

Identification of an Unknown OME Item at COTEC Using Blast, Fragmentation, Velocity Foils,
and FTIR Residue Analysis.

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I. Abstract

An instrumented arena trial was conducted at COTEC to identify an unknown OME item using fragmentation capture, velocity foil timing, blast pressure recording, and FTIR residue analysis of recovered fragments. The munition was not observed prior to initiation; therefore, identification was performed by down-selection against the provided candidate list using post-event measurements. Strawboard recovery produced 90 fragments with a mean fragment mass of 0.826g and morphology consistent with natural casing breakup. FTIR analysis of residue associated with recovered fragments indicated a nitramine-based energetic with additional features consistent with a plasticiser/binder component, supporting an RDX/Binder formulation such as PE-8 and rejecting TNT-based candidates. Velocity foil analysis used first strikes only, applying a trigger-delay correction and outlier handling to obtain a mean fragment velocity that provided supporting agreement with the pipe bomb candidate. Blast gauge data was assessed but was not treated as a reliable discriminator due to ringing and poor agreement with calculator outputs for remaining candidates at 1m. On this basis, the detonated item was identified as a pipe bomb containing PE-8.

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1. Introduction

Identification of an unknown OME item following detonation is best supported by combining independent evidence streams, as no single method is reliable in isolation under field trial conditions. In this trial, the munition was not observed prior to initiation; therefore, identification was based on post-event measurement and laboratory evaluation. An instrumented arena was established to capture blast and fragmentation effects, supported by residue analysis to identify the energetic material. The candidate munition list provided the bounded set of hypotheses, and the recorded evidence was used to down select to the munition most consistent with the measured fragmentation characteristics, energetic signature, fragment velocity evidence, and the trial context.

2. Aim

The aim was to identify the exact munition detonated at the COTEC range using the arena trial measurements and laboratory evaluation of recovered fragments.

3. Down-Selection methodology (Red, Amber, Green System)

The candidate list was the bounded hypothesis set (full data sheet in **Appendix A**):

- 81 mm Mortar AR-M81 (Explosive: TNT; charge mass 0.76 kg)
- RPG PG-7VL (Explosive: “RDX/TNT / 95% HMX + wax”; charge mass 0.73 kg)
- 155 mm (Explosive: Comp B; charge mass 1.15 kg)
- Pipe Bomb (Explosive: PE 8; charge mass 0.264 kg)
- Mk 83 air dropped munition (Explosive: Comp B; charge mass 225 kg)

- M-67 grenade (Explosive: Comp B; charge mass 0.185 kg)
- RGD-5 grenade (Explosive: TNT; charge mass 0.110 kg)

A candidate was marked Red where clear incompatibility existed. Amber was used where partial compatibility remained, but uncertainties were unresolved. Green was used where two or more independent streams aligned. Blank is used when no information is available to inform decision making. Gates were applied in the following order: range feasibility, post-blast inspection, fragment inspection, Fourier Transform Infrared spectroscopy (FTIR) of energetic, and velocity foil timing. Table 1 represents the candidate map.

Munition	Range Feasibility	Post-Blast Inspection	Fragment Statistics	FTIR Energetic	Blast Gauge Interpretation
81 mm Mortar AR-M81					
RPG PG-7VL					
155 mm					
Pipe Bomb					
Mk 83 air dropped munition					
M-67 grenade					
RGD-5 grenade					

Table 1 – Candidate RAG map

4. General Range Information

The trial was conducted at COTEC in damp conditions. The weather was overcast and there was a northwest wind.

Range staff confirmed that the NEQ limit for the range activity was below 10 kg.

Candidates whose charge masses were above this limit were treated as infeasible for the trial context.

Munition	Range Feasibility	Post-Blast Inspection	Fragment Statistics	FTIR Energetic	Blast Gauge Interpretation
81 mm Mortar AR-M81					
RPG PG-7VL					
155 mm					
Pipe Bomb					
Mk 83 air dropped munition					
M-67 grenade					
RGD-5 grenade					

Table 2 – Candidate RAG map – post general Range Information

5. Arena trial set-up

5.1. Strawboards and foils

Strawboard packs were specified as 105 cm (H) × 80 cm (W), mounted portrait.

Pack thickness was 20 sheets; double packs were 40 sheets. Strawboards were mounted on a damp day, however, due to the short period between set up and firing, this limitation was likely minimal although could still affect penetration depth.

Velocity foils were installed on the strawboard faces and connected to a logic analyser in the control room. Foils were labelled to enable mapping of recorded strike times to physical locations.



Figure 1 – Straw Board and Foil Mounting

5.2. Arena Geometry

Arena radius was 1.5 m. The strawboard arc was 113° horizontal and 15° vertical.

The munition was detonated vertically at a central firing height of 0.5 m.

Strawboards were not perfectly aligned to the intended arc, introducing uncertainty in standoffs for some foils (each foil was measured from munition location to foil centre to limit this). Figures 2 and 3 depict this layout.

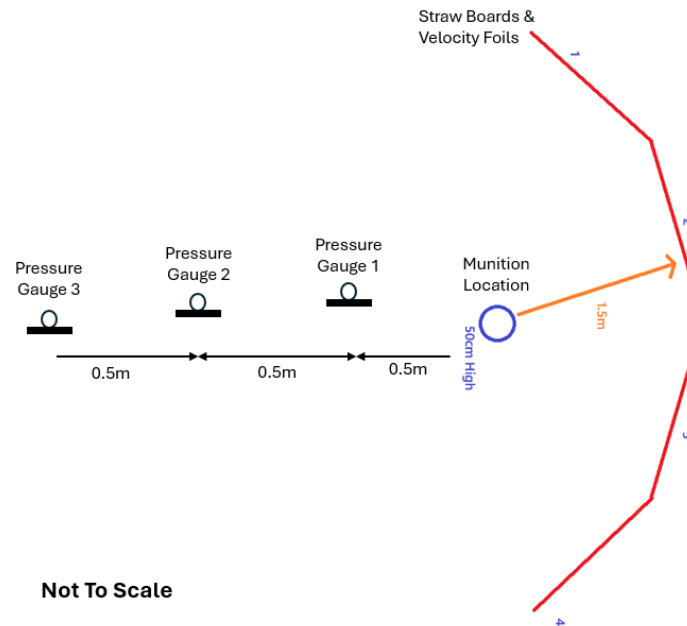


Figure 2 – Birds Eye View, Arena Layout

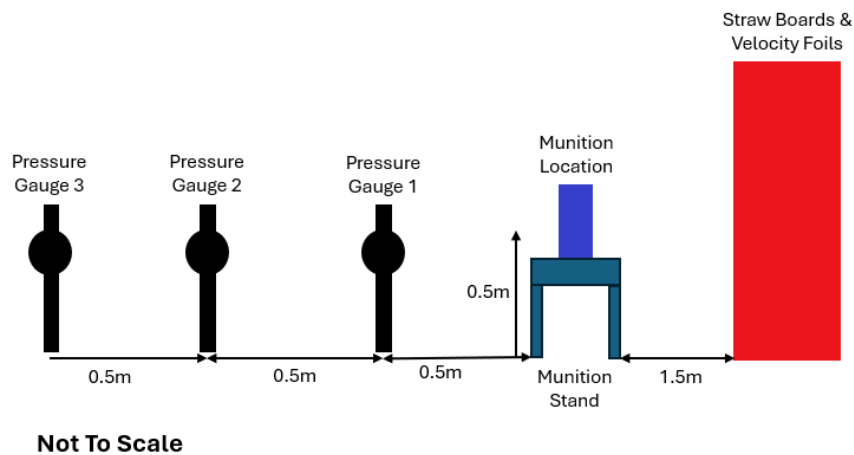


Figure 3 – Plain View, Arena Layout

5.3. Pressure Gauges and Wiring protection

Pressure gauges were connected using labelled BNC cables [1] routed from the control room through a port and protected with structural shielding (behind supports, under steel I-beams, and at junctions with sandbags) (Figure 4). Pressure gauges were staggered laterally (gauge 3 protruding gauge 2, gauge 2 protruding gauge 1) to

ensure the blast wave had travelled through free air before interacting with each gauge [2].



Figure 4 – Pressure Gauges and Cable protection

6. Initial observations and post-blast inspection

Sparks and black smoke were observed suggesting a negative oxygen balance explosive, this was treated as Indicative due to possible kick up of ground dirt.

Post-blast photographs showed heavy strawboard perforation and intact foil panels, foil 7 blown from straw board (Figure 5).



Figure 5 – Post Blast Straw Board Perforation

Blast Gauge 1 was struck by a fragment, and its data was excluded (Figure 6). Only Gauges 2 and 3 were used for pressure interpretation.



Figure 6 – Blast Gauge 1 Fragmentation Strike

Recovered fragments were irregular and curved, consistent with natural casing break-up [3] (Figure 7). The strawboard strike pattern was centralised horizontally and suggested a cylindrical fragment spread. (Figure 7).



Figure 6 – Fragments Post Acetone Bath



Figure 7 – Fragment Cylinder breadth

On this basis, the grenade candidates were marked amber. The observed fragment spread reduced confidence in grenade bodies as the source, as their fragment pattern is omnidirectional from centre [4]. 155mm was marked amber for the same fragment throw reasoning.

The RPG PG-7VL was treated also marked amber. This munition is designed as a shaped charge, where the dominant effect is jet formation rather than a primarily uniform radial fragmentation field from a thin casing [5]. The natural, broadly axisymmetric fragment pattern observed in the strawboards was therefore not considered characteristic of a shaped-charge dominant event, and the RPG candidate was deprioritised pending confirmation from the blast and residue evidence.

Munition	Range Feasibility	Post-Blast Inspection	Physical Fragment Statistics	FTIR Energetic	Fragment Velocity
81 mm Mortar AR-M81					
RPG PG-7VL					
155 mm					
Pipe Bomb					
Mk 83 air dropped munition					
M-67 grenade					
RGD-5 grenade					

Table 3 – Candidate RAG map – Post Initial Post Blast observation

7. Fragmentation Mass Evaluation

Fragments were recovered from the strawboards and returned to the laboratory for cleaning and measurement. A total of 90 fragments were recovered with a combined recovered mass of 74.5 g. The mean fragment mass was 0.826g and the mean fragment thickness was 3.3 mm. These statistics were treated as representative of the fragments

captured by the strawboards at the instrumented standoff, rather than the total casing breakup.

7.1. Comparison to candidate munitions using fragment mass

Candidate Munition	Candidate average fragment mass (g) (Appendix A)	Measured mean fragment mass (g) (from trial)	Assessment at this gate
Pipe Bomb	0.83	0.826	Strong Match
RPG PG-7VL	0.1		Not Consistent
M-67 Grenade	2.0		Not Consistent
RGD-5 Grenade	0.12-0.46		Not Consistent
155mm	2.1		Not Consistent
81 mm Mortar AR-M81	Not provided in data sheet		No direct mass comparison possible

Table 4 – Fragment Mass Comparison to Candidates

The Pipe Bomb candidate aligned closely with the measured mean fragment mass.

The RPG PG-7VL average fragment mass (0.1 g) was significantly lower than the measured mean and was therefore incompatible with the recovered fragment population. This provided a quantitative basis to eliminate the RPG candidate, independent of earlier mechanism-based suspicion. The M-67, 155mm and RGD-5 candidates were also inconsistent with the measured mean fragment mass.

For the 81 mm Mortar AR-M81, an average fragment mass was not available in the candidate dataset provided.

Munition	Range Feasibility	Post-Blast Inspection	Physical Fragment Statistics	FTIR Energetic	Fragment Velocity
81 mm Mortar AR-M81					
RPG PG-7VL					
155 mm					
Pipe Bomb					
Mk 83 air dropped munition					
M-67 grenade					
RGD-5 grenade					

Table 5 – Candidate RAG map – Frag Mass Evaluation

8. Energetic material determination (FTIR)

FTIR analysis was performed post acetone bath on residue associated with the recovered fragment material, with acetone contributions treated as background and not used as identifying features.

8.1. Key absorption features and assignments

The spectrum contained strong bands diagnostic of a nitro-bearing energetic. A strong C–H stretching region was present at 3075 cm^{-1} and 3066 cm^{-1} , with additional weaker features around 3001 cm^{-1} and 2930 cm^{-1} . The latter were treated as consistent with an additional hydrocarbon-containing component rather than the energetic alone [6].

The most diagnostic region was the strong set of nitro/nitramine-associated bands. A strong feature at 1593 cm^{-1} (with further strong bands at 1574 cm^{-1} and 1533 cm^{-1}) was consistent with N–O stretching behaviour expected for nitro-containing energetic functionality. A strong cluster in the $1460\text{--}1430\text{ cm}^{-1}$ region (1460 cm^{-1} , 1434 cm^{-1}) was consistent with H–C–N bending modes. A prominent set of C–N related absorptions was present with strong bands at 1390 cm^{-1} , 1351 cm^{-1} , 1269 cm^{-1} (very strong), 1233 cm^{-1} , 1218 cm^{-1} , and 1040 cm^{-1} (strong). The concentration of strong C–N features, including the very strong band at 1269 cm^{-1} , was treated as characteristic of a nitramine-type compound [7].

Additional nitramine-supporting features were observed in the lower wavenumber region. A strong/broad feature at 1312 cm^{-1} was consistent with N–N stretching, and bands at 924 cm^{-1} (O–N–O bending) together with 882 cm^{-1} , 843 cm^{-1} , and 783 cm^{-1} (N–N–O bending modes) further supported a nitramine/nitro-energetic signature. The group of bands at 753 cm^{-1} , 604 cm^{-1} , 590 cm^{-1} , 461 cm^{-1} , and 410 cm^{-1} were consistent with ring distortion modes and were treated as supportive of a cyclic energetic framework [6].

8.2. Evidence for a secondary component (plasticiser/binder/taggant)

In addition to the energetic bands, a carbonyl-containing component was indicated by a feature at 1738 cm^{-1} , consistent with an ester-type C=O absorption commonly associated with plasticisers/binders. This interpretation was supported by weaker features around 3000 cm^{-1} (3001 and 2930 cm^{-1}), consistent with additional aliphatic

C–H stretching beyond the primary energetic signature. Taken together, these features indicated that the residue was likely derived from a formulation containing an energetic plus a plasticiser/binder/taggant contribution [8].

8.3. Energetic inference and candidate alignment

The combined presence of strong N–O related bands around 1593–1533 cm^{-1} , strong and repeated C–N absorptions including a very strong band at 1269 cm^{-1} and a strong band at 1040 cm^{-1} , an N–N stretch at 1312 cm^{-1} , and N–N–O / O–N–O bending modes below 1000 cm^{-1} , was most consistent with a nitramine energetic (RDX based) rather than an energetic including TNT [9] [6]. The additional carbonyl/plasticiser features were supportive of a plasticised formulation, aligning with the candidate listing of PE-8 (made up of RDX86.5%/Binder12.5%) [10] for the pipe bomb option.

Munition	Range Feasibility	Post-Blast Inspection	Physical Fragment Statistics	FTIR Energetic	Fragment Velocity
81 mm Mortar AR-M81					
RPG PG-7VL					
155 mm					
Pipe Bomb					
Mk 83 air dropped munition					
M-67 grenade					
RGD-5 grenade					

Table 6 – Candidate RAG map – FTIR Evaluation

9. Pressure Output and Interpretation

9.1. Data format and conditioning

The pressure traces were converted into kPa using a condition constant of $30 \text{ mV} = 3 \text{ kPa}$.

9.2. Data Smoothing Method

A centred moving-average (rolling mean) smoothing method was applied to Gauge 2 and Gauge 3 traces before peak selection [11]. This smoothing type was used because it is a low-pass filter that reduces short-duration oscillations (ringing) and high-frequency noise while keeping the underlying blast waveform visible. This was required because the unsmoothed trace contained multiple local maxima that can be misread as separate blast peaks. Figure 8 shows the comparison.

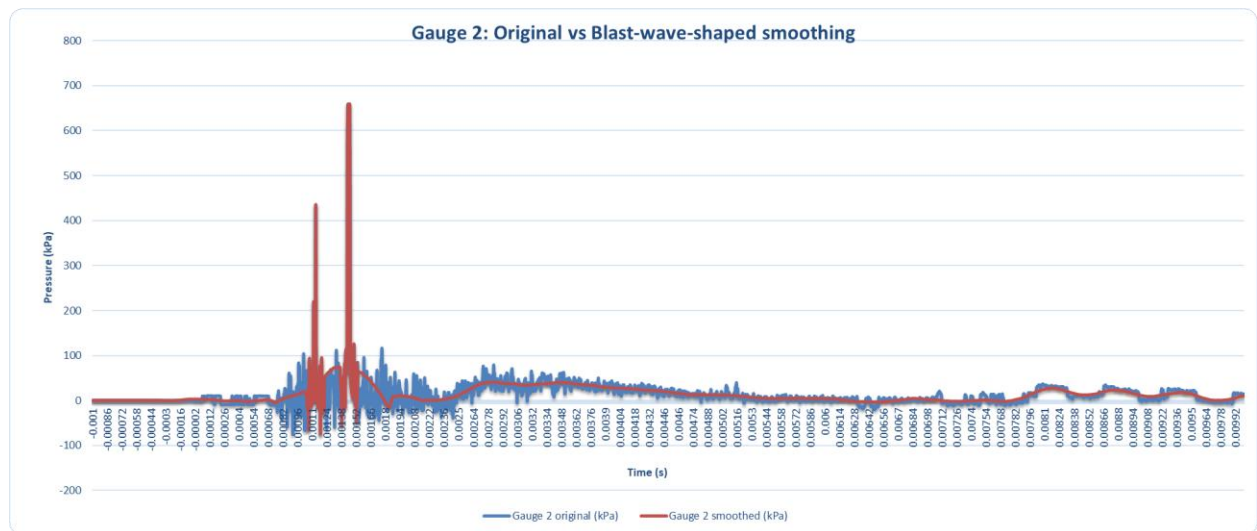


Figure 8 – Gauge 2 Blast Pressure Graph original vs Smoothed

9.3. Scaled Distance

Scaled distance was used to relate pressure at standoff to TNT-equivalent mass:

$$Z = \frac{R}{W^{1/3}}$$

A reference dataset for a 50 lb TNT charge [12] was used to relate incident overpressure to scaled distance. Figure 9 shows this data set.

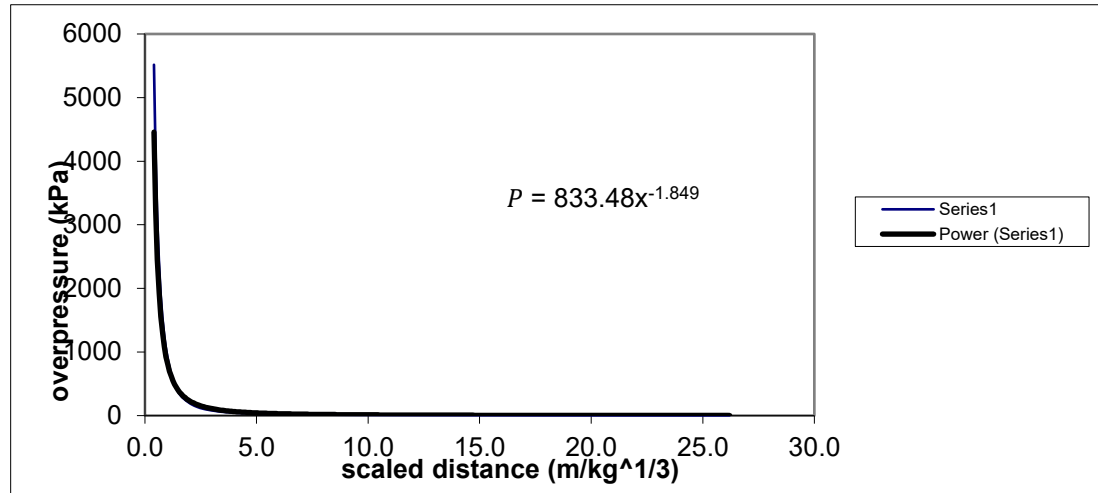


Figure 9 – Scaled Distance TNT Graph

Where P is overpressure (kPa). For a selected pressure at distance R , Z can be inferred and [13]:

$$W = \left(\frac{R}{Z}\right)^3$$

9.4. Calculation of peak overpressure

The blast calculator used a cased-charge correction to convert explosive mass into an equivalent bare charge (then converted to TNT-equivalent for scaling). The correction accounts for energy consumed in casing breakup/acceleration [13]:

$$Wb = 1.19 \left[\frac{1 + Mr(1 - Mc)}{1 + Mr} \right] c$$

where c is explosive mass, M_r is the case-to-charge ratio, and M_c is the confinement factor used by the method [13]. An example of this calculator is shown in Figure 10.

The screenshot shows a 'Blast Calculator' interface with the following fields and values:

- mass of case = 0.213 kg
- mass of explosive = 0.185 kg
- In the Equation: $M_c = 1.19 \left[\frac{1 + M_r(1 - M_c)}{1 + M_r} \right] c$
- Explosive: Comp B
- TNT Equivalence = 1.13
- Equivalent mass of TNT = 0.116 kg
- Required overpressure = 225 kPa
- At distance: 1 m
- $M_r = 1.15$
- $M_c = 1.00$
- $c = 0.185$
- Equivalent bare charge = 0.102 kg
- At 1 m this produces an overpressure of 220.5 kPa
- An overpressure of 225 kPa results at 1.0 m
- For the required overpressure: $Z = 2.64 \text{ mkg}^{-1/3}$
- For the required distance, the required amount of TNT: $m = 0.119 \text{ kg TNT}$

Figure 10 – Blast Calculator Example

9.5. Gauge 2 peak assignment

After smoothing, Gauge 2 showed three dominant peaks. The first two occurred at:

- 0.001112 s (≈ 225 kPa)
- 0.001132 s (≈ 425 kPa)

After smoothing, Gauge 2 showed three dominant peaks. The first two occurred at:

The separation was:

$$\Delta t = 0.000020 \text{ s} = 20 \mu\text{s}$$

If the second peak were an external reflection, the reflection distance would be:

$$d \approx \frac{c\Delta t}{2}$$

Using $c \approx 340 \text{ m s}^{-1}$

$$d \approx 3.4 \text{ mm}$$

A reflecting surface ~ 3.4 mm from the pressure gauge is not realistic for the arena geometry. Therefore, the ≈ 225 kPa feature was treated as noise, the ≈ 425 kPa peak

was treated as the incident blast peak, and the later ≈ 660 kPa peak was treated as the reflected peak (consistent with a realistic ground reflection).

9.6. Calculator comparison to the incident peak

The blast calculator outputs (at 1 m) for the pipe bomb + grenades as comparators were:

Candidate	Explosive	Calculator overpressure at 1m (kPa)	Comparison to measured incident (≈ 425 kPa)
Pipe Bomb	PE-8	257.4	Low
M-67 Grenade	Comp B	220.5	Low
RGD-5 grenade	TNT	125.7	Low

Table 7 – Overpressure calculated vs trialled

None of the calculator outputs match the ≈ 425 kPa incident peak at 1 m. In addition, the presence of strong ringing on Gauge 2 creates multiple peaks close together in time, which can produce false positives if a lower peak is selected.

The blast gauges did not provide useful discrimination for munition identification in this trial, because the calculated pressures for the most likely candidates do not match the incident peak when compared to the measured data, and significant ringing on Gauge 2 produces multiple peaks that can be misinterpreted. Gauge 3 produced no useful data, Figure 11.

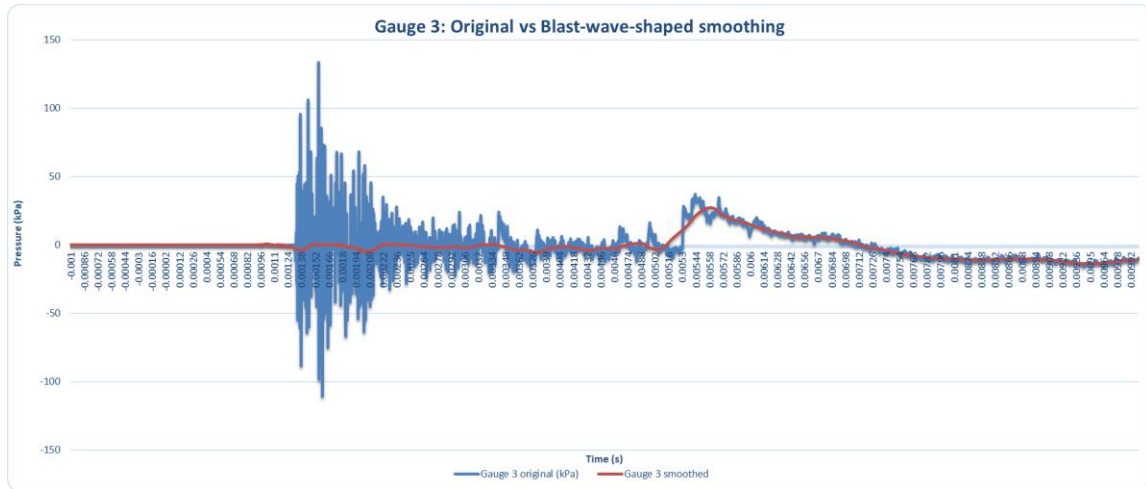


Figure 8 – Gauge 3 Blast Pressure Graph original vs Smoothed

10. Fragmentation velocity

10.1. Method

Velocity foils were used to estimate fragment time-of-flight by recording the first circuit closure on each foil channel. Only first strikes were used. A 1ms trigger delay was applied to all recorded first-strike times (a <1 trigger time was specified by the trials staff, worst case has been assumed). Fragment velocity for each foil was calculated from:

$$v = \frac{d}{(t - 1.000ms)}$$

where d is the distance from the charge point to the foil (m) and t is the recorded first strike time (ms).

10.2. Results

Foil ID	Distance, d (m)	Time, t (ms)	Corrected time	Velocity (ms^{-1})	Included in mean
1F-A	1.46	4.59530	3.59530	406	No
1F-B	1.30	1.71048	0.71048	1830	Yes
1F-C	1.30	1.72476	0.72476	1794	Yes
2F-A	1.41	2.07088	1.07088	1317	No
2F-B	1.40	1.76334	0.76334	1834	Yes
2F-C	1.40	1.73050	0.73050	1916	Yes
3F-A	1.52	2.65346	1.65346	919	No
3F-B	1.40	1.78502	0.78502	1783	Yes
3F-C	1.40	1.76556	0.76556	1829	Yes
4F-A	1.50	2.66250	1.66250	902	No
4F-B	1.40	1.74220	0.74220	1886	Yes
4F-C	1.40	1.78220	0.78220	1790	Yes

Table 8 – First-strike Velocities

Mean first-strike velocity (outliers excluded): $1833 \text{ m}\cdot\text{s}^{-1}$ ($n = 8$).

Outliers were identified using a modified Z-score (median/MAD), which is suitable for small datasets, with $|z| > 3.5$ used to flag significant outliers [14]. All values were retained in Table 8, but flagged outliers were excluded from the mean.

10.3. Why some velocities are likely lower

The foils record the first electrical closure, not the fastest fragment. A low velocity can occur if the earliest fragment did not close the circuit (poor contact/orientation, grazing impact, fragment material effects), and the recorded first closure was caused by a later fragment. This is consistent with the low-velocity channels in Table 8.

10.4. Comparison to candidate fragment velocity

The pipe bomb candidate dataset gives an initial fragment velocity of $V_i = 2047 \text{ m/s}^{-1}$ (mean fragment mass basis). The corrected foil mean ($1833 \text{ m}\cdot\text{s}^{-1}$) was lower by $\sim 214 \text{ m}\cdot\text{s}^{-1}$ ($\sim 10\%$). For this dataset, a deviation of this order is acceptable because the sample size was small ($n = 12$ foils, with $n = 8$ contributing to the mean after outlier removal) and the trigger delay was applied as an assumed correction rather than a measured timing offset. With a larger foil array and a trigger time that was independently characterised, a smaller percentage deviation would be expected. Within these limits, the foil-derived velocity supported the pipe bomb as the most likely munition. The M-67 grenade sits within this 10% acceptance also, however, with the other mismatches across the evaluated data it is discounted.

Munition	Range Feasibility	Post-Blast Inspection	Physical Fragment Statistics	FTIR Energetic	Fragment Velocity
81 mm Mortar AR-M81					
RPG PG-7VL					
155 mm					
Pipe Bomb					
Mk 83 air dropped munition					
M-67 grenade					
RGD-5 grenade					

Table 9 – Candidate RAG map – Fragment velocities

11. Data Limitations

The analysis relied on the candidate munition list being correct for explosive type, NEQ, and fragment statistics. For example, the entry labelled “155 mm ammunition” stated an NEQ of 1150g and a total mass of 3105g, 155 mm ammunition exists in many variants across manufacturers and fills, with specifications that can differ significantly. Because no specific 155 mm model or configuration was stated, a like-for-like comparison against a single real-world 155 mm munition was not possible however the specification provided seemed low. 155mm L15 as a comparator (total weight 43.5kg, 11,3 NEQ RDX/TNT) [15].

12. Conclusion

The detonated item is concluded to be the Pipe Bomb filled with PE-8. This candidate is the strongest because it provides the closest overall alignment to the independent evidence streams produced by the trial: The recovered fragment population matched the pipe bomb fragment statistics and casing behaviour, the FTIR residue signature was consistent with a nitramine-based plasticised formulation compatible with PE-8, and the first-strike velocity foil results provided supporting agreement with the expected fragment velocity for the pipe bomb candidate within the limits of the dataset.

Alternative candidates were not selected because they did not match the recovered fragmentation behaviour and did not align with the energetic residue identification. The RPG PG-7VL, M-67, RGD-5, and 155 mm options were rejected because their

expected fragment throw and listed average fragment masses were significantly different from the strawboard results and the recovered mean fragment mass, and the FTIR residue analysis did not support energetic compositions consistent with their specifications (including TNT-containing formulations where applicable). The 81 mm mortar was rejected because the candidate fill is TNT, which did not align with the nitramine-based FTIR result. On this basis, the pipe bomb (PE-8) was selected as the definitive identification.

Word count $\approx$ 2,410 (excluding abstract, headings, appendices, references, tables).

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14. Appendix A – Candidate Munition list**Mk 83 air dropped munition**

- Charge Mass – 225 kg
- Mass of case – 229 kg
- AUW – 454 kg
- Explosive – Comp B
- Average fragment area - 0.48 cm²
- Average fragment mass – 0.115 kg
- Frag drag coefficient – 0.82
- Density of air 1.23 kg m⁻³
- Frag Vi = 1950 ms⁻¹
- Frag Vf = 1911 ms⁻¹ at 92 m

M-67 grenade

- Charge mass – 185 g
- Mass of case – 213 g
- AUW – 398 g
- Explosive – Comp B
- Average frag area – 1.0 cm²
- Average frag mass – 2g
- Frag drag coefficient – 0.5
- Density of air – 1.29 kg m⁻³
- Frag V @ 5m -1674 ms⁻¹
- Frag V @ 15m – 1424 ms⁻¹
- Frag V @ 230 m – 44 ms⁻¹

RGD-5 grenade

- Charge mass – 110 g
- Mass of case – 200 g
- AUW – 310 g
- Explosive – TNT
- Average frag area – 1.0 cm²
- Average frag mass – 0.12 - 0.46g
- Frag drag coefficient – 0.5
- Density of air – 1.29 kg m⁻³
- Frag Vi = 1567 ms⁻¹
- Number of fragments 350

81 mm Mortar AR-M81

- Charge Mass – 0.76 kg
- Mass of case – 1.334 kg
- AUW – 4.15 kg
- Explosive – TNT
- Frag drag coefficient – 1.6
- Density of air 1.23 kg m^{-3}
- Frag $V_i = 1734 \text{ ms}^{-1}$
- Frag $V @ 1\text{m} = 1700 \text{ ms}^{-1}$
- Frag $V @ 4\text{m} = 1600 \text{ ms}^{-1}$
- Frag $V @ 20\text{m} = 1150 \text{ ms}^{-1}$
- Frag $V @ 32\text{m} = 900 \text{ ms}^{-1}$
- Frag $V @ 77\text{m} = 357 \text{ ms}^{-1}$

RPG PG-7VL

- Charge mass – 730 g
- Mass of case – 1600 g (including rocket motor)
- AUW – 1975 g
- Explosive – RDX/TNT - 95% HMX 5% wax
- Average frag mass – 0.1 g
- Density of air – 1.29 kg m^{-3}
- Frag $V_i = 1831.5 \text{ ms}^{-1}$

155 mm

- Charge mass – 1150 g
- Mass of case – 3105 g
- AUW – 4255 g
- Explosive – Comp B
- Average frag mass – 2.1g
- Density of air – 1.29 kg m^{-3}
- Frag $V_i = 1551 \text{ ms}^{-1}$

Pipe Bomb

- Charge mass – 264 g
- Mass of case – 417 g
- AUW – 681 g
- Explosive – PE 8
- Average frag mass – 0.83 g
- Frag drag coefficient – 1.6
- Density of air – 1.29 kg m^{-3}
- Frag $V_i = 2047 \text{ ms}^{-1}$
- Frag $V @ 1\text{m} = 2022 \text{ ms}^{-1}$
- Frag $V @ 20\text{m} = 1602 \text{ ms}^{-1}$