Determination of the TNT Equivalence of Nitromethane

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1 Background

Nitromethane has previously been used at DNV Spadeadam for large-scale testing for charges of 100 kg TNT equivalence. For smaller-scale trials, PE4 is typically used as the main charge material. Increasing costs and supply issues prompted research to find a suitable alternative energetic material for these smaller trials. Before nitromethane could be introduced in customer trials, its TNT equivalence needed to be determined. Establishing TNT equivalence using peak overpressure and incident impulse ensures continued compliance with standards such as ISO 16933:2007 [1] and NS-EN 13123-2:2025 [2].

2 Aims and Objectives

Aim:

- Establish the TNT equivalence of nitromethane in charges up to 15 kg TNT eq.

Objectives:

- Conduct full-scale blast trials to measure overpressure and impulse.
- Generate representative TNT reference data using numerical simulations.
- Derive TNT equivalence based on peak overpressure and impulse.

3 Live Trial Methodology

Four full-scale arena trials using 13.9 kg of nitromethane were conducted with the following setup:

- Incident overpressure was recorded using PCB piezoelectric pencil gauges. These were configured in pairs at standoff distances of 6, 10 and 15 m.
- The centre of the charge was elevated to 1.2 m above the concrete test pad to reduce the risk of fragmentation and each pressure gauge was aligned to this point.
- High-density polyethylene (HDPE), hexahedral jerry cans were used as the nitromethane charge containers.
- Semtex boosters and Euronel 2 in-hole detonators were suspended centrally within the nitromethane.
- Pressure-time histories were integrated to calculate the incident impulse for each trial.

4 Computational Fluid Dynamics Simulations

CFD simulations were used to support the experimental analysis:

- Using Viper::Blast software, TNT reference data was generated to replace the data from the TNT live trials.
- Data from a cylindrical 2D TNT simulation was used to determine the TNT equivalence of nitromethane.
- A simulation of the nitromethane live trials was used to validate the experimental methodology.
- Viper confirmed an asymmetrical shockwave development, resulting from the hexahedral charge geometry, shown in figure 1.
- A domain-size study ensured the full positive phase of the explosion was captured before any refracted-wave interference from the simulation boundary reached the 15 m gauge.

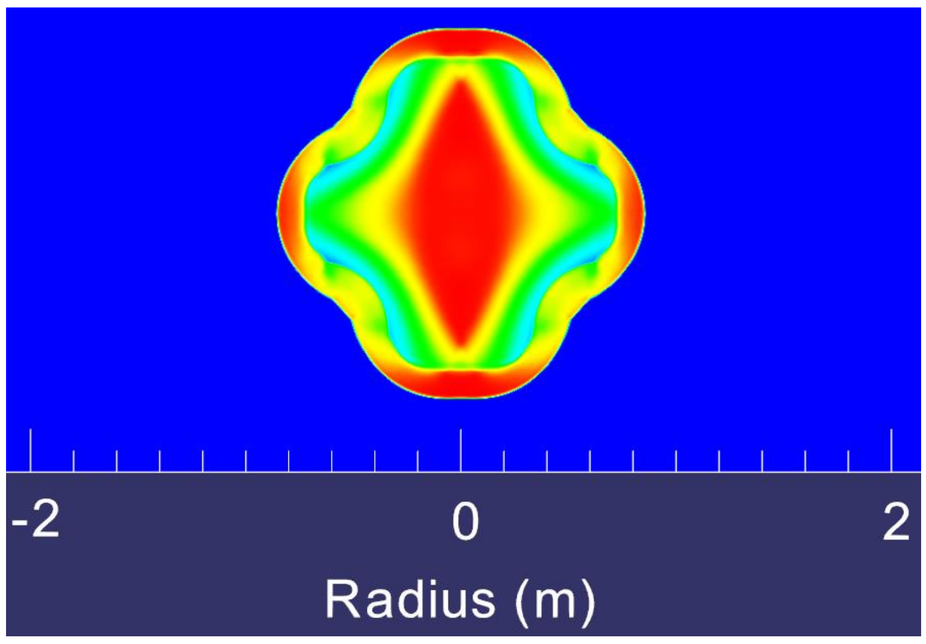

Figure 1: Cruciform-like shockwave shown in the simulation

Figure 2: Fireball geometry indicating asymmetrical shockwave progression

5 Results

The main results for the project are:

- **Peak overpressure TNT equivalence = 1.10**
- **Incident impulse TNT equivalence = 1.13**
- Hexahedral charge geometry produced a cruciform fireball and shockwave, shown in figures 2 and 3.
- Nitromethane simulation data was within 12% of the trial data.

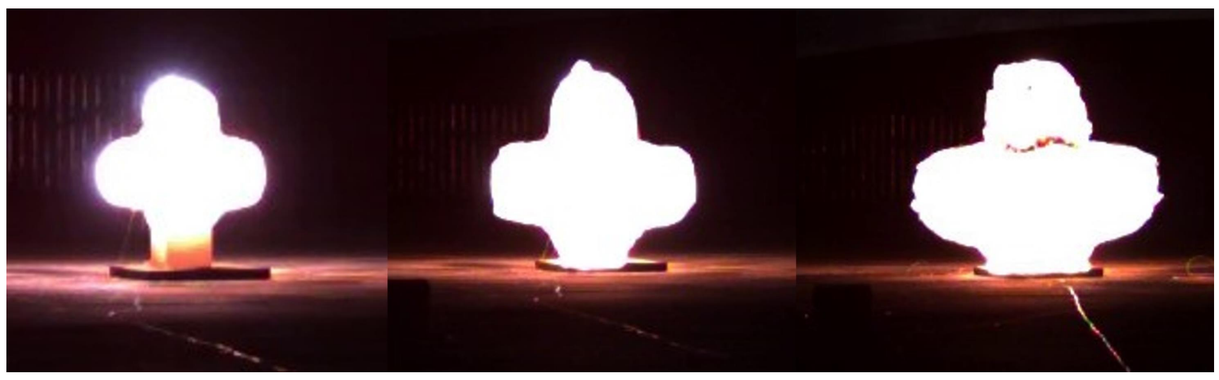

Figure 3: High-speed imaging showed the cruciform fireball development

6 Conclusions, Recommendations and Impact

Conclusions:

- TNT equivalences were successfully determined for peak overpressure and incident impulse.
- Low variation in live testing data provided high confidence in the derived TNT equivalences.
- TNT data was successfully generated through Viper::Blast simulations.
- Simulations of the live trials validated both the methodology and the TNT data simulation approach.
- Charge geometry, Mach stem formation and fireball interactions contributed to the increased peak overpressures.
- Numerical modelling is essential for interpreting non-ideal charge geometries.

Recommendations:

- Collect data at additional standoff distances.
- Repeat the trials with a spherical or cylindrical charge shape.

Impact:

- Nitromethane has been used in five small-scale trials, to date, saving both time and money for DNV and its customers.

References:
[1] International Organization for Standardization, "Glass in building — Explosion-resistant security glazing — Test and classification for arena air-blast loading," ISO, Geneva, 2007.
[2] Standards Norway, "Windows, doors, shutters and curtain walling - Explosion resistance - Requirements and classification - Part 2: Arena test," Standards Norway, Oslo, 2025.

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