Results:

(1)	Tetryl	: 2.5 m
(2)	Powder B (fine)	: > 4 m
(3)	Composite propellant	: > 4 m

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-501

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Pyrotechnics

2. TEST TITLE: Impact with small BAM drop hammer

a. Type of Test: Impact

b. Description: 15 mm^3 of material placed in a cell in the form of a recess are subjected to the impact of a striker with a flat end hit by a guided mass of 1 kg falling from an adjustable height.

The height corresponding to a 0.5 probability of a positive reaction is determined after a series of 30 tests (Bruceton method).

The possible results of a test fall into one of the following categories:

(1) Negative reaction: no reaction
(2) Positive reaction: audible explosion, visible ignition or other observable decomposition.

c. Information Requirements for Assessment: This trial is applicable to primary explosives and to primary compositions of mainly powdery nature.

d. Typical Results:

(1) Tetrazene: 165 mm

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FA 503-A-2

France/201.01.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Percussion by crushing

a. Type of Test: Impact

b. Description: 19 mm^3 of primary explosive compressed in a cell in the form of a recess are subjected to rapid crushing between:

(1) the bottom of the recess deformed inwards by the impact of a striker with a sharp end hit by a guided mass of 112.5 g falling from an adjustable height.
(2) an anvil of rounded form.

The height corresponding to a 0.5 probability of a positive reaction is determined after a series of 30 tests (Bruceton method).

The possible results of a test fall into one of the following categories:

(1) Negative reaction: no reaction
(2) Positive reaction: audible explosion, visible ignition or other observable decomposition.

c. Information Requirements for Assessment: This trial is applicable to all primary explosives in powder form.

d. Typical Results:

(1) Tetrazene: 125 mm

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FA 507-A-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Percussion by penetration

   a. Type of Test: Impact

   b. Description: 19 mm^3 of primary explosive compressed in a cell in the form of a recess are subjected to percussion by a striker with a sharp end hit by a guided mass of 3.2 g falling from an adjustable height.

      The height corresponding to a 0.5 probability of a positive reaction is determined after a series of 30 tests (Bruceton method).

      The possible results of a test fall into one of the following categories:

      (1) Negative reaction: no reaction
      (2) Positive reaction: audible explosion, visible ignition or other observable decomposition.

   c. Information Requirements for Assessment: This trial is applicable to all primary explosives in powder form.

   d. Typical Results:

      (1) Mixture of lead azide/tetrazene (95/5): 150 mm

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FA 507-B-1

France/201.01.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Explosives/Propellants

2. TEST TITLE: Punching

a. Type of Test: Impact

b. Description: The sensitivity to punching of the explosive material confined in a mock-up container is assessed by determining the mean height at which a 50% level of reaction is observed due to the penetration of a punch attached to a 45 kg mass falling from a variable height (Bruceton method).

The mock-up comprises a body of steel 4 mm thick, and the explosive material takes the form of a cylinder of diameter 40 mm and height 123 mm.

The drop heights lie between 0.89 and 10 m.

c. Information Requirements for Assessment: This trial is applicable to compact solid materials.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

SEN-209

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Pyrotechnics

2. TEST TITLE: Friction with the small BAM apparatus

a. Type of Test: Friction

b. Description: The method is to determine the forces causing 0% and 100% functioning of a pyrotechnic material deposited on a rough porcelain plate attached to a moving assembly which makes a single to-and-fro movement of amplitude 10 mm relative to a rough stylus resting on the explosive material.

The test sample is 5 mg of material on each plate.

After making 6 preliminary tests, the method is to determine:

(1) either the threshold of non-sensitivity as the force at which 10 successive negative tests (with no functioning) are observed,
(2) or the threshold of sensitivity as the force at which 10 successive functioning events are observed.

The possible results of a test fall into one of the following categories:

(1)	non-functioning:	no reaction,
(2)	functioning:	audible explosion, visible ignition or other decomposition observed.

c. Information Requirements for Assessment: Any pyrotechnic material whose sensitivity (or non-sensitivity) threshold lies between 0.1 N and 10 N.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-509

France/201.04.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Capability of initiation by an initiator

   a. Type of Test: Sensitivity to shock wave

   b. Description: See 302.03.001

   c. Information Requirements for Assessment: ditto

   d. Typical Results: ditto

   e. Repeatability and Reproducibility: ditto

3. NATIONAL REFERENCES: ditto

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Capability of initiation by a booster

   a. Type of Test: Sensitivity to shock wave

   b. Description: See 302.03.002

   c. Information Requirements for Assessment: ditto

   d. Typical Results: ditto

   e. Repeatability and Reproducibility: ditto

3. NATIONAL REFERENCES: ditto

France/201.05.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: 12.7 calibre bullet impact

a. Type of Test: Vulnerability to projectile impact

b. Description: The explosive materials are placed in containers which are representative of real objects in terms of volume and geometry, for example:

(1) explosives: in high-strength steel cylinders, of thickness 10 mm and internal dimensions 240 mm height and 123 mm diameter, with one end screwed on and the other welded (mass contained: about 5 kg).
(2) blocks of propellant: in steel cylinders of static bursting pressure 20.5 mm, with internal dimensions 360 mm height and 123 mm diameter. The propellant block has a central channel of diameter 62 mm, and one of the ends of the mock-up container has a membrane seal of rupturing pressure 4 MPa (mass contained: about 5 kg).
(3) grain propellants: in a 90 mm shell case (352 mm high) closed by a seamed cylindrical round of mass about 3 kg (mass contained: about 2 kg).

The mock-up, which is replaced for each firing, is held in a vertical position by its base and attacked horizontally in its environment. The velocities of impact lie between 400 and 1000 m/s. A test is carried out for each velocity.

A table is drawn up to indicate, for each bullet velocity, the type of reaction observed (type I to type V or non-reaction).

c. Information Requirements for Assessment:
This method applies to any confined explosive material which can be used for charging a munition. Comparisons are only possible between materials tested in the same type of mock-up.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

VUL-102

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Impact of (spherical) heavy fragment – weighing 250 g

a. Type of Test: Vulnerability – fragment impact

b. Description: The explosive materials are placed in containers which are representative of real objects in terms of volume and geometry, for example:

(1) explosives: in high-strength steel cylinders, of thickness 10 mm and internal dimensions 240 mm height and 123 mm diameter, with one end screwed on and the other welded (mass contained: about 5 kg).

(2) blocks of propellant: in steel cylinders of static bursting pressure 20.5 mm, with internal dimensions 360 mm height and 123 mm diameter. The propellant block has a central channel of diameter 62 mm, and one of the ends of the mock-up container has a membrane seal of rupturing pressure 4 MPa (mass contained: about 5 kg).

(3) grain propellants: in a 90 mm shell case (352 mm high) closed by a seamed cylindrical round of mass about 3 kg (mass contained: about 2 kg).

The mock-up is held in a vertical position. It is attacked in its centre by the impact of a steel ball (of diameter 39.5 mm and mass 252 g) travelling at a speed which may reach 2400 m/s.

The aim is to find the maximum velocity of the ball which does not cause the detonation of the material.

c. Information Requirements for Assessment: This method applies to any confined explosive material which can be used for charging a munition. Comparisons are only possible between materials tested in the same type of mock-up.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-512

France/201.06.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Impact of light fragment – weighing 16 g

   a. Type of Test: Vulnerability – fragment impact

   b. Description: The explosive materials are placed in containers which are representative of real objects in terms of volume and geometry, for example:

      (1) explosives: in high-strength steel cylinders, of thickness 10 mm and internal dimensions 240 mm height and 123 mm diameter, with one end screwed on and the other welded (mass contained: about 5 kg).
      (2) blocks of propellant: in steel cylinders of static bursting pressure 20.5 mm, with internal dimensions 360 mm height and 123 mm diameter. The propellant block has a central channel of diameter 62 mm, and one of the ends of the mock-up container has a membrane seal of rupturing pressure 4 MPa (mass contained: about 5 kg).
      (3) grain propellants: in a 90 mm shell case (352 mm high) closed by a seamed cylindrical round of mass about 3 kg (mass contained: about 2 kg).

   The mock-up is held in a vertical position. It is attacked in its centre by the impact of a 16 g steel fragment in the form of a cylinder of diameter 12.7 mm with a conical point travelling at velocities lying between 500 and 2000 m/s. A test is carried out for each velocity.

   A table is drawn up to indicate, for each fragment velocity, the type of reaction observed (type I to type V or non-reaction).

   c. Information Requirements for Assessment: This method applies to any confined explosive material which can be used for charging a munition. Comparisons are only possible between materials tested in the same type of mock-up.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   VUL-101

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Shaped-charge jet of diameter 62 mm

a. Type of Test: Vulnerability – shaped-charge jet

b Description: The explosive materials are placed in containers which are representative of real objects in terms of volume and geometry, for example:

(1) explosives: in high-strength steel cylinders, of thickness 10 mm and internal dimensions 240 mm height and 123 mm diameter, with one end screwed on and the other welded (mass contained: about 5 kg).

(2) blocks of propellant: in steel cylinders of static bursting pressure 20.5 mm, with internal dimensions 360 mm height and 123 mm diameter. The propellant block has a central channel of diameter 62 mm, and one of the ends of the mock-up container has a membrane seal of rupturing pressure 4 MPa (mass contained: about 5 kg).

(3) grain propellants: in a 90 mm shell case (352 mm high) closed by a seamed cylindrical round of mass about 3 kg (mass contained: about 2 kg).

A 62 mm shaped charge is fired at the mock-up through a metal screen of variable predetermined thickness. The aim is to find the minimum screen thickness corresponding to the thresholds of non-violent reaction and of non-detonation of the material.

c. Information Requirements for Assessment: This method applies to any confined explosive material which can be used for charging a munition. Comparisons are only possible between materials tested in the same type of mock-up.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-511

France/201.08.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Friability

   b. Type of Test: Fragmentation

   c. Description: A bare 9 g cylinder of explosive material is projected against a flat steel surface, with its axis of revolution impinging at normal incidence. The friability of the explosive material is characterized, as a function of the velocity of impact, by the maximum value taken by the function dP/dt of the signal P(t) measured when burning the fragments collected after the impact in a pressure vessel at constant volume.

   The friability is characterized by the value of $(dP/dt)_{max}$ obtained at 150 m/s or by the limiting impact speed corresponding to a given value of $(dP/dt)_{max}$ (for example 15 MPa/ms for explosives and 18 MPa/ms for propellants).

   d. Information Requirements for Assessment: This trial is applicable to all compact solid explosive materials.

   e. Typical Results:

   f. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   SEN-216

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Sensitivity to Hot Wire

a. Type of Test: Sensitivity

b. Description: The method is to determine the electric current in a resistance wire which causes the initiation of a primary explosive in powder form.

The test device consists of a capsule of plastic material filled with 115 mm^3 of uncompacted explosive through which passes a 60 micron nickel-chrome 80/20 resistance wire.

The current is provided by a generator of progressively increasing current with a gradient of 12 mA/s capable of delivering up to 1 amp.

The initiating current intensity (in mA) is obtained by taking the mean of 10 tests which cause initiation of the primary explosive.

c. Information Requirements for Assessment: This trial is applicable to all primary explosives in powder form.

d. Typical Results:

(1)	Lead azide	: 400 mA
(2)	Tetrazene	: 360 mA
(3)	Lead styphnate	: 350 mA

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FA 501-A-1

France/202.01.009

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE:Behaviour under long period at 60°C or a lower temperature

   a Type of Test: Thermal trial

   b. Description: Samples of 1 to 60 g of the material placed in hermetically-sealed flasks are left to age in an enclosure or building where the temperature is maintained at 60°C or at a lower temperature.

   After predetermined periods of heating (for example 42 days, 3 months, 6 months, 1 year, 2 years etc) a sample of the material under test is removed from the enclosure or building.

   After its return to ambient temperature, the material is examined visually and then analysed to establish its physico-chemical, mechanical, ballistic, sensitivity and reactivity characteristics etc.

   The characteristics after ageing are compared with those of the unaged material.

   c. Information Requirements for Assessment: This trial is applicable to all explosive materials.

   d. Typical Results:

   For a single-base grain propellant, the loss of stabilizer (diphenylamine) after ageing at 50°C for 42 days is generally less than 0.2%.

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FP 406-C-1
   FP 406-C-2

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Critical temperature of thermo-initiation

   a. Type of Test: Thermal trial

   b. Description: The method is to determine the behaviour of an explosive material placed in an aluminium boat and subjected to a specified thermal environment in a heated enclosure.

      The sample is 50 mm high and the boat 150 mm high.

      The aim is to find the maximum temperature which does not lead to a pyrotechnic event or, if there is always a pyrotechnic event, the temperatures leading to this event after 20 hours and 100 hours of exposure.

   c. Information Requirements for Assessment: This trial is applicable to shaped solid materials.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   SEN-307

France/202.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2 TEST TITLE: Behaviour in a kerosene fire

a. Type of Test: Vulnerability – thermal trial

b. Description: The explosive materials are placed in containers which are representative of real objects in terms of volume and geometry, for example:

(1) explosives: in high-strength steel cylinders, of thickness 10 mm and internal dimensions 240 mm height and 123 mm diameter, with one end screwed on and the other welded (mass contained: about 5 kg).

(2) blocks of propellant: in steel cylinders of static bursting pressure 20.5 mm, with internal dimensions 360 mm height and 123 mm diameter. The propellant block has a central channel of diameter 62 mm, and one of the ends of the mock-up container has a membrane seal of rupturing pressure 4 MPa (mass contained: about 5 kg).

(3) grain propellants: in a 90 mm shell case (352 mm high) closed by a seamed cylindrical round of mass about 3 kg (mass contained: about 2 kg).

The container is placed horizontally 25 cm above a 2 m x 2 m kerosene fire ignited by vehicle-fuel petrol. Thermocouples placed 10 cm under the mock-up give an indication of the validity of the test. Two tests are carried out.

The results noted are the time before the appearance of a pyrotechnic reaction and the type of reaction observed (type I to type V or non-reaction).

c. Information Requirements for Assessment: This method applies to any confined explosive material which can be used for charging a munition. Comparisons are only possible between materials tested in the same type of mock-up.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-513

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Behaviour in a fire under confinement

   a. Type of Test: Thermal trial

   b. Description: The test is to determine the pyrotechnic behaviour of an explosive material, contained in a steel tube closed by two screw caps, under the effect of a fuel-oil fire. The tube has the following dimensions: diameter 40 mm, length 200 mm, and thickness 4 mm. The material may be granular, machined or cast in situ. The results noted are the duration of the fire before a reaction and the nature (type) of that reaction.

      The test is repeated 3 times; the least advantageous result is the one taken into consideration.

   c. Information Requirements for Assessment: This trial is applicable to all explosives and to all propellants in block or grain form.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   SEN-104

France/202.02.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Very slow heating, at 3.3°C/h

a. Type of Test: Vulnerability – thermal trial

b. Description: The explosive materials are placed in containers which are representative of real objects in terms of volume and geometry, for example:

(1) explosives: in high-strength steel cylinders, of thickness 10 mm and internal dimensions 240 mm height and 123 mm diameter, with one end screwed on and the other welded (mass contained: about 5 kg).
(2) blocks of propellant: in steel cylinders of static bursting pressure 20.5 mm, with internal dimensions 360 mm height and 123 mm diameter. The propellant block has a central channel of diameter 62 mm, and one of the ends of the mock-up container has a membrane seal of rupturing pressure 4 MPa (mass contained: about 5 kg).
(3) grain propellants: in a 90 mm shell case (352 mm high) closed by a seamed cylindrical round of mass about 3 kg (mass contained: about 2 kg).

The mock-up is placed in an oven. An automatic regulation system increases the temperature of the oven by 3.3°C per hour. 2 tests are carried out. The results noted are the temperature at which a pyrotechnic event occurs and the type of reaction observed (type I to type V or non-reaction).

c. Information Requirements for Assessment: This trial is applicable to all explosives and to all propellants in block or grain form.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-515

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Critical diameter

   a. Type of Test: Deflagration-detonation transition

   b. Description: See 302.03.005

   c. Information Requirements for Assessment: ditto

   d. Typical Results: ditto

   e. Repeatability and Reproducibility: ditto

3. NATIONAL REFERENCES: ditto

France/205.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Critical detonation height

   a. Type of Test: Deflagration-detonation transition

   b. Description: The trial is intended to determine the powder height threshold leading to an explosion with or without detonation of a tube in a vertical position, open towards the top, after a local ignition within the base of the tube. A 3 mm thick tube of diameter 82 mm and height 1000 mm is used.

      Firing is by inductive heating.

   c. Information Requirements for Assessment: This trial is applicable to all granular propellants.

   d. Typical Results: Height of detonation

      (1) Single-base powder (coarse): 1000 mm
      (2) Double-base powder (fine): 200 mm

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FMD-862-A-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Detonation Velocity

a. Type of Test: Velocity of the detonation reaction

b. Description: A test piece in the form of a cylinder of diameter 30 mm or a parallelepiped of cross-section (30 x 30) mm^2 is initiated at one end. The time taken for the detonation front to travel between two points at least 100 mm apart is measured.
The passage of the detonation front is registered by the short-circuiting of trigger probes connected to a timing device with a resolution of 20 ns. The test is performed with 2 such bases for measurement; the value measured is only taken into consideration if the difference between the 2 velocities is less than 100 m/s. The result of the trial is the mean of 4 valid individual tests.

c. Information Requirements for Assessment: This trial is applicable to all explosives whose velocity of detonation is greater than 5000 m/s.

d. Typical Results:

(1) Tolite [TNT]: 6620 m/s
(2) Tetryl: 7340 m/s

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-700

France/302.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/Pyrotechnics

2. TEST TITLE: Deflagration in free air in a channel

a. Type of Test: Velocity of combustion

b. Description: The trial involves determination of the rate of flame propagation in a fine train of pyrotechnic material laid out in free air in a semi-cylindrical channel with thick walls and ignited at one end.

The dimensions of the channel are:

(1) Length = 2 m, diameter = 20 mm for propellants in grain form,
(2) Length = 1 m, diameter = 5 mm for pyrotechnic compositions.

The material is poured into the horizontal channel with its normal gravimetric density, and is then levelled off.

The flame heating device is placed under the channel, vertically beneath one end.

The rate of combustion is determined by measuring the time taken to travel between marks placed a known distance apart, using a manual stop watch or a recording chronograph.

The result taken as the velocity of propagation is the mean of at least two tests. Other phenomena are also noted (time before reaction commences, failure to ignite, interruption, explosion).

c. Information Requirements for Assessment: This trial is applicable to grain propellants and pyrotechnic compositions in powder form.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

NF T 70-507

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Firing in a closed pressure vessel

a. Type of Test: Velocity of combustion

b. Description: The curve of variation of pressure as a function of time is recorded for x g of powder placed in a closed vessel whose internal pressure can be measured.

The usual density of charging is 200 kg/m^3. The volume of the container is 700 or 200 cm^3. 1 to 2 g of black powder initiated by an electric heating wire are used for ignition purposes.

The various ballistic parameters, such as maximum pressure, force, powder quickness etc, are calculated by comparison with a reference powder or as absolute figures.

c. Information Requirements for Assessment: This trial is applicable to grain or stick powders.

d. Typical Results:

(1) Artillery powders: quickness 1 to 2 $m^3/s.kg$

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FB 665-A-1
FB 666-A-1

France/302.02.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Rate of combustion of propellant sticks

   a. Type of Test: Velocity of combustion

   b. Description: After inhibition by a lacquer, a stick of propellant (of variable cross-section depending on the material) fitted with fuses at regular intervals is placed in a hermetic container at the selected temperature and pressure.

      After ignition, the intervals of time between the cutting off of the fuses are measured.

   c. Information Requirements for Assessment: This trial is applicable to propellants in block form.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FAP 100-A-1
   FAP 102-A-1
   FAP 102-B-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Firing in standard motor

a. Type of Test: Velocity of combustion

b. Description: Fuel blocks made of the propellant to be tested are fired in standard motors in which the operating pressure and the temperature can be selected.

Such firing allows the main characteristics of the propellant to be deduced, in particular its rate of combustion. The fuel blocks used are:

(1) for the “Épictète” and “Nitrargols” propellants (cast double-base): Panisse block or Bates block,

(2) for the SD propellants (extruded double-base): 32 x 16 block

(3) for composite cast propellants: Mimosa block or Bates block.

c. Information Requirements for Assessment: This trial is applicable to the various propellants in block form.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

FAP 104-A-1

France/302.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Capability of initiation by an initiator

   a. Type of Test: Assessment of performance

   b. Description: The Bruceton method is used to determine the thickness of a barrier which gives a 0.5 probability of initiation of a booster explosive by a defined initiator-detonator. The transmission of the detonation to the explosive under test is observed with the help of a witness plate placed under the latter

   The arrangement ensures confinement of the explosive. The thickness of the barrier varies in discrete steps from 1 to 10 mm. A minimum of 50 tests are carried out. The result is considered satisfactory if the mean thickness converges towards an asymptotic value.

   The trial is carried out on cylindrical test pieces of diameter 10 mm and height 18 mm, obtained by casting, compression or machining.

   c. Information Requirements for Assessment: This trial is applicable to all solid explosives which can be put in the form defined above.

   d. Typical Results:

   (1) Tetryl: 4.25 mm
   (2) Hexocire [RDX/wax]: 2.70 mm
   (3) Octocire [HMX/wax]: 2.80 mm

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FMD-210-A-1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Capability of initiation by a booster

   a. Type of Test: Assessment of performance

   b. Description: The Bruceton method is used to determine the thickness of a barrier which gives a 0.5 probability of initiation of an explosive charge by a defined PETN booster. The transmission of the detonation to the explosive under test is observed with the help of a witness plate placed under the latter

   The arrangement ensures confinement of the explosives. A minimum of 50 tests are carried out. The result is considered satisfactory if the mean thickness converges towards an asymptotic value.

   The trial is carried out on cylindrical test pieces of diameter 10 mm and height 18 mm, obtained by casting, compression or machining.

   c. Information Requirements for Assessment: This trial is applicable to all solid explosives which can be put in the form defined above.

   d. Typical Results:

      (1) Tolite [TNT]: 10.50 mm

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FMD 210-A-2

France/302.03.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Initiating power of a booster

   a. Type of Test: Assessment of performance

   b. Description: The Bruceton method is used to determine the thickness of a barrier which gives a 0.5 probability of initiation by a booster explosive, the acceptor explosive being a PETN pellet. The transmission of the detonation to the explosive under test is observed with the help of a witness plate placed under the latter

   The arrangement ensures confinement of the explosives. The thickness of the barrier varies in discrete steps. A minimum of 50 tests are carried out. The result is considered satisfactory if the mean thickness converges towards an asymptotic value.

   The trial is carried out on cylindrical test pieces of diameter 9 mm and height 10 mm, obtained by casting, compression or machining.

   c. Information Requirements for Assessment: This trial is applicable to all solid explosives which can be put in the form defined above.

   d. Typical Results:

   (1) Tetryl : 21.70 mm
   (2) Hexocire [RDX/wax] : 25.10 mm

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FMD-211-A-2

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Initiating power (primary explosives)

   a. Type of Test: Experimental method

   b. Description: The initiating power of a primary explosive relative to a secondary explosive used as a reference is characterized by the maximum thickness in mm of a barrier which permits the initiation of the secondary explosive.

      The inert barrier which attenuates the shock wave emitted by the primary explosive is made of aluminium disks. The secondary explosive is considered to be initiated when it pierces an aluminium witness perforation disk 3 mm thick.

      The test quantities are 150 mg of primary explosive and 300 mg of secondary explosive.

      The two explosives and the barriers between them undergo compression at 1000 bars.

      The primary explosive is initiated by a laser providing an energy of 2 joules.

   c. Information Requirements for Assessment: This trial is applicable to primary explosives in powder form.

   d. Typical Results:

      (1) Lead azide: 4 mm (associated with hexogen [RDX])

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   FA -603-A-1

France/302.03.005

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Critical diameter

   a. Type of Test: Critical dimensions

   b. Description: A test piece comprising coaxial cylinders of decreasing diameter is initiated to detonate at its larger end. The point where the detonation stops, observed with the help of a lead plate and possibly a resistance-wire probe, indicates the greatest diameter of the part of the test piece which does not detonate. The length of each cylinder is equal to 4 diameters. The critical diameter is determined to within ± 0.5 mm.

   c. Information Requirements for Assessment: This trial is applicable to all solid explosives whose critical diameter lies between 2 and 20 mm.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   NF T 70-701

10.7.5 QUALIFICATION PROCEDURES FOR GERMANY

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10.7.5.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.7.5.1.1 The Federal Office of Military Technology and Procurement (Bundesamt fur Wehrtechnik and Beschaffung - BWB) has full responsibility for qualification of explosives. Within the scope of qualification of a new explosive, the technical sections of BWB are responsible for the following tasks:

a. Initiation of the qualification procedure;

b. Identification of the explosive characteristics (together with the Defence Institute for Materials, Explosives, Fuels and Lubricants (Wehrwissenschaftliches Institut für Werk-, Explosiv- und Betriebsstoffe - WIWEB);

c. Decision on the application of the qualified explosive which is characterized by the substance specification;

d. Decision on the release of explosives data to other NATO partner nations in accordance with STANAG 4170.

10.7.5.1.2 Within the scope of qualification of a new explosive the WIWEB is responsible for the following tasks:

a. Identification of the explosive characteristics (together with the technical sections of BWB);

b. Selections of the required tests in agreement with the technical sections of BWB;

c. Conduct tests and preparation of the qualification report;

d. Assessment of the explosive in accordance with STANAG 4170 and determination of the qualification status;

e. Documentation and updating of qualification records and test data;

f. Release of explosives data to NATO nations in accordance with STANAG 4170 (with the agreement of the project manager in BWB);

g. Preparation of the substance specification for the qualified explosive.

10.7.5..2 NATIONAL AUTHORITY(IES)

10.7.5.2.1 The Defence Institute for Materials, Explosives, Fuels and Lubricants (Wehrwissenschaftliches Institut für Werk-, Explosiv und Betriebsstoffe – WIWEB) is the appointed National Authority for Germany and is responsible for the following functions in accordance with STANAG 4170:

a. Establish and maintain a data bank of qualified explosives used by the military services of the FRG;

b. Coordinate the implementation of STANAG 4170 within the FRG;

c. Serve as Point of Contact within Germany for inputs to AOP-7;

d. Serve as Point of Contact to other NATO nations for the exchange of information.

10.7.5.3 QUALIFICATION PROCEDURES

10.7.5.3.1 In Germany the term "explosives" comprises igniting and initiating substances and mixtures of these, propellants, high explosives and pyrotechnic compositions. The development of new explosives intended for military use is mainly carried out by private firms. It is also the task of certain institutes sponsored by the GE MOD to carry out research in the field of explosives.

10.7.5.3.2 A "new explosive" is defined as one which has not yet been used or qualified, whose composition, nature, manufacturing procedure, manufacturer or manufacturing location has subsequently been changed, or which is intended for a role for which it has not yet been qualified.

10.7.5.3.3 In general, studies and developments are carried out under study or development contracts awarded by the GE MOD or BWB. However, they may also result from a firm's initiative. Beside an application related development, a general development, i.e., without relation to a particular equipment or weapon system, is also practiced.

10.7.5.3.4 The decision as to the suitability of an explosive in principle, which was developed within the scope of one of the above mentioned contracts, is made by BWB after the completion of the study or development contract. This decision is based on various factors, including the fulfillment or nonfulfillment of basic safety requirements and of requirements set up in a specification on which the contract was based.

10.7.5.3.5 After an investigation by WIWEB, the technical sections of BWB also decide on the use in principle of such new explosives which are proposed by firms for a particular role.

10.7.5.3.6 A new explosive whose use is desired, is subjected to a qualification procedure in accordance with STANAG 4170 to ensure that it possesses properties which permit its military use. The appropriate technical sections of BWB are responsible for the initiation of the qualification procedure. WIWEB is responsible for the conduct of the qualification and the subsequent assessment of the new explosive regarding its safety and its basic suitability for military purposes.

10.7.5.3.7 The qualification procedure does not include the equipment/system integrated assessment of the explosive. The qualification procedure is initiated by a written application of the technical sections of BWB to WIWEB.

10.7.5.3.8 Before the start of the investigation, these sections and WIWEB must identify the characteristics which are essential for the type, composition and nature of the explosive and for its intended general use. This identification must not only take into consideration the normal state in which the explosive is used, but also the state after stress caused by expected storage and operational conditions, and must also include the effects of environmental influences, in particular temperature, on the safety and performance characteristics.

10.7.5.3.9 Based on these characteristics, WIWEB (in agreement with the section which applied for the qualification) prepares the list of tests necessary to determine the characteristic data of the explosive. The selection of the tests is influenced by the type, composition and nature of the explosive, the intended role and application and the similarity with explosives already qualified or used for similar purposes.

10.7.5.3.10 The investigation program must take into consideration the legal provisions for explosives and transportation, and must permit an assessment of handling safety, stability, compatibility and service life. In addition, it must provide for the determination of chemical, physical, physicochemical and mechanical properties and performance data.

10.7.5.3.11 The national tests listed in AOP-7 and the tests identified in STANAG 4170 are used for this purpose. Other tests not included in AOP-7, but which are suitable to obtain the required information, may also be used.

10.7.5.3.12 After completion of the investigations, WIWEB prepares an investigation report which not only contains a substance characterization including the manufacturing process, and the legal aspects with regard to explosives and transportation, but also the test procedures applied and their results. The report also contains the assessment of the new explosive in accordance with STANAG 4170 and the resulting qualification status: (a) qualified, (b) not qualified., (c) qualified with certain restrictions. The assessment includes:

a. The evaluation of the new explosive on the basis of the legal provisions for explosives and transportation; and

b. the evaluation of handling safety, stability, compatibility, service life and performance based on the results of the individual tests and on the comparison with results of explosives already qualified or used for similar purposes.

10.7.5.3.13 If IWEB determines that a new explosive is suitable in general for military use, it will prepare a document which characterizes this qualified explosive (specification). This specification stipulates the explosive characteristics such as composition, nature, manufacturing process and use, as far as these ensure reproducible manufacture and delivery. The technical requirements for the explosive, the testing instructions required for their examination, and further, provisions on quality assurance and packaging, are also reflected in this document.

10.7.5.3.14 After the substance specification has been written, the new explosive is approved for immediate or later use. BWB is responsible for the decision to use it in ammunition.

10.7.5.3.15 In case of equipment or system developments requiring the development of explosives, these explosives must be qualified before the equipment design is finalized.

10.7.5.3.16 The qualification of new explosives must be carried out independent of the equipment tests and provings.

10.7.5.3.17 The introduction of the explosive for a particular role before conclusion of the qualification procedure, before declaration of its basic suitability, and before completion of the substance specification is prohibited in general.

10.7.5.4 QUALIFICATION METHODS AND TESTS

10.7.5.4.1 The qualification of high explosives, propellants and pyrotechnic compositions is based on mandatory data obtained in tests listed herein.

a. Special interest is focused on the safety characteristics of booster explosives used in fuzes beyond the shutter to transmit and augment a detonation reaction initiated by a primary explosive. The tests and requirements for booster explosives are to be found in Chapter 7 Section 7.3 of this document.

b. Mandatory Data for Explosive Materials:

Tests	Registry or STANAG No.
(1) BAM Drop-Hammer	STANAG 4489
(2) BAM Friction	STANAG 4487
(3) Electrostatic Sensitivity	201.03.001
(4) BICT Gap	STANAG 4488
(5) Initiation Test in Steel Pipes	201.04.004
(6) Bullet Impact	201.05.001
(7) Deflagration-to-DetonationTransition	201.08.001
(8) Steel Tube (Koenen-Test)	STANAG 4491
(9) 105 ^{o}C (110 ^{o}C) Weight Loss (Holland Test)	202.01.001
(10) Loss of Weight Test at 75^{o}C/90^{o}C	202.01.002
(11) Bergmann-Junk-Siebert	202.01.003
(12) BAM Ignitability (Standard Heat Sources)	202.01.004
(13) Quantitative Heat Test at 100^{o}C	202.01.005
(14) Methyl Violet	202.01.006
(15) Vacuum Stability	STANAG 4479 STANAG 4147
(16) Quantitative Heat Test at 90^{o}C	202.01.008
(17) Temperature of Ignition (Wood's Metal Bath)	STANAG 4491
(18) Simultaneous DTA/TGA	STANAG 4515
(19) Heat Flow Calorimetry	STANAG 4582
(20) Strand Burning	302.02.001
(21) Closed Vessel	302.02.002
(22) Eprouvette	302.03.001

10.7.5.4.4 List of Germany's Test Information Sheets

Category 100	Chemical, Physical & Mechanical Properties
102.01.XXX	Physical Tests
102.01.001	Uniaxial Tensile
102.01 002	Creep
102.01.003	Stress Relaxation
102.01 010	Uniaxial Compression
102.01.011	Shearing
102.01.022	Charpy
102.01.023	Hardness
102.01.042	Peel
102.01.060	Thermal Mechanical Analysis
102.01.070	Density (Pycnometry)
Category 200	Hazard Assessment Sensitiveness/Sensitivity/ Explosiveness
201.01.001	BAM Impact
201.02.001	BAM Friction
201.03.001	Electrostatic Sensitivity
201.04.001	BICT Gap
201.04.004	Initiation Test in Steel Pipes
201.05.001	Bullet Impact
201.08.XXX	Other Tests
201.08.001	Deflagration-to-Detonation Transition
201.08.002	Steel Tube Test (Koenen
202.01.XXX	Thermal Stability
202.01.001	105^{o}C (40^{o}C) Weight Loss (Holland Test)
202.01.002	75^{o}C and 90^{o}C Weight Loss
201.01.003	Bergmann-Junk-Siebert
201.01.004	BAM Ignitability (Standard Heat Sources)
201.01.005	100^{o}C Qualitative Heat
201.01.006	Methyl-Violet
201.01.007	Vacuum Stability/Reactivity
201.01.008	90^{o}C Quantitative Heat
201.01.009	Temperature of Ignition (Wood's Metal Bath)
202.01.010	Simultaneous DTA/TGA
202.01.011	Heat Flow Calorimeter
Category 300	Performance Assessment
302.02.001	Linear Burning Rate
302.02.002	Closed Vessel Test

<u>302.03.XXX</u>	<u>Other Tests</u>
302.03.001	Eprouvette Test

10.7.5.5 CATALOGUE OF TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with their Registry Number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Uniaxial Tensile Test

a. Type of Test: Mechanical Property

b. Description: Specimen: JANNAF type(B or C), gauge length 50 mm, width 10 mm, 6 mm (DB) or 12 mm (Composite) thickness, transition radius 12,5 mm. Crosshead speed: 5 mm/min to 8 m/s. Test temperature: varies from 203 to 343ºK. Control measurements: 50 mm/min and 293ºK. After conditioning to test temperature (1 h), the specimen is pulled to failure with constant crosshead speed. Force and elongation of the gauge section (directly measured) are recorded. Main physical parameters affecting the results: strain rate, temperature and relative humidity. Stress (force/initial cross sectional area)and strain (elongation/initial gauge length) are calculated and plotted. Main results of the stress-strain curve: initial tangent Modul E_o, maximum stress σ_B, stress at rupture σ_r and the corresponding strains ϵ_B and ϵ_r.

c. Information Requirements for Assessment:

(1) Applications: Characterization, quality control.

(2) Significance: Material response(including failure)at different rates of deformation and temperatures.

(3) Limitations: Specimen preparation and preconditioning may influence the results. Elongation must be measured directly on the specimen.

d. Typical Results: (50 mm/min, 293 ^{o}K)

(1) DB rocket prop.: σ_B = 5 MPa, ϵ_B = 30%, E_o = 200 MPa.

e. Repeatability and Reproducibility:

(1) Good

3. NATIONAL REFERENCES:

(1) TL 1376-0701, Teil II, Blatt 4
(2) DIN 53455 (Testing of plastics; tensile test).

Germany/102.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Creep Test

   a. Type of Test: Mechanical Property

   b. Description: A JANNAF type specimen (see tensile test) is deformed by an uniaxial constant tensile stress (load). The elongation of the specimen with time is measured.

      Main physical parameters affecting the results are: temperature, stress, and relative humidity.

      The creep compliance J(t) (strain(t)/stress) and the strain at failure are calculated. From the results at different temperatures a shift factor a_T can be determined.

   c. Information Requirements for Assessment:

      (1) Applications: Material characterization
      (2) Significance: Stress analysis, calculation of visocelastic properties.
      (3) Limitations: To be supplied
      (4) Properties: Specimen dimensions.

   d. Typical Results:

      (1) Results depend strongly on test conditions and on type of material.

   e. Repeatability and Reproducibility:

      (1) Good with the same specimen type.

3. NATIONAL REFERENCES:

   (1) DIN 53444 (Testing of plastics; tensile creep test).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Stress Relaxation Test

   a. Type of Test: Mechanical Property

   b. Description: A specimen, e.g. JANNAF type, is deformed to a preset stress or strain. The strain is kept constant during the relaxation test. Stress (load) is recorded vs time.

   Main physical parameters affecting results: temperature, initial stress, initial strain and initial strain rate. The relaxation modulus E_r (t) (stress (t)/strain) is calculated and plotted. From stress relaxation measurements at different temperatures the shift factor a_T is determined.

   c. Information Requirements for Assessment:

      (1) Applications: Characterization of viscoelastic properties.
      (2) Significance: Used for stress analysis or constitutive equation.
      (3) Limitations: To be supplied
      (4) Properties: Specimen dimensions.

   d. Typical Results:

      (1) Modulus vs time and temperature.

   e. Repeatability and Reproducibility:

      (1) Good, if test facilities are the same.

3. NATIONAL REFERENCES:

   (1) DIN 53441 (Testing of plastics; stress relaxation test.)

Germany/102.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Uniaxial Compression Test

a. Type of Test: Mechanical

b. Description: Specimen: Right circular cylinder with L/D <=2 (e.g. d = 20 mm, l = 40 mm) or propellant grain (solid or perforated). Crosshead speed: 5 mm/min to 8 m/s; Test temperature: 203 K to 343 K; Control measurements: 5 mm/min, 293 ^{o}K. After conditioning to the test temperature (1 h), the specimen is compressed to failure with constant rate. Force and change of specimen length (displacement of the compression bars) are measured and registered (not calculated from crosshead speed). Main physical parameters affecting results: strain rate, temperature, relative humidity, specimen geometry. Stress (force/initial cross sectional area) and strain (displacement/initial length) are calculated and plotted. Main results: initial tangent Modulus E_o, stress and strain at failure (onset of cracking).

c. Information Requirements for Assessment:

(1) Applications: Material characterization

(2) Significance: Material response (including failure)

(3) Limitations: Friction of specimen ends; no mathematical procedure until now to transfer resultsfrom single grains to a powder bed; buckling and web size.

(4) Properties: Specimen dimensions.

d. Typical Results:

(1) (293 ^{o}K, $\epsilon = 2x10^{-2}$ s^{-1})
(2) RDX: δ_{dB} = 50 Mpa, ϵ_{dB} = 2%, E_o = 1850 Mpa
(3) Composite rocket propellant: δ_{dB} = 3 MPa, ϵ_{dB} = 30%,
(4) E_o = 200 MPa.

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) TL 1376-0701, Teil II, Blatt 5
(2) DIN 53454 (Testing of plastics; compression test).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Shearing Test

a. Type of Test: Mechanical Property

b. Description: Specimen: Cylindrical shape, L/D >= 2 (e.g. d = 20 mm, L = 40 mm). The test is done with a normal tensile tester. The fixture consists of two parts, a U-shape outer compartment and a bar that fits in the center of the U. A central boring in the fixture takes the specimen like a bolt. When the two parts of the fixture are pulled in opposite directions, the specimen is sheared. Force and displacement are registered. Main physical parameters affecting the results: crosshead speed, temperature and relative humidity. Maximum shear stress (Force/two times the cross sectional area) and displacement at maximum stress are the results of the test.

c. Information Requirements for Assessment:

(1) Applications: Quality control, material characterization
(2) Significance: Material response under shear load
(3) Limitations: To be supplied
(4) Properties: Specimen geometry

d. Typical Results:

(293 K, 5 mm/min)

(1) tetryl: = 2,5 N/mm^2, L = 0,12 mm
(2) HX 11 : = 0,25 N/mm^2, L = 2,57 mm

e. Repeatability and Reproducibility:

(1) Good

3. NATIONAL REFERENCES:

(1) DIN 50141 (shearing test).

Germany/102.01.022

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Charpy Test

a. Type of Test: Physical Property

b. Description: Specimen: bar-shaped, 6 mm x 6 mm x 70 mm (notched or unnotched). The specimen is fractured in a Charpy tester (4 J, 2.9 m/s) at different temperatures. Specimen taken out of the temperature bath must be fractured within three seconds. The energy required to break the specimen is determined from the loss in kinetic energy of the hammer. Main physical parameters affecting the results: Temperature and specimen geometry. Impact strength a_n is calculated and plotted versus temperature. Straight lines through the data points in the low impact strength region and the high impact strength region cross over in the transition region. Their crossing over marks the transition temperature T_v (brittle to viscous transition).

c. Information Requirements for Assessment:

(1) Applications: Quality control, material characterization.
(2) Significance: Toughness is important for safety.
(3) Limitations: Specimen preparation influences results.

d. Typical Results:

(1) Comp. Rocket Propellant:
(2) T_v = 215 K ($T_v > T_g$)
(3) a_n (215 K) = 5 mJ/mm^2

e. Repeatability and Reproducibility:

(1) Good

3. NATIONAL REFERENCES:

(1) TL 1376-0701, Teil II, Blatt 8
(2) DIN 53453 (Testing of plastics; determination of impact resistance).

Germany/102.01.023

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Hardness Test

a. Type of Test: Mechanical Property

b. Description: No special specimen. Specimen thickness must be a minimum of two times the penetration depth. Surface must be smooth. Test is done in a indentation hardness tester. The indenter is a spherical tip ped cone. The depth of indentation is measured under load, 10s and 60s after loading. Normal load is 50 N. Main physical parameters affecting the results are: temperature and relative humidity. Hardness (H_{10s} and H_{60s}) is calculated as load/area of indentation (depth as a measure of the area is tabulated). From the hardness a "Plasticity Coefficient" k is calculated as $k = (H_{10s} - H_{60s})/H_{10s} \times 100\%$.

c. Information Requirements for Assessment:

(1) Applications: Quick control test
(2) Significance: Comparing materials or same material after different preconditioning or aging.
(3) Limitations: Information is limited to the surface near region.

d. Typical Results:

(1) H_{10s} : HE: 20 to 40 N/mm^2
(2) DB Propellants: 4 to 8 N/mm^2
(3) Composite Propellants: 0,1 to 6 N/mm^2

e. Repeatability and Reproducibility:

(1) High

3. NATIONAL REFERENCES:

(1) TL l376-0701, Teil II, Blatt 9
(2) DIN 53456 (Testing of plastics; indentation hardness test).

Germany/102.01.042

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Peel Test

a. Type of Test: Mechanical property; adhesion

b. Description: Specimen: a) Rectangular bar, consists of two materials. The two materials are partly separated and each part is mounted in one fixture of a tensile tester. b) Disk-shaped specimen, the outer layer (second material) is partly separated and mounted in a fixture of a normal tensile tester. The disk is fixed in the center by a bolt. The sample is pulled and the force required to separate the two materials is measured. Main physical parameters affecting the results are: Temperature, strain rate and peeling angle. The result of the peel test is quoted as the mean force divided by the specimen width.

c. Information Requirements for Assessment:

(1) Applications: Quality control
(2) Significance: Good adhesion is an important property.
(3) Limitations: To be supplied
(4) Properties: To be supplied

d. Typical Results:

(1) T = 2 N/mm

e. Repeatability and Reproducibility:

(1) Good

III. NATIONAL REFERENCES:

(1) DIN 53530 (Testing of organic materials; test for separating layers of laminated woven fabrics).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: TMA (Thermal Mechanical Analysis)

a. Type of Test: Thermomechanical

b. Description: Specimen: cylindrical or rectangular bar, exact dimension depends on material (e.g. GP grain) or device. The length of the specimen is measured over a range of temperatures. Temperature change can be continuous or at fixed intervals. The resolution of the measurement system should be 1 m or better. Main physical parameters affecting the results: The temperature and, with anisotropic material, the measured axis of the specimen. The coefficient of linear thermal expansion is calculated by dividing the slope of the length-temperature plot by the length at 293ºK. A great change in a small temperature interval indicates a transition temperature.

c. Information Requirements for Assessment:

(1) Applications: Material characterization
(2) Significance: Required to calculate thermal stress.
(3) Limitations: To be supplied
(4) Properties: Specimen geometry.

d. Typical Results:

(1) T_g = 200 K, α = 2×10^{-4} K^{-1} for a composite Rocket Propellant (RP)

e. Repeatability and Reproducibility:

(1) Good

3. NATIONAL REFERENCES:

(1) DIN 53752 (Testing of plastics; determination of the coefficient of linear thermal expansion).

Germany/102.01.070

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE:

2. TEST TITLE: Density

a. Type of Test: Physical Property

b. Description: The density is calculated as quotient of mass and volume. The mass is measured with a balance (resolution 0,0001 g) and the volume is measured with a gas pycnometer (air or helium). The specimen must be small enough to fit into the test cell.

The main physical property that affects the result is the temperature.

The density is measured as g/cm^3.

c. Information Requirements for Assessment:

(1) Applications: Material characterization, quality control
(2) Significance: Basic property of an explosive.
(3) Limitations: To be supplied.
(4) Properties: To be supplied.

d. Typical Results:

(1) PBX: 1,6 g/cm^3.

e. Repeatability and Reproducibility:

(1) Good ($\pm$ 0,004 g/cm^3).

3. NATIONAL REFERENCES:

(1) DIN 53479 (Testing of plastics and elastomers; determination of density.)

(2) TL 1376-0600, Blatt 32.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: BAM Impact Test

a. Type of Test: Safety/Impact

b. Description: This test evaluates the sensitivity explosive materials to impact. The test focusses on hazards associated with accidental impact during handling and transporting. It determines, primarily, the lowest response level. The apparatus consists of a steel block mounted on a concrete base. A steel anvil bearing the impact device is embedded in the steel block. A column to support the guide rails of the free-falling drop weight is attached to the rear of the steel block. Drop weights of 1 kg, 5 kg and 10 kg, each assigned a given drop height test range, are used. The maximum height of the apparatus is 1 m. The test substance of 40 mm^3 rests between two coaxially arranged steel cylinders fixed by a steel guide ring. An intermediate steel anvil and a steel centering ring containing vent-holes complete this impact device. Powdered substances are dried and sieved to a size of 0,5 to 1,0 mm before testing. Pressed or cast substances are crushed and sieved to the afore- mentioned particle size. For liquids, a gap of l mm is left between upper and lower cylinder. The upper cylinder is held in position by a rubber ring. The sensitivity is the lowest height at which in a series of six tests at least one explosion is registered. These values are quoted together with the resulting impact energy.

c. Information Requirements for Assessment:

(1) Used to determine the impact sensitivity of explosives in powdered, gelatinous and liquid form. It is required by the German Explosives Law, Transportation Regulations and is accepted for qualification testing of explosives, propellants and pyrotechnics.

d. Typical Results:

	Drop Weight	Drop Height	Impact Energy
Explosives: PETN	l kg	30 cm	3.0 Joule
Tetryl	l kg	40 cm	4.0 Joule
RDX	5 kg	l5 cm	7.5 Joule
TNT	5 kg	30 cm	15.0 Joule

Most solid rocket propellants have impact energies between 4 and 15 Joule (chips) and 15 to 35 Joule (pieces). Solid gun propellants lie between 3 and 10 Joule, whereas pyrotechnic mixtures have impact energies over the entire range of the apparatus.

e. Repeatability and Reproducibility: Repeatability is within the range of approximately ± 1 test increment.

3. NATIONAL REFERENCES:

(1) H. Koenen, K.H. Ide, K.H.Swart, Explosivstoffe 9 (1961) 4-13, 30-42.
(2) P. Langen, BICT Report Az.: 2.2-9/5867/82, Sensitivity to Impact: Test Description and Procedure.
(3) Gesetz uber explosionsgefahrliche Stoffe (Sprengstoffgesetz) vom 13. September 1976, Bundesgesetzblatt Teil I (1976) 2737-2787.

Germany/201.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: BAM Friction Test

a. Type of Test: Safety/Friction

b. Description: The test is used to evaluate the sensitivity of all types of explosive substances to friction. Liquid and gelatinous substances are usually not tested due to their lubricating tendencies and the resulting low heat development that is not sufficient to cause a reaction. The explosive sample is held between a porcelain plate and a porcelain peg under a given load. Frictional forces are applied by a horizontal movement of the porcelain plate. An electric motor drives an eccentric disc and a connecting rod which is fastened to the carriage of the plate. Movement of the plate relative to the peg is a forward and backward motion of 10 mm each, with an average velocity of 5 cm/s. The peg fixture also carries the load arm, which has six equally spaced notches for the attachment of one of nine weights. By various combinations of weight and position on the load arm one can apply loads from 5 to 360 Newton on the test substance. Before testing, powdered substances are sieved through a 0.5 mm mesh screen. Pressed or cast substances are crushed before sieving. The relative sensitivity to friction is indicated by the lowest load expressed in Newton that leads to ignition, crackling or explosion at least once in a series of six tests. The lowest load and the type of reaction observed are registered on the data sheet.

c. Information Requirements for Assessment: The test determines the sensitivity to friction of explosives. It is required by the German Explosives Law, Transportation Regulations and is acceptable for the qualification testing of explosives, propellants and pyrotechnics.

d. Typical Results:

	Load	Reaction
Explosives: PETN	60 Newton	crackling
Tetryl	360 Newton	crackling
RDX	180 Newton	crackling
HMX	160 Newton	crackling
TNT	>360 Newton	
Comp B	>360 Newton	

Solid rocket propellants react with crackling between 40 and 360 Newton. Gun propellants show crackling between 120 and 240 Newton. Pyrotechnics mixtures begin to react with crackling at 20 Newton. The most insensitive lie above 360 Newton.

e. Repeatability and Reproducibility: Repeatability of results is within the range of ±1 test increment.

3. NATIONAL REFERENCES:

(1) H. Koenen, K.H. Ide, Explosivstoffe 3 (1955) 57-65,89-93.
(2) H. Koenen, K.H. Ide, K.-H. Swart, Explosivstoffe 9 (1361) 13-14, 30-42.
(3) Gesetz uber Explosionsgefahrliche StoffeSprengstoffgesetz) vom 13. September 1976, Bundesgesetzblatt Teil I (1976) 2737-2787.
(4) D. Langen, BICT Report Az.: 2.2-9/5868/82, Sensitivity to Friction, Test Description and Procedure.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, and Propellants

2. TEST TITLE: Electrostatic Sensitivity Test

   a. Type of Test: Safety

   b. Description: In this test small samples (approximately 25 mm^3) of the explosive or propellant material are subjected to an electrostatic discharge in order to determine the relative ease of ignition. The test may be conducted in the energy range of 0.001 to 10 Joule using a device consisting essentially of a spring- activated approaching needle electrode and a plane base electrode. The latter supports a large-diameter Trovidur block containing a centrally located Teflon washer as a sample holder. An insulating tape attached to the filled sample holder confines the test substance thereby assuring that the discharge will pass through the entire sample. A series of ten tests is performed at each of the chosen energy levels.

   c. Information Requirements for Assessment: The test is used to determine the lowest discharge energy that will ignite an explosive or propellant sample under the given conditions.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES: N/A

Germany/201.04.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: BICT Gap Test

a. Type of Test: Shock Wave Sensitivity and Detonability.

b. Description: The shock sensitivity and the detonability of an explosive are determined as a function of the height of a water column that is used to transmit and attenuate the shock output of a standard donor explosive. Evidence of a detonation is provided by a detonating cord placed on the acceptor charge and with its other end attached to a lead witness plate. In the normal version, the donor charge of RDX/wax/graphite (94.5/4.5/1) has a diameter of 2l mm and a length of 20 mm. Its density is 1.6 g/cm^3. Initiation is conducted with a standard electric detonator. The acceptor charge has a diameter of 2l mm and a length of 40 mm. Donor, water and acceptor are enclosed in a plexiglass tube of 2l mm inner diameter and 25 mm outer diameter. Explosive materials with a critical diameter greater than 20 mm are tested in a scaled-up version of the test where the plexiglass tube has an inner diameter of 50 mm and an outer diameter of 60 mm. The donor charge consists of 140 g of RDX/wax/graphite pressed to a density of 1.6. g/cm^3. The dimensions are 50 mm diameter and 50 mm length. The acceptor has a diameter of 50 mm and a length of at least l00 mm. The limits of non-detonation (shock wave sensitivity) and detonation (detonability) are determined by a type of up-and-down procedure. Tests above the non-detonation limit will always give negative results and tests below the detonation limit will always result in a detonation. Results are specified as "mm water gap" and may also be supplemented by the corresponding shock pressure. A substance is considered to be more sensitive to shock waves than others if its non-detonation limit is greater than that of the other substance at a given density.

c. Information Requirements for Assessment:

(1) The test is used to determine the shock wave sensitivity of explosives, and occasionally of propellants. It is required by German military specifications (TL) and is acceptable for qualification testing.

d. Typical Results:

(1) (Limit of)	Non-Detonation	Detonation
TNT, cast 1.6 g/cm^3	7 mm 99.5 kbar	6 mm 49.0 kbar
pressed 1.6 g/cm^3	21 mm 17.2 kbar	20 mm 18.3 kbar
Comp B1.7 g/cm^3	12 mm 33.0 kbar	11 mm 35.7 kbar
Tetryl1.6 g/cm^3	24 mm 14.3 kbar	22 mm 16.2 kbar
1.2 g/cm^3	37 mm 5.4 kbar	35 mm 6.2 kbar
PBXN-51.7 g/cm^3	25 mm 13.3 kbar	24 mm 14.3 kbar

e. Repeatability and Reproducibility:

(1) Repeatability is $\pm$ 2 mm, Adjustment of the water gap is 1 mm.

III. NATIONAL REFERENCES:

1. F. Trimborn, Explosivstoffe 15 (1967) 2-8.
2. F. Trimborn, R. Wild, Propellants/Explosives, Pyrotechnics 7 (1982) 87-90.
3. P. Langen, BICT-Report Az.: 2.2-9/5901/S2.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Initiation Test in Steel Pipes

   a. Type of Test: Safety/Detonability

   b. Description: In this test a propellant is confined in a 1" steel pipe and 300 mm long. A 0,6 g PETN detonator is used to initiate the propellant sample. The purpose of the test is to determine whether a standard donor shock will initiate a detonation in the propellant and if so, whether the detonation will propagate through the entire length of the propellant column. Type and extent of reaction are determined by the examination of the remains of the steel pipe. If there is no propagation under these conditions, the test is repeated using a 2" pipe having a length of 500 mm. In this case a standard 50 g RDX/wax pellet serves as a booster charge.

   c. Information Requirements for Assessment: The test is used to determine the detonability of propellants under confinement. Also in certain cases other explosive substances that are not expected to sustain a detonation in their normal mode of application are tested.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Koenen, H., Ide, K. H., Swart, K. H, Explosivstoffe 9 (1961) 4-13, 30-42
(2) Military Specification TL 1376-701, Teil III, Blatt 5.

Germany/201.05.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, and Propellants

2. TEST TITLE: Rifle Bullet Test

a. Type of Test: Safety/Projectile Impact

b. Description: The test is reproducible and the behavior of the test substance in its mode of application is determined. The test can differentiate between the behavior of an explosive in the powdered, pressed, or cast state. Normally, the explosive or propellant is tested in its state of application, i.e., density, cast, pressed, extruded. It is confined in a seamless steel cylinder with an inner diameter of 50 mm, an outer diameter of 55 mm, and a length of 50 mm. Steel caps of 5 mm thick enclose the substance at both ends. The cylinder is placed in a test stand and a 7.62 mm projectile is fired using a NATO G-3 rifle set up 15 m from the cylinder. It impacts the flat end of the cylinder with a velocity of approximately 800 m/s. In a series of ten tests, a detonation, explosion, burning, partial reaction or non-reaction is determined. The damage to the steel cylinder is also noted.

c. Information Requirements for Assessment:

(1) The test is used as an indication of the sensitivity of an explosive or propellant to projectile impact.

d. Typical Results:

10 partial reactions:	Tetryl, TNT pressed, TR 8870
10 detonations:	PETN/wax 95/5
10 non-reactions:	TNT cast
8 partial reactions:	
2 explosions:	Comp B

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

(1) Trimborn, F. BICT-Literatur-Information 2 (1979) III-XII.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Deflagration-to-Detonation Transition Test

   a. Type of Test: Safety

   b. Description: The test is used to determine whether an explosive substance initiated by heat will transit from burning to detonation. For this purpose the test sample is loaded in a steel pipe of 50 mm inner diameter, 60 mm outer diameter, and 500 mm length which is closed at both ends. Burning is initiated at one end by means of an igniter composition consisting of equal parts of black powder and RDX and weighing 5, 10, or 20 grams. No instrumentation is provided, the results being assessed from the degree of fragmentation of the steel pipe.

   c. Information Requirements for Assessment:

      (1) The test is used to determine the tendency of an explosive or propellant to undergo a deflagration-to-detonation transition.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES: N/A

Germany 201.08.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Steel Tube Test (Koenen Test)

a. Type of Test: Safety/Thermal

b. Description: The sensitivity of explosives to thermal stimulus is determined. Solid, liquid and gelatinous materials are tested in steel tubes of 24 mm inner diameter, 0.5 mm wall and 75 mm long. The open end of a tube is sealed with one of a number of steel orifices plates having orifices with diameters from 1 to 20 mm. A plate is secured by a threaded collar. An additional diameter of 24 mm results when the test is performed without a plate. The tube is suspended between two rods placed through holes in the opposite walls of a steel protective box. One side and the top of the box are open. The walls and the base are fitted with burners arranged so that the tube and the closure are heated. Three tests are done at each diameter. If an explosion occurs, testing is continued with a larger diameter orifice plate. The relative degree of thermal sensitivity is denoted by the largest plate diameter at which the test substance explodes at least once in a series of three tests with fragmentation of the steel tube into at least three pieces. This diameter is the limiting diameter. In assessing the behavior of the substance, the time t_1 from ignition of the burners to the onset of a visible decomposition reaction (flame burning) and the duration t_2 of this reaction, resp. the time to explosion, are also considered. The thermal sensitivity increases with increasing limiting diameter and decreasing times t_1 and t_2.

c. Information Requirements for Assessment: The test is used to determine the thermal sensitivity of explosive substances. It is required by the German Explosives Law, Transportation Regulations and is acceptable for the qualification testing of explosives, propellants and pyrotechnics.

d. Typical Results:

(1)	Explosives:	Comp B, TNT:	4 mm
		Tetryl, PETN:	6 mm
		HMX, RDX:	8 mm
(2)	Solid gun propellants:		12 to 20 mm (chips)
			1 to 2 mm (cylinders)
	(3)Pyrotechnic mixtures:	14 to 16 mm	

d. Repeatability and Reproducibility:

(1) Repeatability is usually ± orifice plate, i.e.,
± 0.5 mm for diameters from 1 to 3 mm;
± l,0 mm for diameters from 3 to 6 mm;
± 2,0 mm for diameters from 6 to 20 mm.

3. NATIONAL REFERENCES:

(1) Koenen, H., Ide, K.H., Explosivstoffe 4 (1956) 119-125, 143-148.
(2) Koenen, H., Ide, K.H., Swart, K.-H., Explosivstoffe 9 (1961) 4-13, 30-42.
(3) Gesetz uber explosionsgefahrliche Stoffe Sprengstoffgesetz) vom 13. Sept. 1976, Bundesgesetzblatt Teil I (1976) 2737-2787.
(4) Langen, P., BICT Report Az.: 2.2-9/5880/82, Sensitivity to Heat: Test Description and Procedure.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: 105°C (110°C) Weight Loss Test (Holland-Test)

   a. Type of Test: Stability

   b. Description: The 105°C Weight Loss Test is used for the assessment of the safe chemical life of gun and rocket propellants. In the test, the weight loss caused by the decomposition of the propellant is determined as a measure of the stability. Test samples of 4 g are heated in standardized tubes in an aluminum heating block. Single-base gun propellants are tested at 110°C, double and triple-base gun propellants and rocket propellants and tested at 105°C. The test is terminated after 72 hours. The amount of weight loss after this time is reduced by the loss determined after the first 8 hours and is quoted as percent weight loss.

   c. Information Requirements for Assessment:

      (1) The weight loss caused by the decomposition of the propellant is a measure of its stability. The Holland-Test is required by German specifications TL 1376-600, Blatt 27 (gun propellants) and TL 1376-701, Blatt 19 (rocket propellants).

   d. Typical Results:

      (1) Rocket propellants are required to have a loss in weight below 2%.

   e. Repeatability and Reproducibility:

      (1) Limit of error: ± 0.1%

3. NATIONAL REFERENCES:

      (1) TL 1376-600, Blatt 27, dated October 1979.

      (2) GL 1376-701, Blatt 19, dated May 1981.

Germany/202.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: 75^{o}C and 90^{o}C Weight Loss Tests

a. Type of Test: Stability

b. Description: Samples of 5 g in glass tubes are heated at 75^{o}C or at 90^{o}C in a metal heating block. Weight loss is determined periodically by withdrawing the samples from the heating device. At 75^{o}C measurements are made after approximately 30, 60, 90 days, etc. At 90^{o}C the intervals are 5 days. The amount of weight loss is plotted against time. Testing is continued until the weight loss increases sharply, indicating the onset of autocatalytic decomposition of the propellant. If autocatalysis is not observed the test on gun propellants is discontinued when the amount of weight loss has reached 10%. For most rocket propellants it suffices to determine the time needed to reach a weight loss of 3%. The required data are taken from the weight loss vs. time. Typically these are the times corresponding to 3% weight loss and the onset of autocatalysis.

c. Information Requirements for Assessment:

(1) The Weight Loss Tests are used to assess the safe chemical life of propellants. They are required by German specifications TL 1376-600, Blatt 29 (gun propellants) and TL 1376-701, Blatt 20 (rocket propellants).

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) TL 1376-600, Blatt 29, dated October 1979.

(2) TL 1376-701, Blatt 20, dated May 1981.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Bergmann-Junk-Siebert Test

   a. Type of Test: Stability

   b. Description: The stability of single and double-base gun propellants and double-base rocket propellants is examined in this test. Propellant samples of 5 g are heated in standardized tubes in an aluminum heating block. Single-base gun propellants are heated for 5 hours at 132^{o}C, double-base gun and rocket propellants are tested for 16 hours at 115^{o}C.

   As a measure of the stability, the nitrogen oxide evolved is determined acidimetrically. The results are expressed as consumption of titrant per weight of sample, i.e.,

   ml x n/100 NaOH/5g propellant

   c. Information Requirements for Assessment:

   (1) The Bergmann-Junk-Siebert-Test is used to assess the safe chemical life of propellants. It is required by German specification TL 1376-600, Blatt 28 (gun propellants) and TL 1376-7019 Blatt 17 (rocket propellants).

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: $\pm$ 0,2 ml

3. NATIONAL REFERENCES:

   (1) TL 1376-600, Blatt 28, dated October 1979.

   (2) TL 1376-701, Blatt 17, dated May 1981.

Germany/202.01.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: BAM Ignitability Test (Standard Heat Sources)

   a. Type of Test: Safety/Thermal

   b. Description: In the test, a standard mass of explosive substance is exposed to various sources of heat. Observations are made to determine whether or not the explosive is ignited and if ignition occurs, whether or not it continues to burn after removal from the heat source. Substances that are ignited immediately by the sparks of a cerium-iron igniting device, a short burst of flame of a black powder fuze, or within one second by a gas flame are classified "easy to ignite". Explosives that are ignited by a red-hot bar, a burning match, or after more than one second by a gas flame are classified "ignitable". Finally, substances that ignite only after their introduction into a red-hot iron crucible are classified "difficult to ignite".

   c. Information Requirements for Assessment:

      (1) The test is used to determine the ease of ignition of explosive substances.

   d. Typical Results:

(1)	Explosives:	ignitable
(2)	Gun Propellants:	ignitable
(3)	Rocket Propellants (Chips):	easy to ignite
(4)	Pyrotechnics:	easy to ignite

   e. Repeatability and Reproducibility: To be supplied

III. NATIONAL REFERENCES:

(1) Koenen, H., Ide, K. H., Swart, K.-H, Explosivstoffe 9 (1961) 4-13.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Qualitative Heat Test at 100^{o}C

a Type of Test: Safety/Stability.

b. Description: In this stability test 10 g samples of gun propellants, enclosed in standardized test tubes, are heated at 100^{o}C in an aluminum heating block. The number of days required to cause clearly visible fumes of nitrogen oxides is recorded. It is a measure for the chemical stability of the test substance.

c. Information Requirements for Assessment:

(1) The Qualitative Heat Test at 100^{o}C is used to estimate the safe chemical life of gun and solid rocket propellants and is required by German Military Specifications.

d. Typical Results:

e. Repeatability and Reproducibility: $\pm$ 1 hour

3. NATIONAL REFERENCES:

(1) TL 1376-701, Teil I, Blatt 18, May 1981

(2) TL 1376-600, Blatt 26, March 1976.

Germany/202.01.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Methyl-Violet Test

a. Type of Test: Safety/Stability

b. Description: In this stability test, gun propellants are heated under standardized conditions in a metal heating block. The test temperature for single base propellants is 135°C (408°K) and 120°C (393°K) for double base propellants. The appearance of fumes of nitrogen oxide is detected with the aid of methyl-violet indicator paper. The time elapsed until the change of color sets in, is taken as the measure of stability for the propellants. During a period of five hours, a deflagration must not occur.

c. Information Requirements for Assessment:

(1) The test is used to verify the stability requirements specified for single and double base propellants.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: $\pm$ 2 min.

3. NATIONAL REFERENCES: N/A

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, and Propellants

2. TEST TITLE: Vacuum Stability/Reactivity Test

   a. Type of Test: Safety/Stability

   b. Description: The test material is heated at a constant temperature of 100^{o}C for 40 hours in a vacuum. The volume of gas evolved from 2.5 g of the substance under test is measured at the end of the heating period. When a mixture of equal parts of an explosives and a contact material is tested the volume of the gas evolved is compared with the volume evolved when these substances are heated separately under other identical conditions.

   c. Information Requirements for Assessment:

      (1) Required by military specifications and used to determine the stability of explosives and propellants alone or in contact with other materials. The following requirements are verified:

	Volume of gas evolved (ml)
Explosives:	$\leq$ 3
Explosive/Contact Material:	$\leq$ 3
Propellant/Contact Material:	$\leq$ 5

   d. Typical Results:

(1)	RDX	0.25 ml
(2)	RDX/Wax	0.24 ml
(3)	Comp B	0.04 ml
(4)	TR 8870	0.35 ml

   e Repeatability and Reproducibility:

      (1) 0.05 ml, dependent also on the material under test.

3. NATIONAL REFERENCES:

      (1) TL 1376-701, May 1981

      (2) TL 1376-800, Oct. 1982.

Germany/202.01.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Quantitative Heat Test at 90°C

a. Type of Test: Safety/Stability

b. Description: In this stability test a standard mass of solid rocket propellant is heated in Bergmann-Junk tubes at 90°C in a metal heating block. The total acid produced by oxidation of the decomposition products in the presence of a 3% H_2O_2 solution is determined by titration with NaOH.

Results are expressed in days within which the amount of acid that can be neutralized by 12.5 ml n/100 NaOH has been produced. The result correlates with the 3% limit in the 90°C Weight Loss Test.

c. Information Requirements for Assessment:

(1) This test is required by German Military Specification TL 1376-701 as a means for estimating the safe chemical life of propellants.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: $\pm$ 0.2 ml.

3. NATIONAL REFERENCES:

(1) Military Specification TL 1376-701, Teil 1, Blatt 23, May 1981.

Germany/202.01.009

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Ignition Temperature Test (Wood's Metal Bath)

   a. Type of Test: Safety/Thermal

   b. Description: The ignition or decomposition temperature is determined by heating a standard mass of explosive at a standard rate in a Wood's Metal Bath. Three glass test tubes containing 0.5 g of the explosive are immersed to a fixed depth in the bath which has been preheated to 100°C. Nitrocellulose and nitrocellulose containing substances are heated at a rate of 5ºK/min whereas the heating rate for all other substances is 20ºK/min. The lowest temperature where a visible sign of ignition or decomposition is observed is recorded as the temperature of ignition or decomposition.

   c. Information Requirements for Assessment:

      (1) The test is used to determine the temperature at which an explosive ignites or decomposes.

   d. Typical Results:

(1)	Tetryl:	202°C
(2)	RDX/Wax/Graphite:	232°C
(3)	Comp B:	205°C
(4)	TATB:	no visible sign of reaction up to 360°C
(5)	Gun Propellants:	170-175°C

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Koenen, H., Ide, K.H., Swart, K.-H., Explosivstoffe 9 (1961) 4-13.

Germany/202.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosive, High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Simultaneous Differential Thermal Analysis/-Thermogravimetric Analysis

a. Type of Test: Safety/Thermal

b. Description: About 20 mg of sample are heated on a thermobalance with DTA instrumentation at a rate of 5ºK/min until deflagration or explosion occurs. The normal test atmosphere is dry air. Vacuum, moisture, or temperatures down to –150°C may be used in special cases. During the test period, the weight loss and the temperature difference between sample and reference material are continuously recorded and plotted against the temperature of the reference material.

c. Information Requirements for Assessment:

(1) Used to determine all changes in enthalpy and the loss of weight as a result of chemical or physical changes of the substance during heating at a constant rate. Thus, information on stability and compatibility is obtained.

d. Typical Results:

(1)	Silver Azide:	crystal transformation	190°C
		melting	289°C
		explosion	307°C
(2)	HMX:	crystal transformation 180°C	
		beginning of exothermaldecomposition	262°C
		explosion	271°C

d. Repeatability and Reproducibility:

(1) Melting and transformation temperatures ± 1°K; loss of weight ± 1%.

3. NATIONAL REFERENCES:

(1) Krien, G., Explosivstoffe 13 (1965) 204-220.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Heat Flow Calorimeter Test

a. Type of Test: Stability

b. Description: The heat of decomposition is measured at various constant temperatures as a function of storage time using a heat flow calorimeter. A 25 g sample of the material is placed in a Dewar vessel which is inserted in one of the holes of an aluminum heating block (oven). The temperature may be varied from 30°C to 160°C. An air thermostat maintains a constant temperature around the heating block. As heat is generated the sample temperature rises above the temperature of the oven until equilibrium is reached between the heat generated and the heat dissipated. A thermobattery delivers a voltage signal which is proportional to the temperature difference between sample and oven. This is converted to the heat generated per unit time by means of a calibration curve. The heat generated per unit time and mass are plotted as a function of storage time. Since the thermal outputs, which are constant over the storage time, follow the law of Arrhenius, the determination of the kinetic constants in the temperature range relevant in practice is possible.

c. Information Requirements for Assessment:

(1) The results are used to determine the critical diameter and the time to self-ignition.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Frey, M., "Zur Messung der Zersetzungswarme vons Treibladungspulvern:, Einfuhrungssymposium des CTI, 13.-15.6.1973, 352-365.

Germany/302.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Linear Burning Rate

a. Type of Test: Performance

b. Description: In this test the strand burning technique is employed to determine the linear burning rate of solid rocket propellant under defined temperature and pressure conditions. Before testing begins, the strands having lengths of 230 mm and diameters of 6 mm, are coated with an inhibitor to prevent premature burning of the superficies. Also, holes are drilled into the strands for attaching fuse wires and gauges necessary for ignition and determination of the burning rate. After these wires have been introduced, the strand is fastened to a holding device in the bomb head, which is then screwed into the bomb. The Crawford bomb itself has a volume of 1 liter and may be pressurized to a maximum of 400 bar. Test temperatures may be adjusted between -40^{o}C and +50^{o}C. Constant pressure is maintained throughout burning by means of an expansion tank connected to the bomb.The time of burning between the gauges is recorded, converted to a burning rate, and plotted as a function of pressure.

c. Information Requirements for Assessment:

(1) The results from the test are used for quality assurance.

d. Typical Results: To be supplied

d. Repeatability and Reproducibility:

(1) The test has both good repeatability and reproducibility of $\pm$ 1%.

III. NATIONAL REFERENCES:

(1) TL 1376-701, Teil II, Blatt 2, September 1971.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Closed Vessel Test

a. Type of Test: Performance.

b. Description: The closed vessel is a high pressure combustion chamber of constant volume used to determine the burning characteristics of gun propellants. Closed vessels of 200 cm^3 volume designed for maximum pressures of 5000 resp. 8000 bars are utilized. The propellant charge is ignited by a black powder charge weighing approximately 5% of the propellant charge. The density of loading in the vessel is selected so that the sample consists of at least 100 grains. Relative to the volume of the vessel, however, the density of loading must not be less than 0.2 g/cm^3. The pressure rise is measured by a piezoelectric pressure transducer. Using a computer program, the dynamic vivacity of the test propellant is determined from the pressure-time curve.

c. Information Requirements for Assessment:

(1) The results of the test are used for a ballistic assessment of the test propellant.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) TL-1376-600, part 40, August 1979.

Germany/302.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Black Powder

2. TEST TITLE: Eprouvette Test

a. Type of Test: Performance.

b. Description: The eprouvette is used for the determination of the performance of black powder. It consists essentially of a cylindrical combustion chamber having a conical opening at the upper end and a super-imposed cylindrical weight of 10 kg mass. Both are mounted upright on a device similar to that of the impact test apparatus. In testing, a 10 g sample of black powder is placed in the combustion chamber and ignited by means of an electric fuze head. On ignition the weight is accelerated vertically upward between two guide rails and arrested on reaching the maximum height. This height is determined as a measure of the performance of the black powder.

c. Information Requirements for Assessment:

(1) The test is used to assess the performance of black powder.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) TL 1376-591, para. 5.7

10.7.7 QUALIFICATION PROCEDURES OF ITALY

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10.7.7.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION
(cf. STANAG 4170 Ed2 §3)

10.7.7.1.1 The procurement of weapon systems for the Armed Forces is under the responsibility of the three different bodies :

Body	Procurement of
Direzione Generale degli Armamenti Terrestri (DGAT or TERRARM)	Land Armament Systems
Direzione Generale degli Armamenti Navali (DGAN or NAVARM)-	Navy Armament Systems
Direzione Generale degli Armamenti Aeronautici (DGAA or ARMAEREO)	Air Force Armament Systems

These three General Directorates are subordinated to Defence General Secretariat and National Armament Director (SGD/DNA), which is the national STANAG 4170 implementation responsible.
Qualification is mandatory for all explosive material to be used in munitions intended for the 4 Services: Army, Navy, Air Force and "Carabinieri".

10.7.7.2 NATIONAL AUTHORTY
(cf. STANAG 4170 Ed2 § 4(a) & Annex A)

10.7.7.2.1 Within SGD/DNA, the office appointed as National Authority for the Qualification of explosive materials is the DGAT. So DGAT has the full responsibility of qualifying all explosive materials to be used by the Italian forces.

Direzione Generale degli Armamenti Terrestri
Via Marsala, 104
00185 Roma

10.7.7.3 QUALIFICATION PROCEDURES

10.7.7.3.1 General: (cf. STANAG 4170 Ed2 §3 & 4(c))
According to STANAG 4170, the Qualification of an explosive material is a process whereby it is officially acknowledged that:

a. this well specified explosive material has the necessary properties to provide an expectation of an adequate level of safety and suitability for service in military use, for a given intended role,

b. the manufacture and quality of the explosive material are adequately controlled.

10.7.7.3.2 Qualification request:

a. Generally, and especially for a new composition, the official request for qualifying an explosive has to come from the designer of this explosive.

b. In some cases, the request could come from the manufacturer of the explosive, or even from the munition or munition-component designer. This request is sent directly to the National Authority.

10.7.7.3.3 Approach: (cf. STANAG 4170 Ed2 §4 & 5)

a. In order to make the Qualification decision, the following information has to be brought to the DGAT:

(1) the precise identification/specification of the explosive material to be qualified (which include the manufacturing process),

(2) the assessment data (from tests performed on material coming from industrial production batches) on which the judgement of safety and suitability for service use will be based,

(3) the information justifying that the manufacturing process and quality are adequately controlled.

b. According to STANAG 4170, all these informations are collated in the Qualification report upon which is based the Qualification decision.

10.7.7.3.4 The validity and quality of the informations produced are ensured by involving the DGAT offices and the AQ Services (Army or Navy or Air Force), located on the manufacturers:

(1) DGAT - for technical expertise and testing – in participating in the design of the Qualification programme as well as giving advice on the Qualification report.

(2) AQ Services – for the quality assurance for all armament programmes - mainly involved in verifying that both the designer and the manufacturer of the explosive have a good quality assurance system, and that the manufacturer has the capability of producing it in conformity with the designer specifications. AQ Services verifies that the tests are carried on according to the applicable STANAGs.

10.7.7.3.5 The steps of the qualification procedure:
(cf. STANAG 4170 Ed2 §4 & 5)

a. The following table provides the different steps of the qualification procedure and the parties involved in them:

	Step	Participants
1	Request for Qualification	From Explosive Designer or munition manufacturer (or other requester) To DGAT
2	Definition of the Qualification programme	By DGAT; (issue of the *“Instructions for Qualification”)*
3	Performing of the Qualification programme	By Explosive Designer or munition manufacturer (or other requester) Under the control DGAT and/or AQ Service
4	Production of the *“Qualification report”*	By Explosive Designer or munition manufacturer (or other requester), verified by AQ Service
5	Qualification decision	By DGAT (issue of the Q*ualification certificate”*)

10.7.7.3.6 The term “Qualification” is applied in the following different cases :

a. When it is possible to completely follow the process as described under §5 of STANAG 4170 Ed2 and particularly as described under §10.7.7.3.3 “Approach” of this document, DGAT makes the “Qualification” decision of the explosive material.

b. For the Explosives already in service for which there is a well-established history of safe and satisfactory use, providing the original material specifications remains the same, may be qualified for use in the same role. Without further testing, or with a very limited testing programme, DGAT makes the “Qualification ” decision with possible restrictions of the role.

c. If an explosive material was already qualified according to STANAG 4170 by a foreign National Authority, DGAT is just making a “recognition of the Qualification” - given by this foreign National Authority - decision. This is done on the basis of the Qualification certificate produced by this Authority and, if necessary, of the Qualification report (which should include all informations on this explosive material). Most of the time, DGAT is also asking for additional data according to the methods and tests described at §10.7.7.4.

d. A decision can be taken to satisfy a request from the designer or the manufacturer to qualify a new explosive material, even if there is no immediate application envisaged for national military use. In that case DGAT applies the criteria as described in previous point a.

10.7.7.4 QUALIFICATION METHODS AND TESTS

10.7.7.4.1. List of Tests for Primary Explosives

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Impact	STANAG 4489
(2) Friction	STANAG 4487
(3) Spark sensitivity (small-scale)	STANAG 4490
(4) Thermal characterization	STANAG 4515
(5) Compatibility with materials	STANAG 4147
(6) Thermal stability 60° or lower	202.01.001

b. Optional Tests:

Test	Registry/STANAG Number
(1) Temperature of ignition	STANAG 4491
(2) Thermogravimetric analysis	STANAG 4515

10.7.7.4.2 List of Tests for Booster Explosives:

a. Mandatory Tests

Test	Registry/STANAG Number
(1) Uniaxial tensile (PBX)	STANAG 4506
or Uniaxial compression	STANAG 4443
(2) Impact sensitivity (BAM)	STANAG 4489
(3 Friction sensitivity (BAM))	STANAG 4487
(4) Spark sensitivity (small-scale)	STANAG 4490
(5) Temperature of ignition	STANAG 4491
(6) Differential scanning calorimeter (DSC)	STANAG 4515
(7) Thermogravimetric analysis	STANAG 4515
(8) Vacuum stability	STANAG 4556
(9) Compatibility with materials	STANAG 4147
(10)Shock Sensitiveness (small scale)	STANAG 4488
(11)Stress relaxation	STANAG 4507
(12) DMA	STANAG 4540
(13) TMA	STANAG 4525
(14) Thermal stability at 60 °C or lower	202.01.001
(15) Critical temperature of thermo-ignition	202.01.002
(16) Critical diameter	302.03.001
(17) Density (gravimetric)	102.02.001
(18)Detonation velocity	302.01.001

10.7.7.4. 3 List of Tests for Main Charge High Explosives:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Uniaxial tensile (PBX)	STANAG 4506
or Uniaxial compression	STANAG 4443
(2) Impact sensitivity (BAM)	STANAG 4489
(3 Friction sensitivity (BAM))	STANAG 4487
(4) Spark sensitivity (small-scale)	STANAG 4490
(5) Temperature of ignition	STANAG 4491
(6) Differential scanning calorimeter (DSC)	STANAG 4515
(7) Thermogravimetric analysis	STANAG 4515
(8) Vacuum stability	STANAG 4556
(9) Compatibility with materials	STANAG 4147
(10)Shock Sensitiveness (small scale)	STANAG 4488
(11)Stress relaxation	STANAG 4507
(12) DMA	STANAG 4540
(13) TMA	STANAG 4525
(14) Thermal stability at 60 °C or lower	202.01.001
(15) Critical temperature of thermo-ignition	202.01.002
(16) Detonation velocity	302.01.001
(17) Critical diameter	302.03.001

10.7.7.4.4 List of Tests for Solid Gun Propellants:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Uniaxial compression	STANAG 4443
(2) Impact sensitivity (BAM)	STANAG 4489
(3 Friction sensitivity (BAM))	STANAG 4487
(4) Spark sensitivity (small-scale)	STANAG 4490
(5) Temperature of ignition	STANAG 4491
(6) Differential scanning calorimeter (DSC)	STANAG 4515
(7) Thermogravimetric analysis	STANAG 4515
(8) Vacuum stability	STANAG 4556
(9) Compatibility with materials	STANAG 4147
(10)Shock Sensitiveness (small scale)	STANAG 4488
(11)Stress relaxation	STANAG 4507
(12) DMA	STANAG 4540
(13) TMA	STANAG 4525
(14) Propellant stability	STANAG 4117
(15) Ageing	STANAG 4527
(16) Propellant stability (DB + DPA)	STANAG 4541
(17) Propellant stability (DB + 2-DPA)	STANAG 4542
(14) Thermal stability at 60 °C or lower	202.01.001
(15) Critical temperature of thermo-ignition	202.01.002
(16) Detonation velocity	302.01.001
(17) Closed bomb	302.02.001

10.7.7.4. 5 List of Tests for Solid Rocket Propellants:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Uniaxial tensile	STANAG 4506
(2) Electrostatic discharge (large scale)	STANAG 4490
(3) Uniaxial compression	STANAG 4443
(4) Impact sensitivity (BAM)	STANAG 4489
(5 Friction sensitivity (BAM))	STANAG 4487
(6) Temperature of ignition	STANAG 4491
(7) Differential scanning calorimeter (DSC)	STANAG 4515
(8) Thermogravimetric analysis	STANAG 4515
(9) Vacuum stability	STANAG 4556
(10) Compatibility with materials	STANAG 4147
(11)Shock Sensitiveness (small scale)	STANAG 4488
(12)Stress relaxation	STANAG 4507
(13) DMA	STANAG 4540
(14) TMA	STANAG 4525
(15) Propellant stability	STANAG 4117
(16) Ageing	STANAG 4527
(17) Propellant stability (DB + 2-DPA)	STANAG 4542
(18) Thermal stability at 60 °C or lower	202.01.001

10.7.7.4.6 List of Tests for Liquid Propellants:

a. IT is not interested to the liquid propellants.

10.7.7.4.7 List of Tests for Pyrotechnics:

a. Mandatory Tests:

Test	Registry/STANAG Number
(1) Impact sensitivity (BAM)	STANAG 4489C
(2) Friction sensitivity (large BAM)	STANAG 4487A
(3) Spark sensitivity (small scale)	STANAG 4490A
(4) Temperature of ignition	STANAG 4491B1
(5) Differential scanning calorimeter (DSC)	STANAG 4515B2
(6) Thermogravimetric analysis	STANAG 4515B3
(7) Vacuum stability	STANAG 4556
(8) Compatibility with materials	STANAG 4147
(9) Thermal stability at 60 °C or lower	202.01.001

10.7.7.4.8 Other Tests

a. Chemical analysis

To determine the chemical characteristics of the different types of explosive materials, others general tests can be conducted.
The tests, specific for each explosive material which have to be defined, will be conducted according to the applicable STANAGs or national procedures.

b. Insensitive Munitions (IM_ MURAT)

In case of IM-MURAT (explosives and/or munitions) IT carries on the specific tests according to STANAG 4439, in addition to the mandatory tests of the STANAG 4170.

10.7.7.5 LIST OF ITALY'S TEST INFORMATION SHEETS

Category 100	Chemical, Physical & Mechanical Properties
102.01.XXX	Mechanical properties
STANAG 4443	Uniaxial compression
STANAG 4506	Uniaxial tensile
STANAG 4507	Stress relaxation
STANAG 4540	Dynamic mechanical analysis (DMA)
102.01.001	Apparent density by gravimetric method
102.01.002	Granulometry by microscopic examination
Category 200	Hazard Assessment Sensitiveness/Sensitivity/ Explosiveness
201.01.XXX	Impact
STANAG 4489	Impact sensitivity (BAM)
201.02.XXX	Friction
STANAG 4487	Friction sensitivity (BAM)
201.03.XXX	Electric discharge
STANAG 4490	Spark sensitivity (small scale)
STANAG 4490	Electrostatic discharge (large scale)
201.04.XXX	Shock
STANAG 4488	Water gap test
STANAG 4488	Shock sensitivity (plastic barrier Ø 40)
STANAG 4488	Shock sensitivity (plastic barrier Ø 75)
201.05.XXX	Projectile impact
STANAG 4241	Bullet Impact Test
201.06.XXX	Fragment impacts
STANAG 4496	Heavy Fragment-Impact Test
STANAG 4496	Light Fragment Impact Test
201.07.XXX	Shaped charge jet impact
STANAG 4526	Shaped Charge Jet Impact Test
201.08.XXX	Other tests

STANAG 4396	Sympathetic detonation
202.01.XXX	Thermal tests
STANAG 4491	Temperature of ignition
STANAG 4515	Thermal characterization by DSC
STANAG 4515	Thermal characterization by TGA
STANAG 4556	Vacuum stability
202.01.001	Thermal Stability 60° C or lower
202.01.002	Critical temperature of thermo-ignition
202.02.XXX	Other tests
STANAG 4240	Fast Heating Test
STANAG 4382	Slow Heating Test
203.01.XXX	Compatibility/Reactivity
STANAG 4147	Compatibility
205.01.XXX	Critical diameter evaluation
205.01.001	Critical diameter for detonation
Category 300	Performance Evaluation Theoretical/Experimental methods
302.01.XXX	Detonation velocity
302.01.001	Detonation velocity
302.02.XXX	Burning rate
302.02.001	Closed bomb
302.03.XXX	Other tests
302.03.001	Critical diameter

10.7.7.6 CATALOGUE OF TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with their Registry Number.

Italy/102.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Apparent density by gravimetric method

   a. Type of Test: Physical trial

   b. Description: The method is to measure the mass of a certain quantity of the material which, loose in bulk, exactly fills a container of a given volume.

   The bulk state is obtained by filling the container with the material flowing freely from the orifice of a funnel located a specified distance above the said container, without compaction.

   The ratio of the mass to the volume represents the apparent density of the material (in kg/m^3).

   c. Information Requirements for Assessment:

   d. Typical Results:

   (1) Lead styphnate: 1300 kg/m^3
   (2) Lead azide: 1600 kg/m^3

Italy/102.02.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Granulometry by microscopic examination

   a. Type of Test: Physical trial

   b. Description: A representative fraction of the sample to be analysed is placed on and glued to the electron microscope plate.

      The enlargement is adapted to the material under examination in order to determine the shape and size of the crystals or particles

   c. Information Requirements for Assessment: This trial is applicable to all materials.

Italy/202.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Thermal Stability: behaviour under long period at 60°C or a lower temperature

a Type of Test: Thermal trial

b. Description: Samples of 1 to 60 g of the material placed in hermetically-sealed flasks are left to age in an enclosure or building where the temperature is maintained at 60°C or at a lower temperature.

After predetermined periods of heating (for example 42 days, 3 months, 6 months, 1 year, 2 years etc) a sample of the material under test is removed from the enclosure or building.

After its return to ambient temperature, the material is examined visually and then analysed to establish its physico-chemical, mechanical, ballistic, sensitivity and reactivity characteristics etc.

The characteristics after ageing are compared with those of the unaged material.

c. Information Requirements for Assessment: This trial is applicable to all explosive materials.

d. Typical Results:

For a single-base grain propellant, the loss of stabilizer (diphenylamine) after ageing at 50°C for 42 days is generally less than 0.2%.

Italy/202.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Critical temperature of thermo-ignition

   a. Type of Test: Thermal trial

   b. Description: The method is to determine the behaviour of an explosive material placed in an aluminium boat and subjected to a specified thermal environment in a heated enclosure.

      The sample is 50 mm high and the boat 150 mm high.

      The aim is to find the maximum temperature which does not lead to a pyrotechnic event or, if there is always a pyrotechnic event, the temperatures leading to this event after 20 hours and 100 hours of exposure.

   c. Information Requirements for Assessment: This trial is applicable to shaped solid materials.

Italy /205.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Critical diameter

   a. Type of Test: Deflagration-detonation transition

   b. Description: See 302.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Detonation Velocity

   a. Type of Test: Velocity of the detonation reaction

   b. Description: A test piece in the form of a cylinder of diameter 30 mm or a parallelepiped of cross-section (30 x 30) mm^2 is initiated at one end. The time taken for the detonation front to travel between two points at least 100 mm apart is measured.
   The passage of the detonation front is registered by the short-circuiting of trigger probes connected to a timing device with a resolution of 20 ns. The test is performed with 2 such bases for measurement; the value measured is only taken into consideration if the difference between the 2 velocities is less than 100 m/s. The result of the trial is the mean of 4 valid individual tests.

   c. Information Requirements for Assessment: This trial is applicable to all explosives whose velocity of detonation is greater than 5000 m/s.

Italy/302.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Firing in a closed pressure vessel

   a. Type of Test: Closed Bomb: Velocity of combustion

   b. Description: The curve of variation of pressure as a function of time is recorded for x g of powder placed in a closed vessel whose internal pressure can be measured.

      The usual density of charging is 200 kg/m^3. The volume of the container is 700 or 200 cm^3. 1 to 2 g of black powder initiated by an electric heating wire are used for ignition purposes.

      The various ballistic parameters, such as maximum pressure, force, powder quickness etc, are calculated by comparison with a reference powder or as absolute figures.

   c. Information Requirements for Assessment: This trial is applicable to grain or stick powders.

   d. Typical Results:

      (1) Artillery powders: quickness 1 to 2 $m^3/s\ kg$

Italy /302.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Critical diameter

   a. Type of Test: Critical dimensions

   b. Description: A test piece comprising coaxial cylinders of decreasing diameter is initiated to detonate at its larger end. The point where the detonation stops, observed with the help of a lead plate and possibly a resistance-wire probe, indicates the greatest diameter of the part of the test piece which does not detonate. The length of each cylinder is equal to 4 diameters. The critical diameter is determined to within ± 0.5 mm.

   c. Information Requirements for Assessment: This trial is applicable to all solid explosives whose critical diameter lies between 2 and 20 mm.

10.7.9 QUALIFICATION PROCEDURES OF NORWAY

To be provided

10.7.10 QUALIFICATION PROCEDURES OF POLAND

To be provided

10.7.11 QUALIFICATION PROCEDURES OF ROMANIA

PARAGRAPH | PAGE

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10.7.11.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.7.11.1.1 In Romania, the Procurement and Services Department (P.S.D.) and its Research - Development Directorate (R.D.D), from the Ministry of National Defense, has full responsibility for the qualification of explosives and ammunitions. The Chief of the Testing - Evaluation Department and the Program Managers has the responsibility for the implementation of R.D.D policy.

10.7.11.2 NATIONAL AUTHORITY (IES)

10.7.11.2.1 In Romania, the Research - Development Directorate (R.D.D) is the appointed National Authority. This directorate has responsibility for qualification of military explosives and ammunitions used by Romanian Armed Forces.

10.7.11.2.2 Within the process for qualification of explosive materials and ammunitions, the Research - Development Directorate collaborate with:

a. Military Equipment and Technologies Research Agency;

b. State Owned Company ROMARM S.A.;

c. Ammunition Test Center;

d. Military Technical Academy.

During the process of establishing the tasks, and during the final qualification, R.D.D. co-operates with representatives from the Army, Air Force and Navy Staffs, in order to ensure safety of use, storage and transport of the explosives and ammunitions.

10.7.11.2.3 National Authority performs the following functions:

a. Initiates the procedures of qualification, evaluates the preliminary data, selects the tests for the qualification of military explosives and ammunition used by the Romanian Army, following the Romanian Standard SMT 40362 – 2001 "Principles and methodology for the qualification of military explosives and ammunition", standard which is similar to STANAG 4170 and AOP-7.

b. Establishes the requirements for acceptance or rejection of the explosive materials qualification;

c. Receives from agencies within Romania, or from other nations the test data for qualifying explosive materials, and assesses whether the material is safe and suitable for consideration for use by the Services in a particular role or application;

d. Publishes the test data and assessment which enables qualification, with or without limitations;

e. Co-ordinates the implementation of STANAG 4170, AOP-7, and other international and NATO standards dealing with the explosives within Romania;

f. Co-operates with the Standardisation Bureau for maintaining and enriching the central collection of national and international standards relating to explosive materials and explosive safety test data;

g. Maintains and up-dates a data bank of qualified explosive materials used by the Romanian Armed Forces;

h. Provides a Romanian point-of-contact to other National Authorities from other countries for the exchange of information, on the safety of explosives and the qualification of explosive materials;

i. Liasing with the appropriate governmental organisations responsible for the protection of the environment, regarding the impact of the military explosive and ammunition on the environment, in order to ensure observance of the regulations in this domain;

j. Prepares and up-dates Romania's section in AOP-7.

10.7.1.2.3 The address for the Romanian National Authority is the following:

Ministry of National Defense
Procurement and Services Department
Research – Development Directorate
9 – 11, Drumul Taberei Boulevard
Bucharest
ROMANIA
Telephone +40-1-413 02 52
Fax +40-1-411 59 41

10.7.11.3 QUALIFICATION PROCEDURES

10.7.11.3.1. Romania, as PfP nation, is determined to do its best to joint NATO. Regarding ammunition and explosive safety and suitability for service, Romania is at the beginning of STANAG 4170 implementation. Thus, the information contained in this section should be considered as preliminary and can be a subject of change. All these things happen because of the reorganization process of Romanian Ministry of National Defense and of the institutions dealing with military materials research, development and production; it also happens because of the process of lining up with the international standards.

10.7.11.3.2. Romania is able to produce and to load a wide range of explosive materials: Primary Explosives, Solid Gun Propellants, Solid Rocket Propellants, Booster Explosives, Main Charge High Explosives and Pyrotechnics. In the past, the process of Explosives qualification proceeded according to the military standards of The Warsaw Treaty, and to Romanian military standards. They were based upon the available international regulations or the results of our national researches. The performing of the tests and testing procedures were established by military standards, manuals of requirements and internal norms. After 1990, Romania has dealt with the implementation of international standards, especially NATO and MIL-STD. Thus, the Romanian technical military standards were and will be modified so that the process of estimating – assessing and the tests for qualification will be performed according to STANAG 4170 and AOP-7.

10.7.11.3.3. SMT 40362-2001 “The Principles and methodology for the qualification of military explosives and ammunition” is the Romanian standard, which settles the qualification and represents the implementation in Romania of STANAG 4170. The other NATO standards, established to be compulsory for qualification of explosive materials will be adopted as SMT and will be implemented in the near future, depending on the capability of the Romanian institutions responsible for ammunition and explosive safety and suitability in service.

10.7.11.3.4. In Romania most of the research in military explosives of all types is performed in the following research, design and production units of the Procurement and Services Department or of the State Owned Company ROMARM:

a. Military Equipment and Technology Research Agency;

b. Ammunition Test Center;

c. Military Technical Academy;

d. Special Products Plant Fagaras;

e. Special Products Plant Victoria;

f. Mechanical Plant Sadu – Gorj.

Part of the research, development and evaluation of military explosives and propellants is done in private and public centers or civilian institutions such as National Center for Mining Safety and Anti-explosives Protection “INSEMEX” Petrosani.

10.7.11.3.5. Written requests for qualification of an explosive material are to be submitted to the National Authority, which has to perform all legal actions for the beginning of the qualification process.

10.7.11.3.6. In general, formal qualification testing of an explosive material is not done until it has successfully passed all stages of research and development including laboratory model, prototype lot and pilot - scale production. The explosive also must have been produced in pre-production lots using full - scale production equipment, conditions and methods. However, it is customary to use appropriate qualification tests during the research and development phases to ensure that when an explosive finally reaches production it will be unlikely to encounter unforeseen problems.

10.7.11.3.7. Before qualification, it is necessary for an explosive to have its transportation and storage hazard classification determined in accordance with NATO STANAG 4123, "Methods to Determine and Classify Hazards of Ammunition." This is the responsibility of the Procurement and Services Department of Ministry of National Defense.

10.7.11.4 QUALIFICATION METHODS AND TESTS

The Research-Development Directorate (R.D.D.) has no test facilities of its own. Therefore, the tests are normally carried out in one or more of the Military Equipment and Technologies Research Agency Laboratory, Test Ammunition Centers, Own State Company ROMARM, Military Technical Academy. In some cases, tests may be conducted in other government or private test laboratory, authorized by R.D.D. The organizations or laboratories that have conducted the tests must report the results and any observations occurring during the tests, to the Program Manager. Than, the Program Manager is responsible for arranging a meeting review of the R.D.D. Then, the National Authority can decide as following:

a. Whether the results are sufficient to qualify the explosive;

b. Whether further tests are needed; or

c. Whether the explosive should be considered unsuitable for qualification.

When the R.D.D. is satisfied that the explosive warrants qualification for safety and suitability in service, the Program Manager prepares the appropriate papers and data sheets for approval and issuance by the Chief of R.D.D and P.S.D.

10.7.11.4.1 HIGH EXPLOSIVES:

a. Mandatory Tests for Primary Explosives

	Test	Registry / STANAG Number
(1)	Impact Sensitivity (BAM) /(KAST)	STANAG 4489 (C)/ 201.01.001
(2)	Friction Sensitivity (BAM)	STANAG 4487 (A)
(3)	Electric Spark Sensitivity	STANAG 4490
(4)	Temperature of Ignition	STANAG 4491 (B1)/ 202.03.001
(5)	Vacuum Thermal Stability	STANAG 4556
(6)	Chemical Compatibility with materials	STANAG 4147
(7)	Determination of Primary Explosives Components	101.01.001

b. Optional Tests for Primary Explosives

	Test	Registry / STANAG Number
(1)	Ball and Disc impact	201.01.002
(2)	Bulk Density	102.01.001
(3)	Heat of Explosion	301.01.001
(4)	Specific Volume	301.01.002

a. Mandatory Tests for Booster Explosives

	Test	Registry / STANAG Number
(1)	Impact Sensitivity (BAM)/(KAST)	STANAG 4489 (C)/ 202.01.001
(2)	Friction Sensitivity (BAM)	STANAG 4487 (A)
(3)	Shock Sensitivity (Small Gap Test)	STANAG 4488 (A)

(4)	Electric Spark Sensitivity	STANAG 4490
(5)	Temperature of Ignition	STANAG 4491 (B1)/ 201.03.001
(6)	Vacuum Thermal Stability	STANAG 4556
(7)	Chemical Compatibility with Materials	STANAG 4147
(8)	Determination of Booster Explosives Components	101.02.001
(9)	Detonation Velocity	302.01.001
(10)	Melting Point	102.04.001
(11)	Moisture Content	102.03.001

b. Optional Tests for Booster Explosives

	Test	Registry / STANAG Number
(1)	Density	102.01.003
(2)	Bulk Density	102.01.001
(3)	Chemical Stability (Abel Method)	202.02.004
(4)	Hygroscopicity	102.03.003
(5)	Granulation	102.02.002

a. Mandatory Tests for Main Charge High Explosives

	Test	Registry / STANAG Number
(1)	Impact Sensitivity (BAM)/(KAST)	STANAG 4489 (C)/ 201.01.001
(2)	Friction Sensitivity (BAM)	STANAG 4487 (A)
(3)	Shock Sensitivity (Small Gap Test)	STANAG 4488 (A)
(4)	Electric Spark Sensitivity	STANAG 4490
(5)	Temperature of Ignition	STANAG 4491 (B1)/ 201.03.001
(6)	Vacuum Thermal Stability	STANAG 4556
(7)	Chemical Compatibility with Materials	STANAG 4147
(8)	Determination of Main Charge Explosives Components	101.02.001
(9)	Detonation Velocity	302.02.001
(10)	Melting Point	102.04.001
(11)	Moisture Content	102.03.001

b. Optional Test for Main Charge High Explosives

	Test	Registry / STANAG Number
(1)	Bulk Density	102.01.001
(2)	Density	102.01.003
(3)	Chemical Stability (Abel Method)	202.02.003

10.7.11.4.2 PROPELLANTS

a. Mandatory Tests for Solid Gun Propellants

	Test	Registry / STANAG Number
(1)	Mechanical Strength	103.01.001/103.01.002
(2)	Determination of Solid Gun Components	101.03.001
(3)	Bulk Density	102.01.001
(4)	Density	102.01.003/102.01.004
(5)	Grain Geometry Conformity Test	102.02.001

(6)	Granulation	102.02.002
(7)	Moisture and Volatile Contents	102.03.001/102.03.002
(8)	Impact Sensitivity (BAM)	STANAG 4489C
(9)	Friction Sensitivity (BAM)	STANAG 4487 (A)
(10)	Temperature of Ignition	STANAG 4491 (B1)/ 201.03.001
(11)	Electric Spark Sensitivity	STANAG 4490
(12)	Chemical Stability by Aging	202.01.001
(13	Vacuum Thermal Stability	STANAG 4556
(14)	Chemical Compatibility with Materials	STANAG 4147
(15)	Chemical Stability (Vieille Method at 106.5 ^{0}C)	202.02.001
(16)	Burning Rate Closed Vessel	STANAG 4115

b. Optional Tests for Solid Gun Propellants

	Test	Registry / STANAG Number
(1)	Absolute Density (Mercury Method)	102.01.002
(2)	Chemical Stability by Heating at 120 ^{0}C	202.02.002
(3)	Chemical Stability by Weight Loss at 95 ^{0}C	202.02.003
(4)	Heat of explosion	301.01.001
(5)	Specific Volume	301.01.002

c. Solid Gun Propellants are tested for qualification in two stages, as formulation and in specific charges in ammunitions.

(1) As formulation, the tests are conducted in order to obtain:
(a) Chemical, Physical, Ballistic, and Mechanical Properties;
(b) Compatibility with Materials;
(c) Sensitivity and Stability.

(2) As Specific Charge Ammunitions the tests are conducted for:
(a) Ballistic Characteristics;
(b) The Temperature Influence of Ballistic Characteristics.

a. Mandatory Tests for Solid Rocket Propellants

	Test	Registry / STANAG Number
(1)	Uniaxial Mechanical Properties (constant strain rate)	STANAG 4507/ 103.01.001
(2)	Determination of Solid Rocket Propellants Components	101.03.001
(3)	Density	102.01.003/102.01.004
(4)	Volatile Contents	102.03.002
(5)	Grain Geometry Conformity Test	102.02.001
(6)	Impact Sensitivity (BAM)	STANAG 4489C
(7)	Friction Sensitivity (BAM)	STANAG 4487 (A)
(8)	Temperature of Ignition	STANAG 4491 (B1)/ 201.03.001
(9)	Vacuum Thermal Stability	STANAG 4556
(7)	Chemical Compatibility with Materials	STANAG 4147
(8)	Chemical Stability (Vieille Method at 106.5 ^{0}C)	202.02.001

b. Optional Tests for Solid Rocket Propellants

Test	Registry / STANAG Number
(1) Hygroscopicity	102.03.003
(2) Shock sensitivity	STANAG 4488
(4) Heat of Explosion	301.01.001
(5) Specific volume	301.01.002

c. Solid Rocket Propellants are tested for qualification in two stages: as formulation and in specific motors:

(1) As formulation, the following data are obtained and evaluated:
(a) Chemical, Physical and Mechanical Properties
(b) Compatibility with materials;
(c) Sensitivity and Stability.

(2) In specific rocket motors the following data are obtained and evaluated:
(a) Ballistic properties, such as: Thrust, Total Impulse, Specific Impulse;
(b) Temperature influence on performance characteristics.

10.7.11.4.3 PYROTECHNICS

a. Mandatory Test for Pyrotechnics

Test	Registry / STANAG Number
(1) Determination of Pyrotechnics Components	101.04.001
(2) Granulation	102.02.002
(3) Impact Sensitivity (BAM)/(KAST)	STANAG 4489C
(4) Friction Sensitivity	STANAG 4487A
(5) Electric Spark Sensitivity	STANAG 4490 A
(6) Chemical Compatibility with Materials	STANAG 4147
(7) Vacuum Thermal Stability	STANAG 4556

b. Optional Test for Pyrotechnics

Test	Registry / STANAG Number
(1) Bulk Density	102.01.001
(2) Moisture and Volatile	102.03.001/102.03.002
(2) Hygroscopicity	102.03.003
(3) Heat of Explosion	301.01.001
(4) Specific Volume	301.01.002

10.7.11.5 LIST OF TEST INFORMATION SHEETS

Category 100	Chemical, Physical & Mechanical Properties
101.XX.XXX	Chemical Properties
101.01.001	Determination of Primary Explosives Components
101.02.001	Determination of Main Charge Explosives Components
101.03.001	Determination of Solid Propellants Components
101.04.001	Determination of Pyrotechnics Components
102.XX.XXX	Physical Properties
102.01.001	Bulk Density
102.01.002	Absolute Density (Mercury Method)
102.01.003	Density of Regularly Shaped Samples
102.01.004	Density by Hydrostatic Method
102.02.001	Grain Geometry Conformity Test
102.02.002	Granulation
102.03.001	Moisture Content
102.03.002	Volatile Content
102.03.003	Hygroscopicity
102.04.001	Melting Point
103.XX.XXX	Mechanical Properties
103.01.001	Uniaxial Mechanical Properties (constant strain rate)
103.01.002	Mechanical strength
Category 200	Hazard Assessment Sensitiveness / Sensitivity / Explosiveness
201.XX.XXX	Sensitiveness and Sensitivity
201.01.001	Impact Sensitivity (KAST)
201.01.002	Ball and Disc impact
201.03.001	Temperature of Ignition
202.XX.XXX	Chemical Stability
202.01.001	Chemical Stability by Aging
202.02.001	Chemical Stability (Vieille Method at 106.5 ^{0}C)
202.02.002	Chemical Stability by Heating at 120 ^{0}C
202.02.003	Chemical Stability by Weight Loss at 95 ^{0}C
202.02.004	Chemical Stability (Abel Method)
Category 300	Performance Assessment Experimental methods
301.XX.XXX	Solid Propellants Performance Assessment
301.01.001	Heat of Explosion
301.01.002	Specific Volume
302.XX.XXX	High Explosive Performance Assessment
302.01.001	Detonation Velocity

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10.7.11.6 CATALOGUE OF ROMANIAN TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with the registry number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Determination of Primary Explosives Components

a. Type of test: Chemical Property/Analysis using different techniques of Primary Explosives Components

b. Description:
- The determination of individual components of Primary Explosives can be performed with different analytical techniques.
- Is determined:
  - Primary Explosive (Mercury Fulminate, TNRPb, Tetracene, Lead Azide);
  - oxidants (e.g. $Ba(NO_3)_2$, $KClO_3$);
  - reducing agents (e.g. metallic powder, Sb_2S_3);
  - binders;
  - moisture and volatile.

c. Information Requirements for Assessment: The test results are used to confirm that the composition of the Primary Composition matches the declaration of the manufacturer, or that the composition lies within the limits given in the product performance description. The result represents a quality characteristic.

d. Typical results: The result depends on Primary Composition Type.
- Primary Composition type F:

TNRPb	40 %;
Tetracene	3 %;
$Ba(NO_3)_2$	44 %;
Sb_2S_3	13 %;

e. Repeatability and Reproducibility: Depends on analytical procedure used.

3. NATIONAL REFERENCES:
3.1 PTMI 20-2000 Testing Procedure.
3.2 SF – 17/32-1999. Technical quality requirements for TNRPb.
3.3 SF – 15/32-1999. Technical quality requirements for Tetracene.
3.4 NI – 5619-1974. Technical quality requirements for Barium Nitrate.
3.5 GOST 5593-1978. Technical quality requirements for metallic powders.
3.6 OST V 84-384-1971. Technical quality requirements for Antimony Sulfide.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge HighExplosives

2. TEST TITLE: Determination of Main Charge Explosives Components

a. Type of test: Chemical Property/ Analysis using different techniques of Main Charge Explosives Components

b. Description:

- The determination of individual components of Main Charge Explosives can be performed with different analytical techniques, High Performance Liquid Chromatography, Gas Chromatography.
- For pure Booster Explosives or Main Charge Explosives, acidity, impurities, ash and insoluble material are determined. The melting point is performed for Booster Explosives or Main Charge Explosives (RO/102.04.001) to verify the purity of explosive material.

c. Information Requirements for Assessment: The test results are used to confirm that the composition of the Main Charge Explosives matches the declaration of the manufacturer, or that the composition lies within the limits given in the product performance description. The result represents a quality characteristic.

d. Typical results: The result depends on Main Charge Explosive Type. The methods work for explosive compositions containing 0,01% to nearly 100 % of energetic material.
A IX-1 Main Charge Explosive Composition contents:

- RDX	min. 94.5 %;
- Wax	5.0 – 6.5 %;
- Moisture and volatile	max. 0.1 %;
- Insoluble particles in acetone	max. 0.25 %;
- Ash	max. 0.1 %;
- Acidity	max. 0.05 %.

e. Repeatability and Reproducibility: If the composition of Main Charge Explosives is inhomogeneous, multiple specimens at different locations must be investigated. The relative error of quantitative results should be less than 0.5 %.

3. NATIONAL REFERENCES:

3.1 STP-M 40232-1998. Technical quality requirements for re-crystallized RDX.
3.2 SMT 40251-1999. Technical quality requirements and testing procedures for PETN. (Corresponding to MIL-P-387 C).
3.3 SMT 40252-1999. Technical quality requirements and testing procedures for A IX-1.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Determination of Solid Propellants Components

a. Type of test: Chemical Properties/Analysis using different techniques

b. Description:

⇒ The determination of Solid Propellants Components can be performed using analytical techniques, by atomic absorption spectroscopy and gas chromatography.

⇒ For single base propellants is determine:
- NC content;
- Nitrogen content from NC;
- stabilizer content (DPA);
- inorganic substances content (KNO_3, graphite);
- volatile content;
- moisture content.

⇒ For Double Base Propellants is determine:
- NC content;
- Nitrogen content from NC;
- other energetic material content (e.g. NG, NQ);
- stabilizer content (centralit I, II, III);
- volatile content.

⇒ Some title methods for establishing different contents are presented hereunder.

c. Information Requirements for Assessment: The test results are used to confirm that the composition of Solid Propellants matches the declaration of the manufacturer, or that the composition lies within the limits given in the product performance description. The result represents a quality characteristic.

d. Typical results: Results depend on Solid Propellant composition.

e. Repeatability and Reproducibility: Depend on analytical procedure used. The result relative error must be less than 0,1 %.

3. NATIONAL REFERENCES:

3.1 SMT 40133-1995. Solid Propellant. Preparing methods for physical and chemical tests.
3.2 STP-M 40235-1997. Black powder. Technical requirements.
3.3 SMT 40375/1-1996. Solid Propellants. Technical requirements.
3.4 SMT 40397-1995. Solid Rocket Propellants. Technical requirements.
3.5 STP-M 40375/2-1996. Solid Gun Propellants. Physical and chemical requirements.
3.6 STP-M 40376/1-1998. Nitrocellulose. Technical requirements and methods.
3.7 STP-M 40375/2-1996. Solid Gun Propellants. Physical and chemical requirements.
3.8 STP-M 40376-1992. Solid Gun Propellants. Technical requirements.
3.9 SMT 40164/1-1996. Solid Gun Propellants. Technical quality requirements and testing procedures for DPA, camphor, alcohol and ethyl - ether.
3.10 SMT 40164/4-1996. Solid Gun Propellants. Camphor content determination method.
3.11 SMT 40210-1996. Solid Gun Propellants. Potassium Nitrate content determination methods.
3.12 SMT 40211-1996. Solid Gun Propellants. Potassium Sulphate content determination method.

3.13 SMT 40212-1996. Solid Gun Propellants. Ash content determination method.
3.14 SMT 40231-1996. Solid Gun Propellants. Ceresine content determination method.
3.15 SMT 40163-1994. Solid Propellants. Graphite determination method.
3.16 SMT 40385-1995. Solid Gun Propellants. PVC content determination method.
3.17 SMT 40386-1995 Solid Gun Propellants. Colophony content determination method.
3.18 SMT 40395-1995. Nitrocellulose. Nitrogen content determination method.
3.19 SMT 40382-1993. Solid Rocket Propellants. Nitric ester content determination methods.
3.20 SMT 40383-1993. Solid Rocket Propellants. Butyl phthalate content determination method.
3.21 SMT 40398-1993. Solid Rocket Propellants. Low nitrocellulose content determination method.
3.22 SMT 40399-1994. Solid Rocket Propellants. Centralit content determination method.
3.23 SMT 40404-1996. Solid Rocket Propellants. Vaseline content determination method.
3.24 SMT 40414-1994. Solid Rocket Propellants. Lead dioxide, Calcium Carbonate and Cobalt Trioxide content determination method.
3.25 SMT 40428-1995. Solid Rocket Propellants. Copper and Lead content by atomic absorption spectroscopy.
3.26 SMT 40428-1996. Solid Propellants. Magnesium content by atomic absorption spectroscopy.
3.27 SMT 40429-1995. Solid Propellants. Aluminium Oxide content by spectrophotometric method UV-VIS.
3.28 SMT 40227-1998. Triple Base Propellants. NQ determination content.
3.29 SMT 40226-1998. Triple Base Propellants. Ethyl centralit determination content by volumetric method.
3.30 SMT 40233-1997. Triple Base Propellants. Disc and cone method (similar to MIL-STD-286C, method 103.1.3).
3.31 SMT 40246-1999. Triple Base Propellants. Cryolite determination method.
3.32 SMT 40303-2000. Triple Base Method. Graphite determination content by gravimetry.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Determination of Pyrotechnics Components

   a. Type of test: Chemical Property/Analysis using different techniques

   b. Description: The determination of Pyrotechnics Components can be performed using analytical techniques and by atomic absorption spectroscopy. The determined components are oxidizers (e.g. Nitrates, Chlorates, Perchlorates, Chromates), reducing agents (e.g. Metallic Powders, Sulphur, Sulphates, Phosphorus), binders (e.g. Shellac, PVC), and different aditives (moderators, coloring agents).

   c. Information Requirements for Assessment: The test results are used to confirm that the composition of Pyrotechnic Compositions matches the declaration of the manufacturer, or that the composition lies within the limits given in the product performance description. The result represents a quality characteristic.

   d. Typical results: The result depends on the pyrotechnic composition under investigation, e.g. for V 11 Composition:
      - PbO - 53,2 ± 0,6 %;
      - $BaCrO_4$ - 24,6 ± 0,6 %;
      - $KClO_4$ - 3,0 ± 0,2 %;
      - Zr - 16,8 ± 0,5 %;
      - S - 2,4 ± 0,2 %;
      - NC - 2,0 ± 0,4 % (over 100%)

   e. Repeatability and Reproducibility: Depends on analytical procedure used.

3. NATIONAL REFERENCES:
   3.1 STP-M 40239-1998. Initiation and Delay Pyrotechnic Compositions. Technical requirements. Analytical Methods.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Bulk Density (Gravimetric Density)

a. Type of test: Physical Properties /Determination of Bulk Density by filling the explosive material into a vessel of defined volume.

b. Description: The test is applicable to dry grain and pulverulent material. The dimensions and the volume of the vessel have to be specified since the gravimetric density depends on its. The volume of vessel depends on material type (e.g. a cylinder with 1000 cm^3 volume is used for Solid Gun Propellants). The sample is filled into a funnel which lower opening in closed by a slide valve. After opening of the slide valve, the sample trickles into the cylindrical vessel. The surplus of explosive material is removed by carefully scarping off along the upper edge of the vessel. The explosive's Bulk Density is calculated as mass of explosive present in the vessel divided by the volume of the vessel.

c. Information Requirements for Assessment: The test results represent a quality characteristic of explosive material. The Bulk Density affects the loading density of the Solid Gun propulsive charges or the specific density of explosive charges. Reduction of Bulk Density means that less explosive material can be filled in ammunition cartridges or into an explosive pressing mould. Variations in Bulk Density indicate changes in the granulation process (e.g. extruding and cutting operations).

d. Typical results: The results depend of explosive material and it manufacturing process.

- Granular single and double base propellant: 550 – 1200 g/dm^3;
- P-45 gun propellant: min. 550 g/dm^3;
- 4/7 Tgr gun propellant: min. 900 g/dm^3;
- Black Powder DRP $\geq$ 900 g/dm^3.

e. Repeatability and Reproducibility: The relative error of measurements must be less than 0.1%.

3. NATIONAL REFERENCES:

3.1 STP-M 40235-1997. Black Powders. Technical requirements.
3.2 SMT 40213-1996. Black Powders and solid gun propellants. Method to determine the Bulk Density.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants

2. TEST TITLE: Absolute Density (Mercury Method)

a. Type of test: Physical Properties/Determination of Absolute Density by measuring the mercury volume displaced by a known quantity of energetic material.

b. Description: The test is applicable to dry grain and pulverulent explosive material. The apparatus, a metallic cylindrical vessel, is provided with two hand-operated valves at the top and bottom of the vessel, a vacuum pump, a mercury manometer and connecting tubes. Metallic sieves are disposed between the cylindrical vessel and valves. The cylindrical vessel is full fill by mercury using the vacuum pomp. The mass m2 is than determined. The vessel is full empty and 100 ± 0.1g energetic material is placed into it. Than the vessel is full fill with mercury and the mass m3 is measured. The Absolute Density is calculated with:

$$\rho = \frac{\mathbf{m}_1 \cdot \rho_{\mathbf{Hg}}}{\mathbf{m}_2 - \mathbf{m}_3 + \mathbf{m}_1}$$

Where:
m1 - energetic material mass [g];
m2 - the mass of cylindrical vessel filled with mercury [g];
m3 - the mass of cylindrical vessel filled with explosive and mercury [g];
ρ_{Hg} - the density of mercury at testing temperature [g/cm^3].

c. Information Requirements for Assessment: The test results are a quality characteristic of tested explosive. The Absolute Density affects the performance characteristics.

d. Typical results: Depend on the explosive type and its manufacture process.

- DRP 1R Black powder: 1.70 – 1.77 g/dm^3;
- Single/double base solid propellant: 1.50 – 1.8 g/cm^3.

e. Repeatability and Reproducibility: Two parallel essays are performed and the median value is calculated with 0.01 g/cm^3 precision. The difference between the two results must be less than 0.02 g/cm^3.

3. NATIONAL REFERENCES:

3.1 STP-M 40235-1997. Black Powders. Technical Requirements.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Propellants

2. TEST TITLE: Density of Regularly Shaped Samples

a. Type of test: Physical Properties/Determination of density by measuring the dimensions of a well definite geometry sample.

b. Description: The density of pressed or extruded explosive samples can be calculated as mass of explosive divided by its volume ($\rho=m/V$). The test is applicable only to explosive samples with a well definite geometry: cylinders, conical shapes, tubes, plates and spangles.

- The sample mass is weighed with a high precision balance, the dimensions (height h, inner diameter d and external diameter D) are measured with appropriate instruments (micrometers, calipers), and the volume is calculated.
- Because pressed pellets can have a slightly conical shape, at least three diameters should be measured: one on top, one in the middle and one at the bottom. An averaged value should be used for diameter.
- The density of cast samples is determined by weighing the mould before and after the casting process. The volume can be calculated either from technical drawings, or by determining the volume of a liquid, which is consumed to fill the mould.

c. Information Requirements for Assessment: The test results are used to evaluate a quality characteristic of tested explosives. The explosive density has many influences on the performance and security characteristics. Variations in density mean changes in charge manufacturing process. Reduced density may indicate defects and inclusions as voids and fissures.

d. Typical results: The results depend on explosive type and the parameters of charge manufacturing process.

e. Repeatability and Reproducibility: Two parallel essays are performed and the median value is calculated with 0.01 g/cm^3 precision. The difference between the two results must be less than 0.02 g/cm^3.

3. NATIONAL REFERENCES:

3.1 SMT 40165-1993. Cylindrical hexatol charges. Technical requirements.
3.2 SMT 40182-1993. Cylindrical TNT charges. Technical requirements.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Density by Hydrostatic Method

a. Type of test: Physical Properties/ Determination of density by weighting the explosive in air and by sinking in a liquid with known density.

b. Description:
- The explosive sample is weighed in air with a high precision balance (± 0,0002 g). The explosive mass must be within 0,5 ÷ 1 g (for gun propellants with web ≤ 0.8 mm) and 5÷10 g (for gun propellants with web ≥ 0.8 mm).
- A glass container is filled with a known density liquid and then the recipient is disposed under the hydrostatic balance. On the balance arm is hanging a metallic case, which is placed in immersion at 15 – 20 mm. The metallic case mass (m1) is determined.
- Than the case is filled with explosive samples. The total mass (m2) is determined with 0.0002g precision.
- The density d1 is calculated with:

$$\mathbf{d}1 = \frac{\mathbf{d}2 \cdot \mathbf{m}}{\mathbf{m} - (\mathbf{m}2 - \mathbf{m}1)}$$

Where:
- d2 - liquid density;
- m - explosive mass, weighted in air;
- m1 - metallic case mass, weighted in liquid;
- m2 - metallic case and explosive sample mass, weighted in liquid.

c. Information Requirements for Assessment: The test result is used to evaluate a quality characteristic for Solid Gun Propellants.

d. Typical results:
- Single/double base propellants: 1,50 – 1,8 g/cm^3.

e. Repeatability and Reproducibility: The final result is the average value of two parallel essays. The difference between the two results must be less than 0.015 g/cm^3.

3. NATIONAL REFERENCES:
3.1 STP M 40178-1996. Solid Gun Propellants. Methods to determine density.

RO/102.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Grain Geometry Conformity Test

a. Type of test: Physical Properties/Determination of explosive grain dimensions by micrometry or by measuring under a microscope.

b. Description: The test is applicable to Solid Gun Propellants with one or multi perforated grains, tubular, annular, lamellar, and flake grains.

- For one or multi perforated grains, and for tubular grains web thickness, grain diameters, perforation diameter, and grain height are measured.
- For lamellar and flake grains web thickness, length, width are determined.
- For annular grains web thickness, inner diameter, and external diameter are measured.
- Because of the inhomogeneity of extruded propellants, at least 20 – 30 different grains have to be measured in order to achieve reliable results.
- For lamellar grains, the web thickness is measured at least in three places: at the ends and on the middle.

c. Information Requirements for Assessment: The test results are used for quality assurance. The interior ballistic behavior of a gun propellant depends strongly on its dimensions.

d. Typical results: Depends on Solid Gun Propellant type.

- For 7/1 BP fl single base propellant: web=0.68…0.70 mm; d=0.25…0.35 mm; l=2.7…3.3mm.
- For 7/14 gr single base propellants: web=0.70…0.85 mm; d=0.20…0.35 mm; l=8.8…11mm.

e. Repeatability and Reproducibility: The measurement precision depends on propellant type, measured parameter and used equipment.

3. NATIONAL REFERENCES:

3.1 SMT 40133-1995. Solid Propellant. Preparing methods for physical and chemical tests.
3.2 STP-M 40377-1993. Solid Gun Propellant. Methods to determine the grain conformity dimensions.
3.3 STP-M 40234-1997. Triple base propellants. Method to determine the grains dimensions (similar to MIL-STD-286C, method 504.1.1).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Pyrotechnics

2. TEST TITLE: Granulation

a. Type of test: Physical Properties/Determining the dimensions for propellant grains which has not a regularly shape.

b. Description: The method is used for determining the granulation of low sensitivity explosives. The specimen shall consist of approximately 100 g of the explosive weighed within 0.1g. The portions retained or passed by the various sieves shall be weighed and the results calculated to a percentage basis.

- The sieves are of circular or square shapes, with 400 mm diameter/width.
- The mechanical shaker is set to produce 150 $\pm$ 10 vibrations per minute, with 70 $\pm$ 10 mm amplitude; the sieves, and the tested explosive must be covered and then shaken for 3 minutes.
- The granulation fraction can be calculated with:

$$\mathbf{x_i} = \frac{\mathbf{m_i}}{\mathbf{m}} \cdot 100 \, [\%]$$

Where m_i is the explosive mass retained by “i” sieve, and m is the explosive total mass.

- The minimum and maximum size for the utilized sieves are:
  For VU fl propellant: 0.40-0.56 mm ... 0.7-0.8 mm;
  For VTK propellant: 0.56-0.70 mm …1.1-1.4 mm.

c. Information Requirements for Assessment: The test results are used to evaluating a quality characteristic. The granulation can affect the bulk density.

d. Typical results: Depend on explosive type.

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

3.1 STP-M 40310. Black Powders and Solid Gun Propellants. Method to determine the granulation.
3.2 STP-M 40375/2-1992. Solid Gun Propellants. Technical requirements.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Propellants

2. TEST TITLE: Moisture Content

a. Type of test: Physical Properties/Determination of water content into explosive samples.

b. Description:
- The moisture content is determined by loss of weight, by water extraction with isopropyl alcohol, by propellant decomposition with solvent mixture, and by Karl Ficher method
- Large propellants are ground or cut into pieces of maximum size 10x10x3mm.
- The loss of mass method is used for explosive which not contains volatile solvents. The testing temperature is within 60-80 ^{0}C, and the loss of mass is recorded after 150 minutes.

c. Information Requirements for Assessment: The moisture content is used to evaluating a quality characteristic. Knowledge of the moisture is important because uptake/loss of moisture may lead changes for performance characteristics.

d. Typical results:

A IX-1 Main Charge Composition:	max. 0.1 %;
PETN:	max. 0.1 %;
ST –1 pyrotechnic composition:	max. 0.2 %.

e. Repeatability and Reproducibility: Two parallel essays are performed and the median value is calculated with 0.01% precision. The difference between the two results must be less than 0.03 %.

3. NATIONAL REFERENCES:

3.1 SMT 40209-1996. Solid Gun Propellants. Methods to determine the moisture content.
3.2 SMT 40209/1-1993. Solid Rocket Propellants. Methods to determine the moisture content.
3.3 SMT 40486-1996. High Explosives. Method to determine the moisture and volatile content.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Volatile Content

a. Type of test: Physical properties/Determination of the total volatile content by complete dissolving, precipitation and drying to a constant mass.

b. Description:
- For single base propellants, the volatile substances are moisture (eliminated volatile) and residual volatile (e.g. ethanol, ethyl ether or mixture).
- The residual volatile content is represented by the difference between total volatile content and eliminated volatile content.
- The propellant sample is dissolved into an organic solvent. After precipitation, the solvent is eliminate by drying at 75-85 ^{0}C, until a constant mass.
- Generally, the used solvent is acetone and the precipitation is performed with a mixture ethanol/water (2/1).

c. Information Requirements for Assessment: The test result is used for quality insurance of manufacturing process. The volatile contents may change the performance characteristics of the ammunitions.

d. Typical results:
- P-45 single base propellant: max. 1.8 %;
- VTH-20 single base propellant: max. 3.7 %
- 22/1 TR single base propellant: max. 5.6 %.

e. Repeatability and Reproducibility: Two parallel essays are performed and the median value is calculated with 0.1% precision. The difference between the two results must be less than:
- 0.30 % - for web $<$ 0.7 mm;
- 0.40 % - for 0.7 $\leq$ web $\leq$ 1.0 mm;
- 0.50 % - web $>$ 1 mm.

3. NATIONAL REFERENCES:

3.1 SMT 40164/3-1996. Solid Gun Propellants. Method to determine the volatile content by precipitation.
3.2 STP-M 40375/1-1996. Solid Gun Propellants. Technical requirements.
3.3 STP-M 40375/2-1996. Solid Gun Propellants. Physical and chemical requirements.

RO/102.03.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/Pyrotechnics

2. TEST TITLE: Hygroscopicity

a. Type of test: Physical Properties/Determination of the hygroscopicity by the change in moisture content as a function of air humidity level.

b. Description: Large propellants are cut into small pieces of maximum size 10x10x2mm. Approximately 10 g explosive sample are heated and dry at 100 ^{0}C for 30 minutes, until the mass remain constant.

- After cooling into a desiccator, the explosive sample is weighed with 0.0002g precision.
- Than the sample is disposed into a desiccator which containing a KNO_3/water solution (1200g KNO_3/1000 cm^3 H_2O).
- The testing temperature must be within 18 … 22 ^{0}C, and the sample is maintained into desiccator during 12 h.
- The hygroscopicity is calculated with:

$$\mathbf{H} = \frac{\Delta \mathbf{m}}{\mathbf{m}} [\%]$$

c. Information Requirements for Assessment: Knowledge of the hygroscopicity is important because the changes in moisture content can affect the performance characteristics or lead to malfunction.

d. Typical results: Depend on explosive type.

- ST-1 pyrotechnic composition: max. 0.8 %.

e. Repeatability and Reproducibility: Two parallel essays are performed and the median value is calculated with 0.1% precision.

3. NATIONAL REFERENCES:

3.1 STP-M 40235-1997. Black Powders. Technical requirements.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives

2. TEST TITLE: Melting Point

a. Type of test: Physical Properties/Determination the temperature of solid/liquid transition.

b. Description:
- This method is used for determining the melting point of explosives to be used as a criteria of purity;
- The specimen shall consist of a portion of a sample (not exceeding 5 g).
- The heating apparatus is equipped with an electrical heating controller device, which supplies constant heating speed (e.g. 1÷1.5 ^{0}C / min.);
- The explosive sample is disposed into capillary tubes or between two glass plates. The sample mass is according the used apparatus.
- The melting point is determined with accurately standardized centigrade thermometers.

c. Information Requirements for Assessment: The melting point is used to determinate the purity of booster and main charge explosives. For an explosive composition, many melting points can be determined.

d. Typical results:
- RDX: min. 200 ^{0}C;
- TNT I and II: min. 80.2 ^{0}C

e. Repeatability and Reproducibility: Two parallel essays are performed and the median value is calculated with 0.1 ^{0}C precision. The difference between the two results must be less than 0.3 ^{0}C.

3. NATIONAL REFERENCES:
3.1 STP-M 40232-1998. Hexogen. Technical requirements.
3.2 STP-M 40500-1996. Trinitrotoluen. Technical requirements.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants

2. TEST TITLE: Uniaxial Mechanical Properties (Constant Strain Rate)

   a. Type of test: Mechanical Properties/Compression Behavior of Solid Propellants with Constrain Strain Rate

   b. Description: The testing compression equipment is provided with a mobile slab. The axial motion may be selected with an appropriate constant rate. The strain indicator must indicate the load with 1% precision, and the elongation with 0.01-mm precision. The samples can have many regularly shapes: cylindrical, tubular etc. During the test, the force and elongation are recorded. After the test, it is possible to obtain the maximal strain, E-module, strain-deformation diagram. Parameters as temperature, dimension of the sample and strain rate are influencing the results and have therefore to be specified. At least two tests must be performed.

   c. Information Requirements for Assessment: The test is used for characterizing the mechanical behavior of the solid propellants. The data are required to assess the mechanical properties, and the ability of the propellant to retain its integrity throughout the range of operating conditions.

   d. Typical results: To be supplied.

   e. Repeatability and Reproducibility: The strain must be determined with $\pm$1 MPa precision.

3. NATIONAL REFERENCES:
   3.1 STP-M 40450-1996. Solid Propellants. Method to determine the compressing strength.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Mechanical Strength

a. Type of test: Mechanical Properties /The test consist in the determination of the deformation of solid gun grains at 157 MPa Strain.

b. Description: The test is conducted for single base gun propellants. 20 grains are subjected to geometric measurements. The medium diameter and crossing area are calculated. The samples are machined from a middle region of propellant grain, at length equal with the diameter at .1 mm precision. Than the samples are subjected to a maximal 157 MPa strain, during 5 seconds, until the crack of the sample. The load is calculated as the product between strain and medium crossing area.

c. Information Requirements for Assessment: The compressive behaviour of solid gun propellants is a safety and quality characteristic. The test is used to assess the mechanical compressive strength that may have an effect upon the ballistic behaviour of the propellant.

d. Typical results: The deformation who not produce the samples crack must be:

- Min. 35 % - for 7/7 single base propellants (web ≥ .7 mm);
- Min. 30 % - for 7/14 irregularly shaped grains.

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

3.1 STP-M 40378-1993. Single Base Gun Propellants. Method to determinate the mechanical strength.
3.2 STP-M 40375/2-1992. Single Base Gun Propellants. Physical and Chemical Requirements.

RO/201.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Solid Propellants, and Pyrotechnics

2. TEST TITLE: Impact Sensitivity (KAST)

a. Type of test: Safety/Impact. The test is conducted so as to assess the explosive response of fallhummer (striker) impact.

b. Description:
- The impact sensitivity test is used to determining the liquid, gelatinous and solid energetic materials sensitivity.
- The KAST fallhammer apparatus consists in a solid plate, an anvil, and two guidance bars from witch a striker is dropped down. Tetryl is used to verifying this device. The explosive sample is placed in a confinement device, which consists of two coaxial cylinders placed one on top of the other and guided by a steel ring.
- The weight hammers are 1, 2, 5 and 10 kg. For sensitive explosives such as primary explosives, a small fallhammer is used.
- The usual fall heights are 0.1 – 1.5 m.
- The explosive samples (0.05 g for solid explosive) are sieved (0.9 mm sieve for granular explosive) and pressed at 290 MPa between the steel cylinders.
- The inferior sensitivity ($H_{0-4\%}$), superior sensitivity ($H_{96-100\%}$), the impact sensitivity H_{50} and the frequency of explosions are determinate.
- 25 essays are conducted for every height.

c. Information Requirements for Assessment: The test is conducted so as to determine the sensitivity of explosive materials by a fallhammer impact between two steel cylinders. The results are safety characteristics.

d. Typical results:

- Tetryl (0.2-0.27 mm grain size): H_{50} = 250 mm;
- RDX H_{50} = 150 mm.

e. Repeatability and Reproducibility: The impact sensitivity H_{50} is given with ± 50 mm precision.

3. NATIONAL REFERENCES:

3.1 The Kast method to determine the impact sensitivity of a small explosive samples. A.T.M. Experimental Testing Proceeding.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosive

2. TEST TITLE: Ball and Disc Impact

   a. Type of test: Safety/Impact. The test is used for Primary Explosive and Pyrotechnics - Optional.

   b. Description:
      - A small sample of energetic granular material, 10 – 20 mg, is used for testing.
      - The explosive sample is placed on a steel anvil and entirely covered by a metallic disc (0.5 – 1 mm).
      - It is then subjected to impact from a falling steel ball impacting on a striker with a hemispherical end.
      - The device (metallic disc, explosive sample, and the anvil) is placed under an electromagnetic drop hammer.
      - The method aims at establishing the sensitivity diagram, the height of 50 % explosions.
      - 10 - 25 essays are conducted for every height.

   c. Information Requirements for Assessment: The test is aims at determining the impact sensitivity of Primary Explosives and represents the first step in assessment of the primer compositions. The result is a safety characteristic.

   d. Typical results:
      - Primary Composition: 16 – 17 cm.

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:
   3.1 Method to determine the Ball and Disc Impact Sensitivity. A.T.M. Experimental Testing Proceeding.

RO/201.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives and Solid Propellants

2. TEST TITLE: Temperature of Ignition (BAM)

a. Type of test: Safety/Temperature. The test is conducted to determine the temperature at witch an event occurs, if the temperature is lower than 400 ^{0}C.

b. Description: The explosive sample is heated with 5 ^{0}C/min. or 20 ^{0}C/min and the temperature at witch an event will occur is determinate.

- The apparatus consists of a heating electric bath, which is heated by a constant standard rate, two thermometers (60 - 260 ^{0}C and 200 –400 ^{0}C), and three glass tubes.
- A small quantity of energetic materials is placed into each glass tube (50 – 100 mg for Solid Propellants and Main Charge Explosives or 5-20 mg for Primary Explosives).
- The initial bath temperature is 100 ^{0}C.
- When each event occurs (decomposition, deflagration, detonation), the temperature of ignition is read on the thermometer.
- The final value of test is the lower temperature.

c. Information Requirements for Assessment: The test result is used to determining the thermal behavior of energetic materials. The temperature of ignition is a safety and quality characteristic. The test is also used to assessing the changes after an ageing process.

d. Typical results:

- primary composition type F:	259 - 263 ^{0}C;
- primary composition (based on Hg $(ONC)_2$):	180 - 187 ^{0}C;
- primary composition (based on Hg $(ONC)_2$) aged at 65 ^{0}C for 8 days:	328 - 331 ^{0}C
- double base ball powder type SB 511:	160 - 165 ^{0}C;

e. Repeatability and Reproducibility: The temperature of ignition is determined with ± 0.5 ^{0}C precision.

3. NATIONAL REFERENCES:

3.1 Method to determine the temperature of ignition. A.T.M. Experimental Testing Proceeding.
3.2 STANAG 4491.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Chemical Stability by Aging

   a. Type of test: Stability. The quantity of remaining stabilizer after ageing process is used as a measure of chemical stability.

   b. Description:
      - The propellant samples are kept 60 or 120 days at 65.5 ^{0}C temperature. Then the quantity of remaining stabilizer is measured.
      - 8 samples at 5 g are used for determinate the medium remaining stabilizer content.
      - Each sample is placed in a hermetic glass tube (170 mm height and 27 mm diameter). The tubes are placed in a heated device at 65.5 ^{0}C.
      - 4 tubes are taken out after 60 days and the rest after 120 days.
      - When the brown gases appear, the test is stopped, and the propellant is considered unstable.
      - Spectrometry, chromatography or other analytical methods may measure the remaining stabilizer contents.

   c. Information Requirements for Assessment: The test is used for estimating the chemical stability of the propellants.

   d. Typical results:
      - The propellant is considered stable, for 5 years, if the remaining stabilizer (after 60 days aging) is 1 % at least or it represents more than 50 % from initial content. The minimum value of stabilizer content must be 0.3 %.
      - The propellant is considered stable, for 10 years:
        - If the remaining stabilizer is 1 % at least or it represents more than 75 % from initial content after 60 days; the minimum value of stabilizer content must be 0.7 %;
        - If the remaining stabilizer is 1 % at least or it represents more than 50 % from initial content after 120 days; the minimum value of stabilizer content must be 0.3%.

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   3.1 SMT-40584-2000. Triple base propellants. Method to determine the chemical stability by aging.
   3.2 STANAG 4117.
   3.3 STP-M 40133-1995. Solid Propellants. Methods to prepare samples for physical and chemical analysis.

RO/202.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/ Solid Rocket Propellants

2. TEST TITLE: Chemical Stability (Vieille Method at 106.5 ^{0}C)

a. Type of test: Chemical Stability. Heating the sample at 106.5 ^{0}C for a given period of time and measure the time until the indicator paper changes color.

b. Description:
- A standard mass of the propellant is heated in special apparatus at 106.5 $\pm$ 0.5 ^{0}C.
- The test has more methods: simple, repeated (10 x simple).
- The samples are prepared by cutting, sieving and drying at 95-100 ^{0}C for 2 hours. The propellant is not cut when its weight is under 1 g.
- Two 10 $\pm$0.1 g samples are placed into two hermetic glass tubes (23.5 mm inner diameter and 79 mm height). In each tube is introduced a blue litmus indicator paper.
- The samples are maintained in the heating apparatus until the indicator paper changes its color or brown gases appear.

c. Information Requirements for Assessment: The test is used for estimating the chemical stability of the propellants.

d. Typical results: The test results are expressed in number of hours. For:
- simple method for single base propellant: Min 7 hours;
- repeated method:
  - Min 50 hours for lamellar and porous propellant;
  - Min 60 hours for other propellant.

e. Repeatability and Reproducibility: The test result is one-hour precision.

3. NATIONAL REFERENCES:
3.1 STP-M 40294/1-1993. Solid propellants. Methods to determine the chemical stability by blue litmus indicator paper at 106.5 ^{0}C.
3.2 STP-M 40133-1995. Solid Propellants. Methods to prepare samples for physical and chemical analysis.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/ Solid Rocket Propellants

2. TEST TITLE: Chemical Stability at 120 ^{0}C

   a. Type of test: Chemical Stability. Heating the sample at 120 ^{0}C for a given period of time and measure the time until the methyl indicator paper changes color.

   b. Description:
   - A standard mass of the propellant (2.5 $\pm$ 0.002 g) is heated in special apparatus at 120 $\pm$ 0.5 ^{0}C
   - 5 samples are putted into 5 glass tubes (15 mm inner diameter and 290 mm height). In each tube are placed a methyl indicator paper (70x20mm).
   - At each 5 minutes the sample are observed. When the indicator turns into pink, the test is stopped and time is recorded.

   c. Information Requirements for Assessment: The test is used for estimating the chemical stability of the propellants. The test results are safety and quality characteristics.

   d. Typical results: To be supplied.

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   3.1 STP-M 40238-1999. Triple base propellants. Method to determine the chemical stability by heating at 393 $\pm$ 0.5 K (120 ^{0}C).
   3.2 MIL-STD-286C, Method 404.1.2.
   3.3 STP-M 40133-1995. Solid Propellants. Methods to prepare samples for physical and chemical analysis.

RO/202.02.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/ Solid Rocket Propellants

2. TEST TITLE: Chemical Stability by Weight Loss at 95 ^{0}C

a. Type of test: Stability. Heating the sample at 95 ^{0}C until the propellant decomposition (for a given period of time) and determination of the weight loss.

b. Description:
- 10 ± 0.0002 g are weighed and placed into spherical glass ball (49 mm inner diameter) and than the ball is closed.
- The sample is heated in a special apparatus at 95 ± 0.5 ^{0}C.
- When 24 hours have passed, the ball with sample is weighed and the weight loss is recorded.
- The weight loss is graphically represented as a function of time.
- The start of accelerate decomposition is represented by inflection point (the point where the curve modifies its convexity). The sample is maintained 5 days more at 95 ^{0}C after the inflection point is reached.
- The constant of decomposition characterizes the velocity of uniform decomposition. The loss of weight, in mg for 100 g propellant and 24 hours, is calculated with expression:

$$\mathbf{K}_{100}^{\mathbf{C}} = \frac{\mathbf{a}-\mathbf{b}}{\mathbf{c}-\mathbf{d}} \cdot 1000$$

Where: a - the loss of mass (%) till accelerate decomposition is reached;
b - the loss of mass (%) till uniform decomposition is reached;
c - the time (days) till accelerate decomposition is reached;
d - the time (days) until uniform decomposition is reached;

c. Information Requirements for Assessment: The test is used for estimating the chemical stability of the propellants. The test results are safety and quality characteristics.

d. Typical results:
- For porous gun propellant: min. 8 days;
- For granular propellant: min 10 days.

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

3.1 STP-M 40294-1995. Single base propellants. Method to determine the chemical stability by weight loss.
3.2 STP-M 40375/2-1992. Solid propellant. Physical and chemical requirements.
3.3 STP-M 40133-1995. Methods to prepare samples for physical and chemical analysis.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives and Solid Propellants

2. TEST TITLE: Explosives stability (Abel Method)

a. Type of test: Stability. Heating the sample, at 80 ± 0.5 ^{0}C, till iodine – starch indicator paper change its color

b. Description:
- Four samples, 1.0 ± 0.001 g each of them, are placed into an hermetic glass tube (15.5 inner diameter and 140 mm height) In each tube a iodine – starch indicator paper is introduced too.
- The time passed until the indicator paper changes its color and is recorded.
- The test result is represented by the median value.

c. Information Requirements for Assessment: The test is used to estimating the chemical stability of the propellants. The test results are safety and quality characteristics.

d. Typical results:
- TNT : min. 1 hour;
- PETN: min 1 hour;
- Nitroglycerin: min 0.5 hour.

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e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

3.1 Method to determinate the chemical stability of Explosives (Abel Method). A.T.M. Experimental Testing Proceeding.

RO/301.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Solid Propellants/Pyrotechnics

2. TEST TITLE: Heat of explosion

a. Type of test: Performance. The test determines the quantity of heat liberated in a closed vessel.

b. Description:
- The energetic material is initiated in a vacuum stainless steel container. This container is placed in an adiabatic water-bath calorimeter and heat of explosion of the sample is determined from the temperature raise of the water-bath. Knowing the heat capacity of the calorimeter the heat of explosion can be calculated.
- A standard mass is placed into the container.
- The test results represent the median value of two essays.
- The heat of explosion can be calculated with:

$$\mathbf{Q_v} = \frac{\mathbf{K} \cdot \Delta\mathbf{T} - \mathbf{q_{am}}}{\omega}$$

Where:
- K - heat capacity of apparatus;
- ΔT - raise temperature;
- q_{am} - heat of initiation device;
- ω - mass of the tested sample.

c. Information Requirements for Assessment: The result is a performance characteristic.

d. Typical results:

- primary composition type F:	460 kcal/kg;
- 4/7 T gr single base gun propellant:	max. 875 kcal/kg;
- SB 511 double base gun propellant:	1290 kcal/kg;
- red flare pyrotechnic composition:	min. 1600 kcal/kg.

e. Repeatability and Reproducibility: The difference between the individual results of the heat of explosion must be lower than:
- 0.6 % for the explosive materials with $Q_v \leq 1000$ kcal/kg;
- 0.8 % for the explosive materials with metallic powder;
- 1.3 % for the rest of the Explosives, but not more than 47 kcal/kg.

3. NATIONAL REFERENCES:
3.1 STP-M 40319-1993. Solid propellants. Methods to determine the heat of explosion.
3.2 STP-M 40375/2-1992. Solid propellants. Physical and chemical requirements.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary explosives/Solid propellants/Pyrotechnics

2. TEST TITLE: Specific Volume

a. Type of test: Performance. The test determines the volume of gases products liberated during the explosion.

b. Description:

- The gas products are introduced into a hermetic container and the raise of pressure is measured. The specific volume can be calculated with:

$$\mathbf{V}_{0\mathbf{sp}} = \frac{\mathbf{W}_0 \cdot \Delta\mathbf{H} \cdot 273.15}{\omega \cdot 760 \cdot (273.15 + \mathbf{t})}$$

Where:
- W_0 - volume of the container;
- ΔH - raise pressure;
- ω - mass of tested sample;
- t - ambient temperature.

c. Information Requirements for Assessment: The test result is a performance characteristic.

d. Typical results:

- primary composition type F: 235 l/kg;
- SB 511 double base propellant: 812,5 l/kg;
- MS-2 pyrotechnics composition: 12 l/kg.

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

3.1 Method to determine the specific volume. A.T.M. Experimental Testing Proceeding.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives

2. TEST TITLE: Detonation Velocity

a. Type of test: Performance. The test determines the detonation velocity within the explosive.

b. Description:
- The time that has slipped away between two points at known distance is measured and the velocity is calculated.
- At least two measurement sensors are placed on the explosive charge.
- The final value of the test represents a medium of two essays.

c. Information Requirements for Assessment: The test results are a quality characteristic.

d. Typical results:

Cast TNT	6950 m/s

e. Repeatability and Reproducibility: The measurement precision is ± 2%.

3. NATIONAL REFERENCES:
3.1 Method to determine the detonation velocity. A.T.M. Experimental Testing Proceeding.

10.7.8 QUALIFICATION PROCEDURES OF THE NETHERLANDS

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10.7.8.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.7.8.1.1 The Netherlands does not qualify new military explosives since no new military explosives are developed in this country.

10.7.8.1.2 The Netherlands procures explosives from foreign producers as part of a complete munition or weapon system design or bulk explosives for production or rework of ammunition.

10.7.8.1.3 The approval of explosives, in the Netherlands, is done as part of the approval of the specifications of the complete ammunition or weapon system as procured from either Netherlands or foreign contractors by the involved Materiel Command after consulting the Militaire Commissie Gevaarlijke Stoffen[1], MCGS.

10.7.8.2 NATIONAL AUTHORITY(IES)

10.7.8.2.1 The following authorities within the Netherlands Defense Organization are responsible for approving the specifications for explosives contained in munitions:

a. Directoraat Matrerieel Koninklijke Landmacht (Army Materiel Command)
b. Directoraat Matrerieel Koninklijke Marine (Naval Materiel Command)
c. Directoraat Matrerieel Koninklijke Luchtmacht (Air Materiel Command)

10.7.8.3 QUALIFICATION PROCEDURES

10.7.8.3.1 It is required that the explosives are qualified before taken into service, the qualification is part of the final classification. The properties of the explosive should be identified by TNO Prins Maurits Laboratory (TNO-PML), either by assessing the data provided by the manufacturer or by performing an (additional) experimental test program. This results in a qualification report and draft specifications for the explosive substance.

[1] Military Committee for Dangerous Substances.

10.7.8.4 QUALIFICATION METHODS AND TESTS

10.7.8.4.1 The basis for the approval of new explosives is the specifications with related test-methods and requirements given in NATO STANAGs used for approval in other NATO countries. Specific Netherlands test methods for explosives do not exist. Consequently, Test Information Sheets are not relevant. The tests which the Netherlands authorities consider mandatory for assessing the safety of an explosive material are listed below.

10.7.8.4.2 The activities required for setting up and implementing a qualification program are:

a. Identifying the relevant characteristic properties in relation to STANAG 4170, STANAG 4123, MP 40-22, the expected life cycle and use of the explosive substance.
b. Inaugurating the (additional) test program
c. Implementing the (additional) test program
d. Compiling a qualification report
e. Compiling the specification

The qualification of an explosive substance for military use is recorded by the chairman of the MCGS in a qualification document.

10.7.8.4.3 High Explosives

a. Mandatory Data

(1) Impact Sensitivity (BAM test)
(2) Friction Sensitivity (BAM test)
(3) Electrostatic Sensitivity
(4) Shock Sensitivity (BICT gap test)
(5) Heat Sensitivity (Koenen test)
(6) Vacuum Thermal Stability

10.7.12 QUALIFICATION PROCEDURES OF THE SLOVAK REPUBLIC

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10.7.12.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.12.1.1 Military Technical and Testing Institute Zahorie (Vojensky Technicky a Skusobny Ustav Zahorie - VTSU) has full responsibility for qualification of military explosives.

10.7.12.2 NATIONAL AUTHORITY

Military Technical and Testing Institute Zahorie (Vojensky Technicky a Skusobny Ustav Zahorie – VTSU) is the appointed National Authority for the Slovak Republic and is responsible for the following functions in accordance with STANAG 4170:

a. Initiation of the qualification procedure, assessment of the preliminary data and selection of the tests necessary for qualification of military explosive materials used by the military services of the Slovak Republic.

b. Conducting tests and preparing the qualification reports

c. Assessment of the military explosive in accordance with STANAG 4170 and determination of the qualification status

d. Decision on the application of the qualified explosive

e. Creating and maintaining the Slovak data bank of qualified explosive materials used by the Slovak military services

f. Maintaining Slovak repository for NATO Standardization Agreements and Slovak Technical Standards relating to the military explosive materials

g. Coordination of the implementation of STANAG 4170 within the Slovak Republic

h. Acting as a Point of Contact within the Slovak Republic for inputs to AOP-7

i. Serving as a Point of Contact to other NATO countries for the exchange of information

j. Releasing the qualification data to other NATO and PFP nations in accordance with STANAG 4170

10.7.12.3 QUALIFICATION PROCEDURES

10.7.12.3.1 The Slovak Republic is in the beginning of the implementation process of STANAG 4170 into its testing practice. Thus, the information contained in this section should be considered as preliminary and can be a subject of the change. The basis for the Slovak assessment for the qualification of an explosive composition is laid down in the Slovak Technical Standards. There are plenty of differences between Slovak Technical Standards and STANAGs for military explosives. The Slovak National Standards will be changed in the future and to this time the basis for the Slovak assessment for the qualification of an explosive composition will be laid down in test methods and procedures. These procedures are in preparation. They will be in line with requirements of STANAG 4170 and the STANAGs for explosives testing quoted in STANAG 4170.

10.7.12.3.2 In the Slovak Republic, the research and the development of new military explosives intended for military use are mainly carried out by private firms - e.g. Chemko a.s., Strazske (high explosives), Konstrukta – Defence, a.s., Trencin (pyrotechnics), Zavody Vseobecneho strojarenstva, a.s., Dubnica nad Vahom (high explosives, pyrotechnics) . Additionally, research may also be carried out in certain state institutes sponsored by the Slovak MOD (e.g. Military Technical and Testing Institute, Zahorie).

10.7.12.3.3 In general, the research and the development of new military explosives are carried out under contracts awarded by Slovak Ministry of Defence, or Slovak Ministry of Economy. However, they may also result from a private firm's initiative. Import of military explosives or munitions with military explosives not qualified according to STANAG 4170 can be another source of new military explosives for qualification. In this context a new explosive is an explosive which has not yet been qualified, whose composition, nature or manufacturing procedure has been changed, or which is intended for a role for which it has not been qualified. Existing military explosives may be regarded as being qualified by sufficient long experience representative for its expected life cycle and intended use.

10.7.12.3.4 Written requests for qualification of a new explosive are to be submitted to the National Authority. Requests may be submitted by the military services (Army, Air Force), developers, manufacturers or importers.

10.7.12.3.5 Before the beginning of the qualification procedure, an applicant requesting the assessment of the developed explosive must identify some basic characteristics of the explosive, according to Table 1 to STANAG 4170 and must present results of tests obtained in the development project. The information is evaluated by the National Authority and can be returned for revision if they are unsatisfactory or incomplete. The producer of the new military explosive has to prove the military explosive can be manufactured and processed in a full production scale and the required quality levels can be met consistently. The National Authority can refuse further qualification testing if it is clear from the preliminary results that the new explosive will not satisfy general requirements for safety and suitability in the intended role.

10.7.12.3.6 In case of positive results of the preliminary assessment, the National Authority prepares a list of tests for qualification of the explosive. The tests listed in STANAG 4170 are always taken as mandatory for this purpose, the national tests listed in AOP-7 are usually taken as optional (except those referred by STANAG 4170 to AOP-7, such as electric spark test, detonation velocity and critical diameter test). Other tests not included in STANAG 4170 or AOP-7, but which are suitable to obtain the required information, may also be used. The results of optional tests can be taken from the development project of a new explosive.

10.7.12.3.7 The National Authority is responsible for conducting of the qualification tests and the subsequent assessment of the new explosives regarding its safety and basic suitability for military purposes. If any particular test cannot be conducted by the facilities of the National Authority, the National Authority will delegate other testing laboratory for conducting the test. The qualification procedure does not include the assessment of the explosive in a particular ammunition system (final or type qualification) or legal provisions for storage and transportation.

10.7.12.3.8 The results of the qualification tests, together with other observations and recommendations are considered by committee of specialists of the National Authority, other Slovak military technical institutes, General Staff and Ministry of Defence. The results are evaluated in relation to the results of the same tests carried out on materials of a similar type and role which have proven history of safety and satisfactory use in service. After completion of the investigation, the National Authority prepares a qualification report in accordance with STANAG 4170 and the resulting qualification status: (a) qualified, (b) not qualified, (c) qualified with certain restrictions.

10.7.12.3.9 If the National Authority determines that a new explosive is suitable for military use, an organization developing, manufacturing or importing the explosive will prepare a technical specification for this qualified explosive. The technical specification stipulate characteristics of the explosives such as composition, nature, manufacturing process, type and source of raw materials and use, as far as these ensure reproducible manufacture and delivery. The technical requirements for the explosive, the testing methods, provisions on quality assurance, packaging, storage and transportation conditions are also reflected in this document.

10.7.12.3.10 After the technical specification for explosive has been written, it is to be sent for comments by organizations participating on production, processing or use of the explosive. The final version of this document is ratified by all the organizations (a developer, a manufacturer, a processing company, military authority representatives to these companies, the National Authority, end user etc.).

10.7.12.3.11 In case of ammunition system developments requiring the new explosives, these explosives must be qualified before the system design is finalized. The introduction of the explosive for a particular role before conclusion of the qualification procedure and before completion of the technical specification is prohibited in general.

10.7.12.4 QUALIFICATION METHODS AND TESTS

10.7.12.4.1 List of Tests for Primary explosives:

a. Mandatory Tests

	Test	Registry/STANAG No.
(1)	Thermal characterization by DTA	STANAG 4515
(2)	Thermal characterization by DSC	STANAG 4515
(3)	Thermal characterization by TGA	STANAG 4515
(4)	Chemical compatibility with materials by dynamic TGA*	STANAG 4147
(5)	Chemical compatibility with materials by DSC*	STANAG 4147
(6)	Chemical compatibility of azides with materials by chemical analysis*	STANAG 4147
(7)	Temperature of ignition	STANAG 4491 (B1)
(8)	Impact sensitivity	STANAG 4489 (C)
(9)	Friction sensitivity	STANAG 4487 (A)
(10)	Electric spark	201.03.001

b. Optional Tests for Primary explosives

	Test	Registry/STANAG No.
(1)	Density	102.01.071
(2)	Small BAM friction sensitivity test	201.02.001
(3)	Large scale differential thermal analysis	202.01.003

10.7.12.4.2 List of Tests for Booster and Main Charge High Explosives:

a. Mandatory Tests

	Test	Registry/STANAG No.
(1)	Thermal characterization by DTA	STANAG 4515
(2)	Thermal characterization by DSC	STANAG 4515
(3)	Thermal characterization by TGA	STANAG 4515
(4)	Vacuum stability test	STANAG 4556 (2B)
(5)	Chemical compatibility with materials by vacuum stability test*	STANAG 4147
(6)	Chemical compatibility with materials by dynamic TGA*	STANAG 4147
(7)	Chemical compatibility with materials by DSC*	STANAG 4147
(8)	Temperature of ignition	STANAG 4491 (B1)
(9)	Slow cook-off	STANAG 4491 (C3)
(10)	Fast cook-off	STANAG 4491 (C3)
(11)	Impact sensitivity	STANAG 4489 (C)
(12)	Friction sensitivity	STANAG 4487 (A)
(13)	Electric spark	201.03.001
(14	Large scale electrostatic discharge sensitivity	STANAG 4490 (B)
(15	Shock sensitivity (small, intermediate and super large scale gap)	STANAG 4488 (ABD)
(16)	Large scale gap	201.04.001
(17)	Critical diameter	201.08.001
(18)	Detonation velocity test	302.01.001
(19)	Uniaxial compressive test	STANAG 4443
(20)	Uniaxial tensile test (only for PBX)	STANAG 4506

(21)	Stress relaxation test in tension (only for PBX)	STANAG 4507
(22)	Thermomechanical analysis	STANAG 4525
(23)	Dynamic mechanical analysis (only for PBX)	STANAG 4540

b. Optional Tests for Booster and Main Charge High Explosive

Test		Registry/STANAG No.
(1)	Density	102.01.071
(2)	Large scale differential thermal analysis	202.01.003
(3)	Lead block compression	302.03.001
(4)	Ballistic mortar	302.03.002
(5)	Lead block expansion	302.03.003

10.7.12.4.3 List of Tests for Solid gun propellants

a. Mandatory Tests

Test		Registry/STANAG No.
(1)	Thermal characterization by DTA	STANAG 4515
(2)	Thermal characterization by DSC	STANAG 4515
(3)	Thermal characterization by TGA	STANAG 4515
(4)	Vacuum stability test	STANAG 4556 (2B)
(5)	Chemical stability tests by stabilizer depletion	STANAG 4117 (B) STANAG 4527 STANAG 4541
(6)	Chemical compatibility with materials by vacuum stability test*	STANAG 4147
(7)	Chemical compatibility with materials by dynamic TGA*	STANAG 4147
(8)	Chemical compatibility with materials by DSC*	STANAG 4147
(9)	Chemical compatibility with materials by stabilizer depletion*	STANAG 4147
(10)	Temperature of ignition	STANAG 4491 (B1)
(11)	Slow cook-off	STANAG 4491 (C3)
(12)	Fast cook-off	STANAG 4491 (C3)
(13)	Impact sensitivity	STANAG 4489 (C)
(14)	Friction sensitivity	STANAG 4487 (A)
(15)	Electric spark	201.03.001
(16)	Large scale electrostatic discharge sensitivity	STANAG 4490 (B)
(17)	Shock sensitivity (intermediate and super large scale gap)	STANAG 4488 (BD)
(18)	Large scale gap	201.04.001
(19)	Critical diameter	201.08.001
(20)	Uniaxial compressive#	STANAG 4443
(21)	Thermomechanical analysis#	STANAG 4525
(22)	Dynamic mechanical analysis#	STANAG 4540

b. Optional Tests for Solid gun propellants

Test		Registry/STANAG No.
(1)	Density	102.01.071
(2)	Deflagration to detonation transition	201.08.002
(3)	100°C heat	202.01.001
(4)	Slovak vacuum stability	202.01.002
(5)	Large scale differential thermal analysis	202.01.003
(6)	Closed vessel	302.02.001
(7)	Heat of explosion	302.03.004

10.7.12.4.4 List of Tests for Solid rocket propellants

a. Mandatory Tests

Test		Registry/STANAG No.
(1)	Thermal characterization by DTA	STANAG 4515
(2)	Thermal characterization by DSC	STANAG 4515
(3)	Thermal characterization by TGA	STANAG 4515
(4)	Vacuum stability	STANAG 4556 (2B)
(5)	Chemical stability tests by stabilizer depletion+ (only for double based propellants)	STANAG 4117 (B) STANAG 4527 STANAG 4541
(6)	Chemical compatibility with materials by vacuum stability test*	STANAG 4147
(7)	Chemical compatibility with materials by dynamic TGA*	STANAG 4147
(8)	Chemical compatibility with materials by DSC*	STANAG 4147
(9)	Chemical compatibility with materials by stabilizer depletion* (only for double based propellants)	STANAG 4147
(10)	Temperature of ignition	STANAG 4491 (B1)
(11)	Slow cook-off	STANAG 4491 (C3)
(12)	Fast cook-off	STANAG 4491 (C3)
(13)	Impact sensitivity	STANAG 4489 (C)
(13)	Friction sensitivity	STANAG 4487 (A)
(14)	Electric spark	201.03.001
(15)	Large scale electrostatic discharge sensitivity	STANAG 4490 (B)
(16)	Shock sensitivity (intermediate and super large scale gap)	STANAG 4488 (BD)
(17	Large scale gap	201.04.001
(18)	Critical diameter	201.08.001
(19)	Uniaxial compressive	STANAG 4443
(20)	Uniaxial tensile	STANAG 4506
(21)	Stress relaxation test in tension	STANAG 4507
(22)	Thermomechanical analysis	STANAG 4525
(23)	Dynamic mechanical analysis	STANAG 4540

b. Optional Tests for Solid rocket propellants:

Test		Registry/STANAG No.
(1)	Density	102.01.071
(2)	100^{o}C heat test (only for double based propellants)	202.01.001
(3)	Slovak vacuum stability (only for double based propellants)	202.01.002
(4)	Large scale differential thermal analysis	202.01.003
(5)	Heat of explosion	302.03.004

10.7.12.4.5 List of Tests for Liquid Propellants

a. The tests required for liquid propellants are listed in Chapter 7 of this document.

10.7.12.4.6 List of Tests for Pyrotechnics

a. Mandatory Tests

Test		Registry/STANAG No.
(1)	Thermal characterization by DTA	STANAG 4515
(2)	Thermal characterization by DSC	STANAG 4515
(3)	Thermal characterization by TGA	STANAG 4515
(4)	Vacuum stability	STANAG 4556 (2B)
(5)	Chemical compatibility with materials by dynamic TGA*	STANAG 4147
(6)	Chemical compatibility with materials by DSC*	STANAG 4147
(7)	Temperature of ignition	STANAG 4491 (B1)
(8)	Slow cook-off	STANAG 4491 (C3)
(9)	Fast cook-off	STANAG 4491 (C3)
(10)	Impact sensitivity	STANAG 4489 (C)
(11)	Friction sensitivity	STANAG 4487 (A)
(12)	Electric spark	201.03.001
(13)	Shock sensitivity#	STANAG 4488 (BD)
(14)	Large scale gap#	201.04.001
(15)	Critical diameter#	201.08.001
(16)	Dynamic mechanical analysis#	STANAG 4540

b. Optional Tests for Pyrotechnics

Test		Registry/STANAG No.
(1)	Density	102.01.071
(2)	Small BAM friction sensitivity	201.02.001
(3)	Large scale differential thermal analysis	202.01.003
(4)	Heat of explosion	302.03.004

10.7.12.4.7 Remarks :

* two compatibility tests are usually chosen from the lists
\+ selection of a suitable chemical stability test depends on composition of a propellant under test
\# applicability of the test depends on a resolution of the national authority

10.7.12.5 Aging Characterization

10.7.12.5.1 Determination of the influence of aging on a new explosive's properties is an important part of the qualification process. The aging characterization is mostly based on artificial aging at higher temperatures (50-70^{o}C) for several months with packaging corresponding to the final application of the explosive and following determination of change in selected properties. Some types of explosives materials (especially rocket propellants and main charge high explosives) can be also aged using temperature cycling and shocks. The concrete version of the aging protocol for different types of explosives is established by case to case basis in such a manner allowing to determine the important properties of the explosive after artificial aging corresponding to at least the end of its guaranteed service life (with some safety reserve).

10.7.12.5.2 Determination of change in properties of a new explosive before and after the artificial aging is done by the following methods, in general:

Methods	*Types of explosives*
Impact, friction and electrostatic discharge sensitivity	All types of explosives
Shock wave sensitivity	Booster and main charge high explosives
Thermal stability (DTA, TGA, DSC, temperature of ignition, cook-off)	All types of explosives (except primary explosives for cook-off tests)
Vacuum stability test	All types of explosives
Stabiliser or antioxidant depletion	Propellants
Mechanical properties (in tension, pressure, relaxation, DMA, TMA, hardness)	Propellants, plastic bonded high explosives
Chemical properties (plasticizer migration, active metal degradation)	Propellants, pyrotechnics
Performance properties (heat of explosion, closed vessel test, live firings from ballistic weapons)	Propellants, pyrotechnics

10.7.12.6 LIST OF TEST INFORMATION SHEETS

Category 100	Chemical, Physical & Mechanical Properties
102.01.271	Density
Category 200	Hazard Assessment Sensitiveness/Sensitivity/ Explosiveness
201.02.XXX	Friction
201.02.001	Small BAM Friction Sensitivity Test
201.03.XXX	Electrostatic Discharge
201.03.001	Electric Spark Test
201.04.XXX	Shock Tests
201.04.001	Large Scale Gap Test
201.08.XXX	Other Tests
201.08.001	Critical Diameter
201.08.002	Deflagration to Detonation Transition
202.01.XXX	Thermal Tests
202.01.001	100^{o}C Heat Test
202.01.002	Slovak Vacuum Stability Test
202.01.003	Large Scale Differential Thermal Analysis
Category 300	Performance Assessment
302.01.001	Detonation Velocity Test
302.02.001	Closed Vessel Test
302.03.001	Lead Block Compression Test
302.03.002	Ballistic Mortar Test
302.03.003	Lead Block Expansion Test
302.03.004	Heat of Explosion

10.7.12.7 CATALOGUE OF TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with the Registry Number.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Density

a. Type of Test: Physical Property

b. Description: The density is calculated as a quotient of mass and volume of a sample. The mass is measured with an analytical balance (resolution 0.0001 g) and the volume is measured with a pycnometer by a liquid displacement method at 20 ^{o}C. Liquid that does not dissolve the sample is used as a medium for the pycnometric measurements (e.g. water for high explosives, parafinic oil for propellants and pyrotechnics). A solid sample is used in a form of small pieces that will pass through the pycnometer neck, with smooth surfaces free from crevices and dust.

c. Information Requirements for Assessment: This test is used for material characterization and quality control before some qualification tests.

d. Typical Results:

Cast TNT loading density: 1.58 $g.cm^{-3}$

e. Repeatability and Reproducibility:

Good ($\pm$ 0.005 $g.cm^{-3}$)

3. NATIONAL REFERENCES:

(1) STN 66 8102

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Pyrotechnics

2. TEST TITLE: Small BAM Friction Sensitivity Test

   a. Type of Test: Safety/Friction - Used for Primary Explosives and Pyrotechnics

   b. Description: The sensitivity of primary explosives and very sensitive pyrotechnics is tested by means of the scale-down version of BAM friction test apparatus (according to Annex A to STANAG 4487). The applied friction load ranges from 0.1 N to 18 N. Sensitivity of an explosive is usually expressed as a down level (the maximum load giving 0 ignitions of 6 trials) and an up level (the minimum load giving 6 ignitions of 6 trials).

   c. Information Requirements for Assessment: This test is used to determine the sensitivity of primary explosives and sensitive pyrotechnics at very low loads that can produce errors in results using the standard type BAM friction test apparatus.

   d. Typical Results: Results are quoted as minimum loads for obtaining 6 ignitions or explosions of 6 trials (up level)

      (1) Potassium Chlorate + Red Phosphorous 75/25: 0.4 N (explosion)
      (2) Lead Trinitroresorcinate: 5 N (explosion)

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

   (1) ON 66 8095

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary, Booster, Main Charge High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Electric Spark Test

a. Type of Test: Safety/Electric Spark - used for all types of explosives.

b. Description: An explosive sample (2-30 mg) is placed between an adjustable needle electrode and a static disc electrode. Electrostatic energy stored on a charged variable capacitor (maximum capacity 350 nF, charged with 4-10 kV potential) is discharged to the sample. The standard test interval ranges from 0.1 mJ to 16 J. Using an oscilloscope and high voltage sensors, voltage vs. time dependence is measured on the electrodes and software determines the real energy transferred into the sample. The 50 % probability level of initiation is determined by an „up and down“ Bruceton method. The test should be more representative than usual spark tests owing to direct measurement of spark energy transferred to the sample.

c. Information Requirements for Assessment: To determine the electrostatic charge required to ignite and explosive material at an energy level greater than that found on personnel.

d. Typical Results:

(1) Lead azide: 50 mJ
(2) RDX: 300 mJ

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

(1) TP-VD-1080-(01)-00-ZH

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Large Scale Gap Test

   a. Type of Test: Safety/Detonative Shock

   b. Description: A flat shock wave from a conical donor charge of cast TNT (density 1.58 $g.cm^{-3}$, diameter of the bottom of the charge 68 mm) with coating layer of PETN/TNT 50/50 and a small booster charge of PETN/wax 90/10 is attenuated by layers of PMMA discs (diameter of 68 mm). The occurrence of detonation of the acceptor charge in a steel tube (internal diameter of 60 mm, thickness of 5 mm, length of 200 mm) is assessed by the degree of damage to a steel witness plate under a 3 mm air gap. Thickness of the attenuator giving a 50% probability of detonation is determined by a simplified Bruceton method.

   c. Information Requirements for Assessment: This test determines the sensitivity to shock initiation of explosives that will propagate detonation in confined charges with diameters of 60 mm

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

   (1) TP-VD-1080-(02)-00-ZH

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives/Propellants/Pyrotechnics

2. TEST TITLE: Critical Diameter Test

a. Type of Test: Safety/Critical Diameter - Used for Booster and Main Charge High Explosives, Propellants and Pyrotechnics

b. Description: The explosive under test, contained in a 100 cm steel tube with a selected internal diameter and wall thickness of 10 % of internal diameter, is subjected to an explosive shock known to be sufficient to initiate detonation (using detonator or a plastic explosive booster) and the remains of the tube are examined to determine whether the detonation has propagated through the whole length of the charge. If detonation propagates, internal diameter of the next steel tube is reduced to its half. If detonation fails, internal diameter of the next steel tube is doubled. Using this procedure, critical diameter of the explosive at given loading density is determined as a minimum diameter of the tube at which complete detonation occurs.

c. Information Requirements for Assessment: This test determines the critical diameter of an explosive for sustaining a detonation through a long confined explosive charge.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

(1) TP-VD-1080-(03)-00-ZH

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Deflagration to Detonation Transition Test

a. Type of Test: Safety - Used for Gun Propellants

b. Description: The explosive under test is contained in a steel tube (inside diameter of 32 mm, thickness of 3 mm, length of 500 mm), which is closed at one end by a welded steel disc 3 mm thick. Initiation occurs by means of electric squib at the open end of the tube. The lengths of deflagration and detonation zones are determined by means of a mechanical sensor that is made of 3.15 mm thick steel wire wrapped with 0.6 mm thick copper wire. The mechanical sensor is located inside the tube along all its length. After explosion, the mechanical sensor is collected. The first cut of the copper wire into the steel wire corresponds the transition point from deflagration to detonation.

c. Information Requirements for Assessment: This test determines tendency of an explosive to transition from burning to detonation

d. Typical Results:

(1) A porous nitrocellulose sheet propellant: 250 mm

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

(1) TP-VD-1080-(04)-00-ZH

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: 100°C Heat Test

a. Type of Test: Stability/Thermal - Used for Gun Propellants and Double Based Rocket Propellants

b. Description: 10g samples of propellants, enclosed in standardised glass test tubes, are heated at 100°C in a heating block. The number of days required to cause clearly visible yellow or red fumes of nitrogen oxides is recorded.

c. Information Requirements for Assessment: This test determines the stability level of the single and double based propellants

d. Typical Results:

(1) Double based propellants: 2-10 days
(2) Single based propellants: 6-14 days

e. Repeatability and Reproducibility: within ± 6 hours

3. NATIONAL REFERENCES

(1) STN 66 8102

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Slovak Vacuum Stability Test

   a. Type of Test: Stability/Thermal - Used for Gun Propellants and Double Based Rocket Propellants.

   b. Description: Samples of explosives (2 grams), enclosed in standardised glass test tubes (volume 20 $\pm$ 1 cm^3) with adapters for connection of electronic pressure transducers and a vacuum pump are heated at initial vacuum for a specified period of time at a specified temperature in a heating block. Single based propellants are heated for 5 hours at 125^oC, double based propellants for 5 hours at 115^oC. The volume of gases evolved during the test is recorded from the transducers by computer in regular intervals (5-30 minutes) and volume of gases vs. time graph is finally plotted for every sample. Together with total volume of gases evolved in the test, rate of steady gas evolution is determined from the curve. The rate (extrapolated to 20 hours: $cm^3.g^{-1}$.20hours) is usually taken as a value for stability evaluation.

   c. Information Requirements for Assessment: This test determines the stability level of the propellants.

   d. Typical Results:

      (1) Nitroglycerine propellants: 6-16 $cm^3.g^{-1}$.20hours (115^oC)
      (2) Single based propellants: 10-25 $cm^3.g^{-1}$.20hours (125^oC)

   e. Repeatability and Reproducibility: Within 0.2 cm^3 $ml.g^{-1}$.20hours for propellants.

3. NATIONAL REFERENCES

   (1) STN 26 910

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary, Booster, Main Charge High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Large Scale Differential Thermal Analysis

a. Type of Test: Stability/Thermal - Used for all types of explosives.

b. Description: Commercially available DTA equipment with reinforced design is utilised. The apparatus is capable to withstand explosion of up to 50 mg of primary explosives. Sample weight of 50-500 mg of non-primary explosives can be used. In this apparatus, endothermic and exothermic changes of the sample in a small glass test tube are observed and recorded during heating at a constant rate (usually 5-20 $^{o}C.min^{-1}$) under air atmosphere. The apparatus is very suitable for measurement of highly heterogeneous samples (esp. pyrotechnics) that can produce unrepeatable results with low sample weights. The equipment is also suitable for preliminary assessment of thermal reactivity of an unknown explosive before measurement at more sensitive apparatuses.

c. Information Requirements for Assessment: This test determines the thermal stability of an explosive - start, onset and peak of exothermal decomposition

d. Typical Results (peaks of decomposition at 50 mg sample weight and 5 $^{o}C.min^{-1}$ heating rate):
(1) TNT: 295^{o}C
(2) RDX: 220^{o}C

(3) PETN: 190^{o}C
(4) Double Based Propellants: 165-170^{o}C
(5) Black Powder: 320^{o}C

e. Repeatability and Reproducibility: ± 2^{o}C of peak temperatures

3. NATIONAL REFERENCES

(1) TP-VD-1080-(05)-00-ZH

SK/302.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives

2. TEST TITLE: Detonation Velocity

a. Type of Test: Performance/Experimental - Used for Booster and Main Charge High Explosives.

b. Description: Two measurement probes (insulated copper foils or wires wrapped round or pressed to each other) are inserted into the explosive charge of the selected diameter, length and confinement. The explosive charge is initiated by means of a detonator or a booster charge and the two probes are short-circuited by the passing detonation wave that removes insulation from the probes. The time between the two generated pulses is determined by an electronic counter. Knowing the distance between the two probes, the average detonation velocity is determined.

c. Information Requirements for Assessment: This test determines the detonation velocity of an explosive charge - one of important performance parameters

d. Typical Results:
(1) TNT (pressed 1.62 $g.cm^{-3}$): 6800 $m.s^{-1}$
(2) RDX/wax 95/5 (Pressed 1.62 $g.cm^{-3}$): 8150 $m.s^{-1}$

e. Repeatability and Reproducibility: Precision ± 2%

3. NATIONAL REFERENCES

(1) STN 66 8066

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Closed Vessel Test

a. Type of Test: Performance/Experimental - Used for Gun and Rocket Propellants

b. Description: The basic ballistic properties of a propellant are determined in a closed high-pressure combustion chamber of constant volume (5-200 cm^3). The propellant charge is ignited by a small black powder charge. Loading density of a propellant in the bomb should be 0.19-0.22 $g.cm^{-3}$. The pressure rise is measured by a piezoelectric pressure transducer, with computer evaluation of the pressure-time curve. The force, covolume, quickness, vivacity, form and other ballistic parameters of the propellant are calculated from the curve.

c. Information Requirements for Assessment: The results of the test are used for a ballistic assessment of the test propellant

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

(1) TP-VD-1080-(06)-00-ZH

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives

2. TEST TITLE: Lead Block Compression Test

a. Type of Test: Performance/Brisance - Used for Booster and Main Charge High Explosives

b. Description: 50 g explosive charge of diameter 40 mm is placed on one to three steel plates 10-30 mm thick situated on the top of a lead cylinder of 40 mm diameter and 60 mm height. The charge is initiated by means of a detonator. After explosion, resulting compression of the lead cylinder is measured.

c. Information Requirements for Assessment: The value of the lead cylinder compression corresponds to a brisance of the explosive.

d. Typical Results: (with 3 steel plates)
(1) TNT (pressed, 1.60 $g.cm^{-3}$): 22 mm
(2) RDX/TNT 75/25 (cast, 1.71 $g.cm^{-3}$): 28.5 mm (130% TNT)

e. Repeatability and Reproducibility: within ± 0,5 mm

3. NATIONAL REFERENCES

(1) STN 66 8065

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives

2. TEST TITLE: Ballistic Mortar Test

a. Type of Test: Performance/Explosive power - Used for Booster and Main Charge High Explosives

b. Description: 10 g explosive charge is detonated in a heavy (300 kg) steel mortar, damped with a steel projectile (15 kg). The mortar is attached to a pendulum bar and suspended on knife edges. After explosion of the charge, resulting degree of swing is compared to that produced on detonation of a specific amount of TNT. The result is expressed as percentage of TNT.

c. Information Requirements for Assessment: The value corresponds to an explosive power (working ability) of the explosive.

d. Typical Results:
(1) RDX/TNT 75/25: 144% TNT

e. Repeatability and Reproducibility: ± 2% TNT

3. NATIONAL REFERENCES

(1) STN 66 8075

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives

2. TEST TITLE: Lead Block Expansion Test

a. Type of Test: Performance/Explosives - Used for Booster and Main Charge High Explosives

b. Description: 10 g sample is placed into a tube of diameter 25 mm made of tin sheet and a standard detonator is inserted. The charge is then put into a hole in a lead block of diameter and length 200 mm. Volume produced by the explosion of the charge is measured.

c. Information Requirements for Assessment: The value corresponds to an explosive power (working ability) of the explosive.

d. Typical Results:
(1) TNT (powder): 300 cm^3 (100% TNT)
(2) RDX/Al/wax 76/20/4: 471 cm^3 (157% TNT)

e. Repeatability and Reproducibility: Within ± 1% TNT

3. NATIONAL REFERENCES

(1) STN 66 8064

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/Pyrotechnics

2. TEST TITLE: Heat of Explosion

   a. Type of Test: Performance - Used for Propellants and Pyrotechnics

   b. Description: The heat of explosion of an explosive is determined in a gas-tight stainless steel container. This container is placed in an adiabatic water-bath calorimeter and the heat of explosion of the sample is determined from the temperature raise of the water-bath. Knowing the heat capacity of the calorimeter obtained by combustion of a reference material, the heat of explosion of the explosive can be calculated.

   c. Information Requirements for Assessment: Determination of an energetic content of explosives.

   d. Typical Results:

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES

   (1) TP-VD-1080-(07)-00-ZH

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10.7.13 QUALIFICATION PROCEDURES OF SWEDEN

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10.7.14 QUALIFICATION PROCEDURES FOR SWITZERLAND

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10.7.14.1 GENERAL REMARKS

10.7.14.1.1 Switzerland, as a Partnership for Peace, PfP, nation has taken the decision to make an input in the national part of AOP-7 in view to declare its qualification tests and procedures for explosives intended to be used in military applications. In case of STANAG incompatible generation of data for qualification of explosives, a harmonisation between Swiss tests and procedures and corresponding STANAG test requirements shall be established as a long term objective.

10.7.14.1.2 As Switzerland does not join NATO's MAP (Member Action Plan), a ratification of STANAGs is not foreseen in near future. So a reference to a STANAG within the Swiss national part of AOP-7 does not imply the acceptance of this STANAG without any restrictions. Thus, such references are made in sense of pure literature references.

10.7.14.1.3 In view of a further development of tests and procedures for qualification of explosives to future needs and requirements, as also to harmonize tests and procedures in direction of corresponding STANAGs, Swiss authorities keep the right to adapt those according to the given situation.

10.7.14.2 MILITARY DEPARTMENT'S RESPONSIBILITY FOR QUALIFICATION

10.7.14.2.1 Swiss Defence Procurement Agency (DPA), and therein the "Weapon Systems and Ammunition Test Center" (FA26), hereafter called "Test Center FA26", has full responsibility for qualification of explosives for military applications.

10.7.14.3 NATIONAL AUTHORITY

10.7.14.3.1 The Test Center FA26 is the appointed Swiss National Authority for the qualification of explosives for military purposes and is responsible for the following functions:

a. Defining the tests necessary to obtain evidence for the assessment of explosive materials used by Swiss Army and Airforce, and the requirements applied for the qualification of these materials.

b. Receiving from agencies within Switzerland, or from other nations the test data for qualifying explosive materials, and assessing whether the material is safe and suitable for consideration for use by the Services in a particular role or application.

c. Publishing the test data and assessment which enables qualification, with or without limitations.

d. Co-ordinating the implementation of international standards within Switzerland.

e. Maintaining a central collection of national and international standards relating to explosive materials and explosives safety test data.

f. Providing a Swiss Point of Contact to other countries for the exchange of information, as appropriate, on the safety of explosives.

g. Liasing with the appropriate security responsible of Swiss Defence Procurement Agency to ensure that the security regulations, and requirements for commercial-confidentiality governing the release of information are complied with in respect of data to be provided in response to requests from other nations.

(NOTE: Transportation hazard classifications are the responsibility of the Federal Inspectorate of Dangerous Goods (EGI) which is located at Überlandstrasse 129, CH-8600 Dübendorf)

10.7.14.4 QUALIFICATION PROCEDURES

10.7.14.4.1 In Switzerland research into explosives (of all types) for Army and Air Force is carried out in governmental test centers or full or partially government owned private companies, such as

a. Weapon Systems and Ammunition Test Center (FA26) at Thun

b. Swiss Ammunition Factory (SM) at Thun and Altdorf

c. Nitrochemie Wimmis AG (NCW) at Wimmis

10.7.14.4.2 Additionally, research may also be carried out in private industry, universities and further governmental agencies under contract by Defence Procurement Agency (DPA).

10.7.14.4.3 When a munition containing explosive materials is to be designed within Switzerland or purchased from an other country, the appropriate System Manager of the Swiss Defence Procurement Agency (DPA) tasks for Test Center FA26 to advise on the Safety and Suitability for Service of the munition.

10.7.14.4.4 The Test Center FA26 is a professionally independent, advisory body. It is normally tasked by, and its advice addressed to, the appropriate System Manager of Defence Procurement Agency (DPA).

10.7.14.4.5 The primary purposes of the Test Center FA 26 in view of explosives qualification are:

a. To provide impartial appraisal of the Safety, and advice on the suitability for service, of those parts of weapon systems and stores within its field of operations in which explosives are used. In this context, the term "suitability for service" means that the explosive and associated elements of a weapon system or store are capable of functioning technically as designed, and that neither this functioning, nor safety, will be unacceptably degraded by the service environment through the agreed service life. It does not embrace operational effectiveness or reliability.

b. To provide the Defence Procurement Agency a focus for international standardisation in the field of safety and suitability of explosives.

10.7.14.4.6 During the evaluation phase of the munition procurement process the System Manager has formally to inform the Test Center FA26 about the timetable in which the assessment and qualification of explosive materials has to be considered (paragraph 10.7.14.4.7) and, if appropriate, conducted.

10.7.14.4.7 In a first analysis, all energetic materials involved in a certain system are considered by corresponding specialists to determine whether these are new to service, or known materials being used in a novel role.

10.7.14.4.8 All energetic materials either being new to service or being used in a novel role become subject of assessment and qualification, for their safety and suitability for consideration for use in service. STANAG 4170 will be used as a guideline for this process.

10.7.14.4.9 In certain circumstances, the Test Center FA26 may accept tasks from governmental organisations or even private companies as specified in paragraph 10.7.14.4.1 for the assessment and qualification of a new explosive material before it has been selected for use by an ammunition project.

10.7.14.5 QUALIFICATION METHODS AND TESTS

10.7.14.5.1 The basis for the Swiss assessment for the qualification of an explosive are the requirements of STANAG 4170, whereas restrictions and additional claims are in responsibility of Test Center FA26. It sets out the information required for assessment, with general guidance on the suitable tests for the various types of explosives.

10.7.14.5.2 Selection of Tests. The selection of the specific tests to obtain data is a matter of agreement between all organisations involved in the procurement and munition surveillance process. If a qualification process is initiated outside the procurement process (paragraph 10.7.14.4.9) the selection of tests is made to cover as far as possible the requirements of STANAG 4170. In both cases consideration is given to type of material, to its intended role and to the need to carry out tests at extremes of temperature and on aged material.

10.7.14.5.3 For all materials, information is required to provide answers to Questions 1 to 8 of Table 1 in STANAG 4170.

10.7.14.5.4 Conduct of Tests. Once the test requirements for assessment and qualification have been fixed by the relevant organisations, they are carried out in one or more test laboratories as declared in paragraph 10.7.14.4.1 and 10.7.14.4.2.

10.7.14.5.5 Assessment. The results are considered in relation to the results of the same tests carried out on materials of a similar type and role which have a proven history of safety and satisfactory use in service.

10.7.14.5.6 Qualification. The test results, together with the discussion of the assessment, are presented in a report, in which in case of positive overall conclusions is recommend that the material is safe and suitable for consideration for use, with limitations if necessary.

10.7.14.5.7 Use in Service. Based on the recommendations and restrictions of the explosives qualification report and the final munition evaluation test report, the system manager is responsible for the use of the corresponding explosive materials to be introduced into service.

10.7.14.5.8 High Explosives

a. Mandatory Data for Primary Explosives:

	Tests	Registry/STANAG No.
(1)	BAM Impact Test	201.01.001
(2)	Julius Peters Friction Test	201.02.001
(3)	Electrostatic Discharge Test	201.03.001
(4)	Temperature of Ignition Test	202.01.002

b. Mandatory Data for Booster Explosives

	Tests	Registry/STANAG No.
(1)	HPLC for Energetic Material used in High Explosives not ruled in corresponding STANAGs	101.01.001
(2)	Uniaxial Compression Test	102.01.010
(3)	Density of Regularly Shaped Samples	102.01.071
(4)	Bulk Density	102.01.072
(5)	BAM Impact Test and Effect of Ageing	201.01.001
(6)	Julius Peters Friction Test and Effect of Ageing	201.02.001
(7)	Electrostatic Discharge Test	201.03.001
(8)	21mm BICT (WIWEB) Gap Test	201.04.001
(9)	Steel Tube Test (KOENEN)	202.01.001
(10)	Temperature of Ignition Test and Effect of Ageing	202.01.002
(11)	Vacuum Stability Test (Stability)	202.01.006
(12)	DSC/TG	202.01.007
(13)	Heat Flow Calorimetry Test (Compatibility)	203.01.001
(14)	Vacuum Stability Test (Compatibility)	203.01.002
(15)	Detonation Velocity Test	302.01.001

c. Mandatory Data for Main Charge High Explosives

	Tests	Registry/STANAG No.
(1)	HPLC for Energetic Material used in High Explosives not ruled in corresponding STANAG's	101.01.001
(2)	Uniaxial Tensile Test	102.01.001
(3)	Uniaxial Compression Test	102.01.010
(4)	Dynamic Mechanical Analysis Test (DMA)	102.01.020
(5)	Thermomechanical Analysis (TMA)	102.01.021
(6)	DSC (Glass Transition Temperature)	102.01.050
(7)	Density of Regularly Shaped Samples	102.01.071
(8)	Bulk Density	102.01.072
(9)	Hygroscopicity Test	102.01.073
(10)	BAM Impact Test and Effect of Ageing	201.01.001
(11)	Julius Peters Friction Test and Effect of Ageing	201.02.001
(12)	Electrostatic Discharge Test	201.03.001
(13)	21mm BICT (WIWEB) Gap Test	201.04.001
(14)	Intermediate Scale Gap Test	201.04.002
(15)	EIDS Bullet Impact Test	201.05.001
(16)	High Velocity Fragment Impact Test	201.06.001
(17)	Steel Tube Test (KOENEN)	202.01.001
(18)	Temperature of Ignition Test and Effect of Ageing	202.01.002
(19)	Vacuum Stability Test (Stability)	202.01.006

(20)	DSC/TG	202.01.007
(21)	Tube Test (FCO & SCO)	202.01.010
(22)	Heat Flow Calorimetry Test (Compatibility)	203.01.001
(23)	Vacuum Stability Test (Compatibility)	203.01.002
(24)	Detonation Velocity Test	302.01.001

10.7.14.5.9 PROPELLANTS

a. Mandatory Data for Solid Gun Propellants

Tests		Registry/STANAG No.
(1)	Determination of Propellant Components	101.01.002
(2)	DSC (Glass Transition Temperature)	102.01.050
(3)	Density (Gas Pyknometry)	102.01.070
(4)	Bulk Density	102.01.072
(5)	Hygroscopicity Test	102.01.073
(6)	Grain Geometry Conformity Test	102.01.080
(7)	Low Temperature Embrittlement Test	102.01.090
(8)	BAM Impact Test and Effect of Ageing	201.01.001
(9)	Julius Peters Friction Test and Effect of Ageing	201.02.001
(10)	Electrostatic Discharge Test	201.03.001
(11)	EIDS Bullet Impact Test	201.05.001
(12)	Steel Tube Test (KOENEN)	202.01.001
(13)	Temperature of Ignition Test	202.01.002
(14)	Weight Loss Test at 90 °C	202.01.003
(15)	Bergmann-Junk-Siebert Test	202.01.004
(16)	Heat Flow Calorimetry Test (Stability)	202.01.005
(17)	Vacuum Stability Test (Stability)	202.01.006
(18)	DSC/TG	202.01.007
(19)	HPLC for Stabiliser Depletion not Covered by STANAG 4117, 4541 and 4542	202.01.008
(20)	HPLC for Stabiliser Depletion Covered by STANAG 4117, 4541 and 4542	202.01.009
(21)	Tube Test (FCO & SCO)	202.01.010
(22)	Heat Flow Calorimetry Test (Compatibility)	203.01.001
(23)	Vacuum Stability Test (Compatibility)	203.01.002
(24)	Manometric Bomb Test	302.02.002
(25)	Heat of Combustion Test	302.03.001

b Mandatory Data for Solid Rocket Propellants

Tests		Registry/STANAG No.
(1)	Determination of Propellant Components	101.01.002
(2)	Uniaxial Tensile Test	102.01.001
(3)	Double Plate Tensile Test	102.01.002
(4)	Uniaxial Compression Test	102.01.010
(5)	Dynamic Mechanical Analysis Test (DMA)	102.01.020
(6)	Thermomechanical Analysis (TMA)	102.01.021
(7)	DSC (Glass Transition Temperature)	102.01.050
(8)	Density of Regularly Shaped Samples	102.01.071
(9)	Hygroscopicity Test	102.01.073
(10)	BAM Impact Test and Effect of Ageing	201.01.001
(11)	Julius Peters Friction Test and Effect of Ageing	201.02.001

(12)	Electrostatic Discharge Test	201.03.001
(13)	EIDS Bullet Impact Test	201.05.001
(14)	High Velocity Fragment Impact Test	201.06.001
(15)	50mm Shaped Charge Impact Test	201.07.001
(16)	Steel Tube Test (KOENEN)	202.01.001
(17)	Temperature of Ignition Test	202.01.002
(18)	Heat Flow Calorimetry Test (Stability)	202.01.005
(19)	Vacuum Stability Test (Stability)	202.01.006
(20)	DSC/TG	202.01.007
(21)	HPLC for Stabiliser Depletion not Covered by STANAG 4117, 4541 and 4542	202.01.008
(22)	HPLC for Stabiliser Depletion Covered by STANAG 4117, 4541 and 4542	202.01.009
(23)	Tube Test (FCO & SCO)	202.01.010
(24)	Heat Flow Calorimetry Test (Compatibility)	203.01.001
(25)	Vacuum Stability Test (Compatibility)	203.01.002
(26)	Plasticiser Migration Evaluation	203.02.001
(27)	Heat of Combustion Test	302.03.001

10.7.14.5.10 PYROTECHNICS

a. Mandatory Data for Pyrotechnics

Tests		Registry/STANAG No.
(1)	Determination of Pyrotechnic Components	101.01.003
(2)	Density of Regularly Shaped Samples	102.01.071
(3)	Bulk Density	102.01.072
(4)	BAM Impact Test	201.01.001
(5)	Julius Peters Friction Test	201.02.001
(6)	Electrostatic Discharge Test	201.03.001
(7)	Steel Tube Test (KOENEN)	202.01.001
(8)	Temperature of Ignition Test	202.01.002
(9)	Heat Flow Calorimetry Test (Stability)	202.01.005
(10)	DSC/TG	202.01.007
(11)	Heat Flow Calorimetry Test (Compatibility)	203.01.001
(12)	Burning Rate Test	302.02.001
(13)	Heat of Combustion Test	302.03.001

10.7.14.6 LIST OF TEST INFORMATION SHEETS

Category 100	Chemical, Physical & Mechanical Properties Tests
101.01.XXX	Chemical
101.01.001	HPLC for Energetic Material used in High Explosives not ruled in corresponding STANAGs
101.01.002	Determination of Propellant Components
101.01.003	Determination of Pyrotechnic Components
102.01.XXX Properties Tests	Physical & Mechanical
102.01.001	Uniaxial Tensile
102.01.002	Double Plate Tensile
102.01.010	Uniaxial Compression
102.01.020	Dynamic Mechanical Analysis Test (DMA)
102.01.021	Thermomechanical Analysis (TMA)
102.01.050	DSC (Glass Transition Temperature)
102.01.070	Density (Gas Pyknometry)
102.01.071	Density of Regularly Shaped Samples
102.01.072	Bulk Density
102.01.073	Hygroscopicity
102.01.080	Grain Geometry Conformity
102.01.090	Low Temperature Embrittlement
Category 200	Hazard Assessment
201.01.XXX	Sensitiveness/Sensitivity/ Explosiveness Tests
201.01.001	BAM Impact
201.02.001	Julius Peters Friction
201.03.001	Electrostatic Discharge
201.04.001	21mm BICT (WIWEB) Gap
201.04.002	Intermediate Scale Gap
201.05.001	EIDS Bullet Impact
201.06.001	High Velocity Fragment Impact
201.07.001	50mm Shaped Charge Impact
202.01.XXX	Stability Tests
202.01.XXX	Thermal
202.01.001	Steel Tube (KOENEN)
202.01.002	Temperature of Ignition

202.01.003	Weight Loss at 90 °C
202.01.004	Bergmann-Junk-Siebert
202.01.005	Heat Flow Calorimetry
202.01.06	Vacuum Stabilityt
202.01.07	202.01.007 DSC/TG
202.01.008	HPLC for Stabiliser Depletion not Covered by STANAG 4117, 4541 and 4542
202.01.009	HPLC for Stabiliser Depletion Covered by STANAG 4117, 4541 and 4542
202.01.010	Tube Test (FCO & SCO)
<u>203.01.XXX</u>	<u>Compatibility & Reactivity Tests</u>
203.01.001	Heat Flow Calorimetry
203.01.02	Vacuum Stability Test
203.02.XXX	Other Tests
203.02.001	Plasticiser Migration Evaluation
<u>Category 300</u>	<u>Performance Assessment</u>
<u>302.00.XXX</u>	<u>Experimental Methods</u>
302.01.001	Detonation Velocity Test
302.02.001	Burning Rate Test
302.02.002	Manometric Bomb Test
302.03.XXX	Other Tests
302.03.001	Heat of Combustion Test

10.7.14.7 CATALOGUE OF SWITZERLAND'S TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with the Registry Number.

CH/101.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives

2. TEST TITLE: HPLC for Energetic Material used in High Explosives not Ruled in Corresponding STANAGs

a. Type of Test: Chemical Properties/Determination of the Individual Content of the Components in the Explosives by High Performance Liquid Chromatography (HPLC).

b. Description: A state of the art High Performance Liquid Chromatographic system, including a suitable UV detector and a gradient solvent system is needed. The explosive is dissolved in acetone or in an other convenient solvent. The solution is then injected and the sample components are separated with the aid of a reversed phase column. An optimised liquid phase mixture which allows base line separation of the component peaks has to be used. For a mixture containing RDX, HMX, TNT, Tetryl and PETN a C-18 reverse phase column as a stationary phase and an eluent mixture of about 65% acetonitrile and 35% water is recommended. All eluents need to have HPLC quality (Purity: 99.5% or better). A detector wave length of 220 nm is used. If a diode array detector is available, an optimised wave length for each individual component can be used too. The components of a sample are identified by their eluation time. The run time of the mentioned explosives should be less than ten minutes. For the acquisition of quantitative information the chromatographic peak areas have to be related to their corresponding concentrations by following a sample concentration screening. Thereby the wave length of detection has to be fixed for each component. Based on this calibration function and the detected peak area for a certain component the corresponding concentration can be calculated.

c. Information Requirements for Assessment: The test results are used for the characterisation of energetic materials or as a verification of product specifications.

d. Typical Results: Depends on explosive under investigation. The method works for explosive compositions containing 0.01% to nearly 100% of energetic material.

e. Repeatability and Reproducibility: If the composition of the explosive is inhomogeneous, multiple specimens at different locations must be investigated. The relative error of the quantitative results should be less than 0.5 %.

3. NATIONAL REFERENCES:

(1) Report FA26-SIG BE 980918 1462

CH/101.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Determination of Propellant Components

a. Type of Test: Chemical Properties/Analysis Using Different Techniques

b. Description:

(1) Determination of *organic components* (monomeric or oligomeric compounds): Propellant samples (ground or not ground – according to propellant type) are (i) digested in acetonitrile (containing internal standard), followed by precipitation with water and centrifugation, or (ii) extracted with dichlormethane (attention: stabilisers such as akardite and centralite are only extracted quantitatively from small propellant grains or from ground propellants). The organic compounds are then determined by means of HPLC (high performance liquid chromatography), by GC (gas chromatography), ore by other analytical techniques of similar accuracy.
(2) Determination of ***residual solvents***: Propellant samples (unground) are (i) digested in n-butylacetate as described above, or (ii) soaked in a solvent mixture that swells the propellant and extracts the residual solvents (but not the nitrocellulose). The residual solvents are then determined by means of GC (gas chromatography).
(3) Determination of **inorganic components**: (i) Propellant samples (ground except for fine granular propellant) are digested in nitric acid. The inorganic compounds (metal salts) are then determined by means of AAS (atomic absorption spectroscopy). (ii) Soluble salts can also be extracted with water and then determined by AAS. Other analytical techniques of similar accuracy, such as gravimetry, are also allowed.
(4) Determination of ***moisture***: The propellant is digested in a mixture of "Karl-Fischer Reagent 1" and methanol; then titrated with "Karl-Fischer Reagent 2" in a Karl Fischer titration apparatus.
(5) Determination of ***nitrocellulose content***: (i) The nitrocellulose is extracted from the residue of the dichlormethane extraction using acetone, followed by precipitation with water (gravimetric determination).

c. Information Requirements for Assessment: The test results are used to confirm that the composition of the propellant matches the declaration of the manufacturer, or that the composition lies within the limits given in the product performance description.

d. Typical Results: Depends on propellant type.

e. Repeatability and Reproducibility: Depends on analytical procedure used.

3. NATIONAL REFERENCES:

(1) NITROCHEMIE WIMMIS AG; Different Testing Procedures
(2) German "Technische Lieferbedingungen" TL 1376-0600, Chapter 1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Determination of Pyrotechnic Components

a. Type of Test: Chemical Properties/Analysis using Different Techniques

b. Description: Pyrotechnic compositions consist typically of one or more reducing agents, one or more oxidisers and a binder.

(1) Determination of the ***oxidisers***: A sample of the pyrotechnic composition is dissolved in water or hydrochloric acid. The oxidiser content is determined by using ion chromatography, ion-selective electrodes or by classical analytical methods.

(2) Determination of the ***reducing agent***: A sample of the pyrotechnic composition is dissolved in nitric acid or in a convenient solvent. The reducing agents (metal powders) are detected by using AAS (atomic absorption spectroscopy) or other techniques of similar accuracy as mentioned above.

(3) Determination of the ***binder***: A sample of the pyrotechnic composition is dissolved in an organic solvent as e.g. acetone. The quantitative analysis is done by using a gravimetric method, the identification of the substance is done by IR (infrared spectroscopy) or NMR (nuclear magnetic resonance spectroscopy).

(4) Determination of ***moisture***: A sample of the pyrotechnic composition is digested in a mixture of "Karl-Fischer Reagent 1" and methanol; then titrated with "Karl-Fischer Reagent 2" in a Karl Fischer titration apparatus.

c. Information Requirements for Assessment: The test results are used to confirm that the pyrotechnic composition matches the declaration of the manufacturer, or that the composition lies within the limits given in the product performance description.

d. Typical Results: Depends on the pyrotechnic composition under investigation, e.g.: 20% (w/w) Boron, 79% (w/w) Potassium Nitrate, 1% (w/w) Nitrocellulose.

e. Repeatability and Reproducibility: Depends on analytical procedure used.

3. NATIONAL REFERENCES:

CH/102.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Rocket Propellants /Main Charge High Explosives (PBX)

2. TEST TITLE: Uniaxial Tensile Test

a. Type of Test: Mechanical and Physical Properties/Tensile Behaviour of Poly- mer Based Propellants and Explosives.

b. Description: JANNAF (if geometry allows) or otherwise specified samples are cast or machined from bulk. After conditioning, these samples are subjected to a defined load. Force, elongation and time are recorded. Parameters as Temperature, dimension of the sample and crosshead speed are influencing the results and have therefore to be specified too.

c. Information Requirements for Assessment: Changes in the mechanical properties of polymeric based propellants and explosives may affect their performance and functionability. This test is used to assess the mechanical properties, to ascertain physical ageing behaviour and chemical degradation and to predict the lifetime.

d. Typical Results: The mechanical properties of cured polybutadiene propellant (HTPB/AP) at ambient temperature, JANNAF specimen, crosshead speed 50.8mm/min are

(1)	Strain (max)	6 kg/cm^2
(2)	Elongation (max)	40 %
(3)	Elongation (break)	43 %
(4)	E-Module	46 kg/cm^2

e. Repeatability and Reproducibility:

(1)	Strain	$\pm$ 0.5 kg/cm^2
(2)	Elongation (max)	$\pm$ 7.0 %
(3)	Elongation (break)	$\pm$ 8.5 %
(4)	E-Module	$\pm$ 6.0 kg/cm^2

3. NATIONAL REFERENCES:

(1) Report Nitrochemie AG, SIG BP2666
(2) Report FA26, Nr.1496

CH/102.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Rocket Propellants (Case Bonded)

2. TEST TITLE: Double Plate Tensile Test

a. Type of Test: Mechanical and Physical Properties/Adhesion Between the Interfaces of Propellant , Liner and Case.

b. Description: The test is limited to case bonded rocket motors only. In this test, tapped solid specimen (12 mm x 25 mm x 25 mm) consisting of Propellant, Liner and Case are put under mechanical load. Specimen are pulled in tension at low rate of strain until failure. Bond Tensile Strength and Time to max. Stress are recorded. The Type of Failure is described. Parameters such as specimen dimension, crosshead speed, temperature and applied load will affect the results and have therefore to be specified.

c. Information Requirements for Assessment: Bond failure either between propellant and liner or liner and case influences performance and functionality of a rocket motor. This test is used to assess the state of the interfaces propellant/liner/case.

d. Typical Results: Cured polybutadiene propellant motors (HTPB/AP, HTPB, steel) show at room temperature and a crosshead speed of 12.7 mm/min the following, typical values:

(1) - Bond Tensile Strength: 0.85 N/mm^2
(2) - Time to max. Stress: 0.09 minutes
(3) - Failure Pattern: Propellant on Liner, clean Separation of Case

e. Repeatability and Reproducibility:

(1) - Bond Tensile Strength: $\pm$ 0.2 N/mm^2

3. NATIONAL REFERENCES:

(1) Report Nitrochemie AG, SIG BP2666

CH/102.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Rocket Propellants

2. TEST TITLE: Uniaxial Compression Test

a. Type of Test: Physical and Mechanical Properties/Uniaxial Compression at Constant Deformation Rate.

b. Description: A tensile test equipment with a conditioning chamber (temperature) and a computerised data acquisition system is used to perform uniaxial compression tests at constant deformation rate. Breaking pressures and initial compression E-moduli may be determined as a function of temperature and deformation rate. Cylindrical test samples with a diameter of 21mm and a height of 21mm have to be used for this test. If samples of other dimension are used, the dimension have to be specified and related to typical standard samples. At least three tests have to be conducted.

c. Information Requirements for Assessment: The test is used to assess the mechanical behaviour of explosive pellets when exposed to compression. These parameters show a correlation to sensitivity data of corresponding charges.

d. Typical Results: A wide range of compression moduli and breaking pressures may be measured for high explosives and propellants, depending on composition and application.

	Max. Pressure	Compression E-modulus
(1)	LX-1419.4 ± 0.3MPa	21613 ± 770N/mm^2
(2)	Oktastit VIII	15.7 ± 0.5MPa 11131 ± 700N/mm^2

Dimension: ∅21x15mm
Conditions: Deformation rate 0.005mm/s, ambient temperature

e. Repeatability and Reproducibility: Assuming that the test samples are homogeneous, the breaking pressure should be within 1.0 MPa.

3. NATIONAL REFERENCES:

CH/102.01.020

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives (PBX)/Solid Rocket Propellants

2. TEST TITLE: Dynamic Mechanical Analysis Test (DMA)

a. Type of Test: Mechanical and Physical Properties/Mechanical Behaviour Under Dynamic Load and Temperature.

b. Description: Solid specimens are either machined from bulk or cast. A typical specimen is a rectangular bar of 10 mm x 6mm x 50 mm. Conditioned specimens are cooled down and then heated up continuously (5K/min). The changes in length and temperature are recorded. Changing of heating rate, mechanical load frequency and specimen dimensions will affect the results. These parameters have to be specified.

c. Information Requirements for Assessment: The test is used to determine the Glass Transition Temperature (T_g) of polymer based propellants and main charge explosives (PBX). The glass transition point defines the lower temperature limit for the application of polymer based explosives and solid rocket propellants. If this temperature changes after storage or artificial ageing, a change in the behaviour of the explosive has to be expected. Life time predictions can be made by monitoring the changes of T_g during artificial ageing of the samples.

d. Typical Results: Glass Transition Temperature (T_g):

(1)	- Cured Polybutadiene propellant (HTPB/AP):	- 78 °C
(2)	- Double Base propellant:	- 30 °C
(3)	- LX-14:	- 30 °C

e. Repeatability and Reproducibility: The results are repeatable within 2°C

3. NATIONAL REFERENCES:

(1) Report FA26, Nr. 1521
(2) STANAG 4540

CH/102.01.021

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives/Solid Rocket Propellants

2. TEST TITLE: Thermomechanical Analyses (TMA)

a. Type of Test: Mechanical and Physical Properties/Coefficient of Linear Thermal Expansion.

b. Description: Specimen are cast or machined from bulk. Typical dimension of these solid specimen are 10 mm in length and 10 mm in diameter. After conditioning the samples are cooled down and then heated up continuously. A typical heating rate is 5K/min. A purging gas, e.g. Helium, with a flow rate of 20ml/min is used. Specimen dimension and heating rate are affecting the results. These parameters have to be specified.

c. Information Requirements for Assessment: The test enables the characterisation of the mechanical properties of polymer based propellants and explosives. Significant changes in the coefficient of linear thermal expansion, $\alpha(T)$, result in different behaviour of the materials. By monitoring this Coefficient on samples artificially aged at elevated temperatures, lifetime prediction is possible. Repeating this test several times on the same sample allows to assess hysteresis effects.

d. Typical Results: Coefficient of Linear Thermal Expansion, $\alpha(T)$, of cured polyurethane propellant (HTPB/AP) is:

(1) 8.5×10^{-5} mm/°C (-70°C to 100°C)
(2) 10.1×10^{-5} mm/°C (-70°C to 100°C) Aged sample: 4 weeks, 63 °C

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

(1) Report FA26, Nr. 1521
(2) STANAG 4525

CH/102.01.050

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives (PBX)/Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: DSC (Glass Transition Temperature)

a. Type of Test: Mechanical and Physical Properties/Low Temperature Behaviour of Propellants and Explosives.

b. Description: Commercial equipment is used. Whenever possible the explosive samples are used in their original form. If this is not possible, the samples are cut into adequate pieces or ground and sieved. After loading 10 to 20 mg of this material (film, powder, granular or crystalline form) into an aluminium crucible, the crucible is sealed and then cooled down. Nitrogen is used as an inert purging gas (typical flow rate: 50 ml/min). The sample is then heated up at a constant rate of 20°C/min, whereas heat flow effects indicate a change in the physical state of a polymer. Scan rate, sample size, physical state and purge gas are affecting the results. Therefore these parameters have to be specified.

c. Information Requirements for Assessment: The test is used to characterise the low temperature behaviour of polymeric based propellants and main charge explosives (PBX). Glass Transition Temperature (T_g) is measured. Also the heat capacity (c_p) can be extracted in a certain temperature range. The test allows further the assessment of physical ageing and chemical degradation of polymers. The glass transition point defines the lower temperature limit for the application of polymer based explosives.

d. Typical Results: Glass Transition Temperature (T_g):

(1) Cured Polybutadiene propellant (HTPB/AP): - 82°C

e. Repeatability and Reproducibility: The Results are repeatable within 5°C.

4. NATIONAL REFERENCES:

(1) Laboratory Report, FS261, 28.05.1999
(2) Report FA26, Nr. 1496

CH/102.01.070

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Density (Gas Pyknometry)

   a. Type of Test: Physical and Mechanical Properties/Determination of Density by Gas Displacement in a Gas Pyknometer.

   b. Description: The volume of air which is displaced by an accurately weighted portion of sample is determined by means of a gas pyknometer. The density of the sample is then calculated as quotient sample weight / sample volume.

   c. Information Requirements for Assessment: The test result is used for characterisation and quality assurance. Reduced density values may indicate defects / inclusions such as voids and fissures or insufficient gelatination of the nitrocellulose in the propellant.

   d. Typical Results:

      (1) 1.5 – 1.8 g/cm^3 for single/double/triple base propellants.

   e. Repeatability and Reproducibility: The measured density is accurate to 0.3%.

3. NATIONAL REFERENCES:

   (1) Testing Procedure P 8 010 040; NITROCHEMIE WIMMIS AG
   (2) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 3.31

CH/102.01.071

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Rocket Propellants/ Pyrotechnics

2. TEST TITLE: Density of Regularly Shaped Samples

a. Type of Test: Physical and Mechanical Properties/Density.

b. Description: The density ($\rho = m/V$) of pressed cylindrical pellets can be determined by weighting the pellet with a high precision balance and by calculating the corresponding volume due to the measured height (h) and diameter (d) of the cylinder ($\rho = 4m/\pi d^2 h$). Because pressed pellets can have a slightly conical shape, at least three diameters should be measured: one on top, one in the middle and one at the bottom of the pellet. An averaged value should be used. The roundness of the pellet should also be checked. The density of casted samples is determined by weighting the mould before and after the casting process. The corresponding volume can be calculated either from technical drawings under consideration of filling height or by determining the volume of a liquid which is consumed to fill the mould. If the explosive sample is completely insoluble in water, also the principle of Archimedes can be used. The advantage of this method is, that also samples with a more complicated shape can be measured in an easy way. Rough surfaces should be avoided. The water temperature has to be equilibrated accurately to 20.0 °C. The force used to hold the sample in air (F) and within a water bath (F_w) is measured. The corresponding density can be calculated as $\rho = \rho_w F/(F-F_w)$, whereas ρ_w = 998.206 kg/m^3 at 20 °C. Instead of water other adequate liquids can be used. Also the temperature can be changed. The experimental conditions have to be specified.

c. Information Requirements for Assessment: The test result is used for characterisation of explosives and quality assurance of charge manufacturing processes. Reduced density values may indicate defects/inclusions such as voids and fissures.

c. Typical Results:

(1)	Hextro 60/40 cast cylinder		1.709 g/cm^3
(2)	LX-14	isopressed shaped charge	1.820 g/cm^3
(3)	LX-19	isopressed shaped charge	1.926 g/cm^3

d. Repeatability and Reproducibility: Depends very much on the size of the sample and the method used to determine the density. The accuracy of the density should be within ±0.003 g/cm^3

3. NATIONAL REFERENCES:

(1) Testing Procedure: Swiss Munition Enterprise (SM), PE 4945200 (13.12.1988)

CH/102.01.072

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Gun Propellants and Pyrotechnics

2. TEST TITLE: Bulk Density (Gravimetric Density)

   a. Type of Test: Physical and Mechanical Properties/Determination of Bulk Density by Filling the Sample Through a Funnel Into a Container of Defined Volume.

   b. Description: The test is only applicable to grain explosives. The dimensions of the apparatus have to be specified since the result of the test may depend on vessel dimension and filling height. In case of propellant testing, a cylindrical vessel having a volume of 1 liter is used; adequate volumes for high explosives and pyrotechnics have to be chosen.The sample is filled into a funnel which lower opening is closed by a slide valve. After opening of the slide valve, the sample trickles into a cylindrical vessel. The surplus explosive is removed by carefully scrapping off along the upper edge of the vessel. The explosive's gravimetric density is calculated as mass of explosive present in the vessel divided by the volume of the vessel.

   c. Information Requirements for Assessment:The test result is used for quality assurance. Reduction in bulk density means that less explosive can be filled into the ammunition cartridge or into a explosive pressing mould. Reduced bulk densities indicate changes in the granulation process.

   d. Typical Results:

(1)	Single/double base granular propellants:	950 - 1100 g/dm^3
(2)	LX-14:	880 g/dm^3

   e. Repeatability and Reproducibility: The measured bulk density is accurate to 0.3%.

3. NATIONAL REFERENCES:

   (1) Testing Procedure P 8 010 169; NITROCHEMIE WIMMIS AG
   (2) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 3.21

CH/102.01.073

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Hygroscopicity Test

a. Type of Test: Physical and Mechanical Properties/Determination of the Hygroscopicity of the Propellant by Measuring the Change in Moisture Content as a Function of Air Humidity Level.

b. Description: Large propellants are ground or cut into pieces of maximum size 20 mm x 20 mm x 3 mm. Air of defined humidity can be produced (i) through moistening an air stream by bubbling it through water, followed by dilution with dry air, or (ii) by putting a bowl containing a saturated salt solution into a desiccator. Temperature has to be kept constant as the humidity level obtained does strongly depend on temperature. Humidity levels between 45% and 85% (Swiss method), and between 22% and 86% (German method) should be chosen.

The uptake/loss of moisture can be determined by weighting of the sample or by determination of its water content by the Karl-Fischer method.The result can be displayed as (i) equilibrium value (equilibrium moisture level in function of humidity; so called "Hygroscopicity Curve", German method), or (ii) as curve showing the change in moisture content for a specific humidity level in function of time (Swiss method).

c. Information Requirements for Assessment: Knowledge of the hygroscopicity is important, as in cases when the explosives humidity is far from equilibrium during assembling of the ammunition, uptake/loss of moisture may change the performance characteristics of the ammunition or lead to malfunction.

d. Typical Results: At 65% relative humidity:

(1) - single base propellants: 0.5% – 2.0% equilibrium moisture content
(2) - double base propellants: 0.1% – 0.5% equilibrium moisture content

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

(1) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 6.11

CH/102.01.080

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Grain Geometry Conformity Test

   a. Type of Test: Physical and Mechanical Properties/Determination of Grain Geometry of Propellants by Micrometry or by Measuring under a Microscope.

   b. Description: The dimensions of propellants of larger size are determined using micrometers. The dimensions of small propellant grains (granular, flake or ball propellant) are determined by the use of an optical microscope especially equipped for distance measurements (e.g. equipped with xy-stage being able to submit the actual position to a computer).

   For the determination of web-sizes of one- and multi perforated propellants, cutting of the grains before measurements is sometimes necessary. Alternatively, a system consisting of a video camera, combined with optical image analysis, can be used for the assessment of grain geometry. Because of the inhomogeneity of extruded propellants, at least 20 to 30 different grains have to be measured in order to achieve reliable results.

   c. Information Requirements for Assessment: The test result is used for quality assurance. The interior ballistic behaviour of a propellant depends strongly on its dimensions.

   d. Typical Results: Depending on propellant type.

   e. Repeatability and Reproducibility: The measured dimensions are accurate to 1% to 5%; depending on propellant, measured parameter and used equipment.

3. NATIONAL REFERENCES:

   (1) Testing Procedure P 8 010 026; NITROCHEMIE WIMMIS AG

CH/102.01.090

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Low Temperature Embrittlement Test

a. Type of Test: Physical and Mechanical Properties/Determination of the Increase of Propellant Surface Caused by Compression at -40°C The Increase in Surface is Determined by Manometric Bomb Testing.

b. Description: At lower temperatures, propellants may become brittle. Due to this brittleness, mechanical stress (as for example caused during ignition of the propellant) might cause crushing of the propellant grains, leading to a dangerous increase in the burning surface and, as a consequence, in the peak gas pressure. The test procedure described here is aimed to show the tendency of a propellant to break at low temperatures.

300 g of the propellant is stored in a cylindrical sample vessel of 110 mm inner diameter, covered by an airtight bag, at -40°C for at least 12 hours. The vessel is then put into a press with piston diameter of 110 mm. The sample is then compressed with 30 MPa (300 bar) for 4 seconds. After equilibration at +21°C, the pressed sample as well as an unpressed (reference) sample are tested in the manometric bomb at +21°C using loading densities of 0.21 g/cm^3.

For the interpretation, the quotients (vivacity of pressed sample / vivacity of reference sample) are calculated for p/p_m-values between 0.2 and 0.7 and plotted in a diagram. The extrapolation of a linear regression through the above data points to the ordinate origin ($p/p_m = 0$) yields a value which represents a measure for the relative increase of propellant surface induced by the pressing at -40°C.

Instead of using 300 g sample in a 110 mm vessel, a scaling down to 90 g propellant in a sample vessel of 60 mm inner diameter is also possible. The pressure of 30 MPa is then obtained with a pressing force of 85'000 N.

c .Information Requirements for Assessment: The test result is used in order to reduce the risk of accidents when firing the propellant (in the designated ammunition) at low temperatures.

d. Typical Results:

(1) Values up to 130%: acceptable
(2) Values betw. 130 and 200%: acceptable with conditions Values above 200%: not acceptable

e. Repeatability and Reproducibility: Better than 10%.

3. NATIONAL REFERENCES:

(1) Handbuch Prüfverfahren für die innenballistische Sicherheit von Panzermunition, BWB WM II 6 (Germany)
(2) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 5.11

CH/201.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: BAM Impact Test

a. Type of Test: Sensitivity/Impact Test

b. Description: The BAM impact test is used to determine the sensitivity of solid, gelatinous and liquid explosive substances to impact. The drop hammer apparatus consist of a heavy base plate, a steel anvil, a column of steel pipe fixed to the base plate and two guide rails for the drop weights fastened to the column. To the equipment belong drop weights of (0.025, 0.05, 0.1, 0.5 kg) 1 kg, 2 kg and 5 kg. The maximum height is 1 m. The test substance rests between two steel cylinders.

Powdered substances are dried and sieved on a definite particle size (e.g. Lead azide <160 μm, Lead Styphnate, Tetrazene <300 μm) before testing. A sample size of 10 and/or 40 mm^3 is used. The explosive material is tested with different fall heights until six samples show no reaction at the same drop weight and height, and one or more samples show a reaction with the next higher energy level.

c. Information Requirements for Assessment: The test is used to determine the sensitiveness of powdered material to initiation by mechanical impact between metal surfaces. In ageing studies the change of impact sensitivity gives an indication about shelf life of energetic material from point of view of handling safety.

d. Typical Results:

Explosives	**Drop Height**	**Drop Weight**	**Impact Energy**
Lead Azide (40 mm^3)	25 cm	1 kg	2.5 J
Lead Styphnate(10 mm^3)	15 cm	1 kg	1.5 J
Octogen (40 mm^3)	15 cm	5 kg	7.5 J
PETN (10 mm^3)	30 cm	1 kg	3.0 J

e. Repeatability and Reproducibility: Repeatability of results is within the range of approximately +1 test increment.

3. NATIONAL REFERENCES:

(1) Explosivstoffe (Sonderdruck Nr. 8, 9, 10/58); H. Koenen, K.H. Ide, W. Haupt, P. Langen, BICT Report Az.:2.2-9/5867/82, Sensitivity to Impact: Test Description and Procedure.
(2) Julius Peters K.G., Berlin 21; Apparaturen zur Ermittlung der Sicherheitstechnischen Kenndaten explosiver Stoffe.

CH/201.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Julius Peters Friction Test

a. Type of Test: Sensitivity/Friction Test

b. Description: The sensitivity of explosive substances to friction is tested by means of the BAM Friction Test. The apparatus and the experimental set-up is described in detail in STANAG 4487. Powdered substances are sieved through a 0.5 mm mesh screen. Shavings from solid samples or thin machined discs of the material can be used. A porcelain plate of defined roughness is fixed on the carriage of the friction apparatus transverse to the direction of movement. A test quantity of 10 mm^3 is placed on the plate. To define the force between peg and plate a weight is placed in the desired position on the load arm. The sample is frictioned by moving the porcelain plate against the peg. Because the roughness of the plate and the peg is essential for the reaction of the material, each part of the surface may be used only once. The explosive material is tested with different weights on the peg arm until six samples show no reaction at the same weight and one or more samples show a reaction with the next higher weight. The resulting behaviour of the sample are reported as "No Reaction", "Crackling", "Deflagration" and "Detonation".

c. Information Requirements for Assessment: The friction sensitivity is used for the assessment of handling safety of energetic material. In ageing studies the change of friction sensitivity gives an indication about shelf life of energetic material from point of view of handling safety.

d. Typical Results:

(1)	HMX Class C	96 N	Crackling
(2)	Nitrocellulose E 220	192 N	Burning
(3)	Igniter mixture	80 N	Crackling (Ti(E)/$KClO_4$/NC)
(4)	Lead Azide	10 N	Crackling

e. Repeatability and Reproducibility: Reproducibility of results is within the range of +1 test increment.

3. NATIONAL REFERENCES:

(1) H. Koenen, K.H. Ide, Explosivstoffe 3(1955) 57-65, 89-93
(2) H. Koenen, K.H. Ide, K.-H. Swart, Explosivstoffe 9(1961) 13- 14, 30-42
(3) P. Langen, BICT Report Az 2.2- 9/5868/82, Sensitivity to Friction
(4) UN Recommendation on the Transport of Dangerous Goods, 2nd edition (1995)
(5) STANAG 4487

CH/201.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Electrostatic Discharge Test

a. Type of Test: Sensitivity/Spark Test

b. Description: The apparatus consists of two electrodes, a commercial available pin with an exactly defined point and a brass plate with a defined surface. An electronic control device controls the correct energy charge of the lowerable pin electrode. Powdered substances are sieved through a 0.5 mm mesh screen. From solid samples shavings or thin machined discs of the material can be used. 10 mm^3 of the energetic material is brought into each of the six holes on the sample holder, contacting the brass plate. After an energy has been chosen the pin electrode is moved towards the sample on the brass plate and the reaction of the energetic material is observed. The results are reported as "No reaction", "Burning", "Deflagration" and "Detonation". The explosive material is tested with different discharge energies until six samples show no reaction at the same energy level and one or more sample show a reaction on the next higher energy level.

c. Information Requirements for Assessment: The spark test is used for the assessment of handling safety of energetic material. In ageing studies the change of electrostatic discharge sensitivity gives an indication about shelf life of energetic material from point of view of handling safety.

d. Typical Results:

(1)	HMX	1,0 J	Burning
(2)	NC E 220	5.6 J	No Reaction
(3)	Zirconium Type CX	1.8 µJ	Burning (Glowing)
(4)	Lead Azide	200 µJ	Burning

e. Repeatability and Reproducibility: Repeatability of results is within the range of +1 test increment.

3. NATIONAL REFERENCES:

(1) Report FA26-SIG BIBL / FSFO-SIG FO 10-21 075-01 870409

CH/201.04.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives

2. TEST TITLE: 21 mm BICT (WIWEB) Gap Test

a. Type of Test: Sensitivity/Shock Wave Sensitivity and Detonability.

b. Description: In the BICT Gap Test, the shock wave sensitivity and the detonability of an acceptor explosive are determined as a function of the height of a water column used to transmit and attenuate the shock wave output of a standard donor explosive. Evidence of a detonation is provided by a detonating cord placed on the acceptor charge and having its other end attached to a lead witness plate. The donor charge is of RDX/wax/graphite (94.5/4.5/1) and has a diameter of 21 mm and a length of 20 mm. Its density is 1.60 ± 0.01 g/cm^3. Donor, water and acceptor are enclosed in a plexiglas tube of 21 mm inner diameter and 25 mm outer diameter. The critical diameter of the tested explosives has to be well less than 21 mm.

The limits of non-detonation (shock wave sensitivity) and detonation (detonability) are determined by a step of up-and-down procedure. Tests above the non-detonation limit will always end negatively and tests below the detonation limit will always lead to detonation. Results are quoted as "mm water gap" and may also be supplemented by the corresponding shock pressure. A substance is considered to be more sensitive to shock waves than another if its non-detonation limit is greater than that of the other substance at a given density.

c. Information Requirements for Assessment: The test is used to determine the shock wave sensitivity of booster and main charge explosives.

d. Typical Results:

Explosive	Density [g/cm^3]	Preparation	Limit of detonation [mm] water gap		Limit of non-detonation [mm] water gap	
TNT	1.6	cast	6	-	7	49.5 kbar
TNT	1.6	pressed	20	18.4 kbar	21	17.2 kbar
Oktastit VIII	1.82	pressed	20	18.4 kbar	22	16.2 kbar
PBXW-11	1.79	pressed	18	20.9 kbar	20	18.4 kbar
PBXN-110	1.63	cast-cured	16	24.1 kbar	18	20.9 kbar

e. Repeatability and Reproducibility: Repeatability is ± 1mm water gap

3. NATIONAL REFERENCES:

(1) Report FA26, Nr. 1492
(2) STANAG 4488

CH/201.04.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives

2. TEST TITLE: Intermediate Scale Gap Test

a. Type of Test: Sensitivity/Shock Wave Sensitivity and Detonability

b. Description: In the Intermediate Scale Gap Test, the shock wave sensitivity and the detonability of an acceptor explosive are determined as a function of the height of a Cellulose Acetate Card barrier used to transmit and attenuate the shock output of a standard donor explosive. The thickness of the Cellulose Acetate Cards is 0.19 mm. Evidence of a detonation is proved by a witness charge on a 10 mm thick steel witness plate. The donor and the witness charge are of RDX/wax/graphite (94.5/4.5/1) and have a diameter of 40 mm and a length of 40 mm. Their density is 1.60+/-0.02 g/cm^3. The test specimens are prepared by either casting the sample directly into a 200 mm long steel tube (inner diameter 40 mm, wall thickness 4 mm) or by inserting a cylindrical sample (40 mm diameter by 200 mm length). The critical diameter of the tested explosives has to be well below 40 mm. Donor, Cellulose Acetate Cards, the steel tube with the acceptor charge and the witness charge are placed in three overlapping cardboard tubes.

The limits of non-detonation (shock wave sensitivity) and detonation (detonability) are determined by a step of up-and-down procedure. Tests above the non-detonation limit will always end negatively and tests below the detonation limit will always lead to detonation. Results are quoted as "mm barrier thickness", and are also be supplemented by the corresponding shock pressure. A substance is considered to be more sensitive to shock waves than another if its non-detonation limit is greater than that of the other substance at a given density.

c. Information Requirements for Assessment: The test is used to determine the shock wave sensitivity of main charge explosives.

d. Typical Results:

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

(1) UN Recommendation on the Transport of Dangerous Goods, 2nd edition (1995)

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: EIDS Bullet Impact Test

a. Type of Test: Sensitivity/Reaction Towards 12.7mm Bullet Attack

b. Description: For the EIDS Bullet Impact test a tube (steel 37) with an inner diameter of 47mm, a wall thickness of 4mm and a length of 200mm is used. The end caps are reinforced (outer diameter: 65mm). The explosive ist either cast directly into the tube or pressed to dimensions which tightly fit. Gun propellant grains are filled loosely (gravity feed) into the tube. The loading density has to be recorded.

The test item, which is fixed on a heavy steel table, is impacted by an armour piercing 12.7mm bullet. The impact velocity is 840 ± 40 m/s and the bullet mass is 42g. The impact point is the centre of one of the end caps, whereas a precision of $\pm$1cm has to be achieved. The trajectory of the bullet into the test sample has to be as long as possible. The reaction level of the test item (according STANAG 4241) is assessed by the state the two witness plates (steel 37, thickness 3mm, one at each side) and the fragmentation pattern of the tube. At least three tests have to be conducted per explosive type under consideration, whereas the severest reaction counts for the assessment of the reaction level.

c. Information Requirements for Assessment: This test is used to assess the reaction behaviour of energetic material against 12.7mm armour piercing projectiles.

d. Typical Results:

(1)	Hextro 60/40	1.709 g/cm^3	Deflagration
(2)	Oktastit VIII	1.815 g/cm^3	Explosion
(3)	PBXN-110	1.671 g/cm^3	No Reaction
(4)	PBXW-11	1.792 g/cm3	Burning
(5)	LX-19	1.896 g/cm^3	Detonation

e. Repeatability and Reproducibility: Within the reaction level

3. NATIONAL REFERENCES:

(1) Report, FA26-SIG-BE 960200 1300

CH/201.06.001

TEST INFORMATION SHEET

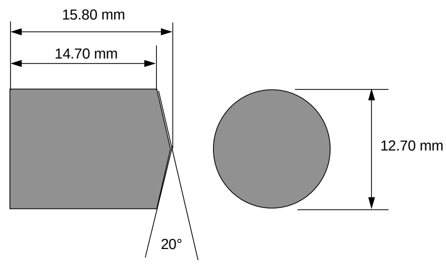
1. TYPE OF EXPLOSIVE: Main Charge High Explosives/Solid Rocket Propellants

2. TEST TITLE: High Velocity Fragment Impact Test

a. Type of Test: Sensitivity/Reaction of Energetic Material Against Intense Shock Generated by an Impacting Fragment

b. Description: For the fragment impact test a tube (steel 37) with an inner diameter of 47 mm, a wall thickness of 4mm and a length of 200 mm is used. The end caps are reinforced (outer diameter: 65mm). The explosive ist either cast directly into the tube or pressed to dimensions which tightly fit. The loading density has to be recorded.

With the aid of a sabot the fragment (14.94 g) is accelerated and launched with a velocity of 1830 ± 60 m/s to the target. The impact velocity is recorded as well as the generated overpressure (corrected by the overpressure generated by the cannon), the state of the witness plates (steel 37, thickness: 2mm) and the fragmentation pattern of the tube. The reaction level is assessed according the definition given in MIL-STD 2105B.



c. Information Requirements for Assessment: This test is used to assess the reaction behaviour of energetic material against light weight high velocity fragments.

d. Typical Results:

(1)	Hextro 60/40 $\rho = 1.709$ g/cm^3	v = 1816 m/s	Detonation
(2)	PBXN-9 $\rho = 1.740$ g/cm^3	v = 1814 m/s	Partial Detonation
(3)	PBXN-110 $\rho = 1.671$ g/cm^3	v = 1822 m/s	Burning
(4)	TATB $\rho = 1.864$ g/cm^3	v = 1824 m/s	No Reaction

e. Repeatability and Reproducibility: depends on the ratio between shock initiation threshold of the sample and the shock generated by the impacting fragment.

3. NATIONAL REFERENCES:

(1) FA26-SIG-BE 971209 1410

CH/201.07.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Rocket Propellants

2. TEST TITLE: 50mm Shaped Charge Impact Test

   a. Type of Test: Sensitivity/Reaction of Solid Rocket Propellants Against Shaped Charge Impact.

   b. Description: A 50 mm shaped charge (RSC), consisting of a copper cone with a 60° angle and Oktastit VIII high explosive is fired against a rocket motor generic unit which is well fixed on a heavy holding device. The firing stand-off is 2CD. The rocket motor generic unit should be similar to the foreseen application. The shaped charge jet should pass the longest possible trajectory through the energetic material. If the rocket motor contains a cavity, such as a centre bore, the jet should be aimed to pass through this cavity at an angle of 90 degrees. An impact angle smaller than 70 degrees should be avoided. Behind the target RHA steel plates should be installed to record the residual penetration and to protect the surrounding area. The reaction of the test item is further recorded by 2 mm steel witness plates at two sides, where most fragments are expected, and by a 10mm steel ground plate. Overpressure measurements have to be conducted, whereas the overpressure generated by firing the shape charge has to be taken into account too. The reaction of the energetic material in the rocket motor generic unit is classified into five classes as defined in MIL STD 2105B.

   c. Information Requirements for Assessment: This test is used to assess the reaction level of a rocket motor energetic material stimulated by shaped charge impact under conditions, which are consistent with a future application.

   d. Typical Results: Detonation of most high filled nitramin motors.

   e. Repeatability and Reproducibility: depends on test item

3. NATIONAL REFERENCES:

CH/202.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Steel Tube Test (KOENEN)

a. Type of Test: Safety/Strong and Sustained Thermal Stimulus

b. Description: Solid, liquid and gelatinous substances are tested by filling them into steel tubes of 24 mm inner diameter, 0.5 mm wall thickness and 75 mm length. The open end of a tube is sealed with one of a number of available steel orifice plates having orifices with diameters from 1 to 20 mm. The plates are firmly secured by a threaded collar and nut. An additional diameter of 24 mm results when the test is conducted without an orifice plate.

The tube is suspended between two rods placed through holes drilled in opposite walls of a steel protective box. One side and the top of the box are open. The walls and the base are fitted with four propane gas burners, each set up in such a manner, that the tip of the inner blue flame just touches the tube with the material to be tested. The propane gas flow is adjusted to a heating rate of about 3.3 °C/s between 50 °C and 250 °C using Dibutylphtalate.

The burners are ignited and the time (t_1) between ignition and the first reaction of the sample a well as the reaction time (t_2) itself are noted. With the aid of a step up and down procedure the orifice plate limiting diameter is determined. This limiting diameter defines a confinement, which leads to at least one explosion in three experiments under the described thermal impact. Explosion is defined as the event causing the steel tube to fragment into three or more pieces.

c. Information Requirements for Assessment: This test is used to assess the thermal sensitivity of explosive substances in solid or liquid form under a defined confinement. It is also required by the Swiss Transportation Safety Board for Transport Classification.

d. Typical Results:

(1)	LX-14	3 mm	t_1:	17 s	t_2:	3 s
(2)	PBXN-5	8 mm	t_1:	10 s	t_2:	2 s
(3)	Single Base	5 mm	t_1:	7 s	t_2:	--
(4)	Double Base	8 mm	t_1:	7 s	t_2:	--
(5)	B/KNO_3	20 mm	t_1:	10 s	t_2:	26 s

e. Repeatability and Reproducibility: ± 1 mm up to 6 mm diameter

3. NATIONAL REFERENCES:

(1) UN Recommendation on the Transport of Dangerous Goods, 2nd edition (1995)
(2) Arbeitsanweisung: FA26 PSE-BSA-P-001.01
(3) STANAG 4491

CH/202.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives/Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Temperature of Ignition Test

   a. Type of Test: Stability/Heating of a Sample Until an Event Occurs

   b. Description: A standard mass of the explosive material under test is heated in a test tube located in a metal oven at a standard rate until an event occurs. The lowest temperature at which a visible sign of ignition or decomposition is observed is taken as the temperature of ignition or decomposition.

   Fine granular explosives are used in original form, whereas explosives of larger size are ground and sieved. The fraction 0.7 - 2 mm is used. Typical sample mass is 0.2 g for propellants and main charge explosives or 0.1 g in case of nitrocellulose and main charge explosives. For primary explosives and pyrotechnics, even smaller amounts might be necessary (such as 0.005 to 0.010 g). A heating rate of 5°C/min is commonly used.

   The actual values of "Temperature of Ignition" obtained are only useful under the particular conditions used, and changing the rate of heating or size of sample will lead to different results.

   d. Information Requirements for Assessment: The test result is used for quality assurance. It determines the temperature at which an explosive ignites or decomposes.

   d. Typical Results:

(1)	Tetryl	179 – 181°C
(2)	RDX	215 – 216°C
(3)	Tetracene	131 – 132°C
(4)	Nitrocellulose	180 – 190°C
(5)	Gun propellants	165 – 180°C

e. Repeatability and Reproducibility: Repeatability within 2°C

3. NATIONAL REFERENCES:

   (1) Testing Procedure P 8 010 852; NITROCHEMIE WIMMIS AG;
   (2) STANAG 4491

CH/202.01.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Weight Loss Test at 90°C

a. Type of Test: Stability / Heating the Sample at 90°C for a Given Period of Time; Determination of the Weight Loss.

b. Description: A standard mass of the propellant under test is heated in "90°C weight loss tubes" in a metal heating block or equivalent heating device at 90°C for 18 days (double/triple base propellants) or for 28 days (single base propellants). The weight loss within the first 8 hours is regarded as "volatiles". The weight loss from "eight hours" to 18 or 28 days is determined.

Fine granular propellants with web sizes < 1.3 mm are used in original form. Propellant of larger size are cut into smaller pieces or ground and sieved. The fraction 0.7 – 2 mm is used for the test.

a. Information Requirements for Assessment: The test result is used for estimating the chemical stability of the propellant.

b. Typical Results:

(1) Requirements: Weight loss ≤ 3.0% without auto catalysis.

e. Repeatability and Reproducibility: Repeatability within 0.2% (abs.)

3. NATIONAL REFERENCES:

(1) Testing Procedure P 8 400 012; NITROCHEMIE WIMMIS AG;
(2) Testing Procedure of ICT, Fraunhofer Institut Chemische Technologie, Pfinztal, D;
(3) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 2.31.1.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Bergmann-Junk-Siebert Test

a. Type of Test: Stability/Heating the Sample at 132°C for a Given Period of Time; Determination of the Evolved Nitrogen Oxides.

b. Description: A standard mass of the propellant under test is heated in "Bergmann-Junk-Siebert tubes" in a metal heating block or equivalent heating device for 5 hours (single base propellants) or at 115°C for 8 or 16 hours (double/triple base propellants). The total acid produced by oxidation of the decomposition products in the presence of a 3% H_2O_2 solution is determined by titration with sodium hydroxide using Tashiro indicator.

Results are expressed as ml 0.01n NaOH/g propellant.

Fine granular propellants with web sizes <1.3 mm are used in original form. Propellant of larger size are cut into smaller pieces or ground and sieved. The fraction 0.7 mm to 2 mm is used for the test.

c. Information Requirements for Assessment: The test result is used for estimating the chemical stability of the propellant.

d. Typical Results:

(1) Requirements: ≤ 6 to 20 ml 0.01n NaOH; depending on propellant type.

e. Repeatability and Reproducibility: Repeatability within 0.5 ml 0.01n NaOH.

3. NATIONAL REFERENCES:

(1) Testing Procedure P 8 010 084; NITROCHEMIE WIMMIS AG;
(2) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 2.22.1.

CH/202.01.005

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Heat Flow Calorimetry Test (Stability)

a. Type of Test: Stability/Ageing at Constant Temperature; Determination of the Heat Production.

b. Description: The heat flow calorimetry method determines the heat flow produced by decomposing explosives at a constant temperature over a given period of time. The heat release is a measure for the sum of ageing reactions taking place. Temperature and duration of isothermal storage are chosen such that they simulate thermal ageing over a long period at standard storage conditions (e.g. 10 years at 25°C). For propellants, the "8 days at 80°C" sequence has proven to be a convenient test condition. Other test conditions (temperature and measurement period) can be chosen as well, depending on the material and goal of investigation.

Propellants are used, when possible, in their original form. If this is not possible, the propellants are cut into smaller pieces or ground and sieved. In the latter case, the fraction 0.7-2 mm is used for the test. For propellants, reconditioning of the sample is usually not performed. Should the storage conditions markedly differ from 65-70% RH at 21°C, precondition may become necessary. Particle size and moisture content may influence the result of the test. For pyrotechnics, the investigation of the influence of humidity on the stability is usually the main goal. In this cases, the sample is preconditioned, or a special sample cell that controls the humidity in the sample vial is used.

The explosive is filled to the top of the measuring ampoules (up). The ampoules are tightly closed and put into a heat flow calorimeter operating at a constant temperature for a certain period of time (e.g. at 80°C for 8 days). The heat flow rate is recorded over this period, and the total heat production is determined (by integrating the heat flow curve over the entire period). Excellent reproducibility can be obtained. However, all deviations from the test conditions, in particular the use of lower filling grades and leaking ampoules, will markedly change the heat flow curve.

c. Information Requirements for Assessment: The result is used to estimate the chemical stability of the propellant.

c. Typical Results:

Explosive	Sequence	Heat Released
Boron	8 d 80°C	17.7 J/g
Single base propellants	8 d 80°C	< 40 J/g
EI-propellants / ball powders	8 d 80°C	30 – 60 J/g
double base propellants	8 d 80°C	< 60 J/g

e. Repeatability and Reproducibility: Excellent reproducibility.

3. NATIONAL REFERENCES:

(1) Testing Procedure P 8 400 144; NITROCHEMIE WIMMIS AG;
(2) S. Wilker, P. Guillaume: International Round Robin Test to Determine the Stability of DB Ball Propellants by Heat Flow Calorimetry – Final Report (1998);
(3) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 2.51.1.
(4) (Draft) STANAG 4582.

CH/202.01.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Vacuum Stability Test (Stability)

   a. Type of Test: Stability/Heating the Sample at a Certain Temperature for 40 h; Determination of the Volume of Gas Evolved.

   b. Description: The vacuum stability test is used to assess the thermal stability of an explosive by measuring the volume of gas evolved on heating the sample for 40 hours at 90°C (double base propellants), 100°C (single base propellants, composite propellants, explosives and pyrotechnics), or 120°C (certain other explosives).

      Fine granular explosives are used in original form, whereas explosives of larger size are ground and sieved. The fraction 0.2 – 2 mm is used in the latter case. As the explosive's moisture level may play a significant role in gas evolution, drying of the sample is inappropriate.

      Five (5) g of the explosive is filled into the sample tube. The sample tube is evacuated before being stored in a metal heating block or equivalent heating device for 40 hours at the desired test temperature. The gas evolved into the vacuum is measured by manometer or pressure transducer.

   c. Information Requirements for Assessment: The test result is used for estimating the chemical stability of the propellant.

   d. Typical Results:

(1)	PBXN-5:	0.13 ml/g (120 °C, 40h)
(2)	Plastite:	< 0.4ml/g (100 °C, 40h)
(3)	LX-14:	0.03 ml/g (120 °C, 40h)

   e. Repeatability and Reproducibility: ± 0.01ml / g.

3. NATIONAL REFERENCES:

   (1) STANAG 4556

CH/202.01.007

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Differential Scanning Calorimetry (DSC)/Thermal Gravimetry (TG)

a. Type of Test: Stability/Thermal Behaviour of Energetic Material

b. Description: **Differential Scanning Calorimetry (DSC):** Commercial equipment is used. Whenever possible the explosive samples are used in their original form. If not, the samples are cut into adequate pieces or ground and sieved. After loading 1 to 10 mg of the energetic material in a normally perforated crucible, the crucible is placed in an oven and heated at a constant rate of typically 5 K/h. Argon is used as an inert purging gas. The thermal behaviour, endothermal processes as melting or crystal phase changes of a sample or exothermal processes as decomposition or oxidation, is detected by comparing heat consumption or production of the sample towards an inert standard. The temperature range is 298 K to 873 K. The peak maximum of endothermal or/and exothermal processes is measured.

Thermal Gravimetry: Commercial equipment is used. The mass loss on behalf of decomposition or the mass increase on behalf of an oxidation reaction is detected. The sample (1 to 10 mg) is put into an open crucible which hangs on a balance in an oven. The oven has a temperature range of 298 K to 1273 K. It is heated with a rate of typically 5 K/min. Argon is used as a purging gas. The result is specified as mass loss or gain of the total sample mass and the Onset Temperature of the detected reaction.

c. Information Requirements for Assessment: DSC/TG is used for characterisation of the thermal behaviour of energetic materials. These methods allow initial screening of new materials as well as the assessment of physical ageing and chemical degradation effects in storage and stability studies.

d. Typical Results:

(1)	DSC: TNT	354 K (melting) 573 K (decomposition)
(2)	DSC: 20% B/ 80% KNO_3	576 K (crystal phase transfer) 830 K (redox reaction)
(3)	TG:	TNT 452 K (Onset weight loss) 492 K (end weight loss)

e. Repeatability and Reproducibility: same sample and heating rate: ±1 K.

3. NATIONAL REFERENCES:

(1) The Equipment Manufacturers Instruction Book, Mettler Toledo, Greifensee, 1997
(2) STANAG 4515

CH/202.01.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: HPLC for Stabiliser Depletion not Covered by STANAG 4117, 4541 and 4542

a. Type of Test: Stability/Heating the Sample at Different Temperatures for Given Periods of Time; Determination of Stabiliser Depletion.

b. Description: The chemical shelf life of propellants can be determined by ageing at different temperatures for given periods of time, followed by determination of stabiliser consumption. The results are then extrapolated from the range of measured temperatures to standard storage conditions (usually 25°C or 20°C), yielding an estimation for chemical shelf life (save life). Procedures for such shelf life assessments are proposed in STANAG 4527 or in Reference [1]. Both procedures can be applied for all stabiliser-containing propellants. For particular propellant types, a less time-consuming procedure can be applied: Ageing at only one temperature for only one ageing period, followed by determination of stabiliser depletion. The remaining stabiliser content allows judging whether the propellant can be safely stored for 10 years at 25°C or not.

(1) The test conditions and requirements have been elaborated from experience. They are described in the following STANAG's:

(a) STANAG 4117 for single base propellants stabilised with diphenylamine (DPA);
single base propellants stabilised with ethyl centralite (EC);
single base propellants stabilised with a mixture of DPA and EC;
double base propellants stabilised with EC.

(b) STANAG 4541 for nitrocellulose based propellants with ≤ 15% nitroglycerine, stabilised with DPA;

(c) STANAG 4542 for nitrocellulose based propellants with ≤ 15% nitroglycerine, stabilised with 2-nitrodiphenylamine (2-NO-DPA).

(2) Shelf life assessments are performed as follows:

(a) First, samples of the propellant under investigation have to be submitted to accelerated ageing at various temperatures (between 40°C and 80°C) for specific periods of time. A possible test scheme for temperatures of 40, 50, 60 and 70°C and intervals ranging from 2 to 108 weeks is given in [1].

(b) Secondly, the unaged propellant as well as all artificially aged samples are tested chemically. The remaining stabiliser content as well as the concentration values of stabiliser derivatives formed during the ageing process are assayed quantitatively by high performance liquid chromatography (HPLC).

(c) Finally, the test results have to be analysed, and the shelf life at the designated storage temperature has to be calculated. Thereby, also the permissible degree of stabiliser consumption for a safe storage period has to be established. For the chemical shelf life, a remaining primary stabiliser content of 0.3 - 0.5% is assumed to be tolerable.

(3) For the extrapolation from the range of test temperatures to standard storage conditions, 3 different approaches are commonly used. These are:

(a) Reaction Kinetics / Arrhenius Extrapolation: The reaction order of the stabiliser depletion is determined, which allows to calculate the reaction rate constants for the different test temperatures. From these data, the rate constant at storage temperature is calculated using the Arrhenius equation. The shelf life at storage temperature can then be calculated from the extrapolated rate constant using the reaction equation applicable for the particular reaction order. This procedure is described in STANAG 4527.

(b) Model Free Evaluation / Arrhenius Extrapolation: The period of time t_x until a given degree of stabiliser consumption is attained is estimated for all test temperatures by fitting suitable interpolation functions to the stabiliser concentration data. These t_x–values can be regarded as "shelf life values at the respective test temperature (for the "acceptable stabiliser depletion" suggested above, t_x represents the time until the concentration of original stabiliser drops to 0.5%). The extrapolation to the shelf life at standard storage temperature (t_x at 20°C or 25°C) can be performed directly using the Arrhenius equation (see Equation 4 in STANAG 4527).

(c) Model Free Evaluation / Berthelot Extrapolation: The procedure follows (ii) except for using the Berthelot equation for the extrapolation to standard storage temperatures. The Berthelot approach is known to be more conservative than the Arrhenius equation. Instead of performing a "standard" Berthelot extrapolation, the prognosis can also be done using Berthelot with a ageing factor of 3.0 per 10°C. It is known from experience that this is a very conservative estimation.

(4) The influence of the selected approach on the resulting shelf life extrapolation is subject of still ongoing investigations. For the moment, it is recommended to use:

(a) The "standard" Berthelod approach (iii) in cases where stabiliser depletion data are available from at least three different temperatures, the lowest temperature not exceeding 50 °C.

(b) The Berthelod approach with ageing factor of 3.0 per 10 °C for all other cases. (ageing temperatures from only one or two different temperatures, of from "too high temperatures" above 50 °C).

c. <u>Information Requirements for Assessment</u>: The test result is used as a means for estimating the chemical stability/chemical shelf life of the propellant. In Swiss surveillance programs the Berthelod extrapolation is considered as a standard.

d <u>Typical Results</u>: Chemical shelf life values of <20 years for single and double base propellants.

e. <u>Repeatability and Reproducibility</u>: not assessed

3. <u>NATIONAL REFERENCES</u>:

(1) Report NITROCHEMIE WIMMIS AG, PFW-SIG BP 2571
(2) STANAG 4527

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: HPLC for Stabiliser Depletion Covered by STANAG 4117, 4541 and 4542

a. Type of Test: Stability/Heating the Sample at a Single Temperature or at Different Temperatures for Given Periods of Time; Determination of Stabiliser Depletion.

b. Description: The chemical shelf life of propellants can be determined by ageing at different temperatures for given periods of time, followed by determination of stabiliser consumption. The results are then extrapolated from the range of measured temperatures to standard storage conditions (usually 25°C or 20°C), yielding an estimation for chemical shelf life (save life). Procedures for such shelf life assessments are proposed in STANAG 4527 or in Reference [1]. Both procedures can be applied for all stabiliser-containing propellants, as described in AOP-7 202.01.008.

For particular propellant types, a less time-consuming procedure can be applied: Ageing at only one temperature for only one ageing period, followed by determination of stabiliser depletion. The remaining stabiliser content allows judging whether the propellant can be safely stored for 10 years at 25°C or not. The test conditions and requirements have been elaborated from experience. They are described in the following STANAG's:

(1) STANAG 4117 for single base propellants stabilised with diphenylamine (DPA);
Single base propellants stabilised with ethyl centralite (EC);
Single base propellants stabilised with a mixture of DPA and EC;
double base propellants stabilised with EC.

(2) STANAG 4541 for nitrocellulose based propellants with ≤ 15% nitroglycerine, stabilised with DPA;

(3) STANAG 4542 for nitrocellulose based propellants with ≤ 15% nitroglycerine, stabilised with 2-nitrodiphenylamine (2-NO-DPA).

c. Information Requirements for Assessment: For propellants of these types shortened test procedures can be applied as described in corresponding STANAG's or if appropriate a complete shelf life assessment can be made as described in AOP-7 202.01.008.

d. Typical Results: Chemical shelf life values of <20 years ("shortened test"), and <20 years (complete shelf life assessment)

e. Repeatability and Reproducibility: not assessed

3. NATIONAL REFERENCES:

(1) Report NITROCHEMIE WIMMIS AG, PFW-SIG BP 25712.
(2) STANAG 4117, 4541, 4542 and 4527

CH/202.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Tube Test (FCO & SCO)

a. Type of Test: Sensitivity/Reaction Towards Slow and Fast Heating

b. Description: For fast or slow heating a tube (steel 37) with an inner diameter of 47 mm, a wall thickness of 4mm and a length of 200 mm is used. The end caps are reinforced (outer diameter: 65mm). The explosive ist either cast directly into the tube or pressed to dimensions which tightly fit. Gun Propellant grains are filled loosely (gravity feed) into the tube. The loading density has to be recorded.

For Slow Cook-off (SCO) experiments the tube is placed into an oven, in which the test item is first equilibrated during 6 hours at 40 °C. After that, it is heated up with a rate of 3.3 ± 0.3 °C/h upon ration takes place. The temperature at different places on the surface of the tube is recorded during the experiment. The reaction temperature as well as the reaction level are denoted. The reaction level, as defined e.g. in STANAG 4382, is assessed according to the fragmentation pattern of the tube.

For Fast Cook-off (FCO) experiments the tube is placed on a holding device over a wood fire. To achieve a well balanced fuel/air ratio a wooden lattice of air dried pieces, each not more than 50mm thick and spaced at about 100mm intervals, has to be constructed. The ignition of the wood is accelerated by the additional use of liquid fuel saturated saw dust. The time to the reaction and the reaction level are recorded. The reaction level is assessed according the penetration pattern of aluminium witness plates (200 x 200 x 2 mm).

c. Information Requirements for Assessment: This test is used to assess the reaction level and reaction temperature of confined energetic material under the stimuli of slow and fast heating. It is also required by the Swiss Transportation Board for classification into class 1.6.

d. Typical Results:

		SCO:		FCO:	
(1)	Hextro 60/40	171 °C	Explosion	13 Min	Part. Detonation
(2)	Oktastit VIII	185 °C	Part. Detonation	21 Min	Part. Detonation
(3)	PBXN-110	178 °C	Burn	15 Min	Burn
(4)	Single Base	129 °C	Burn		

e. Repeatability and Reproducibility: SCO: ± 5 °C, within the reaction level; FCO: ± 3 Min, within the reaction level

3. NATIONAL REFERENCES:

(1) FA26-SIG-BE 970500 1373
(2) FA26-SIG-BE 961000 1330

CH/203.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Heat Flow Calorimetry Test (Compatibility)

a. Type of Test: Compatibility/Determination of the Heat Production Rates of Explosive, Test Material and Mixture.

b. Description: The heat flow calorimetry method determines the heat flow produced by decomposing explosives at a constant temperature over a given period of time. The heat release during this isothermal storage is a measure for the sum of ageing reactions taking place.

For compatibility measurements, the heat flow of a mixture of explosive and test material (material which comes into contact with the explosives during intended use of the ammunition) is compared to the heat flows of the explosive and the test material when heated separately under otherwise identical conditions. Compatibility is judged by means of the additional heat produced because of the contact between the two components of the mixture.

Temperature and duration of isothermal storage have to be chosen in a way that they simulate thermal ageing over a long period of time at standard storage conditions (e.g. 10 years at 25°C).

For propellants, the "8 days at 80°C" sequence already proposed for stability assessment has proven to be a convenient test condition for compatibility testing as well. It must, however, be noted that this sequence differs from the sequence recommended in STANAG 4147.

Explosive and test material are used, whenever possible, in their original form. If this is not possible, they have to be cut into smaller pieces or ground and sieved. In the latter case, the fraction 0.7 – 2 mm is used for the test.

The measuring ampoules are filled up to the top with either explosive, test material, or a mixture of explosive and test material. Usually, a 1:1 mixture by weight is used for the measurements. Depending on the possible contact in the weapon system, other mixture ratios (e.g. 10:1) as well as other arrangements (e.g. varnish coating of the inside of the ampoule) are possible. The ampoules have to be tightly closed.

Preconditioning of the sample is usually not performed. Should the storage conditions, however, markedly differ from 65 – 70% RH at 21°C, precondition might become necessary. Particle size and moisture content of the sample may influence the result of the test.

The ampoules are put into a heat flow calorimeter operating at 80°C for 8 days. The heat flow rates are recorded over this period, and the total heat production is determined for each sample (by integrating the heat flow curve over the 8 day period). From these results, the incompatibility Q_R is calculated (as difference between the actual heat release of the mixture and the heat loss as calculated for the mixture from the results of the isolated compounds).

If all test conditions are carefully observed, good reproducibility can be obtained. However, all deviations from the test conditions, in particular the use of lower filling grades and leaking ampoules, will markedly change the heat flow curves.

c. Information Requirements for Assessment: The test result is used as a means for judging whether explosive and test material are chemically compatible with each other; to make sure that they cause no safety hazard during storage or use.

d. Typical Results: Requirement: $Q_R \leq 20$ J/g in 8 days at 80°C.

Explosive	Test Material		Incompatibility Q_R
Double Base Propellants	Black Powder	8 d 80°C	15 - 50 J/g
Boron (53%)	Potassium Nitrate	8 d 80°C	5.5 J/g
RDX (90%)	TAGN	8 d 80°C	1.2 J/g

e. Repeatability and Reproducibility: Within 10% (abs.) under identical test conditions.

3. NATIONAL REFERENCES:

(1) Testing Procedure; NITROCHEMIE WIMMIS AG
(2) G. Pantel: Report 96/V0065/00026-002 "Compatibility Investigations on Black Powder", WIWEB, Germany (1998);

CH/203.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives/Solid Gun Propellants/Solid Rocket Propellants

2. TEST TITLE: Vacuum Stability Test (Compatibility)

a. Type of Test: Compatibility/Heating the Samples at a given Temperature for 40 hours; Determination of the Volume of Gas Evolved.

b. Description: The volume of gas evolved, when a mixture of equal parts of an explosive and the material under test is heated at a constant temperature into initial vacuum, is compared with the volumes evolved from the explosive and the test material when heated separately under otherwise identical conditions. Compatibility is judged by means of the volume of additional gas produced because of the contact between the two components of the mixture.

Typical test conditions are: 100°C for 40 hours in case of single base propellants and most other explosives; 80°C for 240 hours in case of double base propellants and explosives which decompose too rapidly at 100°C.

Explosive and test material are used, whenever possible, in their original form. If this is not possible, they have to be cut into smaller pieces or ground and sieved. In the latter case, the fraction 0.2 - 2 mm is used for the test.

The sample tubes are filled with either 2.5 g of explosive, 2.5 g of test material, or with a mixture of each 2.5 g explosive and test material.

The sample tubes are then evacuated before being stored in a metal heating block or equivalent heating device for 40 hours at the desired test temperature. The gas evolved into the vacuum is measured by manometer or pressure transducer.

The mixture is considered compatible if the additional gas released (if compared to the isolated samples) does not exceed 5 cm^3.

c. Information Requirements for Assessment: The test result is used as a means for judging whether explosive and test material are chemically compatible with each other; to make sure that they cause no safety hazard during storage or use.

d. Typical Results:

e. Repeatability and Reproducibility: see STANAG 4147.

3. NATIONAL REFERENCES:

(1) STANAG 4147
(2) German "Technische Lieferbedingungen" TL 1376-0600, Procedure 4.11

CH/203.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Rocket Propellant

2. TEST TITLE: Plasticiser Migration Evaluation

a. Type of Test: Compatibility/Migration Behaviour of Plasticiser

b. Description: The test is applicable to plasticiser containing solid rocket propellants (SRP) only. Specimens are selected at different locations of naturally or artificially aged SRP–Motors. Small cubes of 3 x 3 mm are prepared. The plasticiser is extracted quantitatively with an adequate solvent. The plasticiser content of the samples originating from different locations of the rocket motor is measured either by infrared spectroscopy (integration of a separated plasticiser peak) or other adequate methods as HPLC. Based on a uniform plasticiser distribution in a new rocket motor, plasticiser migration can be evaluated by correlating plasticiser content and origin of the sample in the rocket motor. For the investigation of the whole plasticiser migration process equivalent rocket motors have to be aged over different time periods, till a steady state occurs. Plasticiser contents at different locations of the rocket motor have to be expressed as a function of time and temperature.

c. Information Requirements for Assessment:

Migration of plasticiser from propellant into the liner or vice-versa, results in changes of the mechanical properties and can lead to malfunction of the rocket motor. This test is applied to programs for assessing physical ageing and chemical degradation for storage, stability studies and lifetime predictions

d. Typical Results:

(1) Plasticiser content of cured polybutadiene propellant (HTPB/AP) is between 2% and 7%.
(2) Plasticiser content in cured polybutadiene liner is between 5% and 25%

e. Repeatability and Reproducibility:

(1) Reproducibility for propellant: ± 0.4%
(2) Reproducibility for liner: ± 1.5%

3. NATIONAL REFERENCES:

(1) Report FA 26, Nr. 1435

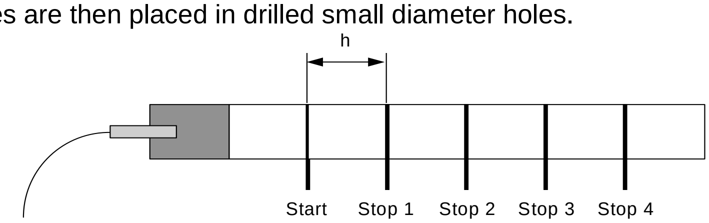
TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives/Main Charge High Explosives

2. TEST TITLE: Detonation Velocity Test

a. Type of Test: Performance/Propagation of Detonation within the Explosive

b. Description: If the critical diameter of the sample is lower than 15 mm, 10 g pellets with a diameter of 21.3 ± 0.03 mm are pressed to an adequate density. If the resulting height of the pellet is lower than 10mm the amount of explosive is augmented. To form a cylinder shaped high explosive test sample, at least six of these pellets are put face to face in a wooden holding device. Starting from the second pellet and ending with the second last one, ionisation probes of a thickness of 0.08 mm are placed between the pellets and then connected to a high precision counter. The whole train is fired using a blasting cap and a HWC-booster. The detonation velocity is calculated from the height of the pellets (with a correction for the ionisation probes) divided by the time the detonation propagation consumed to pass from one probe to the next.
If the critical diameter is larger than 15 mm, the diameter of the explosive pellets as well as the distance and the type of the ionisation probes have to be adjusted. Castable explosives have to be casted to a cylinder of an adequate length and diameter. The probes are then placed in drilled small diameter holes.



c. Information Requirements for Assessment: This test measures the detonation velocity of high explosives at a certain density.

d. Typical Results: (for the standard procedure: 21.3 mm pellets)

(1)	LX-14:	8643 ± 28 m/s (ρ = 1.805 g/cm^3)
(2)	PBXW-11:	8680 ± 12 m/s (ρ = 1.791 g/cm^3)
(3)	LX-19:	9124 ± 12 m/s (ρ = 1.929 g/cm^3)
(4)	PBXN-5:	8840 ± 32 m/s (ρ = 1.865 g/cm^3)

e. Repeatability and Reproducibility: 21.3 mm Standard Procedure: ± 40 m/s

3. NATIONAL REFERENCES:

(1) FA26-SIG BE 961030 1288

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Burning Rate Test

a. Type of Test: Performance/Open Burning in a Burning Trough

b. Description: The burning trough with the dimensions of 2 x 2 x 300mm is located in a 300x25x12 mm brass plate. The first 50 mm are necessary to get a regular burning and the last 50 mm are used as a burn out distance. The burning rate of the pyrotechnic sample is measured over a length of 200mm. The light of the pyrotechnic reaction is transferred by glass fibre optics to a counter system.

The sample size depends on the density and the granule size of the tested material or composition. The average sample weight for this test is about 1 gram. The granule size of the sample should be < 500 μm.

The sample is poured into the burning trough. The surplus material is taken away by pulling a rubber spatula over the burning trough. The sample is ignited by a glowing wire (soft ignition) or using a diode laser. The burning rate is calculated by dividing the distance between the fibre optic probes (200 mm) by the measured time the burning front needs to pass these probes. The burning time of a pyrotechnic sample is usually measured three times. The calculated burning rate value is the mean value of the three measurements

c. Information Requirements for Assessment: Burning rates of pyrotechnic compositions are measured for initial characterisation of pyrotechnic systems.

d. Typical Results:

(1)	Ignition mixture:	40% Ti (Type E) / 59% $KClO_4$ / 1% NC:	0.49 ± 0.02 m/s
(2)	Ignition mixture:	30% B / 69% KNO_3 / 1% NC:	0.44 ± 0.02 m/s
(3)	Black Powder Nr. 2:		0.57 ± 0.03 m/s

e. Repeatability and Reproducibility: Reproducibility is in the range of 5 to 10% depending on the granule size and the homogeneity of the tested composition.

3. NATIONAL REFERENCES:

(1) FA 26 Kurs-Manuskript, "Explosivstoffe für Fortgeschrittene", Nr. 1512, 1997

CH/302.02.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants

2. TEST TITLE: Manometric Bomb Test

a. Type of Test: Performance/Test of Burning Behaviour in Manometric Bomb

b. Description: The propellant is tested in its original shape and size. Manometic bombs (closed bombs) of 70 cm^3, 75 cm^3, 150 cm^3, and 700 cm^3 internal volume are commonly used. Other volumes are possible as well. The propellant is filed into the manometric bomb. Filling grades of 0.10 – 0.20 g/cm^3 are commonly applied. The propellant is ignited by a black powder or nitrocellulose igniter. The increase of gas pressure in the manometric bomb as a function of time is measured by means of a Piezo element and recorded in a transient recorder. The vivacity (liveliness) L of the propellant is then calculated from pressure *p* as a function of time *t* according to:

$$L = \frac{dp}{dt} \cdot \frac{1}{p} \cdot \frac{1}{p_m}$$

This value (graph of L between $p/p_m = 0$ and $p/p_m = 1$; with p_m representing the maximum pressure) is used as a measure for the propellant's burning behaviour. The manometric bomb test might also be applied to determine changes in the interior ballistic behaviour of a propellant due to ageing. For such investigations, unaged as well as artificially aged propellants have to be tested consecutively.

c. Information Requirements for Assessment:

It determines the burning behaviour of a propellant in a closed vessel. There are limitations in the correlation between ballistic bomb and original weapon system. The results of this test, however, gives in most cases at least a good indication on the interior ballistic behaviour of the propellant. In particular, differences between similar propellants (such as initiated by small differences in shape or formulation) can easily be assessed. The manometric bomb has, thereby, to be regarded as a "comparative test".

d. Typical Results: Depending on propellant type and geometry.

e. Repeatability and Reproducibility: Repeatability within 2 to 3%.

3. NATIONAL REFERENCES:

(1) Testing Procedures PW 986 048; P 8 700 049; P 8 700 055; P 8 048 601; NITROCHEMIE WIMMIS AG
(2) Druckbomben-Fibel; H. Jahnk, CCG-Kurs Innenballistik von Rohrwaffen, 1984

CH/302.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Gun Propellants/Solid Rocket Propellants/Pyrotechnics

2. TEST TITLE: Heat of Combustion Test

a. Type of Test: Performance/Adiabatic Calorimetry Test

b. Description: Granular explosives are used in original form whenever possible. Explosives of larger size are either cut into smaller pieces or ground and sieved. In the latter case, the fraction 0.7 – 2 mm is used. Sample size is 1 to 5 g, depending on explosive type and calorimeter used.

A commercial combustion calorimeter, in which the calorimeter bombs are located in a water bath, is used for the measurement.

The measurement is done under 360 psi (about 25 bar) of nitrogen in case of propellants, or under 30 bars of helium in case of pyrotechnics. The sample is ignited by a hot wire. For explosives which are not easily ignitable with a hot wire, the use of an igniting aid (e.g. propellant) may be necessary. The heat produced is recorded by the calorimeter, whereas the heat produced by the igniting system has to be subtracted.

c. Information Requirements for Assessment: This test determines the heat of explosion of energetic material, which is a measure for the energy content of the explosive (heat which can be released in absence of oxygen).

d. Typical Results:

(1)	Nitrocellulose	3'300 – 4'600 J/g
(2)	Single base propellants	3'000 – 4'000 J/g
(3)	Double base propellants	3'500 – 5'000 J/g
(4)	Triple base propellants	3'000 – 4'200 J/g
(5)	20% B/ 79% KNO_3/ 1% NC	7330 J/g

e. Repeatability and Reproducibility: Repeatability within 15 J/g for propellants and within 100 J/g for pyrotechnics.

3. NATIONAL REFERENCES:

(1) Testing Procedure P 8 010 685; NITROCHEMIE WIMMIS AG
(2) MIL STD 286 B; Procedure 802.1
(3) nstruction Book of Manufacturer, IKA, Heitersheim, Germany 1989

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10.7.15 QUALIFICATION PROCEDURES OF THE UNITED KINGDOM

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10.7.15.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION

10.7.15.1.1 The Defence Ordnance Safety Group (DOSG), formerly the Ordnance Board, has full responsibility for qualification of explosives.

10.7.15.2 NATIONAL AUTHORITY (IES)

10.7.15.2.1 The DOSG is the appointed UK National Authority and is responsible for the following functions to fulfil the requirements of STANAG 4170:

a. Defining the tests necessary to obtain evidence for the assessment of explosive materials used by all three services, and the requirements applied for the Qualification of these materials.

b. Receiving from agencies within the UK, or from other nations in the case of munitions purchased overseas, the test data for qualifying explosive materials, and assessing whether the material is safe and suitable for consideration for use by the Services in a particular role or application.

c. Publishing the test data and assessment, which enables Qualification, with or without limitations.

d. Creating and maintaining a UK data bank of Qualified explosive materials used by the UK Services.

e. Co-ordinating the implementation of STANAG 4170 within the UK.

f. Acting as the Point of Contact within the UK for inputs to AOP-7.

g. Maintaining a central UK repository for NATO Standardization Agreements relating to explosive materials and explosives safety test data.

h. Providing the UK Point of Contact to other NATO countries for the exchange of information, as appropriate, on the safety of explosives.

i. Liaising with the appropriate security officers of UK agencies to ensure that the security regulations and requirements for commercial-confidentiality governing the release of information are complied with in respect of data to be provided in response to requests from other nations.

10.7.15.3 QUALIFICATION PROCEDURES

10.7.15.3.1 In the United Kingdom, research into explosives (of all types) for all three services, can be carried out in MOD facilities, in Government Agencies, in academic institutions or in industry by Defence Contractors. Such establishments are:

a. Defence Science and Technology Laboratory (DSTL)

b. Atomic Weapons Establishment (AWE).

c. Cranfield University, Royal Military College of Science (RMCS)

d. BAE Systems Ltd (Royal Ordnance)

e. QinetiQ

10.7.15.3.2 When a munition containing explosive materials is to be designed within the UK, or purchased from overseas, the appropriate Integrated Project Team Leader in either the Defence Procurement Agency (DPA) or in Defence Logistics Organisation (DLO) should task DOSG to advise on the safety and suitability for service of that munition.

10.7.15.3.3 The primary purposes of DOSG are:

a. To provide impartial appraisal of the safety, and advice on the suitability for service, of those parts of weapon systems and stores within its field of operations in which explosives are used. In this context, the term "suitability for service" means that the explosive and associated elements of a weapon system or store are capable of functioning technically as designed, and that neither this functioning, nor safety, will be unacceptably degraded by the service environment through the agreed service life. It does not embrace operational effectiveness or reliability.

b. To give advice on safety matters affecting the use of weapons and other hazardous stores during military training.

c. To provide within the Ministry of Defence a focus for international standardization in the above matters.

10.7.15.3.4 Having accepted the task, the relevant Technical Section of DOSG will identify all the explosive materials used, or proposed for use, in the equipment. These will be considered to determine whether they are new to service, or known materials being used in a novel role. All materials in these two categories become the subject of assessment and qualification, for their safety and suitability for consideration for use in service, not necessarily restricted to a particular munition.

10.7.15.3.5 In certain circumstances, DOSG may accept tasks from Research and Development organisations for the assessment and qualification of a new explosive material before it has been selected for use by a munition project.

10.7.15.4 QUALIFICATION METHODS AND TESTS

10.7.15.4.1 The basis for the UK assessment for the qualification of an explosive composition is currently laid down in Ordnance Board Pillar Proceeding 42700 (Qualification of explosives). This proceeding is in line with the requirements of STANAG 4170. It sets out the information required for assessment, with general guidance on the suitable tests for the various types of explosives. More specific guidance for particular explosive roles is given in OB Pillar proceedings P 111 (pyrotechnics), P119 (secondary HE main charge and boosters) and P127 (solid propellants).

10.7.15.4.2 Selection of Tests. The selection of the specific tests to obtain data is a matter of agreement between the specialist officers of the DOSG and the Tasking Authority. The selection of tests is influenced by the guidance given in Chapter VII "Assessment Principles and Common Requirements" of this manual for each type of material, together with other factors such as the nature of the material and its role. Consideration is given to the need to carry out tests at extremes of temperature and on aged material.

10.7.15.4.3 For all materials, information is required to demonstrate compliance with STANAG 4170.

10.7.15.4.4 Conduct of Tests. The DOSG, although the UK National Authority, has no test facilities of its own. Once the test requirements for assessment and qualification have been agreed by the relevant authorities, the tests are carried out in an approved test house which may be at one or more of the establishments listed in paragraph 10.7.15.3.1. There is an ongoing programme to accredit UK test houses for particular qualification tests.

10.7.15.4.5 Assessment. The results of the tests, together with observations and recommendations, are formally reported by the test establishment to DOSG. The results are considered by officers of DOSG, in relation to the results of the same tests carried out on materials of a similar type and role which have a proven history of safety and satisfactory use in service.

10.7.15.4.6 Qualification. The test results, together with the discussion of their assessment, are presented as a draft Proceeding on the material per se, or as a section in a Proceeding assessing the safety and suitability for service of a complete munition or sub-system, for consideration by peer review by DOSG, representing all three services. If satisfied, DOSG will then publish the Proceeding in which they recommend that the material is safe and suitable for consideration for use, with limitations if necessary.

10.7.15.4.7 Approval for Service Use. The Safety Approving Authority of the relevant service has the final responsibility to accept DOSG advice, or to modify or reject it. The latter seldom, if ever, occurs.

10.7.15.4.8 Compatibility. Materials used in munitions, which may come into direct contact with explosives or propellants, must be compatible as defined in STANAG 4147. This also applies to materials, which although not in direct contact , evolve vapours that can come into direct contact with the explosive or propellant in the munition.

10.7.15.4.9 Terminology Used in the UK. As the methodology for the assessment of safety and suitability for service has developed within the UK, terms have been used which may have somewhat different interpretation from that given by other nations. In order to assist in the understanding of UK assessments, the following explanations of UK usage are recorded. They are not intended as rigid definitions.

a. Sensitiveness is the UK term for a measure of the minimum level of a prescribed stimulus, relevant to an accident situation, required to ignite or initiate an explosive material. Such stimuli include, among others, impact, friction and electric spark. The significance of the word is thus in terms of the hazard characteristics of the explosive material.

b. Sensitivity is the UK term for a measure of a prescribed stimulus required to achieve reliable functioning of an explosive material in its designed mode.

c. Explosiveness is the UK term, which describes the degree of violence shown by an explosive material when it responds to a prescribed stimulus relevant to an accident situation. It is dependent not only on the nature of the explosive material, but also on its mass, physical state, configuration and confinement. The significance of the word is thus in terms of the hazard characteristics of the explosive material.

d. Power is the term used in the UK for high explosive, to indicate the level of explosive response following initiation in the designed mode.

10.7.15.4.10 HIGH EXPLOSIVES

a. Mandatory Data for Primary Explosives:

Test		Registry/STANAG No.
(1)	Ball and Disc	201.01.002
(2)	Small Scale Explosiveness	201.01.003
(3)	Grit Sensitisation	201.01.004
(4)	Emery Paper Friction	201.02.002
(5)	Temperature of Ignition	STANAG 4491 or 4515
(6)	Ease of Ignition	STANAG 4491
(7)	Train Test	202.01.003
(8)	Electric Spark	STANAG 4490

b. Mandatory Data for Booster Explosives

	Test	Registry/STANAG No.
(1)	Rotter Impact Test	STANAG 4489
(2)	Small Scale Explosiveness	201.01.003
(3)	Grit Sensitisation	201.01.004
(4)	Rotary Friction	STANAG 4487
(5)	Temperature of Ignition	STANAG 4491 or 4515
(6)	Ease of Ignition	STANAG 4491
(7)	Train Test	202.01.003
(8)	Electric Spark Test	STANAG 4490
(9)	Small Scale Gap Test	STANAG 4488
(10)	Fragment Impact Test	201.06.003
(11)	Tube Test – Internal Ignition	202.01.005
(12)	Tube Test – Fast Heating (Fuel Fire)	202.01.006
(13)	Tube Test – Electrically Heated	STANAG 4491
(14)	Critical Diameter	302.02.002
(15)	Detonation Velocity	302.02.001
(16)	Vacuum Stability	STANAG 4556
(17)	DMA (for PBX)	STANAG 4540
(18)	TMA (for PBX)	STANAG 4525
(19)	Uniaxial Tensile (for PBX)	STANAG 4506
(20)	Stress Relaxation (for PBX)	STANAG 4507
(21)	Uniaxial Compression (for PBX)	STANAG 4443
(22)	Thermal Characterization by DSC/DTA	STANAG 4515

c. Mandatory Tests for Main Charge High Explosives

	Test	Registry/STANAG No.
(1)	Rotter Impact Test	STANAG 4489
(2)	Small Scale Explosiveness	201.01.003
(3)	Grit Sensitisation	201.01.004
(4)	Rotary Friction	STANAG 4487
(5)	Temperature of Ignition	STANAG 4491 or 4515
(6)	Ease of Ignition	STANAG 4491
(7)	Train Test	202.01.003
(8)	Electric Spark Test	STANAG 4490
(9)	Gap Test	STANAG 4488
(10)	Fragment Impact Test	201.06.003
(11)	Small-Scale Spigot Drop Test	201.01.005
(12)	Tube Test – Internal Ignition	202.01.005
(13)	Tube Test - Fast Heating (Fuel Fire)	202.01.006

(14)	Tube Test – Electrically Heated	STANAG 4491
(15)	Critical Diameter	302.02.002
(16)	Detonation Velocity	302.02.001
(17)	Vacuum Stability	STANAG 4556
(18)	DMA (for PBX)	STANAG 4540
(19)	TMA (for PBX)	STANAG 4525
(20)	Uniaxial Tensile (for PBX)	STANAG 4506
(21)	Stress Relaxation (for PBX)	STANAG 4507
(22)	Uniaxial Compression (for PBX)	STANAG 4443
(23)	Thermal Characterization by DSC/DTA	STANAG 4515

10.7.15.4.11 PROPELLANTS

a. Mandatory Data for Solid Propellants

	Test	Registry/STANAG No.
(1)	Rotter Impact Test	STANAG 4489
(2)	Small Scale Explosiveness	201.01.003
(3)	Grit Sensitisation	201.01.004
(4)	Rotary Friction	STANAG 4487
(5)	Temperature of Ignition	STANAG 4491 or 4515
(6)	Ease of Ignition	STANAG 4491
(7)	Train Test	202.01.003
(8)	Electric Spark Test	STANAG 4490
(9)	Gap Test	STANAG 4488
(10)	Model Scale Motor Test	201.06.001
(11)	Fragment Impact Test	201.06.002
(12)	Shaped Charge Attack Test	201.07.001
(13)	Small-Scale Spigot Drop Test	201.01.005
(14)	Tube Test – Internal Ignition	202.01.005
(15)	Tube test - Fast Heating (Fuel Fire)	202.01.006
(16)	Tube test – Electrical heating	STANAG 4491
(17)	Critical Diameter	302.02.002
(18)	Chemical Stability	STANAG 4527, 4117, 4541
(19)	Vacuum Stability	STANAG 4556
(20)	DMA	STANAG 4540
(21)	TMA	STANAG 4525
(22)	Uniaxial Tensile (for rocket propellant)	STANAG 4506
(23)	Stress Relaxation	STANAG 4507
(24)	Uniaxial Compression	STANAG 4443
(25)	Thermal Characterization by DSC/DTA	STANAG 4515

N.B Solid propellants containing explosives fillers may require additional testing.

b. Mandatory Data for Liquid Propellants

	Test	Registry/STANAG No.
(1)	Liquid Explosives Impact Test	201.01.006
(2)	Gap Test	201.04.002
(3)	Small Sealed Vessel	202.01.004
(4)	Thermal Characterization by DSC/DTA	STANAG 4515

10.7.15.4.12 PYROTECHNICS

a. Mandatory Data for Pyrotechnics

	Test	Registry/STANAG No.
(1)	Rotter Impact Test	STANAG 4489
(2)	Rotary Friction	STANAG 4487
(3)	Temperature of Ignition	STANAG 4491 or 4515
(4)	Ease of Ignition	STANAG 4491
(5)	Train Test	202.01.003
(6)	Electric Spark Test	STANAG 4490
(7)	Thermal Characterization by DSC/DTA	STANAG 4515

10.7.15.4.13 EFFECT OF AGEING ON EXPLOSIVE PROPERTIES

a. For all classes of explosives, it is essential to ensure that there are no unexpected changes in physical or hazard properties occurring with time.

b. The UK tables in Chapter 8 list the properties which require re-testing after accelerated ageing.

10.7.15.5 LIST OF TEST INFORMATION SHEETS

Category 100	Chemical and Physical Properties (Including Mechanical Properties)
101.00.XXX	Chemical Properties
101.01.XXX	Analytical Tests
101.02.XXX	Other Tests
102.00.XXX	Physical Properties (Including Mechanical Properties
102.01.XXX	Physical Tests
102.01.001	Uniaxial Tensile Test
102.01.010	Uniaxial Compression Test
102.01.025	Dynamic Mechanical Analysis Test
102.01.050	D.S.C.
102.01.070	Density
102.01.071	Density - mode 1
102.01.071	Density - mode 2
102.01.071	Density - mode 3
102.01.201	Uniaxial Tensile Test (cast HE)
Category 200	Hazard Assessment
201.0X.XXX	Sensitiveness/Sensitivity/Explosiveness
201.01.XXX	Impact Tests
201.01.001	Rotter Impact Test
201.01.002	Ball and Disc Test
201.01.003	Small Scale explosiveness
201.01.004	Grit Sensitisation
201.01.005	Small Scale Spigot Drop Test
201.01.006	Liquid Explosives Impact Test
201.02.XXX	Friction Tests
201.02.001	Rotary Friction Test
201.02.002	Emery Paper Friction Test
201.03.XXX	Electrostatic Discharge Tests
201.03.001	Electric Spark Test
201.03.002	Electric Spark Test for Sensitive Explosives
201.04.XXX	Shock Tests
201.04.001	Small-Scale Gap Test
201.04.002	Large-Scale Gap Test
201.05.XXX	Projectile Impact Tests
201.06.XXX	Fragment Impact Tests

201.06.001	Model Scale Motor Test
201.06.002	Fragment Impact-Gun Propellant
201.06.003	Fragment Impact-High Explosive
201.07.XXX	Jet Impact Tests
201.07.001	Shaped Charge Attack Test
201.08.XXX	Other Tests
<u>202.00.XXX</u>	<u>Stability and Thermal behaviour</u>
202.01.XXX	Thermal Tests
202.01.001	Ease of Ignition Test
202.01.002	Temperature of Ignition Test
202.01.003	Train Test
202.01.004	Small Sealed Vessel Test
202.01.005	Tube Test – Internal Ignition
202.01.006	Tube Test – Fast Heating (Fuel Fire)
202.01.007	Tube Test – Electrically Heated
202.02.XXX	Other Tests
202.02.001	Vacuum Stability Test
202.02.002	Chemical Stability of NC based Propellants
202.02.003	80°C Self Heating Test
202.02.004	Abel Heat Test
202.02.005	The 50mm Cube Crack Test
<u>203.00.XXX</u>	<u>Compatibility</u>
203.01.XXX	Reactivity Tests
203.02.XXX	Other Tests
<u>204.00.XXX</u>	<u>Toxicity and Environmental Impact</u>
204.01.XXX	Toxicity Evaluation
204.02.XXX	Environmental Impact Assessment
<u>Category 300</u>	<u>Performance Assessment</u>
<u>301.01.XXX</u>	<u>Theoretical Methods</u>
301.01.XXX	Thermodynamic Models
301.02.XXX	Other Models
<u>302.00.XXX</u>	<u>Experimental Methods</u>
302.01.001	Detonation Velocity
302.02.002	Critical Diameter Test
302.03.XXX	Other Tests

10.7.15.6 CATALOGUE OF TEST INFORMATION SHEETS

NOTE: The Test Information Sheets are listed consecutively in accordance with the Registry Number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/PBXs

2. TEST TITLE: Uniaxial Mechanical Properties, Tensile (Constant Stain Rate).

a. Type of Test: Uniaxial Tensile, Dumb-bell (Dogbone).

b. Description:

(1) Geometry of Specimen. A dumb-bell with a rectangular cross- section. The most common shapes used are the PERME and JANNAF C dumb-bells, usually cut from sheet material (10mm thick for PERME, 12.7mm for JANNAF C).

(2) Applied Load. Load applied varies with the material, normally in the range 0.3 to 2.5Mpa for composite propellant at 23^{o}C.

(3) Experimental Method. After conditioning at test temperature for one hour, the sample is pulled axially by the dumb-bell ends using a stiff tensile testing machine. Load is applied at a constant strain rate (crosshead speed). Preferably the strain is measured directly using an extensometer or similar device.

(4) Main Physical Parameters. The main physical parameters affecting the results are strain rate and test temperature.

(5) Results. Tensile strength, σ_m, initial tangent modulus, E_o, and the strain at maximum load $\varepsilon_{m,}$ and at failure, ε_b, are calculated.

c. Information Requirements for Assessment

(1) Applications. Used for characterization and routine process control of plastic, rubbery and colloidal propellants: polymer based high explosives.

(2) Significance. The data are required to assess the ability of the charge to retain its integrity throughout the range of operating conditions envisaged for the material.

(3) Limitations. Can only be used for materials that can be cut or machined to the shape required i.e. not suitable for very soft or brittle materials.

d. Typical Results:

	Temp °C	ε_m%	ε_b%	σm KPa
Rubbery propellant	+25	33.3	40.1	754

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

ASTM D412; BS903 part A2 and BS 2782 part 3; method 320A describe the method in detail but use different dumb-bell shapes. The JANNAF dumb-bells are described in the ICPRG Solid Propellant Mechanical Behaviour Manual, section 4.3.2

UK/102.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/PBXs/Melt-cast Explosives

2. TEST TITLE: Uniaxial Mechanical Properties, Compression (Constant Stain Rate).

a. Type of Test: Uniaxial Compression

b. Description:

(1) Geometry of Specimen. A right circular cylinder with a length to diameter ratio of 2:1; 10 to 25 mm diameter and 20 to 50 mm long is typical.

(2) Applied Load. Load applied varies with the material, normally in the range 0.3 to 2.5Mpa for composite propellant at 23^{o}C; up to 20 MPa for cast HE.

(3) Experimental Method. After conditioning at the test temperature for one hour, the sample is compressed directly between two plane, parallel surfaces using a stiff testing machine. Load is applied at a constant crosshead speed. Compression cages should NOT be used.

(4) Main Physical Parameters. The main physical parameters affecting the results are strain rate and test temperature.

(5) Results. Compressive strength, σ_m, initial tangent modulus, E_o, and the strain at maximum load $\varepsilon_{m,}$ and at failure, ε_b, are calculated.

c. Information Requirements for Assessment

(1) Applications. Used for characterization and routine process control.

(2) Significance. The data are required to assess the ability of the charge to retain its integrity throughout the range of operating conditions envisaged for the material.

(3) Limitations. Can only be used for materials that can be cut or machined to the shape required. The method is not suitable for either soft or pressed materials that do not consolidate well.

d. Typical Results:

RDX/silicone,	σ_m	0.88MPa,	modulus,	E_o	0.16MPa
Torpex,	σ_m	20.7MPa,	modulus,	E_o	6756MPa

e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

ASTM D695 and BS2782 part 3; method 345A describe the method in detail. The BS calls for a l/d ratio of 1:1.

TEST INFORMATION SHEET

1. TEST OF EXPLOSIVE: Solid Propellants/High Explosives/Pyrotechnics.

2. TEST TITLE: Dynamic Mechanical Analysis

   a. Type of Test: Mechanical Spectrometry.

   b. Description:

      (1) Geometry of Specimen. A right circular cylinder (1 to 5mm diameter) or rectangular bar (1 to 6mm x 10mm) 50 mm long.

      (2) Applied Load. Sufficient to result in a strain of about 1%. The applied load is cyclic, normally at 3 frequencies generated at 0.1, 1.0 and 10 radians/sec.

      (3) Experimental Method. The sample is subjected to small amplitude sinusoidal deformation over a temperature range, usually -120^{o}C to 100^{o}C. Stress and strain are continuously recorded and analyzed.

      (4) Main Physical Parameters. The main physical parameters affecting the results are strain rate and test temperature.

      (5) Results. Shear storage modulus, G' and shear loss modulus, G" and the loss tangent, tanδ, are plotted through the temperature sweep. The glass transition temperature, $T_{g,}$ is obtained from a peak in the G" curve.

   c. Information Requirements for Assessment:

      (1) Applications. Characterization and process control of rubbery propellants, PBXs and colloidal propellants.

      (2) Significance. Used to assess the stability of the charge properties over the range of operating conditions.

      3. Limitations. Can only be used for materials that can be cut or machined or pressed to the required shape. This method is not suitable for either soft materials or pressed materials that do not consolidate well.

   d. Typical Results:

Rubbery propellant

	G'MPa	G''MPa	tan σ
at 25^{o}C	9.99	4.22	0.422

T_g peak in G" is at -72^{o}C.

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

T. Murayama, Dynamic Mechanical Analysis of Polymeric Materials, Elsevier Applied Science Publishers, 1978.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants/PBXs/Melt cast explosives.

2. TEST TITLE: Differential Scanning Calorimetry.

a. Type of Test: Heat Flow or Power Compensation.

b. Description:

(1) Geometry of Specimen. Solid or liquid; solids may be in film, powder, granular or crystalline form. Sample size is 5 to 10mg.

(2) Applied Load. No mechanical load. Heating is at a constant rate of between 5 and 20^{o}C.

(3) Experimental Method. Commercial equipment is used. Scanning rate and range are dependant on the material, the mass and the property being measured.

(4) Main Physical Parameters. The main physical parameters affecting the results are scan rate, sample size, physical form, purge gas used.

(5) Results. Heat capacity, C_p, glass transition temperature, $T_{g,}$ melt temperature , T_m, and associated latent heats, H_f. Other peak areas and start temperatures may also be measured eg crystal transition enthalpy, Δh_t.

c. Information Requirements for Assessment:

(1) Applications. Characterization of the thermal properties of polymeric binders. Characterization of the decomposition of energetic materials.

(2) Significance. Initial screening of materials. Used to assess physical ageing and chemical degradation for storage and stability studies.

(3) Limitations. Experiments are limited to the temperature range and heating rates of the equipment available.

d. Typical Results:

(1) Glass transition temperature, T_g, of cured polybutadiene propellant binder is -55^{o}C.

(2) Decomposition temperature of a nitrate ester, T_d , is 160^{o}C.

e. Repeatability and Reproducibility. With non-volatile sample the results are repeatable to within 0.2 millicalories.

3. NATIONAL REFERENCES:

The equipment manufacturer’s instruction book.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/PBXs/Melt Cast Explosives/Pyrotechnics.

2. TEST TITLE: Physical Properties, Density.

a. Type of Test: Determination of Density by Liquid - Displacement, Pyknometer (Density Bottle) Method.

b. Description:

(1) Geometry of Specimen. Small pieces of material that will pass through the pyknometer neck, (4mm x 4mm x 6mm maximum), with smooth surfaces free from crevices and dust. If a 50ml pyknometer is used, the total weight of the pieces should be around 20g.

(2) Experimental Method. The pyknometer is accurately weighed in air and then re-weighed three times, with the sample inside, topped up with a suitable liquid and full of liquid. The density, ρ, is calculated from the four weighings.

(3) Main Physical Parameters. The main physical parameter affecting the results is changes of temperature.

(4) Results. Density, ρ, and/or specific gravity, SG; the void fraction may be derived from a knowledge of the theoretical maximum density.

c. Information Requirements for Assessment:

(1) Applications. Used for characterization and quality assurance.

(2) Significance. The data are used to calculate the stresses applied to the charge and store throughout its storage and operating life.

(3) Limitations. This method can only be used when a liquid is available that does not dissolve or swell the material during weighing. It cannot be used if the materials floats or the particle size is less than a 20 mesh sieve (850 μm).

d. Typical Results:

e. Repeatability and Reproducibility:

The measured density is accurate to 0.2%.

NATIONAL REFERENCES:

BS 2782 part 6, method 620B; BS 903 part A1 method B; ASTM D792 method B; ISO/R 1183-1970; DQA/TS method M18/89.

UK/102.01.071 mode 1

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/PBXs/Melt Cast Explosives/Pyrotechnics.

2. TEST TITLE: Physical Properties, Density.

a. Test of Test: Determination of Density by Mensuration.

b. Description:

(1) Geometry of Specimen. A right regular bar with a uniform cross section, the area of which can be calculated from its dimensions e.g. a rectangle or circle.

(2) Experimental Method. The specimen is accurately measured. Its volume is calculated from its cross sectional area and length. The specimen is then weighed and the density calculated.

(3) Main Physical Parameters. The main physical parameter affecting the results is changes of temperature.

(4) Results. Density, ρ, the void fraction may be derived from acknowledge of the theoretical maximum density.

c. Information Requirements for Assessment:

(1) Applications. Used for characterization and quality assurance.

(2) Significance. The data are used to calculate the stresses applied to the charge and store throughout its storage and operating life.

(3) Limitations. This method can only be used when the specimen are available in a suitably geometry. It is not a suitable method for rubbery materials.

d. Typical Results. Density, ρ, of pressed RDX/TNT is $1.67 Mg/m^3$.

e. Repeatability and Reproducibility. Dependent on the accuracy of measurement. Dimensions measured to $\pm$ 0.2% and weighing to $\pm$ 0.001g will give density to $\pm$ 0.7%.

3. NATIONAL REFERENCES:

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/PBXs/Melt Cast Explosives/Pyrotechnics.

2. TEST TITLE: Physical Properties, Density.

a. Type of Test: Determination of Density by Liquid - Displacement.

b. Description:

(1) Geometry of Specimen. Any piece of material, 2.5 to 25 grams weight, usually of irregular shape, with smooth surfaces free from crevices and dust. If porous it may be necessary to coat the sample with a wax or lacquer.

(2) Experimental Method. The specimen is accurately weighed in air and re-weighed immersed in a suitable liquid of known density. The specimen density is calculated from the two weighings. For materials of density below or near that of the immersing liquid a heavy sinker is added and an extra weighing made.

(3) Main Physical Parameters. The main physical parameter affecting the results is changes of temperature.

(4) Results. Density, ρ, and/or specific gravity, SG; the void fraction may be derived from a knowledge of the theoretical maximum density.

c. Information Requirements for Assessment:

(1) Applications. Used for characterization and quality assurance.

(2) Significance. The data are used to calculate the stresses applied to the charge and store throughout its storage and operating life.

(3) Limitations. This method can only be used when a liquid is available that does not dissolve or swell the material, or its coating when used.

d. Typical Results. Density, ρ, of plastic explosive is 1.60 Mg/m^3.

e. Repeatability and Reproducibility.

The measured density is accurate to 0.2%.

3. NATIONAL REFERENCES:

BS 2782 part 6 methods 620A and C, BS 903 part A1 method A; ASTM D792 method A, ISO/R 1183-1970. DQA/TS M216/74 method C.

UK/102.01.071 mode 3

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Solid Propellants/PBXs/Melt Cast Explosives/Pyrotechnics.

2. TEST TITLE: Physical Properties, Density.

a. Type of Test: Determination of Density by the Density - Gradient Column Method.

b. Description:

(1) Geometry of Specimen. Any small piece (less than 6mm cube) of material, of an easily identifiable shape, with smooth surfaces free from crevices and dust. Samples cut from film should not be less than 0.13 mm thick.

(2) Experimental Method. Three samples are put into a column containing a suitable mixed liquid or solution together with standardized floats whose density brackets that of the sample. When the sample and floats are at equilibrium (10 minutes minimum) the vertical distances from the floats are measured and the density calculated.

(3) Main Physical Parameters. The main physical parameter affecting the results is changes of temperature.

(4) Density, ρ, the void fraction may be derived from a knowledge of the theoretical maximum density.

c. Information Requirements for Assessment:

(1) Applications. Used for characterization and quality assurance.

(2) Significance. The data is used to calculate the stresses applied to the charge and store throughout its storage and operating life.

(3) Limitations. This method can only be used for solid materials that do not absorb, dissolve or swell in the column liquids.

d. Typical Results:

e. Repeatability and Reproducibility: This method has an accuracy of $\pm$ 0.05%.

3 NATIONAL REFERENCES:

BS 2782 part 6, method 620D; ASTM D1505; ISO/R 1183-1970.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Melt Cast Explosives

2. TEST TITLE: Uniaxial Mechanical Properties, Tensile (Constant Strain Rate).

a. Type of Test: Uniaxial Mechanical Properties, Tensile - Used for melt cast explosives.

b. Description:

(1) Geometry of Specimen. Sample is a right circular dumb-bell (dog bone), machined from a solid casting. The preferred gauge length is 50mm long and 20.3mm diameter. The transition radius to the gauge length is 12.7mm.

(2) Applied Load. Applied load varies with the material, normally in the range 0.3 to 10 MPa.

(3) Experimental Method. After conditioning at test temperature for one hour, the sample is pulled axially by the dumb-bell ends using a stiff tensile testing machine. Load is applied at a constant strain rate (crosshead speed). It is preferred that strain is measured directly using an extensometer or similar device and not crosshead movement.

(4) Main Physical Parameters. The main physical parameter affecting the results are strain rate and temperature.

(5) Results. Tensile strength, σ_m, initial tangent modulus, E_o, and the strain at maximum load, ε_m, and at failure, ε_b, are calculated.

c. Information Requirements for Assessment:

(1) Applications. Used for characterization and routine process control of melt cast high explosives.

(2) Significance. The data are required to assess the ability of the charge to retain its integrity throughout the range of operating conditions envisaged for the material.

(3) Limitations. Can only be used on materials that can be machined without shattering. Values obtained for modulus will be unrealistically low if direct methods of strain measurement are not used.

d. Typical Results:

e. Repeatability and Reproducibility:

3. REFERENCES:

The method is essentially that described in ASTM D638 but the dumb-bell is more suitable for explosive materials.

UK/201.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants/Pyrotechnics

2. TEST TITLE: Rotter Impact Test

a. Type of Test: Safety/Drop-weight Impact - Used for all Energetic Materials.

b Description: A small quantity of the material confined between a brass cap and an anvil in a heavy housing is subjected to an indirect impact from a 5 kg weight dropped onto intermediate components (drift and striker). The median height for ignition is determined and compared to that for a standard RDX to produce a figure of insensitiveness (F of I) for the material.

c. Information Requirements for Assessment: To determine the sensitiveness of energetic materials to ignition by impact or nipping between metal surfaces.

d. Typical Results:

Explosive	F of I
PETN	50
HMX	60
RDX	80 (Standard)
TNT	150
COMP B	130
VU (EDB)	15
ATN D28/47 (CDB)	20
SR44	30
SR651	180

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 1A.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Ball and Disc Test.

   a. Type of Test: Safety/Impact - Used for Primary Explosives.

   b. Description: A small sample of the explosive under test is placed on a steel anvil and covered by a brass disc. It is then subjected to impact from a falling steel ball impacting on a striker with a hemispherical end.

   c. Information Requirements for Assessment: This test aims to determine the impact sensitiveness of primary explosives with a degree of discrimination superior to that achieved for such materials by the Rotter Test.

   d. Typical Results: Results are given as the height of drop required to give ignitions in 50% of the impacts.

Service Lead Azide	17 cm
Lead Styphnate RD 1303	11 cm

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 14.

UK/201.01.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Small Scale Explosiveness Test

a. Type of Test: Safety/Drop-weight Impact - Used for all except most pyrotechnics.

b. Description: The sensitiveness of the test material is firstly measured using test UK/201.01.001 (Rotter). Using the same test equipment, data for the mean gas volume of decomposition products for positive events (ignitions) is collected across a range of stimulus levels (up to 2.5 times the median drop-height). These mean gas volumes are compared with the calculated theoretical specific gas production for the test material, expressed as a percentage and corrected with reference to the output from a high explosiveness standard sample of lead azide. When explosiveness is plotted against stimulus level a characteristic curve is obtained for the material. Both an explosiveness figure and a hazard index can easily be derived from such curves. Although this is a small scale test, it clearly demonstrates the effect of the physical properties of the test material and is thus an effective early indicator of charge scale safety characteristics.

c. Information Requirements for Assessment: To assess the relative explosiveness and hazard index for energetic materials.

d. Typical Results:

Test Material	Explosiveness Figure	Hazard Index
RDX	85	100
RDX/Wax 99/1 (Debrix1)	82	71
RDX/Wax 95/5 (Debrix2)	51	34
PETN	77	121
HMX	77	112
TNT	3	1

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 1D.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Grit sensitisation

a. Type of Test: Safety/Impact - Used for Main Charge High Explosives, Booster Explosives and Propellants.

b. Description: The sensitiveness of the test material is firstly measured using test UK/201.01.001 (Rotter). Using the same test equipment, two further Rotter tests are performed on the test material with added grit. A standard alumina grit with a well specified and characterised particle size is added at two concentrations, 0.1 and 1% by weight. It is added in such a way that the sample is as homogeneous as possible. Data from the grit-sensitised samples can be compared with that for the uncontaminated sample in order to determine the degree of sensitisation by the grit. It is often convenient to plot a curve to illustrate the results.

c. Information Requirements for Assessment: The test shows which samples are more likely to be significantly sensitised by the presence of adventitious grit particles.

d. Typical Results

Test Material	F of I – Zero grit	F of I – 0.1% grit	F of I – 1% grit
RDX	82	27	23
Debrix1	85	29	20
Debrix2	95	56	29
PETN	46	20	10
HMX	53	23	18
TNT	135	104	83

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 1B.

UK/201.01.005

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Small Scale Spigot Drop Test

a. Type of Test: Safety/Impact - Used for Propellants, Boosters and Main Charge High Explosives.

b. Description: A steel spigot attached to a 40kg drop-weight is guided vertically under gravity to penetrate a thin steel cover plate and pass into the test explosive contained in a steel tube standing vertically on a witness block.

c. Information Requirements for Assessment: To test the response of explosive materials to intrusion by a steel spigot.

d. Typical Results: Results are given as the height of drop required to give ignitions in 50% of the trials.

VU (EDB)	1.1 m
ATN (D28)/47 (CDB)	1.3 m

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 37

.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Liquid Propellants / Explosives

2. TEST TITLE: Liquid Explosives Impact Test

   a. Type of Test: Safety/Impact - Used for Liquid Explosives

   b. Description: The Rotter test apparatus is used in conjunction with a modified sample housing. A rubber O-ring is inserted at the base of a cylindrical cavity in a robust steel sample cup. A standard volume of the test liquid is dispensed from a micro-pipette into the cavity so formed. The cavity is then approximately half full. It is sealed by placing a stainless steel shim and a steel plunger on top of the O-ring. This assembly is placed in the impact housing and a standard pre-compression is applied to the cavity by rotating the threaded central upper part of the housing. The housing is then placed under the drop-weight machine and a 2kg drop-weight is used to apply a compression stimulus to the cavity via an intermediate drift, ball bearing and plunger. The median height for positive events (ignitions) is determined using a 50 shot Bruceton Staircase technique.

   c. Information Requirements for Assessment: Relative sensitiveness to this stimulus can be ranked and compared for different types of liquid explosive.

   d. Typical Results:

Test Liquid	Median drop-height (cm)
NG	5
Casting liquid 75/24/1 NG/Triacetin/2NDPA	10
Isopropyl nitrate	14
Nitromethane	65
Diesel fuel	> 126

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 8.

UK/201.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants/Pyrotechnics

2. TEST TITLE: Rotary Friction Test

   a. Type of Test: Safety/Friction - Used for all energetic materials

   b. Description: A small quantity of powdered material is placed on a steel block, whose surface has been grit-blasted to standard roughness and is pushed by means of compressed air of standard pressure against a steel wheel whose surface is similarly treated. The wheel is then caused to rotate over a fixed arc at a preset velocity and the resulting friction may ignite the material. The median velocity required to give ignition in 50% of the tests is compared with that for a standard RDX to produce a figure (F of F) for the material.

   c. Information Requirements for Assessment: To determine the sensitiveness of thin layers of powdered materials to friction between surfaces likely to be encountered in real environments, particularly during processing.

   d. Typical Results:

Explosive	F of F
PETN	1.3
HMX	1.5
RDX	3.0 (standard)
LU double base propellant	2.4
RD 2503 Composite propellant	1.6
SR 92 delay composition	0.17
RD 1303 lead styphnate	0.17
RD 1343 lead azide	0.07

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 33.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary Explosives

2. TEST TITLE: Emery Paper Friction Test

a. Type of Test: Safety/Friction - Used for Primary Explosives

b. Description: The material is smeared between two steel surfaces, which are covered with emery paper to provide a rough surface. A load of 15 kg is applied to push the two surfaces together and the impact from a pendulum is used to move the lower metal surface relative to the upper surface. The friction caused by moving the two rough surfaces can ignite the material.

c. Information Requirements for Assessment: This test determines the friction sensitiveness of primary explosives with a degree of discrimination superior to that achieved by the rotary friction test when used to test similar samples.

d. Typical Results: The results can be expressed as the striking velocity of the pendulum required to give ignitions in 50% of the strikes.

Explosive	Striking Velocity (ms^{-1})
Service Lead Azide	1.2
Lead Styphnate RD 1303	2.5

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 13.

UK/201.03.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants/Pyrotechnics

2. TEST TITLE: Electric Spark Test

a. Type of Test: Safety/Electric Spark

b. Description: Small samples of material are subjected to an electrostatic discharge (spark) of 4.5J. If any ignitions occur further samples are subjected to a discharge of 0.45J. If any ignitions occur further samples are subjected to a discharge of 0.045J. Fifty tests are carried out before a result is reported as no ignitions at that level. Samples that are ignited at 0.045J (approximately twice the maximum energy expected to accumulate as static electricity on a person's clothes) are tested using Test No. 201.01.002.

c. Information Requirements for Assessment: To determine the electrostatic charge required to ignite an explosive material at an energy level greater than that found on personnel.

d. Typical Results:

FNH gun propellant	No ignitions at 4.5J
VU rocket propellant	No ignitions at 4.5J
ATN(D28)/47 rocket propellant	No ignitions at 4.5J
NQ gun propellant	No ignitions at 4.5J
Tetryl	Ignites at 4.5J, but not at 0.45J
RDX	Ignites at 4.5J, but not at 0.45J
PETN	Ignites at 4.5J, but not at 0.45J
SR44	Ignites at 4.5J, but not at 0.45J
SR65	No ignitions at 4.5J

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES

EMTAP Manual of Tests, Test No. 6.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants/Pyrotechnics

2. TEST TITLE: Electric Spark Test for Sensitive Explosives

   a. Type of Test: Safety/Electric Spark - Used for Primary Explosives and Pyrotechnics.

   b. Description: In this test, compositions which are ignited by the 0.045J discharge of the UK Electric Spark Test are assessed. Two types of discharge can be used:

      (1). Between metallic electrodes, simulating a discharge from one metal object to another;

      (2) Between a metallic and a non-metallic (rubber) electrode, simulating a discharge from a charged person. In both cases a minimum energy of ignitions is determined but in (b) a minimum capacitance for ignition is also found.

   c. Information Requirements for Assessment: To determine the minimum electrostatic charge required to ignite an explosive material that has been classified as a sensitive explosive by the UK Electric Spark Test.

   d. Typical Results:

Service Lead Azide	-	Metal/metal	0.002mJ
		Rubber/metal	0.225mJ, 400 pF
Lead Styphnate RD 1303	-	Metal/metal	0.025mJ
		Rubber/metal	0.015mJ, 25 pF

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No.7.

UK/201.04.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters

2. TEST TITLE: Small-Scale Gap Test

   a. Type of Test: Safety/Detonative Shock - Used for energetic materials where the critical diameter is less than about 15mm.

   b. Description: This is the small scale gap test described in STANAG4488. The shock wave from an RDX/wax donor is attenuated by a water barrier and the detonation or otherwise of the acceptor assessed by the transmission or otherwise of detonation along a length of detonating cord. The cord is laid against an aluminium alloy witness plate. The thickness of attenuator giving a 50% probability of detonation is calculated from the results of testing using a Bruceton staircase procedure.

   c. Information Requirements for Assessment: This test determines the sensitivity to shock initiation of explosives which will propagate detonation in unconfined charges with diameters of less than about 15mm.

   d. Typical Results:

Explosive	Density ($g\ cm^{-3}$)	Attenuator Thickness (mm)

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   To be supplied.

.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants

2. TEST TITLE: Large-Scale Gap Test

   a. Type of Test: Safety/Detonative Shock - Used for Main Charge High Explosives, Booster Explosives and Propellants.

   b. Description: This test is based closely on the US NSWC Large-Scale Gap Test. The material under test is subjected to a shock wave from a donor pellet (tetryl) that is attenuated by a Perspex™ (polymethyl methacrylate) barrier placed between the donor and acceptor charges. A witness plate is used to distinguish the detonation of the test explosive from sub-detonative reactions.

   c. Information Requirements for Assessment: This test may be used to compare the detonation shock sensitivity of explosive materials having unconfined critical diameters up to about 100 mm.

   d. Typical Results:

VU (EDB)	6.4 Gpa
ATN (D28)/47 (CDB)	7.2 Gpa

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 22.

UK/201.06.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Model Scale Motor Fragment Attack Test for Solid Rocket Propellants

a. Type of Test: Safety/Impact - Used for Rocket Propellants.

b. Description: The propellant, prepared in specified charge form, is mounted in a cylinder externally 250 mm long by 125 mm diameter. Massive steel caps fitted over the ends of the cylinder are joined externally by steel tie-rods of 18 mm diameter. One end cap is fitted with a nozzle of throat diameter, appropriate to a burning pressure specified for the test. The motor, preconditioned to a specified temperature, is mounted vertically nozzle upwards, and attached half-way along its length and half-way between two tie-rods by a single 17 g steel cylinder impacting end-on at 920 m/s. The violence of response of the propellant is assessed principally by the degree of case damage, though measurements of external blast overpressure and pressure within the cylinder are also made.

c. Information Requirements for Assessment: To test the response of a rocket propellant charge to attack by a representative fragment under standardized conditions.

d. Typical Results: (All using fast attack on star-centred charges in aluminium alloy tubes, using nozzles appropriate to design burning pressure 10 MPa).

Propellant	Temperature (^oC)	Tube Fragmentation
CDB	18	Nil
"	-10	2
"	-30	21
"	-50	36
EMCDB	18	Nil
"	-10	Nil
"	-30	Nil
"	-50	22
HTPB	18	Nil
"	-10	24
"	-50	30

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 38.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Fragment Attack of Solid Gun Propellants

   a. Type of Test: Safety/Fragment attack - Used for Gun Propellants.

   b. Description: Attack is by means of a single, non-spinning, cylindrical 17g steel representative fragment fired end-on at right angles centrally into a target face of a cubical cardboard box of 67 mm side, containing the propellant. For qualification, attack velocities of 920 ± 25 and 1500 ± 50 m/s are employed. Slotted stick propellant is cut into 67 mm lengths which are laid out parallel to one another in the box until it is filled; for small multitube grains, random orientation is used, but for larger grains, for which stacking is practical and leads to a greater packing density, that method may be employed. For qualification of stacked strands of grains, vertical orientation is used for attack at right angles to the length of the grain. Propellant weight is about 300g. The maximum blast overpressure at 1m from the front face of the box, 10^{o} off the line of fire, is recorded.

   c. Information Requirements for Assessment: This test assesses the explosiveness of gun propellants under the test conditions and enables comparisons to be made of the vulnerability of charges differing in composition, configuration and web thickness.

   d. Typical Results:

NQ/S	web (mm)	maximum overpressure at 1m (KPa)
	1.42	34, 36
	2.05	31, 28
	3.05	24, 26

   e. Repeatability and Reproducibility: For qualification three attacks at each velocity are carried out but if the results differ by more than 25% a fourth shot is carried out.

3. NATIONAL REFERENCES

   EMTAP Manual of Tests, Test No. 39.

UK/201.06.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters

2. TEST TITLE: Fragment Impact Test

   a. Type of Test: Safety/Projectile Impact - Used for Booster and Main Charge High Explosives

   b. Description: Approximately 260 cm^3 of material at its normal filled density is confined in a standard steel cylinder of wall thickness 9.5 mm. A mild steel or aluminium alloy end cap provides a 3.0 mm thick septum which is impacted by a 13.15 mm diameter flat ended projectile weighing 13.5 g. The projectile impact velocity is varied in the range 400 to 2500 ms^{-1} and the explosive response assessed.

   c. Information Requirements for Assessment: To compare the response of confined explosive charges subjected to projectile impact at velocities up to 2500 ms^{-1}.

   d. Typical Results:

Tetryl	450-500 m/s burning, 700 m/s detonation
RDX/Wax 95/5	530-800 m/s deflagration, 800 m/s detonation
Composition A5	370-650 m/s explosion, 650 m/s detonation
RDX/TNT 60/40	500-900 m/s burning, 1200 m/s detonation
TNT	450-1000 m/s burning, 1350 m/s detonation
PE4	930-1200 m/s burning/deflagration, 470-1000 m/s burning
Torpex 4D	1200 m/s detonation 1300-1400 m/s explosion

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 36.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Shaped Charge Attack Test

a. Type of Test: Safety/Jet Impact - Used for Propellants

b. Description: Gun propellants are tested by loading them into a 165mm length of combustible charge case and fitting card closures to the ends. Rocket propellants are normally tested bare. In either case, the charge mass can be as high as 2.1kg. It is usual to fire duplicate trials. For gun propellants it is useful to compare the test results across a range of web sizes. Charges are supported in a steel frame that also locates spaced jet arrestor plates, a 25mm thick conditioning plate and the shaped charge. The latter is a 63.5mm diameter 45^{o} included angle copper cone. An optional second part of the test varies the thickness of the conditioning plate until the median thickness for high order reaction of the propellant charge is determined. Output from the propellant charge is recorded on an air blast over-pressure gauge and the resultant peak pressure and positive impulse readings are expressed as mass ratios by comparison with air blast over-pressure tables for Comp B.

c. Information Requirements for Assessment: To compare the response of unconfined propellant charges subjected to jet impact .

d. Typical Results:

Propellant	Web size (mm)	Mass Ratio
NQ/S	0.71	0.17
	0.97	0.22
	1.21	0.19
	1.47	0.07
	1.72	0.08
	2.15	0.04
	2.51	0.08
	3.2	0.09
Experimental formulation F300/95/S	0.76	0.25
	1.02	0.12
	1.33	0.17
	1.73	1.09
	2.03	1.21

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 40.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants/Pyrotechnics

2. TEST TITLE: Ease of Ignition Test

   a. Type of Test: Safety/Incendive Spark - Used for all Energetic Materials

   b. Description: A standard mass of the explosive material is subjected to the short burst of flame and hot particles emitted from the end of a length of standard gunpowder fuze. Observations are made as to whether the sample ignites and if so whether it burns or explodes. If a material ignites under the conditions of light confinement used, it must be assumed that any non-electric spark will ignite it.

   c. Information Requirements for Assessment: To determine the response of an explosive material when exposed to a brief flame.

   d. Typical Results:

FNH gun propellant	Ignites and burns quietly
VU rocket propellant	Ignites and burns quietly
ATN(D28)/47 rocket propellant	Ignites and burns vigorously
Service Lead Azide	Explodes
Lead Styphnate RD1303	Explodes
Tetryl	Ignites and burns quietly
RDX	Fails to ignite
PETN	Ignites and burns quietly
SR44 (primer composition)	Explodes
SR651 (delay composition)	Ignites and burns quietly

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 4.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics/Boosters

2. TEST TITLE: Temperature of Ignition Test

   a. Type of Test: Safety/Thermal - Used for all Energetic Materials.

   b. Description: A standard mass of the explosive material under test is heated in duplicate test tubes at a standard rate until an event occurs. This can be regarded as an accelerated stability test. The actual values of "Temperature of Ignition" obtained are meaningful only under the particular conditions used, and changing the rate of heating or size of sample will lead to different results.

   c. Information Requirements for Assessment: To measure the temperature at which a standard mass of an explosive material decomposes.

   d. Typical Results:

FNH (gun propellant)	174°C
VU (rocket propellant)	185°C
ATN(D28)/47 (rocket propellant)	167°C
NQ (gun propellant)	167°C
Service Lead Azide	330°C
Lead Styphnate RD1303	269°C
Tetryl	183°C
RDX	219°C
PETN	186°C
SR44	>400°C
SR651	275°C

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 3.

UK/202.01.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Propellants/Pyrotechnics/Boosters

2. TEST TITLE: Train Test

a. Type of Test: Safety/Flame - Used for all Energetic Materials.

b. Description: The explosive material is laid in a train in a metal trough and one end of the train is exposed to a flame for one minute.

c. Information Requirements for Assessment: To determine the response of an explosive material when exposed to a flame.

d. Typical Results:

FNH (gun propellant)	Ignites and supports train steadily throughout
VU (EDB)	Ignites and supports train steadily throughout
ATN(D28)/47 (CDB)	Ignites and supports train steadily throughout
NQ (gun propellant)	Ignites and supports train steadily throughout
Service Lead Azide	Explodes
Tetryl	Ignites and supports train for 25 mm
RDX	Ignites and supports train steadily throughout
PETN	Ignites and supports train for 25 mm
SR44	Ignites and supports train vigorously throughout
SR651	Ignites and supports train steadily throughout

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 5.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives (Liquids)

2. TEST TITLE: Small Sealed Vessel Test

   a. Type of Test: Safety/Thermal - Used for Liquid Explosives.

   b. Description: A sample of the liquid explosive ($55cm^3$) is heated steadily in a sealed steel vessel until and event occurs. The event (e.g, pressure burst, explosion) provides evidence as to whether a liquid is an explosive or not. For explosive materials it can provide limited information on stability and on explosiveness under the test conditions.

   c. Information Requirements for Assessment: To determine the response of a liquid explosive when heated in a sealed steel vessel.

   d. Typical Results:

Ethyl Nitrate	Pressure Burst
Nitromethane	Pressure Burst
Nitroglycerine/Triacetin 55/45	Detonation

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests, Test No. 9.

UK/202.01.005

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Tube Test – Internal Ignition

a. Type of Test: Safety/Ignition - Used for Main Charge High Explosives, Booster Explosives and Propellants

b. Description: Approximately 184 cm^3 of material at its normal filled density is confined in a standard steel cylinder of wall thickness 6.0 mm. The material is ignited using a standard igniter and the tube fragments produced are examined and counted. Ten trials are performed. This test is used to assess the explosiveness of a material.

c. Information Requirements for Assessment: To test the response of a confined explosive material to ignition.

d. Typical Results:

Explosive	Fragments
Tetryl (NATO Standard)	>100
Debrix 18AS (RDX/Wax 95/5)	19
RDX/TATB/PTFE	1
Composition A5	>100
HMX/TNT 75/25	25
RDX/TNT	15
TNT	1-11
Rowanex 1001(HMX/PU)	2
Torpex 2B	7
PE4	1

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 35.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Tube Test – Fast Heating (Fuel Fire)

a. Type of Test: Safety/Ignition - Used for Main Charge High Explosives, Booster Explosives and Propellants

b. Description: Approximately 184 cm^3 of material at its normal filled density is confined in a standard steel cylinder of wall thickness 6.0 mm. The material is heated over a small fuel fire and the tube fragments produced are examined and counted. Ten trials are performed. This test is used to assess the explosiveness of a heated material.

c. Information Requirements for Assessment: To test the response of a confined explosive material to fast heating.

d. Typical Results:

Explosive	Fragments
Debrix 33	4
LX14	20
RDX/TNT	22
Rowanex 1001	1
PE4	>50

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 41.

UK/202.01.007

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Tube Test – Electrically Heated

a. Type of Test: Safety/Ignition - Used for Booster, Main Charge High Explosives and Propellants

b. Description: Approximately 184 cm^3 of material at its normal filled density is confined in a standard steel cylinder of wall thickness 6.0 mm. The material is heated at a predetermined rate using an electrical heating winding and the tube fragments produced are examined and counted. Trials are performed over a range of heating rates between $3.3^{o}C/hr$ and $10^{o}C/min$. This test is used to assess the explosiveness of a material.

c. Information Requirements for Assessment: To test the response of a confined explosive material to ignition.

d. Typical Results:

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

EMTAP Manual of Tests, Test No. 42.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Vacuum stability test

a. Type of Test: Thermal stability - Used for Booster, Main Charge High Explosives and Propellants

b. Description: This test induces controlled thermal degradation of an explosive sample, typically 5 g, by heating it for a specified temperature and time under vacuum. The volume of gas evolved during the test is measured by use of a pressure transducer or mercury manometer. The test procedure is described in STANAG 4556. The precise test conditions will vary depending on the explosive or propellant composition and are prescribed in the relevant specification. The test may also be used to determine the stability of explosives in contact with non-explosive materials for compatibility assessment as described in STANAG 4147.

c. Information Requirements for Assessment: Volume of gas evolved (at STP) for a given mass of sample, temperature and duration of test. Comparison of this value to specified maxima for test explosives.

d. Typical Results:

Explosive or Propellant	Mass of sample	Test temperature (°C)	Test time (hours)	Typical values (cm^3 at STP)
RDX	5	150	24	1.7
HMX	5	120	40	0.2
PETN	2.3	120	20	4.7
PE4	5	120	40	0.7
Tetryl	5	120	40	4.5
SX2	5	120	24	0.3
KU	5	80	168	0.6
VU	5	80	168	0.6
N type	5	80	168	0.7
DX	5	80	168	1.2
CCC	5	80	168	0.5

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

DQA/TS Method M226

UK/202.02.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Chemical stability

a. Type of Test: Chemical stability - Used for nitrocellulose based Gun and Rocket Propellants

b. Description: The chemical safe life of nitrocellulose based propellants is estimated by determination of the stabilizer content both before and after periods of storage at elevated temperatures. For qualification purposes, the propellant is tested at three or more constant temperatures and samples are withdrawn for analysis at regular periods. This procedure is described in STANAG 4527. The reaction rate is calculated at each temperature according to either pseudo zero order or pseudo first order kinetics, whichever gives the best fit, and this allows the activation energy to be calculated from the Arrhenius equation, which defines the temperature dependence of the reaction rate. Analytical methods for determination of ethyl centralite and diphenylamine stabilizers are given in STANAG 4117. Where assurance of a 10 year life at 25°C is sufficient, testing may be restricted to a single temperature (eg 65.5 or 60°C) and in that case STANAG 4117 or STANAG 4541 may be an appropriate test document.

c. Information Requirements for Assessment: The safe life is assessed by calculation of the time required for 50% depletion of the initial stabilizer content at a constant 25°C

d. Typical Results:

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

DERA Bishopton Laboratory Method No. 35

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: 80°C Self heating test

a. Type of Test: Chemical stability - Used for nitrate ester based gun and rocket propellants

b. Description: A sample of propellant, minimum 70g mass, is heated at a constant 80°C in a specified test apparatus until either brown fumes are observed or a 2°C increase in the propellant temperature is detected. This occurs when the effective stabilizer has been consumed and autocatalytic reactions have commenced. This test can be used to estimate the minimum service life but it is less reliable than multi-temperature ageing. Most in-service propellants give times in excess of 2000 hours. Propellants producing test times of less than 1000 hours are considered to be of dubious stability and unlikely to be acceptable for service use.

c. Information Requirements for Assessment: Time to production of brown fumes or a 2°C rise in temperature in the sample.

d. Typical Results:

Propellant type	Stabilizer level	NG level	Time to fume (hours)
Small arms single base	DPA 1%	nil	2500-3000
Extruded gun triple base	EC 3.5-7%	20%	5000
Rocket extruded double base	2-NDPA 1-2%	35-45%	3000
Rocket cast double base	2-NDPA 0.6% pNMA 0.3%	35-55%	2000-2500

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

Defence Standard 13-187/1

UK/202.02.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Boosters, Propellants

2. TEST TITLE: Abel Heat Test

a. Type of Test: Safety/Stability - Used for nitrate ester explosives

b. Description: The test involves controlled thermal degradation of the explosive by heating a sample (< 2g) under closely specified conditions. Evolved oxides of nitrogen are detected by a colour change on a specially prepared starch-iodide test paper, contained in a specified test apparatus. The time to develop a line on the test paper to the same intensity as that of a standard tint is taken as the heat test time. The time to detection is indicative of the intrinsic stability of the explosive at the time of test. The test cannot be used to determine long term stability or to estimate service life.

c. Information Requirements for Assessment: The Abel Heat Test is a UK legal requirement for military and commercial explosives. For propellants, the time to detection must be less than 10 minutes.

d. Typical Results:

Explosive	Test temperature (°C)	Typical test times (minutes)	Typical test limit (minutes)
Nitroglycerine	82.0	10.5-11.5	10
Nitrocellulose	77.0	10	10
Casting powders	82.2 (71.1)	25	12
Casting liquids	82.2	25	10
Combustible Cartridge Case (CCC)	76.5	25	10
CE (Tetryl)	99.0	22	>20
Single base propellant	82.2	>10	10
Extruded double base propellant (LU,VU)	60.0	15	10
Extruded double base propellant (KU,PU)	65.5	15	10
Triple base propellant	65.5	>10	10
Mechanites	71.1 (60.0)	>10	10
Cast double base propellants	65.5	10	10
PETN	76.7	>120	>40

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

Defence Standard 13-189/1

UK/202.02.005

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: The 50mm Cube Crack Test

   a Type of Test: Stability/Mechanical - Used for cast rocket propellants

   b. Description: The 50mm cube crack test is used primarily to assess the stability of cast double base propellants (CDB) with respect to gas cracking. It provides a measure of the gassing rate and internal strength of the propellant. Samples of propellant are machined into 50mm cubes, inserted into a close fitting aluminium can and then heated at 80°C for a number of days. The cubes, three per can, are subjected to regular X-ray examinations to detect the presence of cracks. The crack life is reported as a range in days from initial to final observed cracking of the cubes.

   c. Information Requirements for Assessment: A crack life of >10 days (initial) is regarded as satisfactory (>7 days for EMCDB).

   d. Typical Results:

Conventional CDB	10-30 days
Composite modified CDB	14-25 days
Elastomer modified CDB	7-14 days
Nitramine loaded CDB	22-28 days

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   EMTAP Manual of Tests Test No.TBA (in draft)

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Boosters

2. TEST TITLE: Detonation Velocity

a. Type of Test: Performance

b. Description: The test uses cylindrical charges of known density, initiated at one end with a booster of similar diameter. The progress of the shock front is monitored using a suitable high-speed camera, with the mirror speed adjusted to optimise the time and distance dimensions. The length of the booster should be at least twice the diameter of the acceptor and the cylinders should have a length to diameter ratio of at least six, but this may vary depending on experience. Analysis should be carried out on the last two or three diameter lengths. Where a sample is not self-illuminating, additional illumination such as an argon flash bomb may be used.

c. Information Requirements for Assessment: To compare the detonation velocity of energetic materials.

d. Typical Results: Results are given as the velocity ($mm.\mu s^{-1}$ or $km.s^{-1}$) at the density of the test sample.

Composition B (UK) (cast) VoD = 7.69$mm.\mu s^{-1}$ @ 1671$kg.m^{-3}$

Composition B (UK) (pressed) VoD = 7.75$mm.\mu s^{-1}$ @ 1703$kg.m^{-3}$

e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

DERA Method Statement: DRA/WSS/WX4/DA/MS/041/1

.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives/Boosters/Propellants

2. TEST TITLE: Critical Diameter

   a. Type of Test: Safety/Performance - Used for Booster and Main Charge High Explosives and Propellants

   b. Description: The test uses either a 5^{o} included angle truncated cone and selection of cylindrical charges or just the cylindrical charges. If the cone is used, it is initiated at its larger diameter end with a booster of similar diameter and the progress of the shock front is monitored using a suitable high-speed camera. The diameter at which detonation ceases gives a good approximation to critical diameter, but for a more accurate value, cylinders should be machined in a range of diameters close to and just above the indicated diameter value. The cylinders should have a length to diameter ratio of at least six, preferably eight. These are tested in the same way as the truncated cone and monitored either with a high-speed camera or a witness plate can be used to determine whether or not detonation is maintained.

   c. Information Requirements for Assessment: To compare the critical diameter of energetic materials.

   d. Typical Results:

   e. Repeatability and Reproducibility: To be supplied.

3. NATIONAL REFERENCES:

   DERA Method Statement DRA/WSS/WX4/DA/MS/046/1.

10.7.15 QUALIFICATION PROCEDURES FOR THE UNITED STATES

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10.7.15.1 MILITARY DEPARTMENTS RESPONSIBLE FOR QUALIFICATION IN THE UNITED STATES

10.7.15.1.1 Each Service, the Army, the Navy (which includes the Marine Corps), and the Air Force, is responsible for selecting and qualifying explosive materials for its own application. This authority is delegated from the Secretary of Defense to, respectively, the Secretary of the Army, the Secretary of the Navy, and the Secretary of the Air Force. The Service Secretaries delegate these responsibilities to organizations in their command. There is no single National Qualification Authority identified for the United States. To comply with STANAG 4170, however, the Department of Defense (DoD) has identified a Coordinating National Authority to work with the NATO CNAD-sponsored organizations. He is the responsible agent, in the United States for all matters relating to the implementation of STANAG 4170; however this Coordinating National Authority does not Qualify explosive materials or issue qualification documents.

10.7.15.1.2 To support the DoD Coordinating National Authority, each military Service has identified an authority responsible for the qualification of explosive materials for its own needs and to assist the Coordinating National Authority in the implementation of STANAG 4170. These Service Authorities or their delegated representatives are responsible for staffing all NATO correspondence and action items dealing with explosive materials qualification, safety, and suitability for service to the proper organizations within their respective Commands.

10.7.15.2 NATIONAL AUTHORITIES

10.7.15.2.1 The U.S. Department of Defense National Authority for Explosives responsible for the implementation of STANAG 4170 is as follows:

Office of the Undersecretary of Defense (Acquisition, Technology, and Logistics/
Defense Systems, Land Warfare and Munitions) [OUSD(AT&L)/DS,LW&M]
Room 3B 1060
3090 Defense Pentagon
Washington, D C 20301-3090

a. The DoD National Authority for Explosives performs the following functions:

(1) Coordinates the implementation of STANAG 4170.

(2) Coordinates the preparation, publication, and maintenance of the U.S. portion of this manual and of AOP-26 Edition 1 – “NATO Catalogue of NATO Explosives”.

(3) Provides a DoD central point-of-contact to NATO countries for information exchange on explosives technology, and qualification of explosive materials.

(4) Provides a DoD point of contact to NATO countries for the exchange of information on safety and suitability for service of explosives and munitions.

(5) Oversees and sponsors, in coordination with the three U.S. Services, all DoD activities related to the NATO AC/310 and its four subgroups.

10.7.15.2.2 The U.S. Military Qualification Authorities are as follows:

a. U.S. Army:

(1) For explosive materials developed by the U.S. Army Tank-Automotive and Armaments command:

Commander
TACOM-ARDEC
ATTN: AMSTA-AR-WEE
Picatinny Arsenal, NJ 07806-5000

(2) For explosive materials developed by the U.S. Army Missile Command:

Commander
U.S. Army Aviation and Missile Command
Redstone Arsenal, AL 35898-5249

b. U.S. Navy and Marine Corps:

Commander
Naval Ordnance Safety and Security Activity
23 Strauss Avenue, Bldg. D-323
Indian Head, MD 20640-5035

c U.S. Air Force:

Executive Secretary
USAF Nonnuclear Munitions Safety Board
Air Armaments Center
1001 N. 2nd Street, Suite 366
Eglin Air Force Base, FL 32542-6838

d Each U.S. Service Qualification Authority is responsible for the following:

(1) Defining the tests required to determine the safety and performance characteristics of the explosives used by that Service and the associated requirements for qualification.

(2) Receiving and assessing data for qualification generated by the various technical organizations involved in the development of explosive materials. Determining whether an explosive should be qualified based on test results indicating whether that material is safe and suitable for consideration in a particular role. Ensuring that all explosives incorporated in fielded weapon systems are qualified.

(3) Qualifying explosive materials by issuing appropriate documentation and promulgating this information into the various activities.

(4) Maintaining records of all explosives qualified including the data on which qualification was based and provide such information to the other Services for their consideration in qualification.

(5) Determining whether explosives qualified by the other Services are suitable for their own applications.

10.7.15.3 QUALIFICATION PROCEDURES

a. Requests for qualification are submitted to the Service Qualification Authorities identified above. In general, a new explosive is subjected to the qualification procedure outlined in MIL-STD-1751A[1]. This Military Standard is the U.S. implementing document for STANAG 4170. The U.S. has mandatory and advisory pass – fail criteria for most explosive materials. These are listed below for each type of explosive.

b. A Hazard or Interim Hazard Classification[2] is required before qualification and is assigned in accordance with the "Department of Defense Explosives Hazard Classification Procedures". This document is identified by a different number by each Service and by the Defense Logistics Agency as follows:

Department of the Army	TB 700-2
Department of the Navy	NAVSEAINST 8020.8
Department of the Air Force	TO 11A-1-47
Defense Logistics Agency	DLAR 8220.1

The test requirements for hazard classification are not repeated in this document.

c. The qualification procedure followed by the Services provides the mandatory data for assessing an explosive's safety and performance characteristics related to a specific role or a potential military application. Certain tests are required as the data are deemed essential to the assessment process. A test method may be waived by a Service Qualification Authority if rational is provided indicating that the mandatory data are not relavant or can be accurately derived by using an alternative procedure.

d. The Service Qualification Authorities reserve the option to waive or change mandatory data requirements and pass - fail criteria specified in STANAG 4170 and in this document. The Service waiving the requirement must document the reasons and the possible consequences of any waiver or change.

e. Since variations exist between facilities using similar equipment for obtaining qualification data, the data on new explosives are compared to that obtained with two "Reference Comparison Explosives" (as defined in Chapter 4 above). The new explosive and the comparison explosives are evaluated under the same test conditions and with the same test apparatus. If possible, the two reference explosives are chosen such that they bracket the sensitivity of the new explosive.

f. In general, the Service Qualification Authority will require a statement on the processability and producibility of the new explosive material and a material specification.

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[1] MIL-STD-1751A, "Safety and Performance Tests for the Qualification of Explosives (High Explosives, Propellants, and Pyrotechnics", Issued 11 December 2001.

[2] NATO STANAG 4123, "Methods to Determine and Classify Hazards of Ammunition", has been ratified by the United States, and is implemented by the above Tri-Service/DLA document.

g. A toxicity evaluation of the explosive is performed as part of the qualification process. This includes the ingredients, combustion and detonation products, and by-products of the processing of the explosive.

h. Slight modifications to the composition of a qualified explosive could have a significant effect on the sensitivity of the material. As a result, any changes to the formulation of a qualified material, such as particle size adjustments or changes in the allowable tolerances, are reviewed by the appropriate Service Qualification Authority who then determines if the new material must be requalified.

i. Qualification of an explosive material is necessary but not sufficient to obtain approval for limited production (ALP), approval for full production (AFP), or approval for Service Use (ASU) in a specific application.

j. Final (Type) Qualification as described in Chapter 9 of this AOP is required before an explosive material is approved for military operational or training use. This latter status is conferred by the Service Qualification Authority after the material has been tested in accordance with MIL-STD-2105B[3] and shown to be safe and suitable for use in the intended application. Each new application requires a reassessment and approval by the appropriate Service Qualification Authority. Requests for qualification of propellants and pyrotechnic materials are generally combined with requests for Final (Type) Qualification.

[3] MIL-STD-2105B, "Hazard Assessment Tests for Non-Nuclear Munitions" dated 12 January 1994 or latest revision.

10.7.15.4 QUALIFICATION METHODS AND TESTS

10.7.15.4.1 High Explosives: These materials are qualified independently of specific end-items. The tests and data requirements listed below for each type of high explosive materials are required by the Service Qualification Authorities. Advisory or required pass/fail criteria are applied for most test performed. Failure to meet any or all of the advisory criteria shall normally be cause for rejection of the explosive. In general, the data requirements given in STANAG 4170 and in this section of AOP-7 are used. However, other tests may be required by the Service Qualification Authority when more data are required. Even though multiple tests are listed below for some stimuli, it is necessary to conduct only one test for each unless otherwise directed by the Service Qualification Authority. A brief description of tests used to obtain the data required by the National Authorities is provided in the Test Information Sheets provided below in section 10.7.15.7. The following is a list of mandatory data and appropriate tests for high explosives.

Mandatory Data / Test	Primary	Booster	Main Charge
Impact sensitivity	x	x	x
Friction sensitivity	x	x	x
Electrostatic sensitivity	x	x	x
Stability (Constant Temperature)	x	x	x
Self-heating	x	x	x
Compatibility	x	x	x
Detonation velocity	—	x	x
Critical Diameter	—	x	x
Shock sensitivity	—	x	x
Hot Wire Ignition	x	—	—
Exudation and Growth	—	x	x

a. Requirements for Primary Explosives: The following is a list of data, tests, and advisory acceptance criteria for primary explosives:

(1) Impact Sensitivity. The data are compared to normal lead styphnate conforming to MIL-L-757 or dextrinated lead azide conforming to Type I of MIL-L-3055, measured contemporaneously with the candidate explosive. Tests normally used are: Ball Drop Impact (U.S. 201.01.002), Bureau of Mines Impact (U.S. 201.01.003, ERL/Bruceton Impact Sensitivity (U.S. 201.01.001), or NATO STANAG 4489 tests. The Ball Drop Impact test (U.S. 201.01.002) is preferred.

(2) Friction Sensitivity. The data are compared to normal lead styphnate conforming to MIL-L-757 or dextrinated lead azide conforming to Type I of MIL-L-3055, measured contemporaneously with the candidate explosive. The tests normally used are: Pendulum Friction (U.S. 201.02.001), ABL Sliding Friction, (U.S. 201.02.005), Small BAM Friction apparatus (U.S. 201.02.006), Steel/Fiber Shoe Friction (U.S. 201.02.008), and STANAG 4487 tests.

(3) Electrostatic Sensitivity. The data are compared to normal lead styphnate conforming to MIL-L-757 or dextrinated lead azide conforming to Type 1 of MIL-L-3055, measured contemporaneously with the candidate explosive. The tests normally used are: Electrostatic Discharge (ESD), - ARDEC Method (U.S. 201.03.001), NAWC Method (U.S. 201.03.002), and NSWC Method (U.S. 201.03.003).

(4) Stability (Constant Temperature). The advisory criterion is that there is no more than 2 ml gas evolved per gram of explosive per 48 hours at 100 °C. The tests normally used are: Vacuum Thermal Stability (U.S. 202.01.001), Modified Vacuum Thermal Stability (202.01.022), and STANAG 4556 tests.

(5) Self-Heating. Although primary explosive charge sizes are not large enough to warrant a self-heating analysis (U.S. 202.01.012), the minimum temperature for exotherm onset is determined for information purposes using Differential Thermal Analysis, DTA, (U.S 202.01.007), Differential Scanning Calorimetry, DSC, (U.S. 202.01.020), or STANAG 4515 tests.

(6) Compatibility. The interaction of the explosive with common materials (e.g., metals, adhesives, acids, bases) that it may come into contact during production and use is assessed. This is done by comparing the results for the explosive in a 1:1 mixture with the material being tested with the results for the candidate explosive alone. The advisory criterion when using DTA or DSC is a change of no more than 10 °C in the exotherm peak temperature, measured at a heating rate of 10 °C/minute or less. See (U.S. 203-01-001) for details.

(7) The tests normally used are: VTS (U.S. 202.01.001, CRT (U.S. 204.01.001), DTA (U.S 202.01.007), DSC (U.S. 202.01.020), TGA (U.S. 202.01.008) or STANAG 4515.

(8) Ignition Sensitivity. No advisory criterion. The data are compared to normal lead styphnate conforming to MIL-L-757 or dextrinated lead azide conforming to Type I of MIL-L-3055 measured contemporaneously with the candidate explosive. The Hot Wire Ignition Test (U.S. 202.01.006) is used.

b. Requirements for Booster High Explosives: These materials are used in fuze components on the warhead side of the interrupter (shutter) of safety and arming devices and in items such as, leads, relays, ignition devices, and detonating cords. The pass-fail criteria in the table provided in section 7.5.3.1 complimented by those listed below are used to determine the suitability for service of booster explosives. Normally, failing to meet one or more of these criteria is cause for rejection. However, the Service Qualification Authority may accept the material if additional tests show that the material is safe to use in its intended role. The following is a list of data required, tests, and acceptance criteria for booster explosives:

(1) Impact Sensitivity. The candidate explosive passes the Impact Sensitivity Test if it is shown to be no more sensitive than a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398, measured contemporaneously with the candidate explosive. The tests normally used are: ERL/Bruceton Impact (U.S. 201.01.001), Bureau of Mines Impact (U.S. 201.01.003), Los Alamos Impact

(U.S. 201.01.004), BAM Impact (U.S. 201.01.005), or NATO STANAG 4489 tests.

(2) Friction Sensitivity. The candidate explosive passes the friction sensitivity test if it is shown to be no more sensitive than a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398, measured contemporaneously with the candidate explosive. The tests normally used are: Rotary Friction (U.S. 201.02.004), ABL Sliding Friction (U.S. 201.01.005), BAM Friction (U.S. 201.02.006), Steel/Fiber Shoe Friction (U.S. 201.02.008), or STANAG 4487 tests.

(3) Electrostatic Sensitivity. The candidate explosive passes the electrostatic sensitivity test if it is shown to be no more sensitive than a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398, measured contemporaneously with the candidate explosive. The tests normally used are: Electrostatic Discharge test, ARDEC method (U.S. 201.03.001), NAWC method (U.S. 201.03.002), and NSWC method (U.S. 201.03.003). Other test apparatus may be used as long as the above passing criterion is met.

(4) Stability (Constant Temperature). The passing criterion is that no more than 2 ml gas is evolved per gram of explosive per 48 hours at 100°C when using the Vacuum Thermal Stability, VTS, test (U.S. 202.01.001), (U.S. 202.01.022) or STANAG 4556. When using the Chemical Reactivity Test, CRT, test (U.S. 204.01.001) the passing criterion is 4 ml gas evolved per gram of explosive per 22 hours at 120°C.

(5) Self-Heating. Self-heating is assessed either experimentally or by calculation. Test data from DTA (U.S 202.01.007), DSC (U.S. 202.01.020), or STANAG 4515 experiments are used. The advisory criterion is a calculated critical temperature of no less than 180°F for 500 days for a given geometry and mass. The “One Liter Cook-Off” test (U.S. 202.01.021) may be used to determine experimentally the self-heating temperature and severity of reaction of melt-cast compounds or formulations for unconfined, spherical geometry.

(6) Compatibility. The interaction of the candidate explosive with common materials (e.g., metals, adhesives, acids, bases) with which it may come into contact in production and use is assessed. This is done by comparing of the results for the candidate explosive in a 1:1 mixture with the material being tested for compatibility with the results for the candidate explosive alone. The criterion when using DTA or DSC is change of no more than a 10°C or greater in the exotherm peak temperature, measured at a heating rate of 10°C/minute or less. The tests normally used are: VTS (U.S. 202.01.001), CRT (U.S. 204.01.001), Modified VTS (U.S. 202.01.022), DTA (U.S 202.01.007), DSC (U.S. 202.01.020). TGA (U.S. 202.01.008) or STANAG 4515. See (U.S. 203-01-001) for details.

(7) Detonation Velocity. No passing criterion is assigned. Tests per (U.S. 302.01.001) or (U.S. 302.01.004) are performed to ensure that the explosive will detonate.

(8) Critical Diameter. For information purposes. No passing criterion is assigned. Tests performed per (U.S. 302.01.003) are used to find the smallest diameter that can support a steady state detonation.

(9) Shock Sensitivity. Tests are performed in accordance with the NOL Small-Scale Gap Test, (U.S. 201.04.003) or the STANAG 4488 Small-Scale Gap Test. Twenty samples are fired using 4.0-decibang attenuators which corresponds to an input pressure of 12.1 kbar. The explosive passes if there are no detonations in 20 consecutive trials. Any reaction causing a dent of 0.002 inch or more in the target plate is considered a detonation.

(10) Exudation and Growth: No advisory criterion but data from tests performed per U.S. 202.01.010 (Exudation) and U.S. 202.01.011 (Growth) are required for TNT based explosives. Tests performed per U.S. 202.01.010 are required for explosives containing energetic plasticizers.

c. Requirements for Main Charge High Explosives: No mandatory pass or fail criteria are assigned. Advisory criteria are presented for several measures of sensitivity. Failure to meet any or all of the advisory criteria is normally cause for rejection of the explosive by the Service Qualification Authority. An exception to this preference for rejection is made for impact and friction sensitivity for explosives containing ammonium perchlorate. Such materials have sensitivities, as determined in these tests that could lead to rejection. A thorough appraisal of all relevant safety data must be made before any explosive is rejected. If a preponderance of the tests listed below indicates that the explosive is in the same sensitivity range as booster explosives, the Service Qualification Authority may require that the booster tests and criteria shown above apply. The following data are required:

(1) Impact Sensitivity: The new explosive is compared both to a Type I or II, Class 5 RDX conforming to MIL-DTL-398, measured contemporaneously with the candidate explosive, and to a qualified main charge explosive. The advisory criterion is that the sensitivity should be no greater than that of Comp B conforming to MIL-C-401, cast at a density of 1.65 g/cm^3. The impact tests normally used are: ERL/Bruceton (U.S. 201.01.001), Bureau of Mines (U.S. 201.01.003, Los Alamos Impact (U.S. 201.01.004), BAM (U.S. 201.01.005) or NATO STANAG 4489 tests.

(2) Friction Sensitivity: The candidate explosive is compared to a Type I or II, Class 5 RDX conforming to MIL-DTL-398, measured contemporaneously with the candidate explosive, and to a qualified main charge explosive. The advisory criterion is that the sensitivity should be no greater than that of Comp B conforming to MIL-C-401, cast at a density of 1.65 g/cm^3. The tests normally used are: ABL Sliding Friction (U.S. 201.02.005), Rotary Friction (U.S. 201.02.004), Steel/Fiber Shoe Friction (U.S. 201.02.008), BAM Friction (U.S. 201.02.006) or STANAG 4487 tests.

(3) Electrostatic Sensitivity: The candidate explosive is compared both to a Type I or II, Class 1 or Class 5 RDX conforming to MIL-DTL-398, measured contemporaneously with the candidate, and to a qualified main charge explosive. Trials normally used are: Electrostatic Discharge (ESD), (U.S. 201.03.001), (U.S. 201.03.002), (U.S. 201.03.003), or equivalent tests. The advisory criterion is that the electrostatic sensitivity is no greater than that of Comp B conforming to MIL-C-401, cast at a density of 1.65 g/cm^3.

(4) Stability (Constant Temperature): The passing criterion is that no more than 2 ml gas are evolved per gram of explosive per 48 hours at 100°C when

the VTS tests (U.S. 202.01.001), (U.S. 202.01.022), or STANAG 4556 are used. When using CRT test (U.S. 204.01.001) the passing criterion is 4 ml gas evolved per gram of explosive per 22 hours at 120°C.

(5) Self-Heating: Self-heating is assessed either experimentally or by calculation. Test data from DTA (U.S 202.01.007), DSC (U.S. 202.01.020), or STANAG 4515 experiments are used. The advisory criterion is a calculated critical temperature of no less than 180°F for 500 days for a given geometry and mass. The "One Liter Cook-Off" test (U.S. 202.01.021) may be used to determine experimentally the self-heating temperature and severity of reaction of melt-cast compounds or formulations for unconfined, spherical geometry.

(6) Compatibility: The interaction of the candidate explosive with common materials (e.g., metals, adhesives, acids, bases) with which it may come into contact in production and use is assessed. This is done by comparing of the results for the candidate explosive in a 1:1 mixture with the material being tested for compatibility with the results for the candidate explosive alone. The advisory criterion when using DTA or DSC is no change greater than 10°C in the exotherm peak temperature, measured at a heating rate of 10°C/minute or less. The tests normally used are: VTS (U.S. 202.01.001), CRT (U.S. 204.01.001), Modified VTS (U.S. 202.01.022), DTA (U.S 202.01.007), DSC (U.S. 202.01.020). TGA (U.S. 202.01.008) or STANAG 4515. See (U.S. 203-01-001) for details.

(7) Detonation Velocity: No passing criterion is assigned. However, the information is useful for other purposes and tests are generally conducted per (U.S. 302.01.002) to ensure that the explosive will detonate.

(8) Critical Diameter: No passing criterion is assigned. Data from tests performed per (U.S. 302.01.003) are used to find the smallest diameter that can support a steady state detonation.

(9) Shock Sensitivity. The advisory passing criterion is that the sensitivity should be no greater than that of Comp B conforming to MIL-C-401, cast at a density of 1.65 g/cm^3. Tests used are selected as appropriate for the critical diameter of the candidate explosive. Tests normally used are: NOL LSGT, (U.S. 201.04.002), Expanded LSGT (U.S. 201.04.001), IHE Gap Test (U.S. 201.04.005), Super LSGT (201.04.004) and STANAG 4488 tests.

(10) Exudation and Growth: No advisory criterion but data from tests performed per U.S. 202.01.010 (Exudation) and U.S. 202.01.011 (Growth) are required for TNT based explosives. Tests performed per U.S. 202.01.010 are required for explosives containing energetic plasticizers.

d. Requirements for Fuel Air Explosives: Because of the nature of these materials, qualification is generally concurrent with Final (Type) Qualification. Specific data requirements for qualification are assigned on a case-by-case basis by the Service Qualification Authority. No pass of fail criterion is assigned. However, qualification, as described herein, is required for the conventional explosives used in the fuel-air weapon.

10.7.4.15.2 Propellants: Propellants are generally qualified in accordance with a specific application. The final formulations are established late in the development cycle of the end item and requests for qualification may be concurrent with requests for Final (Type) Qualification. Advisory pass or fail criteria are applied for most sensitivity tests performed. Failure to meet any or all of the advisory criteria may be cause for rejection of the propellant. In general, the data requirements given in STANAG 4170 and in this section of AOP-7 are used. However, other tests may be required by the Service Qualification Authority. Even though multiple tests are listed for some stimuli, it is necessary to conduct only one test for each unless otherwise directed by the Service Qualification Authority. A brief description of tests used to obtain the data required by the National Authorities is provided in the Test Information Sheets provided below in section 10.7.15.7. The following is a list of mandatory data and appropriate tests for propellants:

Mandatory Data / Test	Solid	Liquid
Impact sensitivity	x	x
Friction sensitivity	x	x
Electrostatic sensitivity	x	x
Stability (Constant Temperature)	x	x
Self-heating	x	x
Compatibility	x	x
Shock sensitivity (gap test)	x	x
Flash point	—	x
Minimum pressure for vapor ignition	—	x
Critical diameter	x	—

a. Solid Propellants: The following tests and acceptance criteria are recommended:

(1) Impact Sensitivity: The new propellant is compared to a Type I or II, Class 5 RDX conforming to MIL-DTL-398, measured contemporaneously with the candidate material, and to a qualified propellant used in a similar application. The advisory criterion is that it is no more sensitive than the reference comparison propellant. The impact tests used are: Bureau of Mines (U.S. 201.01.003, ERL/Bruceton (U.S. 201.01.003), Los Alamos Impact (U.S. 201.01.004), BAM (U.S. 201.01.005) or NATO STANAG 4489 tests.

(2) Friction Sensitivity. The candidate propellant is compared to a Type I or II, Class 5 RDX conforming to MIL-DTL-398, measured contemporaneously with the candidate material, and to a qualified propellant used in a similar application. The advisory criterion is that the sensitivity is not greater than that of the reference comparison propellant. The tests used are: Rotary Friction

(U.S. 201.02.004), ABL Sliding Friction (U.S. 201.02.005), BAM Friction (U.S. 201.02.006), Steel/Fiber Shoe Friction (U.S. 201.02.008), or STANAG 4487 tests.

(3) Electrostatic Sensitivity: The candidate solid propellant is compared both to a Type I or II, Class 1 or Class 5 RDX conforming to MIL-DTL-398, measured contemporaneously with the candidate, and to a qualified propellant used in a similar application. The advisory criterion is that the sensitivity is not greater than that of the reference comparison propellant. Trials are normally performed in accordance with Electrostatic Discharge, ESD, (U.S. 201.03.001), (U.S. 201.03.002), or (U.S. 201.03.003), In addition, a large-scale ESD test in accordance with (U.S. 201.03.004) and STANAG 4490 may be required by the Service Qualification Authority for some types of solid propellant.

(4) Stability (Constant Temperature): The advisory criterion is that no more than 2 ml gas is evolved per gram of explosive per 48 hours at 100°C when using the VTS (202.01.001), (U.S. 202.01.022) or STANAG 4556 tests. When using CRT test (U.S. 204.01.001) the passing criterion is 4 ml gas evolved per gram of explosive per 22 hours at 120°C.

(5) Self-Heating: Self-heating is assessed either experimentally or by calculation. Test data from DTA (U.S 202.01.007), DSC (U.S. 202.01.020), or STANAG 4515 experiments are used. The advisory criterion is a calculated critical temperature of no less than 180°F for 500 days for a given geometry and mass.

(6) Compatibility: The interaction of the candidate propellant with common materials (e.g., metals, adhesives, acids, bases) with which it may come into contact in production and use is assessed. This is done by comparing of the results for the candidate propellant in a 1:1 mixture with the material being tested for compatibility with the results for the candidate alone. The advisory criterion when using DTA or DSC is no change greater than 10°C in the exotherm peak temperature, measured at a heating rate of 10°C/minute or less. The tests normally used are: VTS (U.S. 202.01.001), CRT (U.S. 204.01.001), Modified VTS (U.S. 202.01.022), DTA (U.S 202.01.007), DSC (U.S. 202.01.020). TGA (U.S. 202.01.008) or STANAG 4515. See (U.S. 203-01-001) for details.

(7) Shock Sensitivity. The shock sensitivity of the candidate propellant is assessed. Tests normally used, as appropriate for the critical diameter of the candidate propellant, are: NOL LSGT, (U.S. 201.04.002), Expanded LSGT (U.S. 201.04.001), IHE Gap Test (U.S. 201.04.005) or Super LSGT (201.04.004) or STANAG 4488 tests.

(8) Critical Diameter: The critical diameter of the candidate propellant is assessed if it is shown to detonate in the shock sensitivity test. Data from tests performed per (U.S. 302.01.003) are used to find the smallest diameter that can support a steady state detonation.

b. Liquid propellants: These materials are generally qualified in accordance with a specific application or end use. This class of explosive material includes thixotropic gels and mono- or multi-component liquid propellants used in guns, rocket motors, naval torpedoes, or other military applications. Qualification requests are generally submitted concurrently with the request for Final (Type) Qualification. No pass or fail criteria are assigned or advisory criteria provided for these materials. The decision on whether a material meets the qualification requirements is left to the Service Qualification Authority. The following data are required to evaluate the overall safety characteristics:

(1) Impact Sensitivity: The impact sensitivity is compared to that of n-propyl nitrate measured contemporaneously with the candidate propellant. The impact tests used are: Bureau of Mines (U.S. 201.01.003, ERL/Bruceton (U.S. 201.01.003), Los Alamos Impact (U.S. 201.01.004), BAM (U.S. 201.01.005), JANNAF Impact (U.S. 201.01.010) or NATO STANAG 4489 tests.

(2) Friction Sensitivity: The friction sensitivity is compared to that of n-propyl nitrate measured contemporaneously with the candidate propellant. The friction tests used are: ABL Sliding Friction (U.S. 201.02.005), Rotary Friction (U.S. 201.02.004), BAM Friction (U.S. 201.02.006), Steel/Fiber Shoe (U.S. 201.02.008) or STANAG 4487 tests.

(3) Electrostatic Sensitivity: The electrostatic sensitivity is compared to that of n-propyl nitrate measured contemporaneously with the candidate propellant. The tests used are: ESD, (U.S. 201.03.001), (U.S. 201.03.002), (U.S. 201.03.003), or equivalent tests.

(4) Shock Sensitivity: The shock sensitivity is assessed using the NOL LSGT (U.S. 201.04.002), IHE Gap Test (U.S. 201.04.005) or STANAG 4488 tests.

(5) Flash Point: The test is performed and the results are reported for information purposes. No advisory criterion is provided. The test normally used is (U.S. 201.08.002). TGA (U.S. 202.01.008) may be used for liquid propellants with low volatility.

(6) Minimum Pressure for Vapor Phase Ignition: The test is performed and the results are reported for information purposes. The minimum pressure for vapor phase ignition is verified using (U.S. 201.08.001).

10.7.4.15.3 Pyrotechnics Materials: Pyrotechnics are qualified in accordance with requirements of a specific application. Qualification requests may be concurrent with the request for Final (Type) Qualification. The following is a list of mandatory data and appropriate tests for pyrotechnics:

Mandatory Data / Test	Pyrotechnics
Impact sensitivity	x
Friction sensitivity	x
Electrostatic sensitivity	x
Stability (Constant Temperature)	x
Self-heating	x
Compatibility	x

a. Mandatory Tests and Data Requirements**:** No passing criteria are assigned; however, advisory criteria are provided for each stimulus. Even though multiple tests are listed for some stimuli, it is necessary to conduct only one test for each unless otherwise directed by the Service Qualification Authority. The following data are required for qualification:

(1) Impact Sensitivity: The impact sensitivity is compared to that of a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398, measured contemporaneously with the candidate pyrotechnic and to a qualified pyrotechnic material used in a similar application. The advisory acceptance criterion is that the candidate be no more sensitive than the reference comparison pyrotechnic. The impact tests normally used are: ERL/Bruceton (U.S. 201.01.001), Bureau of Mines (U.S. 201.01.003, Los Alamos Impact (U.S. 201.01.004), BAM (U.S. 201.01.005) or NATO STANAG 4489 tests.

(2) Friction Sensitivity: The friction sensitivity is compared to that of a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398, measured contemporaneously with the candidate pyrotechnic and to a qualified pyrotechnic material used in a similar application. The advisory acceptance criterion is that the candidate be no more sensitive than the reference comparison pyrotechnic. The friction tests normally used are: Sliding Friction (U.S. 201.02.005), Rotary Friction (U.S. 201.02.004), BAM (U.S. 201.02.006), Steel/Fiber Shoe (U.S. 201.02.008) or STANAG 4487 tests.

(3) Electrostatic Sensitivity: The electrostatic sensitivity is compared to that of a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398, measured contemporaneously with the candidate pyrotechnic and to a qualified pyrotechnic material used in a similar application. The advisory acceptance criterion is that the candidate be no more sensitive than the reference comparison pyrotechnic. The sensitivity tests normally used are ESD, (U.S. 201.03.001), (U.S. 201.03.002), (U.S. 201.03.003), or STANAG 4490 or equivalent tests.

(4) Stability (Constant Temperature): The advisory criterion is that no more than 2 ml gas is evolved per gram of explosive per 48 hours at 100°C when using the Vacuum Thermal Stability (VTS), test (202.01.001), (U.S. 202.01.022) or STANAG 4556. When using CRT test (204.01.001) the passing criterion is 4 ml gas evolved per gram of explosive per 22 hours at 120°C.

(5) Self Heating: Self heating is assessed by calculation. The data required for this calculation is acquired by DTA (U.S. 202.01.007) or DSC (U.S. 202.01.020). The critical temperature is estimated using (U.S. 201.02.012).

(6) Compatibility: The interaction of the new pyrotechnic with materials (e.g., metals, adhesives, acids, bases) with which it may come into contact in production and use is assessed. The results for the candidate pyrotechnic in a 1:1 mixture with the material being tested for compatibility is compared with the results for the candidate material alone. The advisory criterion when using DTA or DSC is no change greater than 10°C in the exotherm peak temperature, measured at a heating rate of 10°C/minute or less. The tests normally used are: DTA (U.S 202.01.007), DSC (U.S. 202.01.020). TGA (U.S. 202.01.008) or STANAG 4515.

10.7.15.5 TESTS PERFORMED TO OBTAIN MANDATORY DATA

a. In general, the tests acceptable to the U.S. Service Qualification authorities and used to acquire the data necessary to satisfy the requirements of STANAG 4170 are described in Standardization Agreements, STANAGS, prepared by the AC/310 Subgroup 1 (Explosive Materials) and in Test Information Sheets catalogued in this document. The STANAGs that may be used from time to time by the Service Qualification Authorities are listed below. The other tests used by the Qualification authorities and not necessarily covered by STANAGS are described in the Test Information Sheets section provided below.

	Tests	STANAG No
(1)	Uniaxial Compressive	STANAG 4443
(2)	Impact Sensitivity (Drop-Hammer)	STANAG 4489
(3)	Friction Sensitivity	STANAG 4487
(4)	Electrostatic Sensitivity	STANAG 4490
(5)	Gap Shock Sensitivity	STANAG 4488
(6)	Thermal Sensitivity	STANAG 4491
(7)	Uniaxial Tensile	STANAG 4506
(8)	Stress Relaxation in Tension	STANAG 4507
(9)	Temperature of Ignition	STANAG 4491
(10)	Thermal Characterization (DTA, DSC, & TGA)	STANAG 4515
(11)	Thermomechanical Analysis (TMA)	STANAG 4525
(12)	Chemical Stability – NC Propellants	STANAG 4527
(13)	Dynamic Mechanical Analysis (DMA)	STANAG 4540
(14)	Stability – NC & NG, Propellants with DPA	STANAG 4541
(15)	Stability – NC & NG, Propellants with 2NDPA	STANAG 4542
(16)	Vacuum Stability	STANAG 4556
(17)	Aging of Composit Propellants	STANAG 4581
(18)	Heat Flow Calorimetry	STANAG 4582

10.7.15.6 List of US Test Information Sheets

Category 100	MIL-STD 1751A Method Number	Chemical, Physical & Mechanical Properties Tests
102.01.001		Uniaxial Tensile
102.01.071		Specific Gravity (Density) (Pycnometry)
102.01.251		Thermal Conductivity
102.01.275		Coefficient of Thermal Expansion (Dilatometer)

Category 200	MIL-STD 1751A Method Number	Hazard Assessment Tests
201.01.001	1012	Impact - NSWC/NAWC/ERL/Bruceton
201.01.002	1016	Impact - Ball Drop
201.01.003	1014	Impact - Bureau of Mines
201.01.004	1013	Impact - Los Alamos Laboratory
201.01.005	1015	Impact – BAM
201.01.006		Impact - Picatinny Arsenal
201.01.007	1011	Impact - Bureau of Explosives
201.01.008		Impact - Lawrence Livermore Laboratory
201.01.009		Impact - Hercules Radford
201.01.010	1017	Impact – Liquid Explosives (JANNAF Method)
201.02.001		Friction - Bureau of Mines Pendulum
201.02.002		Friction Pendulum - Picatinny Arsenal Method
201.02.003		Friction Sensitivity - NAWC China Lake Method
201.02.004	1023	Friction - Rotary
201.02.005	1021	ABL Sliding Friction
201.02.006	1024	BAM (Julius Peters) Friction
201.02.007		Friction - Hercules Radford AAP
201.02.008	1022	Friction, Steel/Fiber Shoe
201.03.001	1032	Electrostatic Discharge – ARDEC Picatinny Arsenal Method
201.03.002	1033	Electrostatic Discharge - NAWC Method
201.03.003	1031	Electrostatic Discharge - NSWC Method
201.03.004	1034	Electrostatic Sensitivity - Large Scale
201.03.006		Electrostatic Discharge - Hercules Radford AAP Method
201.03.007		Electrostatic Sensitivity - Closed Cup
201.04.01	1043	Shock Sensitivity - Expanded Large-Scale Gap (ELSGT)
201.04.002	1041	Shock Sensitivity - NOL Large-Scale Gap (LSGT)

Category 200 MIL-STD 1751A Hazard Assessment Tests

	Method Number	
201.04.003	1042	Shock Sensitivity - NOL Small-Scale Gap (SCGT)
201.04.004	1044	Shock Sensitivity - Super Large-Scale Gap (SLSGT)
201.04.005	1045	Shock Sensitivity – IHE Gap
201.04.006	1046	Shock Sensitivity – Wedge Test
201.04.007		Shock Sensitivity - Picatinny Arsenal
201.04.008		Shock Sensitivity - NSWC Low Pressure - Long Duration Shock
201.04.009		Blasting Cap Test (2-inch Cubes)
201.05.001		SUSAN Projectile Impact
201.08.001	1141	Minimum Pressure for Vapor Phase Ignition - Liquid Propellants
201.08.002		Flash Point - Liquid Propellants
202.01.001	1061	Vacuum Thermal Stability (VTS)
202.01.002		Variable Confinement Cook-Off (VCCT)
202.01.003		Thermal Detonability (Fast Cook-Off) – NAWC (China Lake) Method
202.01.004		Explosion Temperature
202.01.005		Cook-Off Temperature Determination
202.01.006	1151	Hot-Wire Ignition
202.01.007	1071	Differential Thermal Analysis (DTA)
202.01.008	1073	Thermogravimetric Analysis (TGA)
202.01.009		100°C Heat Test
202.01.010	1161	TNT Exudation Characteristics
202.01.011	1162	TNT Growth Characteristics
202.01.012	1074	Critical Temperature and Self-Heating
202.01.013		Thermal Stability (2-inch Cubes, (75°C)
202.01.014		Unconfined Burning
202.01.015		Internal Ignition
202.01.016		Henkin 5-Second Ignition Temperature
202.01.017		Taliani
202.01.018		Surveillance DB Propellants
202.01.019		Minimum Ignition Temperature
202.01.020	1072	Differential Scanning Calorimetry (DSC)
202.01.021	1075	One Liter Cook-Off Test
202.01.022	1063	Modified VTS Test
202.02.001		U-Tube Adiabatic Compression Sensitivity
203.01.001		Compatibility with Materials
204.01.001	1062	Chemical Reactivity (CRT)
204.02.001		Environmental Impact of Firings

Category 300	MIL-STD 1751A Method Number	Performance Assessment Tests
301.01.001		Theoretical Performance Calculations
302.01.001	1101	Detonation Velocity
302.01.002		Detonation Velocity - Liquid Propellants
302.01.003	1091	Critical Diameter
302.01.004	1092	Very small Critical Diameter
302.02.001		Strand Burning Rate (Linear Burning Rate)
302.02.002		Closed Bomb Burning Rate
302.02.003		Burning Characteristics (Configurational)
302.02.004		Burning Characteristics (Loose)
302.03.001	1131	Detonability for Fuel-Air Explosives
302.03.002		Sub-Scale Motor
302.03.003		Hot/Cold Ignition/Burning
302.03.004		Moisture Content of Composition vs. Performance

10.7.15.7 CATALOGUE OF TEST INFORMATION SHEET FOR THE UNITED STATES

NOTE: The Test Information Sheets are compiled consecutively in accordance with their Registry Number.

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TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2 TEST TITLE: Uniaxial Tensile Test

a. Type of Test: Mechanical Property.

b. Description: The test specimens are prepared by die cutting or milling. Configuration and dimensions use the JANNAF specifications. The JANNAF Class C (dogbone) sample is die cut. The JANNAF Class A specimen, a milled truncated Class C configuration specimen with tabs (usually aluminum) bonded to the ends, is used to obtain more accurate results. The specimens are measured and conditioned at the test temperature for a minimum of one hour prior to testing. An Instron, or equivalent tester with temperature conditioning chamber and appropriate fixtures, load cells, and readout equipment is listed for applying extension to the specimen at a constant crosshead rate.

c. Information Requirements for Assessment: Data from these tests are used to characterize propellant response and failure behavior.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: Good to excellent

3. NATIONAL REFERENCES:

(1) JANNAF Solid Propellant Mechanical Behavior Manual, CPIA Publication 21, Sections 4.3, March 1971, and 4.3.2 October 1988.

(2) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979.

(3) STANAG 4506, “Explosive Materials, Physical/Mechanical Properties, Uniaxial Tensile test.”

US/102.01.071

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Specific Gravity (Density) (Pycnometry)

   a. Type of Test: Physical Property.

   b. Description: This test is used to determine the specific gravity of propellants by immersing the material in a liquid of known specific gravity (or density) and volume, measuring the volume and weight change of the combined materials. If water is used as the immersion liquid, the specific gravity and density values will be equivalent to each other. However, if mercury is used as the immersion material (to prevent penetration of the liquid into pores, surface imperfections, etc. of the propellant), the density is obtained. The use of mercury is a modification of reference (1).

   c. Information Requirements for Assessment: The value of specific gravity (or density) is necessary for calculations in the design of the motor, and/or the determination of output characteristics.

   d. Typical Results: Most propellants have density values about 1.8 g/cc.

   e. Repeatability and Reproducibility: Since the density vs. temperature values of both water and mercury are known and precise, the test is considered very repeatable and reproducible. Accuracy depends on the equipment used.

3. NATIONAL REFERENCES:

(1) MIL-STD-286B, Methods 510.1.1 and 510.2.1, 1 Dec. 1967.

(2) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of, 30 March 1979.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Thermal Conductivity

   a. Type of Test: Physical Property.

   b. Description: The Guarded Meter method used to determine the thermal conductivity of insulating materials (Ref. 1) and the method for estimating the thermal conductivity of leather with the Cenco-Fitch apparatus (Ref. 2) were modified to provide a method to determine the thermal conductivity of explosive materials. This method provides a one-dimensional transient heat conduction between two faces of a flat specimen 102 mm x 102 mm x 6.4 mm. One face of the specimen is heated by a copper plate held at a constant temperature, while the opposite face of the specimen yields its heat to a known mass of a thermally isolated copper disc. The temperature-time profile of the isolated disc yields the required thermal conductivity of the specimen.

   c. Information Requirements for Assessment: This test provides background information for qualification of explosives.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

   (1) ANSI/ASTM C177-76.

   (2) ANSI/ASTM D2214-70(76).

US/102.01.275

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Coefficient of Thermal Expansion (Dilatometer)

   a. Type of Test: Physical Property.

   b. Description: Care must be taken to assure that minimum clearances are maintained between explosive charges and containers in the upper range of storage or operating temperatures because of different expansion coefficients of explosives and container materials. The coefficient of thermal expansion is measured with a bulk mercury dilatometer or with a standard laboratory linear expansion test apparatus. If the material is known to be isotropic, its cubic expansion coefficient is calculated by multiplying its linear coefficient by three.

   c. Information Requirements for Assessment: This test provides background information for qualification of explosives.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

   (1) ANSI/ASTM D696-70; 1975.

   (2) ANSI/ASTM D864-52; 1978.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: NSWC/NAWC/ERL/Bruceton Impact Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The apparatus consists of vertical framework of rods or rails designed to guide a free-falling weight, a drop weight, an anvil to hold the explosive sample, and a striker to transfer the impulse from the drop weight to the sample during impact. Several weights of 2, 2.5, and 5 kg are available. A hand windlass is used to position the drop weight at any height above the sample to a maximum of 320 cm. An electromagnet retains the weight until released. The drop weight impacts against a "striker" pin that transmits the shock to a 35 mg test sample resting without restraint on a 6.5 cm (1-inch square) piece of garnet paper placed on the anvil (Type 12 tool). When the sandpaper is omitted and the sample is placed directly on the anvil, the arrangement is referred to as “Type 12B Tools.”

   c. Information Requirements for Assessment: Fifty percent impact height of the test material determined by the Bruceton method is compared to two reference comparison explosives tested on the same machine under the same test conditions. A minimum of 20 shots per sample is used to determine a 50% point.

   d. Typical Results:

High Explosives (powder):	50% Point (cm)
Lead Azide	4
PETN, Class 4	13
RDX, Type I or II, Class 5	18
Tetryl	38
TNT, Type I or II	78
HMX, Grade B, Class 1	19
HMX, Grade B, Class 5	28

   e. Repeatability and Reproducibility: Good on same machine

3. NATIONAL REFERENCES:

(1) Walker, G. R., Whitbread, E. G., and Hornig, D. C., ed. *Manual of Sensitiveness Tests*, Balcartier, Quebec, Canada: Canadian Armament Research and Development Establishment. Published for Tripartite Technical Cooperation Program (TTCP), Panel O-2 (Explosives), Working Group on Sensitiveness, February 1966.
(2) NATO STANAG 4489, Explosives, Impact Sensitivity Test(s).
(3) Dixon, W. J., and Massey, F. M. Jr., *Introduction to Statistical Analysis*. 2nd ed. New York: McGraw-Hill Co., Inc., 1957.
(4) MIL-STD-1751A issued on 11 December 2001, Method 1012.

US/201.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary High Explosives

2. TEST TITLE: Impact Test - Ball Drop Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The apparatus consists of a free falling steel ball, a movable platform on a vertical stand, and a hardened steel anvil block to hold the explosive powder. The steel ball, 1.3 cm (1/2-inch diameter), weighing 8.35 grams, is made from chrome alloy steel and has a Rockwell C hardness of 64-66. By means of a platform (ball-track) on a vertical stand, the steel ball is dropped from heights varying by 2.50 cm (1-inch) increments onto the explosive powder spread in a 0.330 mm (0.013-inch) thick layer on a hardened and polished steel block. The anvil is made of steel hardened to Rockwell C 60-62.

   c. Information Requirements for Assessment: Impact sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results:

Explosive	50% Point (cm)	σ
Lead Styphnate	22.9 (8.7 in)	1.6
Dextrinated Lead Azide	54.6 (21.5 in)	3.3

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Voreck, W., "Photomicrographic Examination of Explosives," PATR-4093, August 1970.

(2) MIL-STD-1751A issued 11 December 2001, Method 1016.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, propellants, and Pyrotechnics

2. TEST TITLE: Impact Test - Bureau of Mines

a. Type of Test: Hazard Assessment/Sensitivity.

b Description: In this device, a sample of explosive material is subjected to the impact of a free-falling 2 kg, 2.5 kg, or 5 kg drop hammer. The hammer is guided by a steel T-beam frame. The hammer is held by an electromagnet within a movable yoke can be moved up or down by a windlass at the base of the machine. A recording device in the windlass measures the drop height, maximum 330 cm. The assembly mounted to the base of the machine consists of a hardened steel anvil and a plunger 3.2 cm (1-1/4 inches) diameter and 15.24 cm (6 inches) long, machined to give a sliding fit through a steel guide ring. The drop hammer strikes the plunger that transmits the impact forces to a small striking pin that fits into a steel cup containing the test sample, 35 mg explosive in powder form.

c. Information Requirements for Assessment: An up-and-down method is used to obtain a 50% probability of reaction eight. Impact sensitivity data on two reference comparison explosives tested on the same machine.

e. Typical Results:

Explosive	50% Probability Height	
	(inch)	(cm)
PETN, Class 7	16.93	43
RDX, Class 5	31.10	79
Tetryl	37.00	94
TNT, Type I or II	72.05	183

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1014.

(2) Becker, K.R., *Bureau of Mines Instrumented Impact Tester*. U.S. Department of Interior, Bureau of Mines, Report of Investigations 7670, 1972.

(3) Dixon, W.J., and Mood, A.M., “Method for Obtaining and Analyzing Sensitivity Data.” Journal of the American Statistics Association. 43: 109-126, 1948.

(4) Dixon, W.J., and Massey, A.M. Jr. *Introduction to Statistical Analysis*. 2nd Ed. New York: McGraw-Hill Co., Inc., 1957, pp. 318-327.

US/201.01.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosive, Propellants, and Pyrotechnics

2. TEST TITLE: Impact Test - Los Alamos Laboratory

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test determines the sensitivity to a normal impact of explosives in powder and liquid form. The machine was originally similar to the ERL/Bruceton apparatus described in 201.01.001. In about 1957, some mechanical modifications were introduced to improve test reproducibility. Reports indicated that the sensitivity scale was unchanged, however.

The original drop weight was a hollow, conical, truncated nose-tipped cylinder fabricated of tool steel hardened to 60 HRC. The redesigned drop weight has the same general external appearance and the same weight of 5.5 pounds (2.5 kg). It consists of a steel core hardened to 55-58 HRC surrounded by a solid case of Dural (aluminum alloy). The redesign concentrates more of the mass centrally, along the line of impact.

c. Information Requirements for Assessment: Sample response is measured with an electronic noise meter with which a threshold is established to differentiate between explosions (go's) and non-explosions (no-go's). By a series of trials, the drop weight that causes 50% of the test samples to explode is determined. Results are reported at the 50% point using a Bruceton analysis.

d. Typical Results:

	No. of 25-shot tests	H_{50} (cm)	σ (cm)
PETN	14	12.0	1.1
RDX	96	22.2	1.0
HMX	62	26.0	1.8
Tetryl	6	41.6	1.3
Comp B	25	59.1	3.6
TNT	23	154.0	7.6

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued 11 December 2001, Method 1013

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: BAM Impact Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test was developed to evaluate the sensitivity of solid and liquid substances to a normal impact. The device consists of a cast steel block whose base is bolted to a concrete block. Imbedded in the steel block is the main anvil on which an intermediate anvil holding the impact device rests. Guide rails, which are attached to the steel block, facilitate free vertical movement of the drop weight and release mechanism. A toothed rack is incorporated into one of the guide rails to arrest the rebounding drop weight. The drop weight is positioned at various heights by means of a motor driven winch. Drop weights of 1, 2, 5, and 10 kg are available for testing.

Solid explosive substances are tested dry. Powders are sieved and the fraction with a particle size ranging from 0.5 to 1.0 mm is used. Pressed, cast, and otherwise compacted substances are crushed and then sieved. Liquid explosives are tested without preparation.

A limited number of tests are performed to ensure that results group together fairly well. A 25-shot test is then performed using a Bruceton analysis to determine a 50% point. In judging test results, reactions are classified as either "no reaction," decomposition, or explosion.

c. Information Requirements for Assessment: The device is calibrated using Type I or II, Class 5 RDX, conforming to MIL-R-398, as the standard reference material.

d. Typical Results:

Explosive	50% Probability Height	
	(inches)	(cm)
PETN	14	36
RDX, Class 5	23	58
TNT	68	173

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) NATO STANAG 4489, Explosives, Impact Sensitivity Test(s).

(2) MIL-STD-1751 issued 11 December 2001, Method 1015

US/201.01.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants and Pyrotechnics

2. TEST TITLE: Impact Test - Picatinny Arsenal and Bureau of Mines

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test is conducted using either the Picatinny Arsenal (PA) apparatus or the U.S. Bureau of Mines (BoM) apparatus. Each apparatus is used with two variations, one for solid and one for liquid explosives. The PA apparatus consists of an anvil, two guide bars equipped with an adjustable support for a weight, vented plugs, die cups, and die cup covers. This machine is used with weights of 2 kg, 1 kg, or 1 pound. The lighter weights are used for the more sensitive materials. A yoke equipped with a release pin is attached to two bars, which serve as guides for the falling weight. The yoke can be moved to the desired height and held in place by hand screws. The BoM apparatus consists of an impact block, a plunger and one of three weights (500, 1000, 2000 gm), which can be dropped from any height from 1 to 100 cm. The weight is raised by an encased magnetic coil, held in place by sleeves, and attached to two guide bars. A contact point on the yoke breaks the electromagnetic circuit and allows the weight to fall when it is touched by the contact point on the top of the magnetic coil. The Picatinny apparatus used for this test is based on an older BoM design and is not to be confused with the apparatus used in AOP-7 Registry No. 201.01.003.

c. Information Requirements for Assessment: Impact sensitivity data on two reference comparison explosives tested on the same machine.

d. Typical Results: 10% Point Using 2 Kg Weight

Explosive (Powder)	PA Apparatus (cm)	BoM Apparatus (cm)
Lead Azide	1.3 (0.5 in)	17
PETN	15.2 (6.0 in)	17
Tetryl	20.3 (8.0 in)	26
RDX	20.3 (8.0 in)	32
HMX	22.9 (9.0 in)	32
Comp B	35.6 (14.0 in)	75
TNT	38.1 (15.0 in)	100

e. Repeatability and Reproducibility: Good on the same machine.

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, February 1966. Edited by E. R. Walker, E. G. Whitbread, and D. C. Hornig, page 340.

(2) MIL-STD-1751 issued 11 December 2001, Method 1014

TEST INFORMATION SHEET

1 TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Impact Test - Bureau of Explosives

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test is used to determine the impact sensitivity explosives in powder and liquid form. Results are reported at the 50% point using a Bruceton analysis and are Compared to a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398. A 3.6 kg (8-pound) weight suspended between two cylindrical guide rods is used. The maximum drop height is 83.8 cm (33 inches). Both solids and liquids can be tested with this machine. For solids, the weight is dropped on a plunger and plug assembly in contact with the explosive. For liquids, one drop is placed in a copper cup fixed in a positioning block. A sticker is placed over a cup positioning block partly into the cup but not touching the explosive. The assembly is placed on the same mechanism as used for solids.

c. Information Requirements for Assessment: Impact sensitivity of the test material compared to two reference comparison explosives tested on the same machine.

d. Typical Results:

Test Sample	(H_{50})* Drop Height	
	(cm)	(in.)
HMX, Grade B (12µ)	7.9	3.1
RDX (850µ - 30%; 300µ - 30%; 150µ - 15%; 75µ - 25%)	9.4	3.7
HNS-II	15.8	6.2

e. Repeatability and Reproducibility: Good on same machine.

3. NATIONAL REFERENCES:

(1) Recommendations on the Transport of Dangerous Goods, Tests and Criteria. 2nd Edition. United Nations, New York, 1990. (UN publication ST/SG/AC.10/11/Latest Rev.)

(2) MIL-STD-1751 issued 11 December 2001, Method 1011

US/201.01.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Impact Test - Lawrence Livermore Laboratory

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: A hollow drop weight of 5 kg is usually used and a 2.5 kg weight is also available. Half of the mass of the weight consists of loose lead shot. An electric hoist positions an electromagnet, which suspends the drop weight at any desired height up to 177 cm. A pair of rollers attached to the weight guides the fall of the weight. The rollers run in groves cut in the parallel vertical tracks. The test may be conducted with or without flint paper. In its absence, the explosive sample is placed directly on the anvil. The sample may or may not be pelletized before testing.

c. Information Requirements for Assessment: Impact sensitivity data on two reference comparison explosives tested on the same machine.

d. Typical Results:

Explosive	50% Point for 5 kg (cm) With Flint Paper	Without Flint Paper
PETN (powder)	11	20
Tetryl (powder)	24	30
RDX (pellet)	28	--
HMX (pellet)	29	39
TNT (pellet)	76	--

e. Repeatability and Reproducibility: Good on same machine.

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, Feb. 66. Edited by G. Walker, E. Whitbread, and D. Hornig, p 52.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Impact Test - Hercules Radford AAP

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: Test samples are placed on the flat metal surface (typically 12.7 mm diameter) of an anvil. A metal impact hammer, with flat contact surface equal in size and shape to the anvil surface, is brought to rest on the propellant sample. A 2 kg weight is dropped on the hammer, and initiation is detected visually, audibly, or by other sensory means and by infrared analysis of decomposition products. The threshold initiation level is defined as 20 consecutive trials in which no initiation occurs at a drop height of one level below that level in which at least one initiation occurred in 20 trials. Strict calibration and sample preparation techniques are used to increase result repeatability. All samples are conditioned at fixed temperature and humidity prior to testing. Solid propellant samples are tested at 0.84 mm thickness. Gun propellant samples are tested lying on their long dimension, in a monolayer for smaller granules, and are also tested in ground form in a monolayer to simulate dust. Impact force and duration are measured for calibration purposes and the impact machine calibrated regularly to ensure consistent results. Hammer and anvil materials are changed for special tests.

c. Information Requirements for Assessment: Impact sensitivity data on two reference comparison explosives tested on the same machine.

d. Typical Results: Standard finished propellants are initiated by drop heights of 100-130 mm, depending on formulation and granule size. Sensitivity decreases when testing larger granules.

e. Repeatability and Reproducibility: Strict calibration and sample preparation techniques have resulted in good test repeatability.

3. NATIONAL REFERENCES:

(1) "Chemical Rocket/Propellant Hazards", CPIA PUB No. 194, Vol. II, May 1970.

US/201.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Liquid Propellants and High Explosives

2. TEST TITLE: Impact Test – JANNAF Method

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test is performed with a standard impact apparatus described for Registry Nos. 201.01.001, 005 and 009. The liquid test sample (0.03 ml) is enclosed in a cavity formed by a steel cup, an elastic ring, and a steel diaphragm. A piston rests on the diaphragm and carries a vent hole that is blocked by the steel diaphragm. A 2 kg weight is dropped onto the piston. A positive result is indicated by a puncture of the steel diaphragm accompanied by a loud noise or severe deformation of the diaphragm and evidence that the sample was completely consumed. Data are reported as the height at which it yields a 50% probability of initiation.

c. Information Requirements for Assessment: Impact sensitivity data is compared to n-propyl nitrate measured contemporaneously with the candidate explosive.

d. Typical Results: Tests are performed up to 91.4 cm (36 inch) drops, at which point the hydrostatic pressure developed by the impact is sufficient to burst the diaphragm even with non-explosive materials (e.g., water).

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Liquid Propellant Test Methods CPIA, July 1969.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1017.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Pendulum Friction Test – Bureau of Mines

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is performed with a weighted pendulum. The lower end is attached to a shoe with an interchangeable face of steel or fiber. The shoe is permitted to fall from a height of 1-1.5 meters and sweep back and forth, across a grooved steel friction anvil. The pendulum is adjusted to pass across the anvil 18 ± 1 times before coming to rest when no explosive is present. A 7-gram sample of explosive is spread in and about the grooved of the anvil and the shoe is allowed to sweep back and forth over the anvil until it comes to rest. The number of sweeps, cracklings, ignitions, and/or explosions is noted.

   c. Information Requirements for Assessment: Friction sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results:

Explosive	Wood-Fiber Shoe	Steel Shoe
Composition B	--	Passed
PETN	Passed	Failed
TNT	--	Passed
Tetryl	Passed	Failed
RDX	Passed	--

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests, TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, Feb. 66. Edited by G. Walker, E. Whitbread, and D. Hornig, p 90.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1023.

US/201.02.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Friction Pendulum Test - ARDEC Method

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test and apparatus is similar to AOP-7 Registry No. 201.02.001. It is based on the design originated by the Bureau of Mines. The bob of a weighted pendulum, a curved plate called a "shoe", is allowed to brush across the explosive sample at a low angle of incidence to the horizontal. The observations made and recorded are "explosion", "burning", "local crackling", and "no local crackling".

   c. Information Requirements for Assessment: Friction sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results:

Explosive	With Fiber Shoe	With Steel Shoe
PETN	Passed	Failed
RDX	Passed	Failed
Tetryl	Passed	Failed
Composition B	Passed	Passed
TNT	Passed	Passed
Explosive D	Passed	Passed

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, February 1956. Edited by G. R. Walker, E. G. Whitbread, and D. C. Hornig, p 98.

(2) MIL-STD-1751A issued on 11 December 2001, Method 10132.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Friction Sensitivity Test - NAWC (China Lake) Method

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: Same as described under AOP-7 Registry No. 201.02.001 (Friction Sensitiveness Test - Pendulum Friction Test- BoM Apparatus). The apparatus for this test is smaller scale than that of the BoM Apparatus. The bob of the pendulum is a fixed, metal wheel. In this instance, the rigid support for the explosive is called a "striker plate" rather than an "anvil". The NASW (NOTS) test procedure uses the statistical method of "up and down" testing common to many U.S. impact tests.

   c. Information Requirements for Assessment: Friction sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results: To be supplied on demand.

   e. Repeatability and Reproducibility: Acceptable.

3. NATIONAL REFERENCES:

   (1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, February 1966. Edited by G. R. Walker, E. G. Whitbread, and D. C. Hornig, page 94.

   (2) MIL-STD-1751A issued on 11 December 2001, Method 10133.

NOTE: The NAWC has no longer use a pendulum friction machine. The NAWC uses, chiefly, an ABL friction tester but for certain materials, a BAM tester is also used.

US/201.02.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Rotary Friction Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: For High Explosives and Propellants the friction sensitivity of an explosive material is measured by applying a vertical force to a piston resting on the test specimen, which is contained in a rotating cup. The normal load on the sample can be varied to utilize an up and down test method for determining the 50 percent fire point. The rotational speed is held constant at 2000 RPM. The maximum test duration is 10 seconds, and if no fire or explosion occurs within this time, the test is considered negative.

For Pyrotechnic Compositions a friction rod spins on top of a 20-milligram sample contained in an aluminum holder. Loads on the rod and the angular velocity of the rod are varied. Total time to ignition up to 60 seconds is used and torque is measured. Results typically reported in "foot pounds required" to "FIRE" or "NO FIRE".

Reaction levels reported for Fire are: “Fire”, “Spark”, or “Burn”. Reaction levels reported for No-Fire are “Melt”, “Glaze”, or “No detectable change in the physical state”.

c. Information Requirements for Assessment: The results are reported as "No-Fire..." or "Fired at a torque of ___ lbf-foot and at _____seconds." Class 7 PETN is used as a standard reference material against which the results will be compared.

d. Typical Results: Pyrotechnic compositions samples yielding "FIRE" results below 100 foot-pounds are normally considered sensitive to friction. Typical examples of results are:

Explosive	Result
Mk 45 Illuminating Composition	FIRE (@ 175 ft.lbs.)
Red Phosphorus (6% Linseed Oil)	NO FIRE (@ 550 ft.lbs.)
TNT	NO FIRE (@ 11,300 ft.lbs.)

e. Repeatability and Reproducibility: At a given load, values are reproducible to $\pm$ 10%

3. NATIONAL REFERENCES:

(1) Armour, Carl and Smith, Lloyd A., The Invention of a New Type of Friction Sensitivity Apparatus, ROTR No. 60, 11 June 1965, Naval Weapons Support Center, Crane, Indiana. (AD 617382).

(2) MIL-STD-1751A issued on 11 December 2001, Method 1023.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: ABL Sliding Friction Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test simulates the conditions occurring when a material is subjected to a frictional force between moving surfaces. A sample is placed on an anvil, a known force is applied hydraulically through a stationary wheel, and a pendulum is used to propel the sliding anvil to a known velocity perpendicular to the force vector. Normally, sample initiation is detected audibly, visually, or by other sensory means. Sample size is approximately 50 mg. A valid test is comprised of twenty consecutive negatives and at least one initiation at the next highest test level. Force levels are usually decreased by 25% increments. Velocity levels are reduced 30.5 cm/sec (1 ft/sec) whenever an initiation is obtained at 4.5 kg (10 lb force) and the standard test velocity of 244 cm/sec (8 ft/sec). Reported values are the calibrated velocity and final force gauge reading.

   c. Information Requirements for Assessment: A trial is considered positive if any of the following results are obtained; visible sparks, visible flame, audible explosion, loud crackling, or the detection of reaction products by a gas analyzer. A twenty-shot sample is used to determine a 50% point by the Bruceton method using a 0.1 log-pound ram force as the test variable. This is then compared to results obtained using a Type I or II, Class 5 RDX standard conforming to MIL-DTL-398.

   d. Typical Results:

Explosive	Result
Tetryl (powder)	180 lbs-force
PETN (powder)	235 lbs-force.

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

   (1) MIL-STD-1751A issued on 11 December 2001, Method 1021.

   (2) TB 700-2, Department of Defense Explosives Hazard Classification Procedures. October 1993.

   (3) Recommendations on the Transport of Dangerous Goods, Tests and Criteria. 2nd edition, United Nations, New York: 1990.

US/201.02.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: BAM (Julius Peters) Friction Test

a. Type of Test: Hazard Assessment/Sensitivity

b. Description: The BAM apparatus consists of a reciprocating sample table that holds a porcelain sample plate and a lever arm to which is attached a porcelain pin. Weights of varying mass are attached at different distances on the lever arm to adjust the force applied on a sample placed between the porcelain pin and plate. The sample table is driven by an eccentric arm attached to a geared-down electric motor that executes one revolution of the eccentric arm (one full cycle of reciprocating motion in the horizontal direction) when the motor is actuated. The 50% probability level of initiation is determined by an "up and down" Bruceton method. This level is reported as a load in Newtons

c. Information Requirements for Assessment: A positive result is judged to have occurred if there is evidence of ignition (flash or smoke), crackling, an explosion, or sparking. Negative results are indicated by a decomposition (slight black smear on the porcelain plate) or by no physical evidence of a reaction.

d. Typical Results:

Explosive	Initiation Level 50% Point (Newtons)
PETN, Class 4	56
Lead azide, Type I or II	10
RDX, Type I or II, Class 1	96
RDX, 2.5μ	128
HMX, Grade B, Class 1	80
TNT, Type I or II	> 360
Composition B, Type I	> 360

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Harris, J., "Friction Sensitivity of Primary Explosives", ARRADCOM Technical Report ARLCD-TR-82012, September 1982.

(2) NATO STANAG 4487, Friction Sensitivity Tests for the Qualification of Explosives for Military Use.

(3) MIL-STD-1751A issued on 11 December 2001, Method 1023.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Friction Test - Hercules Radford AAP

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: A sample is placed on a flat metal anvil. A known force is applied hydraulically on a stationary metal wheel over the sample. A pendulum strikes the anvil, propelling it perpendicular to the force applied with the wheel. Initiation is detected audibly, visually or by other sensory means and by infrared analysis of decomposition gases. Samples are conditioned at fixed temperature and humidity before testing. Granular gun propellants are tested in a monolayer, typically ground to known size. Solid propellants are sliced to known thickness. Samples are placed under the wheel and along the wheel slide path. The standard anvil speed is 240 cm/sec (8 ft/sec). Anvil speed and material may be varied for specific test conditions. Threshold initiation level is defined as that force level at a given speed in which no initiation occurs in 20 consecutive trials, given at least one initiation in 20 trials at the next higher level.

   c. Information Requirements for Assessment: Friction sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results: Most standard finished propellants are initiated in the 68 - 110 kg (150-250 lb) force range at 240 cm/sec velocity.

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) "Chemical Rocket/Propellant Hazards", CPIA Publication No. 194, Vol. II, May 1970.

US/201.02.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Friction, Steel/Fiber Shoe Friction Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: The pendulum friction device consists of a steel swinging shoe, which is the bob of a pendulum. The frame supporting the pendulum is known as the "A-frame". The two free-bases of the A-frames at the lower ends of the device can be raised or lowered simultaneously, thus controlling the friction between the shoe and anvil. In testing, a steel shoe or one faced with red-hard fiber (called the "hard-fiber-faced shoe") may be used. This facing is fixed permanently to the face of the particular shoe to which it is attached. Seven gram samples are normally used. Results reported as "explosion", "burning", "local crackling", "no local crackling", "snaps", or "unaffected".

An automatic tripper is used to allow the shoe to be dropped upon the anvil from any desired vertical height ranging from 50 to 200 cm. Height of drop normally used is 100 cm. This test should be conducted in a temperature controlled room so that the temperature of the anvil and shoe is 70 ± 5°F.

Any type of explosion, burning, crackling, or scorching is considered a positive reaction.

c. Information Requirements for Assessment: Twenty trials are conducted using the steel shoe or fiber shoe. To pass, the test material using the steel shoe should not react in any of the twenty trials.

d. Typical Results:

Material	Steel Shoe	Fiber Shoe
NH_4ClO_4	Snaps	Unaffected
RDX	Explodes	Unaffected
Lead Azide	Explodes	N/A

e. Repeatability and Reproducibility: Repeatable.

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1022.

(2) Munroe, Charles E. and Tiffany, J.E., Physical Testing of Explosives at the Bureau of Mines Explosives Experiment Station, Bruceton, *PA*. U.S. Dept. of Commerce, Bureau of Mines, Bulletin 346, 1931. pp.78-84.

(3) "Engineering Design Handbook: Explosive Series, Properties of Explosives of Military Interest", Army Materiel Command, January 1971.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Electrostatic Discharge Sensitivity – ARDEC (Picatinny Arsenal) Method

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: The apparatus consists of a charging circuit and a spring loaded approaching electrode (needle). The needle is lowered to a preset distance above the lower (cathode) electrode and immediately raised again to its initial position. Adjustments to the gap length are made by raising or lowering the lower electrode. The upper portion of the lower electrode is a detachable solid cylinder of hardened steel that serves as the sample holder. A nylon or polyethylene washer of 0.049 ± 0.014 inch thick by 0.13 to 0.16 inch inner diameter is fastened to the top of the steel cylinder. The powder sample is placed in the center of the washer. Electrical insulating or Mylar tape approximately 0.075 inch thick is placed over the sample opening to confine the powder. The charging circuit consists of a variable high-voltage power supply (25 kV), a capacitor-charging circuit, and an electrostatic voltmeter. The circuit is designed so that the appropriate low-inductance, high voltage capacitance, from 0.00025 to 0.02 µF, can be connected in the circuit.

The electrostatic sensitivity test is divided into two parts. Part I is a screening test devised to distinguish between relatively insensitive and relatively sensitive materials to electrostatic. Part II is a more intensive procedure used to rank or to determine the energy required to ignite the sensitive materials.

c. Information Requirements for Assessment: For tests performed according reference (2) no reaction in twenty out of twenty trials at 0.25 joules is a pass.

d. Typical Results:

Primary Explosive	Energy for 0/20 (Millijoules)
Basic Lead Styphnate	<0.2
RD 1333 Lead Azide	4.7
Tetracene	28.0

Booster and main charge explosives are subjected to a 0.25 Joule test. If a sample is initiated at that energy level, the material is evaluated like a primary explosive.

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Kirshenbaum, M., "Response of Primary Explosives to Gaseous discharges in an Improved Approaching Electrode Electrostatic Sensitivity Apparatus," PATR-4955, October 1976.
(2) MIL-STD-1751A issued on 11 December 2001, Method 1032.

US/201.03.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Electrostatic Discharge Sensitivity – Naval Air Warfare Center Method

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: The apparatus consists of a series of capacitors, an electrode control assembly with a pointed steel electrode, and a sample holder. The explosive is subjected to an electrostatic spark discharge. The power supply provides a single, regulated output of 5 kilovolts direct current at 10 milliamperes to charge a 0.02 µF capacitor. The capacitor is wired to a selector switch that allows the capacitors to discharge. The discharge apparatus consists of a needle electrode and a grounded sample post that form a point-to-plane electrode geometry. The needle electrode is connected to a Teflon push rod that allows movement of the electrode towards the sample holder post.
Approximately 50 mg of the explosive sample is placed in a thin layer in the sample holder. Solid samples are cut to a minimum dimension of 0.625 inch square or 0.625 inch diameter and microtomed to a thickness of 0.033 ± 0.004 inch. Powder samples are sieved to determine the particle size of the sample. Hygroscopic or granular materials are dried in an oven at 120 °F or vacuum desiccated to remove any moisture prior to testing.

c. Information Requirements for Assessment: The test is begun at the 0.25 joule (0.02 µF) level. If results are negative, i.e., no reaction, the test is continued until 20 consecutive failures are reported. If the test sample has a positive result, i.e., flash, spark, burn, odor, or noise other than instrument noise, then testing is performed at the next lower level until 20 consecutive failures are reported. The test is normally conducted at 5 kVdc at an ambient temperature of between +65 and +90°F, and a relative humidity not exceeding 40 percent. A reference standard, such as Class 5 RDX, is tested in conjunction with the test sample. This test measures the relative ease with which powders or solids can be ignited by electrostatic (DC) discharge. Testing is normally conducted in the range of 0.001 to 0.25 Joule (0.02µF, 100 - 5000 V). This test will indicate high sensitivity, but it is not designed for precision testing of highly sensitive materials such as primary explosives.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1033.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Electrostatic Discharge Sensitivity Test - (Naval Surface Warfare Center Method)

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: The explosive is subjected to an electrostatic spark discharge. The apparatus consists of a series of capacitors, an electrode control assembly with a pointed steel electrode, and a sample holder. The capacitor bank consists of up to 12 capacitors which vary in capacitance from 0.0001 to 0.5 µF and are rated for 10 kV working voltage. Each of the capacitors is wired to a capacitor selector switch that allows only one of the capacitors to discharge at a time. By varying the capacitance, the energy level of the spark can be controlled over approximately three orders of magnitude. The power supply provides a single, regulated output of 5 kilovolts direct current at 10 milliamperes to charge the capacitors. The discharge apparatus consists of a needle electrode and a grounded sample post that forms a point-to-plane electrode geometry. The needle electrode is connected to a Teflon push rod that allows movement of the electrode towards the sample holder post.

Approximately 50 mg of the explosive sample is placed in a thin layer in the sample holder. Solid samples are cut to a minimum dimension of 0.625-inch square or 0.625-inch diameter and microtomed to a thickness of 0.033 ± 0.004 inch. Powder samples are sieved to determine the particle size of the sample. Hygroscopic or granular materials are dried in an oven at 120 °F or vacuum desiccated to remove any moisture prior to testing.

c. Information Requirements for Assessment: Data on sensitivity to electrical stimuli.

d. Typical Results: Range of results is:

Test Sample	Threshold Level (joules)	50% Point (joules)
HMX, Class 1	0.165	NA
RDX, Class 1	0.095	0.162
TNT	1.72	NA
PETN	0.095	NA

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1031.

US/201.03.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Electrostatic Sensitivity – Large Scale

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: The setup consists of a high voltage power supply, a high efficiency capacitor (34.7nF) with independent coupling, an explosive sample, negative and positive brass electrodes, and high voltage cables. The positive electrode is a 10 mm diameter by 210 mm in length brass rod with the end in contact with the test charge tapered to a 60° conical shape. The negative electrode is a brass disk 110 mm in diameter by 5 mm thick.

The explosive material is placed between a conical positive electrode and a negative plane electrode. The bare explosive sample or the one contained in the PMMA holder is subjected to a series of electrostatic discharges with a fixed intensity of 15.6 joules. This energy level is obtained by charging the selected capacitor to 30kV. After each discharge, the explosive material behavior is noted. Consecutive discharges are then repeated until an explosive reaction is observed or up to 30 discharges, whichever comes first. The test is then repeated in triplicate on two additional samples of the same energetic component.

c. Information Requirements for Assessment: Explosive samples are tested in one of two ways: (1) As bare billets, 90 mm in diameter by 90 mm long, with one face painted with a conductive silver lacquer and (2) as granular or powder samples placed in a polymethylmethacrylate (PMMA) container with 90 mm I.D., 102 mm O.D., and a length of 125 mm with a polyvinylchloride cover plate with a center hole for the electrode glued on top of the container.

d. Typical Results: Sample behavior is defined according to the following reaction levels:

(1) No reaction
(2) Rising of the cover with flash
(3) Fragmentation of the explosive billet
(4) Combustion/burning
(5) Detonation

The explosive sample is judged to have failed the test if the results of (3), (4), and (5) above are noted on any one of the three samples after 30 ESD pulses are performed on each.

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) NATO STANAG 4490, Explosives, Electrostatic Discharge Sensitivity Test, Large Scale.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1034.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Electrostatic Discharge Sensitivity -Hercules Radford AAP

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The test sample is placed on a grounded metal plate. A needle, which is connected to a charged capacitor, is lowered toward the sample on the plate until discharge occurs. Initiation of the sample is detected visually, audibly, or by other sensory means and by infrared analysis of decomposition products. Threshold initiation level is defined as the level of energy at which no initiation occurs in 20 consecutive trials, with at least one initiation in 20 trials at the next higher energy level. The sample is distributed as a monolayer of dust or granules of known size for gun propellants and 0.76 mm thick for other solid propellant samples. Samples are conditioned before testing. Typical tests are in the 4000 to 5000 Volt level. Tests are performed at 70^{o}F, 50% relative humidity.

   c. Information Requirements for Assessment: Data on the sensitivity to electrical stimuli.

   d. Typical Results: Most standard finished propellant granules are initiated by discharges of 1 to over 5 Joules depending on the composition and granule size of the propellant. Dusts are initiated by discharges of 0.2 to 1.5 Joules, depending on the particle size and composition.

   e. Repeatability and Reproducibility: Good.

3. NATIONAL REFERENCES:

(1) "Chemical Rocket/Propellant Hazards", CPIA Publication No. 194, Vol. II, May 1970.

US/201.03.007

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Electrostatic Discharge - Closed Cup

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: Capacitor discharges through 20-30 milligram samples contained in a closed cup. Voltages up to 5000 volts are utilized.

c. Information Requirements for Assessment: Data on the sensitivity to electrical stimuli.

d. Typical Results: Results are reported as "FIRE" or "NO FIRE". Typical examples of results are:

Explosive	Result
Mk 45 Illuminating Composition	NO FIRE (at 1.0 Joules)
Red Phosphorus (6% Linseed Oil)	NO FIRE (at 0.2 Joules)
RDX	FIRE (at 0.019 Joules [50%])

e Repeatability and Reproducibility: Results are repeatable within $\pm$ 10%.

3. NATIONAL REFERENCES:

(1) Test Procedure for Electrostatic Sensitivity, WQEC TP 3403-47, 22 March 1976, Naval Weapons Support Center, Crane, Indiana.

(2) Brown, R. W. et al., Sensitivity of Explosives to Initiation by Electrostatic Discharges, Bureau of Mines Report of Investigation, 5002, September 1953.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives and Propellants

2. TEST TITLE: Shock Sensitivity – Expanded Large Scale Gap Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This is a scaled version of the NOL Large Scale Gap Test (201.04.002). It is used for evaluating the shock sensitivity of explosives that can not be evaluated in the LSGT because of critical diameter constraints. The dimensions of the acceptor system of the ELSGT apparatus are twice the dimensions of the acceptor system of the LSGT apparatus. The dimensions of the donor system of the ELSGT are 1.875 times larger than the dimensions of the donor system of the LSGT system. The witness plate thickness is scaled by a factor of two.

The gap components are made from a 3.75-inch diameter cast polymethylmethacrylate (PMMA) rod stock having a density of 0.0078 lb/in^3 (1.185 g/cm^3). The gap size is prepared by stacking various component thicknesses of standard PMMA blocks. Standard thicknesses are 4.0, 2.0, 1.0, 0.5, 0.25, 0.2, 0.1, .050, .025, and .010 inches. As required, circular layers of 0.010-inch thick cellulose acetate are used to adjust the gap to the desired thickness.

Acceptors are cast directly into the charge body or machined to a diameter that is small enough to enable them to slide into the cold-drawn, mild-steel tubes. If required, chilling the acceptor to permit a slip fit into the tubes is permissible. The tubes are fabricated from seamless tubing with the ends machined to ± 0.010 inch of the desired length. The tube has an inner and outer diameter of 2.88 inches and 3.75 inches, respectively, while the length is 11.00 inches.

c. Information Requirements for Assessment: Explosive density and Gap thickness for 50% point.

d. Typical Results:

Explosive Material	Density	50% Point
PBXN-109	1.64	405 to 456
Comp B	1.69	489
PBXW-126	1.79	164

c. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Jaffe, I., Beauregard, R.L., and Amster, A.B., The Attenuation of Shock in Lucite, NAVORD 6876, May 1960.
(2) Liddiard, T.P. and Price, D., The Expanded Large-Scale Gap Test, NSWC TR 86-32, March 1987.
(3) Tasker, D.G. and Baker, R.N., Experimental Calibration of the NSWC Expanded Large Scale Gap Test, NSWC TR 92-54, January 1992.
(4) MIL-STD-1751A issued on 11 December 2001, Method 10134.

US/201.04.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Shock Sensitivity - NOL Large-Scale Gap Test (LSGT) Method.

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test measures the sensitivity of a material to explosive shock. A standard donor explosive provides an explosive shock pressure of uniform magnitude. The shock is transmitted and attenuated through a barrier of inert material. The thickness of the barrier required to prevent detonation of the acceptor (test sample) is determined at some level of probability. The test apparatus consists of a one-piece steel tube, two Pentolite pellets pressed to 1.56 $\pm$ 0.02 g/cm^3 piece steel tube, a #8 blasting cap (or equivalent output), a 15 x 15 x 1 cm mild steel witness plate, 5 cm diameter by 0.025 cm thick (2-inch x 0.01 inch) cellulose acetate cards, and PMMA discs of varying heights. The explosive sample is pressed or cast into the steel tube measuring 3.66 cm I.D. x 13.97 cm (1.44 inch I.D. x 5.5 inch) long. Detonation is indicated when a clean hole is cut in the witness plate. The first test begins with 8 cards, halving or doubling the cards until detonation occurs. The measure of charge sensitivity is the length of the attenuation (gap) length at which there is a 50% probability of detonation.

c. Information Requirements for Assessment: Gap measurement and/or pressure calibration curve data for go – no go to determine 50% point for the shock initiation of the test explosive.

d. Typical Results:

Explosive	% TMD	Density (g/cm^3)	50% point (mm)*	
RDX - pressed	91.0	1.64	82.0	(3.23 in)
Tetryl - pressed	94.8	1.64	60.5	(2.38 in)
Comp B - cast	97.7	1.70	51.1	(2.01 in)
TNT - cast	98.2	1.61	33.8	(1.33 in)
Pentolite (50/50) cast	95.9	1.64	71.1	(2.80 in)

* The test result is the gap in inches that corresponds to a 50% probability of detonation of the test explosive.

e. Repeatability and Reproducibility: Good at same density of test material.

3. NATIONAL REFERENCES:

(1) Price, D, Clairmont, A. R., Jr., and Erkman, J.O., “The NOL Large-Scale Gap Test. III. Compilation of Unclassified Data and Supplementary Information for Interpretation of Results”, NOLTR 74-40, March 1974.

(2) Erkman, J.O., Edwards, D.J., Clairmont, A.R., Jr., and Price, D., “Calibration of the NOL Large-Scale Gap Test; Hugonoit Data for Polymethyl Methacrylate”, NOLTR 73-15, April 1973.

(3) MIL-STD-1751A issued on 11 December 2001, Method 1041.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster Explosives

2. TEST TITLE: Explosive Shock Sensitivity Test - NOL Small-Scale Gap Method.

   a. Type of Test: Hazard Assessment/Sensitivity - Mandatory for Booster Explosives

   b. Description: The apparatus consists of an RDX donor, a PMMA attenuating spacer, an explosive acceptor, and a steel dent block. A No. 6, or equivalent output, electrical detonator is set within a plastic detonator holder. The donor and acceptor bodies are identical brass cylinders, 1-inch 0.D.; 0.2-inch I.D. by 1.5-inch long. The PMMA attenuator is, 1.0-inch in diameter. Discs of various thickness, selected on a logarithmic scale, are used to obtain a variable gap. The dent block is a steel disk 3.00 inches in diameter and 1.50 inches thick.

   c. Information Requirements for Assessment: Density of the explosive, gap thickness, and calibration curve.

   d. Typical Results:

Explosive	Density	50% Point - DBg*
HMX - pressed	95.3% TMD	4.6
RDX - pressed	94.5% TMD	4.4
Tetryl - pressed	93.8% TMD	4.4
TNT - pressed	93.8% TMD	5.9

*Value of point representing 50% probability of a fire. The unit of initiation intensity is called the gap decibang.

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosive) Working Group on Sensitivity, February 1966. Edited by G. R. Walker, E. G. Whitbread, and D. C. Hornig, p 144.
(2) MIL-STD-1751A issued on 11 December 2001, Method 1042.
(3) Ayres, J. N., "Standardization of the Small-Scale Gap Test Used to Reserve the Sensitivity of Explosives", NAVWEPS 7342, 16 January 1961.
(4) Price, D. and Liddiard, T. P. Jr., *The Small-Scale Gap Test: Calibration and Comparison with the Large Scale Gap Test*, NOLTR 66-87, 7 July 1966, Naval Surface Warfare Center, White Oak, MD 20903-5000.
(5) Ayres, J. N., Montesi, L. J., and Bauer, R. J., *Small-Scale Gap Test (SSGT) Data Compilation: 1959-1972*: Volume I, Unclassified Explosives, NOLTR 73-132, 26 October 1973, Naval Surface Warfare Center, White Oak, MD 20903-5000.
(6) Hampton, L. D. and Blum, G. D., *Maximum Likelihood Logistic Analysis of Scattered Go/No-Go (Quantal) Data*, NOLTR 64-238, 26 August 1965, Naval Surface Warfare Center, White Oak, MD 20903-5000.
(7) Price, D. and Liddiard, T. P., "The Small-Scale Gap Test: Calibration and Comparison with the Large-Scale Gap Test", NOLTR 66-87, 7 July 1966.

US/201.04.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Shock Sensitivity – Super Large Scale Gap Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test is applicable to explosives with critical diameters ranging up to 7.0 inches. The donor is an 8-inch diameter by 8-inch long unconfined Composition B cylinder initiated with an electric detonator boosted with a 1-inch diameter by 1 inch thick Composition A-5 pellet. Polymethylmethacrylate (PMMA) disks stacked to various thicknesses are used to attenuate the shock. The disks are 8 inches in diameter and range from .063 to 2.00 inches thick. The acceptor charge is cast into a 0.50 inch thick steel case with an O.D. of 8 inches and a length of 16 inches. Piezoelectric pins, used to measure detonation velocity, are spaced every 2 inches along the acceptor charge with the first pin being 1/2 inch from the forward explosive metal interface. A mild steel (e.g. SAE 1015 - 1026) witness plate is used to evaluate whether a detonation has occurred. The evaluation is similar to that used in performing the LSGT and ELSGT tests.

c. Information Requirements for Assessment: The plate is inspected after each shot with a positive result or "go" defined as a neat hole punched in the plate. An example of a negative result or "no-go" is a broken plate or one with a poor quality hole. Twelve charges are usually required to obtain the mean or 50% point.

d. Typical Results:

Explosive	Density (g/cm^3)	50% Point (Inches)	50% Point (kbar)
TNT	1.58	12.0	7.5
PBXN-109	1.64	9.40	13.1
H-6	1.69	9.54	12.5
AFX1100 Mod II	1.529	6.5	31.5
PBXW-126	1.78	4.10	58.1

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Foster, Craig, Parsons and Gunger, “Suppression of Sympathetic Detonation,” Proceedings of the 22nd Explosive Safety Seminar, Houston, TX, August 1983.

(2) Glenn, J. G. Aubert, S. A.; and Gunger, M. E., “Development and Calibration of a Super Large Scale Gap Test,” WL-TR-96-7039, August 1996.

(3) NATO STANAG 4488, Explosives, Shock Sensitivity Tests.

(4) MIL-STD-1751A issued on 11 December 2001, Method 1044.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Shock Sensitivity **- Insensitive High Explosive (IHE) Gap Test**

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: Two pellets, each 1.0-inch thick and 2.0-inch diameter pressed pentolite (ρ = 1.56 g/cm^3) are used as the donor. Attenuators used are Two inch diameter Polymethylmethacrylate (PMMA) disks in thicknesses of 0.010, 0.050, 0.100, 0.250, 0.500, 0.750, 1.00, and 1.50 inches. The test samples are cast into a steel cylinder 2 inches long, 0.5 inch inner diameter and 0.75 inch outer diameter. Pressed samples are fabricated outside then inserted into the test assembly. Powders are sieved and the fraction ranging from 37 to 75 µm is used. A 0.59 inch thick PMMA spacer is used to separate the base of the acceptor charge and the witness block. The assembly is placed on a steel witness block (3.0 inches in diameter and 1.5 inches thick) which is used to determine whether a detonation has occurred.

   The test samples are conditioned at 25 °C for 4 hours prior to test. “A detonator (E1A, No. 8 blasting cap, or equivalent EBW detonator) is used to initiate the pentolite donors. For the first test, no attenuator is used in order to obtain an example of a “go”. A "go" is defined as a dent exceeding half the depth of the result obtained without an attenuator.

   c. Information Requirements for Assessment: Shock sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results:

Explosive	Density (g/cm³)	% TMD	50% PT (inch)	50% PT (kbar)
HMX	1.81	95.1	2.23	16.4
TATB	1.84	94.9	0.85	63.1
TNT (pressed)	1.55	93.8	2.03	20.1
PBXN-7	1.81	95.8	1.93	22.5
PBXN-5	1.75	92.1	2.01	20.5

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Adolph, Horst, The Insensitive High Explosives Gap Test, NSWC TR 86-058, January 15, 1987.
(2) Spivak, Timothy, et al., Insensitive High Explosives Gap Test Data, NSWC TR 88-282, September 30, 1988.
(3) Erkman, J.O., Edwards, D.J., Clairmont, A.R., Jr., and Price, D., Calibration of the NOL Large-Scale Gap Test; Hugonoit Data for Polymethyl Methacrylate, NOLTR 73-15, April 1973.
(4) MIL-STD-1751A issued on 11 December 2001, Method 1045.

US/201.04.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster and Main Charge High Explosives

2. TEST TITLE: Wedge Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is used to determine the shock initiation characteristics of an energetic material. A planar shock wave is introduced into the test explosive. As the shock progresses through the explosive, it generates hot-spots that results in a detonation. The objective of the wedge test is to determine the point at which the detonation wave overtakes the shock wave. This point is characterized by a unique time and distance to detonation for a specific set of input conditions.

   The wedges are prepared by casting the explosive into the Plexiglas mold . The wedges are radiographed to check for defects and density variations. A plane wave generator introduces a planar shock wave into the booster charge. The booster charge detonates, introducing a shock wave into the attenuator plates and hence, into the explosive wedge sample. Different booster/attenuator combinations can be used to vary the input pressure into the sample.

   A streak camera is used to record the event. The surface of the wedge is mirrored to reflect light into the camera. A laser is used to align the test fixture and the light sources to the streak camera axis. When either the shock wave or detonation wave reaches the surface, the surface distorts so that light is no longer reflected into the camera. As the detonation wave overtakes the shock wave, the slope of the reflected light trace on the film changes. Thus, the run to detonation point can be determined from the film record.

   c. Information Requirements for Assessment: The results of a series of wedge tests are presented as plots of input pressure versus distance and time to detonation (Pop-plots). These plots are used to determine the relative sensitivity of explosive materials.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Davis, W. C. and Craig, B. G., "Smear Camera Technique for Free Surface Velocity Measurement," Review of Scientific Instruments, Vol. 32, No. 5, May 1961, p. 579.
(2) Craig, B. G., Personal Communication, May 1987.
(3) Gibbs, T. R. and Popolato, A., eds., LASL Explosive Property Data, University of California Press, Berkeley, CA, 1980, pp. 295-296.
(4) Los Alamos Scientific Laboratory, Selected Hugoniots, by Group GMX-6, Report LA-4167MS, Los Alamos, NM, May 1969.
(5) Lindfors, Allen J. and Sandstrom, Frederick W., Wedge Test Results for PBXN-107 Type II, NWC TM 6792, Naval Weapons Center, China Lake, CA, July 1990.
(6) MIL-STD-1751A issued on 11 December 2001, Method 1046.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Shock Sensitivity Test - Picatinny Arsenal Method

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The test elements consist of a donor explosive consisting of two tetryl pellets, cast Aerowax spacers (gap), the test explosive, and a metal witness plate. The witness plate is used to determine whether the test result was a "go" or "no-go".

   c. Information Requirements for Assessment: Shock sensitivity data on two reference comparison explosives tested on the same machine.

   d. Typical Results:

Explosive	50% Probability Point (cm)
Tetryl	5.11 (2.01-inch)
Comp B	3.56 (1.40-inch)
TNT (Case)	2.08 (0.82-inch)

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, February 1966. Edited by G. R. Walker, E. G. Whitbread, and D. C. Hornig, p 166.

US/201.04.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: NSWC Low Pressure - Long Duration Shock Test.

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: High explosive samples (acceptors 50.8 mm diameter x 12.7 mm thick) submerged in water are subjected to spherical shocks. The distances between an 0.45 kg (one-pound) spherical donor charge and the acceptors are adjusted to give various peaks entering shock pressures in the acceptors, typically in the range of 5-25 kBar. Burning is detected by the expansion of the acceptor after being struck by the shock. Observations are made with a high-speed framing camera using diffuse reflected back-lighting. The threshold for burning in this geometry is deduced from plots of expansion velocity vs. entering pressure. The results on numerous solid high explosives show that the threshold for burning obtained in the underwater test is between 3 and 10 kBar. This low threshold for burning in the underwater system is attributed to the long pulse duration, less curvature of the wave front, and the confinement offered by the water.

c. Information Requirements for Assessment: This test information is used to assess reaction from situations where low pressure-long duration, (nominally 25 μ pulse width) shock exists.

d. Typical Results:

Explosive	Density (g/cm^3)	Burning Threshold (kBar)
H-6	1.71	6.6
PBXW-109 (I)	1.66	7.0

e. Repeatability and Reproducibility: The thresholds for burning reactions are repeatable and reproducible. To determine the threshold of the test sample in terms of pressure requires knowledge of the unreacted Hugoniot of the test material.

3. NATIONAL REFERENCES:

(1) Frankel, M. J., Liddiard, T. P., and Forbes, J. W., "Low- Level Shock Reaction Thresholds in High Explosives and Propellants", Combustion and Flame, Vol. 45, No. 1, January 1982.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Blasting Cap Test.

   a. Type of Test: Hazard Assessment/Sensitivity

   b. Description: This test determines whether or not a high explosive can be initiated by a blasting cap. The sample, a 5-cm (2-inch) cube, is centered on top of a 4-cm (1.57 inch) diameter solid lead cylinder, and a # 8 electric blasting cap (or equivalent) is centered perpendicular to and in contact with the top flat surface of the sample, using a 5-cm (2-inch) diameter wood or cork cylinder with a hole drilled in the center to position and secure the blasting cap to the sample. The cap is detonated and evidence of sample detonation is considered to be deformation (mushrooming) of the lead cylinder, which rests on a steel plate.

   c. Information Requirements for Assessment: This test determines the initiability of high explosives and propellants.

   d. Typical Results: RDX (powder) detonates; EAK negative.

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) NAVORDINST 8020.8, Explosives Hazard Classification Procedures, Department of the Navy, Latest revision.

(2) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979.

(3) UN ST/SG/AC.10/11/Latest Revision, Recommendation on the Transport of Dangerous Goods – Test and Criteria.

US/201.05.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: SUSAN Projectile Impact Test - Lawrence Radiation Laboratory

   a. Type of Test: Hazard Assessment

   b. Description: This test employs a 5.4 kg (12 lb) projectile which contains slightly less than 0.45 kg (1 lb) of test explosive. The projectiles are fired from a smooth bore converted (3"/70) Naval gun. The gun muzzle is 3.6 m (12 ft) from the target plate. The projectile velocities range from 100 to 1400 feet per second (fps), although velocities up to 3500 fps are possible. If the explosive survives the initial impact in this test, other energy transfer mechanisms become dominant. After impact there is a rapid viscous flow of the explosive followed by friction associated with crushing, and eventually a "pinch" stage for explosive caught between the rear section of the projectile and the steel target plate.

   c. Information Requirements for Assessment: To determine the impact sensitivity of explosive billets in order to assess the relative behavior of explosives under field conditions of impact.

   d. Typical Results: Refer to SUSAN sensitivity curves in the detailed Procedure and Expression of Results segments of the detailed method description of this test.

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Canadian Armament Research and Development Establishment - The Technical Cooperation Program Manual of Sensitiveness Tests by TTCP Panel 0-2 (Explosives) Working Group on Sensitivity, February 1966. Edited by G. R. Walker, E. G. Whitbread, and D. C. Hornig, p. 74.

(2) NAVORD OD 44811, Method 5.6.2, pgs. 5-13, 1 January 1972.

(3) UN ST/SG/AC.10/11/Latest Revision, Recommendation on the Transport of Dangerous Goods – Test and Criteria.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Liquid Propellants

2. TEST TITLE: Minimum Pressure for Vapor Phase Ignition.

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is used to determine the minimum pressure below which it is impossible to ignite a monopropellant vapor or fuel vapor-air mixture by using a fixed quantity of energy applied in a well-defined manner. The apparatus consists of a thermostat equipped stainless-steel bomb into which vapor or vapor-air mixture is placed.
   The temperature and pressure of the internal volume of the bomb can be varied. Ignition is accomplished by the electrical fusion of 0.0025 inch diameter Nichrome V wires. The wire-fusion time is determined by the voltage applied to the wire and the characteristics of the fuse wire.
   The bomb is heated and can be regulated from ambient temperature to 260°C. In this temperature range, sufficiently high pressures can be obtained with most compounds to determine the minimum pressures for vapor-phase ignition.

   c. Information Requirements for Assessment: For monopropellants the fusion time and ignition energy are held constant (approximately 5 milliseconds and 0.07 joules).

   d. Typical Results: Acetylene at 100°C has minimum ignition pressure of 3.5 cm.

Characteristic	Ethylene Oxide	N-Propyl Nitrate	Acetylene	
	100°C	160°C	100°C	150°C
Minimum Ignition Pressure, atm	2.18	2.2	3.50	5.26
Fusion Time, ms	1.15 to 5.20	2.3	1.2 to 16.0	1.20
Ignition Energy, joules	0.065 to 0.080	0.10	0.074 to 0.090	0.12
Minimum Ignition Pressure, atm, at t = 5 ms, H = 0.07 joules	2.2	2.5 to 3.0	3.5	3.6

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Chemical Propulsion Information Agency (CPIA), Liquid Propellant Test Methods, July 1969.
(2) MIL-STD-1751A issued on 11 December 2001, Method 1041.

US/201.08.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Liquid Propellants

2. TEST TITLE: Flash Point

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is designed to measure the temperature where the sample will emit vapors that may be ignited by an open flame. The flash point is determined in an open cup tester. A test cup is filled to a specific level with the sample. The temperature of the sample is increased rapidly at first and then at a slow constant rate as the flash point is approached. At specific intervals, a small test flame is passed across the cup. The lowest temperature where the application of the test flame causes the vapors above the surface of the liquid to ignite is recorded as the flash point. To determine the fire point the test is continued until the application of the test flame causes the sample to ignite and burn for at least 5 seconds.

   c. Information Requirements for Assessment: Temperature when a flash appears at any point on the surface of the sample is the observed flash point.

   d. Typical Results: NOS 365, No flash to 75^{o}C.

   e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) ASTM D92-90, Standard Test Method for Flash and Fire Points by Cleveland Open Cup. Philadelphia: American Society for Testing and Materials, 1990.

(2) ASTM D93-90, Standard Test Methods for Flash Point by Pensky-Martens Closed Tester. Philadelphia: American Society for Testing and Materials, 1990.

(3) MIL-STD-1751A issued on 11 December 2001, Method 1021.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Vacuum Thermal Stability (VTS)

a. Type of Test: Hazard Assessment - Stability.

d. Description: This test determines thermal stability as a function of the volume of gas liberated on heating an explosive under vacuum. Two types of pressure measuring instruments are used, the mercury monometer and a pressure transducer. The monometer apparatus consists of a constant temperature bath, a bent capillary tube, a heating tube containing the sample that is connected to the capillary tube, and a cup for mercury filling. The capillary and heating tubes are calibrated with known volumes of mercury. The capillary is filled with mercury, and a ground specimen is placed in the heating tube. The sample is heated at the specified temperature (not less than 100^{o}C for 48 hours. For propellants the sample is heated for 40 hours. The volume of gas liberated is recorded after a 20-minute surge and upon completion.

Because of the toxicity of Mercury, NATO STANAG 4556, reference (4), describes a pressure transducer method that can be used as an alternative to the manometer method. Different assemblies for the connection between the heating elements and the pressure transducers are used. Examples are given in the STANAG.

d. Information Requirements for Assessment: Determination of the volume of gas liberated on heating the propellant under vacuum. It is used to obtain information used to evaluate shelf-life or compatibility.

e. Typical Results: No more than 2.0 ml gas/gram/48 hours at 100 °C is acceptable.

Explosive	Temperature (°C)	Test Duration (hrs)	VTS Value (ml/g)
COMP B	100	48	0.30
HMX	100	48	0.50
PETN	100	48	0.21
RDX	100	48	0.12
TNT	100	48	0.10

e. Repeatability and Reproducibility: Normally repeatable within $\pm$ 0.1 ml.

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1061.
(2) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", dated 30 March 1979.
(3) STANAG 4556, Explosives, Vacuum Stability Test..

US/202.01.002

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Variable Confinement Cook-Off (VCCT) Test

a. Type of Test: Hazard Assessment/Sensitivity/ Thermal Detonability.

b. Description: This test is used to study the explosiveness of solid explosive materials in fast and slow cook-off condition. A sample of explosive, confined in an aluminum liner within a steel tube, is heated by means of electrical windings.

The apparatus consists of an aluminum liner, one from a series of increasing wall thickness steel tubes, heating bands, thermocouples, steel spacer washers, steel end plates and retaining bolts. The thickness of the aluminum sleeve is 2.5 mm and the thickness of the steel tube can be 0.375 to 3 mm in 0.375 mm increments. Two thermocouples are fitted, one in each of two diametrically opposing grooves in the aluminum sleeve. Either two mica-insulated band heaters or an insulated nichrome wire winding are located on the steel tube, spacer washers are added to each end and the assembly is located in recesses between steel witness plates. The retaining bolts are evenly tightened to a torque of 40.7 +/- 4Nm.

c. Information Requirements for Assessment: The degree of tube fragmentation is used to determine the reaction category and the objective of the test is to determine the median tube thickness just resulting in a deflagration reaction rather than burning.

d. Typical Results: Five levels of severity of reaction are observed in this test:

(1) Burning: The steel sleeve is recovered in one piece. The aluminum sleeve is usually recovered in one or two pieces. Witness plates exhibit no deformation. Retaining bolts usually remain intact, although in some cases they may be bowed.
(2) Deflagration: The steel sleeve is recovered in one or two pieces. The aluminum sleeve usually fragments into large pieces. Witness plates exhibit slight deformation. Retaining bolts fail in shear.
(3) Explosion: Both steel and aluminum sleeves fragment into several large pieces. Witness plates exhibit some deformation.
(4) Partial detonation: Steel and aluminum sleeves fragment into both large and small pieces. Witness plates exhibit severe deformation.
(5) Detonation: Steel and aluminum sleeves fragment into very small pieces. Witness plates exhibit severe damage.

CH-6 repeatedly cooks-off with a partial detonation (Level 4). Tetryl repeatedly cooks-off with high order (Level 5).

e. Repeatability and Reproducibility: The severity of the reactions is repeatable and reproducible.

3. NATIONAL REFERENCES:

(1) STANAG 4491 Edition 1, Explosives, Thermal Sensitiveness and Explosiveness Tests.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Thermal Detonability (Fast Cook-Off) - NAWC (China Lake) Method

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The test fixture, a super small-scale cook-off bomb (SSCB), consists of a steel tube 2.8 cm 0D/2.3 cm ID X 7.6 cm long (~1.1" OD/O.9" ID X 3" long) spot welded (4 pts) to a witness plate 6 cm diameter x 1 cm thick (3" diameter X 3/8" thick). A similar top plate is used and bolted to the tube-witness plate for explosive confinement. An internal aluminum sleeve 2.3 cm OD/2.0 cm ID X 7.6 cm long (~0.9" OD/O.8" ID X 3" long) is used to spread input heat evenly and temperature measurement is made with a thermocouple. The explosive material is cast, pressed, or cured in steel tubes 2 cm OD/1.5 cm ID X 3.2 cm long (0.8" OD/O.6" ID X 1.25" long). Each tube contains about 10 grams of explosive and two steel tubes are used per test. This allows a 1.3 cm (0.5-inch) void area for thermal expansion. The outer steel tube is heated with two, 125-watt band heaters. With 220 VAC applied, the heating rate is ~1^{o}C/sec and is ~0.2^{o}C/sec with 110 VAC. The higher heating rate is similar to a heavy steel wall 1.3 cm (~0.5 inch) munition in a fuel fire, the lower heating rate is similar to an area that is not in a direct heat path from the fuel fire, i.e., fuze cup, thermally protected case, etc.

   c. Information Requirements for Assessment: This test is used to determine the cook-off temperature and reaction of a confined explosive. The time-temperature plot is used to determine the cook-off temperature at a given heating rate. The body fragments and witness plate are used to assess the severity of the reaction.

   d. Typical Results: The severity of the cook-off reaction is assessed in the following manner and is listed below:

Outer Tube	Witness Plate	Cook-Off Reaction
Intact/Split	Dent $\leq$ 1.3 cm (0.05")	Burning
1-4 Pieces	Dent $\leq$ 1.3 cm (0.05")	Deflagration
Many Pieces	Dent $\leq$ 1.3 cm (0.05")	Explosion
Many Pieces	Nearly Punched	Partial Detonation
Small Pieces	Punched Hole	Detonation

   The severity of the cook-off reaction is dependent on the heating rate. CH-6 booster explosive yields a detonation. PBXC-123 will yield a burning reaction, which is similar to the cook-off reaction of this explosive in a warhead.

   e. Repeatability and Reproducibility: The tests have been repeatable in regard to thermal response and reaction.

3. NATIONAL REFERENCES:

(1) Pakulak, J. and Cragin, S., National Weapons Center TP-6414, July 1983.

US/202.01.004

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Explosion Temperature.

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: Heat causes the decomposition of an explosive at a rate that varies with temperature. Almost all explosives are characterized by a critical temperature, below which the rate of decomposition is so small that it is negligible. If a small mass of an explosive is suddenly subjected to a high ambient temperature, an induction or incubation period ensues during which the explosive absorbs heat. If the ambient temperature is sufficiently high, decomposition of part of the explosive liberates heat and causes acceleration of the increase in temperature of the remaining explosive. When the temperature reaches a certain value characteristic of the explosive, the rate-of-decomposition value becomes so great that explosion of the remaining material takes place. The temperature of the products of explosion is much greater than that developed during the period prior to slow decomposition. If the explosion is brought about at the end of a column of explosive, self-propagating detonation of the column can ensue.

   In this test, a blasting cap containing the explosive is immersed to a fixed depth in a bath of molten Woods' metal. The time of immersion required to cause flashing or explosion is noted. The temperature of the bath is varied and a number of tests are made in order to produce smoke, fume, flashes or explosions over a range of approximately two to ten seconds. Visible signs of evolution of smoke, fumes, etc., are recorded. A pressure-time curve is constructed in order to finalize the temperature required to cause flashing or explosions in five seconds.

   c. Information Requirements for Assessment: To determine the relative sensitivity of booster and main charge explosives to heat.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) Clear, A. J., "Standard Laboratory Procedures for Determining Sensitivity, Brisance and Stability of Explosives", PA Technical Report 3278, Rev. 1, April 1970.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Primary High Explosives

2. TEST TITLE: Cook-Off Temperature Determination Test.

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: A 5 mg specimen of the candidate explosive is placed on a hot plate, with an imbedded temperature sensor well, having a proportional heating control of $\pm$ 2.5°C or better. The measurements start at 50°C and the temperature is raised in 10°C increments until ignition is observed. The test is repeated until 5 ignitions occur out of 5 trials.

   c. Information Requirements for Assessment: This test determines the thermal sensitivity of primary explosives.

   d. Typical Results: Not available

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

   (1) NAVORD OD 44811, pgs. 1-20, 1 January 1972.

US/202.01.006

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives

2. TEST TITLE: Hot-Wire Ignition Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test employs a 0.0508 mm (2 mil) diameter tungsten or chrome wire that is in contact with the charge. When sufficient electrical energy is supplied, the wire becomes hot and ignites the explosive charge. The particle size of the test material must be small compared to the diameter of the ignition wire. The sample is dried to constant weight at 55^{o}C and then pressed into a cup at 27.56 MPa (4000 psi) and 103.35 MPa (15000 psi).

c. Information Requirements for Assessment: The candidate explosive is reported to have passed the hot wire test if none of the 40 samples show any evidence of reaction in the form of visible, audible, or measurable external change to the test explosive, the test unit, or the witness plate. The tungsten wire must be burned out.

d. Typical Results: Tetryl generally passes this test while PETN generally fails.

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Fedoroff, B. T. and Sheffield, O. E., "Encyclopedia of Explosives and Related Items", Vol. 5, Picatinny Arsenal, Dover, NJ (1972).

(2) MIL-STD-1751A issued on 11 December 2001, Method 1151.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Differential Thermal Analysis (DTA)

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The temperature difference between an inert reference compound and the material is measured as they are heated at a constant rate. Because the reference material undergoes no thermal reactions over the temperature range used, any endo- or exothermic changes of the test sample causes its temperature to be lower or higher than that of the reference material. The differential temperatures are recorded as a function of the sample or furnace temperature. The sample and a reference material are placed in separate test tubes side by side in a heating element. The temperature is raised at a constant rate of $5^{o}C$-$10^{o}C$/minute to destruction. The temperature difference is plotted as a function of the reference temperature.

   For high explosives and propellants, a maximum weight of 2 mg is recommended with a maximum heating rate of 10°C/minute. For pyrotechnics, the sample size may be up to 30 mg with a heating rate up to 50°C/minute.

   c. Information Requirements for Assessment: Exothermic and endothermic reactions observed as heat is applied at a given rate.

   d. Typical Results: N/A

   e. Repeatability and Reproducibility: Routinely reproducible.

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1071.
(2) NATO STANAG 4515, Thermal Characterization of Explosives.
(3) ASTM E537-86, Standard Test Method for Assessing the Thermal Stability of Chemicals by Methods of Differential Thermal Analysis, Philadelphia: American Society for Testing and Materials, 1986.
(4) MIL-STD-2100 (OS), Method 5.4.15, dated 30 March 1979.
(5) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979.
(6) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).
(7) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

US/202.01.008

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnic

2. TEST TITLE: Thermogravimetric Analysis (TGA)

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is used to measure the change in weight, as a function of temperature and time, of a test sample under isothermal conditions and in a flowing inert or oxidizing atmosphere. The technique is useful in distinguishing between phase changes (solid-state, melting) and weight changes resulting from chemical reactions (thermal degradation, metal oxidation, etc.).

   The Apparatus used is a Thermogravimetric analyzer capable of heating rates of up to 20°C/minute, with a weighing accuracy of ±0.01 mg, and an automatic capability for recording of sample weight loss or gain as a function of temperature.

   The heating rate (dynamic experiment) is determined by the objective of the experiment. Some energetic materials are volatile and will volatilize from the sample pan during this test, sometimes prior to reaching the melting temperature

   Samples used are representative of the material in the final form anticipated for service use. Cast-cured materials are to be fully cured. Powders are used as such or consolidated to a density similar to that proposed for a final configuration.

   c. Information Requirements for Assessment: The derivative weight loss/gain trace is a measure of the change in weight as a function of time/temperature and is characteristic of the material or composition. It generally consists of a series of peaks, each corresponding to a weight loss or gain step. It can be used as a thermogravimetric fingerprint for characterization purposes.

   d. Typical Results: Varies with materials under test.

   e. Repeatability and Reproducibility: Very Good

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1073.

(2) NATO STANAG 4515, Thermal Characterization of Explosives.

(3) ASTM E1641-99, Standard Test Method for Decomposition Kinetics by Thermogravimetry, Philadelphia: American Society for Testing and Materials, 2000.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: 100°C Heat Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is performed to measure the resistance of explosives to decomposition by heat. The end points used are loss in weight of the sample following exposure at the specified condition, and noting if ignition or explosion occurs following exposure in an oven maintained at 100°C for a period of 100 hours.

   c. Information Requirements for Assessment: This method is used for determining the stability of high explosives by subjecting them to 100°C at atmospheric pressure.

   d. Typical Results: Kinetic data from DTA or other tests for the calculation.

   e. Repeatability and Reproducibility: Should be good for test performed under the same conditions.

3. NATIONAL REFERENCES:

(1) MIL-STD-650, dated 3 August 1962.

(2) Clear, A. J., "Standard Laboratory Procedures for Determining Sensitivity, Brisance and Stability of Explosives", Picatinny Arsenal Technical Report 3278, Rev. 1, April 1970, Dover N.J.

US/202.01.010

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: TNT Exudation Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: As the confined explosive is heated, TNT expands and an internal pressure is developed which squeezes the exudate from the pores to a region of lower pressure, e.g., nose of the shell or booster cavity. The droplets coalesce and dissolve the TNT, cutting channels through the TNT and the main charge becomes more porous and of lower density. With increased gun setback forces, any cracks in the charge can increase the probability of a premature explosion. The test simulates the confinement of a closed shell and the length to diameter ratio of the cast explosive approximates that of typical artillery shell fillers. The paper wrap, which absorbs the exudate, serves as an insulator between the cast specimen and the heavy walled cylinder, which tends to keep the temperature constant. The cast TNT charge is loaded into the upright sleeve of the test apparatus weighed and placed in a steam- heated chamber (157^o to 160^oF). The amount of exudate is determined from the increase in weight of the paper wrap.

c. Information Requirements for Assessment: Visual observation and or chemical test of the exudates.

d. Typical Results: Depends on quality of the TNT

e. Repeatability and Reproducibility: N/A

3. NATIONAL REFERENCES:

(1) Voigt, H. W., "Exudation Test for TNT Explosives Under Confinement: Exudation Control and Proposed Standards", ARRADCOM Technical Report ARLCD-TR-83004, February 1983.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1161.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: TNT Growth Characteristics Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: Explosives may undergo irreversible dimensional changes when temperature cycled between -65^{o} and +160^{o}F. In explosives containing TNT, the dinitrotoluenes form low melting liquid eutectics, which contribute to the growth. Mononitrotoluenes, added as anti-cracking agents, cause irreversible growth in TNT explosives.

      Irreversible growth and exudation causes many problems in ordnance items such as damaging the fuze well in a warhead. The test is conducted by temperature cycling between the appropriate temperature extremes for 30 cycles or more and noting whether exudation or growth has occurred.

   c. Information Requirements for Assessment: To determine if irreversible dimensional changes or exudation occurs to an explosive following temperature cycling three times or more.

   d. Typical Results: Depends on quality of the TNT.

   e. Repeatability and Reproducibility:

3. NATIONAL REFERENCES:

(1) NAVORD OD 44811, Method 5.5.66, dated 1 January 1972.

(2) Gryting, H. J., Pennington, O. K., Falterman, C. U., and Seaman, H., "Additives for Controlling Cracking of Explosives Made with TNT", NAVORD Report 5595, NWC, China Lake, CA, 1 November 1957.

(3) Pakulak, J., Jr. and Kuletz, Edward, "Thermal Analyses Studies on Candidate Solid JPL Propellants for Heat Sterilizable Motors", National Weapons Center TP 4258, China Lake, CA, July 1970.

(4) MIL-STD-1751A issued on 11 December 2001, Method 1162.

US/202.01.012

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives, Boosters, and Propellants

2. TEST TITLE: Determination of Critical Temperature and Self-Heating Properties

a Type of Test: Thermal Stability

b. This Method is used both to predict and to experimentally determine the critical temperature and self-heating properties of an explosive material.

An energetic material subjected to an elevated temperature for a prolonged period may undergo self-heating. In this process, thermal energy is liberated in the interior of the explosive because of chemical decomposition. At some point, a state of equilibrium exists where the energy released is equal to the energy dissipated. If the thermal energy is released is faster than is dissipated, the temperature of the explosive will increase until a catastrophic event occurs. The critical temperature is defined as the lowest constant surface temperature above which a given energetic material of a specific size and shape will catastrophically self-heat.

The experimental critical temperature for a given size and geometry can be determined by carrying out a variety of tests with the explosive confined or unconfined. These tests include the isothermal cook-off (ICO), slow cook-off (SCO), one-liter cook-off (1-LCO) and isothermal Time-To-Explosion (Henkin TTE) tests. The ICO and SCO are large-scale and confined, the 1-LCO is large-scale and unconfined and the Henkin TTE is small-scale and moderately confined. **T**he first three tests must incorporate the use of at least one thermocouple placed at the geometrical center of the explosive and one to monitor the temperature of the heat source.

c. Information Requirements for Assessment: Data obtained from DTA, DSC, or TGA experiments are used to determine the various kinetics parameters required in this method, i.e., Arrhenius activation energy and pre-exponential.

e. Typical Results: Calculated results depend on the formulation.

Explosive	Critical temperature (°C)	Diameter, inch	500-day cook off temp (°C) (MK 84 bomb)
PBXN-9	233	0.5	129
PBXN-9	179	6.0	
PBXN-9	166	12.0	

e. Repeatability and Reproducibility: N/A

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1074.
(2) Zinn, J. and Rogers, R.N., "Thermal Initiation of Explosives," Journal of Physical Chemistry, Vol. 66 (1962), p. 2646.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Thermal Stability Test

   a. Type of Test: Hazard Assessment/Sensitivity

   b. Description: This test must demonstrate that the candidate high explosive is thermally stable at 75^{o}c. A sample of up to 50g is placed transferred to a tared beaker, covered with a watch glass and weighed. The covered beaker is then placed in a constant temperature explosion-proof oven. The temperature of the oven is raised to 75^{o}C and maintained at that temperature for 48 hours unless an ignition or explosion of the sample occurs. The temperature is recorded continuously. The beaker is then removed and cooled in a desiccator and weighed. The weight loss as a percent of the sample weight is calculated.

   c. Information Requirements for Assessment: This test is be used to evaluate the thermal stability of explosive materialsy.

   d. Typical Results: The sample is considered to have failed the test if it explodes, burns, or decomposes.

   e. Repeatability and Reproducibility: Not Applicable

3. NATIONAL REFERENCES:

   (1) TB 700-2, NAVSEAINST 8020.8, T011A-1-47, DLAR 8220.1, of 5 January 1998.

US/202.01.014

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Unconfined Burning

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: This test is used to determine if a small quantity of the test material will transition from deflagration to detonation when unconfined. A 125-gram sample is placed in a plastic beaker and placed on a bed of kerosene-soaked sawdust. The sawdust is ignited with an electric igniter. Three samples are tested. The material fails the test if an explosion or detonation occurs.

   c. Information Requirements for Assessment: The data are used to determine whether an explosive is safe to handle, transport, and store.

   d. Typical Results: Not Applicable

   e. Repeatability and Reproducibility: Not Applicable

3. NATIONAL REFERENCES:

   (1) TB 700-2, NAVSEAINST 8020.8, T011A-1-47, DLAR 8220.1, of 5 January 1998

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Internal Ignition Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The explosive material is contained in a steel pipe that is capped at both ends. A black powder igniter is located at the center of the explosive sample and is used to ignite the explosive. Three tests are performed. The test is considered positive if either the pipe or one of the end caps is fragmented into at least two distinct pieces separated from the pipe.

   c. Information Requirements for Assessment: This is hazard classification test.

   d. Typical Results: Not Applicable.

   e. Repeatability and Reproducibility: Not Applicable.

3. NATIONAL REFERENCES:

   (1) TB 700-2, NAVSEAINST 8020.8, T011A-1-47, DLAR 8220.1, of 5 January 1998.

US/202.01.016

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Henkin 5-Second Ignition Temperature

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description:

(1) Apparatus - A molten Wood's metal bath and sample tubes (copper or brass) are used.

(2). Procedure - A 1 gm sample is loaded into a copper or brass tube (usually a No. 6 blasting-cap shell). The tube is immersed the Wood's metal bath heated to a temperature (T), and the time interval (t) before ignition is recorded. The bath temperature is then varied and additional samples are tested to obtain five or six points through which a temperature-time curve can be drawn. The ignition temperature is the one for which ignition occurs at five seconds.

c. Information Requirements for Assessment: Hazardous Component Safety Data Statement (HCSDS) requires this test.

d. Typical Results: Temperatures that are always higher than the ignition temperatures as determined by differential thermal analysis (DTA) are reported.

e. Repeatability and Reproducibility: Normally reproducible.

3. NATIONAL REFERENCES:

(1) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

(2) Henkin, H. and McGill, R., "Rates of Explosive Decomposition of Explosives", Industrial and Engineering Chemistry, 44, 1391 (June 1952).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Taliani Test

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The Taliani Test determines the stability of an explosive material by subjecting it to a specified temperature and atmosphere (usually 110^{o}C and nitrogen) and monitoring the rise in pressure over the propellant with time. The Taliani test apparatus consists of the following: heating block, helix (2-mm ID), connecting tube, gas infusion evacuating system (vacuum pump/gas supply), manometer, and heating tube. The sample is heated until pressure has risen 150-mm or for 6 hours (whichever occurs first). The pressure change as a function of time is recorded.

   c. Information Requirements for Assessment: This test is used to determine stability.

   d. Typical Results: Stable compounds have slopes of less than 1.0-mm Hg/min.

   e. Repeatability and Reproducibility: Duplicate determinations should agree within 2.8-mm in the 0-50-mm range, within 4.9-mm in the 50-100-mm and within 4.6-mm above 100-mm.

3. NATIONAL REFERENCES:

(1) MIL-STD-286C, "Military Standard: Propellants, Solid, Sampling, Examination and Testing", Method 406.1.3 Notice 1 of 8 January 1999.

(2) MIL-STD-2100, "Military Standard: Propellant, Solid, Characterization of", 30 March 1983.

US/202.01.018

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Surveillance of Single and Double Base Propellants

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: A 224 gm (8-oz) glass bottle having a wide-mouth with a velvet ground mushroom stopper is used for this test. It is placed in a chamber at 65 $\pm$ 1^{o}C. Daily observations are made; samples may be withdrawn for mechanical and/or closed bomb testing. The number of days required to cause the liberation of visible reddish fumes is recorded. If mechanical properties and/or closed bomb tests are conducted, the results are also reported.

   c. Information Requirements for Assessment: This test is used to predict the safe storage life of a propellant.

   d. Typical Results: Single-base propellant should last several hundred days before fuming. Double-base propellant should last at least 100 days before fuming. The test is not reliable for triple-base propellants.

   e. Repeatability and Reproducibility: This is a qualitative test, but reproducibility is fair.

3. NATIONAL REFERENCES:

(1) MIL-STD-286B, "Military Standard, Propellants, Solid, Sampling, Examination and Testing", Method 407.1, 1 December 1967.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Minimum Ignition Temperature

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The sample is placed in a metal cup and immersed in a molten Wood's metal bath. Samples are ignited at various bath temperatures and the time to ignition is recorded. A graph of results is prepared and the temperature at which a minimum ignition temperature would be observed at t = infinity is determined.

   c. Information Requirements for Assessment: Data required for safe drying of composition life.

   d. Typical Results: The minimum ignition temperature is usually the same as that determined by DTA.

   e. Repeatability and Reproducibility: Repeatable to $\pm$ 1^{o}C.

3. NATIONAL REFERENCES:

(1) Johnson, Duane M., Ignition Theory: Application to the Design of New Ignition Systems, NWSC/CR/RDTR No. 56, Naval Weapons Support Center, Crane, IN 24 November 1965.

(2) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

(3) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

(5) Henkin, H. and McGill, R., "Rates of Explosive Decomposition of Explosives", Industrial and Engineering Chemistry, p. 44, 1391 (June 1952).

(6) STANAG 4491, Explosives, Thermal Sensitiviness and Explosiveness Tests

US/202.01.020

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Differential Scanning Calorimetry [DSC]

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test is used to evaluate the behavior of an energetic material when it is subjected to a temperature rise. Characteristics displayed on the thermograms can be used to monitor samples in comparison to controls and examine if changes have occurred in a sample that may affect stability. Results provide onset temperature and peak maxima of any endothermic or exothermic events.

The Apparatus used is a Differential Scanning Calorimeter capable of heating rates of up to 20°C/minute, with the capability to automatically record the differential heat flow between the sample and the reference materials with the required precision and accuracy. It should have an upper temperature capability of at least 500°C. Cast-cured materials should be fully cured. Powders can be used as such or consolidated to a density similar to that proposed for a final application.

Sample crucibles must be manufactured from material that is chemically inert to the material under test and have high thermal conductivity. Typical materials of construction are aluminum and platinum. Purge gas supply (usually nitrogen, argon or helium) and an associated flow controller.

c. Information Requirements for Assessment: The weight loss (or gain) of is determined.

d. Typical Results: Not Applicable

e. Repeatability and Reproducibility: Routinely reproducible.

3. NATIONAL REFERENCES:

(1) NATO STANAG 4515, Thermal Characterization of Explosives.

(2) ASTM E1641-99, Standard Test Method for Decomposition Kinetics by Thermogravimetry, Philadelphia: American Society for Testing and Materials, 2000.

(3) MIL-STD-1751A issued on 11 December 2001, Method 1072.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: One-Liter Cook-Off Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: This test is used to determine the critical self-heating temperature associated with melt-cast energetic materials and the severity of the unconfined, thermal decomposition reaction. Energetic materials decompose exothermically when exposed to elevated temperature for prolonged times. When this process produces heat faster than it is dissipated, the material will self-heat and explode. The accuracy of a T_c prediction for larger geometry made by using the Frank-Kamenetskii equation along with data generated by small-scale tests can be determined by conducting the 1-liter test.

The apparatus consists of a 1-liter, Pyrex, round-bottom flask and a disposable oven. The flask equipped with a thermocouple bundle inserted into the center of the sample and extending to the bottom of the flask. The neck of the flask protrudes through a fitted circular opening in the top of the oven. The sample either is cast directly into the flask or may be loaded in chunk or powder form. The sample is heated rapidly (minimum 10 °C/min) to a temperature that is 10 to 20 °C above its melting point and held for approximately 5 hours.

c. Information Requirements for Assessment: Energy of activation (E_a) and pre-exponential (Z) of the material determined (e.g., through variable heating DSC) and the critical temperature (T_c) for larger scale geometry predicted.

d. Typical Results:

Explosive	Self-Heating Temperature (°C)	Final Event Temperature (°C)	Severity of Final Reaction
Composition B	143-144	199-206	Partial Detonation
Octol (65/35)	142	167	Burn
RDX Classes 1/5 (80/20) Particulate $\rho = 1.2$ g/cm^3	154	208	Partial Detonation

e. Repeatability and Reproducibility: Routinely reproducible.

3. NATIONAL REFERENCES:

(1) McKenney, R.L., Jr. and Krawietz, T.R., One-Liter Test: A Mid-Scale Safety Characterization Test for Melt-Castable Explosives, AFRL-MN-EG-TR-1999-7049, Air Force Research Laboratory, Eglin AFB, FL, July 1999.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1075.

US/202.01.022

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics

2. TEST TITLE: Modified Vacuum Stability Test

a. Type of Test: Hazard Assessment/Stability.

b. Description: The standard vacuum thermal stability (VTS) test, developed in the early 1900s, measures the chemical stability of an explosive at an elevated temperature under an initial vacuum for a specific time. Generally, a weighed sample of explosive (5.00 ± 0.05 g) is sealed in an all-glass apparatus designed to measure gas pressure by the mercury manometer method. The system is evacuated and that portion containing the sample is heated at 100°C for 48 hours. The pressure generated by the decomposition gases is measured after the entire system has equilibrated to ambient temperature. The problem with this system include (1) the toxic characteristics of mercury and the fragility of the all-glass system, (2) condensation of water due to the experimental setup, (3) potential inaccuracies associated with corrections and (4) time/labor requirements associated with the test.

In the Modified Vacuum Thermal Stability (MVTS) Test, the energetic material is contained in a glass tube that is inserted in a calibrated, stainless steel reaction vessel assembly that is connected to a pressure sensor. The entire system is heated in an oven and the real-time pressure/time data are recorded by a computerized data acquisition system. This provides a continuous pressure/time record for the specific time period of the test. From this the total volume of gas generated at STP can be calculated. Gas chromatographic analysis provides the identity of the components and their individual volumes. This allows one to distinguish between those gases associated with thermal decomposition and those resulting from the evolution of adsorbed water/solvent.

c. Information Requirements for Assessment: Data required for processing and testing.

d. Typical Results: Results are presented in psig or as a pressure ratio (Pi/Pa) where Pi is the driving pressure and Pa is the local ambient pressure. Ethyl or propylnitrate are utilized as calibration standards.

e. Repeatability and Reproducibility: Results are repeatable within 5%.

3. NATIONAL REFERENCES:

(1) AFRPL-TR-66-294.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1063.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Liquid Propellants

2. TEST TITLE: U-Tube Adiabatic Compression Sensitivity

   a. Type of Test: Hazard Assessment/Sensitivity.

   b. Description: The U-tube adiabatic compression tester consists of a U-shaped tube closed at one end and containing a slug of test liquid in the curvature of the tube. The test is conducted by suddenly pressurizing the open end of the tube, which forces the liquid slug violently into the closed end. Peak pressures many times greater than the driving pressure are attained in the closed end of the tube. The rate of pressurization is fast enough to provide adiabatic compression.

   c. Information Requirements for Assessment: Data required for processing and testing

   d. Typical Results: Results are presented in psig or as a pressure ratio (Pi/Pa) where Pi is the driving pressure and Pa is the local ambient pressure. Ethyl or propyl nitrate are utilized as calibration standards.

   e. Repeatability and Reproducibility: Results are repeatable within 5%.

3. NATIONAL REFERENCES:

   (1) AFRPL-TR-66-294.

US/203.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellant, and Pyrotechnics

2. TEST TITLE: Compatibility with Materials Test

a. Type of Test: Hazard Assessment/Sensitivity.

b. Description: Used for determine the reactivity of explosives in contact with materials used in production and in munition designs.

(1) High Explosives: The Vacuum thermal stability test AOP-7 Registry No: US/202.01.001 is used. Normally, the explosive and the materials are subjected to 100°C for 48 hours. For a 5 gm sample of explosive, no more than 2.0 ml/gm/48 hours is allowed. For materials like HNS, the test is performed at higher temperatures.

(2) Propellants: Most frequently the Taliani, Vacuum Stability, or Differential Thermal Analysis (DTA) is used. Generally the AOP-7 Registry No: US/202.01.001 test is used.

(3) Pyrotechnic Compositions: Compatibility tests are designed around the materials and potential contaminants. In general, the vacuum thermal stability tests AOP-7 Registry No: US/202.01.001 is used.

c. Information Requirements for Assessment: Reactivity of explosives with materials that may be in close proximity.

d. Typical Results: No more than 2.0 ml/gm/48 hours is allowed.

e. Repeatability and Reproducibility: Normally repeatable results are obtained.

3. NATIONAL REFERENCES:

(1) MIL-STD-650, 31 May 1973.
(2) NAVORD OD 44811, pp. 1-14, 1 January 1972.
(3) MIL-STD-286B, "Military Standard, Propellant, Solid, Sampling, Examination and Testing", 1 December 1967.
(4) MIL-STD-2100 (OS), "Military Standard, Propellant, Solid, Characterization of", 30 March 1979.
(5) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).
(6) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: High Explosives, Propellants, and Pyrotechnics.

2. TEST TITLE: Chemical Reactivity Test

a. Type of Test: Hazard Assessment/ Thermal Stability (Constant Temperature).

b. Description: This test evaluates the stability of an explosive in a fixed volume at an elevated temperature and under vacuum. A gas chromatograph is used to measure the volume and composition of gases evolved. A temperature control unit heats and circulates the heating fluid. Temperature of the bath is maintained up to 120°C to within 1°C.

The test is normally run on a powder unless thee test material is a paste or cast/cure PBX. The sample size for the material being tested is 0.250 g. For compatibility tests, both ingredients are weighed to 0.250 g and then blended together. In general, duplicate samples are prepared and run for all materials being tested.

Samples are placed in the loop assembly and the loop is evacuated with vacuum until all outgassing stops. The gas chromatograph is calibrated with a calibration gas containing a small percentage of each of the gases being analyzed. In addition, PBX-9404 is routinely run as the standard explosive composition.

c. Information Requirements for Assessment: A material is considered thermally unstable, if ignition or an explosion occurs.

d. Typical Results:

Explosive Material	N_2	O_2	CO	NO	CO_2	N_2O	Total
PETN (powder)	0.046	0	0.038	0.080	0.131	0.014	0.309
PETN (pellet)	0.013	0	0.011	0.028	0.069	0.005	0.126
Comp B (powder)	0.011	0	0	0.024	0.039	0.018	0.092
Comp B (pellet)	0.014	0	0	0.021	0.018	0.020	0.073
PBX-9404 (powder)	0.020	0	0.039	0.244	0.137	0.023	0.463
PBX-9404 (pellet)	0.056	0	0.049	0.171	0.198	0.039	0.513

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(1) Prokosch, David W., et al., *Chemical Reactivity Test for Thermal Stability*, UCRL-JC-117941, July 1994.

(2) MIL-STD-1751A issued on 11 December 2001, Method 1062.

US/204.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Environmental Impact of Firings

a. Type of Test: Hazard Assessment/Toxicity.

b. Description: An environmental impact assessment based on the products in the expanded after plume zone is prepared. Effects at sea level and intermediate or high altitudes, if applicable, are considered. Noise and electromagnetic (radar) attenuation are not factors in this assessment. Primary and secondary smoke and handling toxicity, if applicable, are considered qualitatively.

c. Information Requirements for Assessment: This test determines the impact on the environment of firing the propellant.

d. Typical Results: Varies

e. Repeatability and Reproducibility: Varies

3. NATIONAL REFERENCES:

(1) MIL-STD-2100 (OS), "Military Standard: Propellants, Solid, Characterization of", 30 March 1979.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Theoretical Performance Calculations

   a. Type of Test: Performance Assessment

   b. Description: Computer programs to calculate thermodynamic properties and performance characteristics are used. Among the programs used are the NWC Thermochemical Program, PEP code, Blake code, and the NASA-Lewis code. The parameters computed are flame temperature, chemical compositions enthalpy, entropy, specific heat ratio and molecular weight in both the combustion chambers and exhaust, frozen and shifting equilibrium, specific impulse, boost velocities, thrust coefficient, characteristic velocity, and exhaust gas velocity.

   c. Information Requirements for Assessment:

   The data are used to characterize the propellant or pyrotechnic system and in the prediction of the performance.

   d. Typical Results: N/A

   e. Repeatability and Reproducibility: N/A

3. NATIONAL REFERENCES:

(1) Cruise, D. R., "Theoretical Computations of Equilibrium Compositions, Thermodynamics Properties, and Performance Characteristics of Propellant Systems", NWC TP-6037, Naval Weapons Center, China Lake, CA, April 1979.

(2) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979.

US/302.01.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge High Explosives and Booster Explosives

2. TEST TITLE: Detonation Velocity

   a. Type of Test: Performance Assessment - Mandatory for High Explosives

   b. Description: The detonation velocity of an explosive is affected by its degree of confinement, diameter, and loading density. If confined only slightly (cardboard or glass tube), the explosive detonates at a lower rate than if heavily confined. Each explosive has a characteristic maximum rate of detonation for D^{∞} (infinite diameter) and a given density. There are many acceptable methods for determining the detonation velocity of an explosive. The references given below list some of the methods used.

   c. Information Requirements for Assessment:

   This test provides background information for qualification of high explosives.

   d. Typical Results: N/A

   e. Repeatability and Reproducibility: Depends on the method used.

3. NATIONAL REFERENCES:

(1). NAVORD OD 44811, p 1-15, 1 January 1972.

(2) Campbell, A. W., et al, "Precision Measurement of Detonation Velocities in Liquid and Solid Explosives," Rev. Sci. Instr., pgs. 27, 567 (1956).

(3) Akst, J. and Hershkowitz, J., "Explosive Performance Modifications by Co-solidification of Ammonium Nitrate with Fuel", PATR 4987, Oct 1976.

(4) MIL-STD-1751A issued on 11 December 2001, Method 1101.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Liquid Propellants

2. TEST TITLE: Detonation Velocity - Liquid Explosives

   a. Type of Test: Performance Assessment - Mandatory for Liquid explosives

   b. Description: The procedure for measuring the detonation velocity of liquids and vapor-air mixtures is similar to that described for solid high explosives described in AOP-7 Registry Nos. US/302.01.001. A detonation tube is used for vapor-air mixtures as described in US/302.03.001.

   c. Information Requirements for Assessment: Steady state detonation velocity.

   d. Typical Results: N/A

   e. Repeatability and Reproducibility: N/A

3. NATIONAL REFERENCES:

   (1) MIL-STD-1751A issued on 11 December 2001, Method 1131

US/302.01.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Main Charge and Booster High Explosives

2. TEST TITLE: Critical Diameter

a. Type of Test: Performance Assessment

b. Description: There is no well-defined test for critical diameter that is applicable to all explosives at all diameters, d_c; however, there are three main techniques used for measuring the d_c.

(1) A conical charge is initiated at the large end and the detonation is followed optically or electronically until it fails. For the Electronic method, an embedded copper wire is placed in parallel to a Nichrome wire in the center of the explosive. A constant current source of about 200 mA is connected between the copper and the Nichrome wires. The detonation front, which has a low resistance, completes the circuit. An oscilloscope reads the potential difference between the copper and the nichrome wire. Since the resistance per unit length of the nichrome wire is known, from Ohm's law the resistance of the nichrome wire remaining will tell where the detonation failed.

(2) A stepped cylindrical charge is initiated at the large end and progress of the detonation front is followed through the various sections. The length of each step or diameter must be about 4d or greater to allow over-boostering to fade out and sufficient length of steady state propagation to measure detonation velocity. The camera cannot view an extremely long charge and still give a record that can yield an accurate value. Hence, the step cylinder, like the cone is best suited for obtaining an approximate value of the critical diameter. Both of these methods should be followed by more precise measurements on cylindrical charges.

(3) A series of cylindrical charges of different diameters and the smear camera records are used to map the detonation velocity versus the diameter relationship. By keeping the differences between the diameters small, the average of the smallest diameter charge that gives a steady-state detonation and the largest charge that does not, will give a reasonably accurate value of the failure diameter. The first two methods will tend to give estimates of the critical diameter that are smaller than the true value.

c. Information Requirements for Assessment: Not Applicable

d. Typical Results: Material dependant.

e. Repeatability and Reproducibility: Good if quality charges are used.

3. NATIONAL REFERENCES:

(1) MIL-STD-1751A issued on 11 December 2001, Method 1091.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Booster High Explosives

2. TEST TITLE: Very Small Critical Diameter

   b. Type of Test: Performance Assessment.

   c. Description: This test defines the threshold d_c for the propagation of a steady state detonation. The procedure is used for injection-loaded explosives with a d_c in the order of 0.010 inch (0.025 cm) or less. The apparatus consists of a base with a variable diameter groove and a cover plate. The groove is filled with the test explosive making sure that there are no gaps, voids, or inclusions. If the explosive is curable, the uncured explosive is loaded in the test hardware and fully cured before testing. The cover plate is mounted on the base plate containing the test sample with an adhesive. A mild detonating fuze (MDF) and shock absorbing tubing is installed in the cover plate making sure that the MDF is in contact with the test explosive. After firing, the distance from the reference end of the aluminum cover plate to the end of the detonation imprint is measured to obtain the critical diameter.

   d. Information Requirements for Assessment: N/A

   d. Typical Results: Material dependant.

   e. Repeatability and Reproducibility: Good if quality charges are used.

3. NATIONAL REFERENCES:

   (1) MIL-STD-1751A issued on 11 December 2001, Method 1092.

US/302.02.001

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Strand Burning Rate (Linear Burning Rate)

   a. Type of Test: Performance Assessment.

   b. Description: Strands 15-20 cm long and 0.3-1 cm in diameter are coated with an inhibitor compound to assure vertical burning. Each strand is placed in a jig equipped with fuse wires. Strands are conditioned at -54°C (65°F), 25°C (77°F), and 74°C (165°F) before testing. Test pressures are 500, 1000, 2000, 3000, 4000, 5000 psi. A Crawford type stainless steel Strand Burning Rate Bomb with a volume of about one liter is used. It must have an 0-ring closure and a working pressure of at least 5000 psi. Each unit is hydrostatically tested for 30 minutes at 10,000 psi, is equipped with electrical wiring contacts for ignition and timing, and has an opening for pressurizing and exhausting gases. Temperature conditioning chambers with ranges from -65°C (-85°F) to +99°C (210°F), controllable to ±0.5°C (± 1°F) must be available.

   c. Information Requirements for Assessment: Data used to calculate motor performance and for quality assurance.

   d. Typical Results: N/A

   e. Repeatability and Reproducibility: Good repeatability and reproducibility over the most of its range. The test is difficult to use when the burning rate exceeds 7.5 cm (3") per second.

3. NATIONAL REFERENCES:

   (1) MIL-STD-286B, Method 803.1.1 of 28 August 1991.

   (2) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Closed Bomb Burning Rate

a. Type of Test: Performance Assessment.

b. Description: The closed bomb is a constant- volume, high pressure combustion chamber used to determine the linear regression rate of burning propellant. The bomb volume is usually 100-300 cm. The propellant is loaded in the bomb. The igniter is placed in a small bag with the propellant. An electric match is used to initiate combustion. A piezoelectric pressure transducer measures the pressure rise.

c. Information Requirements for Assessment: This test determines the quickness and force of a propellant.

d. Typical Results: To be supplied

e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

(1) MIL-STD-286B, "Military Standard: Propellant, Solid, Sampling, Examination and Testing", Method 801.1 of 28 August 1991.

(2). Round Robin Results of the Closed Bomb and Strand Burner, CPIA Publication 361, July, 1982.

US/302.02.003

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Burning Characteristics (Configurational)

   a. Type of Test: Performance Assessment.

   b. Description: The test apparatus, procedure, results and criteria all vary according to the end-item requirements of the pyrotechnic system. Specific criteria are established in terms of end-item performance requirements. These criteria are normally examined in prototype hardware similar to that envisioned in the final design. To this degree, some performance characteristics are examined and pyrotechnic compositions are either modified, accepted, or rejected.

   c. Information Requirements for Assessment: Information required to establish final design and specifications.

   d. Typical Results: Typical results could be reported in burning times, burning rates, electromagnetic radiation intensity versus burning time, spectral outputs, visual color, obscuration or screening times, or other results that would be specifically related to the pyrotechnic end-item's characteristics required.

   e. Repeatability and Reproducibility: Normally repeatable.

3. NATIONAL REFERENCES:

(1) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

(2) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Burning Characteristics (Loose)

   a. Type of Test: Performance & Hazard Assessment.

   b. Description: The loose composition is ignited in containers, mixing trays, etc., as it is handled in the manufacturing process. Results are observed.

   c. Information Requirements for Assessment: Data is required for handling/processing/storing of the composition.

   d. Typical Results: Depending on the composition, it may (1) deflagrate, (2) burn as virtually a solid state reaction leaving a solid residue, (3) ignite and eject out of a container as a flaming mass or (4) flame in place.

   e. Repeatability and Reproducibility: Normally repeatable if ignited the same way each time.

3. NATIONAL REFERENCES:

(1) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

(2) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Fuel Air High Explosives

2. TEST TITLE: Detonability Test for Fuel-Air Explosives

a. Type of Test: Performance & Hazard Assessment.

b. Description: A tube opened at both ends is used. It is fitted with hoops at each end for sealing the tube with plastic a film. The tube is 60 cm in diameter and 180 cm long. For liquid, a spray manifold is installed along the top. For particulates, cups are placed along the bottom of the tube. The cups are connected to an air supply that ejects the fuel from the cups. The thin plastic (Mylar) film is placed over both ends and an explosive charge is placed at one end. Pressure transducers and foil switches are located along the sides of the tube to measure the pressure and velocity of the detonation wave. Detonability is determined by varying the fuel-air ratio by changing the amount of fuel dispersed in the tube, or by changing the explosive initiator size. The fuel-air ratio is changed both up and down until detonation failures are obtained. If a detonation is not obtained with a stoichiometric mixture, the size of the initiating charge is increased until a detonation occurs or the blast from the initiating charge would mask the pressure pulse from the fuel-air detonation. The typical starting initiator charge size is 3 gm.

c. Information Requirements for Assessment: The data recorded for each test are generally as follows: fuel type; fuel quantity; concentration; spray or mix time; ambient temperature, pressure, and humidity; temperature drop caused by evaporation of fuel (optional); type and size of initiator; data records showing closure time for detonation velocity gauges; and data records of the pressure transducer outputs. The data records are assessed to determine the detonation velocity and detonation pressure.

d. Typical Results: If a detonation is not obtained, the fuel is not considered a practical fuel for FAE applications. If a detonation is obtained, the testing is continued with decreased initiator size and/or off-stoichiometric concentrations until the detonability limits are established as a function of both fuel-air ratio and initiator energy.

e. Repeatability and Reproducibility: Good

3. NATIONAL REFERENCES:

(4) NAVORD OD 44811, p D-1 to D-13, 1 January 1972.

(5) MIL-STD-1751A issued on 11 December 2001, Method 1131.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Propellants

2. TEST TITLE: Subscale Motor Test

   a. Type of Test: Performance Assessment.

   b. Description: Subscale motors are fitted with nozzles sized to operate at designated average pressures (usually 1000, 2000, and 4000 psi), conditioned at the temperatures of either -54^{o}C, 25^{o}C, and +74^{o}C (-65^{o}F, 77^{o}F, and 165^{o}F, respectively), or -40^{o}C, 25^{o}C, and 60^{o}C (-40^{o}F, 77^{o}F, and 140^{o}F, respectively). They are examined radiographically for cracks, voids, etc., and only those without defects are statically fired.

   c. Information Requirements for Assessment: These tests are used to obtain more precise values for the burning rate of the propellant than can be obtained from slab motor or strand burning tests, and for the determination of the dependence of the burning rate on temperature.

   d. Typical Results: To be supplied

   e. Repeatability and Reproducibility: To be supplied

3. NATIONAL REFERENCES:

   (1) MIL-STD-2100 (OS), "Military Standard: Propellant, Solid, Characterization of", 30 March 1979.

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Hot/Cold Ignition/Burning Tests

   a. Type of Test: Performance Assessment.

   b. Description: The design configuration is used. The pyrotechnic units are brought to the desired temperatures. The ignition and burning characteristics are noted.

   c. Information Requirements for Assessment: The unit functions safely and within the performance specifications for the design.

   d. Typical Results: Under colder conditions pyrotechnics generally are more difficult to ignite and typically burn slower. Under hotter conditions pyrotechnics will generally ignite more readily and burn faster. In some extremes cases, there are ignition failures under cold conditions and deflagrations under hot conditions.

   e. Repeatability and Reproducibility: Normally reproducible and repeatable.

3. NATIONAL REFERENCES:

(1) McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

(2) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

TEST INFORMATION SHEET

1. TYPE OF EXPLOSIVE: Pyrotechnics

2. TEST TITLE: Moisture Content of Composition vs. Performance

   a. Type of Test: Performance Assessment.

   b. Description: The moisture content of the composition will be determined using analytical techniques accurate for the chemicals involved. The effect of the moisture on the performance characteristics of the composition in the test vehicle will be determined. The allowable range of moisture content can then be extrapolated from the maximum and/or minimum permissible for end-item performance requirements.

   c. Information Requirements for Assessment: Information required to determine allowable levels of moisture in pyrotechnic compositions.

   d. Typical Results: Reported as "percent water".

   e. Repeatability and Reproducibility: Normally repeatable.

3. NATIONAL REFERENCES:

(1). McLain, Joseph H., Pyrotechnics, The Franklin Institute Press, Philadelphia, PA (1980).

(2) Ellern, Herbert, Military and Civilian Pyrotechnics, Chemical Publishing Co., Inc., New York, NY (1968).

10.7.13 QUALIFICATION PROCEDURES OF BELGIUM

To be provided