

Propellant qualification

An overview of UK propellant qualification strategy

Nigel Rutter

UK MoD

OVERVIEW

A presentation providing an overview of changes to propellant qualification protocols for the UK AOP 7 Chapter 10 section,

Information regarding changes to STANAG 4170 and AOP 7 and a final question regarding future test protocol requirements.

WHO

The Defence Ordnance Safety Group (DOSG)

- **The UK MOD's independent source of OME safety expertise.**
- **Provides advice and assurance as required and defined within the relevant MOD Safety regulations.**

- **JSP 520 - Safety and Environment Management of OME over the Equipment Acquisition Cycle.**
- **JSP 482 – MOD Explosives regulations**
- **ASEMS – Acquisition Safety and Environment Management System**
- **SEMS – Weapons OC Safety and Environmental Management System**

DOSG ST1 are the UK National Authority for the qualification of military energetic materials

History



Initially formed as The Office of Ordnance by Henry VIII in 1544.

The first Board of Ordnance was created in 1597.

Other forms of office have existed throughout the last 400 years...

New office created as the Ordnance Board in 1905 which ran until 1996 with the formation of DOSG.

UK Qualification may not have been so demanding back 1544 but records are a little unclear.

Although arguing if the material was fully qualified may have involved an interesting outcome?

Possibly the loss of your head?

Why Qualify Energetic Materials?

- **Legal Obligation** – Health and Safety at work Act (1974)
 - Sections 2 - Ensure (so far as reasonably practicable) the health, safety and welfare of employees.
 - Section 6 – Manufacturers have a statutory responsibility to ensure equipment is safe and safety data is available
- **Def Con 68** contractual requirements (JSP 520, Def Stan 13-129 EHDS provision)
- **Explosive Regulations 2015, CLP, and REACH regulations**
- **Can save money and time if conducted appropriately.**
 - Highlights areas which may cause concern when the energetic material is used in a particular role.
- **Provides a minimum acceptable level of testing for all Energetic Materials.**
- **Assists with multinational procurements:**
 - DOSG / DGA (Fr)
 - 6 Nations – missile projects

Non-Military Explosives

- HSE Health and Safety Executive is the UK Notified Body
- COVERED BY:
 - Explosive Regulations (ER 2015)
 - Explosives Regulations L151 (Security provisions)
 - Pyrotechnic safety regulations (2010)
- Explosives Regulations include Licensing, Ammonium Nitrate,
 - Separation distances, Revision of acquire and keep certification
 - Fireworks act
- Military Explosives are excluded



Regulatory Compliance:

- **Def Con 68** requires compliance with **Defence Standard 13-129**
- **JSP 520:** (Design Requirements for Weapons and Associated Systems: Mandatory Design Requirements) requires compliance with **Defence Standard 13-129**

Defence Standard 13/129 (Comprises two parts)

- **Part One:** MSDS data in accordance with the ECHA requirements.
- **Part Two:** Small Scale hazard test results, including Impact, Friction, T of I, Ignition characteristics (Train test), Thermal analysis data (DSC), and ESD behaviour.
- Specifies the need for compatibility testing.

BUT these are only really very basic requirements

- Essential to allow manufacture and handling of the material.
- So it's a good start in terms of data acquisition but not enough for full qualification

AOP 7 Chapter 10 Protocol for Propellant testing

Mandatory data requirements for Solid Gun Propellants

	<u>Test</u>	<u>Registry No</u>	<u>STANAG No.</u>	<u>EMTAP No</u>
1	Impact sensitivity		4489	1A
2	Small Scale Explosiveness	201.01.003		1D
3	Grit Sensitisation	201.01.004		1C
4	Friction sensitivity	201.02.001	4487	33/44
5	Temperature of Ignition	202.01.002	4491 ¹	3
6	Ease of Ignition	202.01.002	4491 ¹	4
7	Train Test (Ignition)	202.01.003		5
8	ESD sensitivity	201.03.001	4490	6
11	Tube test – Internal ignition	202.01.005	4491 ¹	35
12	Tube test - Fast heating (Fuel fire)	202.01.006	4491 ¹	41
13	Tube test – Electrically heated	202.01.007	4491 ¹	42
14	Chemical stability of NC based propellants	202.02.002	4620/ AOP 48	
15	Anti-oxidant content		4581	
16	DMA	102.01.025	4540	
17	TMA		4525	
18	Uniaxial tensile (for rocket propellant)	102.01.001	4506	
19	Stress relaxation		4507	
20	Uniaxial compression	102.01.010	4443	
21	Thermal characterisation DTA/DSC/HFC/TGA	102.01.050	4515 /4582	
22	90° C mass loss test	202.03.02		
23	Vacuum stability	202.02.001	4556	
24	Chemical analysis	101.01.001		
25	Chemical compatibility	203.01.001	4147	

Protocol Methodology

- AOP 7 Ch10 protocols based on historical national qualification requirements and all nations have different requirements.
- Amendments added for newer energetic materials and analytical techniques over time.
- Based on national **experience** with propellant materials, built up over many years, including design and development, manufacture, service use and service history.
- Including data gained from In-Service Surveillance (ISS) reports, Munition Incident Database (MID), and whole life testing.
- Based on specification, ageing criteria and performance requirements
- Tendency to use a limited number of traditional methods.
- Nothing '**new or novel**' is the phrase that is frequently applied.

STANAG 4170 / AOP-7 (Energetic Material Qualification)

- The current need to review national protocols is driven by the NATO STANAG / AOP update.
- STANAG 4170/AOP 7 are being rewritten to comply with AAP3-J (Guidance on standards).
- UK as custodian of STANAG 4170 working with US as custodian of AOP 7 regarding changes to the documents.
- UK wrote an initial draft version of AOP 7 last year which included the 'useful bits' to be transferred from STANAG 4170
- Most technical requirements and details will go into AOP 7; STANAG 4170 will become the covering agreement.

New version of AOP 7 to include the following sections from STANAG 4170:

- Chapter 1 Aim
 - Chapter 1 Agreement
 - Chapter 1 Details of agreement
 - Scope of documents
 - Methodology for the qualification of new explosives
 - Composition details, use and safety – mandatory requirements table
 - Mandatory qualification data and associated STANAG table
 - Guidance tables on the use of test STANAGs and associated methods.
 - **Add section regarding qualification of in service materials (Old Section 6)**
 - Review Chapter 10 all national sections
 - Chapter 11 National contacts list and update
 - Annex A: Associated STANAGs
 - Annex B: Explosive qualification certificate template
-
- **Remove ageing requirements tables to national sections.**
 - **Remove booster qualification requirements section (7.3.6)**

STANAG 4170 / AOP-7 (Energetic Material Qualification)

- All Nations represented at AC326 Sub Group A (EMT) were requested to undertake a review / update of qualification ageing and testing protocols for the new version of AOP 7
- UK has updated test and ageing protocol requirements to ensure they reflect current UK material manufacturing and qualification practice.
- UK has a rolling review programme for UK Small Scale Hazard Test manual of tests via **Energetic Material Testing and Assessment Policy (EMTAP)** meetings involving UK industry, UK Test houses, Government bodies, and Academia in support of the Chapter 10 requirements.

Work in Support of AOP 7 Test Protocol:

- UK MOD funded QinetiQ research programme
- Dr Ruth Tunnell examined the following propellant test methods.
- Using a series of naturally aged ball powders and gun propellants.

Abel heat test (AHT)

AOP 48 Ed 2 to assess stabiliser decomposition

Accelerated rate calorimetry (ARC)

Heat flow calorimetry (HFC)

Isothermal DSC

Karl Fischer moisture analysis

Mass loss at 90°C

Vacuum stability test (VST)

- Phase 3 of the work will examine the variability of some of the methods.
- Also used UK experience at our EMTAP material working group meetings
- Formation of the UK HFC working group

Retirement of the Abel Heat Test



Ministry of Defence

Defence Standard

13-189/Issue 1 13 December 1996

**DETERMINATION OF THE ABEL HEAT TEST OF
EXPLOSIVES**

This Defence Standard supersedes
Laboratory Method M15
dated 17 February 1988

- Abel heat test will still be performed by manufacturers and test houses but the standard will not be maintained.
- Test has been inconsistent especially with the newer generation of propellants.
- UK will not mandate the provision of AHT data for qualification in future.

Retirement of the 80°C Self heating (Silvered vessel test)



Ministry of Defence

Defence Standard

13-187/Issue 1

29 November 1996

DETERMINATION OF THE 80°C SELF-HEATING
TEST OF PROPELLANT (SILVERED VESSEL TEST)

This Defence Standard supersedes
Laboratory Method M107
dated 17 March 1993

- 80°C SV test will still be carried out by some UK manufacturers but the standard will not be maintained.
- Test is still regarded as a good measure of propellant stability but the safety implications in performing the test are an issue.

Promotion of other tests:

This is the first update to AOP 7 since 2006 and the protocols for propellant testing have been altered to reflect the changes in requirement.

New qualification:

- HFC and the 90°C Mass loss test have been included. These tests have been performed for some time but they are now mandated for UK material qualification.

In service surveillance:

- We have been requesting HFC, Vacuum Stability, and Mass loss testing as part of ISS work on propellant samples to build up a picture of naturally aged propellant characteristics.

STANAG 4170 Section 6

QUALIFICATION OF IN-SERVICE EXPLOSIVE MATERIAL

6. Providing there has been no change to the specification, explosive material already in service for which there is a history of satisfactory application may be considered Qualified by the National Authority for use in the same role (e.g. main charge filling, booster, primary, rocket motor propellant, gun propellant, pyrotechnic, etc.), without further testing.

The National Authority will define the need for any restrictions of the role and for any further testing in specific cases.

STANAG 4170 Section 6

- The use of Section 6 which was seen as acceptable practice in 1985 but it is currently not regarded as appropriate or relevant by some NATO nations.
- Removal from the update to AOP 7 was discussed at the April 2018 AC 326 SGA (EMT) meeting.
- UK are reviewing the qualification status of all energetic materials to implement the change to qualification policy.
- In future UK qualification certificates will be limited to 5 years.
- A new Qualification status review system has been implemented.

STANAG 4170 Section 6

Why make the changes?

- Section 6 issues have resulted in 'specification creep'.
- Subtle changes to manufacturing processes.
- Material obsolescence issues requiring regular 'status' reviews.
- REACH directives.
- Receipt inspection of manufacturing materials.

WHAT IF THE MATERIAL IS NEW AND NOVEL?

Our current propellant qualification protocols are based on a generation of materials that are almost exclusively NC / NG formulations.

Final question for consideration

- Are the current qualification protocols applicable to the new generation of propellant formulations?

Thank You

Any questions?