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HRM Test Report

Prepared for: Protective Structures, LLC

DRAFT- 25 June 2013

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Introduction:

During the week of 6 – 10 May 2013, Applied Research Associates (ARA) conducted three blast exposures of various Hardened Resistant Module (HRM) or Blast Resistant Module (BRM) structures at the ARA operated Pecos Research and Testing Center (PRTC), located 18 miles southeast of Pecos, TX.

The exposure charge was a nominal 9,000 lb of enhanced Ammonium Nitrate / Fuel Oil (ANFO) with an approximate TNT equivalence of 0.89. The charge was detonated in a vertically oriented metallic culvert with top initiation. The HRM stand-off distances were either 150 or 175 ft.

Basic test layout showing relative HRM and charge locations

Test Preparation:

Typical HRM off-loading, final positioning, and securing to support pilings

Test Preparation:

BRM 2 as deployed

Test Preparation:

Charge as viewed from incident BRM 2 transducer

Test Preparation:

BRM 3 as viewed from charge

Test Preparation:

BRM 3, incident transducer radial, and connex container as deployed

Instrumentation Matrix:

The initial test on 07 May was fully instrumented with the following equipment. The test on 08 May utilized only the high-speed video and BRM 3 internal pressure. The test on 09 May was not instrumented.

Blast Over-Pressure

- Three incident transducers mounted at 150, 175, and 200 ft. on a single radial
- BRM 1 – 2 x reflective, 2 x incident
- BRM 2 – 2 x reflective, 1 x incident, 1 x internal
- BRM 3 – 2 x reflective, 2 x incident, 1 x internal
- Shipping Connex – 1 x internal

All transducers recorded at 1.0 MHz on either MeDAQ or ARA MicroDAS data acquisition systems. The BRM reflective gauges were mounted on the horizontal midline of the structures at the “1/3 - Left” and “2/3 - Right” locations, with the incident gauges centered on the side walls. Frag poles were positioned in front of the reflected transducers to shield the gauges from direct impact by culvert fragments.

High-Speed Digital Video

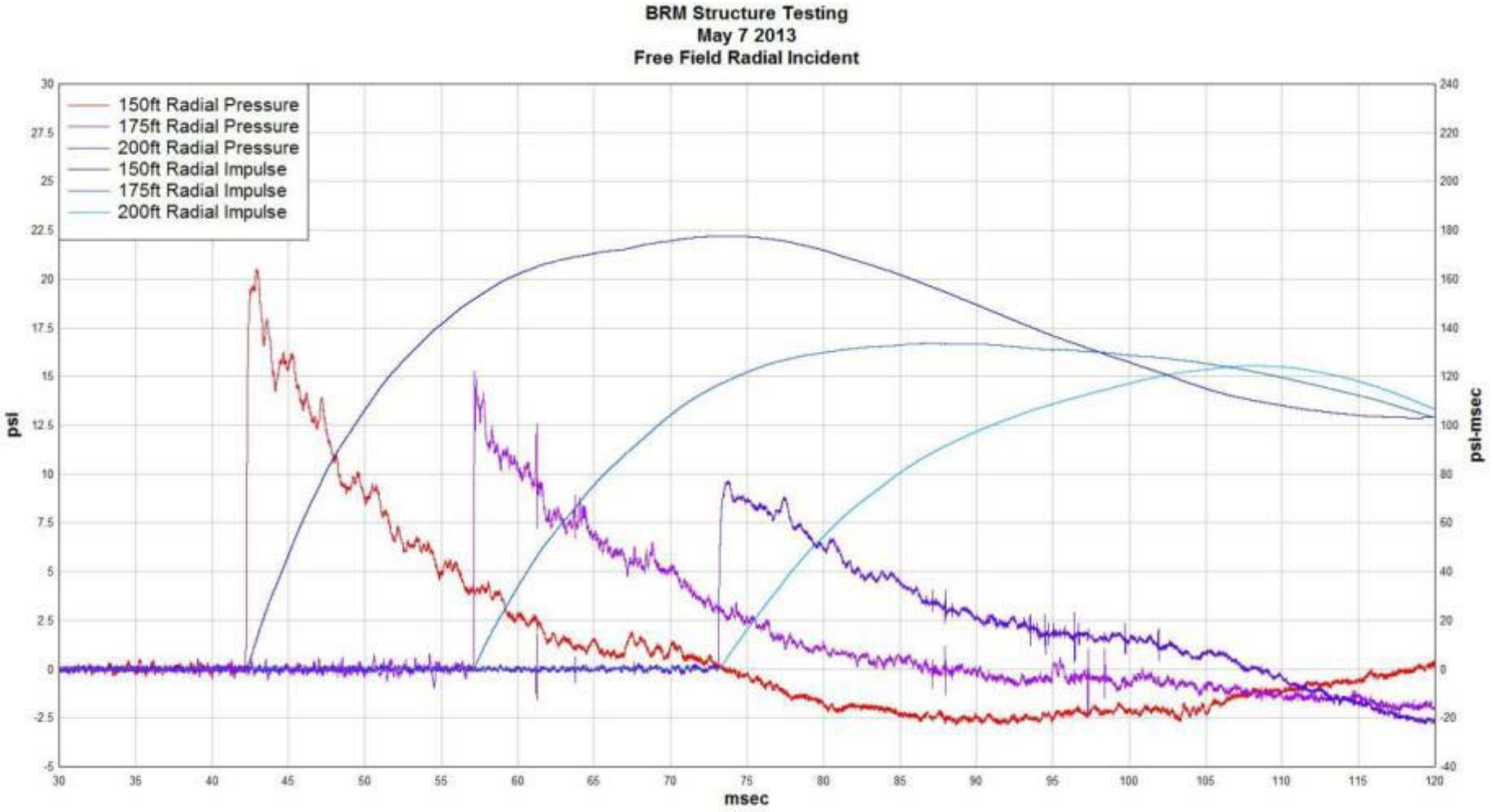
- Phantom 7.1 color overview of entire arena (4,700 frames per second)- Failed to trigger on 07 May test.
- Phantom 7.3 black and white detail view of BRM 3 and Connex (5,000 frames per second)
- BRM 3 – Internal GOPRO camera (240 frames per second) monitoring human surrogate

Blast Pressure Results Summary for 07 May 2013 test:

Location	Max Pressure	Total Impulse	Positive Phase Duration
• Incident Radial (150 ft):	20.52 psi	177.6 psi-msec	31.3 msec
• Incident Radial (175 ft):	15.29 psi	133.5 psi-msec	29.6 msec
• Incident Radial (200 ft):	9.67 psi	124.3 psi-msec	35.3 msec
• BRM 1 Reflected Right:	46.62 psi	275.9 psi-msec	18.0 msec
• BRM 1 Incident Left:	18.58 psi	104.8 psi-msec	16.5 msec
• BRM 1 Incident Right:	24.24 psi	141.5 psi-msec	20.5 msec
• BRM 2 Reflected Left:	71.17 psi	315.2 psi-msec	15.4 msec
• BRM 3 Reflected Left:	78.55 psi	353.5 psi-msec	17.9 msec
• BRM 3 Reflected Right:	54.54 psi	338.2 psi-msec	18.5 msec
• BRM 3 Incident Left:	15.75 psi	117.6 psi-msec	25.5 msec
• BRM 3 Incident Right:	15.45 psi	134.4 psi-msec	19.7 msec
• BRM 2 Internal:	1.20 psi max		
• BMR 3 Internal:	0.98 psi max		
• Connex Internal:	9.57 psi max (prior to gauge becoming disconnected)		

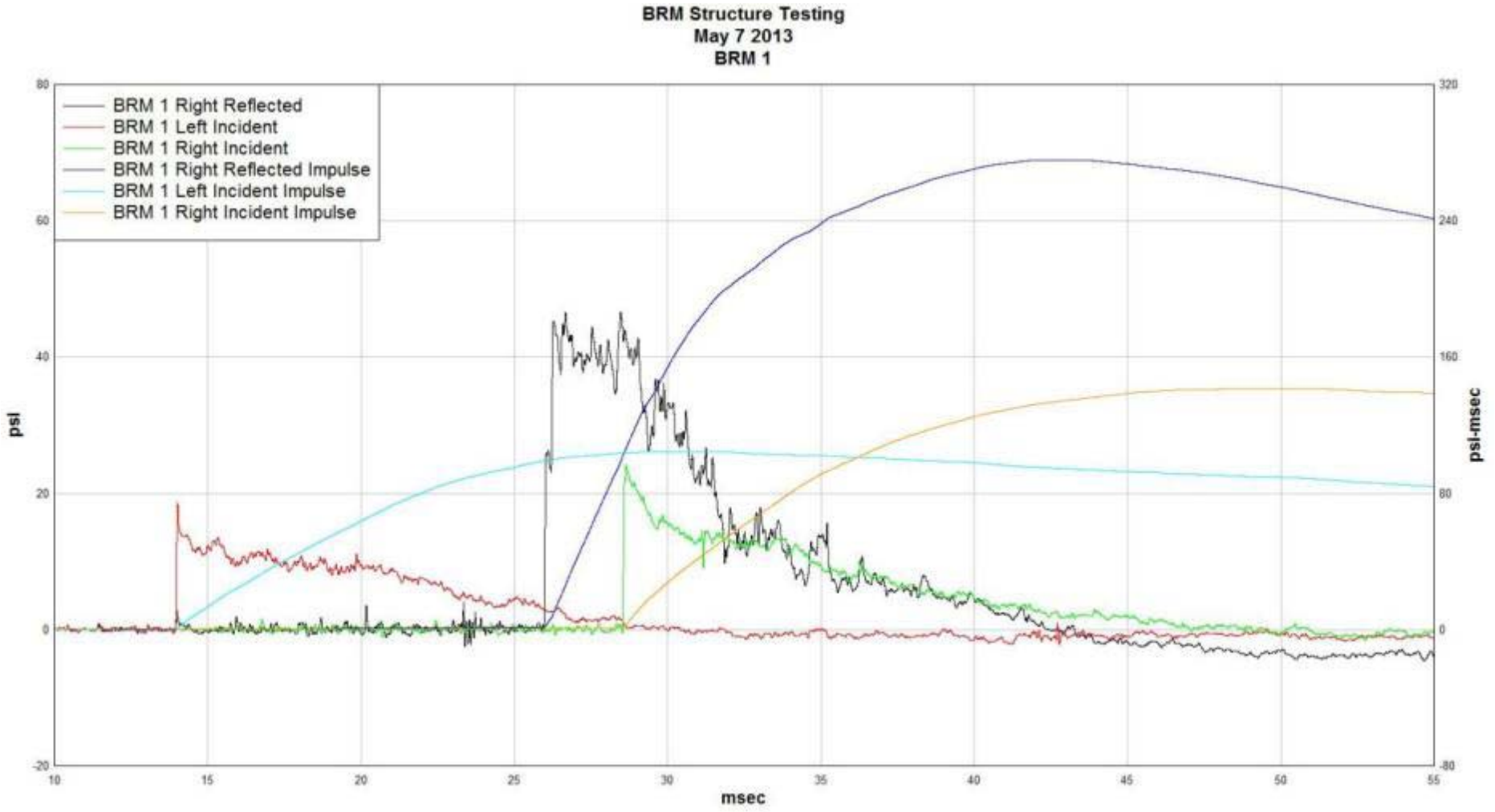
Blast Pressure Results:

Incident Radial



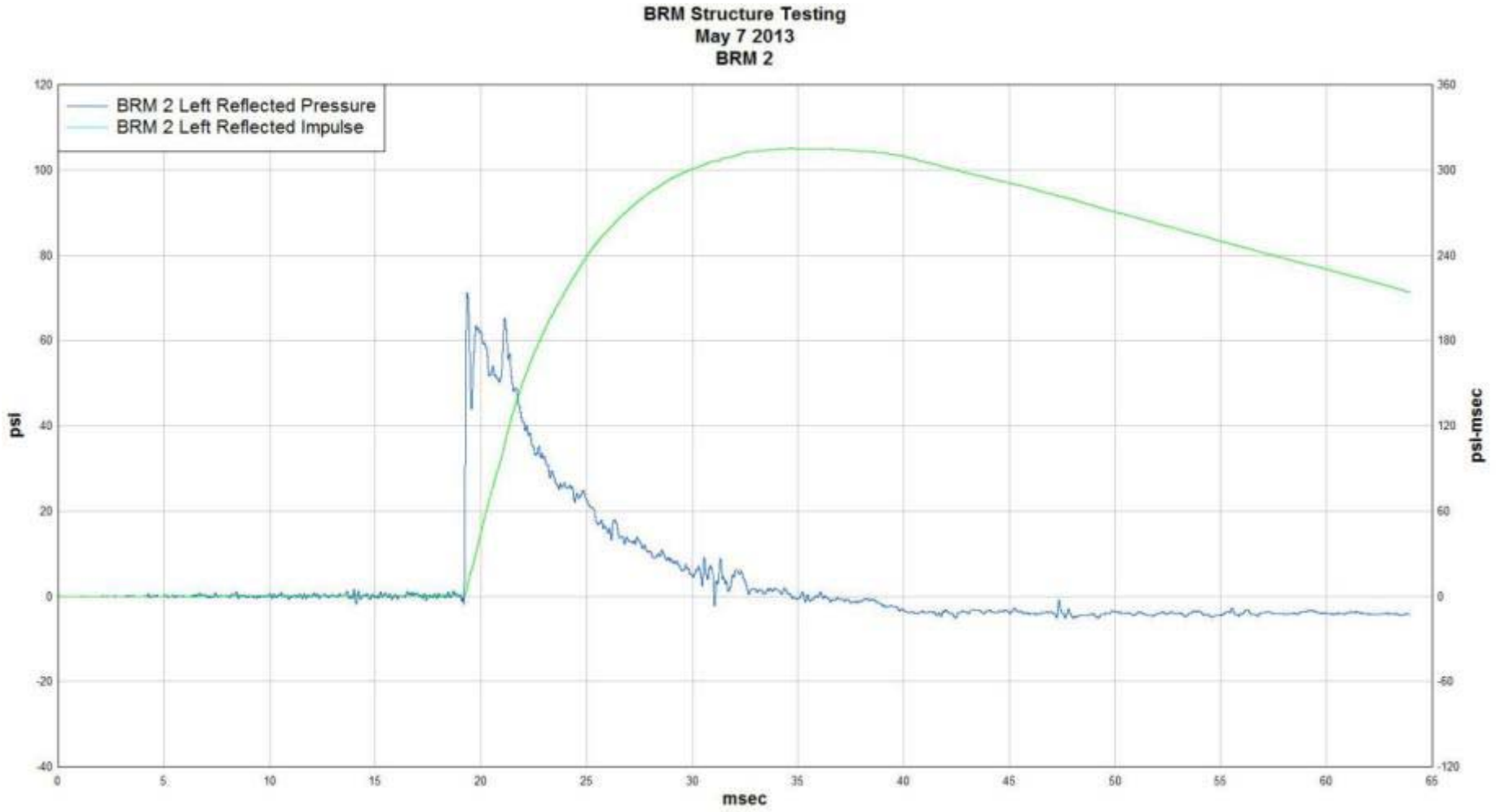
Blast Pressure Results:

BRM 1 Reflected and Incident Pressures



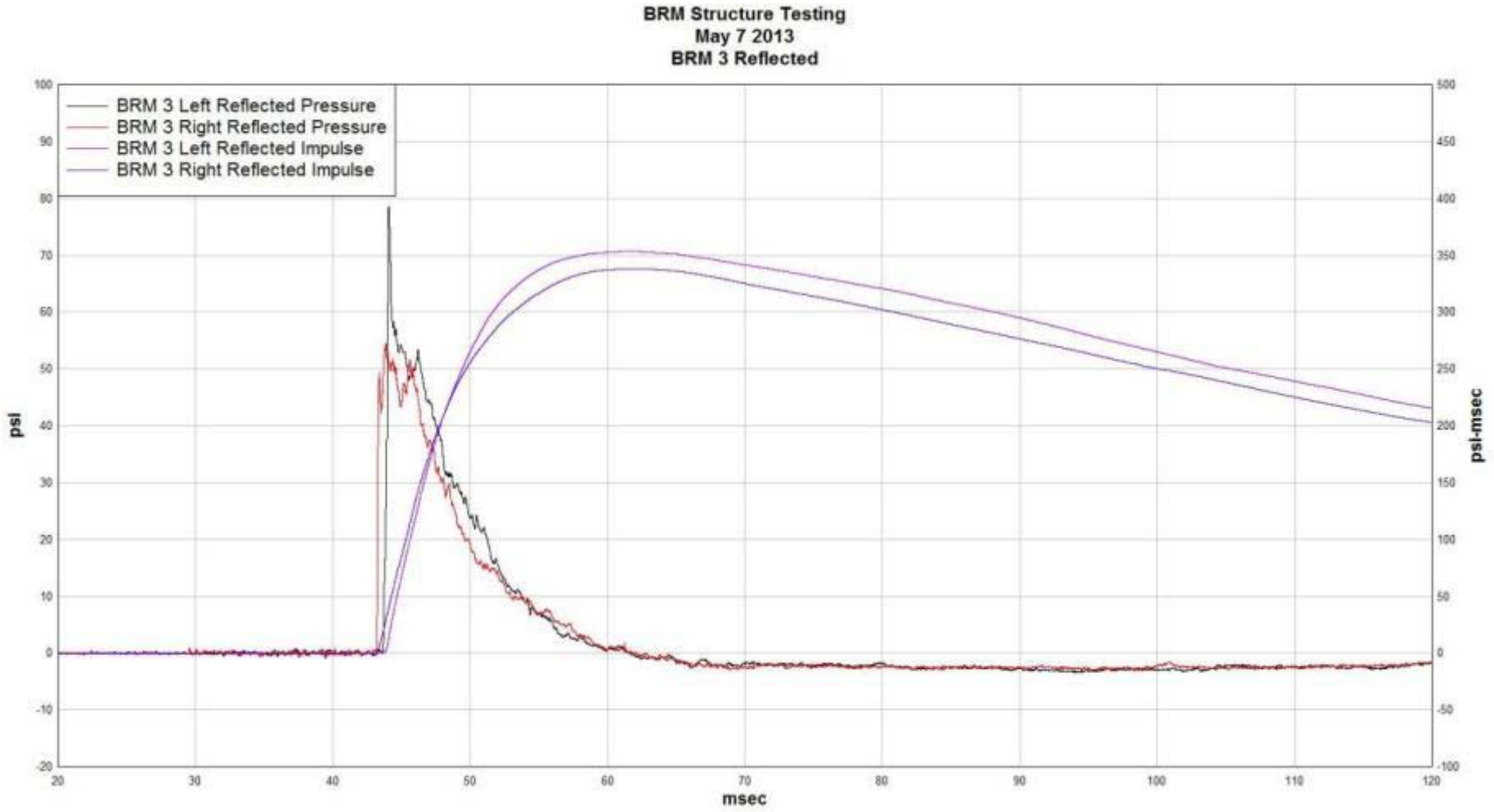
Blast Pressure Results:

BRM 2 Reflected Pressure



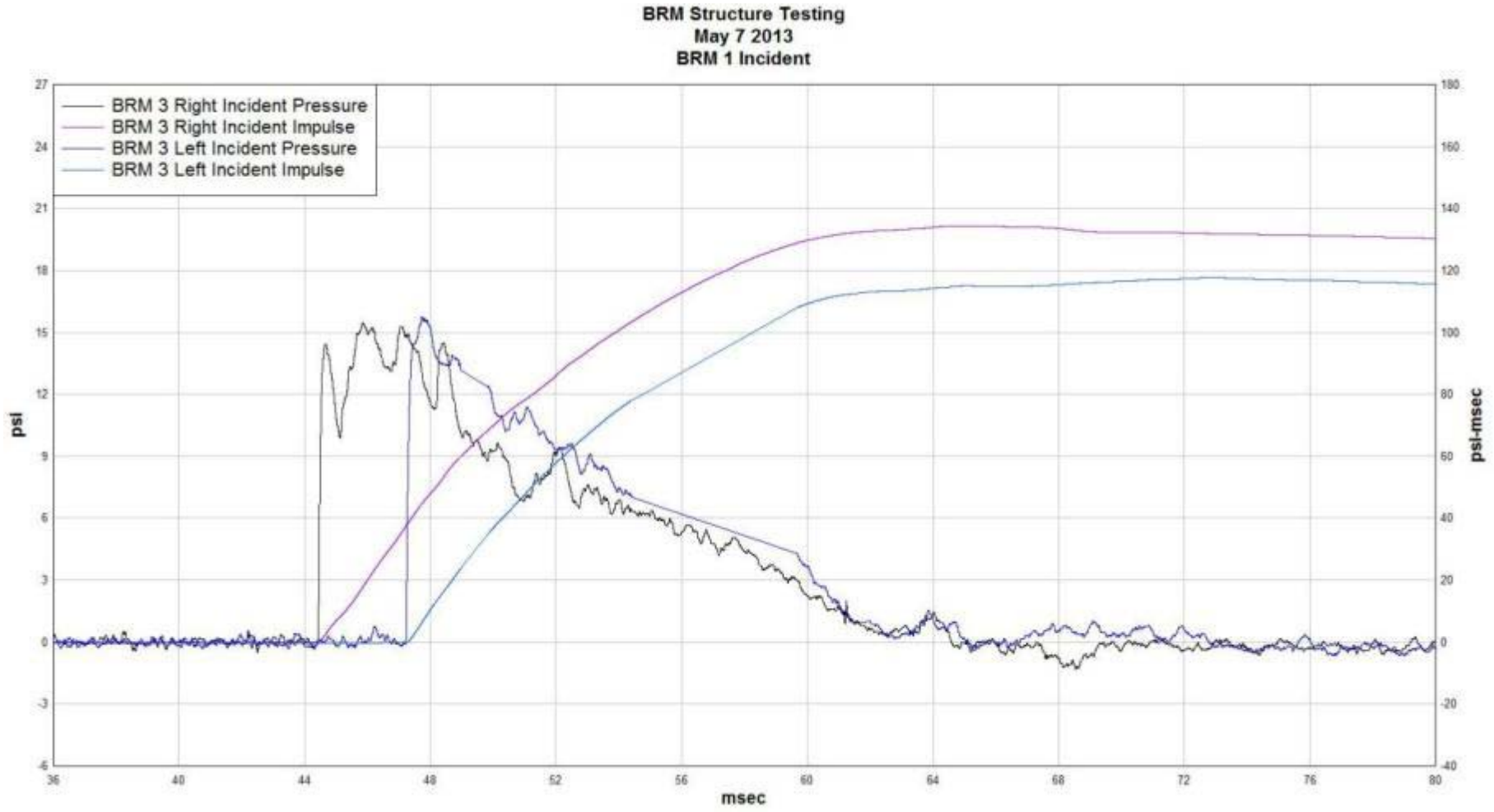
Blast Pressure Results:

BRM 3 Reflected Pressure



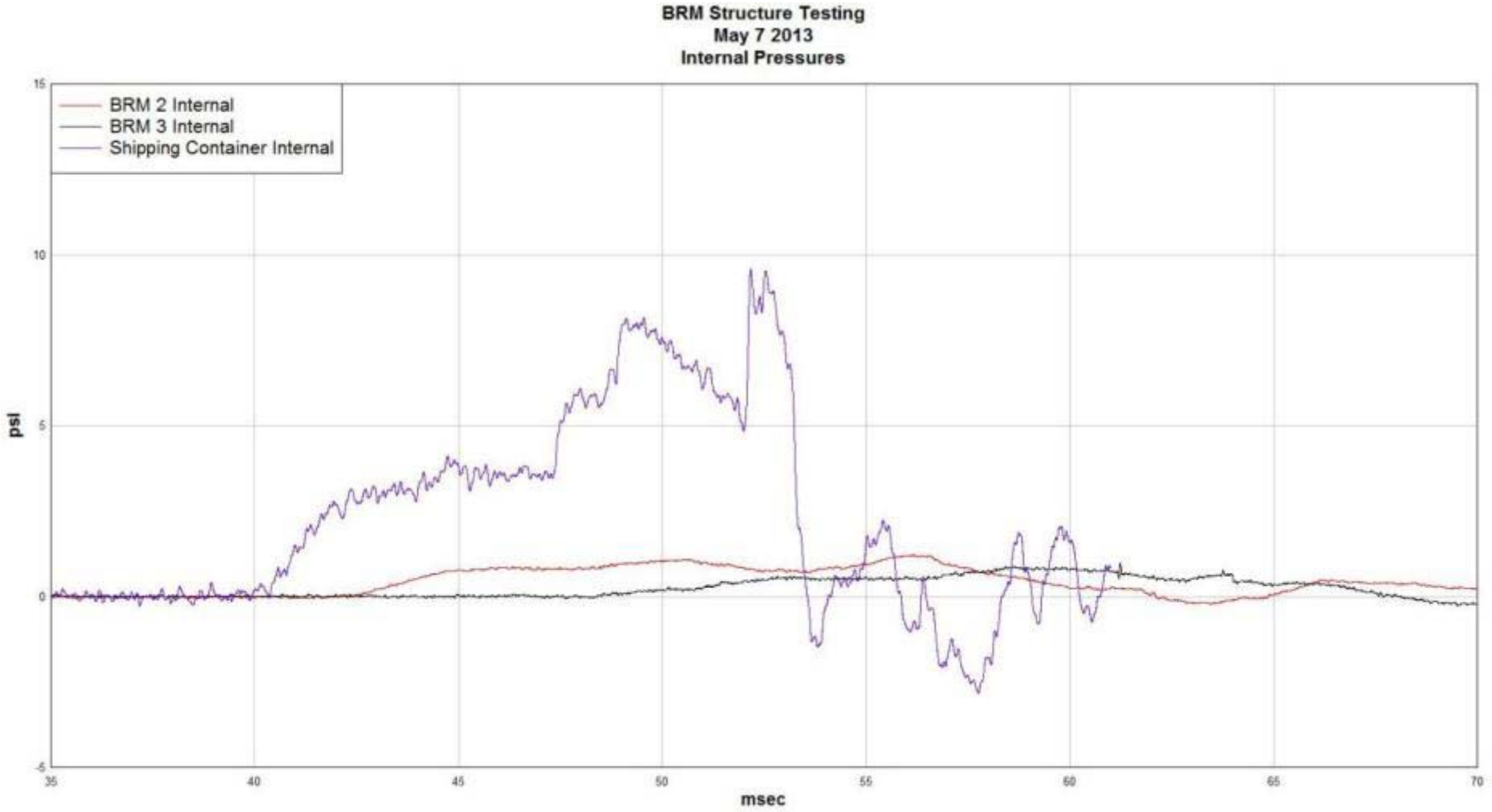
Blast Pressure Results:

BRM 3 Incident Pressure



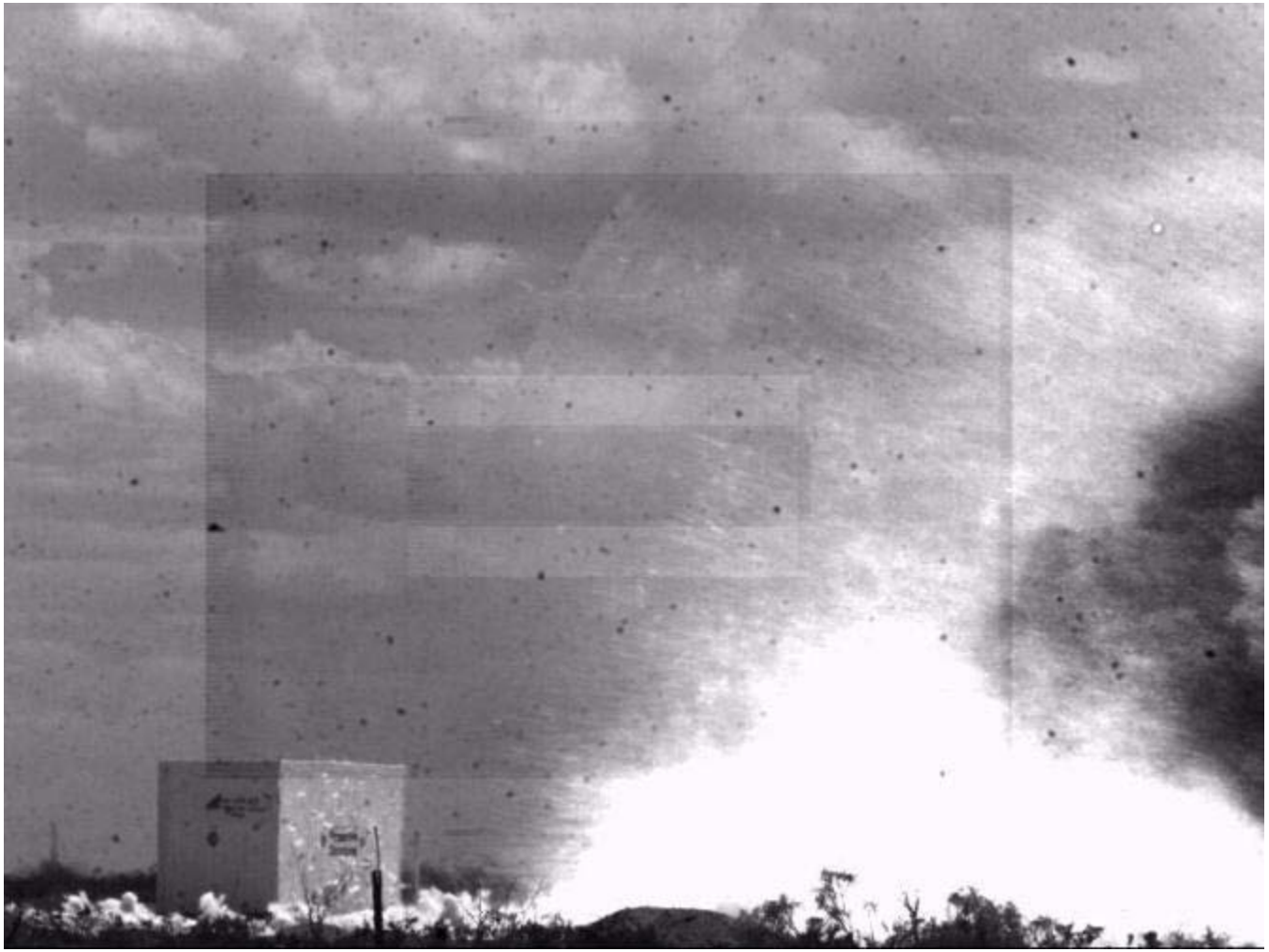
Blast Pressure Results:

BRM and Connex Internal Pressures



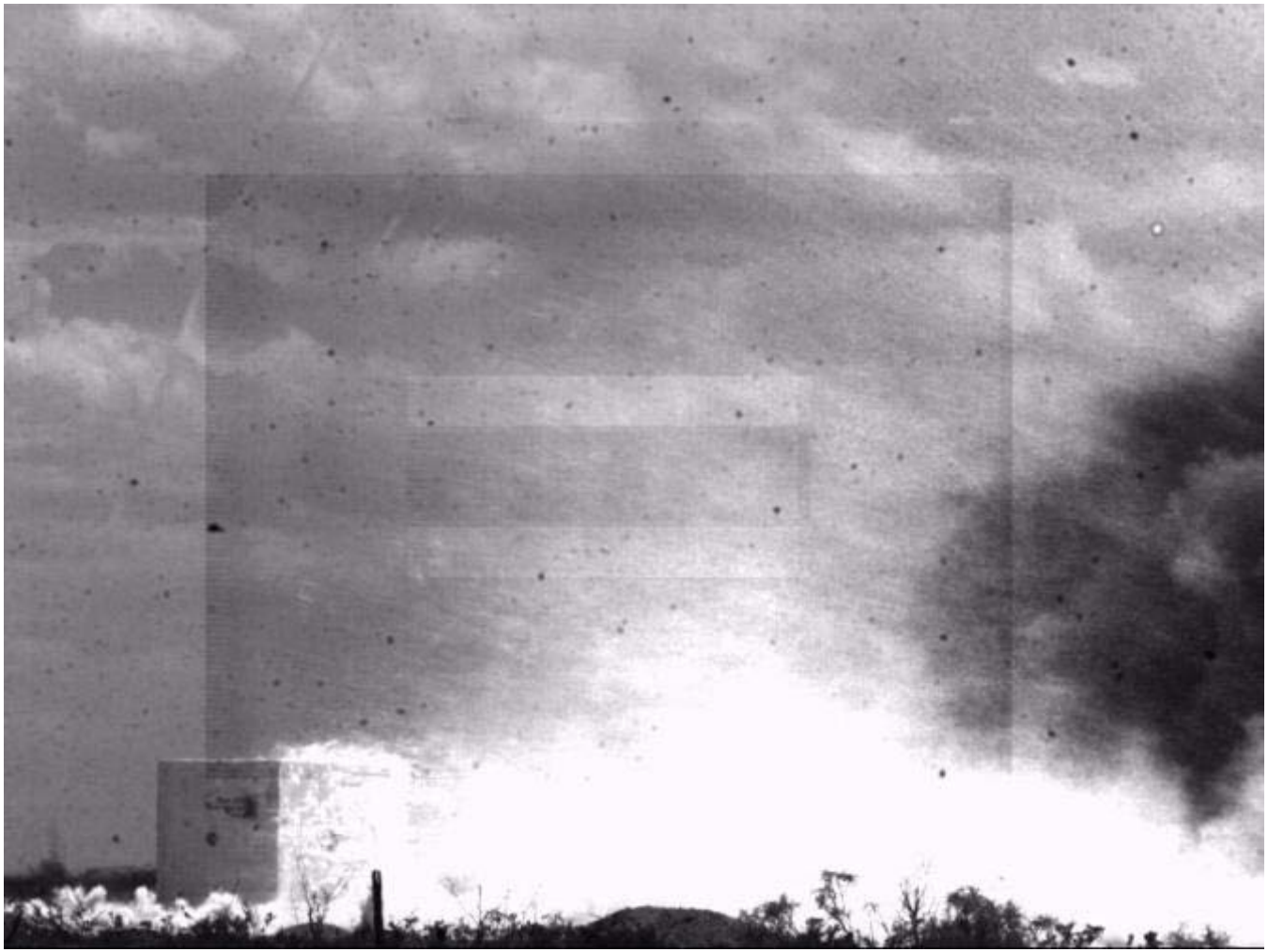
High Speed Video Results:

07 MAY 2013 Phantom 7.3 Black and White BRM 3



High Speed Video Results:

07 MAY 2013 Phantom 7.3 Black and White BRM 3



High Speed Video Results:

07 MAY 2013 Internal GOPRO BRM 3

Post Test Assessment:

07 MAY 2013 BRM 1

Post Test Assessment:

07 MAY 2013 BRM 2

Post Test Assessment:

07 MAY 2013 BRM 3

Post Test Assessment:

07 MAY 2013 BRM 3

Post Test Assessment:

07 MAY 2013 BRM 3

Post Test Assessment:

07 MAY 2013 CONNEX