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Surveillance and in-service proof

UN SaferGuard
Securing ammunition, protecting lives

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Warning

The International Ammunition Technical Guidelines (IATG) are subject to regular review and revision. This document is current with effect from the date shown on the cover page. To verify its status, users should consult www.un.org/disarmament/ammunition

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Foreword

Ageing, unstable and excess conventional ammunition stockpiles pose the dual risks of **accidental explosions at munition sites** and **diversion to illicit markets**.

The humanitarian impact of ammunition-storage-area explosions, particularly in populated areas, has resulted in death, injury, environmental damage, displacement and disruption of livelihoods in over 100 countries. Accidental ammunition warehouse detonations count among the heaviest explosions ever recorded.

Diversion from ammunition stockpiles has fuelled armed conflict, terrorism, organized crime and violence, and contributes to the manufacture of improvised explosive devices. Much of the ammunition circulating among armed non-State actors has been illicitly diverted from government forces.[1] In recognition of these dual threats of explosion and diversion, the General Assembly requested the United Nations to develop **guidelines for adequate ammunition management**.[2] Finalized in 2011, the International Ammunition Technical Guidelines (IATG) provide voluntary, practical, modular guidance to support national authorities (and other stakeholders) in safely and securely managing conventional ammunition stockpiles. The UN SaferGuard Programme was simultaneously established as the corresponding knowledge-management platform to oversee and disseminate the IATG.

The IATG also ensure that the United Nations entities consistently deliver high-quality advice and support – from mine action to counter-terrorism, from child protection to disarmament, from crime reduction to development.

The IATG consist of 12 volumes that provide practical guidance for 'through-life management' approach to ammunition management. The IATG can be applied at the guidelines' **basic, intermediate, or advanced levels**, making the IATG relevant for all situations by taking into account the diversity in capacities and resources available. Interested States and other stakeholders can **utilize the IATG for the development of national standards and standing operating procedures**.

The IATG are reviewed and updated at a minimum every five years, to reflect evolving ammunition stockpile-management norms and practices, and to incorporate changes due to changing international regulations and requirements. The review is undertaken by the UN SaferGuard Technical Review Board composed of national technical experts with the support of a corresponding Strategic Coordination Group comprised of expert organizations applying the IATG in practice.

The latest version of each IATG module can be found at www.un.org/disarmament/ammunition.

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[1] S/2008/258.

[2] See also the urgent need to address poorly-maintained stockpiles as formulated by the United Nations Secretary-General in his Agenda for Disarmament, *Securing Our Common Future* (2018).

Introduction

Surveillance of ammunition is the gathering and assessment of all data on an item of ammunition to determine its condition throughout its life. It includes physical inspection, proof, chemical testing and taking into account reports on its use, ie its accuracy, safety, any accidents or incidents, its age, components and the conditions and climates in which it has been used or stored.

It is undertaken to ensure that the ammunition continues to meet the required quality standards throughout its life. Quality, from this perspective, includes the performance of ammunition during use and its safety and stability during storage and handling. The chemical, electrical and mechanical properties of ammunition change and degrade with time, leading to a finite serviceable life for each munition. The accurate assessment of munition life is of paramount importance in terms of both safety and cost effectiveness.

All ammunition and explosives should be formally classified as to their condition, which requires a surveillance and in-service proof system. The ammunition is then allocated a condition code[3], which defines the degree of serviceability of the ammunition and any constraints imposed on its use.

Surveillance is the systematic method of evaluating the properties, characteristics, and performance capabilities of ammunition throughout its life cycle. It is used to assess the reliability, safety, and operational effectiveness of stocks. Proof is the functional testing or firing of ammunition and explosives to gather data on performance and reliability, ultimately to ensure safety and stability in storage and intended use.

Effective surveillance and proof of ammunition requires a systems approach that will optimise the useful life of ammunition, whilst also significantly improving safety in storage and use towards the end of the life of the ammunition. Such an approach will ensure that optimal return is gained for the significant financial investment that the ammunition represents.

[3] See IATG 03.10 and 07.20.

Surveillance and in-service proof

1 Scope

This IATG module introduces and explains the concept and requirements for a technical surveillance and in-service proof programme to support the safe, effective and efficient storage of conventional ammunition.

2 Normative references

A list of normative references is given in Annex A. These documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

A further list of informative references is given in Annex B in the form of a bibliography, which lists documents that contain additional information related to the contents of this IATG module. .

3 Terms and definitions

For the purposes of this module the following terms and definitions, as well as the more comprehensive list given in IATG 01.40 *Glossary of terms, definitions and abbreviations,* shall apply.

The term 'proof' refers to *the functional testing or firing of ammunition and explosives to ensure safety and stability in storage and intended use*.[4]

The term 'service life' (or alternatively 'shelf life') refers to *the period for which an explosive or device can be stored or maintained under specific conditions before use or disposal without becoming unsafe or failing to meet specified performance criteria*.

The term 'stability' refers to *the physical and chemical characteristics of ammunition and explosives that impact on their safety in storage, transport and use*.

The term 'storage life' refers to *the time for which an explosive item in specified storage may be expected to remain safe and serviceable within the envelope of service life*.

The term 'surveillance' refers to *a systematic method of evaluating the properties, characteristics and performance capabilities of ammunition throughout its life cycle in order to assess the reliability, safety and operational effectiveness of stocks and to provide data in support of life reassessment*. *The constant review of accumulating test results will ensure that the overall quality remains acceptable. The term is also applied to the continuing examination of the stores themselves.*

Within ammunition surveillance and proof, the 'chemical shelf life' determines the maximum period in which a specific ammunition nature remains chemically stable and hence safe for storage and logistical handling under the given storage conditions, whereas the 'operational shelf life' determines the maximum period in which the same ammunition nature remains safe for use and achieves the specified accuracy, performance and reliability requirements. The chemical shelf life normally significantly exceeds the operational shelf life because degradation processes other than chemical ageing may constitute the limiting factor (e.g. physical integrity of solid rocket motors, micro-fissures in propellant grains, corrosion in fuzing systems). The assessment of chemical shelf life is essentially conducted with laboratory analysis of the contained explosive components while the operational shelf life is assessed with physical inspection, live firing and ballistic testing.

[4] In-service proof is really a particular type of surveillance, but it is usually referred to as a separate issue as it requires the live firing of munitions rather than the other technical inspection and chemical analysis components of surveillance.

Example: A tested lot of small arms ammunition may show satisfactory propellant stability and sufficient stabiliser content but may still be banned from operational use due to abnormally high weapon chamber pressures during in-service proof firing tests.

When ammunition producers provide an expiry date, they normally refer to the operational shelf life within the warranty period and under ideal storage condition

In all modules of the International Ammunition Technical Guidelines, the words 'shall', 'should', 'may' and 'can' are used to express provisions in accordance with their usage in ISO standards.

a) **'shall' indicates a requirement**: It is used to indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

b) **'should' indicates a recommendation**: It is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form, 'should not') a certain possibility or course of action is deprecated but not prohibited.

c) **'may' indicates permission**: It is used to indicate a course of action permissible within the limits of the document.

d) **'can' indicates possibility and capability**: It is used for statements of possibility and capability, whether material, physical or casual.

4 Rationale for surveillance and in-service proof

The safety and stability of ammunition and explosives in storage can only be established by a comprehensive 'ammunition surveillance' system that uses a methodology of both physical inspection by trained personnel and chemical analysis. The surveillance is carried out systematically by evaluating the characteristics and properties the ammunition type possesses and measuring how the ammunition performs throughout its entire life cycle. This will in turn allow assessment of the safety, reliability and operational effectiveness of the ammunition. Only then can safety in storage be properly assessed. The use of 'ammunition surveillance' can then be used to extend 'shelf life' if appropriate. Shelf life extension if appropriate may provide significant financial savings as there will no longer be a requirement to procure new ammunition.

The introduction of a surveillance and in-service proof system mid way through the service life of a munition should always be considered, as results from such a system may enable an extension of the initial in-service life. The life cycle costs of the munition would therefore be reduced with sub-sequential financial benefits as procurement of new stock could then be delayed.

Ammunition is subjected to technical surveillance and in-service proof for a wide range of reasons. It is a vitally important component of responsible ammunition stockpile management and is the only way that the safety and stability of ammunition stockpiles can be properly addressed. Major reasons include:

a) to ensure the safety and stability of ammunition during storage, handling and transportation;

b) to ensure the safety, reliability and performance of ammunition during use;

c) the requirement to predict, and therefore prevent, ammunition failures that are inherent in their design or are the result of ageing;

d) to monitor the environmental conditions the ammunition has been stored in;

e) to ensure that the first point of detection of catastrophic failures is not the user;

f) to predict failure and degraded performance, thereby supporting effective ammunition procurement cycles;

g) to predict future performance and service life and limitations;

h) to extend the in-service life of ammunition beyond that which would be possible without such a system; and

i) to identify and monitor critical characteristics of the ammunition that change with age and exposure to the environment.

States should therefore allocate the same level of priority to the development and implementation of an effective surveillance and proof system programme as they do, for example, to the physical protection of ammunition stocks.

5 Requirements for effective surveillance and in-service proof

An effective system of surveillance and in-service proof requires an integrated range of capabilities and mechanisms to ensure overall system efficiency and effectiveness. These are:

a) an effective ammunition management plan;

b) trained, qualified and experienced technical staff;

c) a capable explosives laboratory;

d) effective sampling mechanisms; and

e) an efficient ammunition accounting system.

Once these capabilities and mechanisms are combined with knowledge of the likely failure mechanisms of an item of ammunition, then decisions may be taken on the extension of the in-service life of a munition, or the need for early use at training, demilitarization or destruction.

6 Responsibilities for in-service proof and surveillance (LEVEL 2)

The appropriate national technical authority should be responsible for:

a) the development and promulgation of an in-service proof and surveillance plan for each munition type in the national inventory;[5]

b) ensuring that the plan is carried out;

c) the analysis of results and tests;

d) ensuring that ammunition is allocated the appropriate condition code;[6]

e) the rapid identification of stocks that are unsafe to either use or store; and

f) ensuring that the disposal of life-expired stocks takes place within an expedient time period following in-service proof and surveillance.

g) The surveillance and proof tasks can be mandated to different entities to carry out specific tasks at different stages of TLM. The overview of tasks linked to the phases of TLM can be found in *01.35 Organizational Capabilities, chapter 3.5*

[5] This could be included in the Ammunition Management Policy Statement (AMPS), or equivalent document. See IATG 03.10 *Inventory management*, Clause 6.2.4 and Annex C for further details of AMPS.

[6] See IATG 03.10 *Inventory management*, Clause 18 for further details of Condition Codes.

7 Ageing and degradation of ammunition

For most ammunition, one or two of the degradation mechanisms will limit its available life. Some of the more common failure mechanisms are (but are not limited to):

a) energetic materials:
   - de-bonding between the material and inert surfaces;
   - stabiliser depletion within the energetic material, (see Clauses 7.3 and 12);
   - migration of compounds within the energetic material;
   - cracking of brittle materials; and/or
   - compatibility problems.

b) electronics:
   - component ageing; and/or
   - component shock damage.

c) structure:
   - mechanical damage (impact, corrosion);
   - vibration; and/or
   - failure of seals.

In addition to the physical damage caused by shocks and vibration, munitions can degrade chemically. The energetic items that cause the explosive effect are invariably of organic chemical composition and, in common with all other chemical compositions, breakdown, migrate or change over time. This change is normally accelerated with increased temperatures. Degradation will also be hastened by:

a) large variations in temperature (diurnal cycling, e.g. night-to-day, cycling from hot to cold);

b) low temperatures;

c) high or low humidity;

d) vibration;

e) shock; and/or

f) pressure.

The conditions in that a munition is stored, maintained and transported during its normal in-service life will eventually have an impact on the munition and a critical failure mode will be reached, which will be the service-life limiting factor.

7.1 Design evaluation

Potential life-limiting features of a munition may be predicted during the design evaluation stage of its development. Fatigue and corrosion of components parts can be predicted, and small-scale laboratory testing of energetic materials should be used to determine baseline properties that will affect the in-service life. This should usually be undertaken by the manufacturer, who should provide this information to the appropriate national technical authority. This information should also be supplied as a standard requirement to the national technical authority of a country to which ammunition is exported.

7.2 Baseline data

Baseline data should be obtained from research, studies and tests to estimate potential failure modes of a munition. This data is very useful for comparative purposes during a subsequent in-service proof and surveillance system. Data may be obtained from:

a) manufacturer's test results;

b) manufacturer's proof results;

c) explosive safety assessment data;

d) accelerated aging tests;

e) component fatigue tests;

f) measurement against known norms, such as propellant master standards;

g) test results from other nations, including proof and test results; accident reports; defect and other incident reports;

h) explosive hazard data sheets; and

i) compatibility data.

Without access to much of this data subsequent in-service proof and surveillance cannot be optimised, which may reduce the in-service life of the munition as safety during storage and use cannot be as efficiently assessed.

7.3 Climatic impact on the degradation of explosives

The effects of weather, hot temperatures, direct solar radiation, daily temperature changes (diurnal cycling) and high humidity may rapidly degrade the performance and safety of explosives. Ammunition is designed for use under stated climatic conditions, and its service life will be significantly reduced if it is stored under climatic conditions that it was not designed for. In some cases, the ammunition may rapidly become unserviceable and dangerous to use.

In the Middle East recorded temperatures have ranged from -1^{0}C to +31^{0}C in the winter months and from +22^{0}C to +51^{0}C in the summer months. This means that the ammunition can be exposed to daily diurnal cycles of up to +32^{0}C in the winter months and +29^{0}C in the summer months. These are usually considered as extreme ranges for ammunition, and a reduction in service life shall be expected. Yet, these temperatures are ambient air temperatures and do not take into account the effects of direct solar radiation on ammunition or on packaged ammunition.

Tests have shown that when fully exposed to the sun that the temperature on the external surface of the ammunition can be as much as 50^{0}C higher than the ambient air temperature. This means that ammunition could theoretically reach external surface temperatures of 101^{0}C in the Middle East. It should be noted that the melting point of TNT based explosives is approximately 80^{0}C; the very real danger of using TNT ammunition at this temperature cannot be overstated.

An example of the impact that such storage conditions have on ammunition is the chemical deterioration of propellant. During prolonged periods of storage, the rate of chemical deterioration of propellant is at least doubled[7] for every 10°C rise in temperature above 30°C. Most propellants, dependent on design, have a shelf-life of at least 15 to 40 years when stored at a constant 30°C, and will last much longer in temperate climates. In high heat environments, the stabiliser is depleted far quicker and the probability of spontaneous combustion due to autocatalytic ignition becomes much higher. It has to be emphasized, that surveillance of propellants according to AOP-48 does not provide data on the operational shelf life. The result of a surveillance test on a propellant following AOP-48 (stabilizer depletion) or STANAG 4582 (heat flow calorimetry) provides guidance, if criteria are met for a safe ten-years-interval for next inspection or not.

Propellant lots shall not be given a predicted overall chemical shelf life based on one single testing campaign. Instead, the residual stabiliser content and prevailing storage temperature shall be used to determine the safe time interval until the next surveillance campaign for this specific lot must occur. Higher storage temperatures shall invariably lead to a shorter time interval in order to prevent accidental auto-ignition between scheduled surveillance campaigns.

Where no initial safe interval is available, the stabilizer depletion rate for a specific propellant should be established with a set of two testing campaigns within a limited time period and then corrected to the prevailing storage conditions.

There is some evidence that suggests that the reduction in shelf life versus temperature is as shown in Table 1. There are two columns with different assumptions on the acceleration of aging induced by increased storage temperature. An acceleration factor three is recommended for conservative strategy. Values in this table have to be regarded as an illustrative rule of thumb and planning tool for inspection periods of propellants exposed to climatic stress.

Temperature	**Safe interval for next inspection with a determined interval of 10 years at 25°C [days]**	
	Acceleration factor/10°C: 2	Acceleration factor/10°C: 3
30°C	2581	2107
35°C	1825	1217
40°C	1290	702
45°C	913	406
50°C	645	234
55°C	456	135
60°C	323	78
65°C	228	45
70°C	161	26
75°C	114	15
80°C	81	9
85°C	57	5
90°C	40	3

Table 1: Propellant degradation due to high temperature

Ammunition could theoretically reach external surface temperatures of 101^0C in the Middle East, although internal temperatures would be substantially less. Propellant degradation and stabiliser depletion is not linear, and the decay rate reduces during the night when the ammunition cools. Inappropriate storage conditions for propellant in these types of temperature extremes is detrimental and will require extensive surveillance to ensure stability in storage. States with hot climates should therefore ensure that effective systems are in place in explosive storehouses to keep ammunition within acceptable 'temperate' limits.

8 Ammunition quality standards

The national technical authority should assess, on a regular basis, the appropriate quality level required for the national stockpile and ammunition that falls below this quality level should be destroyed. The quality should be assessed using all data from surveillance programmes (ie, inspection, proof etc) and any reported incidents concerning the ammunition, eg accidents, faults etc.

Table 2 contains example ammunition quality standard levels that the national technical authority may wish to adopt:

a) the Standard Acceptance Limited Quality (SALQ) is the minimum quality standard for ammunition accepted into operational service;

b) the Functional Limited Quality level (FLQ) is the minimum quality standard for ammunition that may be used operationally. Any ammunition used operationally below this quality level will have a significant impact on operational efficiency; and

c) the Operational Limited Quality level (OLQ) is the minimum quality standard for ammunition to remain in service for either operations or training. Any ammunition that falls below this quality standard should be removed from service and destroyed.

Ammunition Type	SALQ	FLQ	OLQ
Small Arms Ammunition (SAA)	99%	96%	92%
High Explosive (HE) Ammunition	97.5%	92%	85%
Ammunition for Training	92.5%	85%	75%

Table 2: Suggested ammunition quality standards

Note: The national authority may choose much lower limits depending on local factors, eg if new stocks cannot be purchased due to lack of funding.

9 In-service proof

9.1 Background

In-service proof is a technique that is applied to many weapon systems. For example:

a) guns, mortars and small arms have their muzzle velocity, chamber pressure, firing interval, range, target penetration and accuracy assessed;

b) grenades and mines have their delay time and reaction to functioning stimulus assessed; and

c) pyrotechnics and rocket motors have their time of burning, chamber pressure and thrust assessed.

The proof assessment of direct fire weapons should be based on the ability of the munition to hit and function in a satisfactory manner against the agreed standard targets at the required ranges. For indirect fire weapons the assessment should be based on the effectiveness of observed fire measured against standard criteria. In both cases, the munition will usually be conditioned to a standard temperature prior to firing to ensure consistency of results and to allow for cross comparison of results.

In-Service proof should be used to provide an assurance of the continued satisfactory performance of an ammunition type. It should also assist in predictions of how long it will be before the performance falls below the level at which operational efficiency will be significantly impaired. This can then be used to inform procurement decisions. The measured performance is plotted against time and an estimate made of when the performance will no longer be acceptable. This may be sooner than the design life would predict or, more usually, later (because the original estimates of life are often conservative).

Proof results and data should not be used in isolation to determine the serviceability of ammunition stocks. Other surveillance results, such as stabiliser content of propellant, should also be considered before making decisions to extend or reduce the service/shelf life of a munition.

The national technical authority should have the authority to extend the service life of a munition after analysis of test results has indicated that the munition still falls within acceptable performance parameters.

9.2 Proof schedule (LEVEL 3)

A schedule should be developed and implemented for each generic type of munition in the national inventory. Table 3 contains such a schedule with explanatory notes:

Schedule Requirement	Explanatory Notes
Safety	▪ Additional specific safety requirements that may be necessary.
Sample size and selection	▪ The sample size shall be dependent on the lot or batch size. It shall be selected to ensure statistical validity. ▪ The sample size should be as small as possible consistent with the level of safety, performance and reliability assurance required. ▪ Sampling shall be in accordance with the appropriate ISO sampling standards contained within Annex A.[8] ▪ The proof sample shall be taken at random from the selected lot or batch.
Sequence of testing (if appropriate)	▪
Pre-proofing inspection	▪ Physical inspection requirements.
Preparation and conditioning of ammunition prior to test	▪ Ammunition held at what temperature and for how long?
Proof procedure and parameters to be recorded	▪ Detailed operating procedures.
Post-proofing inspection	▪ Physical inspection requirements for the particular type of ammunition. (See Annex C).
Authority and criteria for acceptance, reproof or rejection	▪ This shall be clear and unambiguous. Where reproof is allowed the exact authority for reproof shall be clearly stated.
Criteria for suspension of proof and retention of defective components	▪ As above.
List of proof equipment required	▪
Proof equipment control	▪ Calibration requirements.
Tolerance on parameters and measurements	▪
Evaluation of results	▪
Disposal instructions for items remaining after proof tests	▪

Table 3: Example in-service proof schedule

[8] Sample selection is a complex issue, which requires a high level of expertise in statistical analysis. The level of detail required for accuracy is beyond the scope of this IATG and professional statistical analysis advice shall be sought when developing the sample size.

9.3 Recording proof results (LEVEL 3)

The results of in-service proof should be recorded on a standard form designed to contain all the information required by the proof schedule. The format should be included in the proof schedule; an example form is at Annex D.

10 Surveillance (LEVEL 2)[9]

Surveillance can be summarised as the process of conducting regular checks on the actual condition of the munition inventory. It can then be used to confirm initial in-service life predictions and enable extensions to the in-service life.

Surveillance requires the gathering of data, the physical inspection of munitions and sometimes the chemical testing of energetic material properties. The testing can involve techniques such as x-ray inspection or other non-destructive testing methods. Alternatively, it may simply be a visual inspection. Because failure to ensure chemical stability can lead to disastrous consequences, it is treated separately, and guidance is given below. An effective surveillance system should be able to confirm or assess:

a) the environmental conditions to which munition systems have been exposed during their storage and deployment to date. This information can be used to confirm either munition stock records or data from environmental data loggers;

b) any physical degradation of the condition of the munition;

c) any degradation of munition and component performance, which is possible through:

  - recording and monitoring reliability and defect reports concerning in-service usage of the munition system;
  - carrying out functional proof (performance) firings; and/or
  - gathering performance data during training use.

d) changes in the physical and chemical characteristics of energetic materials and non-energetic materials judged to affect the life of the munition.

The design of the surveillance programme should be determined by the complexity of the munition and the likely failure mechanisms. Analysis of these factors should then determine the types and frequency of inspections and tests that are required to make assessments of future in-service life.

11 Selection of munitions for in-service proof or surveillance

The selection mechanism for the surveillance of munitions should be included in the in-service proof and surveillance plan, or equivalent document, for each type of munition. It should be primarily based on the following criteria:

a) age;

b) exposure to adverse climatic conditions;

c) length of time held by units and not by specialist ammunition depots;

d) ammunition that has displayed unusual performance during training;

[9] Surveillance should be initiated at Level 2 to determine whether any propellant in storage is in an unstable condition. Full surveillance may be a Level 3 activity.

e) number of times handled or transported; and/or

f) number of tests already conducted on the munition.

Ammunition should be selected from the stockpile that has been stored in the most adverse climatic conditions and hence should be the worst case in terms of degradation and ageing effects. Statistical analysis will be required to ensure that a representative and statistically viable number of ammunition items are selected for surveillance.

In many developing countries, where records have either been lost or not kept, the condition of the explosives cannot be effectively assessed. There is then a high risk of undesirable explosive events within ammunition storage areas. In such cases, where stability must be in doubt, then the criteria for assessing such munitions shall be based on:

a) munitions that have been exposed to high temperature during their previous life;

b) age;

c) munitions of unknown origin;

d) munitions of unknown composition;

e) munitions where there is suspected deterioration; and

f) munitions that exhibit unusual characteristics such as discoloration or staining.

Consideration shall be given to the immediate destruction of such explosives. Alternatively, they should be sampled and subjected to appropriate stability tests as soon as possible. However, until the results of these tests are known, the explosives should be regarded as presenting an increased risk of auto-ignition and as far as practicable should be segregated from other explosives or flammable materials.

WARNING. In the final stages of decomposition, some propellants can give off brown fumes of nitrogen dioxide. This is an extreme situation and indicates that auto-ignition is imminent and that a fire could occur at any time.

Ammunition recovered during post-conflict operations from abandoned stockpiles should be destroyed and not considered for inclusion in a stockpile under any subsequent security sector reform programmes. Unless an effective surveillance and in-service proof system has survived the conflict, the time and costs of implementing one are unlikely to be a cost benefit when compared to the procurement of new ammunition with known safety standards.

12 Environmental monitoring and recording (LEVEL 3)

Environmental monitoring should be conducted to accurately record the environmental conditions that a munition is subjected to during its service life. The more accurate the monitoring, the more accurate predictions can be made of safe in-service life, and hence the best value for money can be gained for that particular ammunition type. Results from environmental monitoring can be used to develop and update ageing algorithms as more data is obtained.

This data also provides benefits to the state by:

- Safety & Performance: giving a greater understanding of current munition conditions in relation to their capability to safely and reliably meet mission objectives. The acquired data and knowledge will in turn be used to assess the safety and suitability of munitions as well as provide recommendations on the employment, shipment, and reconstitution of munitions.

- Hazard Mitigation: identifying early potential hazards, such as high humidity or high temperature, enabling the timely implementation of preventive measures that will reduce or stop munition environmental degradation or incidents. Additionally, the type of qualification tests required can be identified to assess the munition against the identified hazards. For example, if certain types of munitions are exposed to high temperatures for long periods of time, High Performance Chromatography tests can be conducted to assess the safety of the propellant

- Availability – providing improved knowledge of remaining munition systems safe service life.

Effective environmental monitoring should be conducted using electronic data loggers in the explosive storehouses, although time-temperature indicator strips may be used as a less expensive option.

The level and frequency of monitoring should be assessed as early as possible in the service life of the munition and included in the Ammunition Management Policy Statement (AMPS). The type of munition and likely failure mechanisms should influence the level and frequency of monitoring. For simple and inexpensive ammunition held in large quantities with a high consumption rate, such as small arms ammunition, the surveillance requirement may be considered to be low. In contrast, for expensive and complex munitions with a low consumption rate, such as guided weapons, more detailed surveillance could result in significant long-term cost benefits.

Environmental data should be stored in a central system within the appropriate national technical authority as part of a Munitions Life Assessment Database (MLAD). This system should be made available to all stakeholders in the surveillance and in-service proof system.

13 Chemical stability of propellant[10]

13.1 Chemistry of propellant

The most extreme example of chemical degradation of stability is that of nitrate ester based propellants, which at the end of their safe lives, will become chemically unstable, possibly causing auto-ignition; often resulting in the loss of a storehouse. Most gun and many rocket propellants contain nitrate esters such as nitrocellulose and nitroglycerine. Whereas batch to batch differences can be blended out during manufacture to give satisfactory proof results, this cannot be done for chemical stability and the safe life shall be determined by the stability of the least stable single grain of propellant in a charge. Chemical stability is also critically dependent on the storage conditions undergone by any particular munition. Hence, sampling for chemical stability testing shall be much more rigorous than for proof. Every lot or batch should be sampled when it reaches its first test date.

Propellants in the ammunition of many developing countries are likely to be either Single Base, containing only nitrocellulose as the energetic component, or Double Base, containing both nitrocellulose and nitro-glycerine as energetic components. Even if the propellant is kept in ideal storage conditions, these components will begin to decompose over time to form oxides of nitrogen, mainly dinitrogen tetroxide. If these oxides of nitrogen are not removed from the propellant as they are formed, they will catalyse further degradation. This is an example of autocatalytic decomposition since the free radicals being formed accelerate the chemistry creating more free radicals, which, therefore, causes further degradation and so on.

One factor that can increase the rate of chemical reaction is temperature. Thus, any increase above 20^{o}C will have an adverse effect on the storage life of propellant. (See Clause 7.3).

This autocatalytic decomposition of propellants is a serious safety issue, as it is known to lead to spontaneous ignition during storage, usually resulting in the loss of one or more explosive

[10] See Druet L and Asselin M. *A Review of Stability Test Methods for Gun and Mortar Propellants; The Chemistry of Propellant Ageing.* DRE Valcartier, Quebec, Canada in *Journal of Energetic Materials*, 6: 1, 27-43. 1988.

storehouses. To prevent this occurrence, chemical additives are introduced into the propellant formulation and are known as stabilisers. They slow the degradation process of the nitrocellulose and nitro-glycerine by removing the oxides of nitrogen, which would cause it to happen. The stabiliser reacts chemically with these oxides removing them from the system. Of course, in doing this, the stabiliser will slowly be consumed.

Thus, the reduction in stabiliser content will lead to a point where it becomes insufficient to guarantee chemical stability and this should be a measure of the safe storage life of that propellant. Both chemical analysis and instrumental methods can be employed to measure the stabiliser content, the latter being a more recent advance in propellant analysis.

There are several chemicals which are used routinely as stabilisers. One example is diphenylamine (DPA), which has been used in Single Base propellants (and some double based propellant and SAA) from the early years to the present time. Chemically it behaves as a base, reacting with the initial decomposition products of nitrocellulose, initially to form nitrosodiphenylamine, which is then converted into various nitro-derivatives of diphenylamine. This stabiliser is too basic to be used if nitro-glycerine is present and therefore is only sometimes used in Double Base propellants. Instead an example of the stabiliser used is diphenyldiethylurea such as carbamite or ethyl centralite. This acts as a weak base reacting with the decomposition products, again to form nitro- and nitroso-derivatives. The overall chemistry of the action of stabilisers is extremely complex but the end result is to keep the propellant chemically stable.

13.2 Propellant stability tests[11] (LEVEL 2)

Traditional chemical methods of analysing for stabiliser content of propellants by accelerated ageing are relatively slow requiring a day to carry out the test. Thus, the total number that can be done will be completely dependent on the number of apparatus available and the size of laboratory in which to house them. Accelerated ageing is achieved by carrying out tests at elevated temperature and this is can be done by several methods used in different countries, as summarised in Table 4. These tests should be carried out by trained chemists in a properly constituted laboratory. As some of these tests take many hours a back-up power system should be immediately available to the explosives laboratory.

Test	Requirements / Comments
Abel Heat	▪ Qualitative Assessment of stabiliser content levels. ▪ Requires that samples of between 1 and 2 g are heated at temperatures in the range 60-85ºC (depending on the specific source of the test and which propellant is being tested). ▪ The results are obtained in a matter of minutes, typically no longer than 15 minutes. Sentencing for retest is then obtained from tables, for example, if the time for the test is over 10 minutes then retest in 3 years. The time is the number of minutes from the start of the test until a colouration is seen on a standard test paper. ▪ This may seem simple; however, to obtain reliable results requires a high degree of skill at carrying out this particular test.
Bergmann-Junk	▪ Easily within the capabilities of chemical analysts and can be carried out in one day. ▪ In this test, the sample is heated at 132ºC for 5 hours for Single Base propellants or at 115ºC for 8 or 16 hours for Double Base propellants. The gases evolved are absorbed into a hydrogen peroxide solution and then the acidity is titrated against a standard sodium hydroxide solution. ▪ Practically, this is a reasonably simple test to perform.

[11] See Annex B for background references on specific tests.

Test	Requirements / Comments
Colour	▪ Used to rely on visual inspection and assessment of the propellant against standard colour solutions. ▪ Recently spectrophotometry techniques have been developed which have improved effectiveness of this test.
German	▪ Propellant is heated at 134.5C (single base) or 120C (double base). ▪ The operator constantly observes the propellant to identify; 1) when nitrogen oxides detected using detector paper; 2) nitrogen oxides visually observed; and 3) deflagration of the sample. ▪ Tables are then used to determine results.
Methyl Violet	▪ The sample is heated under standardised conditions in a test tube until nitrogen oxides above the sample are detected by means of a standard methyl violet paper. The time elapsed from the start of heating until the detection is then recorded as a chemical stability value.
NATO 65.5^{0}C	▪ A primary tool for stability testing. It is an accelerated aging process, known as the 'fume test'. ▪ It is designed to pre-empt the auto-ignition of propellant in storage by forcing it to happen much earlier in a laboratory. When a tested propellant lot's 'days to fume' reaches a defined minimum level, all quantities of that lot, wherever stored, should be immediately destroyed.
Silvered Vessel	▪ The time for a sample, maintained at 80°C, under specified conditions to produce brown fumes or to self-heat to give a 2°C rise in temperature is recorded. This occurs when the effective stabiliser has been consumed and autocatalytic reactions have commenced.
Vielle	▪ Assesses rate of decomposition. A very lengthy procedure in which a sample is heated at 110^{o}C for 8 hours or until a standard tint is seen on a litmus test paper. The sample is then left overnight on a tray in the open. This is repeated day by day until it takes only one hour until the standard tint is seen. At this point, all the times from each day are added and the total time recorded used to assess the period before retest from standard tables. ▪ This test, therefore, can take weeks before a result is obtained. If at any time during the elevated temperature phase of the test there is a loss of heating such that the temperature falls more than a few degrees for a short time then the whole test becomes invalid. This could happen after a long period as the test duration is so long and thus much time would be wasted in the test programme.
VST (Vacuum Stability Test)[12]	▪ The vacuum stability test is used to assess the thermal stability of an explosive or propellant by measuring the volume of gas evolved on heating the explosive or propellant under specified conditions. ▪ A sample of the explosive compound is heated at a constant specified temperature for 40 hours in an evacuated tube. The volume of gas evolved is determined by measuring the variation of the pressure in the tube. ▪ The test is applicable to solid high explosives, propellants and pyrotechnics used in conventional armaments
HFC (Heat Flow Calorimetry)[13]	▪ The aim of this method is to test the stability for single base (SB), double base (DB), and triple base (TB) propellants using heat flow calorimetry. ▪ This STANAG describes a method for establishing the chemical stability of the propellants for a minimum of 10 years when stored at 25°C

Table 4: Propellant stability chemical tests

[12] Annex B: STANAG 4556 (Explosives: Vacuum Stability Test) ed. 1 from 22.11.1999

[13] Annex B: STANAG 4582 (Explosives, nitrocellulose bases propellants, stability test procedure and requirements using Heat Flow Calorimetry) ed. 1 from 09.03.2007

A more efficient method to increase the analysis of stabiliser content should be to move to a physical method, as summarised in Table 5. The High Performance Liquid Chromatography (HPLC) tests should be carried out by trained chemists in a properly constituted laboratory, whilst the Near Infra Red (NIR) and Thin Layer Chromatography (TLC) tests both have field expedient equipment available that is capable of adequate testing.

Test	Requirements / Comments
High Performance Liquid Chromatography (HPLC)	▪ A sample of the extracted stabiliser(s) is passed through a micro-bore column eluted by a solvent and the time taken by different materials to pass through the column separates them at the exit. A detector can then measure quantitatively the amount of stabiliser in that sample. ▪ To obtain the sample, a known weight of propellant under test has the stabiliser extracted by solvent in an ultrasonic bath. ▪ The time for the HPLC to carry out an analysis is approximately 10 minutes and the sampling of the prepared solutions can be carried out by an auto-sampler, thus, the throughput is 6 samples per hour. The ultrasonic bath will easily keep pace with the HPLC. It is estimated that one HPLC system would be capable of analysing 10,000 samples in a year. ▪ Requires a comprehensive, effective and efficient means of taking propellant samples from depot and unit storage and transporting to a central propellant surveillance laboratory.
Near Infra Red (NIR)[14]	▪ A non-destructive system that can test approximately 10 samples an hour. It consists of a spectrometer, a laptop computer and an uninterruptible power supply. ▪ The operator loads propellant into a removable cell and places the cell into the unit's transport module. The optical window-side of the cell faces a tungsten-halogen light source as the cell moves through the light. Any differences in the sample, such as colour, size, shape, or grain orientation, are averaged. The light is reflected onto detector elements of silicon and lead sulphide. Differences in the reflected light patterns (spectra) indicate varying stabiliser levels. These spectra are compared to predictive chemo-metric models of the same propellant type that are stored in the computer. ▪ The results of these comparisons indicate if the sample's stabiliser level is at or below the cut-off level that requires more extensive analytical testing. ▪ The disadvantage of the system is that it requires the chemical characteristics of the propellant to be pre-loaded into the system, and therefore it currently covers only US manufactured propellants.
Thin Layer Chromatography[15]	▪ A miniaturised wet laboratory system with single-person portability. The TLC test kit can be used to test for safe levels of stabiliser in solid propellants that are stabilised with diphenylamine, 2-nitrodiphenylamine, ethyl centralite, or Akardite II. The ability to analyse all four of the most-used stabilisers makes it a useful system. ▪ Unlike column chromatography approaches, such as HPLC, that can only process single samples sequentially, a single TLC plate can accommodate and analyse multiple samples and standards. Samples are chromatographed simultaneously in a solvent tank, separating the stabiliser analytes from the sample matrix. Semi-quantitative assessments with nanogram detection limits are readily obtained by inspection of the plates. The kit is designed and equipped with sufficient supplies and equipment for the analysis of up to 30 individual samples by a single operator per day. ▪ Once the chromatography is completed, the resolved propellant stabiliser components that appear as separated spots on the TLC plates are further enhanced by colouring with a unique reagent if the samples are

[14] US Ammunition Peculiar Equipment (APE) 1995. See Elena M Graves. *Field-Portable Propellant Stability Test Equipment*. Army Logistician, PB-700-08-04, Volume 40, Issue 4. USA. July – August 2008.

[15] US TLC Propellant Stability Test Kit.

Test	Requirements / Comments
	diphenylamine or 2-nitrodiphenylamine stabilised propellant types. If stabilised with ethyl centralite or Akardite II, the spots are viewed under the ultraviolet light that is fitted to the camera box. A further quantitative analysis could be performed using the digital imaging box, camera, and data acquisition equipment, such as for the HPTLC. ▪ The major advantages of the TLC method are simultaneous chromatography of multiple samples and standards, extremely low detection limits, the ability to calculate within a given range, and simplicity of operation.

Table 5: Propellant stability physical tests

14 Chemical stability of explosives

Most high explosive compositions have good chemical stability over long periods and give no cause for concern, but satisfactory results of performance, e.g. proof testing of stores, are not related to, and give no indication of, the stability of the explosives involved.

Nitrate ester-based explosives are liable to decomposition (see Clause 13) but many other explosives are extremely stable under normal storage conditions. Thus TNT, RDX, TATB, etc. and many other pyrotechnics and primary explosives will remain stable for many years, particularly if they have been manufactured to a high standard of purity and have been stored correctly in a controlled environment. However, it is essential that all new unfamiliar explosives and explosive compositions are assessed for chemical stability and changes in sensitiveness.

15 Stability surveillance system (LEVEL 2)

15.1 Information requirements

Proper sampling techniques should be used so that representative samples of the explosive stocks are obtained. For any system to operate successfully it is essential that the information on which it is based is reliable. The following information should be recorded for each quantity of explosives in order to maintain the necessary surveillance over the stability of the explosives concerned:

a) date of manufacture of the explosive;

b) batch or lot number, including manufacturer's monogram;

c) nomenclature of explosive composition;

d) form in which the explosive is held;

e) quantity held;

f) date by which next stability test or destruction required;

g) type of stability test required; and

h) the current storage location of the explosive.

Explosives that have been subjected to high temperatures should also be clearly identified within the recording system.

15.2 Stability test schedule

The test schedule should be determined by the type of explosive compositions present in the national inventory. The test schedule shown in Table 6, although an example, is based on the best current information available. It ensures that the tests are credible, whilst reducing the amount of work required for effective stability testing to the minimum necessary for explosive safety.

Explosive / Propellant	First Test	Test Type	Retest Interval[16]
Nitroglycerine (NG) and other Liquid Nitrate Esters[17]	At manufacture	Abel Heat	3 months
Casting Liquid with Stabiliser	At manufacture	Abel Heat	12 months
Dry Nitrocellulose (NC) or Dry NC/NG Pastes[18]	Within 1 month of drying	Abel Heat and Bergmann Junk	3 months
Wet Nitrocellulose	6 months	Abel Heat	6 months
Wet NC/NG Pastes	At manufacture	Abel Heat	3 months
Dynamite and Blasting Gelatin	12 months	Abel Heat on extracted NG	12 months
Triple Base Gun Propellants	As determined during qualification[19]	Stabiliser Depletion[20]	10 years
Extruded Double Base Propellants	As determined during qualification	Stabiliser Depletion	10 years
Double Base Powders	As determined during qualification	Stabiliser Depletion	10 years
Single Base Powders	As determined during qualification	Stabiliser Depletion	10 years
Experimental and other Foreign Propellants	As determined during qualification	Stabiliser Depletion	10 years
Rocket Propellants	As determined during qualification	Stabiliser Depletion	10 years
Casting Powders	At manufacture	Stabiliser Depletion	10 years

Table 6: Propellant stability test schedule (example)

[16] Although this shall be determined by test results. The time shown is that expected, although this may be significantly reduced for older explosive compositions.

[17] NG should not be stored for any length of time in the pure form. If it fails the Abel Heat Test at manufacture (less than 10 minutes) it shall be immediately destroyed.

[18] Dry NC should not be stored for any length of time. It should be wetted with water or alcohol to reduce the hazard. The storage temperature is critical below 15^{0}C as the NG freezes below 13^{0}C and shock sensitivity then becomes a significant issue.

[19] Qualification is the process by which an explosive is tested after manufacture and prior to acceptance into service. It involves a further range of sensitivity and stability testing that is usually a manufacturer's responsibility.

[20] Select appropriate test from Table 4 or 5.

Annex A
(normative)
References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of the guide. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of the guide are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO maintain registers of currently valid ISO or EN:

a) IATG 01.40 *Glossary of terms, definitions and abbreviations*. UNODA. 2015;

b) IATG 03.10 *Inventory Management*. UNODA. 2015;

c) IATG 06.40 *Packaging and marking.* UNODA. 2015:

d) ISO 2859 *Sampling procedures for inspection by attributes;*

e) ISO 3951 *Sampling procedures for inspection by variables;*

f) ISO 8422 *Sequential sampling plans for inspection by attributes;*

g) ISO 8423 *Sequential sampling plans for inspection by variables for percent nonconforming (known standard deviation);*

h) ISO/TR 8550 *Guide for the selection of an acceptance sampling system, scheme or plan for inspection of discrete items in lots;*

i) ISO/TR 10017 *Guidance on statistical techniques for ISO 9001:2000;*

j) ISO 11453 *Statistical interpretation of data - Tests and confidence intervals relating to proportions;*

k) ISO 13448 *Acceptance sampling procedures based on the allocation-of-priorities principle (APP);*

l) ISO 14560 *Assessment and acceptance sampling procedures for inspection by attributes in number of nonconforming items per million items;*

m) ISO 16269 *Statistical interpretation of data;*

n) ISO 18414 *Accept-zero sampling schemes by attributes for the control of outgoing quality;*

o) ISO/TR 18532 *A Guide to the application of statistical methods to quality and standardization; and*

p) ISO 21247 *Quality plans for product acceptance - Combined accept-zero and control procedures.*

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UN ODA) holds copies of all references[21] used in this guide. A register of the latest version/edition of the International Ammunition Technical Guidelines is maintained by UN ODA, and can be read on the IATG website: www.un.org/disarmament/ammunition. National authorities, employers and other interested bodies and organisations should obtain copies before commencing conventional ammunition stockpile management programmes.

[21] Where copyright permits.

Annex B
(informative)
References

The following informative documents contain provisions, which should also be consulted to provide further background information to the contents of this guide:[22]

a) AOP 48. *Explosives - Nitrocellulose Based Propellants, Stability Test Procedures and Requirements Using Stabilizer Depletion*. NATO Standardization Office (NSO);

b) AOP 62. *In-Service Surveillance of Munitions General Guidance.* NATO Standardization Office (NSO);

c) AOP 63. *In-Service Surveillance of Munitions Sampling And Test Procedures.* NATO Standardization Office (NSO);

d) AOP 64. *In-Service Surveillance of Munitions Condition Monitoring of Energetic Materials.* NATO Standardization Office (NSO);

e) *Conventional Ammunition in Surplus - A Reference Guide.* Small Arms Survey. ISBN 2-8288-0092-X. Geneva. January 2008.

f) Joint Service Publication 762, *Through Life Munitions Management*. MOD. UK. 2005;

g) STANAG 4117 (Edition 3). *Stability test procedures and requirements for propellants stabilised with Diphenylamine, Ethyl Centralite or mixtures of both*. NATO Standardization Office (NSO);

h) STANAG 4315, *The Scientific Basis for the Whole Life Assessment of Munitions*. NATO Standardization Office (NSO);

i) STANAG 4527 (Edition 1). *Explosives - Chemical, Stability, Nitrocellulose based propellants, procedure for assessment of chemical life and temperature dependence of stabiliser consumption rates*. NATO Standardization Office (NSO);

j) STANAG 4541 (Edition 1). *Explosives - Nitrocellulose Based Propellants Containing Nitroglycerine and Stabilized with Diphenylamine, Stability Test Procedures and Requirements*. NATO Standardization Office (NSO);

k) STANAG 4556 (Edition 1) *Explosives - Vacuum Stability Test*. NATO Standardization Office (NSO);

l) STANAG 4581. *Explosives - Assessment of Ageing of Composite Propellants Containing an Inert Binder*. NATO Standardization Office (NSO);

m) STANAG 4582. *Explosives - NC Based Propellants Stabilised with DPA - Stability Test Procedure and Requirements using HF – Calorimetry*. NATO Standardization Office (NSO);

n) STANAG 4620. *Explosives - Nitrocellulose based Propellants - Stability Test Procedures and Requirements Using Stabilizer Depletion*. NATO Standardization Office (NSO);

o) STANAG 4675. *In-Service Surveillance (ISS) of Munitions.* NATO Standardization Office (NSO);

[22] Data from many of these publications has been used to develop this IATG.

p) UK Defence Standard 05-101, Part 1, *Proof of Ordnance, Munitions, Armour and Explosives: Requirements*. UK Defence Standardization. 24 November 2006;

q) UK Defence Standard 05-101, Part 2, *Proof of Ordnance, Munitions, Armour and Explosives: Guidance*. UK Defence Standardization.

r) UK Defence Standard 05-101, Part 3, *Proof of Ordnance, Munitions, Armour and Explosives: Statistical Methods for Proof*. UK Defence Standardization.

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UN ODA) holds copies of all references[23] used in this guide. A register of the latest version/edition of the International Ammunition Technical Guidelines is maintained by UN ODA, and can be read on the IATG website: www.un.org/disarmament/ammunition. National authorities, employers and other interested bodies and organisations should obtain copies before commencing conventional ammunition stockpile management programmes.

[23] Where copyright permits.

Annex C
(informative)
Guidance on physical inspection of ammunition (LEVEL 2)

C.1 Introduction

The physical (visual) inspection of ammunition is an important component in ensuring the overall safety of the ammunition stockpile. It should be carried out by trained ammunition technical staff who are conversant with the design principles of the ammunition and its modus operandi. This Annex summarises Inspection Points that should be addressed during the physical inspection of ammunition.

C.2 Inspection of ammunition packaging

It is important that the ammunition packaging is inspected as part of the in-service proof as the packaging is a means of: 1) accurately identifying the ammunition; and 2) protecting the ammunition during storage and transport. The following inspection points should be used:

a) the packaging should be marked with the correct details of the ammunition;[24]

b) the metal fitments should be free from oxidation (rust);

c) the package should be intact with minimal external damage; and

d) the seals should be intact.

C.3 Inspection of ammunition

Table C.1 contains inspection points to be checked for the main generic types of ammunition.

[24] See IATG 06.40 *Packaging and marking.*

Generic Type	Determine Rust Level[25]	Correct Markings	Percussion Cap / Primer	Undamaged Cartridge Case	Round/Shell Secure in Cartridge Case	Round/Shell/Munition Body Undamaged	Undamaged Primary and Secondary Cartridges	Undamaged Fins	Undamaged Fuze (If Fuzed)	No Exudation of Explosive/Pyrotechnic Filling	Propellant Uncongealed and Well Distributed	No Discolouration of Charge Container	No Foreign Items In Charge Container	Safety Pin/Wire Secure (If Fuzed)	Fuze Cavity Clear and Clean (If Unfuzed)	Explosive Charge Intact and Unbroken	Good Plasticity (If Applicable)	Wax on Fuze Body (Pyrotechnic Time Fuzes)	No Segment Rotation (Mechanical Time Fuzes)	Ignition System Undamaged	Nose Cap Intact	Base Cap Intact	
Small Arms Ammunition	X	X	X	X	X	X																	
Mortar Ammunition	X	X	X			X	X	X	X	X													
Artillery Ammunition (Fixed)	X	X	X	X	X	X			X	X					X								
Artillery Ammunition (SL)	X	X	X			X			X	X					X								
Artillery Propelling Charges											X	X	X										
Fuzes	X	X				X				X				X				X	X				
Grenades	X	X				X				X				X	X								
Anti-Tank Mines	X	X				X			X	X				X	X								
Pyrotechnics	X	X	X			X				X													
Demolition Charges		X								X		X	X		X	X	X						

[25] See Table C.2.

Generic Type	Determine Rust Level[25]	Correct Markings	Percussion Cap / Primer	Undamaged Cartridge Case	Round/Shell Secure in Cartridge Case	Round/Shell/Munition Body Undamaged	Undamaged Primary and Secondary Cartridges	Undamaged Fins	Undamaged Fuze (If Fuzed)	No Exudation of Explosive/Pyrotechnic Filling	Propellant Uncongealed and Well Distributed	No Discolouration of Charge Container	No Foreign Items In Charge Container	Safety Pin/Wire Secure (If Fuzed)	Fuze Cavity Clear and Clean (If Unfuzed)	Explosive Charge Intact and Unbroken	Good Plasticity (If Applicable)	Wax on Fuze Body (Pyrotechnic Time Fuzes)	No Segment Rotation (Mechanical Time Fuzes)	Ignition System Undamaged	Nose Cap Intact	Base Cap Intact	
Rockets and Missiles	X	X				X		X	X	X										X	X	X	

Table C.1: Inspection points

Rust levels often represent a useful indicator of the overall condition of ammunition. Table C.2 provides an example system that may be used to compare ammunition serviceability against visible rust.

Rust Level (R_L)		% of Rust on Surface Area	Serviceability Assessment	Recommended Action
Code	Summary			
$R_L = 1$	Little visible rust levels	<5	Serviceable	None
$R_L = 2$	Medium rust levels	>5	Serviceable	Expend at Training
$R_L = 3$	Heavy rust levels	>10	Limited Serviceability	Repair Request In-Service Proof
$R_L = 4$	Very heavy rust levels	>40	Unserviceable	Destroy

Table C.2: Rust identification levels

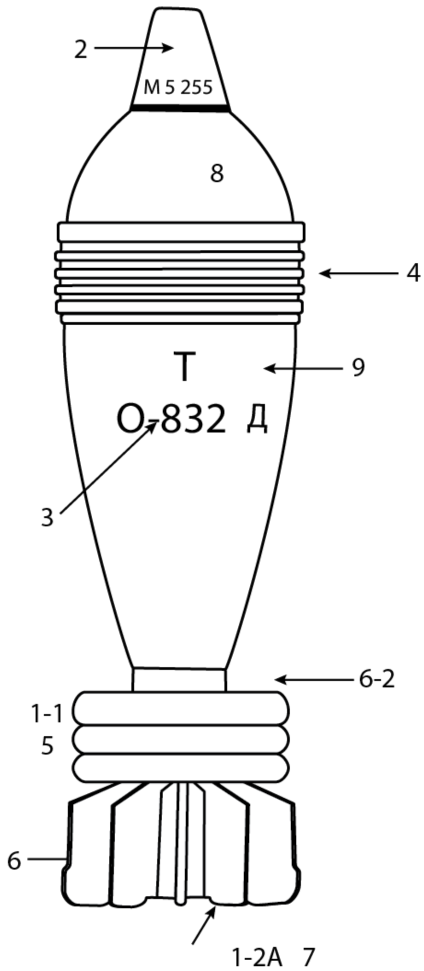
C.4 Inspection and Repair Instruction (I&RI) Example

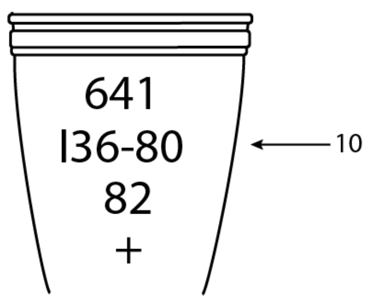
Mortar, 82mm, HE, Model O-832Д fitted with Fuze, PD, M-5

Sub-Process: Inspection of Unpacked Mortar Cartridge

1	Confirm unfired condition and that munition is not a misfire: 1-1 Propellant increments present and/or primary cartridge unfired; 1-2 Percussion cap undented; 1-3 Immediately report any fired or misfired munition to supervisor.	
2	Fuze: 2-1 Confirm fuze is present; 2-2 Check markings of fuze for readability: 2-3 Confirm fuze is of M-5 type; 2-4 Check for signs of exudation or crystallisation, especially around thread; 2-5 Check fuze for splits, dents, cracks and corrosion; 2-6 Confirm that fuze is well fixed to the munition; 2-7 Confirm that there is no gap between fuze body and main body.	
3	Model Designation: 3-1 Check stencilled markings on main body for readability; 3-2 Confirm that model designation is O-832Д; 3-3 Confirm that model designation is not Д -832Д (SMK WP).	
4	Gas Check Bands:	

	4-1 Check gas check band for splits, dents, cracks and corrosion; 4-2 Remove any protective lacquer or grease (where applicable); 4-3 Confirm each ring for exact calibre with calibre gauge; 4-4 Apply protective lacquer or grease.
5	Propellant increments: 5-1 Remove propellant increments; 5-2 Confirm number of propellant bags; 5-3 Check propellant bags for tear, holes and exiting propellant dust; 5-4 Check propellant for any signs of cracks or physical deterioration; 5-5 Check propellant bags for signs of fungi or biological decomposition; 5-6 Check whether propellant bags feel damp or show any change of colour; 5-7 Check primary cartridge through flash holes for any signs of deterioration; 5-8 Confirm that all flash holes are open and unobstructed; 5-9 Refit propellant bags and check for secure seat.
6	Tail Boom Assembly: 6-1 Confirm that tail boom is fixed securely to main body; 6-2 Confirm that there is no gap between tail boom and main body; 6-3 Check tail boom and fins for splits, dents, cracks and corrosion; 6-4 Check each fin for straightness and alignment; 6-5 Check fin assembly for outer dimensions with calibre gauge.
7	Percussion Cap: 7-1 Confirm percussion cap is present and undented; 7-2 Check percussion cap for correct seat; 7-3 Check percussion cap for splits, dents, cracks and corrosion;
8	Main Body: 8-1 Check body for splits, dents, cracks and corrosion; 8-2 Check body for missing protective paint, mark for later remediation; 8-3 Confirm alignment of components with straightness gauge.
9	Explosive Filler: 9-1 Check stencilled markings on main body for readability; 9-2 Check type of explosive filler; 9-3 Separate by type of explosive filler.





10	Production Lot: 10-1 Check stencilled markings on main body for readability; 10-2 Check Lot number and year of filling 10-3 Separate by year of filling	

Annex D
(informative)
Example proof report (LEVEL 3)

In-Service Proof Reporting Form			
Serial			**IATG Form 07.20**
1	**Ammunition Details**		
1.1		ADAC	**34638-27A**
1.2		Description	**Shell 155mm HE L15A2**
1.3		Lot/Batch	**GD 0897 020**
1.4		Date of Manufacture or Filling	August 1997
1.5		Associated Products	Nil
2	**Proof Details**		
2.1		Results of Pre-proof Inspection	Shell was clear of rust with no explosive exudation apparent. In good condition.
2.2		Details of Proof Apparatus	155mm Howitzer Self Propelled 35GA46 155mm Gun Serial Number 23877543
2.3		Climatic Conditions	Ammunition conditioned at 15^{0}C for 8 hours Temperature at time of firing 12^{0}C Fine weather with no wind.
2.4		Proof Results	See Attachment 1 containing: 1. Muzzle Velocities. 2. Chamber Pressures. 3. Projectile Range. 4. Projectile Accuracy.
2.5		Results of Post-proof Inspection	Not Applicable as all Shells functioned as designed.
3	**Certification**		
3.1		This form certifies that the in-service proof has been carried out in accordance with the proof schedule and instructions listed.	Proof Schedule 2009/10/A
3.2		Certifying Individual	Major A D Smith
3.3		Certifying Authority	Proof and Experimental Establishment 12
3.4		Signature	
4	**Distribution**		
4.1		Appropriate National Technical Authority	
4.2		Contractor (where appropriate)	

Amendment record

Management of IATG amendments

The IATG are subject to formal review on a five-yearly basis. This does not preclude amendments being made within these five-year periods for reasons of operational safety, efficacy and efficiency or for editorial purposes.

As amendments are made to this IATG module they will be given a number, and the date and general details of the amendment will be shown in the table below. The amendment will also be shown on the cover page of the IATG by the inclusion of the amendment number and date.

As the formal reviews of each the IATG module is completed, new editions will be issued. Amendments will be incorporated into the new edition and the amendment record table cleared. Recording of amendments will then start again until a further review is carried out.

The most recently amended, and thus extant, IATG module is posted on www.un.org/disarmament/ammunition

Number	Date	Amendment Details
0	01 Feb 15	Release of Edition 2 of IATG.
1	31 March 21	Release of Edition 3 of IATG.