Chemical characterisation and qualification of Thales manufactured Trinitrotoluene to US Military specification requirements

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DEVCOM Armaments Center

Trinitrotoluene (TNT) Production at Mulwala

Distribution Statement A: Approved for Public Release

TNT Production at Mulwala

- Routine production at Mulwala since the 1990's
- Currently manufactured by the Royal Ordnance TNT Process
- Purification method based on washing with Sodium Sulphite as opposed to Nitric Acid Extraction
- Traditionally analysis has been in accordance with the DEF(AUST) 5367

QUALIFICATION TO MIL SPEC REQUIREMENTS

WHY??

MIL-DTL-248D Requirements

Property	Requirement
Form	Flake or Crystalline
Colour	No Darker than No. 30257
Solidification Point (°C)	80.20 min.
Moisture (%)	0.10 max.
Acidity (as Sulphuric Acid) %	0.02 max.
Alkalinity	Nil
Insoluble Matter (%)	0.05 max.
Sodium (%)	0.001 max.
Flake Thickness (inch)	0.04 max.

MIL Spec. vs DEF(AUST)

Property	MIL Spec Limit	DEF (AUST) Limit
Form	Flake or Crystalline	
Colour	No Darker than No. 30257	Less than Colour Standard No. 3
Solidification Point (°C)	80.20 min.	80.2 min.
Moisture (%)	0.10 max.	0.1 max.
Acidity (as Sulphuric Acid) %	0.02 max.	0.005 max.
Alkalinity	Nil	Nil
Insoluble Matter (%)	0.05 max.	0.05 max.
Sodium (%)	0.001 max.	0.001 max
Sulphated Ash (%)	Not Required	0.05 max.
Gritty Particles - Retained on a 63um AS Sieve	Not Required	0.01 max.
Flake Thickness (inch)	0.04 max.	Not Required

TNT Qualification

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QUALIFICATION OF THALES MULWALA AUSTRALIAN TNT BY DEVCOM AC ARMAMENTS CENTRE

- Requirement to qualify Thales Australia manufactured TNT for Pressed and Melt Pour Use
- PM-CAS requested DEVCOM AC characterise TNT and certify for both applications i.e. pressed & melt pour
- DEVCOM AC Energetic Material Qualification Board reviewed AOP 7 Edition 2 test requirements and determined the appropriate tests to characterise shock sensitivity, performance and chemical /physical tests.
- Aging was determined to not be necessary for the qualification in this instance

Qualification Testing Required

Item	Task	Deliverable
1	MIL-DTL-248 Analytical Testing	VTS, DSC, Solidification Point, Moisture Content, Acidity, Alkalinity, Insoluble Matter, Sodium Content, NMR, Elemental Analysis
2	Cap Sensitivity	Flake TNT
3	Safety Testing (Impact, Friction, ESD)	Safety & Handling Test Results
4	Large Scale Gap Test	Shock Sensitivity Results for Melt Pour & Pressed
5	Detonation Velocity	Detonation Velocity Results for Melt Pour & Pressed
6	Critical Diameter Test	Narrow Down Unconfined Critical Diameter for Melt Pour & Pressed
7	Detonation Velocity Test	Detonation Velocity Results
8	One Litre Cook Off Test	Critical Temperature Determination
9	Critical Temperature Determination	F-K and Semenov Determination utilising variable Rate DSC & Thermal Conductivity Determination
10	Exudation Test	% Exudation Compared to Historical Data
11	Growth Test	% Growth Compared to Historical Data
12	Mechanical Properties	Uni-Axial Compression
13	Setback Sensitivity	Gun Launch Survivability

Qualification Test Results for Chemical Testing to MIL-DTL-248D

Property	Requirement for Type I or II	Thales Mulwala TNT
Solidification Point (°C)	80.20 min.	Meets all Properties
Moisture (%)	0.10 max.	
Acidity (as Sulphuric Acid) %	0.02 max.	
Alkalinity	Nil	
Insoluble Matter (%)	0.05 max.	
Sodium (%)	0.001 max.	
Average Flake Thickness (inch)	0.025 max.	

TNT Qualification – Safety Testing

Impact Testing

➢ ERL Type 12 Impact Tester

- ➢ Thales TNT less sensitive than RDX Class I

Friction Testing

➢ BAM Friction Test

- ➢ Thales TNT less sensitive than RDX Class I

ESD Testing

➢ Electrostatic Discharge

- ➢ Thales TNT less sensitive than RDX Class I

TNT Qualification – Sensitivity Testing

➢ Cap Sensitivity

- ➢ Test designed to determine the sensitivity to shock from a standard detonator or blasting cap
  - ➢ Meets Requirements

➢ Setback Sensitivity

- ➢ Performed at Picatinny Arsenal in accordance with experimental technique defined by Harold W. Sandusky
  - ➢ Meets Requirements

➢ Large Scale Gap Test

- ➢ Measures the sensitivity of a material to explosive shock.
  - ➢ Meets Requirements

TNT Qualification – Mechanical Properties

➢ Density

- ➢ Pressing study conducted at Picatinny Arsenal to determine how close the Thales Mulwala TNT can get to Theoretical Maximum Density when pressed & Cast
  - ➢ Theoretical Maximum Density measured using a Gas Pycnometer = 1.65 g/cc
  - ➢ Meets Requirements

➢ Uni-axial Compression

- ➢ Performed at Thales Mulwala on Instron Model 5500
  - ➢ Meets Requirements

➢ Irreversible Growth Test

- ➢ Conducted on both pressed and cast TNT in accordance with AOP-7
  - ➢ Meets Requirements

Thermal Property Testing

➢ Critical temperature Determination

- ➢ Thermal Stability test that is defined as the lowest constant surface temperature at which a material of a given size and shape will self heat catastrophically.
- ➢ Explosive should have a critical temperature greater than 82°C for a given geometry & size
  - ➢ Meets Requirements

➢ One Litre Cook-Off Test

- ➢ Experimentally determines critical self-heating temperature for melt cast energetics
- ➢ Performed in a plywood oven with 1.4kg of Thales Mulwala TNT
- ➢ Heated at 95°C for 6 hours to allow material to change phase fully then heated at a ramp rate of 3.3°C per hour
- ➢ Self-heating temperature is defined as the temperature at which the material temperature increases at a rate greater than the ramp rate of the oven
- ➢ Thales Mulwala TNT self-heating temperature was determined to be 223.9°C
  - ➢ Meets Requirements

Performance Testing

➢ Large Scale Detonation Velocity (Melt Pour)

- ➢ Performed in Large Scale Gap Tube tubes.
- ➢ Theoretical Material Density ranged between 1.50-1.54 g/cc. Jaguar Thermochemical code calculations suggest a detonation velocity range of 6.56 – 6.69 km/s based on these densities.
  - ➢ Meets Requirements

➢ Unconfined Detonation Velocity and C-J Pressure

- ➢ Pressed Pellet
  - ➢ Pressed to a density of 1.63 g/cm^3
  - ➢ Results obtained support theoretical calculations based on Jaguar Thermochemical Code
    - ➢ Meets Requirements

Performance Testing (cont.)

➢ Unconfined Detonation Velocity and C-J Pressure

- ➢ Melt Pour
  - ➢ The 'feather feed' method was used for pouring these test articles.
    - ➢ Meets Requirements

➢ Critical Diameter

- ➢ Tested in accordance with AOP-7 Revision 2
  - ➢ TNT was pressed & machined to size
  - ➢ Two shots at .375"diameter x 1.5" length and two at 0.500" diameter x 2" Length were tested

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Conclusion

- Thales Mulwala TNT met all requirements of MIL-DTL-248D specification tests as well as sensitivity & performance tests from AOP-7
- DEVCOM AC Energetic Material Qualification Board provided a memo to Thales/PM-CAS approving Thales Mulwala TNT for use in melt pour and pressed supplementary charge applications
- Thales Mulwala are testing TNT to the MIL Spec now for use the Thales Benalla Facility & export to approved customers

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