NATO OTAN

NATO STANDARDIZATION AGENCY
AGENCE OTAN DE NORMALISATION

NSA

12 March 2007 NSA/0266(2007)-JAS/4517

See CNAD AC/326 STANAG distribution

STANAG 4517 JAS (EDITION 1) – LARGE CALIBRE ORDNANCE/MUNITION COMPATIBILITY DESIGN SAFETY REQUIREMENTS AND SAFETY AND SUITABILITY FOR SERVICE EVALUATION

Reference: PFP(AC/326)D(2003)001 dated 8 July 2003

1. The enclosed NATO Standardization Agreement, which has been ratified by nations as reflected in the **NATO Standardization Document Database (NSDD)**, is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

ACTION BY NATIONAL STAFFS

3. National staffs are requested to examine **their ratification status of the STANAG** and, if they have not already done so, advise the Defence Investment Division through their national delegation as appropriate of their intention regarding its ratification and implementation.

J. MAJ
Major General, POL(A)
Director, NSA

Enclosure:
STANAG 4517 (Edition 1)

North Atlantic Treaty Organisation – Organisation du Traité de l'Atlantique Nord
B-1110 Brussels Belgium
E-mail: mc.mortier@hq.nato.int – Tel 32.2.707.3942 – Fax 32.2.707.4103

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

NATO STANDARDIZATION AGENCY
(NSA)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: LARGE CALIBRE ORDNANCE/MUNITION COMPATIBILITY DESIGN SAFETY REQUIREMENTS AND SAFETY AND SUITABILITY FOR SERVICE EVALUATION

Promulgated on 12 March 2007

for: J. Maj

J. MAJ
Major General , POL(A)
Director, NSA

RECORD OF AMENDMENTS

No.	Reference/date of Amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Director NATO Standardization Agency under the authority vested in him by the NATO Standardization Organisation Charter.

2. No departure may be made from the agreement without informing the tasking authority in the form of a reservation. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

4. Ratification, implementation and reservation details are available on request or through the NSA websites (internet http://nsa.nato.int; NATO Secure WAN http://nsa.hq.nato.int).

FEEDBACK

5. Any comments concerning this publication should be directed to NATO/NSA – Bvd Leopold III - 1110 Brussels - BE.

NATO STANDARDIZATION AGREEMENT
(STANAG)

LARGE CALIBRE ORDNANCE/MUNITION COMPATIBILITY, DESIGN SAFETY REQUIREMENTS AND SAFETY AND SUITABILITY FOR SERVICE EVALUATION

Annexes:
A - Design Safety Requirements - Large Calibre Ordnance.
B - Safety and Suitability Assessments - Ordnance.
C - Safety and Suitability Tests - Ordnance.

Related Documents:

AECP-1	Mechanical Environmental Conditions
AECTP-200	Environmental Testing - Definitions Of Environments
AECTP-300	Climatic Environmental Tests.
AECTP-400	Mechanical Environmental Tests.
AEP-4	Nuclear Survivability Criteria For Armed Forces Material And Installations.
AOP-15	Guidance On The Assessment Of The Safety And Suitability For Service Of Non-Nuclear Munitions For Nato Armed Forces
AOP-24	Electrostatic Discharge, Munition Assessment And Test Procedures.
AOP-25	Rationale And Guidance Concerning Stanag 4327 - Lightning, Munition Assessment And Test Procedures
ARSP-1 Vol I	Weapon Danger Areas/Zones For Unguided Weapons For Use By Nato Forces In A Ground Role - Factors And Processes
STANAG 1307	Maximum NATO Naval Operational Electromagnetic Environment Produced By Radio And Radar.
STANAG 1402	Guidelines For The National Test Authority (NTA) Assessment Of Naval Ammunition Interchangeability

STANAG 4110 Definition Of Pressure Terms And Their Interrelationship For Use In The Design And Proof Of Cannons Or Mortars And Ammunition.

STANAG 4147 Chemical Compatibility Of Ammunition Components With Explosives (Non-Nuclear Applications).

STANAG 4170 Principles and Methodology for the Qualification of Explosives Materials for Military Use.

STANAG 4187 Fuzing Systems-Safety Design Requirements.

STANAG 4224 Large Calibre Artillery and Naval Gun Ammunition Greater than 40 mm, Safety and Suitability for Service Evaluation.

STANAG 4234 Electromagnetic Radiation (Radio Frequency) - 200 kHz to 40 GHz Environment - Affecting the Design of Materiel for Use by NATO Forces.

STANAG 4235 Electrostatic Discharge Environment

STANAG 4236 Lightning Environmental Conditions Affecting the Design of Materiel for Use by NATO Forces.

STANAG 4239 Electrostatic Discharge, Munition Test Procedures.

STANAG 4240 Liquid Fuel/External Fire, Munition Test Procedures.

STANAG 4241 Bullet Impact, Munition Test Procedures

STANAG 4297 Guidance On The Assessment Of The Safety And Suitability For Service Of Munitions For NATO Armed Forces.

STANAG 4327 Lightning, Munition Assessment And Test Procedures

STANAG 4423 Cannon Ammunition (12.7 to 40 mm), Safety and Suitability for Service Evaluation.

STANAG 4516 Cannon (Greater Than 12.7mm), Design Safety Requirements And Safety And Suitability For Service Evaluation Of The Weapon/Munition Combination

AIM

1. The aim of this agreement is to provide design safety requirements and to define standard tests required to support the evaluation of the safety and suitability for service(S^3) of large calibre ordnance/munition compatibility within the parameters of an ordnance as defined in this STANAG. Mortars, free flight rocket launchers, hand held weapons and guided weapon (GW) launchers are not covered by this STANAG.

AGREEMENT

2. Participating nations agree that both design safety assessment and safety and suitability testing and assessment (including adequate documentation), performed in accordance with this STANAG, shall be considered valid for evaluation by the ratifying nations. Further, they agree that any design safety assessment, safety and suitability tests and assessment of ordnance performed in accordance with this document shall be acceptable to the ratifying nations.

SCOPE

3. Ordnance. For the purposes of this STANAG, an ordnance is defined as having a calibre normally greater than 40 mm and a rate of fire of less than 100 rpm and consists of a barrel assembly, breech assembly and loading system complete with, if fitted, an integral automatic ramming, loading and extraction system.

4. Further definitions are :

   a. Barrel Assembly. The barrel assembly comprises the barrel and, if fitted, the muzzle brake, fume extractor, muzzle blast deflector, thermal sleeve and cooling system.

   b. Breech Assembly. The breech assembly comprises the breech ring, the breech block (or blocks in the case of split block breeches), the breech block opening mechanism, the firing mechanism, the extractors and, if fitted, the breech obturators and tube/primer loader.

   c. Cradle Assembly. The cradle assembly comprises the recoil system incorporating the buffer cylinder(s), recuperator cylinder(s), control cylinder(s) and any balancing devices.

GENERAL

5. The purpose of design safety assessment and safety and suitability for service evaluation of ordnance weapon systems is to establish that:

   a. The ordnance and its components will remain safe and suitable for service and will function within acceptable performance limits after being exposed to environmental conditions equivalent to those which are likely to be found in storage and operation during the entire stated service life of the ordnance.

b. The risk of a safety failure occurring at any point throughout the service life is acceptably low.

c. There is no damaging interaction between the ordnance and its associated mount when operating under normal service conditions.

PROCEDURES

6. Each nation will be responsible for the evaluation of design safety and safety and suitability for service of ordnance to be used by its own Services, and for this purpose will require copies of the design characteristics, safety analyses and trial reports from the nation responsible for the development of the ordnance being evaluated. The nation, or group of nations, carrying out the evaluation of design safety and safety and suitability for service on an ordnance weapon system agree to make their test parameters, safety analyses and trials reports available to other NATO nations intending to purchase or to take over that ordnance weapon system, on receipt of a valid request.

7. Variations on the Procedure.

a. Notwithstanding the intention to avoid duplication of testing, each nation reserves the right to carry out additional testing if considered appropriate and, when necessary, to bear the financial costs of so doing.

b. The service environment to which the ordnance may be subjected will be specified by the user nation. The specific test programme need not be limited to tests described in this document. The selection of tests, test parameters and test sequences shall be based on design safety assessment including hazard analysis and the measured, or analytically forecast, environmental life cycle profile of the ordnance.

c. Any significant changes proposed to the agreed evaluation procedures will be provided to the user nation for comment and concurrence; any changes made without the mutual acceptance of the ratifying nations may negate the acceptability to the user nations of the evaluation procedures.

d. The final safety evaluation will take account of development trials, and may take account of individual national safety appraisal procedures, in order to make a valid evaluation of the ordnance in the specified service environment.

ORDNANCE, INSTALLATION AND AMMUNITION INTERACTION

8. Ordnance may be developed to fire from several differing weapon installations with new, specifically developed, natures or types of ammunition of the same calibre, or to fire a range of existing natures.

a. Installation. The interaction of the ordnance, the ammunition to be fired, and the installation need to be assessed for safety and suitability for service. The safety assessment of ordnance installations, which includes the buffers, recoil systems, trunnions, carriage or turret interface, together with sighting and aiming controls, and assessment of toxicity levels, is essential in considering the overall weapon system safety. Installation safety assessment is not covered in this STANAG and until a specific land systems Weapon Installation STANAG is produced, nations will need to follow national procedures.

b. Ammunition. The evaluation of each type of ammunition will need to take account of the ordnance design criteria (eg. chamber characteristics and design pressure) and the environment envisaged for the ammunition when cycled through the gun ammunition supply system (manual, semi-automatic or automatic). In deciding the trial requirements, the envisaged combinations of ordnance and ammunition natures must be established to ensure that all relevant dimensional, pressure, wear rate and fatigue criteria are taken into account. Reference should be made to STANAG 4224 or STANAG 4493 for Large Calibre Artillery and Naval and Tank ammunition respectively.

PRESSURE RELATIONSHIPS AND TERMINOLOGY

9. The pressure relationships and terminology detailed in STANAG 4110 are relevant and are to be applied to ordnance covered by this STANAG.

LIFE CYCLE

10. During its life cycle, an ordnance may encounter great variations in ground, air or sea environmental conditions. Within any of these environments, the ordnance may be subjected to: maintenance; repair; testing; loading and firing. The tests required to establish the safety and suitability for service characteristics of the ordnance shall take account of the need to demonstrate the effects of the expected environment on the ordnance during its predicted life cycle in accordance with the User Requirement Document(URD). The tests will need to establish that the durability of components is satisfactory.

ENVIRONMENTAL SPECIFICATIONS

11. To ensure that environments used during tests are representative, the anticipated environment shall be consistent with the Operational Requirement and the design specification for the ordnance. The appropriate Operational Requirements office of the developing nation's Service, or Services, shall certify that the anticipated environment has been correctly defined. This process, for the ammunition, is defined in the Environmental Questionnaire AOP-15 and is applicable to its interface with the ordnance. When the weapon system is required to withstand a nuclear environment, the appropriate levels from AEP 4 shall be used.

ENVIRONMENTS

12. Environments selected for testing should represent those extremes anticipated for the planned life cycle of the ordnance and in terms of the climatic conditions defined

in AECTP-200. Environments which shall be considered for the assessment and testing of ordnance are summarised as:

a. Natural environments created regardless of human intervention, eg. temperature, pressure, humidity, sand, lightning or salt spray.

b. Induced environments associated with the mechanical stresses of the installation of the ordnance in a ship, vessel, fighting vehicle, or other military installation.

c. Induced environments associated with operation in the ship, vessel, fighting vehicle or other military installation, including the ordnance ammunition supply system, loading and firing.

d. Induced electromagnetic, electrostatic and nuclear environments resulting from human intervention.

e. Hazardous environments associated with enemy action and accidents, eg. fire, impact by other munitions or fragments, handling, loading accidents, etc.

DESIGN SAFETY ASSESSMENT

13. The weapon /munition interface shall be assessed against the design safety requirements specified in Annex A of this STANAG and as further amplified by the developing nation, or group of nations, if required. Complex elements of the ordnance may need to be analysed by formal hazard analysis methods in accordance with AOP 15. These safety analyses shall identify particular safety tests as being required and may highlight the need to examine in more detail some particular feature(s), or perceived weakness, of the design.

SAFETY AND SUITABILITY TEST AND ASSESSMENT PROGRAMME

14. The Safety and Suitability for Service (S^3) test programme shall be developed for the ordnance based on design safety assessment, hazard analysis and the environmental profile as indicated in Paragraphs 7b, 13 and 16. The programme will include both non-sequential functioning and safety tests and sequential environmental tests and is to be representative of in-service usage patterns as described in Paragraph 19 below. The selection of tests, test methods, parameters, duration and sequence and the logic pertaining to these choices, in relation to the specified environment, shall be documented.

SAFETY AND SUITABILITY FOR SERVICE TESTS AND ASSESSMENTS

15. The S^3 tests and assessments are those which shall be conducted to establish adequate safety, during the complete life cycle of the ordnance, in operational use, in credible accident situations and to determine suitability for service. These assessments and tests are given in Annexes B and C respectively. The design of an ordnance will dictate which of these tests and assessments are applicable, but all tests and assessments must be fully considered when developing an S^3 test

programme for that particular ordnance. The tests and assessments are grouped in the following categories:

a. Safety Tests and Assessments. Tests and assessments are to demonstrate that:

(1) Operation of the ordnance will not cause a hazard to the crew, vehicle, installation or platform.

(2) The ordnance will withstand the firing forces created under extreme service conditions.

(3) The ordnance will not endanger life when responding to potentially hazardous events that could occur.

(4) The ordnance design will not permit unintentional firing of the weapon when subjected to environmental or accidental stimuli.

b. Environmental Functioning and Durability Tests. Environmental Functioning and Durability tests are to ensure that:

(1) The ordnance ammunition loading and supply systems function satisfactorily in, or after exposure to, the specified environment, as required by the (URD).

(2) The durability of components is satisfactory.

ADDITIONAL TESTS

16. Further assessments and tests, not included in Annexes B or C, may be conducted if considered necessary by the developing authority. In particular, novel designs may require further assessments or tests to be undertaken. They may be configured to examine any specific areas of concern highlighted during the design safety assessment. Any assessment or test intended to gauge the response of the ordnance to a particular environment or hazard is to be conducted to simulate satisfactorily the extremes of the environment or hazard.

TEST PARAMETERS

17. Standard test procedures and test parameters are given in Annex C. Test severity shall be at least in accordance with the minimum requirements presented in, or referred to in the Annex. If the results of analyses lead to more severe testing, or to the conduct of tests not mentioned in the Annex, the appropriate severity of tests, or additional tests, shall be included in the test programme. Nothing in this STANAG should prevent a nation deciding on a higher or more severe criterion if it so wishes. The developing nation must be consulted in the event that a more severe test is specified to establish wether the test exceeds the specified design parameters of the ordnance or installation.

TEST PROCEDURES

18. The tests described in Annex C shall be conducted in accordance with ratified test STANAGs. In those instances where appropriate STANAGs have not yet been approved, national procedures will apply until superseded by ratified STANAGs. Components of the gun (eg. a barrel) may be tested in isolation from the gun provided this does not detract from the purpose of the test or the test sequence. Such configurations must be specified in the test plan and documented in the test report.

CHOICE OF TEST AND TEST SEQUENCE

19. Some or all of the safety and suitability tests within the programme are conducted sequentially to verify that the ordnance will be safe and suitable for service in the expected environment. Such sequences may end with firing tests or detailed disassembly and examination. Components may be withdrawn at various points for detailed examination to ascertain the effects of specific tests or environments. The detailed design of the ordnance should be critically examined so that the sequence or sequences represent the best compromise between a realistic life cycle and those sequences which will cumulatively produce the most severe degradation of the ordnance under test. The scope of the testing, content of test sequences and the extent of assessment will also be influenced by any similarities with previous designs or by technical innovation in the design. Where an ordnance being assessed is a modification of a known and previously assessed design, some reduction of testing may be possible. Any such reduction, including the reason for it, shall be fully documented. Any tools used in the assessment methodology shall be fully documented particularly where used as the rationale for reduced testing.

RESULTS OF ASSESSMENTS AND TESTS

20. Reports of tests and assessments shall be made available by the developing nation to participating nations on receipt of a valid request. Where there is evidence of unacceptable or unsatisfactory results, the significance of these shall be explained by the developing nation. The environmental conditions against which the ordnance has been tested shall be identified to establish the requirement for any subsequent testing.

RELATIONSHIP WITH DEVELOPMENT TESTING

21. Tests on ordnance shall be classified as “development” or “safety and suitability for service” tests. During the development stage of an ordnance it is feasible to expect that tests, covering the spectrum of assessments and tests in Annexes B and C, as well as additional tests devised by that manufacturer, will have been conducted. However any ordnance selected for the safety and suitability test programme must be fully representative of the final production standard and is required to have successfully passed the environmental and safety test criteria. The results of development trials carried out with an ordnance or components which have been proven to be representative of the production build standard may be taken into

consideration in the evaluation of safety and suitability for service, provided that test data are made available.

REPORTS ON SAFETY AND SUITABILITY TESTS AND ASSESSMENTS

22. It is essential that adequate data are available to national/service safety evaluation organisations for the evaluation of ordnance safety and suitability for service. Therefore, nations developing the ordnance shall compile a data package that documents the test methods and rationale for the programme selection. Reports should be from officially recognised test houses/ranges/authorities and carry a satisfactory assurance of quality. The package will also give the detailed results obtained during safety and suitability tests. Where results from component development have been used to permit reductions in the scope or the duration of tests, then the results of these development trials should also be included, providing the aspect of development munitions under test has not been changed in the production version. This data package shall be supplemented by a technical design data package.

IMPLEMENTATION OF THE AGREEMENT

23. This STANAG is implemented when a nation has issued instructions that all new ordnance procured for service use will be designed, assessed and tested in accordance with the requirements and procedures detailed in this agreement.

(Intentionally Blank)

DESIGN SAFETY REQUIREMENTS - LARGE CALIBRE ORDNANCE

ORDNANCE

1. STRENGTH OF DESIGN.

a. The design of the ordnance shall be sufficient to sustain all anticipated firing loads during its service life without incurring catastrophic failure. The probability of the system pressure reaching, or exceeding Cannon Design Pressure (Cannon DP) shall be less than 1 in 10^6, under extreme service conditions as defined in STANAG 4110.

b. Adequate strength of design is to be demonstrated by firing matched ammunition to produce the Cannon DP, as defined by STANAG 4110. This may be achieved either by firing with a unique charge, or by firing the top service charge, temperature conditioned to achieve the required pressure.

2. LIFE. Components of the ordnance, as defined in this STANAG shall operate safely for their full declared service life. The safe life, whether limited by wear or fatigue, is to be established.

3. SAFE OPERATION.

a. The ordnance shall remain safe to operate under all climatic, mechanical and electrical environmental conditions specified in the URD and AOP15.

b. Safe operation is to be assessed or tested in the climatic, mechanical and electrical environments stated in the following References:

AEP 4 Materiel	-Nuclear Hardening Criteria for Armed Forces and Installations
AECP-1	- Mechanical conditions.
STANAG 1307	- Maximum Naval electromagnetic conditions.
STANAG 2895	- Climatic conditions.
STANAG 4234	- rf environment 200 kHz to 40 GHz.
STANAG 4235	- Electrostatic environment.
STANAG 4236	- Lightning environmental conditions.

(1) When assessing ordnance safety, the natures, internal ballistics and, if appropriate, source of manufacture of the ammunition to be fired must be defined.

(2) The technical specification for ordnance may include the nuclear environment in which it must be capable of operating. The ordnance developing nation is required to identify the design features incorporated to meet the following requirements:

(a) Nuclear electromagnetic pulse (NEMP).

(b) Initial nuclear radiation (INR).

(c) Blast.

(d) Thermal radiation.

These environments are defined in AEP 4.

4. SINGLE FAULT FAILURE.

a. No single fault or failure shall result in the unintentional firing of the weapon, or in it becoming unsafe.

b. A Fault Tree Analysis (FTA) and a Failure Modes Effects and Criticality Analysis (FMECA) should be completed for assessment against the safety principles for all modes of operation of the ordnance and all envisaged natures of ammunition.

5. PROOF. All ordnance manufactured for service use, including attachments, must be proof fired before issue to service, except where the user nation has agreed a proof regime based on sampling, statistical and engineering analysis and design authority expertise,

BARREL ASSEMBLY

6. PRESSURE.

a. The barrel shall be capable of sustaining safely the full range of pressures to which it may be subjected during its service life. The ordnance Cannon Design Pressure (DP), defined as that pressure which should not be exceeded statistically by more than one round in 10^6 rounds , shall be greater than the highest chamber pressure anticipated for Extreme Service Conditions Pressure (ESCP) as defined in STANAG 4110, Annex A.

b. The ability of the barrel to withstand safely any pressure to which it may be subjected by the specified ammunition natures is to be assessed against the criteria in STANAG 4110. All barrels shall be subjected to either pressure proof or assessment as per paragraph 5.

Proof stamping and certification should allow differentiation in methodologies to be identified. The maximum proof pressure shall be the Cannon DP. The minimum proof pressure shall be the Cannon Permissible Maximum Pressure (Cannon PMP) and the range from maximum to minimum proof pressure shall be 1.75 standard deviations (sd). If it is necessary to increase this range, then the minimum proof pressure production tolerance should be lowered and the Cannon PMP reduced accordingly.

7. LIFE.

a. The barrel of an ordnance is to be safe to fire throughout its intended service life. The safe life of the barrel is defined by 2 principal factors; wear and fatigue.

b. The barrel safe life is to be established both for wear and fatigue, and the lesser, and therefore safer, value is to be taken as the safe service life.

(1) The wear life of the barrel is to be established to identify the limits that could result in instability, inaccuracy, inconsistency or unsafe performance of projectiles (see Appendix 2 to Annex C).

(2) Unless it is evident that wear is the limiting factor, the fatigue life of a barrel shall be established for all natures of ammunition that it is intended to use with the ordnance (see Appendix 3 to Annex C).

(3) Wear taking the form of channel, or guttering, erosion that does not affect projectile stability may cause a reduction in the residual fatigue life. The declared service safe life may be limited to a set depth of erosion which is shown to leave a safe margin of residual fatigue life.

8. PROJECTILE STABILITY.

The barrel internal configuration shall ensure that projectiles remain safe, stable, accurate and consistent, for all natures of specified ammunition. The barrel should be tested or assessed over the operational range of the system.

9. FALL BACK.

General. The interface configuration between chamber and ammunition shall ensure that no projectile falls back out of its seating, at any angle of elevation, between the action of loading and exiting the barrel by firing. To reduce the risk of fall back to a minimum, the following shall be taken into account during design and development:

a. The configuration of the chamber must be compatible with the projectile. In particular the taper of the forcing cone at the forward end of the chamber shall match the leading edge of the driving band on the projectile. Additionally, the relative dimensions of chamber and projectile shall be such that it is not possible for the projectile to be impeded before the driving band can be gripped by the forcing cone.

b. When a follow through power ramming mechanism is used, the axis of the ram must coincide with the axis of the bore, and the rammer head must remain in firm contact with the base of the projectile as it drives the projectile into its seating.

c. When flick ramming is used, it is critically important that the loading tray is accurately aligned with the axis of the chamber. The shell shall be rammed with sufficient velocity to guarantee an adequate retention force.

d. When hand ramming is in operation, with or without the use of a stave, contact between hands and the equipment should be prevented when ramming at any angle of elevation and traverse.

10. NOISE AND BLAST.

a. The blast overpressure in the vicinity of crew members, or locations likely to be occupied by other adjacent personnel, shall be within declared national limits.

b. Noise and blast produced at each crew position by an ordnance, in each mode of operation, and with each nature of ammunition specified, shall be assessed or tested. Exposure and duration limits for noise and blast promulgated by national safety authorities shall be used.

11. BARREL ATTACHMENTS.

a. Barrel attachments (fume extractors and muzzle brakes etc.) shall withstand the forces of firing, recoil and interaction with a projectile, sabots/pushers etc., both during shot-travel and exiting the bore, and function safely.

b. The safe functioning of any barrel attachments shall be assessed or tested in each mode of operation of the ordnance and with each nature of ammunition specified. They shall be subject to proof firing.

BREECH ASSEMBLY DEVICES

12. SEALING AND OBTURATION.

General. The breech and obturating mechanism shall be designed, in conjunction with the ammunition, to ensure effective obturation. The sealing and obturation of the weapon system shall be assessed against the technical description provided by the developing nation or tested as necessary to ensure that:

a. Firing does not take place unless the round is fully chambered and the breech block is correctly positioned and locked.

b. The breech block and obturation device shall not unlock or unseal the chamber until the projectile has left the barrel, the residual gas pressure has vented and noxious gases have been evacuated, unless appropriate devices are incorporated to ensure no hazard to the crew or damage to the weapon occurs.

c. It shall not be possible to assemble any component of the breech and obturating assembly in an incorrect manner and be able to fire the weapon.

d. There shall be no ability for the breech and obturation system to unlock due to vibration.

e. Satisfactory obturation shall be achieved under all environmental conditions including adverse conditions (eg. wet or oily ammunition, icy conditions).

f. It shall be possible to manually close the breech quickly from outside the path of recoil.

g. It must be possible to operate the Lever Breech Mechanism (LBM) by hand outside the path of recoil.

h. When the LBM is used to open the breech, the firing mechanism shall automatically be rendered inactive before the breech is unlocked from the closed position.

i. In a remotely operated system, such as a naval gun, there should be a method of indication of the position of the breech block.

j. Obturation systems should include a 2 stage failure mode such that the likelihood of failure is physically indicated and further firing prevented.

13. LIFE.

a. The breech block, ring and obturating devices shall operate safely for their full declared safe service life and in all environmental conditions.

b. The safe service life of the breech ring, block and obturating devices must be established for fatigue and, where appropriate, wear.

LOADING AND EXTRACTION MECHANISM

14. LOADING/EXTRACTION OPERATION.

a. The ordnance loading and extraction mechanisms for both main rounds and tube initiators shall not cause damage to the ammunition being cycled in the weapon that will result in a hazard or unsatisfactory functioning of either the weapon or ammunition.

b. Safe operation of the loading and extraction system shall be demonstrated or assessed for each mode of operation of the ordnance and for each ammunition nature. Dry cycling tests shall be included in preliminary safety trials. There shall be a method of indicating whether a primer tube has, or has not, been loaded.

15. DOUBLE LOADING.

a. The ordnance loading and extraction mechanisms should not permit the loading of a round into an already occupied chamber.

b. The design features used to prevent double loading shall be subject to analysis (eg. FMECA) to verify their effectiveness. Feed mechanism failures shall be artificially induced to assess any potential hazard.

16. UNLOADING.

a. The ordnance loading and extraction mechanism shall enable unloading of ammunition from the ordnance without hazard to the crew, ship or vehicle.

b. Safe unloading shall be demonstrated with all natures of ammunition and in all potentially applicable ordnance states. For the primer tube in particular:

(1) Primer tube loaders should allow the ejection and reloading of primer tubes without opening the breech mechanism and without the operator entering the path of recoil.

(2) Primer tube ejection shall be such that the velocity of ejection, particularly of hot tubes, does not cause a hazard to crew or equipment, in particular to explosive items in the vicinity of the breech.

FIRING MECHANISM/FIRING CIRCUITS

17. GENERAL.

a. The firing mechanism must be safe to use. It should not be possible to fire the ordnance unless the breech is fully closed and locked, before the ordnance is fully run out, or with safety switches set to “SAFE”.

b. The act of firing the ordnance must require a positive manual act. The firing circuits and mechanisms shall be so designed that they cannot apply the firing impulse, be it electrical or percussion, unless the breech and obturating mechanisms are fully and safely closed, the ordnance fully run out, and without safety switches set to "FIRE".

c. When the mechanism is set to “SAFE” there should be a minimum of two, mechanical or electrical, independent safety breaks fitted to prevent accidental operation.

18. FIRING MECHANISM OPERATION

a. The firing mechanism shall be a lanyard, lever, switch, button or pedal which requires a positive manual activity to operate. A switch, button or pedal should be protected from inadvertent application.

b. The operator must only be able to operate the firing mechanism while outside the path of recoil of the ordnance.

c. Any sear mechanism used in the firing train shall be designed to withstand the mechanical environment likely to be seen in its installation and shall be resistant to erosion or wear caused by constant metal to metal abrasive contact.

d. In the case of a percussion firing system it shall be possible to re-cock the firing mechanism without unsealing the breech obturation. Operation of any re-cocking device shall be from outside the path of recoil of the ordnance.

19. VIBRATION AND SHOCK.

a. firing mechanism, whether cocked or un-cocked, shall not function inadvertently as the result of vibration, shock or any single mode of failure.

b. effect of vibration and shock likely to be experienced by the weapon system (including underwater shock for naval mountings and gun shock) shall be assessed to determine the probability of inadvertent operation of the firing mechanism. If a significant probability of inadvertent operation exists then the firing mechanism shall be subjected to a safety test (see Annex B) with possible redesign as a consequence.

20. ELECTRICAL/ELECTRONIC SAFETY.

General. The design of firing circuits and electronic gun control units shall ensure that no single fault or failure of any nature can result in the inadvertent firing of a round.

a. The electrical design shall be assessed using FTA, FMECA or other structured analysis technique for component or sub-system failure or its consequences. Environmental effects shall also be examined including the effect of conducted and radiated electromagnetic interference on the firing circuits and electronic gun control units. Tests, if appropriate, shall be made to ensure that a satisfactory degree of immunity to inadvertent operation or firing is demonstrated. Appropriate levels and tests identified in national documents shall be used, but the assessment shall also identify the immunity against the environments defined in STANAG 4234 and STANAG 1307 where relevant.

b. It shall not be possible for the needle in the firing mechanism to come into contact with the base of the primer, or to be in an "armed/energised" condition, until the breech is fully closed and locked.

21. ELECTRO EXPLOSIVE DEVICE (EED) SAFETY.

a. When an ordnance which fires electrically ignited ammunition is exposed to the specified electromagnetic environment, it shall not induce a level of electromagnetic energy into the firing circuit which would encroach upon a defined safe margin below the established No-Fire Threshold (NFT) energy level of the EED.

b. Where EED are used in the natures of ammunition in an ordnance, the NFT for each nature shall be established by the developing nation to the 0.1% power energy level at 95% single sided lower level of confidence. The safe margin below the established NFT which the firing circuit achieves shall be determined in accordance with the guidance provided by national authorities. If a significant probability of operation is assessed as existing then the circuit shall be subjected to a safety test (Annex C).

22. APPLIED SAFETY.

a. It shall be possible to interrupt the method of firing using a sequence of drill, as laid down in the appropriate gun drill book, without destroying the obturation seal.

b. There must be a lever or switch, outside the path of recoil of the ordnance , that can prevent the firing of the ordnance when fully loaded. With percussion firing mechanisms the restraint must be applied to the firing pin itself. With electrical firing mechanisms the switch must interrupt the firing circuit. The lever or switch should be marked "SAFE" and "FIRE".

SAFETY MECHANISM/DEVICE

23. SAFETY INTERLOCKS.

General. Safety mechanisms/devices shall be provided to prevent the unintentional firing of an ordnance weapon system. The ability of the safety mechanisms/devices to prevent the unintentional firing of the ordnance shall be tested or assessed in all appropriate modes of the ordnance.

a. For mechanically operated percussion firing mechanisms a device should normally provide a mechanical interlock that would prevent the cartridge primer being struck.

b. For electrically operated firing mechanisms, at least 2 independent safety switches, connected in series between the EED and its source of firing power should be provided. All switches controlling the initiation of an EED should be designed so that it is possible to return them to their open circuit condition, in the event of a misfire or cancellation of the firing, so that the required level of safety can be restored. The detailed assessment of the safety of firing and safety switches circuits shall be conducted in accordance with national safety documentation.

(Intentionally Blank)

SAFETY AND SUITABILITY ASSESSMENTS – ORDNANCE

1. FLASH CHANNEL EROSION.

a. Reason for Assessment. To ensure that ignition performance and fatigue life of the breech are not degraded.

b. Information. Where initiation occurs by primer tube through a flash channel in the breech, the erosion of the channel can affect both the ignition performance and the fatigue life of the breech component.

c. Assessment Procedure. A sample of breeches is to be monitored through development for measurement of flash channel erosion and the developer shall declare the maximum depth permissible. Where applicable, the breech components used in the life assessment fatigue trials should reflect the effect of maximum acceptable erosion.

2. OBTURATION LIFE.

a. Reason for Assessment. To ensure that no obturation failures occur during the stated life of the obturation system.

b. Information. The assessment of the obturation system will be based on a study of the design of the components, the safety features (Annex A, Paragraphs 12 and 13) and results of the firing trials at Appendix 1 to Annex C. With a manned equipment, the obturation system would be provisionally assessed as safe if no gas leaks occurred and no deterioration was apparent in the components during the firing of the stated number of rounds at the extremes of temperature and pressure detailed in the trials specification. A full assessment involving reliability can only be made after prolonged firing including all charges to be used in the system.

c. Assessment Procedure. A sample number of 10 obturator sets should be monitored during development firing to establish the maximum number of rounds that it is safe to fire.

3. FIRING MECHANISM LIFE.

a. Reason for Assessment. To establish, ideally, that the life of the firing mechanism is equal to or greater than the declared life for the breech and breech ring. Should this prove not to be the case, to establish a safe inspection and repair regime.

b. Information. Where mechanical means are used in the firing of the gun, it must be established that wear or fatigue of any component of the mechanism will not lead to an unsafe condition occurring.

c. Assessment Procedure. A sample number of firing mechanisms should be monitored during development firing. At intervals specified by the developer the components should be inspected and measured for wear and non-destructively tested for fatigue.

4. SAFE OPERATION BREECH LOCKING.

a. Reason for Assessment. To ensure that breech locking mechanisms function correctly during the life cycle of the breech.

b. Information. A safety assessment shall be carried out to verify that the design principle of a positive breech lock has been applied.

c. Assessment Procedure. Prior to any firing trials, the breech mechanism will be subjected to dry cycling to demonstrate its safety in relation to design safety features (Annex A, Paragraph 12). Evidence of satisfactory performance and reliability must be obtained from other firing trials carried out during development.

5. SAFETY INTERLOCKS TEST.

a. Reason for Assessment. To ensure that firing mechanism safety interlocks function correctly during the life cycle of the firing mechanism.

b. Information. A safety assessment shall be carried out to verify that design safety principles for the firing mechanism safety interlocks have been applied.

c. Assessment Procedure. Prior to any firing trials, the firing mechanism/firing circuits will be subjected to dry cycling to demonstrate the safety of the interlocks in relation to design safety features (Annex A, Paragraph 22). Evidence of satisfactory performance and reliability must be obtained from other firing trials carried out during development.

6. EXTRACTION.

a. Reason for Assessment. To ensure that cartridge cases or primers when extracted from the breech, whether live or spent, do not cause a hazard to the crew or equipment.

b. Information. Live cartridge cases or primers must be able to be removed from the breech under control. The potential for spent items, particularly when hot, to ricochet off the breech or adjacent components should be minimised in the design. Ejection of stub cartridge case primers or primer tubes must not hazard the crew or be able to ignite other propelling charges.

c. Assessment Procedure. Until such time as an appropriate STANAG is ratified the assessment is to be conducted in accordance with national procedures.

7. OPERATION OUTSIDE RECOIL.

a. Reason for Assessment. To establish that the breech operator(s) remain safe during all operations of the breech.

b. Information. It must be possible to fire the gun, re-cock the firing mechanism, operate any applied safety device, open and close the breech and load and unload primers, without any part of the body, other than an arm, being in the path of recoil. The action of recoil should throw an arm clear rather than drag the remainder of the body into the path of recoil.

c. Assessment Procedure. Prior to any manned firing trials the breech mechanism will be subjected to dry cycling to demonstrate the safety of the drills and procedures used during breech operations in relation to design safety features (Annex A, Paragraphs 12, 14, 16 and 17). Evidence of safe operation of the breech must be monitored and documented during all development firing trials conducted. National procedures are to be used.

8. RANGE SAFETY.

a. Reason for Assessment. To identify the extent of the hazards produced by firing the ordnance. These measurements will be applied to the establishment of the Weapon Danger Area (WDA) and Noise/Toxicity hazard areas.

b. Information. The assessment is required to identify the dimensions of the WDA and hazard areas for land ranges, training areas and sea firings. Further information on the WDA may be sought from STANAG 2401, currently in draft form, when it is ratified. The following information on ballistic performance for Range Tables will be required:

(1) Burst safety distance (explosively filled projectiles).

(2) Ricochet danger area (inert and explosive projectiles).

(3) Levels of toxic contaminants (for range installation).

(4) Impulse Noise/Muzzle Blast Overpressure (MBO) data.

(5) Minimum arming distance, for all types of shell/fuze in use.

(6) The behaviour of any breakaway parts of projectiles, such as sabots, petals, after exiting the bore.

c. Assessment Procedure. The assessment shall be conducted in accordance with national procedures until STANAG 2401, currently in draft form, is ratified.

SAFETY AND SUITABILITY TESTS - ORDNANCE

Appendices:

1 - Obturation Test Procedures.
2 - Barrel Wear Test Procedures.
3 - Fatigue Test Procedures.
4 - Follow Through and Hand Ramming Test Procedures.
5 - Flick Ramming Upper and Lower Threshold Test Procedures.
6 - Flash Back Test Procedures.

STRENGTH OF DESIGN (SOD) TESTS

1. BARREL/BREECH SOD.

   a. Reason for Test. The strength of the ordnance must be demonstrated to show that it will remain safe up to its Design Pressure (DP).

   b. Information. The ordnance, in its final design configuration complete with all attachments, is to be fired under precautions with ammunition prepared to produce Cannon DP. When ammunition is being developed either independently, or in conjunction with the cannon/tube/barrel, sufficient evidence from any projectile SOD testing conducted at Cannon DP may preclude requirement for such firings.

   c. Test Procedure. Until such time as an appropriate appendix is developed for this STANAG, the test shall be conducted in accordance with national procedures.

2. OBTURATION TESTS.

   a. Reason for Test. The safe obturation of the ordnance chamber/pressure vessel during firing is to be demonstrated for all envisaged environmental and operationally induced conditions.

   b. Information. The ordnance is to be fired “under precautions” to test obturation and freedom from flashback. The test should be carried out at the highest envisaged service induced temperature, at the lowest envisaged environmentally induced temperature, and in dry, wet and oily and sand/dust induced conditions. Both new and fatigued obturating mechanisms should be used. Rounds which provide both highest and lowest incremental service chamber pressures should be used.

   c. Test Procedure. See Appendix 1.

3. TRUNNION, BUFFERS AND RECOIL.

a. Reason for Test. Where the trunnion, buffer or recoil system is new, or greater firing forces than previously tested are envisaged, for example during projectile development, it shall be demonstrated to be safe at the maximum recoil forces expected from the ordnance and with its ammunition at upper and lower temperature extremes. Where semi-automatic breech opening is employed, the recoil system is to be tested at low temperature low charge firings (or the round producing the lowest trunnion pull) to ascertain that sufficient energy remains to open the breech.

b. Information. The recoil system forms an integral part of any ordnance system. The complete elevating mass should be tested as early as possible in the development of the ordnance.

c. Test Procedure. Until such time as an appropriate appendix is developed for this STANAG, the test shall be conducted in accordance with national procedures.

4. PROOF.

a. Reason for Test. All ordnance to be issued for manned firing must be subjected to proof firing prior to issue (See Annex A, Paragraph 5.) except where a waiver exists for a particular ordnance.

b. Information. Proof firing normally uses special proof rounds which generate a chamber pressure with a space time curve emulating that of the service charge being fired at Extreme Service Conditions Pressure (ESCP), but designed also to produce a peak pressure in the proof pressure band between Cannon PMP and Cannon DP.

c. Test Procedure. Until such time as an appropriate appendix is developed for this STANAG the proof shall be conducted in accordance with national procedures. The proof is to include all the ordnance complete with any components which may be subject to the pressures and shock of firing.

LIFE ASSESSMENT TESTS

5. BARREL.

a. Reason for Test. It is necessary to determine the service life, in terms of number of rounds fired, during which a barrel and its attachments, such as fume extractor and muzzle brake, will remain safe and suitable for service.

b. Information. The service life of a tube/barrel can be limited by firing damage to the interior surface of the tube/barrel, particularly erosion of the metal of the bore surface, known collectively as wear or by fatigue to the complete tube/barrel structure. Service life for a tube/barrel, in both cases, can be more easily expressed in terms of the number of equivalent-full-charge (EFC) rounds, currently estimated from a mixture of firing trials and hydraulic cycling trials, that any tubes/barrels of the same build standard could sustain before an unsafe condition might occur. When many projectiles of differing natures are fired through a tube/barrel the following conditions may occur:

(1) Wear caused by excessive firing damage to the bore surface. The intense heat and pressure generated by the ignition of propellant within the chamber coupled with the resultant rapid movement of the projectile may cause damage to the bore surface of the tube/barrel such as:

(a) Erosion of the steel.

(b) Interruption of the rifling in rifled tubes/barrels.

(c) Loss or damage of chrome or other plating.

Such wear damage can ultimately cause a decrease in both projectile velocity and chamber pressure resulting in a greater dispersion in fall of shot. This is more marked in rifled tubes/barrels where driving bands might shear as they engage in the rifling. It should be noted that whereas these symptoms are considered as a safety hazard in indirect fire systems they are more likely to be regarded as reliability or performance failures in direct fire systems. Safety hazards to be detected during wear testing conducted on direct fire systems include projectile failures which result in in-bore detonation or mechanical damage to the bore.

(2) Fatigue caused by excessive metal fatigue to the components of a tube/barrel. Most modern propellants incorporate wear-reducing additives, such as titanium dioxide, which have the effect of substantially reducing tube/barrel damage resulting in enhancement of tube/barrel life. This means that excessive metal fatigue, which ultimately leads to tubes/barrels being in an unsafe condition, is becoming the dominant limiting factor, rather than firing damage, relative to the service life of tubes/barrels. Each firing of the weapon contributes to metal fatigue of the tube/barrel which could eventually cause catastrophic failure. It is essential to establish a margin of safety to ensure that such a catastrophic failure cannot occur. Where tube/barrel bores are plated, for instance with chromium, it is equally essential to understand that erosive wear, in the form of a channel or guttering, may not be seen to affect projectile stability but may

however effect the residual fatigue life of that tube/barrel. It is necessary to establish the number of rounds that cause such channel erosion to commence, the subsequent rate of erosion and to demonstrate that the residual fatigue life of any tube/barrel exhibiting maximum erosion still provides a sufficient margin of safety.

c. Test Procedure.

(1) See Appendix 2.

6. BREECH COMPONENTS FATIGUE TESTS.

a. Reason for Test. It is necessary to demonstrate the safe fatigue life of the breech ring and block.

b. Information. The service life of breech mechanisms is pre-dominantly limited by metal fatigue. Erosion or other surface firing damage is typically not a limiting factor for breech mechanisms. Service life for the breech mechanism can be expressed in terms of the number of EFC rounds that can be fired before an unsafe condition could develop.

c. Test Procedure. Two breech assemblies are first subjected to firing and then pressure cycled to destruction. The initial safe fatigue life is taken as 1/3 of the lower of the test results allowing development trials to proceed. On completion of testing, as they become available, on a further four assemblies, statistical analysis of results from all six assemblies allows a final safe fatigue life to be declared as described at Appendix 3.

7. ELECTRICAL SAFETY TESTS.

a. Reason for Test. To ensure that electrical firing circuits are not susceptible to induced or conducted currents arising from other electrical installations on the parent or adjacent weapon platforms which could cause the gun to fire inadvertently.

b. Information. The tests are only applicable to gun systems containing electrical circuits which influence safety and suitability for service. Environments appropriate for use in tests are described in STANAGs 1307, 4234, 4235 and 4236.

c. Test Procedure. Tests which may be required are:

(1) Transient Test. All electrical switching sequences within the weapon system are to be operated and the effect recorded. Such measurements are best made using test equipment that simulates an electro-explosive device (EED) in its electrical properties but has no explosive content.

(2) Internal Radiation Hazard (RADHAZ). The operational EED in the ignition system is replaced with an inert, instrumented device which measures the level of induced power. All internal rf sources are then operated in turn or together to a set plan representative of the worst operational combination and all likely frequency variations. Where practicable, power is enhanced by 6 dB to allow for equipment variations.

(3) External RADHAZ. Using the instrumented device, likely combinations of external radio and radar transmitters are operated to a set plan and the results recorded. Levels may be extrapolated to give the worst case, except for electronic circuits which may be non-linear. In such cases, a higher level can be simulated by use of the current injection and measurement techniques. The tests shall be conducted in accordance with STANAG 4324 or national procedures.

(4) Electrostatic. If required, the test shall be conducted in accordance with STANAG 4239 and AOP 24.

(5) Lightning. The test shall be conducted in accordance with STANAG 4327 and AOP 25.

8. VIBRATION AND SHOCK.

a. Reason for Test. This test is conducted to demonstrate that the ordnance will not function unintentionally whilst being subjected to anticipated service vibration and shock regimes, and will remain safe and serviceable afterwards.

b. Information. The real environment is a mixture of random and sinusoidal vibration. Mountings in ships will experience a dominant sinusoidal component at specific low frequencies, whereas random vibration is more significant in fighting vehicles. Track vibration, sometimes described as “patter”, is mainly random in nature but may have specific peak sine vibration at discrete frequencies. The action of the ordnance will be exposed to significant and repetitive gun shocks during firing. The type of vibration testing selected must be chosen from the worst cases identified from the life cycle specified. It may be necessary to carry out the selected vibration tests at appropriate high and/or low temperatures associated with specified areas for operational deployment. The service environment vibration needs to be measured both at the point of mounting of the ordnance and at the breech. This is most easily done using one ordnance, or prototype, mounted in the intended vehicle/ship.

c. Test Procedure. Tests shall be conducted in accordance with AECTP 400 - Methods 401 and 403, using data gathered from the appropriate platforms.

9. UNDERWATER SHOCK.

a. Reason for Test. These tests are conducted to demonstrate that the ordnance, when installed in a naval or merchant vessel and subjected to the shock of underwater explosion, will not function unintentionally, and where appropriate will remain safe and suitable for service after the shock.

b. Information. There are 2 levels of severity of test:

(1) For the level pertaining to survival of the vessel, the ordnance is required not to function unintentionally and any associated ammunition is required to remain safe for handling and disposal.

(2) For the level pertaining to Survival for Service Use, the ordnance and any associated ammunition must remain safe and serviceable. The Survival for Service Use test is to be conducted as part of the sequential trial.

The shock levels will vary according to the class of ship, location of the mounting and any associated ammunition magazine/stowage.

c. Test Procedure. Until such time as an appropriate STANAG is ratified the tests shall be conducted in accordance with national procedures.

10. LOADING.

a. Reason for Test. To ensure that the loading method employed is safe and suitable for service and to reduce the risk of fall-back to a minimum.

b. Information. Loading with fixed or semi-fixed ammunition generally causes few loading problems. With separately loaded ammunition however, all aspects of the loading sequence are tested from ramming the projectile, loading the cartridge case or charge bag to loading the percussion, or electric primer.

c. Test Procedure.

(1) Ramming the Projectile. See "Fall-back" tests at Paragraph 11.

(2) Loading the Cartridge Case or Charge Bag. National procedures are to be used. When ammunition is being developed either independently, or in conjunction with the cannon/tube/barrel, sufficient evidence from any projectile SOD testing conducted at Cannon DP may preclude requirement for such a test.

(3) Loading the Primer. National procedures are to be used. When ammunition is being developed either independently, or in conjunction with the cannon/tube/barrel, sufficient evidence from any projectile SOD testing conducted at Cannon DP may preclude requirement for such a test.

11. FALL-BACK.

a. Reason for Test.

(1) Hand and Follow Through Power Ramming. To establish the mean retention force and determine whether fall-back is likely to occur in service.

(2) Flick Ramming. To establish that a flick rammer has a sufficient margin of safety at the upper and lower thresholds such that projectile which have been flick rammed have a negligible risk of damage or fall-back.

b. Information. As, potentially, fall-back can cause premature explosion in the bore, trials are required to establish the degree of risk involved in both power ramming, in follow- through and flick modes, and hand ramming. In these trials, the force required to eject a projectile which has been correctly rammed is measured by a load cell or other device. The ejection force is assumed to be the same as the retention force holding the projectile in the rammed, seated, position. Flick rammed projectile subjected to too high velocity of ram may sustain filling, cargo, sub-components or fuze damage. Trials to establish the margin of safety (upper threshold) are required. Other trials are necessary to ensure that rammed, correctly seated projectiles do not become dislodged during laying drills, movement (in the case of tanks when loaded in readiness for engagement) or as a result of any operational vibration.

c. Test Procedures.

(1) Follow through and hand ramming fall-back trials - see Appendix 4.

(2) Flick ramming upper and lower threshold trials - see Appendix 5.

(3) During development, trials should be performed on at least 4 prototypes to ensure that the results obtained are representative of service equipment. After introduction into service, the trials should be repeated when any replacement, change, modification or condition of the ordnance or its associated attachments or ammunition system, as listed below, occurs:

(a) Barrel .

(b) Chamber.

(c) Rammer system.

(d) Barrel wear exceeds declared second quarter of life parameters.

(e) Projectile or fuze.

12. FLASH BACK.

a. Reason for Test. To determine whether any flash back occurs and to determine the duration and extent of any such flash.

b. Information. A flash back caused through poor obturation, premature breech mechanism opening, or re-ignition of unburnt propellant gases on exposure to additional oxygen as the breech opens, could hazard crews and other propelling charges. All firing conducted during development, obturation testing, and initial firing of the ordnance in a turret are occasions that must be monitored and documented with regard to flash-back. The ordnance should be fired complete with all its ancillary equipment fitted and, if applicable, utilising automatic breech opening mechanisms. High speed cine/video should be used to monitor specific firings.

c. Test Procedure. See Appendix 6.

13. BLAST/NOISE.

a. Reason for Test. To determine firing impulse noise at internal and external crew positions of an Armoured Fighting Vehicle (AFV), Self-Propelled (SP) or towed gun, naval turret and in the immediate vicinity, so that the physiological effects on crew and other personnel can be assessed.

b. Information. The muzzle blast produced on firing may both have a harmful effect on personnel and cause damage to equipment. The main hazard for personnel is loss of hearing, although high levels of muzzle blast may cause injury to organs other than the ear. Regarding equipment, muzzle blast may damage fitments, for example optics, on, or in the vicinity of, an installation thereby degrading operational effectiveness. Should such equipment breakaway at velocity a hazard to personnel may occur. The likelihood of such events must be tested with worst case rounds before manned firing takes place. In general, the intensity of muzzle blast at any particular point depends on distance from the muzzle and on the muzzle pressure developed by the charge. More powerful charges produce greater muzzle pressures, while personnel stationed nearer the muzzle (unless shielded from the blast) are in greater danger than those further away. An efficient muzzle brake increases the level of blast overpressure at and around the gun, in comparison to a low efficiency muzzle brake, or where no muzzle brake is fitted. Shock waves reflected from surfaces surrounding an installation, may increase the intensity of muzzle blast. These factors should be considered during the design stage with particular emphasis on installations used in confined spaces.

c. Test Procedure. Trials are needed during development to establish the pattern of muzzle blast overpressure in the immediate vicinity of the gun using blast gauges placed at the positions to be occupied by the crew and any other operational personnel. The peak overpressure is to be measured at each gauge position for each round fired. The siting of the blast gauges and the trial arrangements will depend on the type of weapon system and its intended method of use. The muzzle blast produced by the maximum charge, as representative of the worst case, is usually measured. Lower charges may also have to be fired. Assessment may conclude that the effects of muzzle blast on personnel and/or equipment are too severe. This may cause the charge or muzzle brake to have to be modified, or other design changes to be made to the weapon system. For this reason, muzzle blast trials and their assessment should take place as early as possible in development. Until such time as an appropriate appendix to this STANAG is developed the test is to be conducted in accordance with national test procedures.

14. COOK-OFF.

a. Reason for Test. This test is conducted to establish the conditions under which cook-off may occur and therefore the operational limitations of the ordnance.

b. Information. The cook-off temperatures and the dwell time for all natures of ammunition used in the ordnance shall be established before this test. The temperature gradient between the outside and inside of the chamber, obtained by experiment if necessary, must be known. The ordnance is fired at the maximum rate and duration of sustained fire laid down by the developing nation. The temperature of the ordnance is monitored continuously during firing by means of thermocouples attached to the outside of the barrel. If the external reading indicates the chamber may have reached the cook-off temperature threshold, firing is to cease immediately, leaving the gun empty. Immediately after firing ceases, the temperature of the chamber is to be measured to confirm that the cook-off threshold was reached. If the cook-off temperature threshold is reached before the required rates and duration of fire are achieved, slower rates and/or shorter duration will be recommended to ensure safety. Alternatively, for artillery systems, a reduced level of charge having a lower heat input may be recommended for the required rates and duration.

c. Test Procedures. Until such time as an appropriate appendix to this STANAG is developed the test shall be conducted in accordance with national procedures.

OBTURATION TEST PROCEDURES

1. COLD FIRING TRIAL.

a. Aim. The aim of this trial is to establish whether the obturation system is safe and reliable in conditions of extreme cold and must be conducted under the cold climatic conditions specified for the weapon system.

b. Ordnance. The breech is to be conditioned for 24 hours to the lowest temperature at which the ordnance is required to function. Obturator components for pad or metal obturation may be cooled either separately or together with the breech. The breech temperature must be re-established after each series (Sub-Paragraph 1.c) has been fired.

c. Ammunition. Twelve rounds at the lowest service charge, 12 rounds at the top service charge and 12 rounds at the charge producing the highest rate of rise of pressure are to be fired in series of 3 rounds each. All charges and fixed ammunition are to be conditioned to the Lower Firing Temperature (LFT). Projectiles may be fired at ambient temperature.

d. Sample Size. For cartridge or stub case obturation systems, every fired round provides an obturator test and the sample size is therefore the total of all rounds fired. Pad and metal obturation systems require a sample of 4 sets of components (2 new and 2 at, or beyond, half life) to be tested. The ammunition is to be allotted so that each set of components experiences one series of 3 rounds with the both the lowest charge, top charge, and the charge producing the highest rate of rise of pressure.

e. Observations. The following are required:

(1) Visual observation and/or video recording of the breech during firing.

(2) Colour high speed cine, and/or video photography of the complete breech action during firing, recoil and run out. Turret mounted ordnance require at least 2 cameras.

(3) Chamber pressure for each round.

(4) Chamber temperature at the start of each series.

(5) Ambient temperature for each series.

(6) Charge temperature, type of charge and propellant lot numbers.

f. Inspection. For cartridge or stub case obturation, a visual inspection of the case is to be made after each round. For pad or metal obturation, a visual inspection only is to be made after each round without dismantling the components, and a full visual and dimensional examination made at the end of the series.

2. HOT FIRING TRIAL.

a. Aim. The aim of this trial is to establish whether the obturation system is safe and reliable when the complete ordnance is hot and is firing the top service charge subjected to the hottest of the climatic conditions specified for the weapon system.

b. Ordnance. The ordnance is to be conditioned to the top temperature achieved with the most extreme duty cycle specified either by sustained firing or by pre-heating, as convenient. This temperature is to be maintained during the trial series of rounds (Sub-Paragraph 2.c.) by firing at an appropriate rate.

c. Ammunition. Four series of 5 rounds are to be fired with the top service charge conditioned to the Upper Firing Temperature (UFT). Projectiles may be fired at ambient temperature.

d. Sample Size. For cartridge or stub case obturation systems, the sample size is the total of all rounds fired. For pad and metal obturation systems, a sample of 4 sets of components (2 new and 2 at or beyond half life) are to be tested; the ammunition is to be allotted so that each set of components experiences one series of 5 rounds.

e. Observations and Inspection. To be the same as for the Cold Firing Trial (Sub-Paragraphs 1.e. and f.).

3. ADVERSE SERVICE CONDITIONS TRIAL.

a. Aim. The aim of this trial is to establish whether the obturation system will be safe and reliable under typical adverse conditions expected in a normal service environment, namely contamination by oil, rain, sea water, dust and sand.

b. Conditions. For this trial, the adverse service conditions are to be created artificially to a standard agreed with the developer nation. Where appropriate, test conditions from STANAG 2895 should be used. This enables assessment to be based on specific conditions as opposed to those which would be encountered randomly in natural climatic and other trials of the weapon system. The obturation system is to be tested under each of the following separate conditions:

(1) Oily, representing excessive oiling of the barrel and breech during crew maintenance.

(2) Wet and oily, representing ingress of rain or sea water on lightly oiled breech components.

(3) Dust and sand, representing typical operations in a dry environment.

c. Ordnance. An ordnance in its first quarter of life is to be used for the trial. It is to be fired at ambient temperature. For pad and metal obturation systems, 2 sets of serviceable obturator components are to be tested.

d. Ammunition. Top service charges conditioned to the UFT are to be fired. Projectiles may be fired at ambient temperature. The rounds are to be fired as follows:

(1) For cartridge or stub case obturation systems, 5 rounds are to be fired under each of the 3 conditions. The ordnance is to be re-conditioned (Sub-Paragraph 3.b.) after each round is fired.

(2) For pad and metal obturation systems, each set of obturator components is to experience a 5 round series under each of the 3 conditions. The ordnance is to be re-conditioned (Sub-Paragraph 3.b.) after each round is fired.

e. Observations and Inspection. To be the same as for the Cold Firing Trial (Sub-Paragraphs 1.e. and f.).

4. DURABILITY. The durability and safe functioning of the obturation system with all charges at sustained and burst rates of fire is to be assessed using data from all development firings. Any special trials that may be required will depend on the type of obturation and the kind of weapon system under assessment. From prolonged firing trials, evidence, from statistically significant firing samples only, should be used to demonstrate that the obturation system adequately matches the durability of other components in the complete weapon system.

5. SIGNS OF FAULTY OBTURATION. A serious (or critical) obturation failure is easily recognised by a bright jet of flame from the breech. Gas leaks can be detected photographically, or sometimes visually, aided by smell. Other signs of weakness and impending failure can be found from examining the obturating components. The following signs should be looked for:

a. Cartridge Case Obturation.

(1) Cracking of the base, longitudinally along, or on the lip of, the case.

(2) Distortion of the case due to gas penetrating between the case and the chamber wall.

(3) Distortion of the primer housing (sometimes known as set-back) or evidence of gaswash in its vicinity.

(4) Soot deposits on the outside of the case.

(5) Erosion at the mouth of the case.

b. Pad Obturation. Any lifting or "nibbling" of the fibrous pad, especially near the joins between the metal segments, or erosion/damage of the pad or scarfe rings.

c. Metal Obturation. Gaswash on the obturator ring matched by corresponding gaswash on the mating surface of the breech block insert. This aspect is amplified in Paragraph 6.

6. GASWASH IN METAL OBTURATORS. Gaswash varies between a small surface discoloration and a hole burned right through the obturator ring. In the latter case, the breech block insert (not visible until the breech block is dismantled) will also be severely damaged, and the gas seal will have failed completely. Gaswash can be started by the entrapment of charge bag material or by the scoring of the obturator ring by grit caught between the ring and the breech block insert. Burn marks or scoring will rapidly develop into gaswash and destruction of the seal, if firing continues.

BARREL WEAR TEST PROCEDURES

INTRODUCTION

1. Aim. The aim of this trial is to determine the amount of barrel wear beyond which performance and/or safety requirements are not met, and hence to assess the wear life of the barrel.

EQUIPMENT AND AMMUNITION REQUIREMENTS

2. Barrels. A minimum of two barrels are required in order to provide 2 sets of data. The barrels must be of the same type and build standard and at a similar state of wear before firing begins. Ideally both barrels should be new, but they may be partially worn provided their firing histories have been properly documented and are reasonably representative of service use.

3. Mountings.

   a. For Control Rounds. The current build standard mounting must be used. The weapon may be fired from a proof stand or rig, as agreed with the developer, provided it is suitable for the determination of ballistic performance including accuracy and consistency.

   b. For Expenditure Rounds. Any suitable mounting may be used.

4. Ammunition.

   a. Control Rounds. Control rounds are fired to document degradation of performance of the round associated with barrel wear. Since projectiles of differing type, shape and weight may react differently to different bore conditions a statistically significant sample of each type/nature should be fired as a group during any control firings. If the risk of projectile failure is assessed as likely to increase at high or low temperatures a number of those rounds from within the samples should be fired at the Upper Firing Temperature(UFT) and Lower Firing Temperature(LFT) required for those projectile natures. Use inert filled projectiles, if necessary, inert fuzed or fitted with Plug Representing Fuze (PRF).

   b. Expenditure Rounds. Expenditure rounds, which should be service, (inert filled if necessary), or proof projectiles, (fitted PRF if appropriate), should be fired with the service charge assessed as producing the greatest firing damage, conditioned to 21 ± 2^0C.

TRIAL SEQUENCE OR FIRING CYCLE

5. Cycle. The trial is to be carried out in stages in accordance with the following firing cycle:

Serial	Stage	Number of rounds to be fired		
		Expected tube/barrel service life (rounds)		
		Below 500	500-2000	Above 2000
1.	Ordnance inspection	-	-	-
2 .	Firing of control rounds	10	20	20
3.	Firing of expenditure rounds	40	160	260
4.	Firing of control rounds		See para 4a	
5.	Ordnance inspection	-	-	-

The cycle is to be repeated until wear degrades the performance of the control rounds to the point where accuracy, velocity, stability etc. requirements are not met. The number of rounds to be fired may need to be adjusted as evidence from development trials, and other firings becomes available, to ensure that the Safe Fatigue Life is not exceeded. The actual rate of wear experienced during the trial may suggest that the number of expenditure rounds should be reduced or increased. The trial must be stopped immediately if gross instability or projectile break-up occurs. Consideration should be given to firing control rounds, in their groups, more frequently if extreme bore conditions are detected in order to identify more accurately those conditions and levels that can cause poor performance.

RANGE REQUIREMENTS

6. Indirect Fire Systems. Fire the control rounds to a range which is at least 65% of the maximum range of the system. During the latter stages of the trial when extreme bore wear occurs, position observers capable of obtaining cross observation data on short ranging rounds over the complete anticipated trajectory.

7. Direct Fire Systems. Fire the control rounds at a vertical target to determine dispersion and to monitor projectile stability. Yaw cards are to be positioned along the trajectory to measure the amount of yaw.

8. Recovery. Examination of recovered rounds will indicate the extent of driving band shear and engraving as a result of bore wear. If it is assessed as desirable, recover a sample of at least 5 of the control rounds and/or expenditure rounds at intervals throughout the trial, particularly in the later stages. Photography of any recovered rounds will provide evidence of any progressive change in driving band shearing. Recovery may not be practicable with kinetic energy rounds.

OBSERVATIONS

9. For each control round record:

a. Barrel number.

b. Cycle number and time of firing.

c. Round number.

d. Muzzle velocity.

e. Chamber pressure.

f. Ammunition type, lot numbers.

g. Projectile mass.

h. Ammunition temperature.

i. Impact location of direct fire projectiles on vertical targets.

j. Impact location for each indirect fire projectile.

k. For each recovered round, extent of driving band shear and engraving.

l. Yaw (direct fire only).

10. For expenditure rounds record:

a. Barrel number.

b. Cycle number and time of firing.

c. Round number.

d. Ammunition type, lot numbers.

e. Muzzle velocity and chamber pressure for the first and last 10 rounds fired on each day of expenditure firing.

f. Barrel and ammunition temperatures.

g. Rate of fire.

h. For each recovered round, extent of driving band shear and engraving.

11. Ordnance Inspections.

a. Inspect the tube/barrel, whether smooth-bore or rifled, for wear in accordance with the appropriate inspection criteria for the ordnance under test. Check, for example, for cracks, chrome plate lifting or chipping, or eroded lands and grooves. Measure and record barrel wear at agreed points/positions within the tube/barrel and after the firing of an agreed number of rounds, as agreed by the developer, specialist adviser and other interested parties/nations, in the interest of commonality of data capture.

b. Make gutta-percha, or similar, impressions of any erosion of, or damage to, the bore or chamber as necessary.

c. Record the results of the inspections for each firing cycle.

PRESENTATION OF DATA

12. For each group of control rounds fired, calculate the means and standard deviations of pressures and velocities and the impact probable errors/target impact dispersion for indirect/direct fire systems respectively.

13. Prepare graphs to show:

a. Rounds fired versus barrel wear.

b. velocity versus barrel wear/rounds fired.

c. Pressure versus barrel wear/rounds fired.

d. Consistency versus barrel wear/rounds fired.

e. Crack growth versus barrel wear, if applicable.

f. Chrome plate lifting/chipping vs. barrel wear and rounds fired, if applicable.

FATIGUE TEST PROCEDURES

INTRODUCTION

1. Aim. The aim of this trial is to determine the amount of barrel and breech ring fatigue beyond which safety requirements are not met, and hence to assess the safe fatigue life of the ordnance.

TRIAL

2. In order to determine the Safe Fatigue Life of the barrel and its breech assembly a total of 6 ordnance are fired and laboratory cycled to the point of fatigue failure. Initially however, during the early stage of a production run, 2 ordnance are tested in this manner in order to be able to determine the Interim Safe Fatigue Life. As the production run continues, and as a further 4 ordnance become available, these are also fired and laboratory cycled to fatigue failure. The data from all 6 ordnance is then analysed in order to be able to determine statistically the Final Safe Fatigue Life. Ideally all 6 ordnance should be of the final build standard but if this is not the case due account should be taken on the impact of any modifications on the analysis. The trial is conducted in 2 separate stages:

a. Firing Test.

b. Laboratory Pressure Cycling.

FIRING TEST

3. A number of inert expenditure rounds are to be fired from each ordnance using top service charge conditioned to the Upper Firing Temperature (UFT). Each tube, prior to laboratory cycling, must have fired sufficient rounds to initiate firing damage and no less than the lowest number of rounds to achieve any of the following:

a. Half tube design fatigue life.

b. Stated desired tube interim safe fatigue life.

c. number of rounds, as determined by the wear test, required to reach firing damage which adversely affects performance.

d. number of rounds required for the tube to develop an established crack pattern (i.e., a continuous pattern of heat checking/craze cracking, as opposed to a random pattern).

NB. Barrels at the appropriate criteria for suitability for laboratory fatigue cycling may be available from those used in concurrent ammunition performance testing.

4. the muzzle the action of the driving band has a greater effect than gas pressure on the fatigue life of the barrel. Data can be obtained, if it is considered a requirement, by the fitting of strain gauges to the muzzle, on the representative strain levels for each nature of ammunition authorised for use with the weapon. The data thus obtained can be used in the subsequent laboratory pressure cycling of the muzzle section.

LABORATORY PRESSURE CYCLING

5. n sufficient rounds have been fired to initiate firing damage, critical sections are to be cut from each barrel assembly, as advised by the developer. This includes muzzle sections except those for which no current testing techniques exist. These sections are to be subjected to laboratory pressure cycling until failure occurs. Associated breech assemblies are also separately cycled until failure. Although the apparatus used for pressure cycling cannot reproduce the pressure rise times and duration that the ordnance experiences on firing the slower pulses used in pressure cycling are considered more demanding on the ordnance. Pressure is applied at approximately 3 cycles per min.

6. Maximum Pressures. The maximum chamber pressure used for pressure cycling is the Cannon Fatigue Design Pressure (Cannon FDP) as defined in STANAG 4110. Unless otherwise specified, the ordnance FDP shall not be less than the Extreme Service Condition Pressure (ESCP). The value of Cannon FDP will vary along the barrel and the Cannon FDP curve (STANAG 4110) shows the maximum pressure at which each section of the barrel is to be tested.

7. Barrel Sections. Simulation of firing by hydraulic pressure cycling in a laboratory is performed on sections cut from the critical areas of the barrel. In preparation the ends of each section are machined to provide seal pockets. The section is then mounted within a loading frame to hold the end closures in place and with facilities to apply high pressure fluid to the interior of the section. A core bar is placed within the section to reduce the volume of oil required. A maximum pressure, derived from the Cannon FDP curve, is repeatedly applied by means of an intensifier type pumping system. The minimum pressure during a fatigue cycle will be of the order of 8 MPa. The pressure is constantly monitored using a pressure transducer. Fatigue cracks are detected and monitored at intervals during the testing by visual and ultrasonic examination. The test is continued until failure occurs.

8. Breech Assemblies. Breech assemblies used to evaluate the interim safe fatigue test need not have been fired prior to laboratory cycling. However the interim safe fatigue life determined from laboratory cycling can not be declared valid until at least one breech mechanism of an identical build standard has fired a number of rounds equal to the lower of the following:

a. One half breech design life.

b. Required breech interim safe fatigue life

Breech assemblies are tested partially assembled so that the breech blocks are securely retained in position but the components can be readily dismantled for inspection. A solid stub barrel with outside dimensions identical to an actual barrel is attached to the breech in a normal manner. A small pocket at the chamber end of the stub barrel contains a floating piston whose diameter duplicates that of the obturator system or cartridge case. Oil is pumped through the centre of the stub barrel to pressurise the cavity and load the breech blocks via the piston. The maximum pressure within the cavity is to be the Cannon FDP. During the pressure cycling test, at predetermined intervals, the components are examined for evidence of crack initiation by visual and ultrasonic inspection. The test is continued until an established crack pattern has developed, and will generally continue until total failure of one or more components has occurred.

TRIAL OBSERVATIONS

9. Firing Test. The observations required during the firing test are listed below.

a. For each control round record:

(1) Barrel number.

(2) Cycle number and time of firing.

(3) Round number.

(4) Muzzle velocity.

(5) Chamber pressure by copper crusher gauges only (not required provided that charges are from approved production lots). The use of CCG may not be viable in certain ordnance where physical chamber space may not be available.

(6) Ammunition type, lot numbers.

(7) Projectile mass.

(8) Ammunition temperatures.

(9) Impacts locations of direct fire projectiles on vertical targets.

(10) Impact location for each indirect fire projectile.

(11) For each recovered round, extent of driving band shear and engraving.

(12) Yaw (direct fire only).

b. For expenditure rounds record:

(1) Barrel number.

(2) Cycle number and time of firing.

(3) Round number.

(4) Ammunition type, lot numbers.

(5) Muzzle velocity and chamber pressure for the first and last 10 rounds fired on each day of expenditure firing (chamber pressure not required provided that charges are from approved production lots).

(6) Barrel and ammunition temperatures.

(7) Rate of fire.

(8) For each recovered round, extent of driving band shear and engraving.

10. Laboratory Test. During laboratory pressure cycling, the required data is as follows:

a. The number of cycles.

b. Cycle duration.

c. Inspection results.

FOLLOW THROUGH AND HAND RAMMING FALL-BACK TEST PROCEDURES

GENERAL REQUIREMENTS

1. The ordnance, ramming systems and projectiles used in these trials must conform to the production build standard. Fuzes may be replaced by Plug Representing Fuze (PRF). Ordnance should be new having proof fired only since this represents a worst case scenario.

2. A separate trial using the same ordnance and the same ramming system is to be conducted for each type of projectile authorised for use with the weapon. This provides evidence of no fall back, due to differing driving band characteristics, throughout the full range of ammunition natures.

POWER RAMMING TRIAL

3. A series of not less than 20 projectiles is to be rammed and ejected with the ejection force being measured for each projectile in the series. After ejection, each round should be examined, and if found to be satisfactory, rammed again and fired.

4. The chamber and bore are to be in the condition specified in the User manual; normally described as having completed pre-firing checks. The ramming mechanism is to be set up in accordance with the maintenance manual and operated in accordance with User drills.

5. The test projectiles and the ordnance are to be at ambient temperature, unless the ordnance is required to be hot (Paragraph 10).

6. Ramming is to be carried out at the maximum permissible loading elevation and at any lower elevations considered critical.

HAND RAMMING TRIAL

7. On completion of the series at Paragraph 3, a further series of 20 projectiles is to be rammed by hand and ejected. After ejection, each round should be examined, and if found to be satisfactory, rammed again and fired.

8. Ramming is to be carried out either at the maximum elevation feasible for hand ramming or at the elevation specified for ramming in the user manual/drill book.

9. The correct ramming drills are to be followed and the effort exerted is to be representative of that used by crew members in service.

ADDITIONAL TRIALS

10. Projectiles fitted with non-metallic driving bands will require additional ramming trials conducted using a hot ordnance at a temperature specified by the developer. In certain cases it may be necessary to carry out these trials in a worn barrel, or in a barrel which has ovality due to wear, in order to create a worst case scenario.

OBSERVATIONS

11. The following data are to be recorded:

a. Projectile type and lot number.

b. Projectile mass.

c. Diameter of the projectile driving band in the horizontal and vertical planes before ramming.

d. Quadrant elevation of the barrel

e. Velocity of ram.

f. For hydraulic power ramming, the pressure in the ramming system at the start of each ram.

g. Depth of ram.

h. Ejection force.

i. Photography of the driving bands of the first, tenth and last projectiles in each series before ramming and after ejection.

j. Barrel wear at the start of each trial.

k. Ambient temperature/event time/temperature at C of R during each trial.

ASSESSMENT.

12. In estimating the risk of fall-back the assumption is made that fall-back is likely to occur if the retention force is less than 5 times the mass of the projectile. Minimum retention force should provide sufficient safety margin to preclude potential dislodgement of the projectile as a result of opening/closing the breech or normal laying/operating drills when the ordnance is loaded. From the retention (ejection) forces recorded during the trials, the mean and standard deviation (sd) are calculated separately for follow-through and hand ramming. If the mean retention force of the series less 4.75 sd is equal to, or

greater than, 5 times the projectile mass the probability of fall-back is considered acceptably low.

13. Thus, the criterion for an acceptable low risk of fall-back is:

$$x - 4.75\, s \geq 5\, w$$

where x = the mean retention force of the series.

s = the standard deviation of the retention force.

w = the mass (standard mass) of the projectile.

Additional useful information may be gained by comparing the resultant retention forces with those of guns of similar calibre identified as having a satisfactory history of absence of fall-back.

(Intentionally Blank)

FLICK RAMMING UPPER AND LOWER THRESHOLD TEST PROCEDURES

GENERAL REQUIREMENTS

1. The ordnance, ramming systems, projectiles and fuzes used in these trials must conform to the production build standard. Except when specifically testing fuzes, fuzes are to be inert or be Plug Representing Fuze (PRF). Consideration should be given to measuring deceleration forces for use in fuze evaluation. Ordnance should be as new as possible, preferably proof fired only.

2. A separate trial using the same ordnance and the same raming system is to be conducted for each type of projectile/fuze authorised for use with the weapon. This provides evidence of differing driving band characteristics and fuze designs.

3. The chamber and bore are to be in the condition specified in the user manual; normally described as having completed pre-firing. The ramming mechanism is to be set up in accordance with the developer’s instructions for upper and lower threshold velocities.

4. The ordnance is to be at ambient temperature, unless it is required to be hot (Paragraph 11).

LOWER THRESHOLD TRIAL

5. The lower htreshold will be established by reducing the ramming velocity until projectile fall-back occurs. Projectiles will be rammed and ejected with the ramming velocity and retention force measured on each occasion. The mean ramming velocity of the rammer must first have been established. The lower ramming threshold obtained will be compared to the mean ramming velocity of the rammer and the margin of safety will be established. A margin of safety of at least 4.75 standard deviations (sd) will be judged acceptable. Projectiles that have been flick rammed and ejected are not to be fired.

6. Ramming is to be carried out at the maximum permissible loading elevation and at any lower elevations considered critical.

7. Projectiles are to be at ambient temperature.

UPPER THRESHOLD TRIAL

8. Twenty projectiles/fuzes will be rammed with a velocity equating to the mean ramming velocity plus 4.75 sd. The projectiles will then be ejected, broken down and examined for damage. The margin of safety will be judged acceptable if no damage, attributable to flick ramming, has occurred to the projectile or filling/cargo. For fuze trials, the fuze is to be fired fitted to an inert

shell with the fuze set to a representative time. The time to fuze event is to be recorded. No recovery is necessary for fuze trials.

9. Rapping is to be carried out at the elevation that gives the maximum retention force for the gun.

10. Projectiles/fuzes are to be environmentally stressed at the upper and lower temperatures specified for the munitions, prior to ramming. For fuze trials the fuzes are to be fired conditioned to the upper and lower temperatures specified for the fuze.

ADDITIONAL TRIALS

11. Projectiles fitted with non-metallic driving bands will require additional flick ramming trials conducted using a hot ordnance at a temperature specified by the developer. In certain cases it may be necessary to carry out these trials in a worn barrel, or in a barrel which has ovality due to wear, in order to create a worst case scenario.

OBSERVATIONS

12. The following data are to be recorded;

a. Projectile/fuze type and lot number.

b. Projectile mass.

c. Diameter of the projectile driving band in the horizontal and vertical planes before ramming.

d. Velocity of ram.

e. Quadrant elevation of the barrel.

f. The pressure in the ramming system at the start of each ram.

g. Depth of ram.

h. Ejection force (not for fuze trial).

i. Photography of the driving bands of the first, tenth and last projectiles in each series before ramming and after ejection (not for fuze trial).

j. Barrel wear at the start of each trial.

k. Ambient temperature/event time/temperature at C of R during each trial.

l. Fuze time set (fuze trial only).

m. Time to fuze event (fuze trial only).

ASSESSMENT

13. Fall-back. Trials evidence shows that flick rammers generate retention forces that are considerably higher than those of follow-through rammers and that the values vary widely. For this reason flick rammers cannot be assessed as safe using the criterion for follow-through and hand ramming. The lower threshold (fall-back) assessment is made by reducing the ramming velocity by considered stages until projectile fall-back occurs. This lower threshold velocity is compared to the mean velocity and sd determined from trials of the flick rammer and the margin of safety is established. A margin of safety of at least 4.75 sd is judged to be acceptable representing a probability of failure of less than 1 in 10^6, assuming a nomal distribution of ramming velocities.

14 Ramming Velocity Upper Thresholds. It is not practicable to determine experimentally the ramming velocity which leads to damage to the projectile, its filling, and fuze. As a practical alternative 20 projectiles/fuzes shall be rammed with a velocity equating to the mean ramming velocity, determined from trials, plus 4.75 sd. The ramming system will be judged to be safe if no damage has occurred to the projectile, its filling and fuze.

(Intentionally Blank)

FLASH BACK TEST PROCEDURES

INTRODUCTION

1. Flash back may not be discovered during either propelling charge development trials or the Safety of Propelling Charge Trial (STANAG 4224) because semi-automatic breech opening mechanisms are de-activated. Also, in unmanned firings, manually operated breeches are not opened immediately after firing. The flash back trial must therefore reproduce the worst case situation considered likely to occur in service.

ORDNANCE

2. The ordnance and its mounting shall conform to the production build standard, complete with muzzle brake and fume extractor, as appropriate. For MBT and SP equipments, the ordnance shall be mounted in its complete turret and preferably in a complete vehicle.

3. The ordnance is to be fired remotely.

4. Where the breech block is designed to be opened only manually, mechanical arrangements are to be made so that the breech block opens immediately on run out.

5. The barrel should ideally be in its second quarter of life, or exceptionally well into its first quarter of life, to represent an average degree of wear in service.

AMMUNITION

6. A series of 20 rounds is to be fired using the lowest charge in the system.

7. All charges are to be conditioned to the Lower Firing Temperature (LFT) in order to keep the chamber pressure as low as possible.

8. Projectiles may be fired at ambient temperature.

WIND SPEED

9. Flash back is most likely to occur in head wind or still air conditions. Wind speed and direction for the trial should be representative of anticipated service conditions.

OBSERVATIONS

10. The following observations are required:

a. Visual and/or closed circuit television observation of the breech during firing for turret mounted ordnance.

b. High speed colour cine, and/or infra red camera, and/or video photography of the breech to cover the ignition sequence, recoil, run out and breech opening.

c. Chamber pressure and muzzle velocity for each round.

d. Ambient temperature, wind speed and direction.

e. Charge temperature.

f. Details of the charge and propellant lot numbers.

g. Visual inspection of the ordnance before and after firing.

h. Direction of line of fire.

ASSESSMENT

11. A gun is considered safe for service use with a charge when:

a. For towed guns and SP guns without turrets, 2 (or less) of the 20 trial rounds exhibit flash back.

b. For armoured vehicles and self-propelled guns with enclosed turrets, none of the 20 trial rounds exhibit flash back.

If the limits given in Sub-Paragraphs a or b above are exceeded, the trial is to be repeated using the next higher charge conditioned to the LFT and restrictions imposed on the charges that exhibit flash back.