MSIAC
Munitions Safety Information Analysis Center

Supporting Munitions Safety

Energetic Material Qualification: Yesterday, Today & Tomorrow

PARARI 2024

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Overview

- What is Energetic Material Qualification?
- Where did start?
- Where is it now?
- Options for the future?

Where to start?

At the beginning is traditional …

What is Energetic Material Qualification?

- Definition of Qualification (Oxford English Dictionary)
  - “an exam that you have passed or a course of study that you have successfully completed”

- Definition of EM (NATOTerm)
  - “A substance or mixture of substances that, through chemical reaction, is capable of rapidly releasing energy.”

- So EMQ could or should be:

“A substance or mixture of substances that have passed or completed a course of study”

What do the standards say?

Key Documents

STANAG 4170
(Edition 3)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

NATO STANDARDIZATION AGENCY
(NSA)

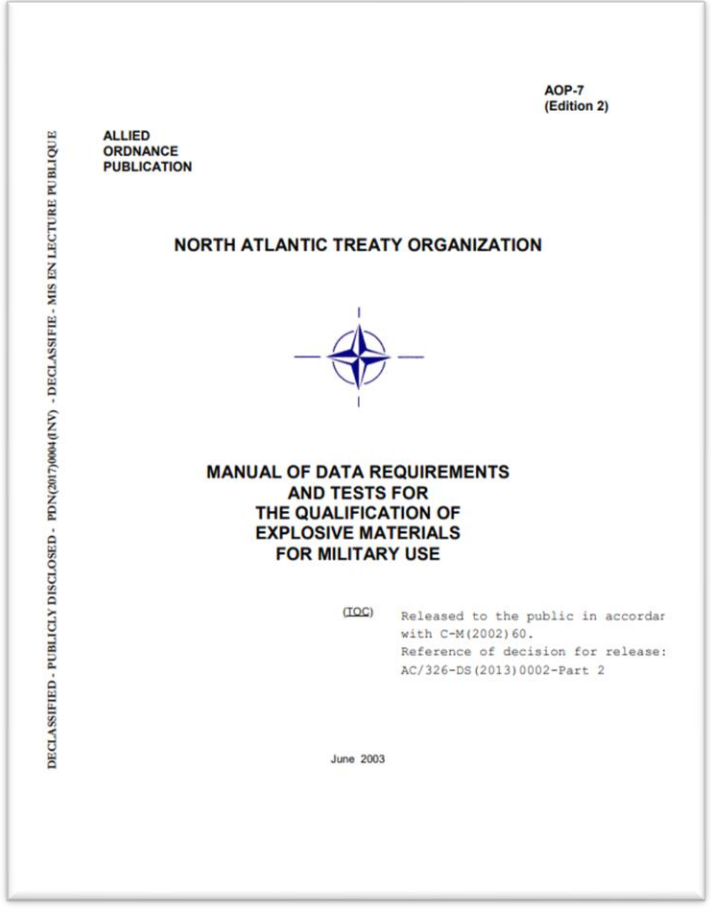
STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: PRINCIPLES AND METHODOLOGY FOR THE QUALIFICATION OF EXPLOSIVE MATERIALS FOR MILITARY USE

Promulgated on 4 February 2008

Juan A. MORENO,
Vice Admiral, ESP(N)
Director, NATO Standardization Agency

NATO/PFP UNCLASSIFIED



AOP-7
(Edition 2)

ALLIED
ORDNANCE
PUBLICATION

NORTH ATLANTIC TREATY ORGANIZATION

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

(TOC)

Released to the public in accordar
with C-M(2002)60.
Reference of decision for release:
AC/326-DS(2013)0002-Part 2

June 2003

NATO STANAG & AOP History

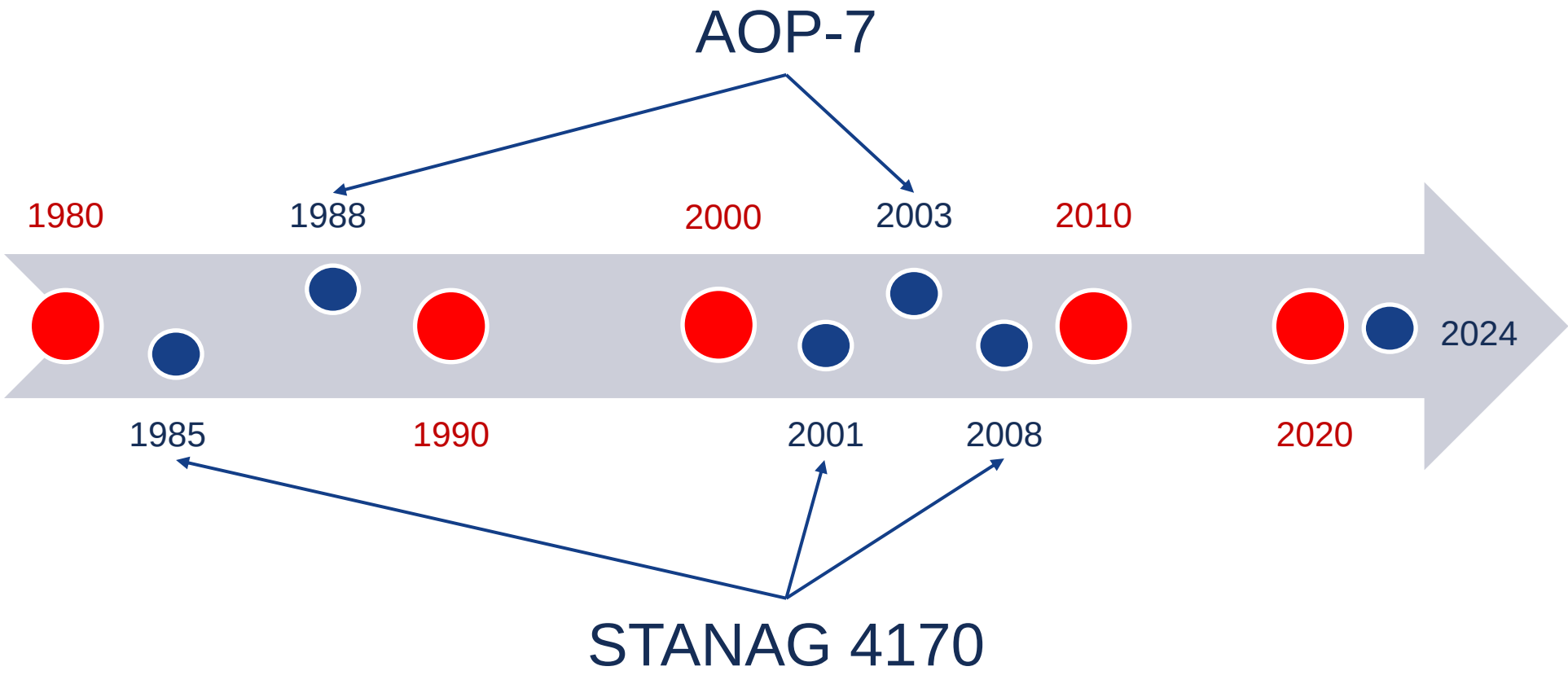
STANAG 4170

- Edition 1 – October 1985
- Edition 2 – February 2001
- Edition 3 – February 2008
- Edition 4 – (2024?)

AOP-7

- Edition 1 – February 1988
- Edition 2 – June 2003
- Edition C Ver 1 – (2024?)

Publication Timeline



What does AOP-7 / 4170 say?

- First STANAG 4170 published in 1985

AIM

1. The aim of this agreement is to ensure that new explosive materials shall possess properties which make them suitable for military use, and to provide within NATO, an acceptable basis for the certification of explosive materials for use in munitions and weapon systems.

5. General. There are three principal stages in the development of explosives for military use:

(a) the Research Phase. The principles governing safety and performance assessments during this stage are determined by local laboratories, and are not the subject of this agreement;

(b) the Qualification of the explosive material for consideration for use in a particular role or applicatic

(c) the Final or Type Qualification of a Qualified explosive material in a specific munition or weapon system for military operational or training use. This is not the subject of this agreement.

NATO UNCLASSIFIED

STANAG 4170
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

MILITARY AGENCY FOR STANDARDIZATION
(MAS)

STANDARDIZATION AGREEMENT

SUBJECT: PRINCIPLES AND METHODOLOGY FOR THE QUALIFICATION OF EXPLOSIVE MATERIALS FOR MILITARY USE

Promulgated on 22 October 1985

M. KORKOLIS
Major-General,HEAR
Chairman MAS

First AOP-7 Document

The principles, tests, and criteria used by each NATO country to qualify or accept explosives for military use have not been readily available, centrally located, nor, in general, well documented. This has often delayed the NATO-wide acceptance of explosives, hindered munitions interoperability programs, caused unnecessary research, development, and testing redundancy among nations, and wasted valuable material and financial resources of countries in the Alliance.

A recognition of the differences and deficiencies led, within the NATO community, to this attempt to develop a rational approach for the qualification of explosives for military use. It was recognized by NATO AC/225 Panel IV Subgroup 2, and the succeeding NATO/AC310 Subgroup I, that substantial efforts should be directed toward:

1. The development of uniform principles and methodology for the qualification of explosives for military use;

2. The formation and identification, within each member country, of central repositories of data on qualified explosives to facilitate the exchange of data required for the co-development or cross-procurement of munitions;

3. The documentation of tests and criteria to permit NATO members to understand, interpret, and assess the exchanged data in terms of specific apparatuses, procedures, and criteria employed.

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ALLIED
ORDNANCE
PUBLICATION

AOP-7

FINAL DRAFT

MANUAL OF TESTS
FOR
THE QUALIFICATION OF
EXPLOSIVE MATERIALS
FOR
MILITARY USE

FINAL DRAFT

AOP-7

AUGUST 1986

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What is the purpose of EMQ?

STANAG 4170, "Principles and Methodology for the Qualification of Explosive Materials for Military Use", was developed to provide a mechanism to standardize the assessment principles and methodology. This Manual, as a supplement to STANAG 4170, presents the techniques and tests to enable compliance with this STANAG.

CHAPTER 2

2.0 OBJECTIVES

AIM

1. The aims of this agreement are:

(a) to establish the concept and requirement for Qualification of explosive materials by a National Authority for military use by NATO nations;

(b) to ensure that only explosive materials sufficiently characterised and assessed as possessing properties making them safe and suitable for consideration for military use are Qualified for an intended role. A change of role (e.g. the use of a Qualified booster as a main charge explosive) will require a separate assessment on a case-by-case basis, to determine whether that explosive can be used in a new particular application not covered under the intended (original) role;

(c) to provide for NATO nations an acceptable and uniform basis to achieve Qualification status of explosive materials by the adoption of the principles and methodology described in this STANAG and related document AOP-7.

nations to evaluate the properties of explosive materials and, within the limits of national regulations, standardize methods for recording and exchanging data on explosive materials.

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

What does this mean?

1. Provide a framework / mechanism for standardisation of energetic material property assessment (qualification)

2. Provide a minimum set of data for the assessment of the characteristics of an energetic material (for a given role)

3. Reduce the time, cost and burden on NATO nations with regards to qualification of EM for military use

What has MSIAC done to help the community?

Technical Meeting History

- MSIAC Technical Meetings held in
  - 2011 – Brisbane, Australia
  - 2019 – DGA Bourges, France (Government only)
  - 2022 – NATO HQ, Brussels, Belgium (Industry Only)
  - 2022 – DGA, Paris, France (Government only)
  - 2024 – TNO, den Haag, Netherlands (Government & Industry)

- 2019 – 8 nations, 9 organisations, 18 attendees
- 2022 Industry – 5 nations, 8 organisations, 9 attendees
- 2022 Goven. – 7 nations, 10 organisations, 26 attendees
- 2024 – 8 nations, 12 organisations, 25 attendees

BLUF

- Industry & Governments are generally closely aligned on major topics
  - Agreement by both in the need for EMQ
  - Both see it as a useful and worthwhile activity
- Consistency in the process and greater standardisation would enable greater utilisation of existing data
- Insufficient pre-planning / changes during the programme the main causes of problems

Differences in Approach

- While obvious the different approaches taken by nations or industry very depending on their products or national procurement opportunities.
  - Nations that design and develop new munitions / EM
    - EMQ seen in the traditional sense (as per the current intention of the Standard)
  - Nations who purchase already designed / tested / qualified munitions
    - EMQ seen as part of the risk reduction / qualification process, however if the design is mature what they are really doing is Type Qualification

Mandatory Testing

- Those nations with limited or no testing capability or purchasing existing designs are often limited to accepting EMQ from other nations by default
  - They wouldn't choose to do it, if they didn't have too.

- There remains a difference in philosophy between some nations as to link (or not) between EMQ and final use cases
  - EG. France's removal of small scale hazard for most EMQ

EMQ Process

- Agreement that the *idea* behind EMQ is to de-risk future material development and munition qualification programmes
  - However, that is often not how it used

- Data sharing between nations still one area which presents the biggest hurdle to overcome
  - Ownership of data varies massively between nations
    - Government vs Industry owned

Discussion Points

- Implication of national / legal framework
- How to relate failure modes to safety or reliability aspects?
- How long should EMQ last, ideally?
- Use of a questionnaire to define the EMQ process → to be included as good practice?
- What is a lot? A batch?
- How far down the production line should we requalify in case of changes?

Discussion Points

- Consistency of tests across nations
- Can we accept calculated or modelled values?
- Discussions on accelerated ageing process – standardisation

- Discussion on small scale testing – its relevance and importance

Discussion Points

- Can we qualify families of compositions instead of a single composition?
- Should we add the possibility to issue intermediate EMQ certificates? Or EMQ certificates with restrictions? In which cases?
- How to decrease the time to issue the EMQ certificate?
  - Government / NA Resources

Discussion Points

- What is the appropriate level/amount of EMQ data to be shared? Ideally, up to raw data if the intent is to publish in a scientific forum/journal
- How to maximise the chances that an EMQ certificate issued by a nation A be accepted by a nation B?
- Accessibility of EMQ certificates / data to
  - other nations, and / or
  - industrial partners within a nation
- Should we share (or keep record) of data from non-qualified EM?

Failure is not an option

- One quote from the meetings was that EMQ can often be seen as something you pass or fail, such as you failed the EMQ aging:

“You didn’t fail aging, you successfully identified a failure mode”

So, where are we now?

Latest Updates

- STANAG 4170 Ed 4

- Fits the new NATO format of STANAGS being a small document covering the “agreement”

- Limited in technical detail

- Should not require frequent updates
  - Should be less quickly out-of-date

- AOP-07

- Contains the general statements require “mandatory” information, the need for ageing & EMQ process

- National test details, Qualified EM & List of National Authorities all moved in 3 off SRD’s
  - SRD-AOP-7.1: List of qualified EM
  - SRD-AOP-7.2: National sections
  - SRD-AOP-7.3: List of NA for EMQ

Benefits

- STANAG should remain extant and relevant for longer due to a lack of technical information
- AOP-7 updated to include current think on mandatory data but is kept at a high level (with test details)

TABLE 2 – QUALIFICATION DATA REQUIREMENTS

Test/Assessment	High Explosives			Propellants			Pyrotechnic Compositions
	Primary	Booster	Main Charge	Gun	Solid Rocket	Liquid	
Sensitivity Testing							
-Impact Sensitivity	M	M	M	M	M	M	M
-Friction Sensitivity	M	M	M	M	M	M	M
-Electrostatic Sensitivity	M	M	M	M	M	M	M
-Shock Sensitivity	R	M	M	R	M	M	
-Adiabatic Compression						M	
Thermal Characterization							

- Details in SRD documents mean they can be updated at the NATO SG level – do not need to go through the full ratification process

Elephant in the room

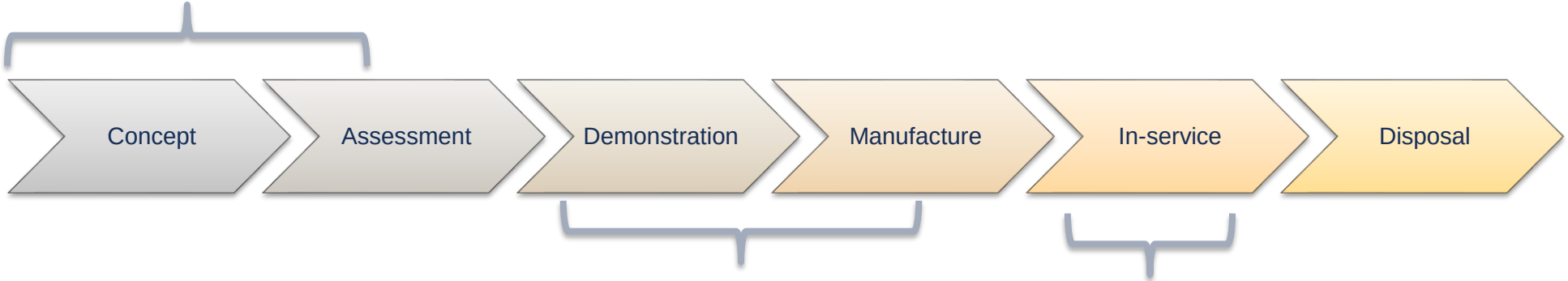
- Does not address the core issue surrounding EMQ and AOP-7
  - Data Sharing
  - Ability to accept others qualification status
  - Differences between national approaches to qualification
  - SRD-AOP-7.2 (old chapter 10) national section….
    - 577 pages long!
    - List of how each nation does it slightly differently

So, what is next?

What about the future?

EMQ Process

Ideal location for EMQ activities

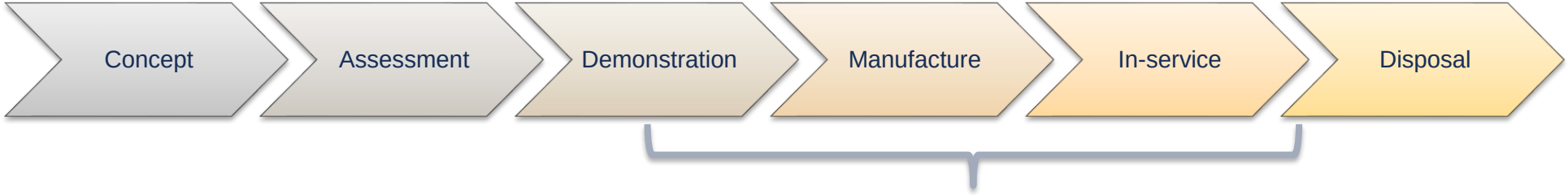


Often when EMQ is conducted

…and for some nations, here!

EMQ Process

- EMQ per its original intent needs to be conducted earlier in the CADMID cycle (where possible)
- Those conducting in later in the process, or during the later stages of Qualification – what is it really telling you then?
- Ideally we should be qualifying or nearly qualifying materials before a design is envisioned



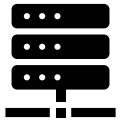
EMQ is not a de-risking activity when conducted here

EMQ 2.0

- 2024 MSIAC Technical Meeting Attendees where split into two teams

- The aim was to establish a new EMQ process from a blank sheet of paper
  - No restrictions on ideas – no idea is a bad idea!
  - Not to be limited by perceived or real limitations in making it work

Explored Ideas – Red Team

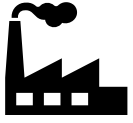


- Data exchange is critical
  - Raise to CNAD via CASG and AC/326 SG/A
  - Route to clear process
  - Legal

- AOP-7 as framework
  - Agreement that the mechanisms are captured within the doc

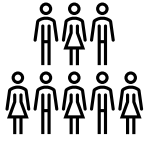
- Improving communication
  - Visual
  - Increase detail on certs
  - The process to national DT and seniors
  - Trust

- Centralise body for EMQ assessment
  - NATO
  - National



- Moving requirement for EMQ to industry
  - Analogy to MSDS
  - Legal framework to enact

- Minimum data set for new process
  - Deltas in data requirement at national level



- Maturity of composition
  - Specification, CoA
- People

Explored Ideas – Blue Team

1. Keep AOP-7 with its initial intended use but drastically improve it
2. Keep AOP-7 but rename it as “process for gathering energetic materials properties in a catalogue” instead of EMQ process
3. Remove AOP-7 and introduce EMQ as part of the S3 assessment
4. Do nothing

To decide between these options, perform a cost-benefit analysis

Next Steps

- Discussed at recent CNAD AC/326 SG/A EMT meetings within NATO
- Issue is bigger than just MSIAC
- EMQ / AOP-7 likely staying on the SG/EMT agenda for some time to come
- Community seem interested a potential new or “radical” approach

However …

We must remember for all EMQ's problems, we don't have major accidents like we did in 1950's / 60's, we know more about some materials now than we ever have

- so something must be working!

Any Questions?