ERDC/GSL TR-16-27

Geotechnical and Structures Laboratory

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# Blast Load Simulator Experiments for Computational Model Validation

Report 5

Andrew T. Barnes, Carol F. Johnson, and James L. O'Daniel

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Report 5 of a series



Prepared for Defense Threat Reduction Agency, Nuclear Technologies Directorate
Fort Belvoir, VA 22060-6201

Under Project 444856, Nuclear Airblast and Thermal Environments Testing and Modeling

# Abstract

The Department of Defense (DoD) needs the capability to accurately predict airblast environments produced by explosive detonations and their interaction with geometrically complex objects that create complex flow fields, such as buildings, bridges, dams, etc. First-principles computer codes are typically used to generate high-fidelity simulations of these explosive events and their effects. These codes are continuously improving, yet still require validation against experimental data to establish confidence in the results produced by simulations. This report describes two sets of replicate experiments in which two steel box-type structures were installed in a Blast Load Simulator (BLS) with varying spacing between them and subjected to a simulated blast loading to provide pressure-time data at multiple locations on the surfaces of the structures. The BLS is a highly tunable, compressed-gas-driven, closed-end shock tube designed to simulate blast waveforms for explosive yields up to 20,000 lb of TNT equivalent at a peak reflected pressure up to 80 psi and a peak reflected impulse up to 1,100 psi-msec. Pressure and impulse waveforms are presented, and comparisons are made among the replicated experiments to evaluate repeatability. The uncertainty in the experimental pressures and impulses was evaluated by computing 95% confidence intervals on the results.

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## Figures

## Tables

# Preface

This study was conducted for the Defense Threat Reduction Agency (DTRA). The ERDC technical monitor was Dr. James L. O'Daniel. The DTRA technical monitor was Dr. Culbert B. Laney.

The work was performed by the Structural Mechanics Branch (GSM) and the Research Group (GSR) of the Geosciences and Structures Division (GS), U.S. Army Engineer Research and Development Center, Geotechnical and Structures Laboratory (ERDC-GSL). At the time of publication, Mr. Bradford A. Steed was Chief, CEERD-GSM; Mr. James L. Davis was Chief, CEERD-GS; and Ms. Pamela G. Kinnebrew, CEERD-GZT, was the Technical Director for Military Engineering. The Deputy Director of ERDC-GSL was Dr. William P. Grogan, and the Director was Mr. Bartley P. Durst.

COL Bryan S. Green was the Commander of ERDC, and Dr. David W. Pittman was the Director.

# Unit Conversion Factors

| Multiply | By | To Obtain |
|---|---|---|
| degrees (angle) | 0.01745329 | radians |
| feet | 0.3048 | meters |
| inches | 0.0254 | meters |
| pounds (force) per square inch | 6.894757 | kilopascals |
| pounds (mass) | 0.45359237 | kilograms |

# 1 Introduction

## 1..1 Background

The U.S. Department of Defense (DoD) needs the capability to accurately predict the airblast environment produced by explosive detonations and its interaction with geometrically complex objects (such as buildings, bridges, dams, and many others) that create complex flow fields. First-principles computer codes are typically used to generate high-fidelity simulations of these explosive events and their effects. These codes are continuously improving, but they still require validation against experimental data to establish confidence in the simulation results specific to their intended use.

One method for providing experimental data for computational model validation is to use a blast load simulator, such as a shock tube, to produce a simulated high-explosive blast environment. Generally, a shock tube can provide a repeatable blast environment at a significantly lower cost than conducting field experiments using explosives. Repeated experiments are often necessary to quantify the uncertainty in the experimental results for validating computational models.

The previous report in this series (Barnes et. al 2017) described three series of replicate experiments utilizing a two-structure configuration in the 8-ft×8-ft BLS configuration. Those three sets of experiments were computationally reproduced, the results of which are documented in a separate technical report. This report documents an additional two configurations that produced data suitable for computational validation. However, since these two configurations were not computationally reproduced, they are not included in the separate technical report.

## 1.2 Objective

The objective of this effort was to conduct a set of replicate experiments in the U.S. Army Engineer Research and Development Center (ERDC) Blast Load Simulator (BLS) to measure the pressure loading on two nonresponding box-type structures located in the flow of the BLS-simulated blast environment for use in evaluating computational models.

## 1.3 Approach

To meet the objective of this effort, two series of five replicate experiments were conducted in the BLS, using what is referred to as the 8-ft×8-ft BLS configuration (Dallriva et al. 2016). In order to reduce the influence of the reflected pressure from the calibration plate on the recorded data, the BLS configuration maintained a 4-ft gap prior to the target vessel as described in Johnson et al. (2017). The nonresponding structures were installed in the BLS at a distance far enough downstream of the driver and near the reflecting target plate to provide increased testing time undisturbed by the interface (contact surface) between the driver gases and the driven gases. Otherwise, the contact surface impinging on the structures would result in turbulent effects that significantly reduce experiment repeatability. Data from the five experiments were used to calculate 95% confidence intervals in the results. The confidence intervals account for uncertainties associated with any small unknown or uncontrollable variations in experiment setup and conditions and for any inherent random variability in the dynamic environment produced in this BLS experimental process.

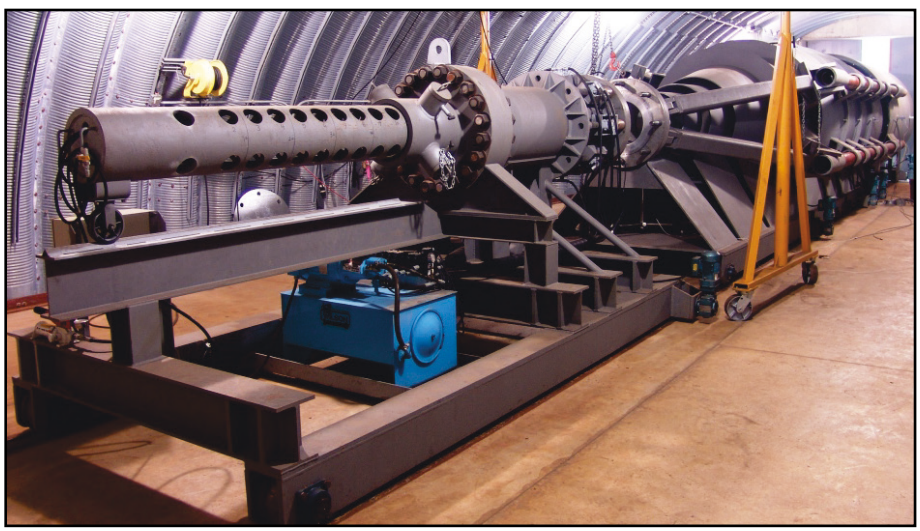
Pressure gauges were installed on the four sides and top of each structure, in the wall of the BLS near the structures, and in a fixed steel reflecting plate (referred to as the calibration plate) at the end of the BLS, all for recording pressure vs. time at the gauge locations. Data plots are provided that include pressure-time and impulse-time histories, and a few comparison plots are provided for visual evaluation of test repeatability.

# 2 Experiment Descriptions

## 2.1 Blast load simulator

The ERDC BLS (Figure 1) is a highly tunable, compressed-gas-driven shock tube designed to simulate blast waveforms for explosive yields up to an equivalent of 20,000 lb of TNT at a peak reflected pressure up to 80 psi and a peak reflected impulse up to 1,100 psi-msec (Johnson and Simmons 2008). The BLS has been used to evaluate the blast response of various structural test articles including windows, walls, and structural retrofit systems. It can simulate blast waveforms from very low pressures (1 to 2 psi) related to failures of conventional annealed glass and hollow concrete masonry unit walls to higher blast pressures required to evaluate the performance of protective construction methods.

Figure 1. ERDC Blast Load Simulator (BLS).



A recent addition to the BLS, referred to as the 8-ft×8-ft configuration shown in Figure 2, includes a section to transition from the circular cross-section that begins just downstream of the driver to a square cross-section for testing 8-ft×8-ft-square test articles, such as windows and walls. A detailed description of the BLS is provided in the first report of this series (Dallriva et al. 2016).

Figure 2. View from exterior of 8-ft×8-ft configuration.

## 2.2 Two-structure experiments with 26-in, and 32-in. spacing in the BLS 8-ft×8-ft configuration with a 4-ft gap

The BLS configuration for the set of experiments described herein is a modification of the two-structure configuration described in Report 4 of this series (Barnes et al. 2017). The configuration was modified by increasing the spacing between the two structures above the maximum spacing used in Report 4. The upstream structure was maintained at the same location as the unrotated case in Johnson et al. (2017) for both sets of experiments. The second structure was then placed downstream and directly behind the upstream structure. The location of the downstream structure was varied to conduct two sets of experiments with different spacings between the back face of the first structure and the front face of the second structure. The spacings used in the tests were 26 in. and 32 in. This second downstream structure was introduced to assess the ability of the codes to predict the pressures on a structure shielded from the incident blast wave by an upstream structure.

An elevation drawing of the BLS configuration with a 26-in. structure-to-structure separation is shown in Figure 3, and a cross-section view from inside the GSA cascade section of the BLS looking towards the target vessel showing the vertical location of the box structures is shown in Figure 4. The tops of the box structures were located 19.5 in. below the horizontal centerline of the BLS. The centerline of the BLS is always defined with respect to the centerline of the pressure vessel, regardless of

asymmetry of the C2SQ section observable in Figure 3. The box structures were 13 in. x 13 in. x 26.5 in. tall as shown in Figure 5. Figure 6 shows a photograph inside the BLS viewing the structures at 26-in. separation and the steel calibration plate. Figures 7 and 8 show the spacing between the two structures from a side view at 26-in. and 32-in. spacings, respectively. Figures 9 and 10 show the spacing between the two structures from a top front view at 26-in. and 32-in. spacings, respectively. The faces of the structure were defined as follows: the front side of the structure faced the pressure vessel, and the rear side faced the calibration plate. The left and right sides of the structure were defined looking upstream from the target vessel towards the pressure vessel.

Instrumentation included 4 pressure gauges mounted on the steel calibration plate, 2 pressure gauges mounted in the wall of the BLS, and 40 pressure gauges mounted on the box structures. Figure 11 shows the gauge layout on the calibration plate. Figure 12 shows the gauge layout on the sidewall of the BLS in the square and C2SQ sections. Figures 13 through 17 show the gauge layouts on the surfaces of box structure 1 including the direction of flow for the top and side surfaces. Figures 18 through 22 show the gauge layouts on the surfaces of box structure 2 including the direction of flow for the top and side surfaces. The grayed-out locations on the structures in Figures 13 through 22 were inactive during this series of experiments.

Figure 3. BLS 8-ft×8-ft configuration with two box structures at 26-in. spacing.

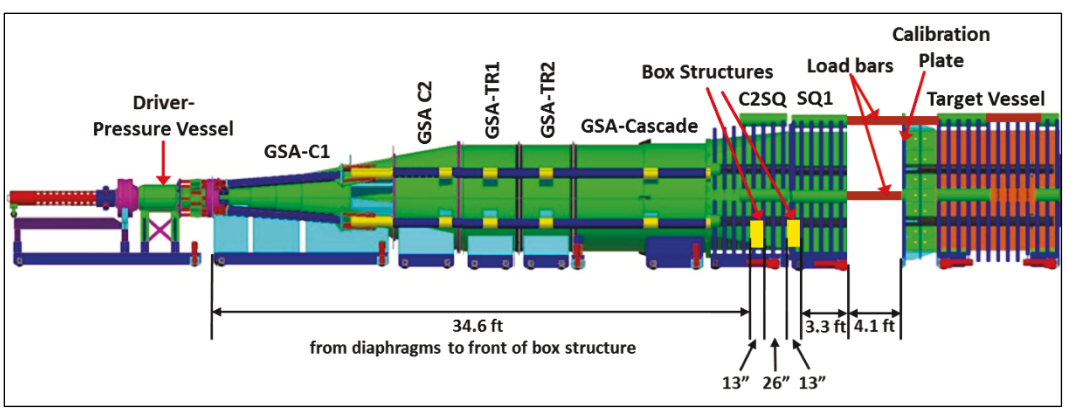


Figure 4. BLS cross-section showing the location of the box structures.

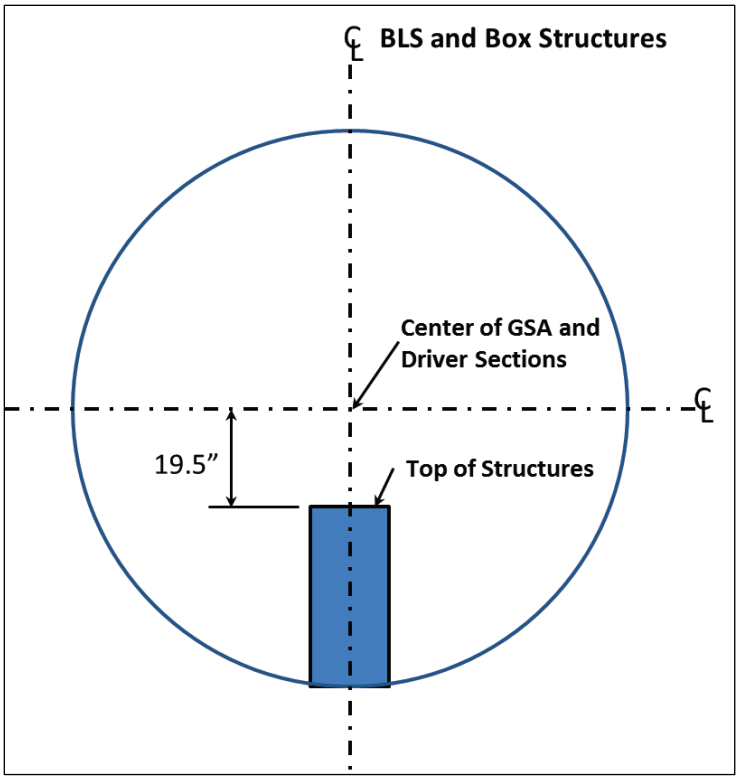



Figure 5. Box structure dimensions.

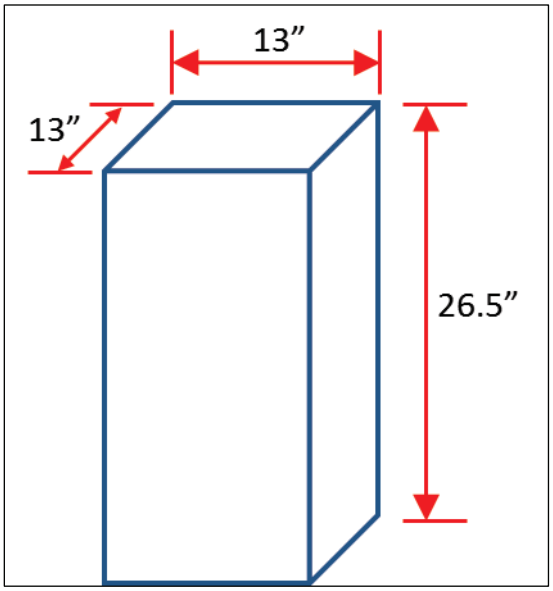


Figure 6. Photograph of the box structures at 26-in. spacing and calibration plate.

Figure 7. 26-in. spacing between structures.

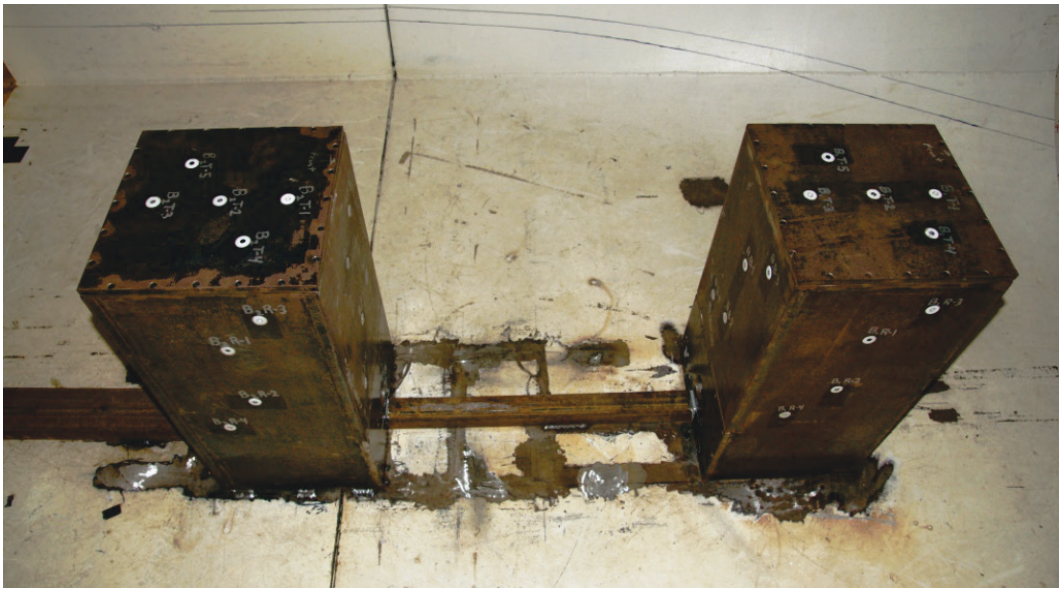


Figure 8. 32-in. spacing between structures.

Figure 9. Front-top view of structures at 26-in. spacing.

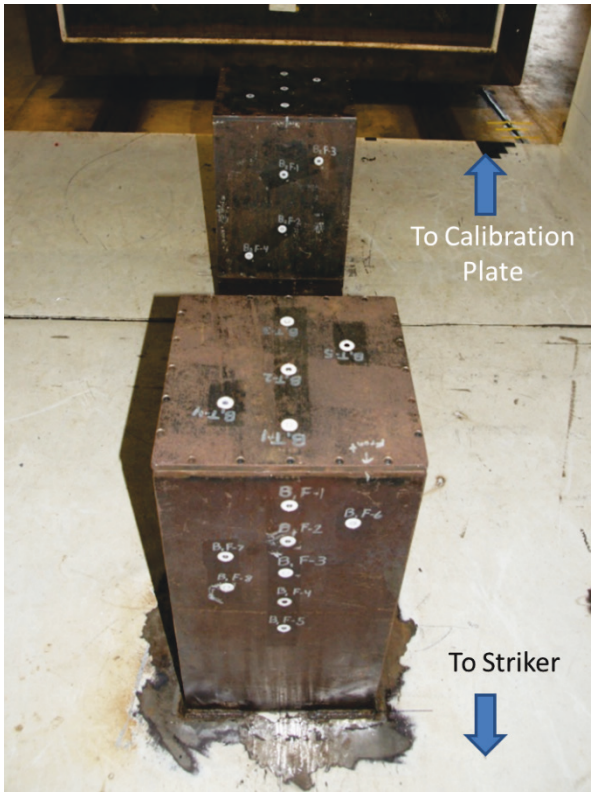


Figure 10. Front-top view of structures at 32-in. spacing.

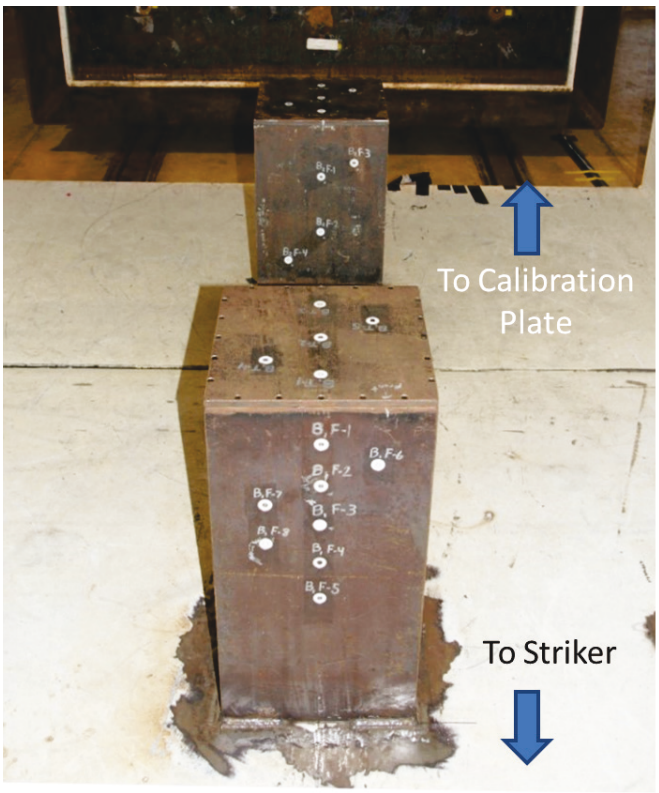



Figure 11. Gauge layout on the calibration plate.

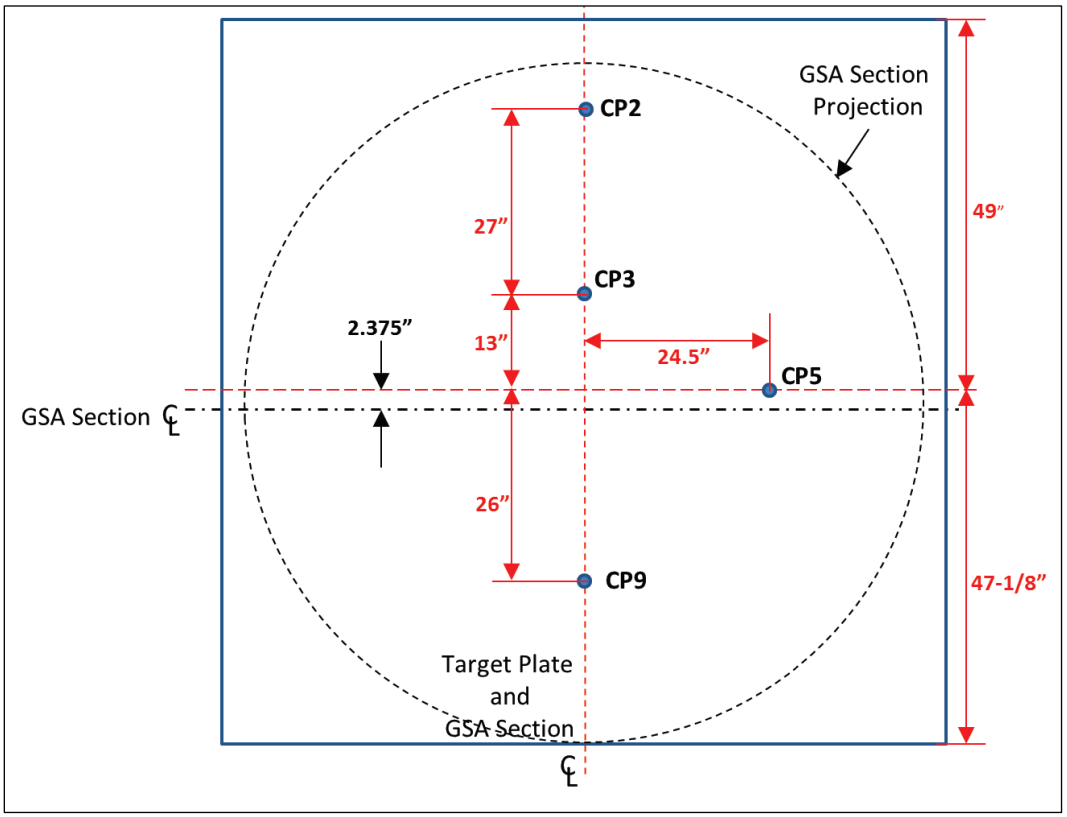


Figure 12. Gauge layout on the BLS sidewall.

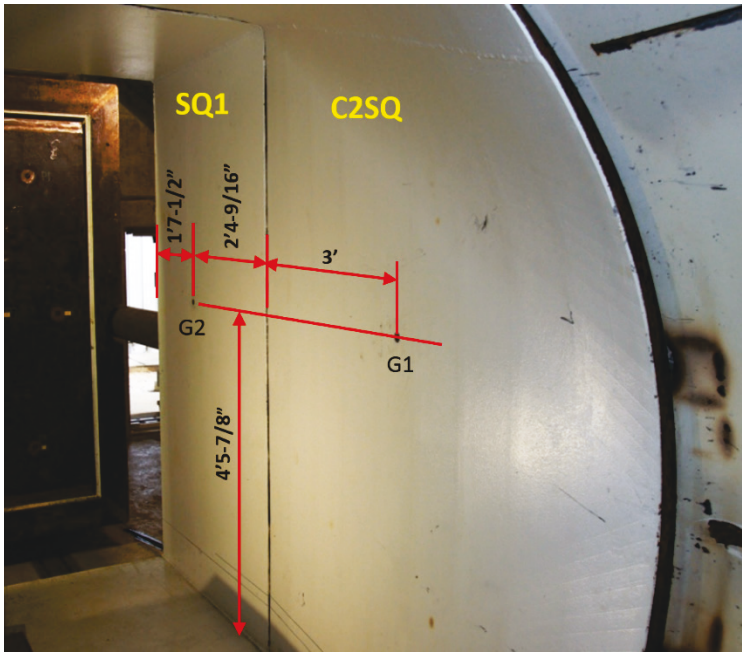



Figure 13. Gauge layout on the front of box structure 1.

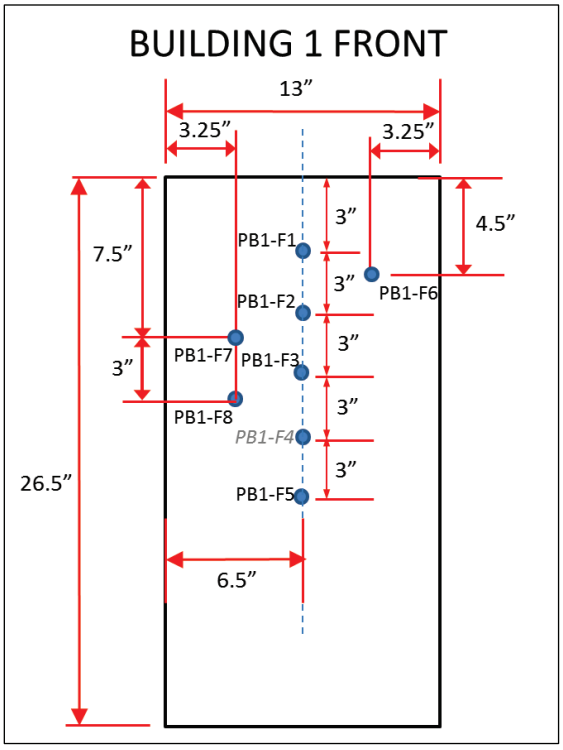


Figure 14. Gauge layout on the back of box structure 1.

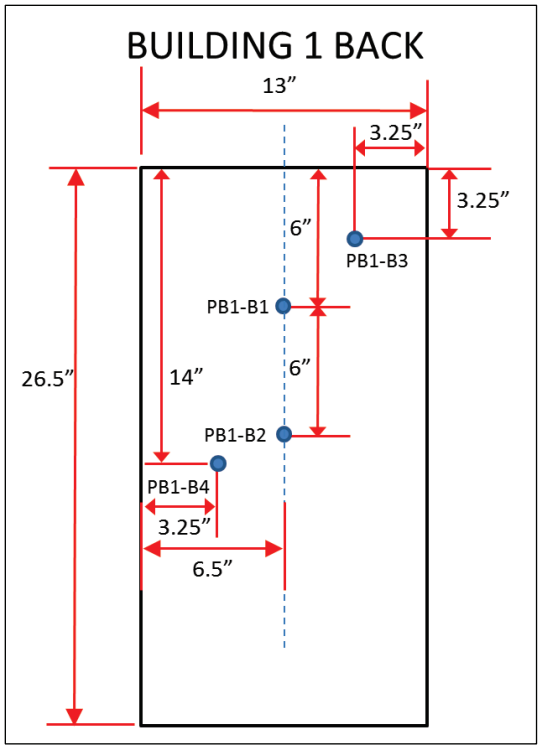



Figure 15. Gauge layout on the top of box structure 1 and direction of flow.

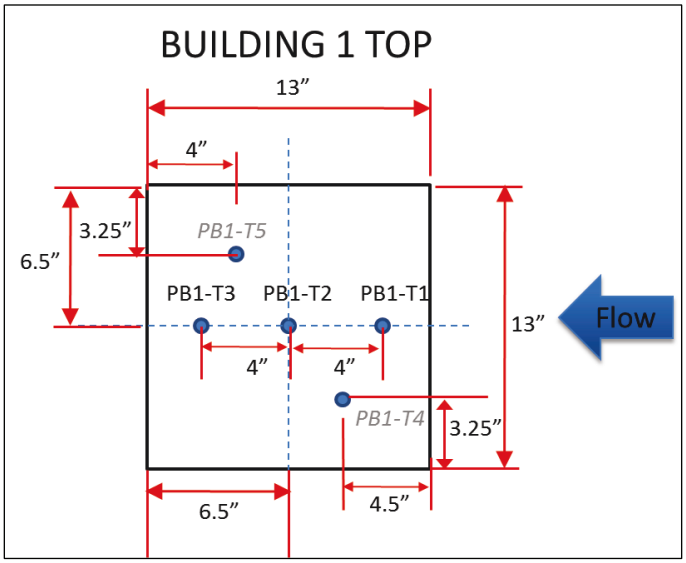


Figure 16. Gauge layout on the left side of box structure 1 and direction of flow.

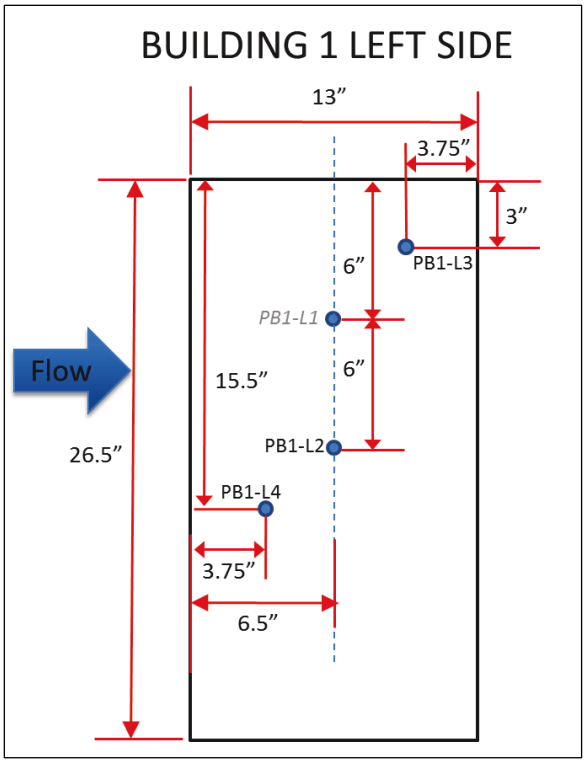



Figure 17. Gauge layout on the right side of box structure 1 and direction of flow.

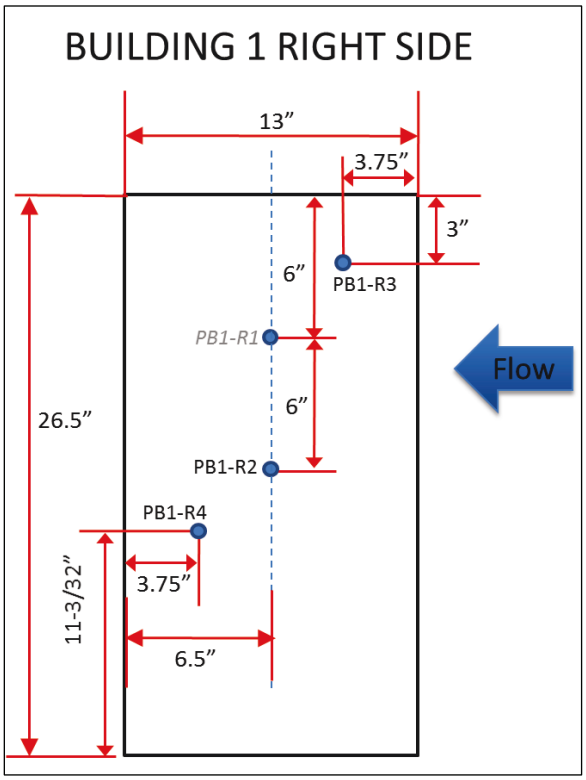


Figure 18. Gauge layout on the front of box structure 2.

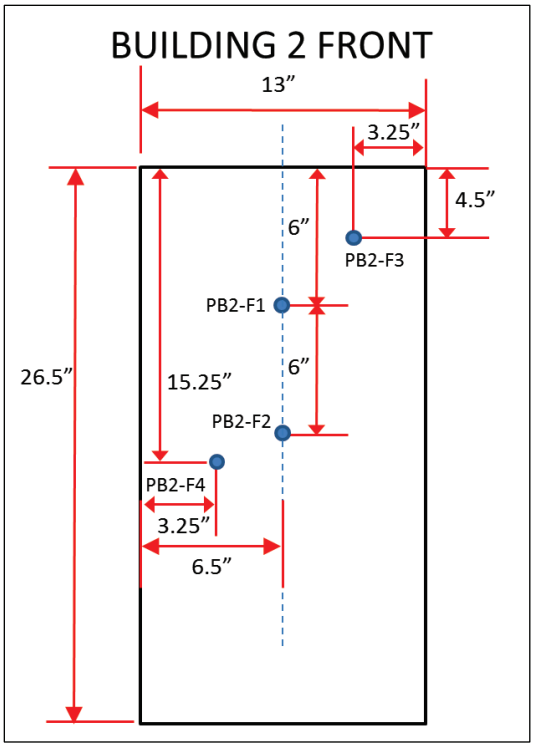



Figure 19. Gauge layout on the back of box structure 2.

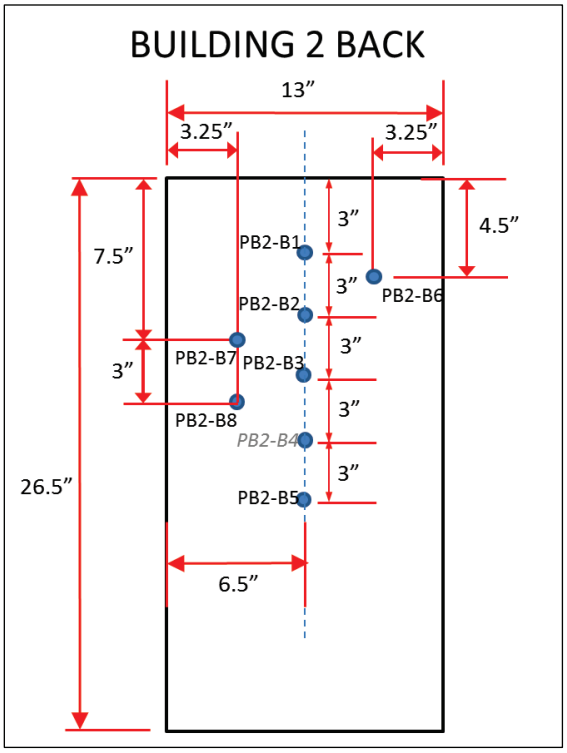


Figure 20. Gauge layout on the top of box structure 2 and direction of flow.

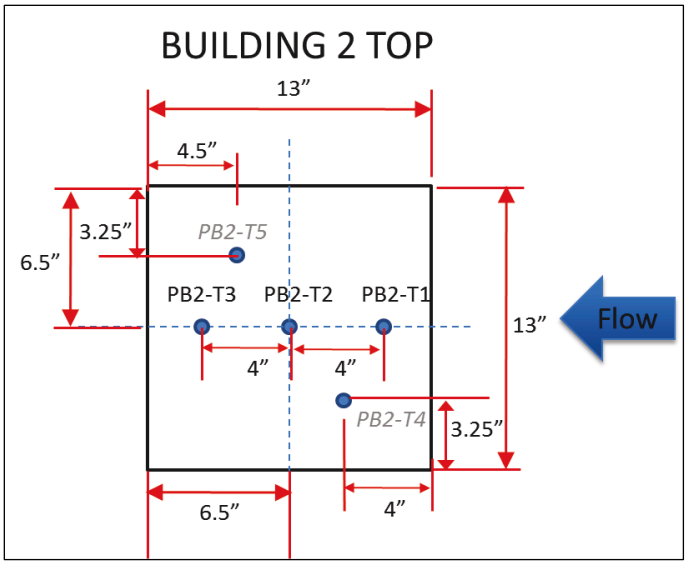



Figure 21. Gauge layout on the left side of box structure 2 and direction of flow.

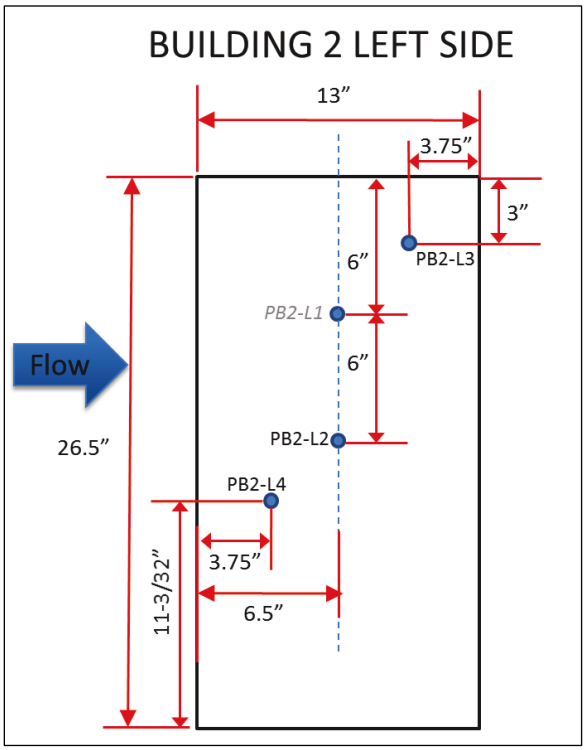
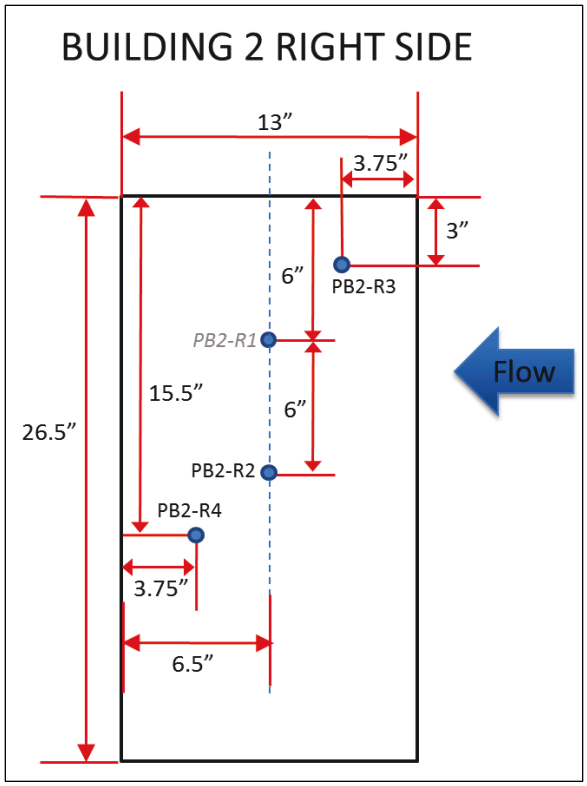


Figure 22. Gauge layout on the right side of box structure 2 and direction of flow.




Pressure measurements were made using either Kulite Model HKS-11-375 or XT-190 piezoresistive pressure transducers. The data were transmitted over shielded mil-spec cable and recorded on a 16-bit Pacific Model 5810 Data Acquisition System. The acquisition system’s sample rate was set for 1.0 µsec per point for the pressure measurements. The data after collection were post-processed using a 100-kHz low-pass filter.

In each test, the pressure vessel was pressurized, using air only, i.e., not helium or dry nitrogen, to 800 psi. A mechanical striker was used to initiate the pressure release through rupturing of diaphragms. The diaphragms consisted of three layers that included two layers of 0.0330-in. to 0.0345-in.-thick steel and one layer of 0.0235-in. to 0.0260-in.-thick aluminum.

# 3 Experimental Results

## 3.1 Comparison of pressure waveforms

### 3.1.1 26-in. spacing

Reflected pressures on the calibration plate were very consistent among the five tests conducted at 26-in. spacing, demonstrating a high degree of repeatability. Figures 23 and 24 show comparisons of the pressure and impulse from all five tests for gauges CP3 and CP5, respectively, located on the calibration plate. Pressures along the sidewall of the BLS near the structures were very consistent until approximately 50 msec, after which minor variability could be observed in the histories. Figures 25 and 26 show comparisons of the pressure and impulse from all five tests for gauges G1 and G2, respectively, located on the sidewall of the BLS. The greater variation observed after approximately 50 msec corresponds to the arrival of the driver gases and associated contact surface at the sidewall and structure gauge locations. Comparisons of representative pressure waveforms recorded on the front of Structure 1 are shown in Figures 27 and 28, on the back of Structure 1 in Figures 29 and 30, on the right side of Structure 1 in Figures 31 and 32, and on the top of Structure 1 in Figures 33 and 34. All of these show excellent repeatability among the replicate experiments until about 45 msec, after which time the effect of the contact surface at the pressure gauge locations manifests in higher experimental variability. In particular a pressure spike is observed on the front of the Structure 1 during Test 2 in Figures 27 and 28 at about 45 msec, resulting in a rising impulse at this time, whereas the other 4 tests in this series show a decreasing impulse.

Spurious peaks in the pressure data occur at several gauge locations (e.g., between 75 and 90 msec at gauge location PB1-R2, Figure 31) due to the interaction of the reflected shock with a hardened junction box located inside the BLS tunnel. The spurious peaks are not measurements of pressure at the gauge locations.

Individual plots showing both pressure and impulse for all gauges from the experiments are shown in Appendix A.

Figure 23. Comparison of pressure records on the calibration plate – 26-in. spacing – Gauge CP3.

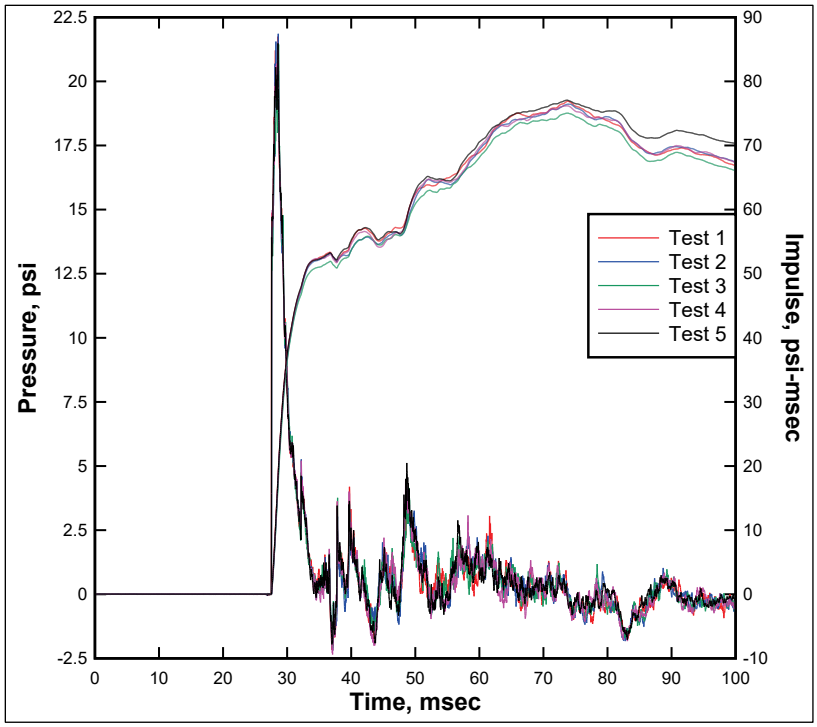



Figure 24. Comparison of pressure records on the calibration plate – 26-in. spacing – Gauge CP5.

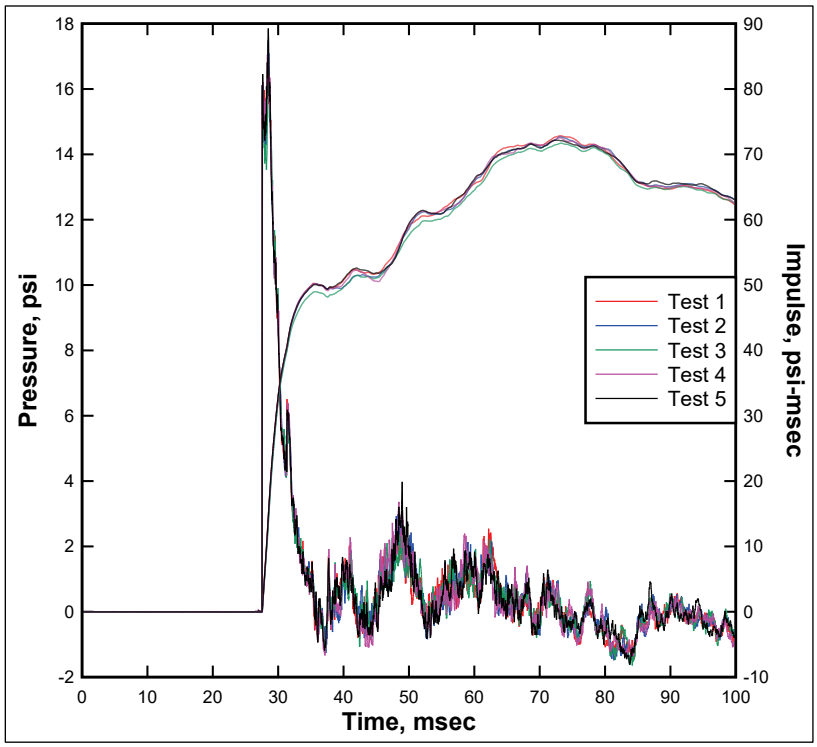


Figure 25. Comparison of pressure records on the BLS sidewall – 26-in. spacing – Gauge G1.

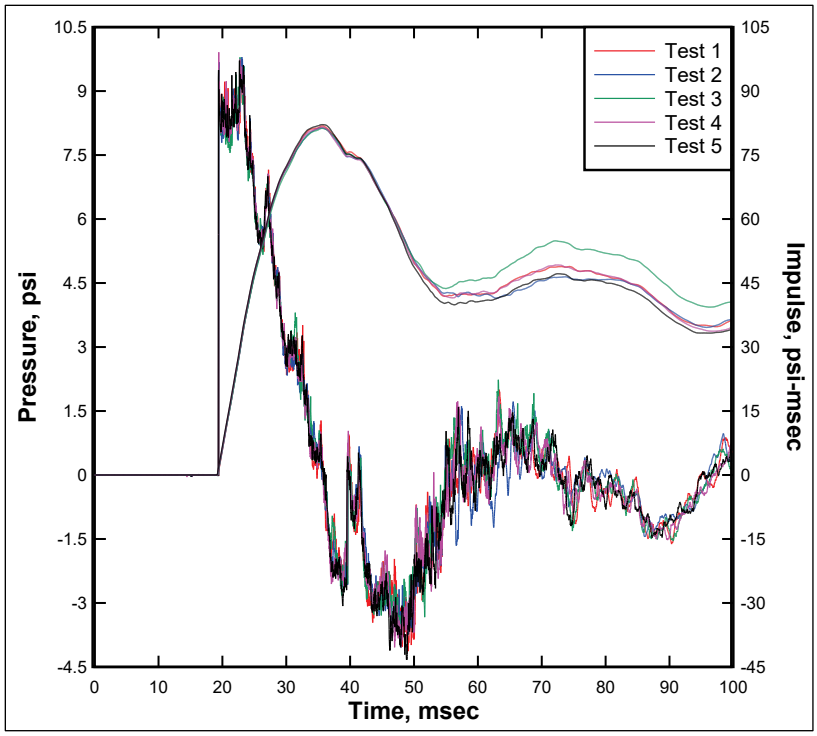



Figure 26. Comparison of pressure records on the BLS sidewall – 26-in. spacing – Gauge G2.

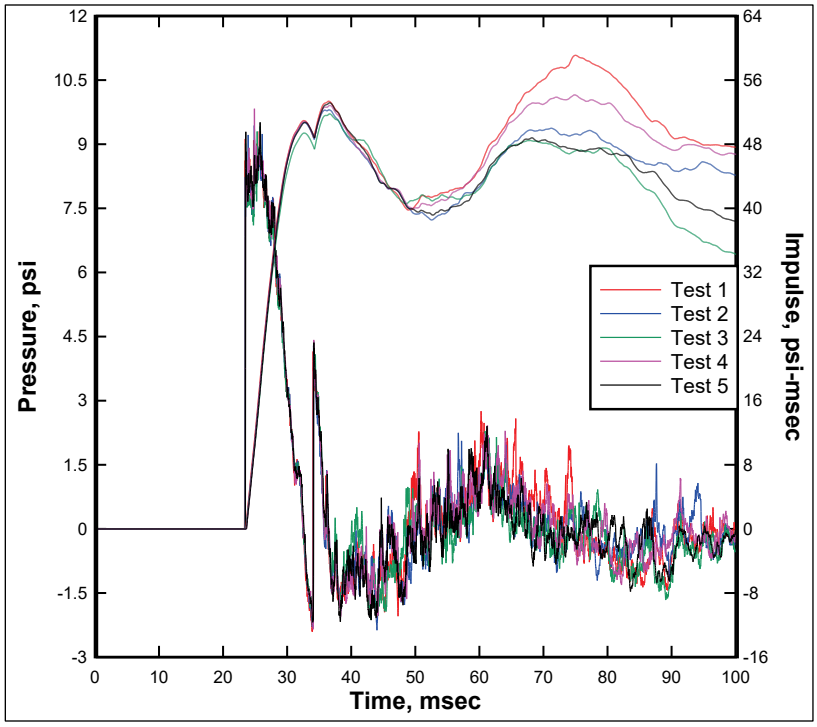


Figure 27. Comparison of pressure records on the front of Structure 1 – 26-in. spacing – Gauge PB1-F2.

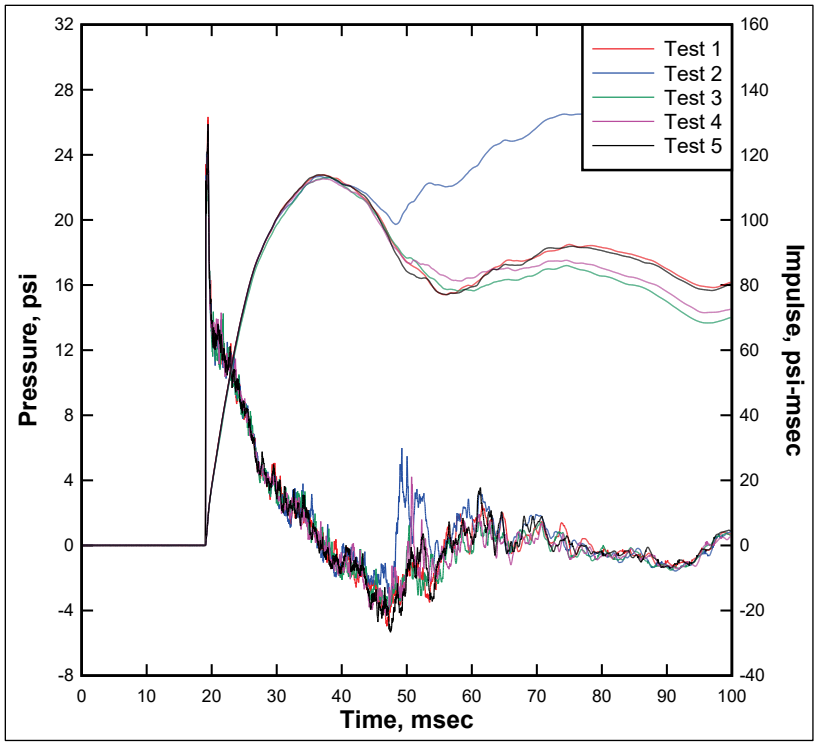



Figure 28. Comparison of pressure records on the front of Structure 1 – 26-in. spacing – Gauge PB1-F8.

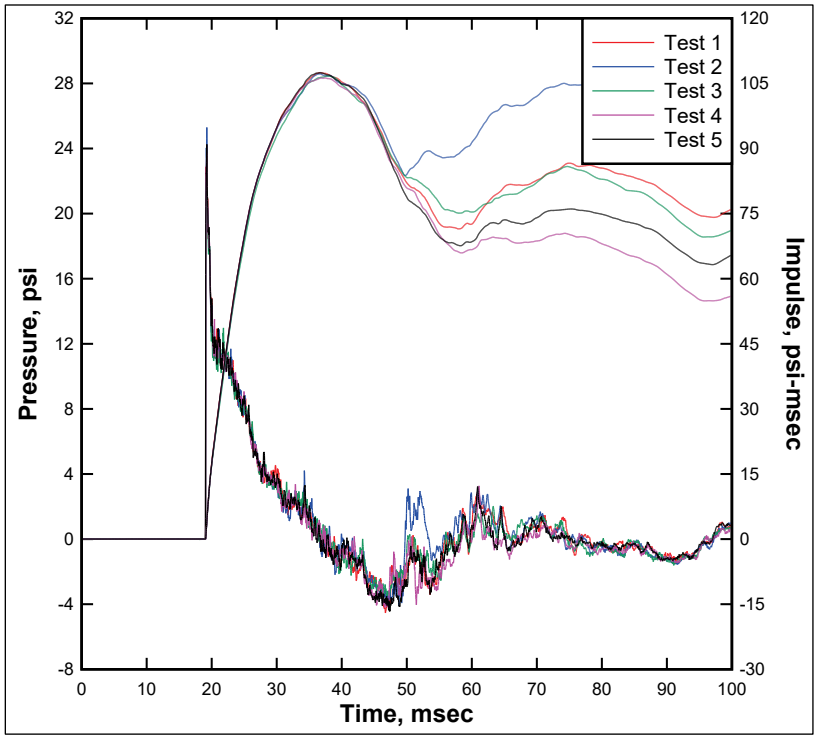


Figure 29. Comparison of pressure records on the back of Structure 1 – 26-in. spacing – Gauge PB1-B1.

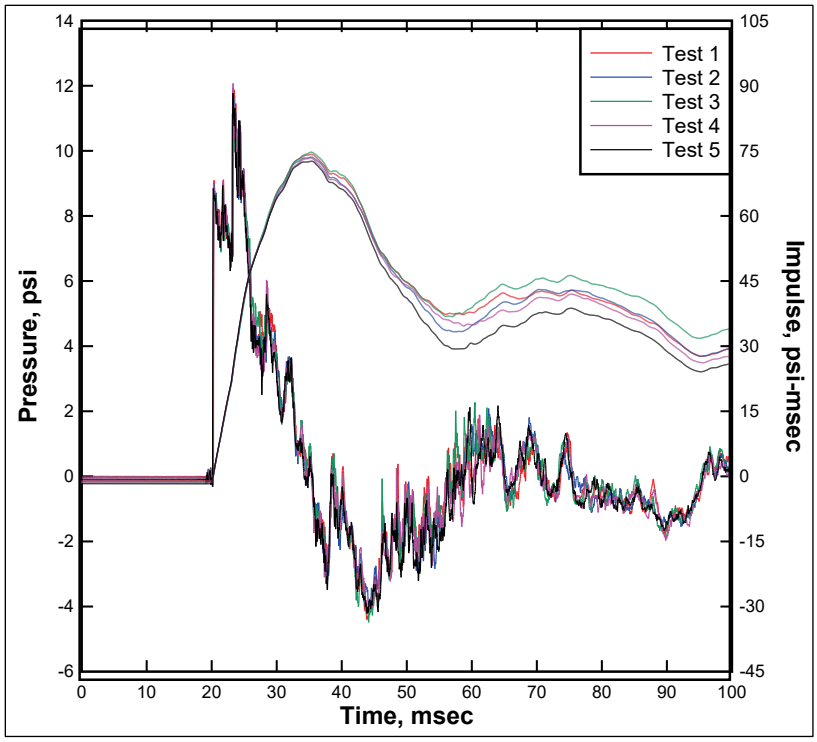



Figure 30. Comparison of pressure records on the back of Structure 1 – 26-in. spacing – Gauge PB1-B4.

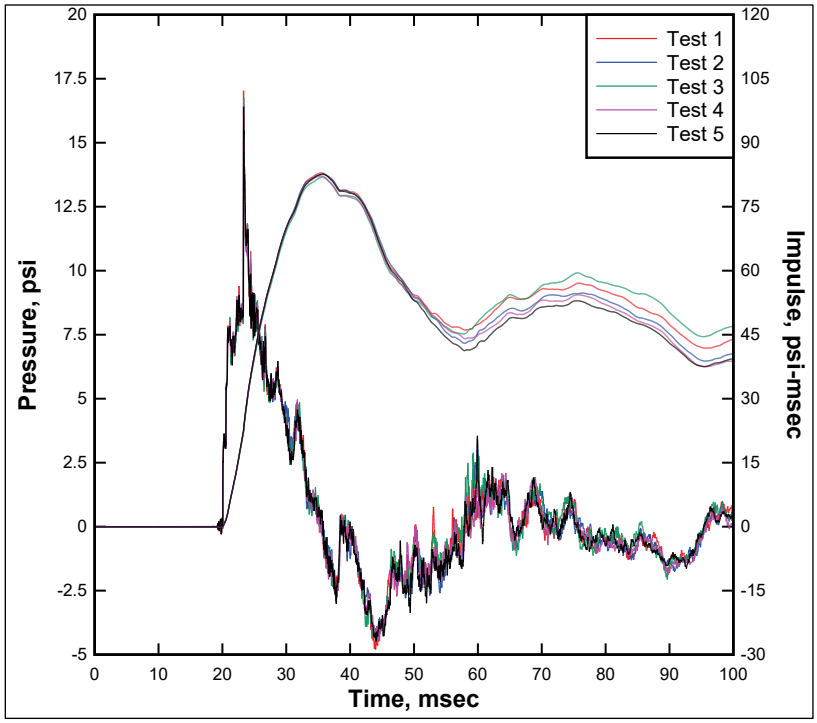


Figure 31. Comparison of pressure records on the side of Structure 1 – 26-in. spacing - Gauge PB1-R2.

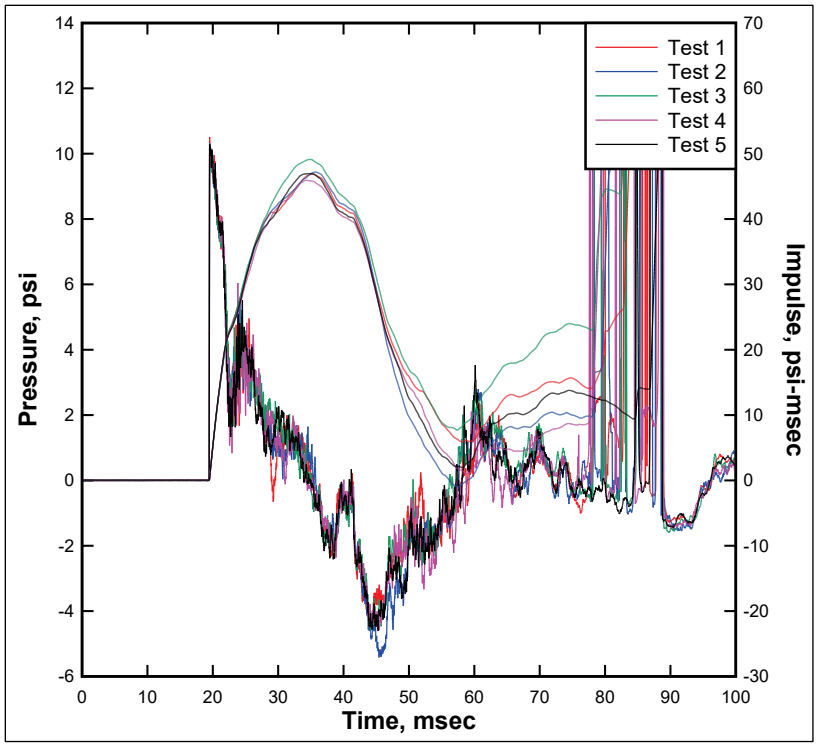



Figure 32. Comparison of pressure records on the side of Structure 1 – 26-in. spacing – Gauge PB1-R4.

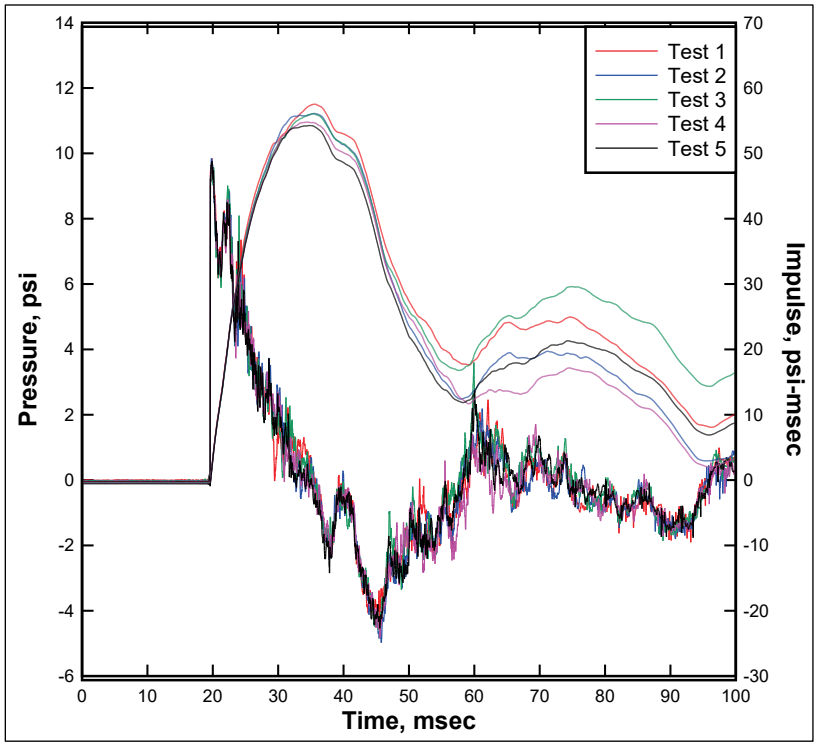


Figure 33. Comparison of pressure records on the top of Structure 1 – 26-in. spacing - Gauge PB1-T1.

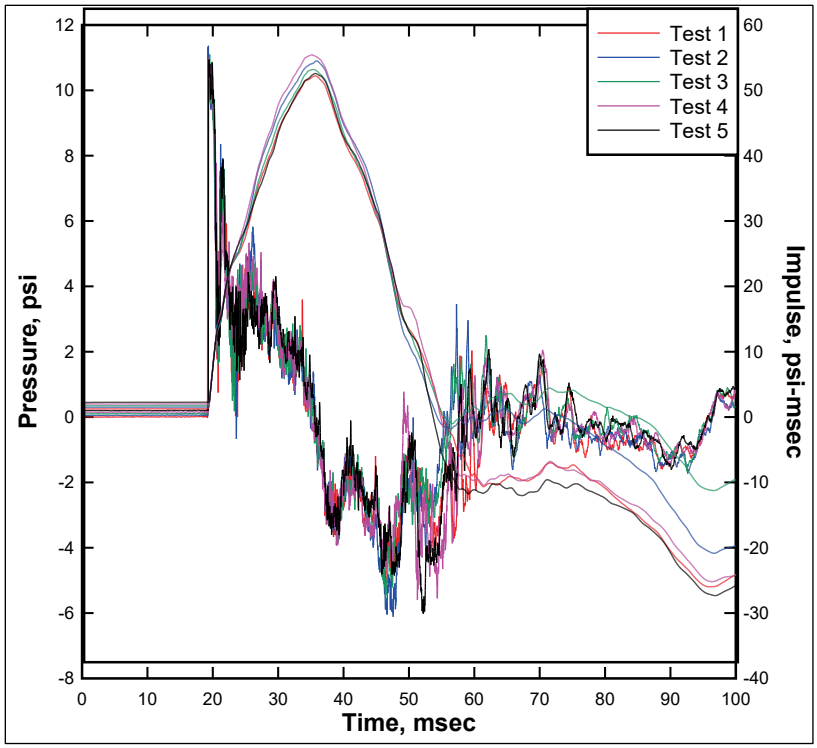



Figure 34. Comparison of pressure records on the top of Structure 1 – 26-in. spacing – Gauge PB1-T3.

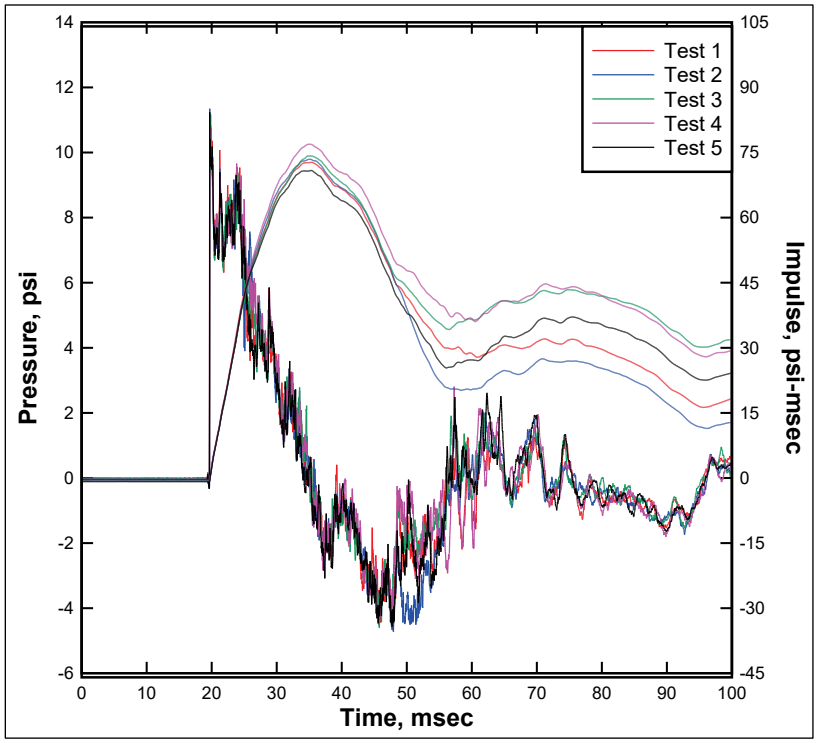


Figure 35. Comparison of pressure records on the front of Structure 2 – 26-in. spacing – Gauge PB2-F1.

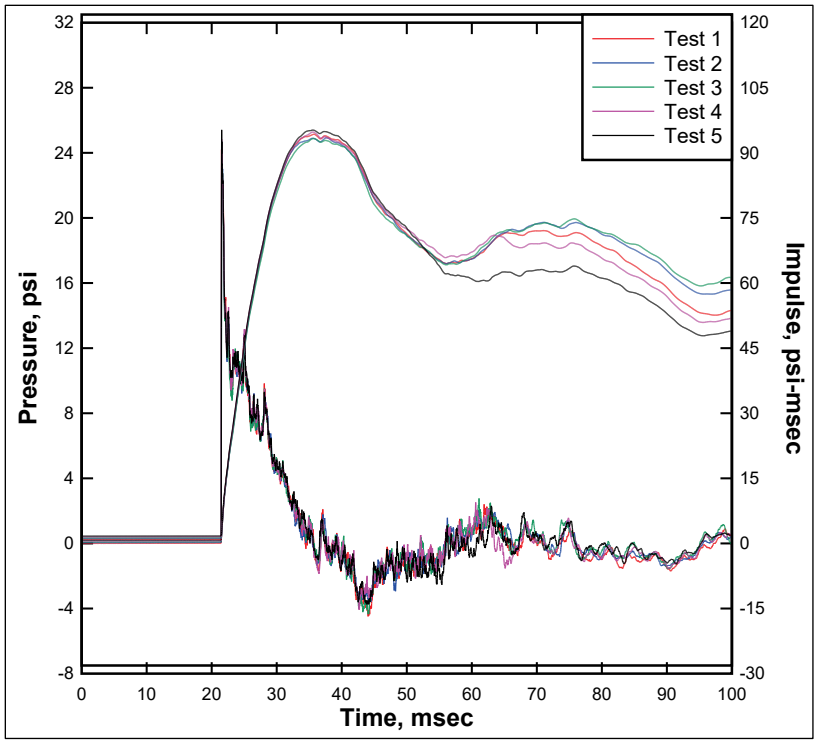



Figure 36. Comparison of pressure records on the front of Structure 2 – 26-in. spacing – Gauge PB2-F4.

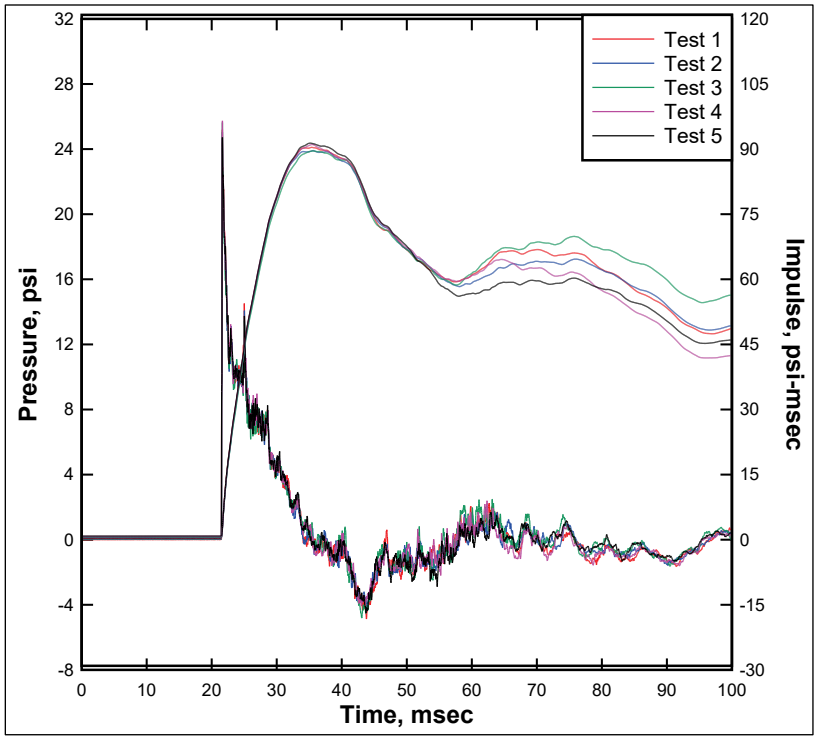


Figure 37. Comparison of pressure records on the back of Structure 2 – 26-in. spacing – Gauge PB2-B2.

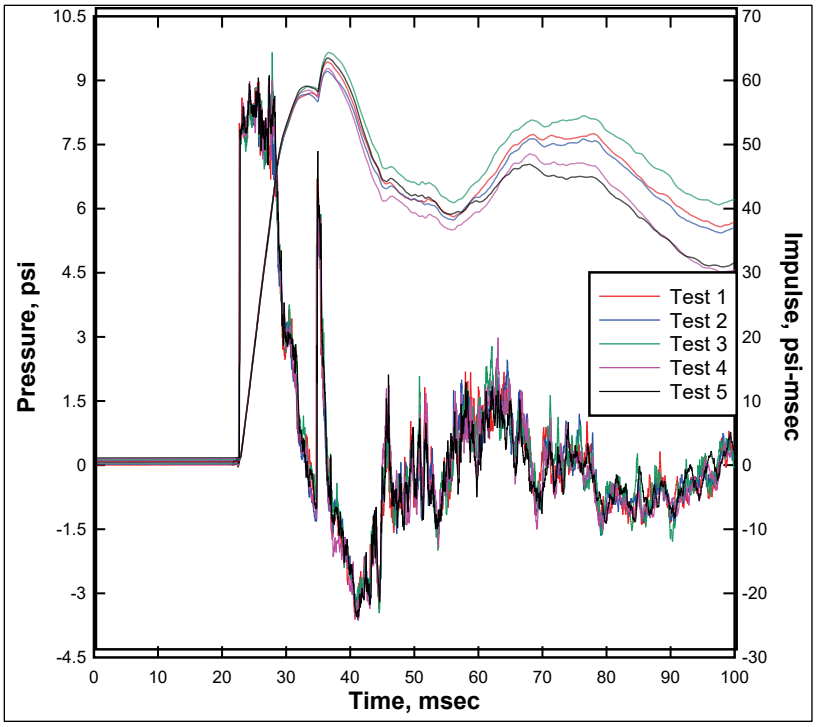



Figure 38. Comparison of pressure records on the back of Structure 2 – 26-in. spacing – Gauge PB2-B8.

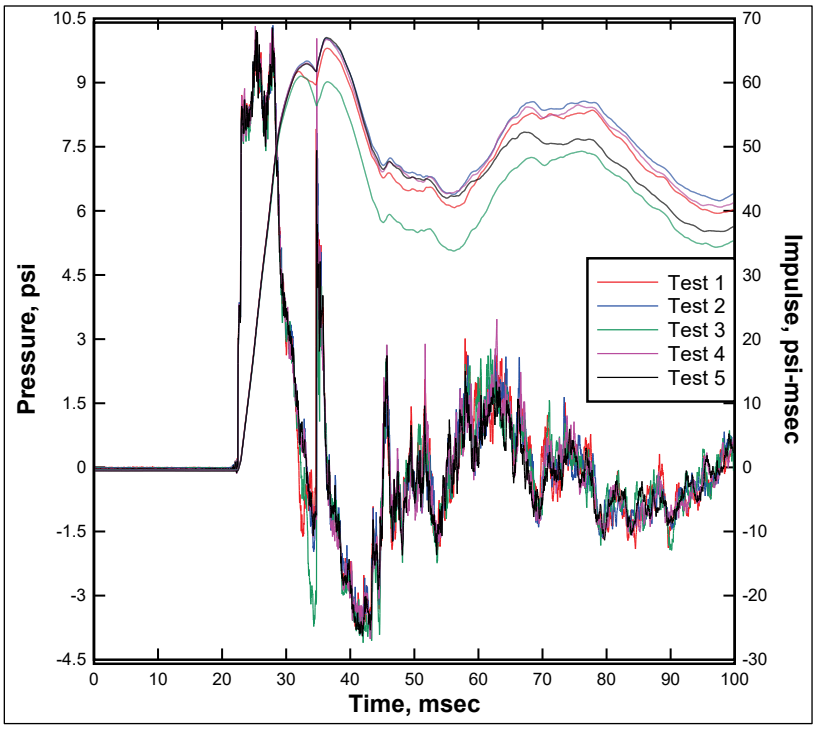


Figure 39. Comparison of pressure records on the side of Structure 2 – 26-in. spacing - Gauge PB2-R2.

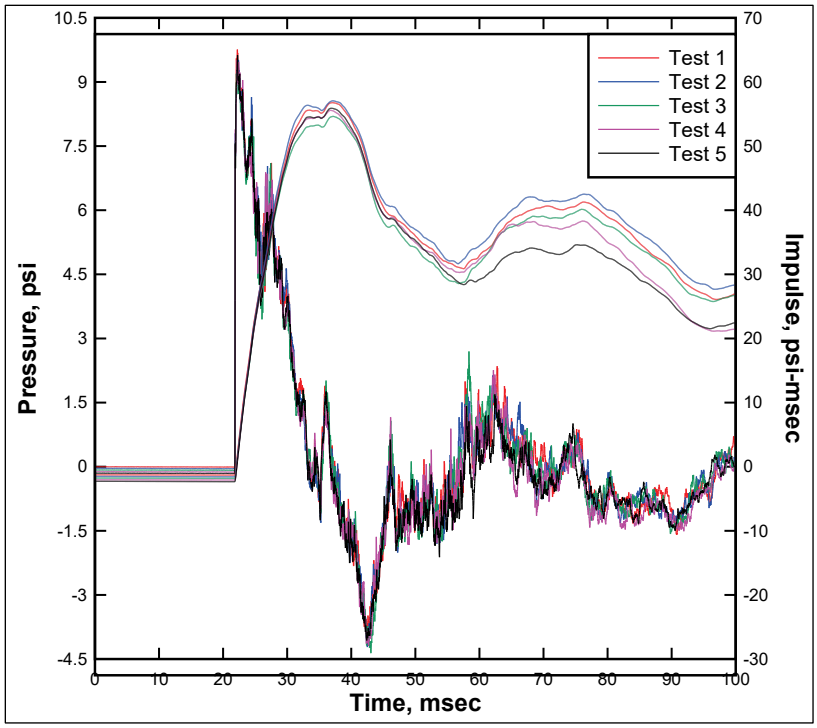



Figure 40. Comparison of pressure records on the side of Structure 2 – 26-in. spacing – Gauge PB2-R4.

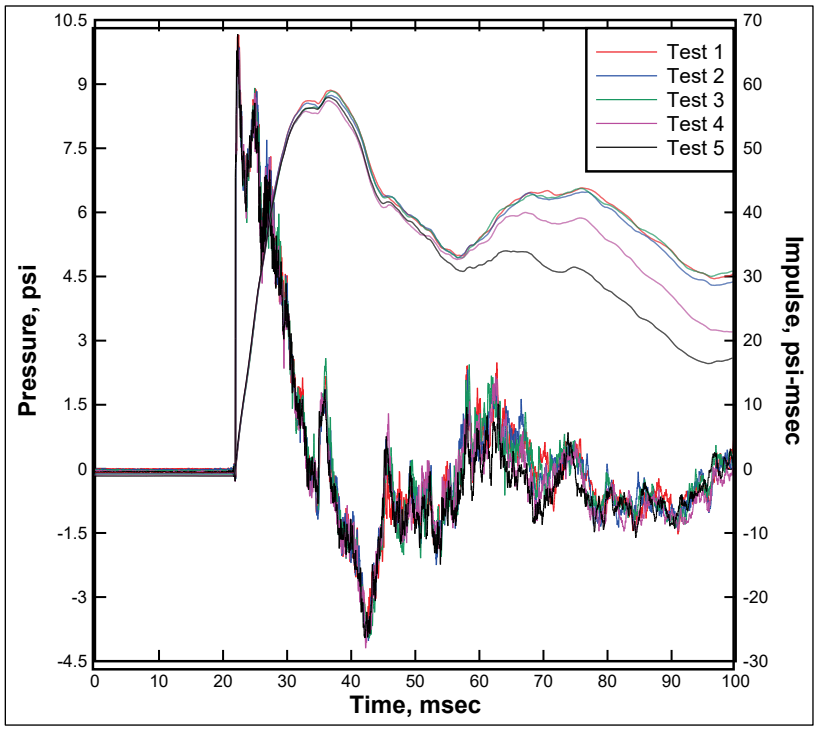


Figure 41. Comparison of pressure records on the top of Structure 2 – 26-in. spacing - Gauge PB2-T1.

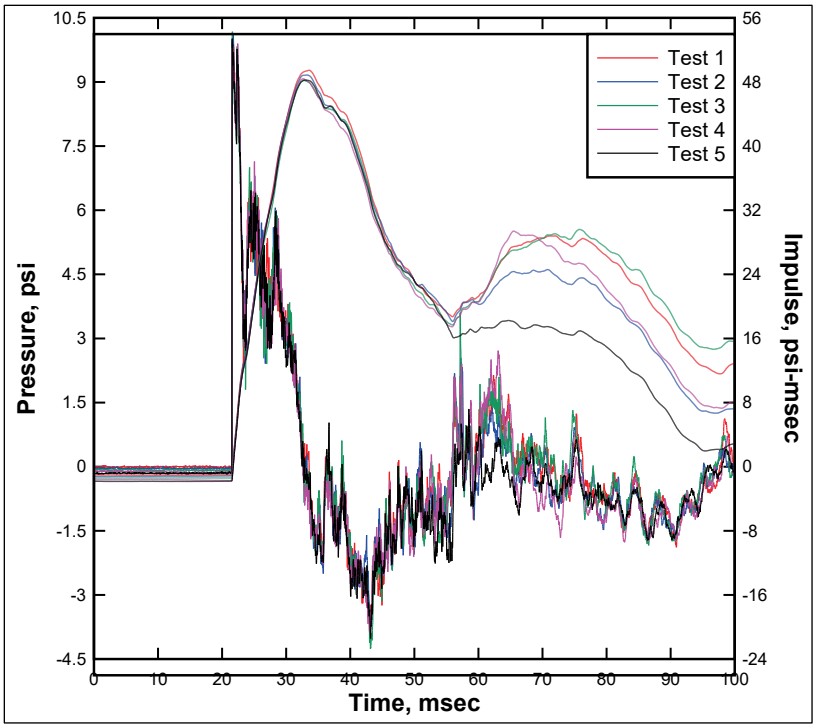
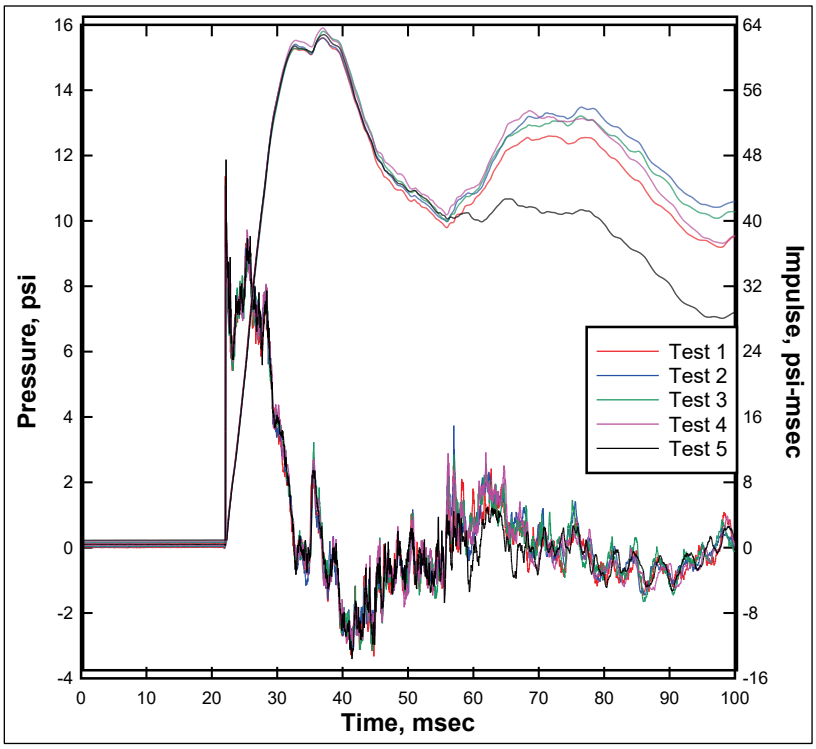



Figure 42. Comparison of pressure records on the top of Structure 2 – 26-in. spacing – Gauge PB2-T3.



### 3.1.2 32-in. spacing

The pressure at the calibration plate and sidewall gauges exhibited behavior similar to the 26-in. spacing case. Figures 43 and 44 show comparisons of the pressure and impulse from all five tests for gauges CP3 located on the calibration plate and G1 located on the BLS sidewall, respectively.

A comparison of representative pressure waveforms recorded on the front of Structure 1 is shown in Figures 45 and 46 and, on the back of Structure 1 in Figures 47 and 48, on the right side of Structure 1 in Figures 49 and 50, and on the top of Structure 1 in Figures 51 and 52. With the exception of the impulse for Test 1 and gauge location PB1-R2, all of these show excellent repeatability among the replicate experiments until about 45 msec, after which time the effect of the contact surface at the pressure gauge locations manifests in higher experimental variability. Similar results were observed for Structure 2 for the front face in Figures 53 and 54, the back face in Figures 55 and 56, the right face in Figures 57 and 58, and the top face in Figures 59 and 60.

Individual plots showing both pressure and impulse for all of the gauges from the experiments are shown in Appendix B.

Figure 43. Comparison of pressure records on the calibration plate – 32-in. spacing – Gauge CP3.

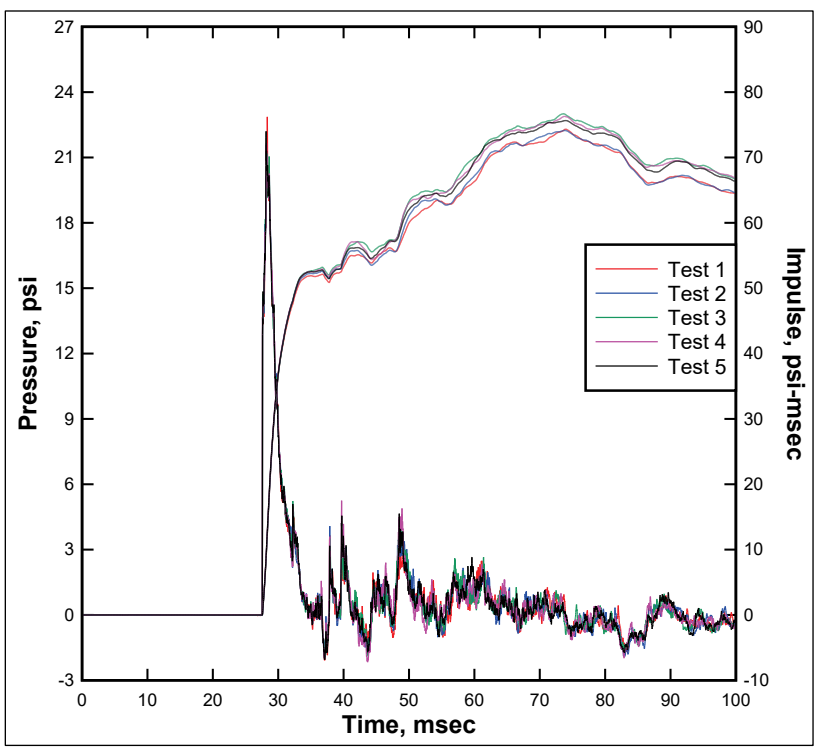


Figure 44. Comparison of pressure records on the BLS sidewall – 32-in. spacing – Gauge G1.

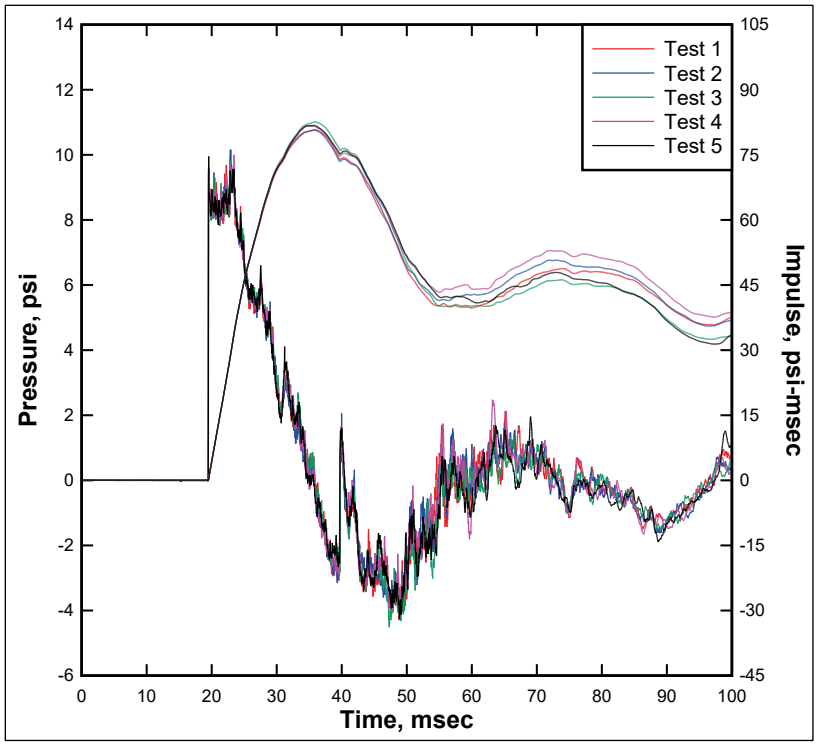



Figure 45. Comparison of pressure records on the front of Structure 1 – 32-in. spacing – Gauge PB1-F2.

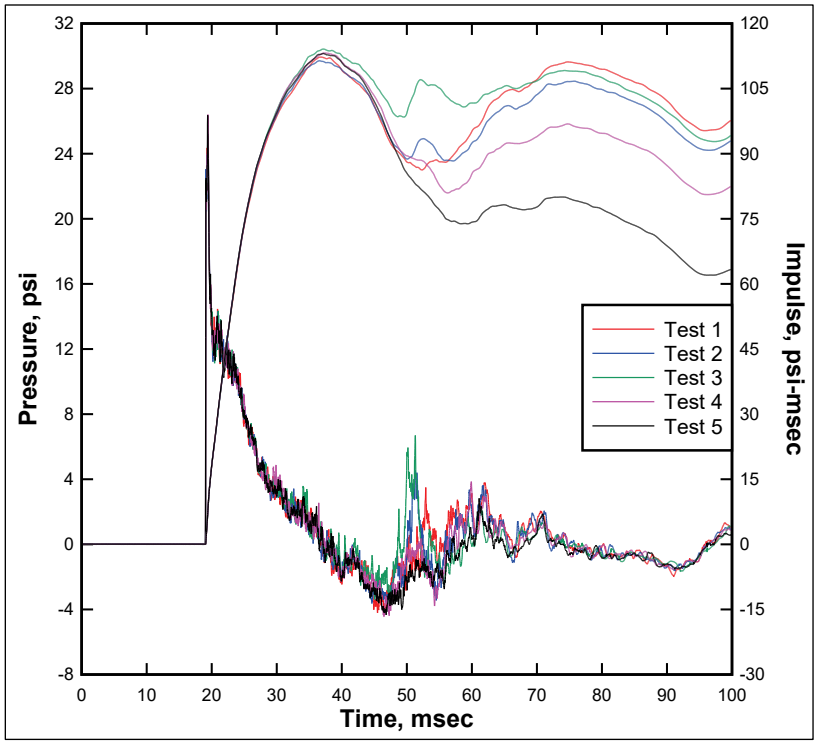


Figure 46. Comparison of pressure records on the front of Structure 1 – 32-in. spacing – Gauge PB1-F8.

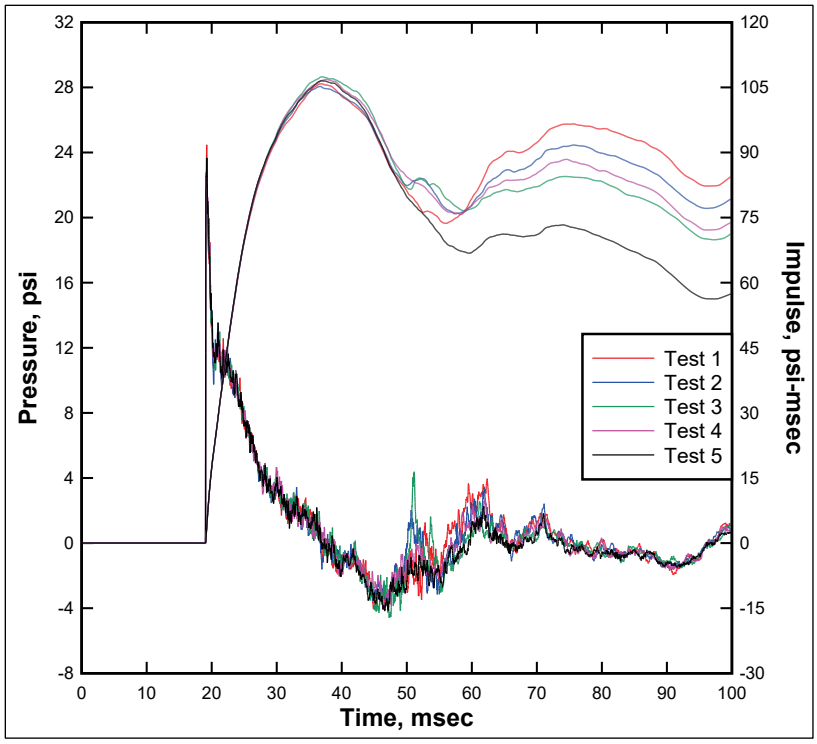



Figure 47. Comparison of pressure records on the back of Structure 1 – 32-in. spacing – Gauge PB1-B1.

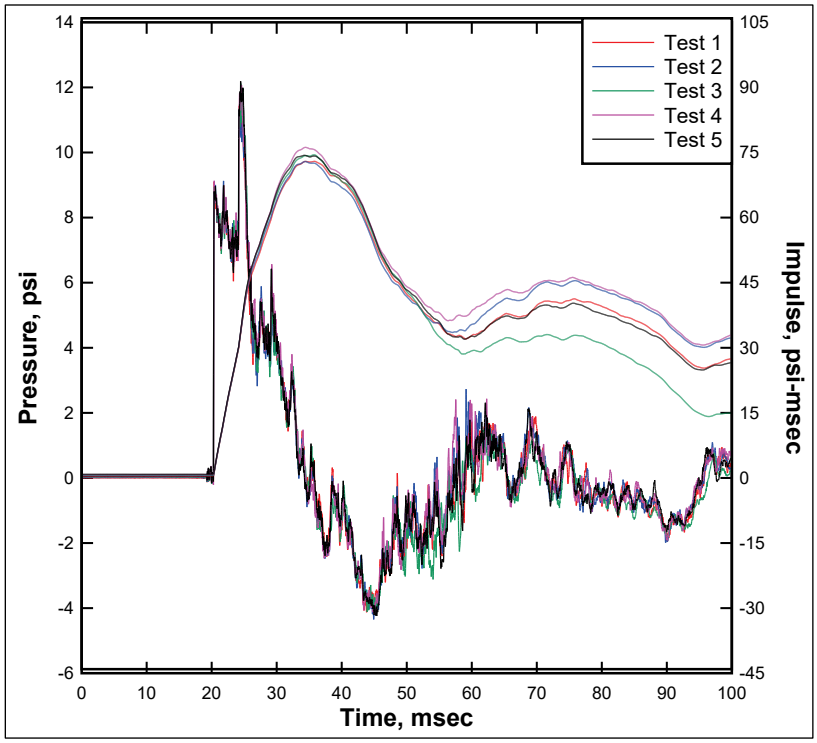


Figure 48. Comparison of pressure records on the back of Structure 1 – 32-in. spacing – Gauge PB1-B4.

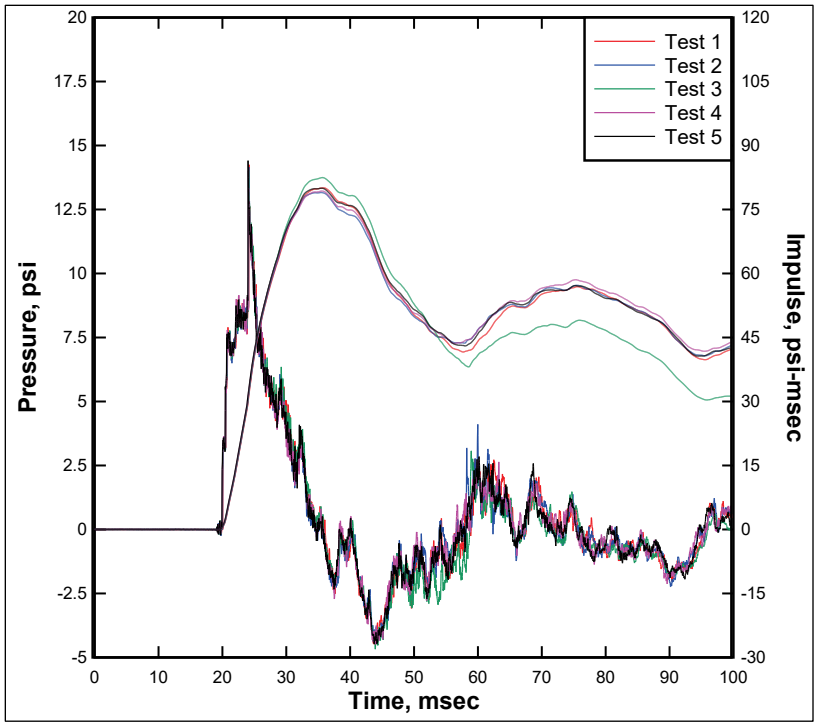



Figure 49. Comparison of pressure records on the side of Structure 1 – 32-in. spacing - Gauge PB1-R2.

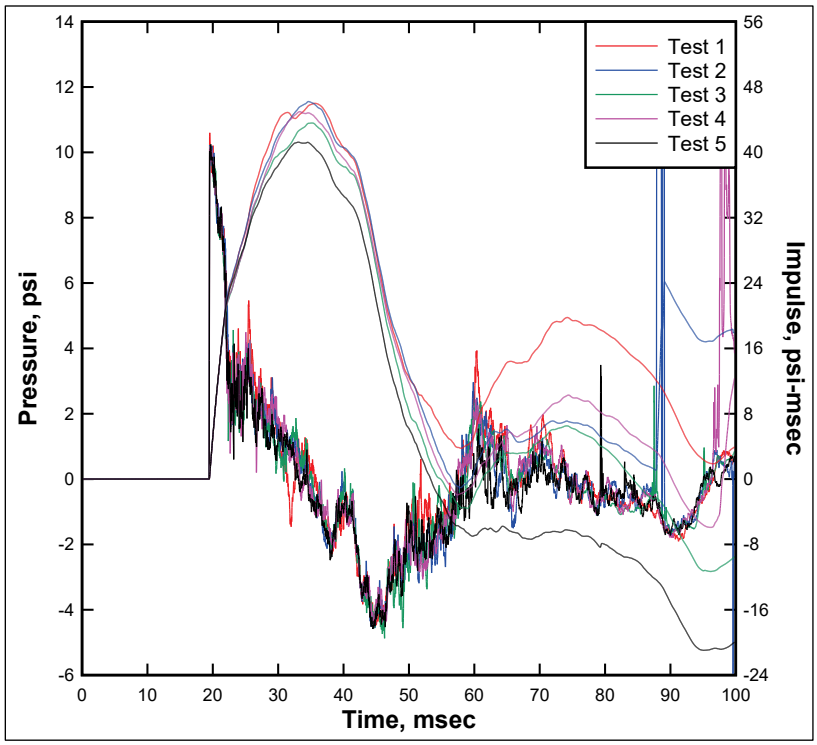


Figure 50. Comparison of pressure records on the side of Structure 1 – 32-in. spacing – Gauge PB1-R4.

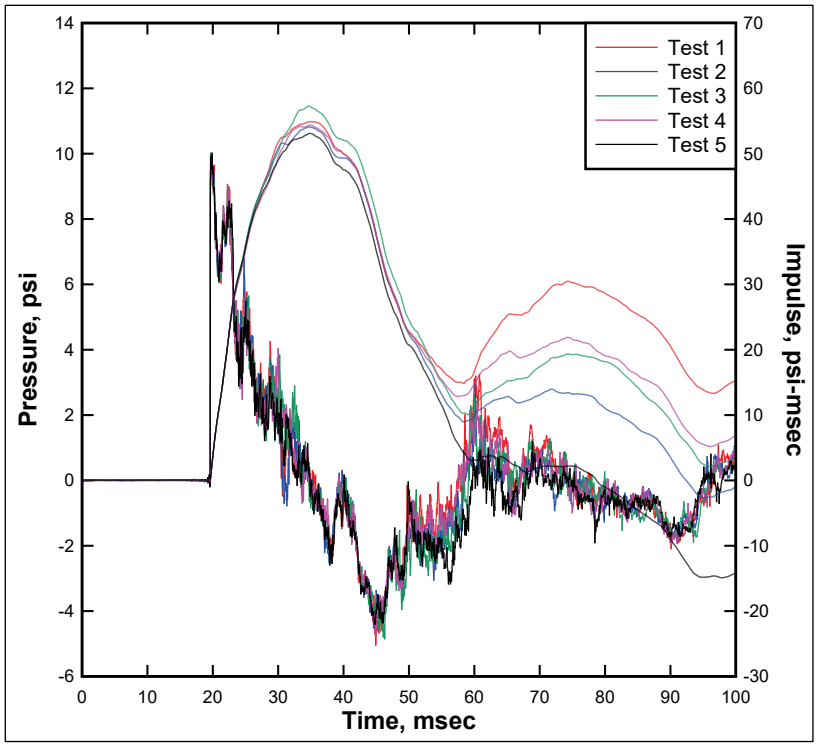



Figure 51. Comparison of pressure records on the top of Structure 1 – 32-in. spacing – Gauge PB1-T1.

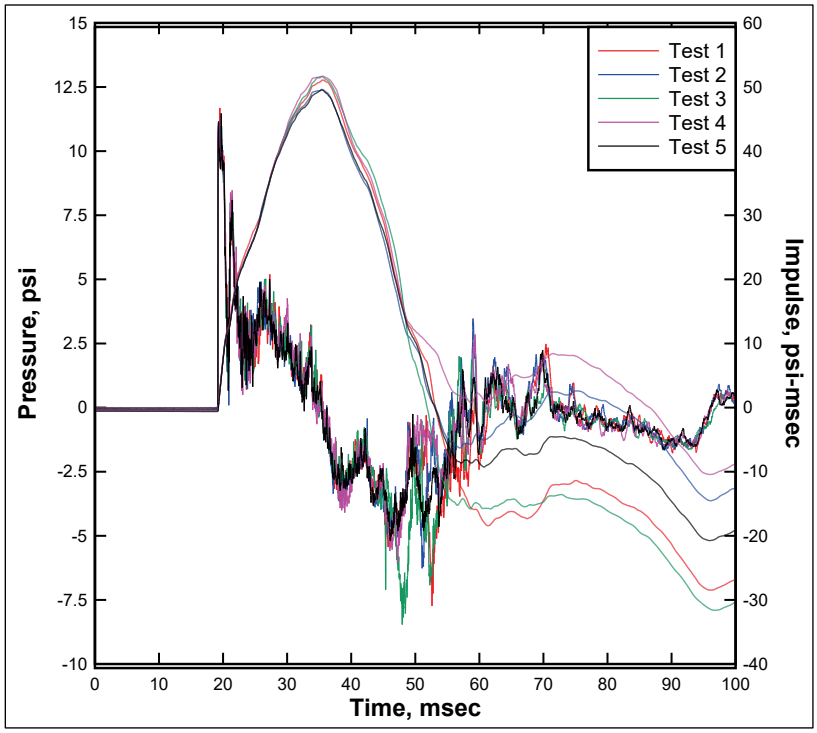


Figure 52. Comparison of pressure records on the top of Structure 1 – 32-in. spacing – Gauge PB1-T3.

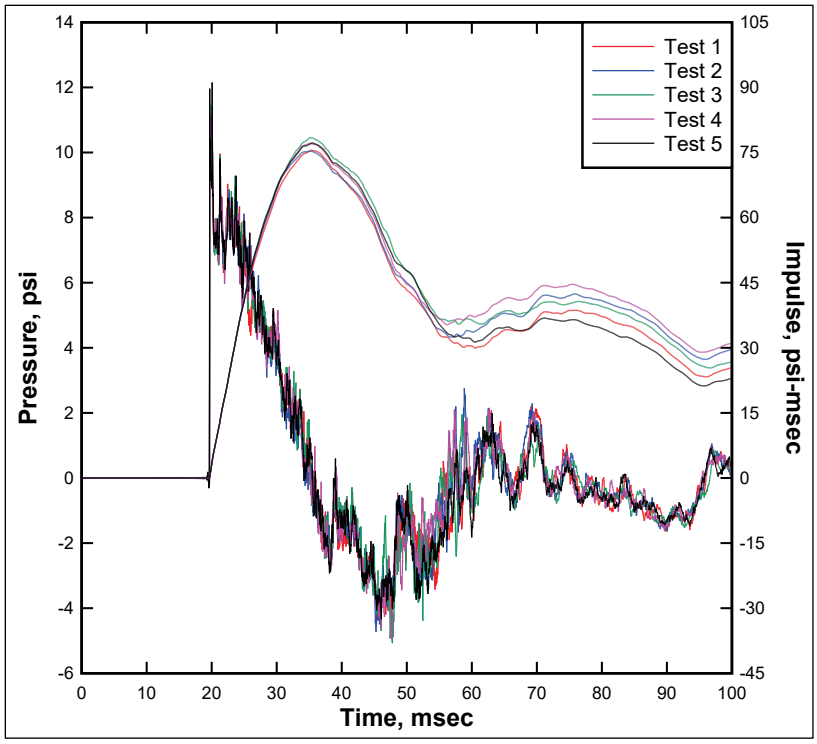



Figure 53. Comparison of pressure records on the front of Structure 2 – 32-in. spacing – Gauge PB2-F1.

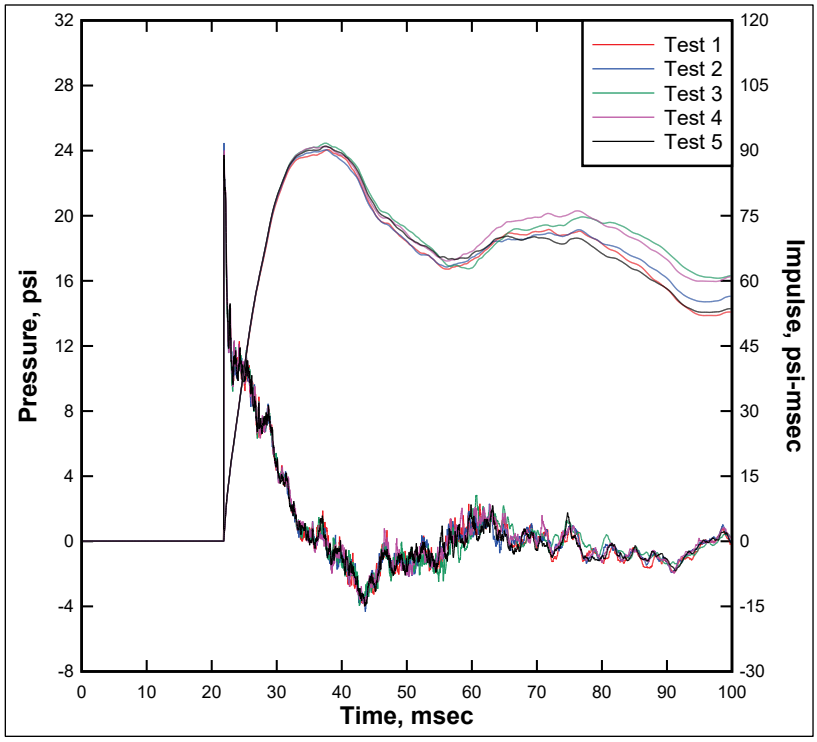


Figure 54. Comparison of pressure records on the front of Structure 2 – 32-in. spacing – Gauge PB2-F4.

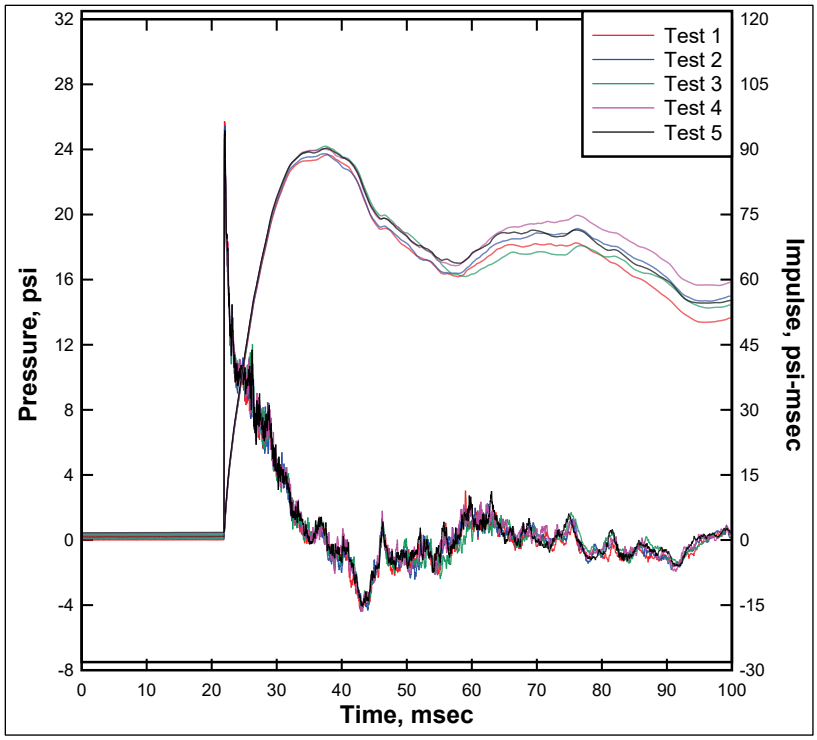



Figure 55. Comparison of pressure records on the back of Structure 2 – 32-in. spacing – Gauge PB2-B2.

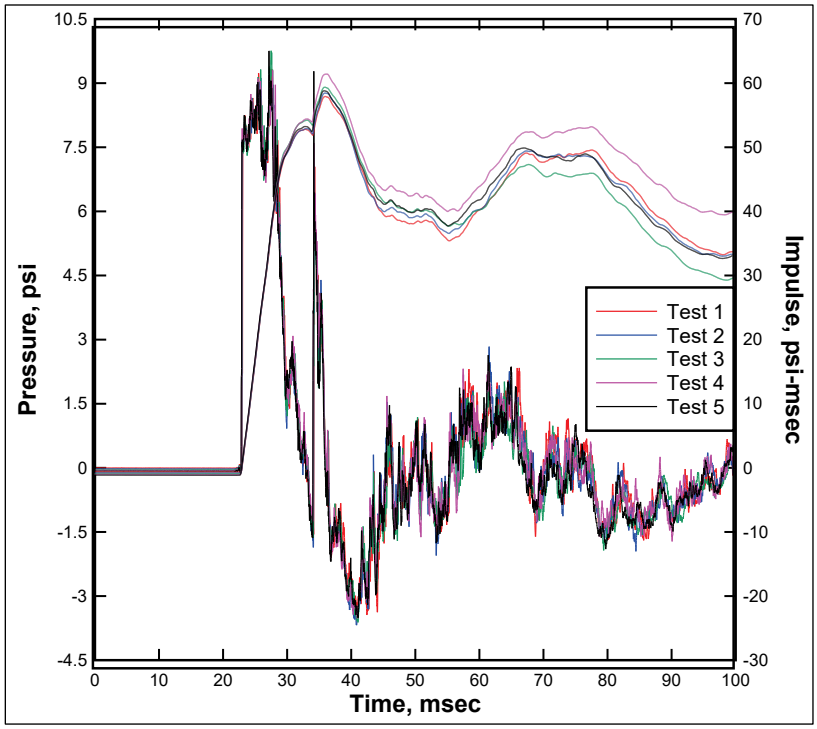


Figure 56. Comparison of pressure records on the back of Structure 2 – 32-in. spacing – Gauge PB2-B8.

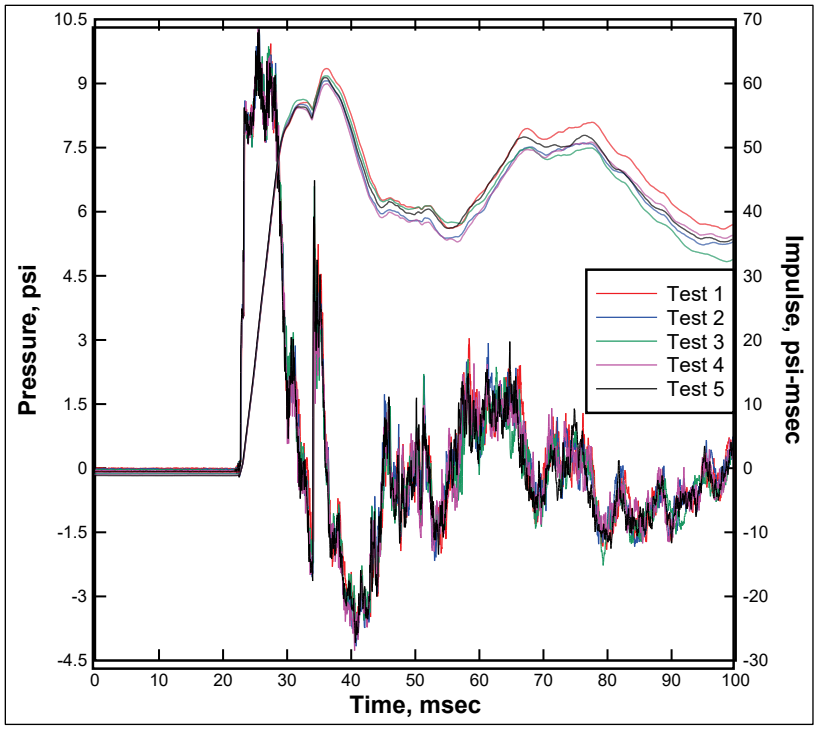



Figure 57. Comparison of pressure records on the side of Structure 2 – 32-in. spacing – Gauge PB2-R2.

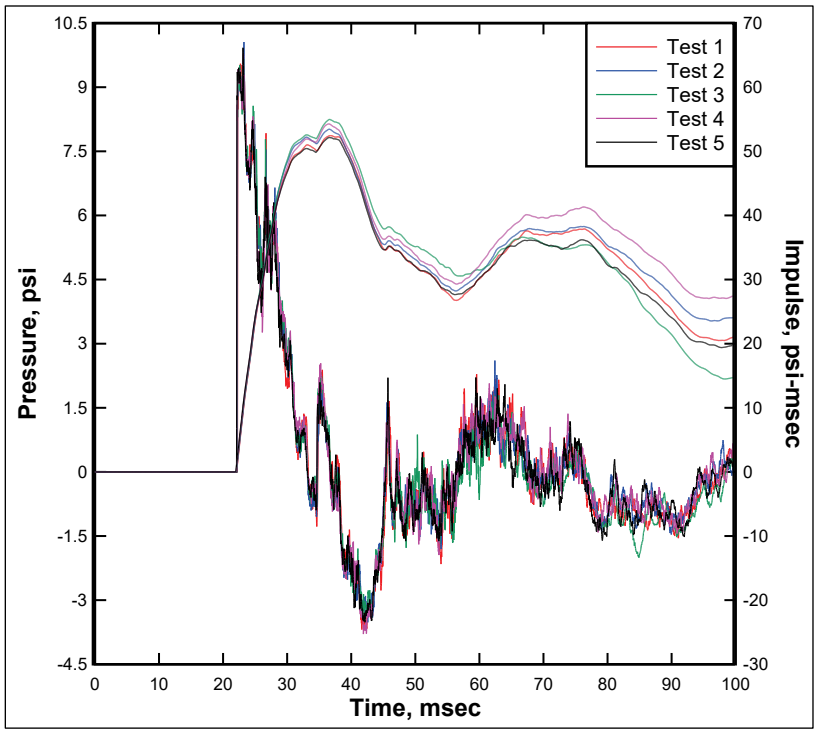


Figure 58. Comparison of pressure records on the side of Structure 2 – 32-in. spacing – Gauge PB2-R4.

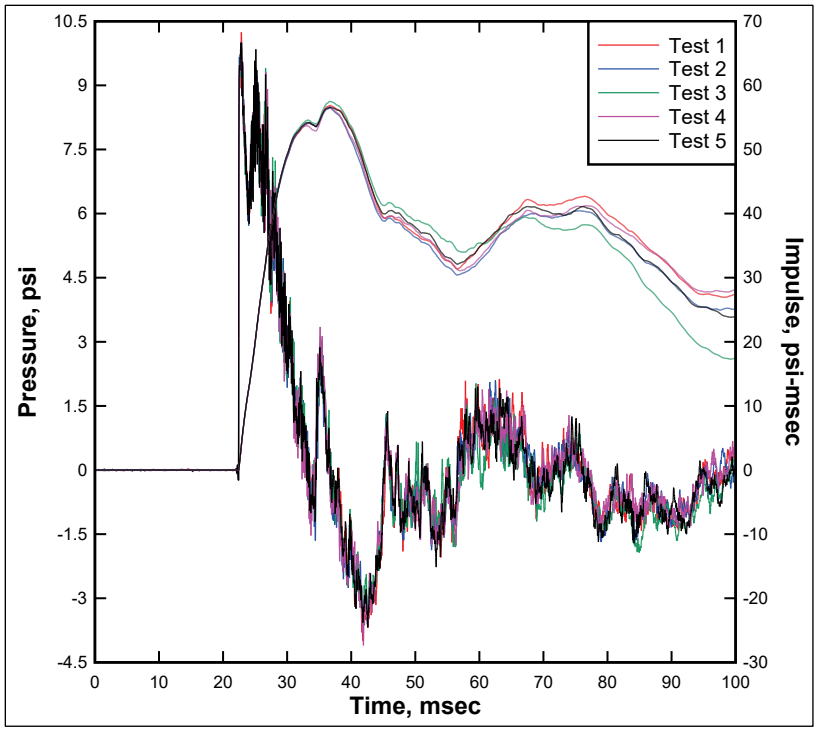



Figure 59. Comparison of pressure records on the top of Structure 2 – 32-in. spacing – Gauge PB2-T1.

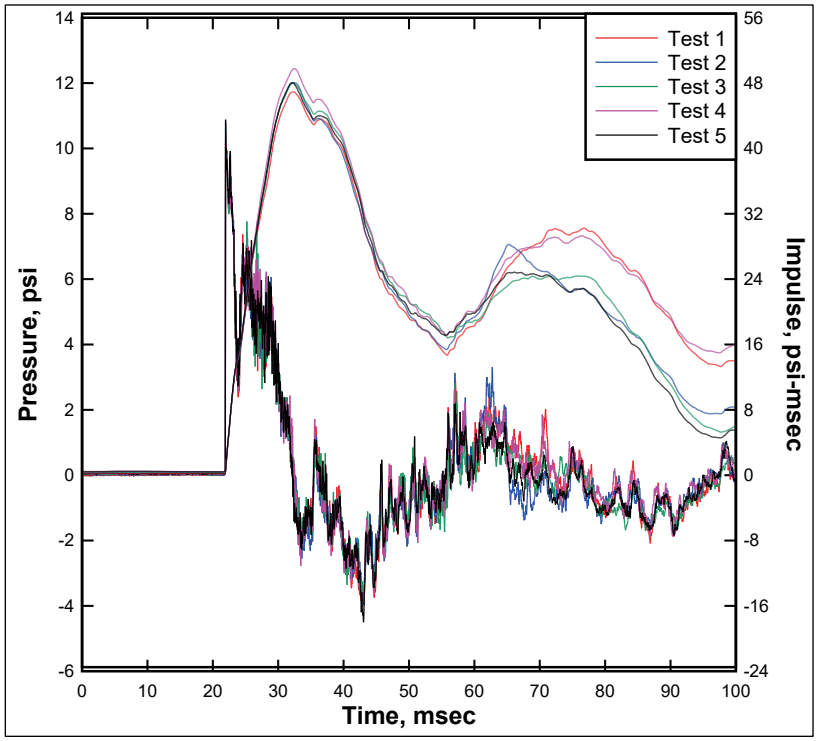
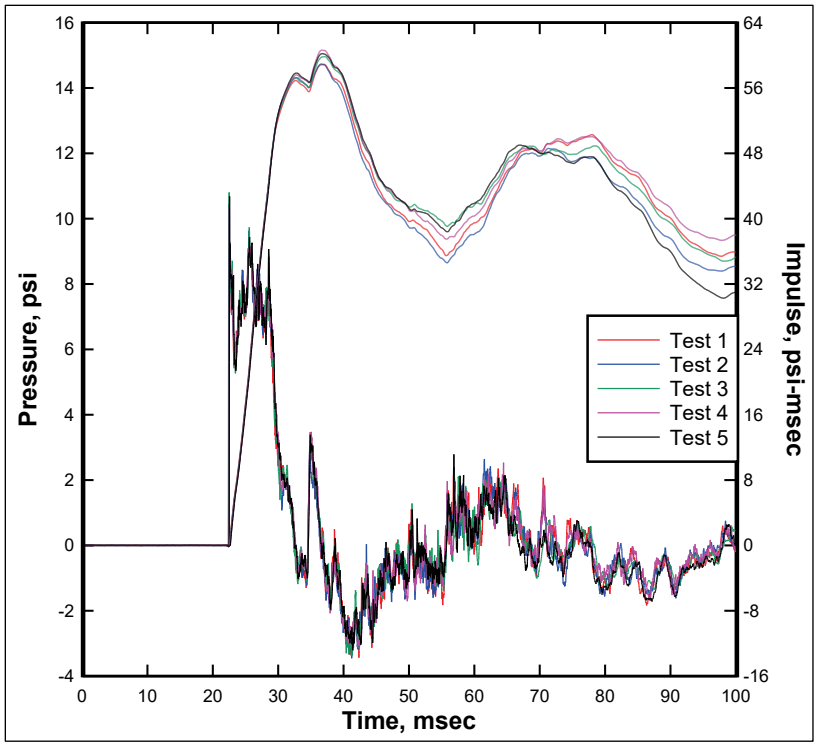


Figure 60. Comparison of pressure records on the top of Structure 2 – 32-in. spacing – Gauge PB2-T3.




## 3.2 Experiment uncertainty

The uncertainty in the experimental values of peak pressure and peak impulse was evaluated for each set of replicate experiments for which, as closely as possible, the identical BLS setup was used from test to test. The analysis assumes that the data values constitute a sample population drawn from an underlying Gaussian parent population. Ninety-five percent confidence intervals were computed to provide the range within which one should expect the next data value to lie if an additional test was to be conducted.

The 95% confidence interval for a sample of $N$ measurements of $X$ drawn from a Gaussian distribution was based on the precision index, $P$, defined by the equation

$$P_X = tS_X$$

and the estimated 95% confidence interval is defined by

$$\overline{X} \pm P_X$$

where

$\bar{X}$ = the sample mean of $X$
$S_x$ = the sample standard deviation
$t$ = the value from the t distribution with $N$-1 degrees of freedom corresponding to the 95% confidence limit.

For each set of replicate experiments, the peak pressure and peak impulse associated with the positive phase of the simulated blast wave were compared. The initial peak pressure and peak impulse are both evaluated between 0 and 45 msec to exclude the effect of the contact surface on the measurement. For gauge locations where a small initial peak is immediately followed by a larger sharply defined peak, Figure 29 for example, the peak pressure is simply defined as the maximum value occurring between 0 and 45 msec.

### 3.2.1 26-in. spacing experimental uncertainty

Figures 61 and 62 present the mean values and 95% confidence intervals computed for the peak pressures at the BLS and Structure 1 gauge locations and at the Structure 2 gauge locations, respectively, for all five tests conducted at the 26-in. spacing. Figures 63 and 64 present the mean values and 95% confidence intervals computed for the peak impulse at the BLS and Structure 1 gauge locations and at the Structure 2 gauge locations, respectively, for all five tests conducted at 26-in. spacing. The data can be found in tabular form in Tables 1 and 2.

As indicated by the confidence intervals in Figures 61 through 64 and the waveform comparisons presented in Section 3.1.1, the data exhibited an excellent degree of repeatability among the five experiments prior to the arrival of the contact surface at about 45 msec.

Figure 61. 95% confidence intervals on measured peak pressure for BLS and Structure 1 gauge locations at 26-in. spacing.

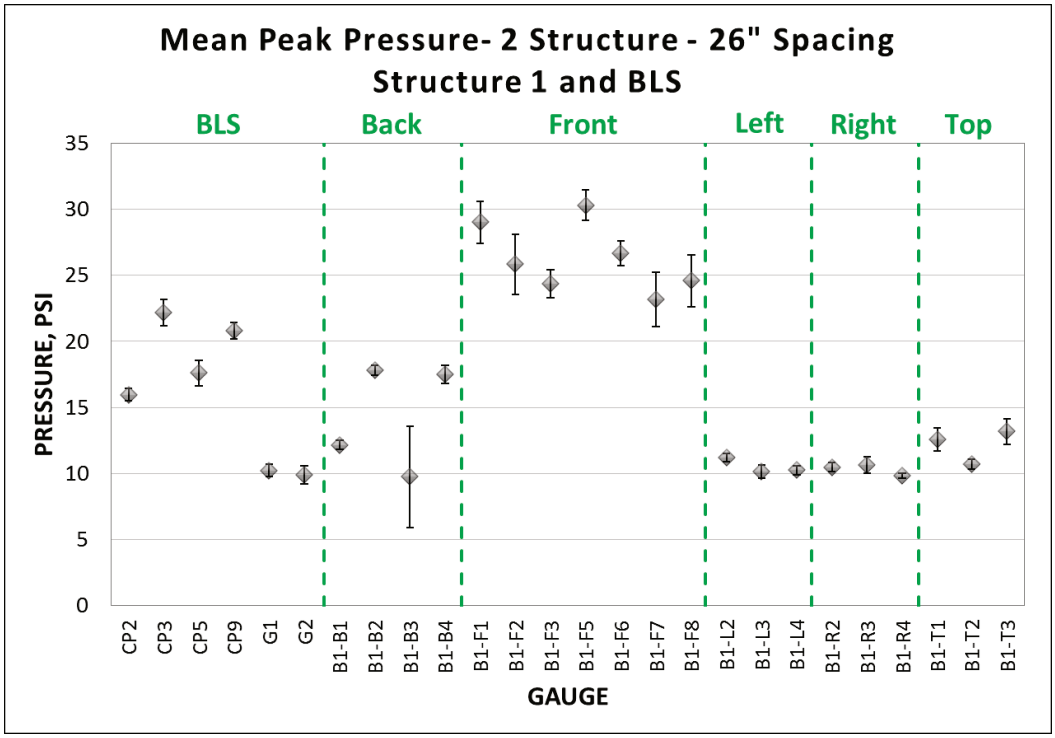



Figure 62. 95% confidence intervals on measured peak pressure for Structure 2 gauge locations at 26-in. spacing.

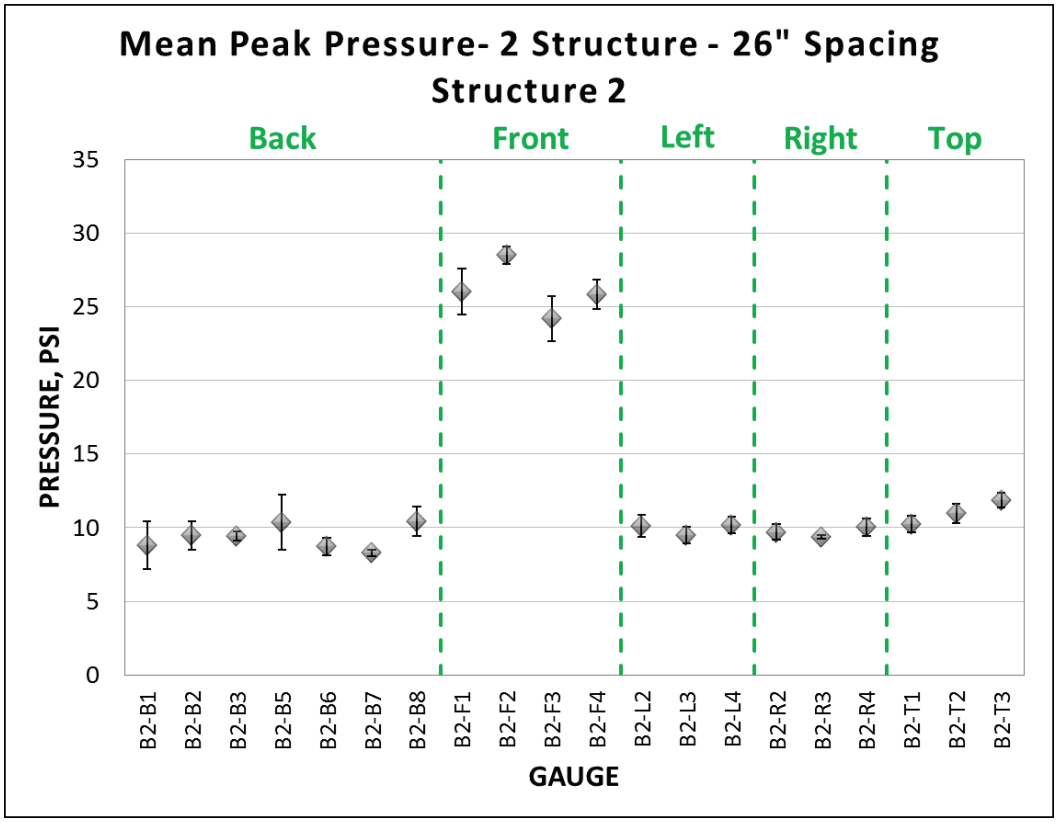


Figure 63. 95% confidence intervals on measured peak impulse between 0 and 45 msec for BLS and Structure 1 gauge locations at 26-in. spacing.

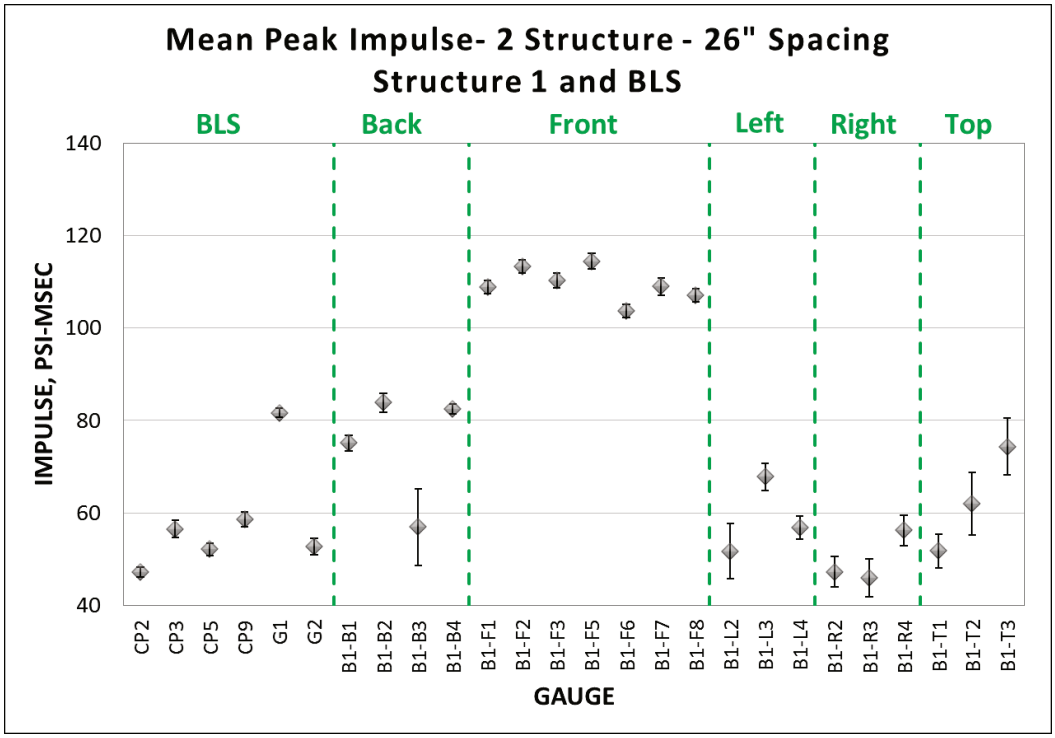



Figure 64. 95% confidence intervals on measured peak impulse between 0 and 45 msec for Structure 2 gauge locations at 26-in. spacing.

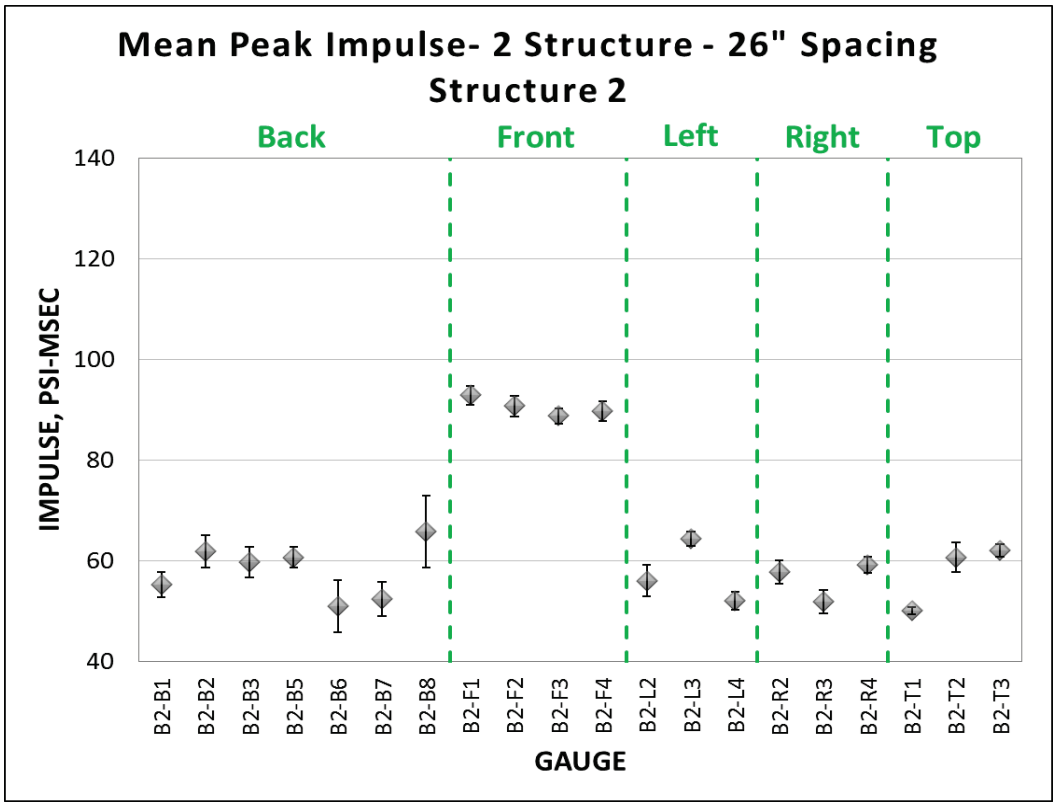


Table 1. Data confidence intervals – BLS and Structure 1 at 26-in. spacing.

| Gauge | 95% Confidence on P (psi) | 95% Confidence on $P_{mean}$ (psi) | 95% Confidence on I (psi-msec) | 95% Confidence on $I_{mean}$ (psi-msec) |
|---|---|---|---|---|
| CP2 | 16.0 +/- 0.5 | 16.0 +/- 0.2 | 47 +/- 1 | 47 +/- 0 |
| CP3 | 22.2 +/- 1.0 | 22.2 +/- 0.5 | 56 +/- 2 | 56 +/- 1 |
| CP5 | 17.6 +/- 1.0 | 17.6 +/- 0.4 | 52 +/- 1 | 52 +/- 1 |
| CP9 | 20.8 +/- 0.6 | 20.8 +/- 0.3 | 59 +/- 2 | 59 +/- 1 |
| G1 | 10.2 +/- 0.5 | 10.2 +/- 0.2 | 82 +/- 1 | 82 +/- 0 |
| G2 | 9.9 +/- 0.7 | 9.9 +/- 0.3 | 53 +/- 2 | 53 +/- 1 |
| B1-B1 | 12.2 +/- 0.4 | 12.2 +/- 0.2 | 75 +/- 2 | 75 +/- 1 |
| B1-B2 | 17.8 +/- 0.4 | 17.8 +/- 0.2 | 84 +/- 2 | 84 +/- 1 |
| B1-B3 | 9.7 +/- 3.8 | 9.7 +/- 1.7 | 57 +/- 8 | 57 +/- 4 |
| B1-B4 | 17.5 +/- 0.7 | 17.5 +/- 0.3 | 82 +/- 1 | 82 +/- 1 |
| B1-F1 | 29.0 +/- 1.6 | 29.0 +/- 0.7 | 109 +/- 1 | 109 +/- 1 |
| B1-F2 | 25.8 +/- 2.3 | 25.8 +/- 1.0 | 113 +/- 1 | 113 +/- 1 |
| B1-F3 | 24.4 +/- 1.1 | 24.4 +/- 0.5 | 110 +/- 2 | 110 +/- 1 |
| B1-F5 | 30.3 +/- 1.2 | 30.3 +/- 0.5 | 114 +/- 2 | 114 +/- 1 |
| B1-F6 | 26.7 +/- 1.0 | 26.7 +/- 0.4 | 104 +/- 1 | 104 +/- 1 |
| B1-F7 | 23.2 +/- 2.1 | 23.2 +/- 0.9 | 109 +/- 2 | 109 +/- 1 |
| B1-F8 | 24.6 +/- 2.0 | 24.6 +/- 0.9 | 107 +/- 1 | 107 +/- 1 |
| B1-L2 | 11.2 +/- 0.3 | 11.2 +/- 0.1 | 52 +/- 6 | 52 +/- 3 |
| B1-L3 | 10.2 +/- 0.5 | 10.2 +/- 0.2 | 68 +/- 3 | 68 +/- 1 |
| B1-L4 | 10.2 +/- 0.3 | 10.2 +/- 0.1 | 57 +/- 3 | 57 +/- 1 |
| B1-R2 | 10.5 +/- 0.3 | 10.5 +/- 0.1 | 47 +/- 3 | 47 +/- 1 |
| B1-R3 | 10.6 +/- 0.6 | 10.6 +/- 0.3 | 46 +/- 4 | 46 +/- 2 |
| B1-R4 | 9.8 +/- 0.2 | 9.8 +/- 0.1 | 56 +/- 3 | 56 +/- 1 |
| B1-T1 | 12.6 +/- 0.9 | 12.6 +/- 0.4 | 52 +/- 4 | 52 +/- 2 |
| B1-T2 | 10.7 +/- 0.4 | 10.7 +/- 0.2 | 62 +/- 7 | 62 +/- 3 |
| B1-T3 | 13.2 +/- 0.9 | 13.2 +/- 0.4 | 74 +/- 6 | 74 +/- 3 |

Table 2. Data confidence intervals –Structure 2 at 26-in. spacing.

| Gauge | 95% Confidence on P (psi) | 95% Confidence on $P_{mean}$ (psi) | 95% Confidence on I (psi-msec) | 95% Confidence on $I_{mean}$ (psi-msec) |
|---|---|---|---|---|
| B2-B1 | 8.8 +/- 1.6 | 8.8 +/- 0.7 | 55 +/- 2 | 55 +/- 1 |
| B2-B2 | 9.5 +/- 1.0 | 9.5 +/- 0.4 | 62 +/- 3 | 62 +/- 1 |
| B2-B3 | 9.4 +/- 0.3 | 9.4 +/- 0.1 | 60 +/- 3 | 60 +/- 1 |
| B2-B5 | 10.4 +/- 1.9 | 10.4 +/- 0.8 | 61 +/- 2 | 61 +/- 1 |
| B2-B6 | 8.7 +/- 0.6 | 8.7 +/- 0.3 | 51 +/- 5 | 51 +/- 2 |
| B2-B7 | 8.3 +/- 0.2 | 8.3 +/- 0.1 | 52 +/- 3 | 52 +/- 2 |
| B2-B8 | 10.4 +/- 1.0 | 10.4 +/- 0.5 | 66 +/- 7 | 66 +/- 3 |
| B2-F1 | 26.0 +/- 1.6 | 26.0 +/- 0.7 | 93 +/- 2 | 93 +/- 1 |
| B2-F2 | 28.5 +/- 0.6 | 28.5 +/- 0.3 | 91 +/- 2 | 91 +/- 1 |
| B2-F3 | 24.2 +/- 1.5 | 24.2 +/- 0.7 | 89 +/- 2 | 89 +/- 1 |
| B2-F4 | 25.8 +/- 1.0 | 25.8 +/- 0.4 | 90 +/- 2 | 90 +/- 1 |
| B2-L2 | 10.1 +/- 0.7 | 10.1 +/- 0.3 | 56 +/- 3 | 56 +/- 1 |
| B2-L3 | 9.5 +/- 0.6 | 9.5 +/- 0.3 | 64 +/- 1 | 64 +/- 1 |
| B2-L4 | 10.2 +/- 0.6 | 10.2 +/- 0.2 | 52 +/- 2 | 52 +/- 1 |
| B2-R2 | 9.7 +/- 0.5 | 9.7 +/- 0.2 | 58 +/- 2 | 58 +/- 1 |
| B2-R3 | 9.4 +/- 0.1 | 9.4 +/- 0.1 | 52 +/- 2 | 52 +/- 1 |
| B2-R4 | 10.0 +/- 0.6 | 10.0 +/- 0.3 | 59 +/- 2 | 59 +/- 1 |
| B2-T1 | 10.2 +/- 0.6 | 10.2 +/- 0.2 | 50 +/- 1 | 50 +/- 0 |
| B2-T2 | 11.0 +/- 0.7 | 11.0 +/- 0.3 | 61 +/- 3 | 61 +/- 1 |
| B2-T3 | 11.9 +/- 0.5 | 11.9 +/- 0.2 | 62 +/- 1 | 62 +/- 1 |

### 3.2.2 32-in. spacing experimental uncertainty

Figures 65 and 66 present the mean values and 95% confidence intervals computed for the peak pressures at the BLS and Structure 1 gauge locations and at the Structure 2 gauge locations, respectively, for all five tests at 32-in. spacing. Figures 67 and 68 present the mean values and 95% confidence intervals computed for the peak impulse at the BLS and Structure 1 gauge locations and at the Structure 2 gauge locations, respectively, for all five tests conducted at 32-in. spacing. The data can be found in tabular form in Tables 3 and 4.

As indicated by the confidence intervals in Figures 65 through 68 and the waveform comparisons presented in Section 3.1.2, the data exhibited an excellent degree of repeatability among the five experiments prior to the arrival of the contact surface at about 45 msec.

Figure 65. 95% confidence intervals on measured peak pressure for BLS and Structure 1 gauge locations at 32-in. spacing.

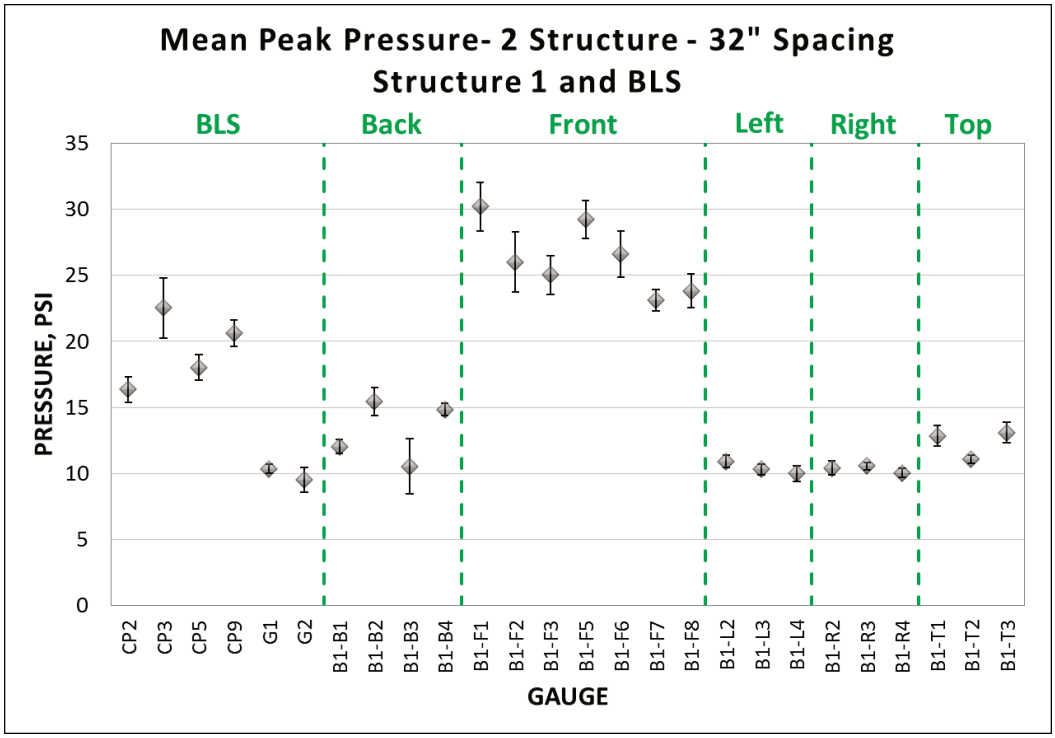



Figure 66. 95% confidence intervals on measured peak pressure for Structure 2 gauge locations at 32-in. spacing.

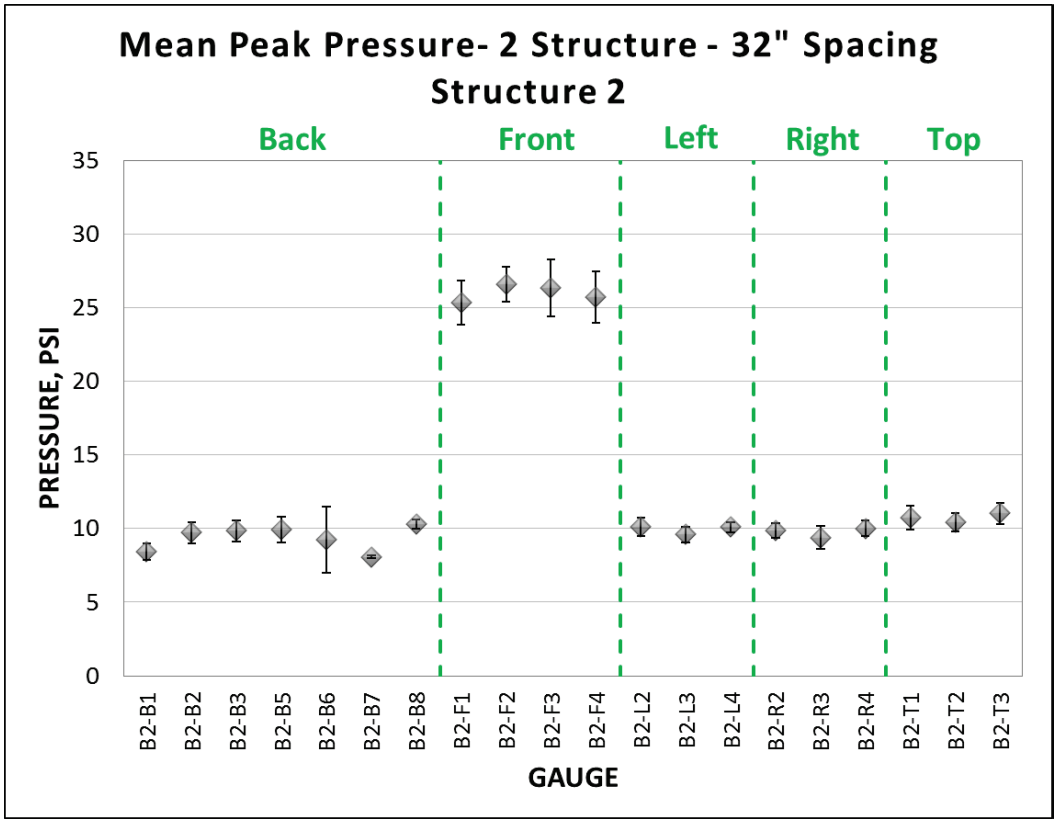


Figure 67. 95% confidence intervals on measured peak impulse between 0 and 45 msec for BLS and Structure 1 gauge locations at 32-in. spacing.

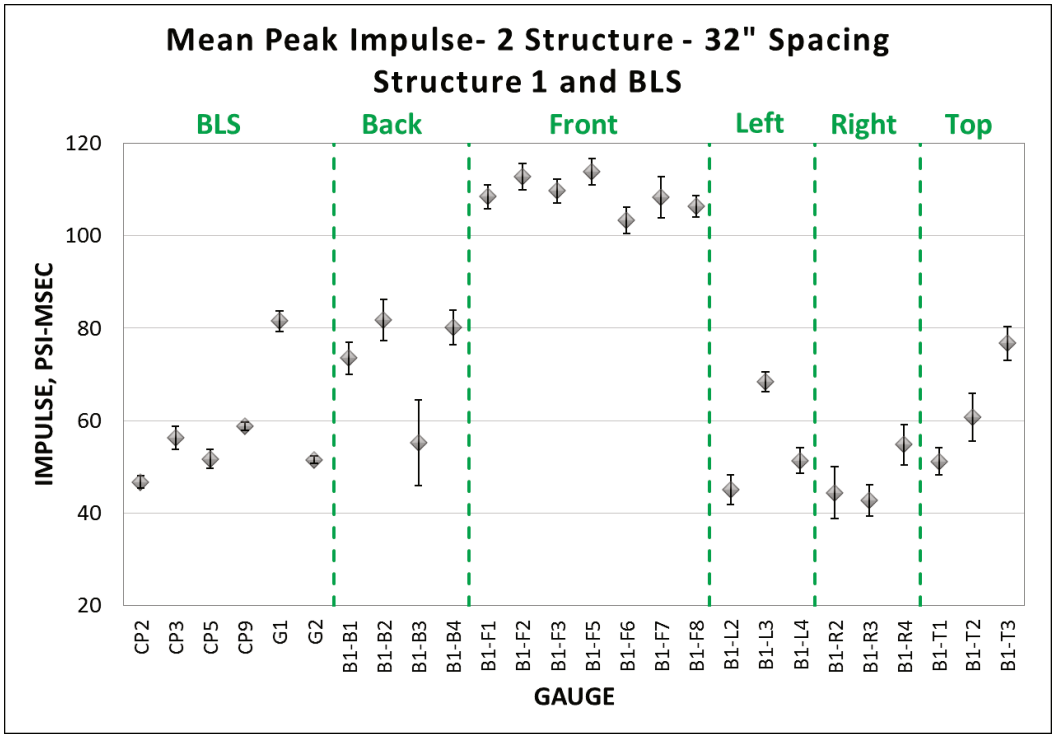



Figure 68. 95% confidence intervals on measured peak impulse between 0 and 45 msec for Structure 2 gauge locations at 32-in. spacing.

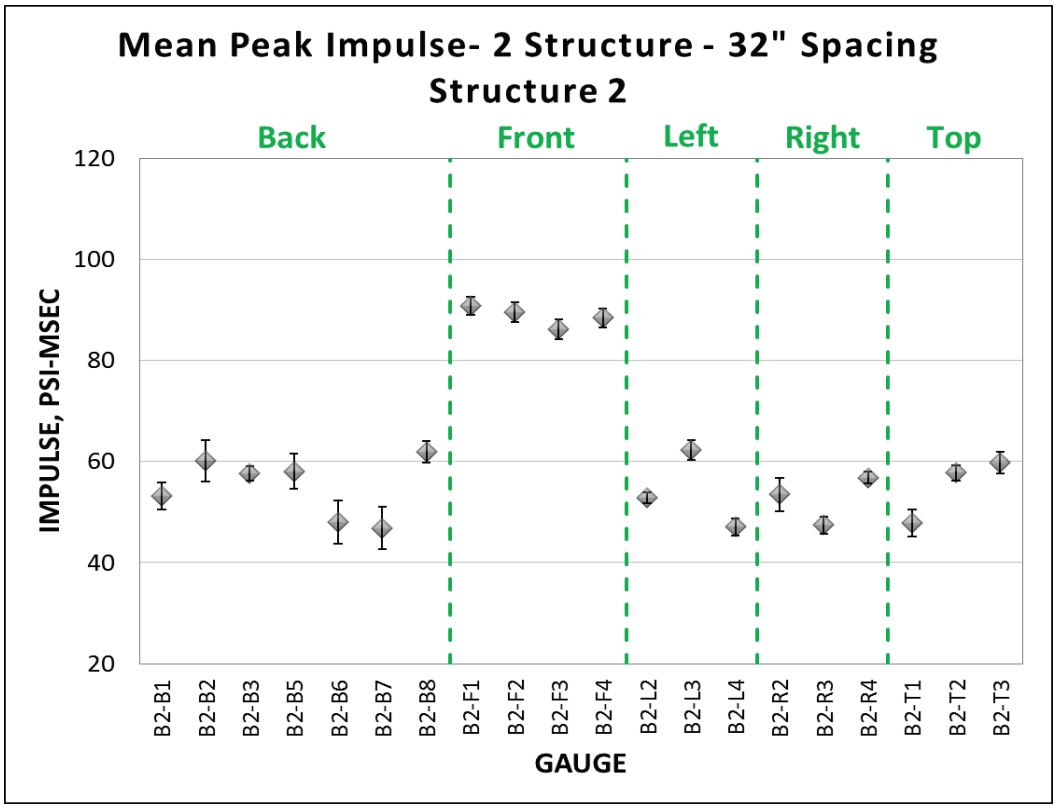


Table 3. Data confidence intervals – BLS and Structure 1 at 32-in. spacing.

| Gauge | 95% Confidence on P (psi) | 95% Confidence on $P_{mean}$ (psi) | 95% Confidence on I (psi-msec) | 95% Confidence on $I_{mean}$ (psi-msec) |
|---|---|---|---|---|
| CP2 | 16.3 +/- 1.0 | 16.3 +/- 0.4 | 47 +/- 1 | 47 +/- 1 |
| CP3 | 22.5 +/- 2.3 | 22.5 +/- 1.0 | 56 +/- 2 | 56 +/- 1 |
| CP5 | 18.0 +/- 1.0 | 18.0 +/- 0.4 | 52 +/- 2 | 52 +/- 1 |
| CP9 | 20.6 +/- 1.0 | 20.6 +/- 0.4 | 59 +/- 1 | 59 +/- 0 |
| G1 | 10.3 +/- 0.3 | 10.3 +/- 0.2 | 82 +/- 2 | 82 +/- 1 |
| G2 | 9.5 +/- 0.9 | 9.5 +/- 0.4 | 52 +/- 1 | 52 +/- 0 |
| B1-B1 | 12.0 +/- 0.5 | 12.0 +/- 0.2 | 73 +/- 3 | 73 +/- 2 |
| B1-B2 | 15.4 +/- 1.1 | 15.4 +/- 0.5 | 82 +/- 4 | 82 +/- 2 |
| B1-B3 | 10.5 +/- 2.1 | 10.5 +/- 0.9 | 55 +/- 9 | 55 +/- 4 |
| B1-B4 | 14.8 +/- 0.5 | 14.8 +/- 0.2 | 80 +/- 4 | 80 +/- 2 |
| B1-F1 | 30.2 +/- 1.8 | 30.2 +/- 0.8 | 108 +/- 3 | 108 +/- 1 |
| B1-F2 | 26.0 +/- 2.3 | 26.0 +/- 1.0 | 113 +/- 3 | 113 +/- 1 |
| B1-F3 | 25.0 +/- 1.4 | 25.0 +/- 0.6 | 110 +/- 3 | 110 +/- 1 |
| B1-F5 | 29.3 +/- 1.4 | 29.3 +/- 0.6 | 114 +/- 3 | 114 +/- 1 |
| B1-F6 | 26.6 +/- 1.7 | 26.6 +/- 0.8 | 103 +/- 3 | 103 +/- 1 |
| B1-F7 | 23.1 +/- 0.8 | 23.1 +/- 0.4 | 108 +/- 5 | 108 +/- 2 |
| B1-F8 | 23.8 +/- 1.3 | 23.8 +/- 0.6 | 106 +/- 2 | 106 +/- 1 |
| B1-L2 | 10.9 +/- 0.5 | 10.9 +/- 0.2 | 45 +/- 3 | 45 +/- 1 |
| B1-L3 | 10.3 +/- 0.4 | 10.3 +/- 0.2 | 68 +/- 2 | 68 +/- 1 |
| B1-L4 | 10.0 +/- 0.6 | 10.0 +/- 0.3 | 51 +/- 3 | 51 +/- 1 |
| B1-R2 | 10.4 +/- 0.5 | 10.4 +/- 0.2 | 44 +/- 6 | 44 +/- 3 |
| B1-R3 | 10.6 +/- 0.3 | 10.6 +/- 0.1 | 43 +/- 3 | 43 +/- 1 |
| B1-R4 | 10.0 +/- 0.4 | 10.0 +/- 0.2 | 55 +/- 4 | 55 +/- 2 |
| B1-T1 | 12.9 +/- 0.8 | 12.9 +/- 0.4 | 51 +/- 3 | 51 +/- 1 |
| B1-T2 | 11.1 +/- 0.3 | 11.1 +/- 0.1 | 61 +/- 5 | 61 +/- 2 |
| B1-T3 | 13.1 +/- 0.8 | 13.1 +/- 0.3 | 77 +/- 4 | 77 +/- 2 |

Table 4. Data confidence intervals – Structure 2 at 32-in. spacing.

| Gauge | 95% Confidence on P (psi) | 95% Confidence on $P_{mean}$ (psi) | 95% Confidence on I (psi-msec) | 95% Confidence on $I_{mean}$ (psi-msec) |
|---|---|---|---|---|
| B2-B1 | 8.4 +/- 0.5 | 8.4 +/- 0.2 | 53 +/- 3 | 53 +/- 1 |
| B2-B2 | 9.7 +/- 0.7 | 9.7 +/- 0.3 | 60 +/- 4 | 60 +/- 2 |
| B2-B3 | 9.8 +/- 0.7 | 9.8 +/- 0.3 | 58 +/- 1 | 58 +/- 1 |
| B2-B5 | 9.9 +/- 0.9 | 9.9 +/- 0.4 | 58 +/- 3 | 58 +/- 2 |
| B2-B6 | 9.3 +/- 2.2 | 9.3 +/- 1.0 | 48 +/- 4 | 48 +/- 2 |
| B2-B7 | 8.1 +/- 0.1 | 8.1 +/- 0.0 | 47 +/- 4 | 47 +/- 2 |
| B2-B8 | 10.3 +/- 0.3 | 10.3 +/- 0.1 | 62 +/- 2 | 62 +/- 1 |
| B2-F1 | 25.3 +/- 1.5 | 25.3 +/- 0.7 | 91 +/- 2 | 91 +/- 1 |
| B2-F2 | 26.6 +/- 1.2 | 26.6 +/- 0.5 | 90 +/- 2 | 90 +/- 1 |
| B2-F3 | 26.3 +/- 1.9 | 26.3 +/- 0.9 | 86 +/- 2 | 86 +/- 1 |
| B2-F4 | 25.7 +/- 1.8 | 25.7 +/- 0.8 | 88 +/- 2 | 88 +/- 1 |
| B2-L2 | 10.1 +/- 0.6 | 10.1 +/- 0.3 | 53 +/- 1 | 53 +/- 1 |
| B2-L3 | 9.6 +/- 0.5 | 9.6 +/- 0.2 | 62 +/- 2 | 62 +/- 1 |
| B2-L4 | 10.1 +/- 0.4 | 10.1 +/- 0.2 | 47 +/- 2 | 47 +/- 1 |
| B2-R2 | 9.9 +/- 0.5 | 9.9 +/- 0.2 | 53 +/- 3 | 53 +/- 1 |
| B2-R3 | 9.4 +/- 0.8 | 9.4 +/- 0.4 | 47 +/- 2 | 47 +/- 1 |
| B2-R4 | 10.0 +/- 0.5 | 10.0 +/- 0.2 | 57 +/- 1 | 57 +/- 1 |
| B2-T1 | 10.7 +/- 0.8 | 10.7 +/- 0.4 | 48 +/- 3 | 48 +/- 1 |
| B2-T2 | 10.4 +/- 0.6 | 10.4 +/- 0.3 | 58 +/- 2 | 58 +/- 1 |
| B2-T3 | 11.0 +/- 0.7 | 11.0 +/- 0.3 | 60 +/- 2 | 60 +/- 1 |

# 4 Conclusions and Recommendations

Replicate experiments conducted in the BLS produced very repeatable pressure data on the surfaces of the box structures, the walls of the BLS, and the calibration plate. Ninety-two peak pressure and peak impulse records were created for comparison. All except five of the peak pressure records produced 95% confidence intervals that were within +/- 15% of the mean. Furthermore, all except seven of the pressure records measured 95% confidence interval that were within +/- 10% of the mean. All except for seven of the measured peak impulse records produced 95% impulse confidence intervals that were within +/- 10 % of the mean. Furthermore, sixty two of the measured peak impulse records produced 95% impulse confidence intervals that were within +/- 5% of the mean. Visual evaluation of overlaid waveforms for all five experiments at individual gauge locations showed excellent experiment repeatability. The pressure and impulse waveforms from the experiments combined with uncertainty information in the form of confidence intervals for peak pressure and impulse result in a very suitable data set that can be used to evaluate the accuracy of computational models.

# References

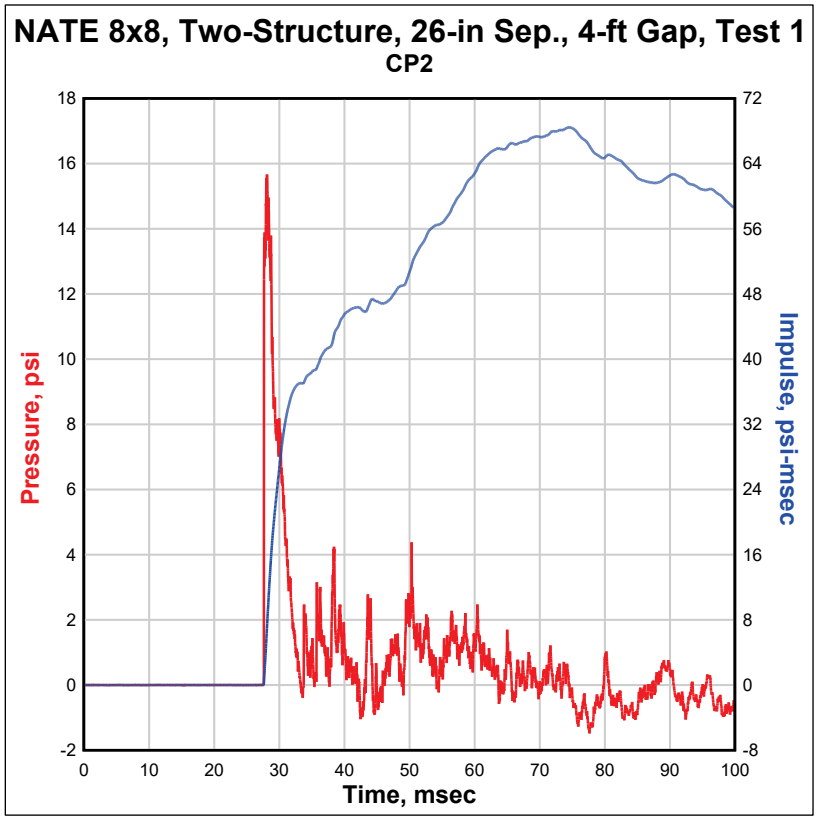
Barnes, A. T., C. Johnson and J. O'Daniel. 2018. *Blast load simulator experiments for computational model validation – Report 4*. ERDC/GSL TR-16-27 Vicksburg, MS: U.S. Army Engineer Research and Development Center.

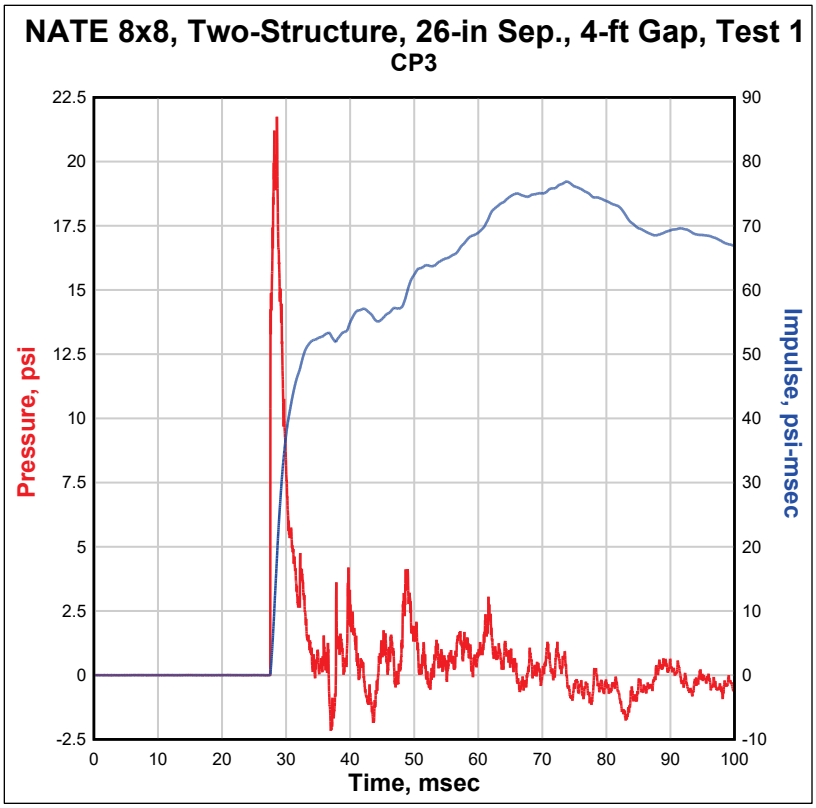
Dallriva, F. D., C. Johnson, and J. O'Daniel. 2016. *Blast load simulator experiments for computational model validation – Report 1*. ERDC/GSL TR-16-27. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

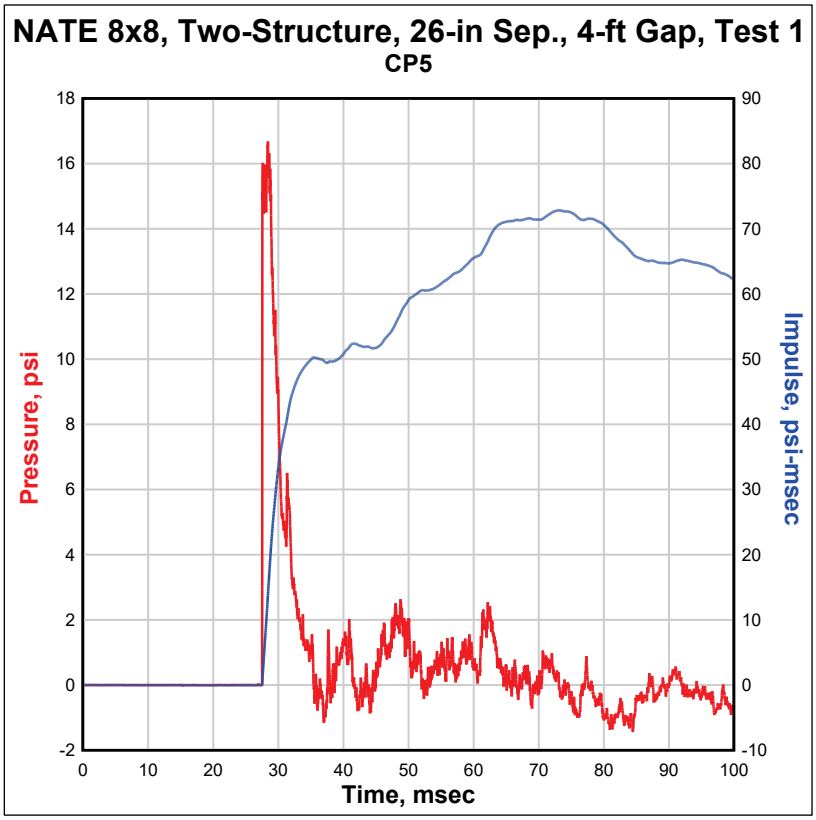
Johnson, C. F., A. Barnes and J. O'Daniel. 2017. *Blast load simulator experiments for computational model validation – Report 3*. ERDC/GSL TR-16-27. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

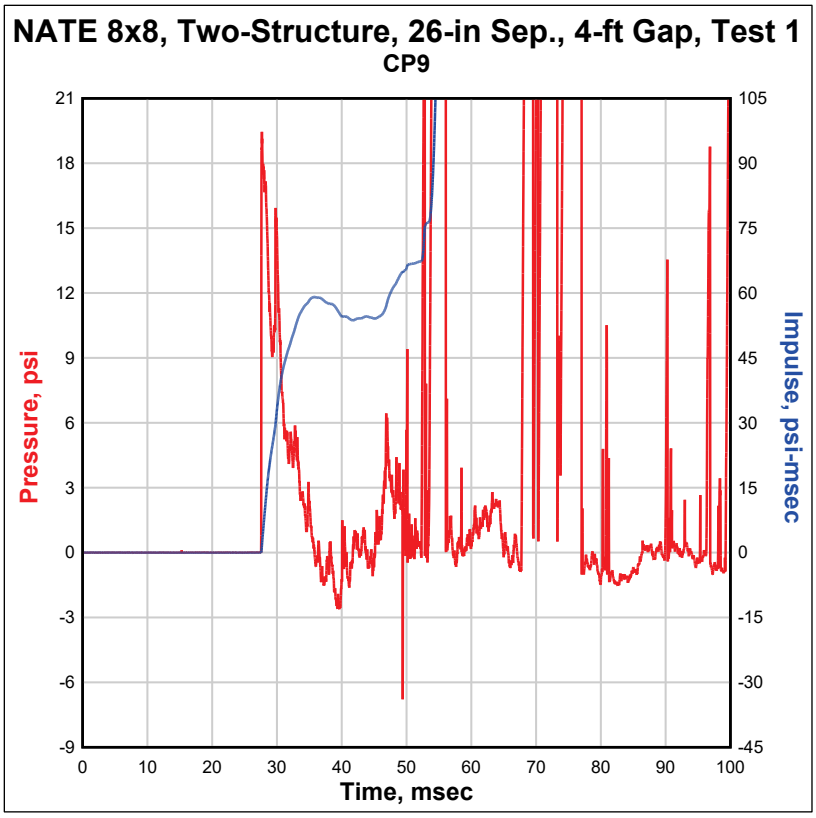
Johnson, C. F., and L. Simmons. 2008. *Blast load simulator/Shock tube testing facilities in the United States*. Information Paper. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

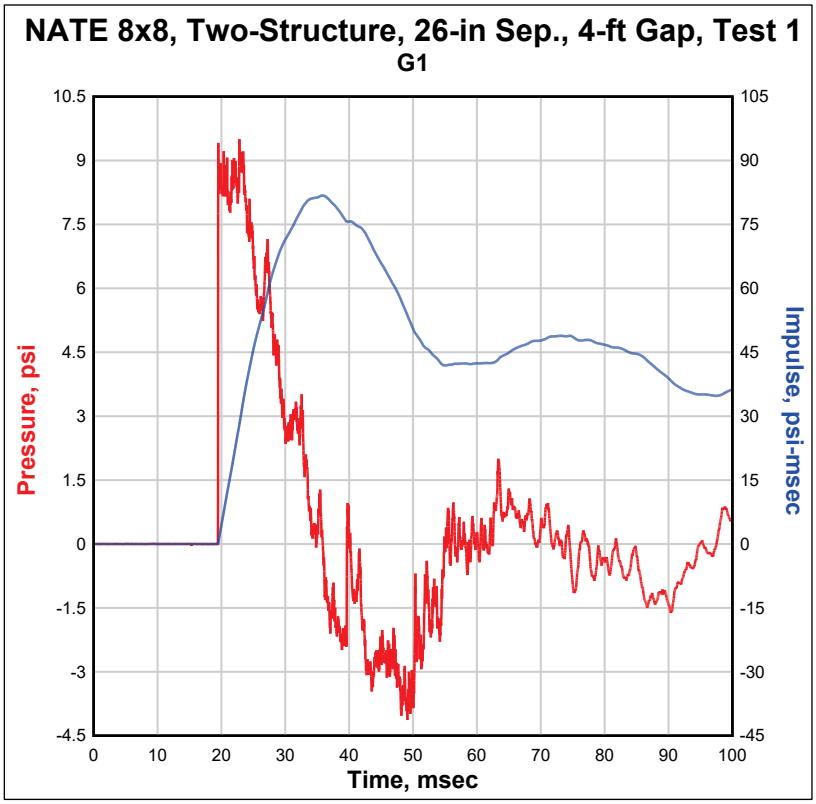
# Appendix A: Pressure and Impulse Data from Two-Structure Tests with 26-in. Spacing

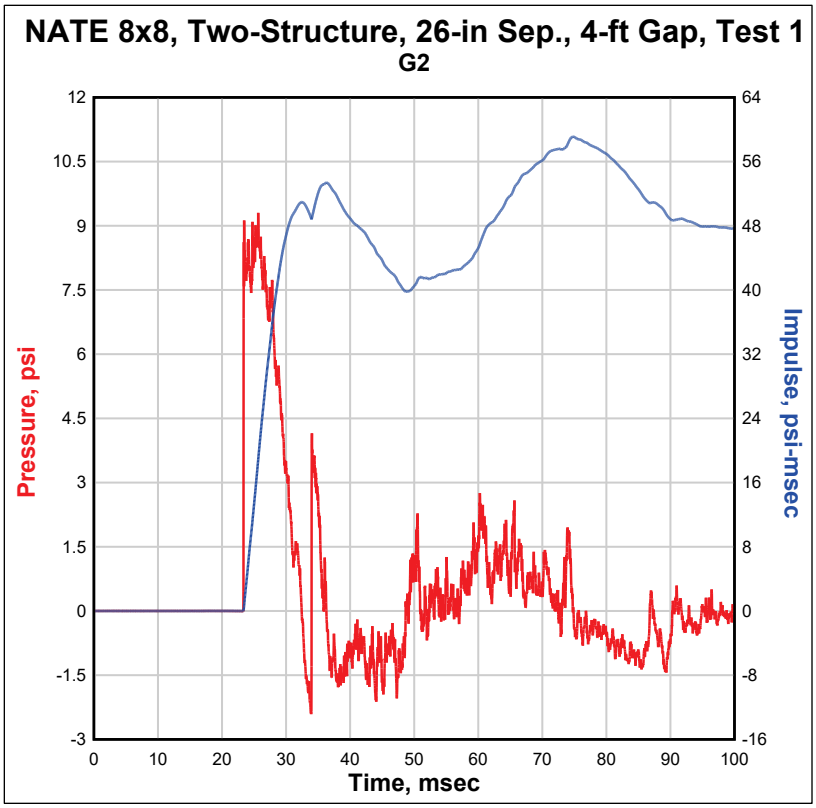


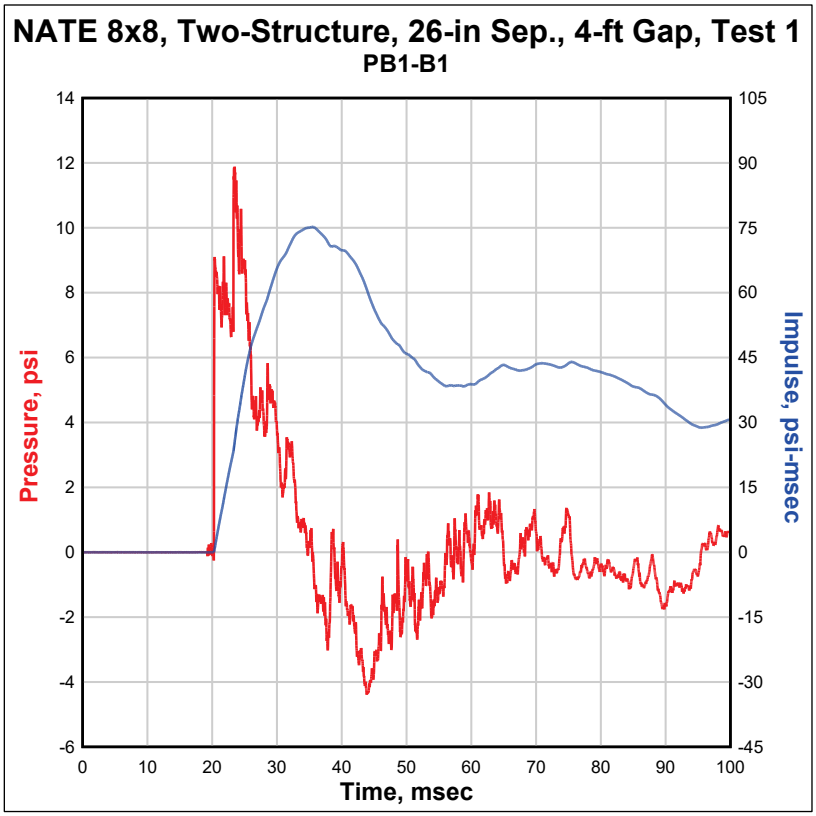

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

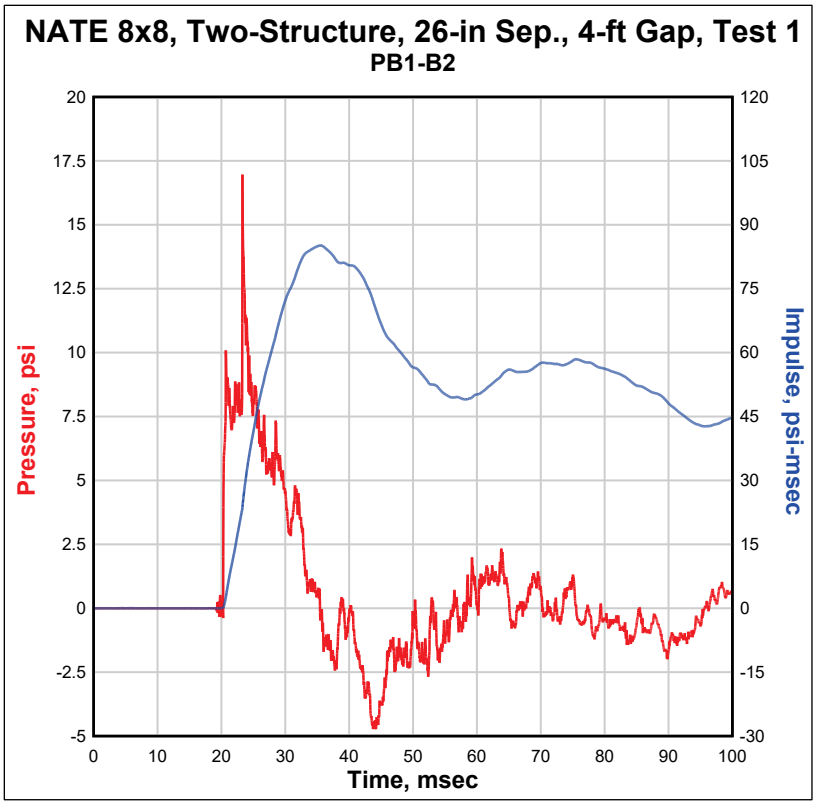

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
21
18
15
12
9
6
3
0
-3
-6
-9
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100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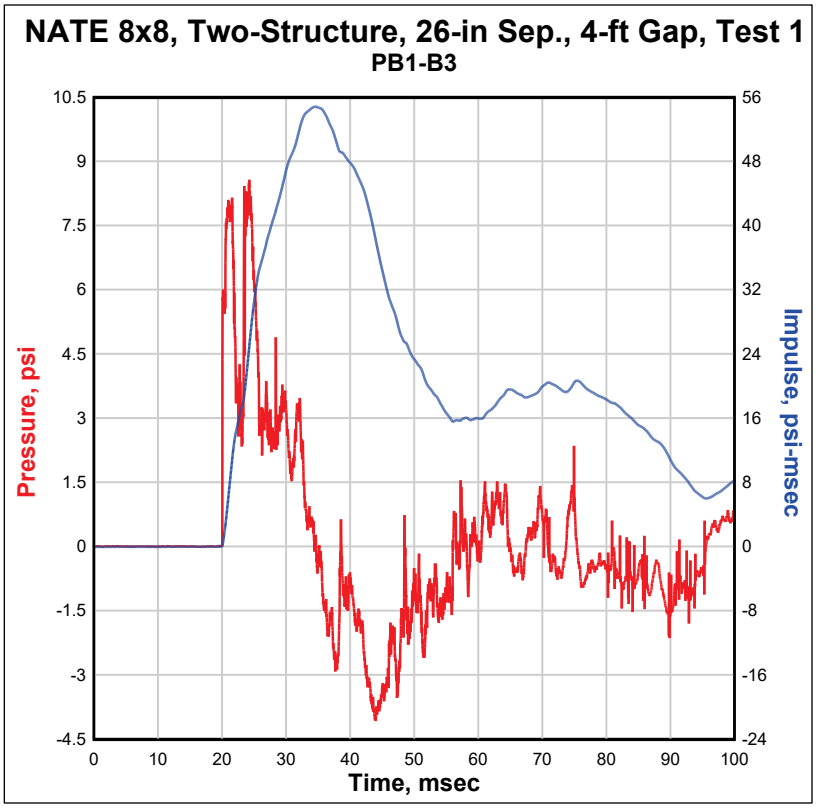
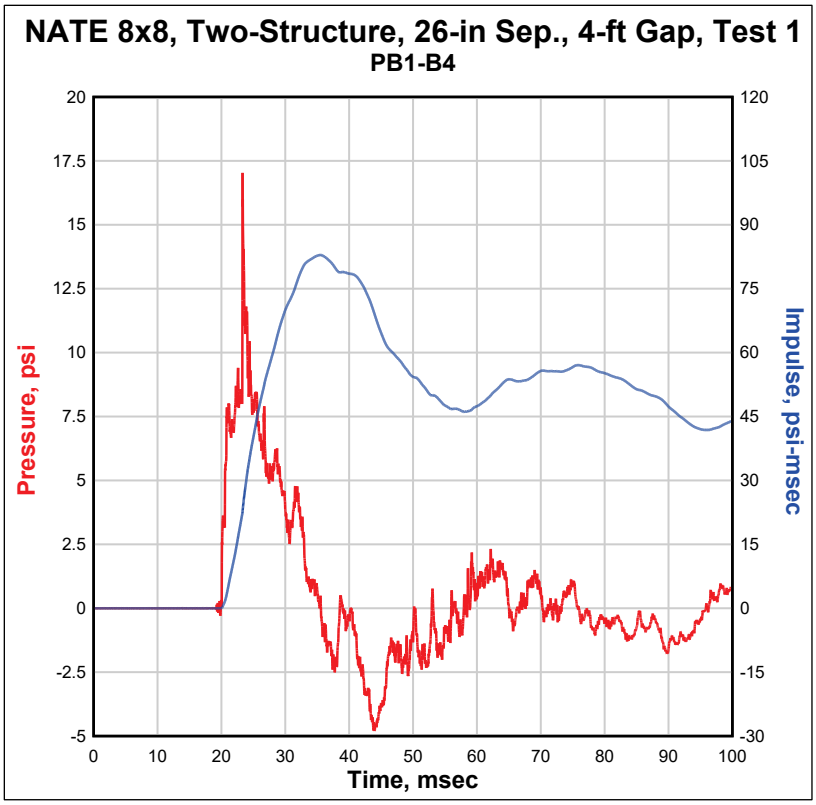
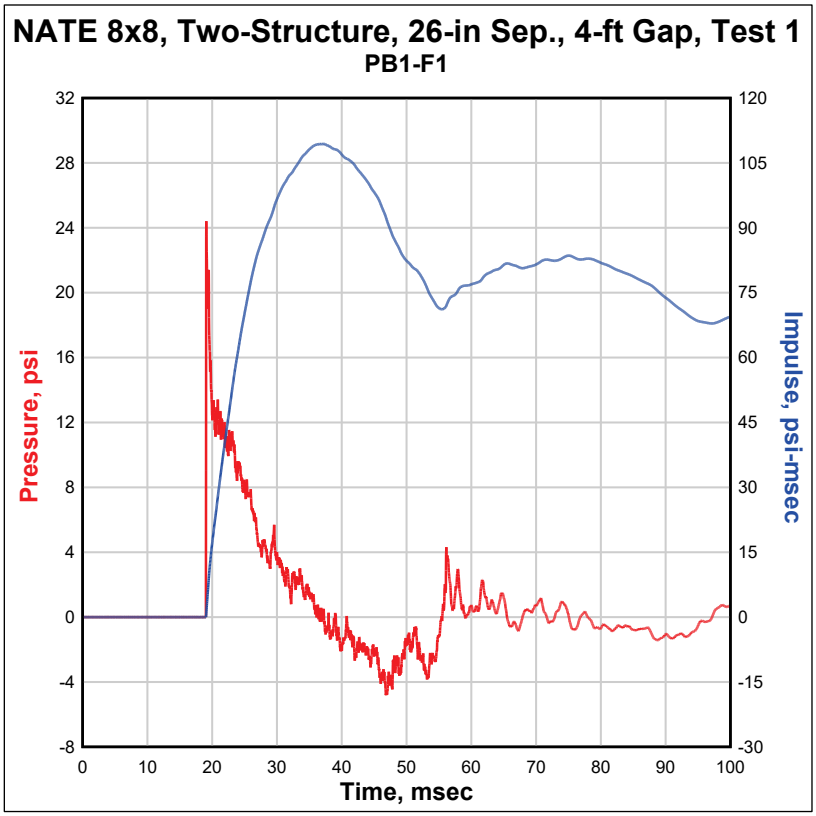
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
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0
-15
-30
0
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60
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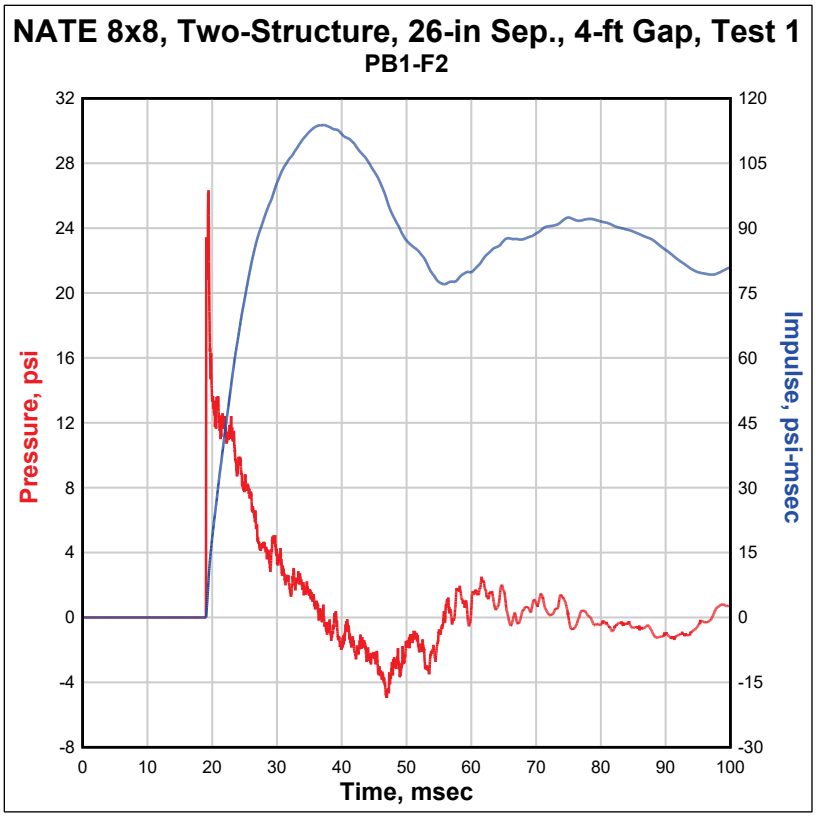
80
90
100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PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
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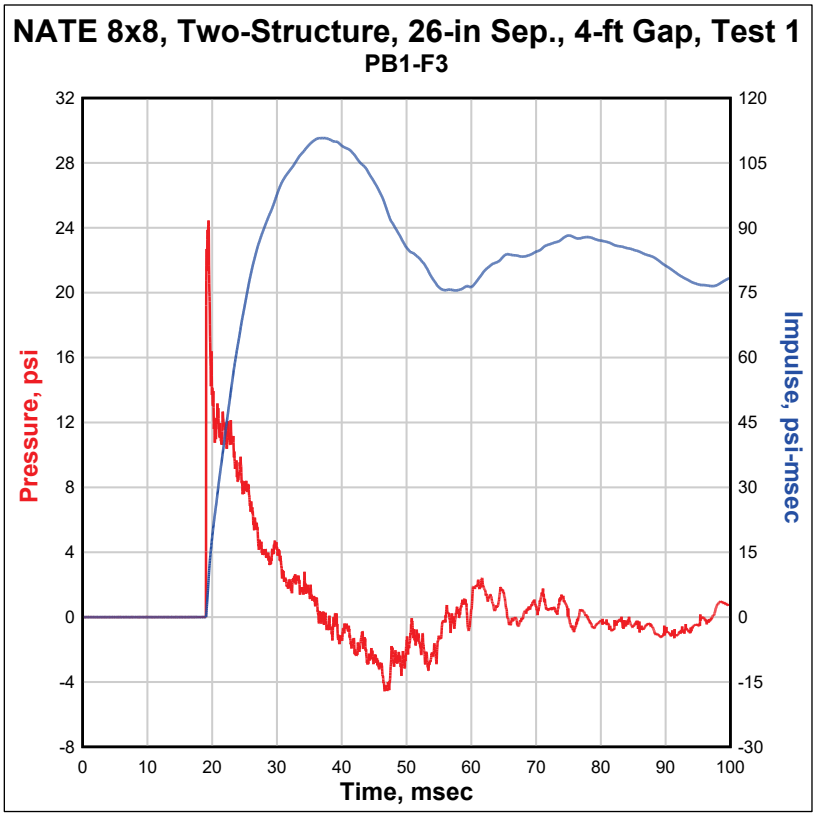
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
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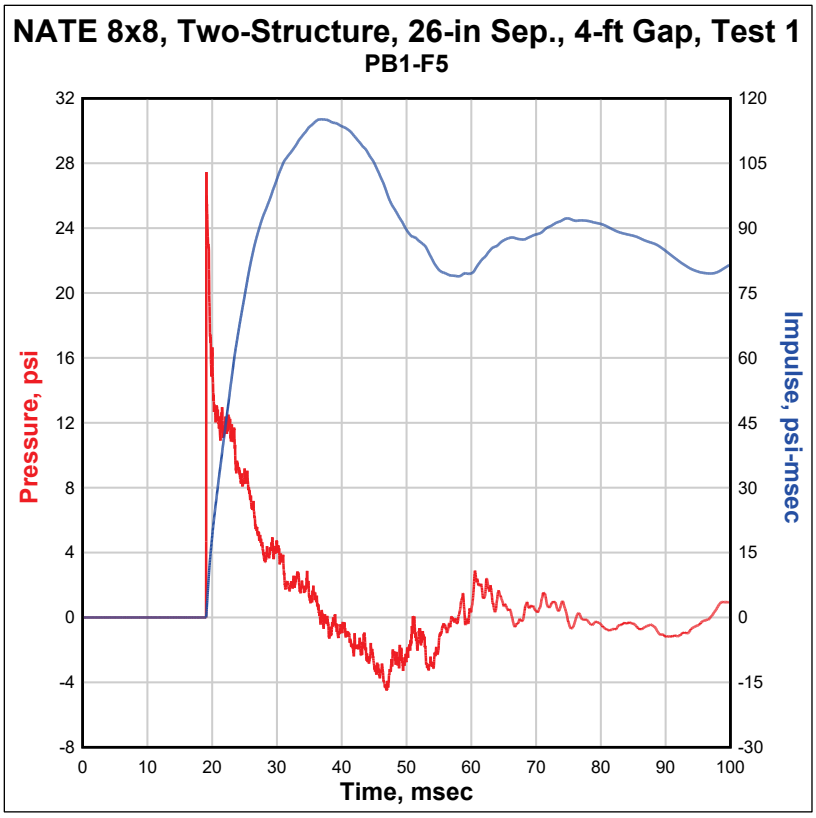
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PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
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0
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-30
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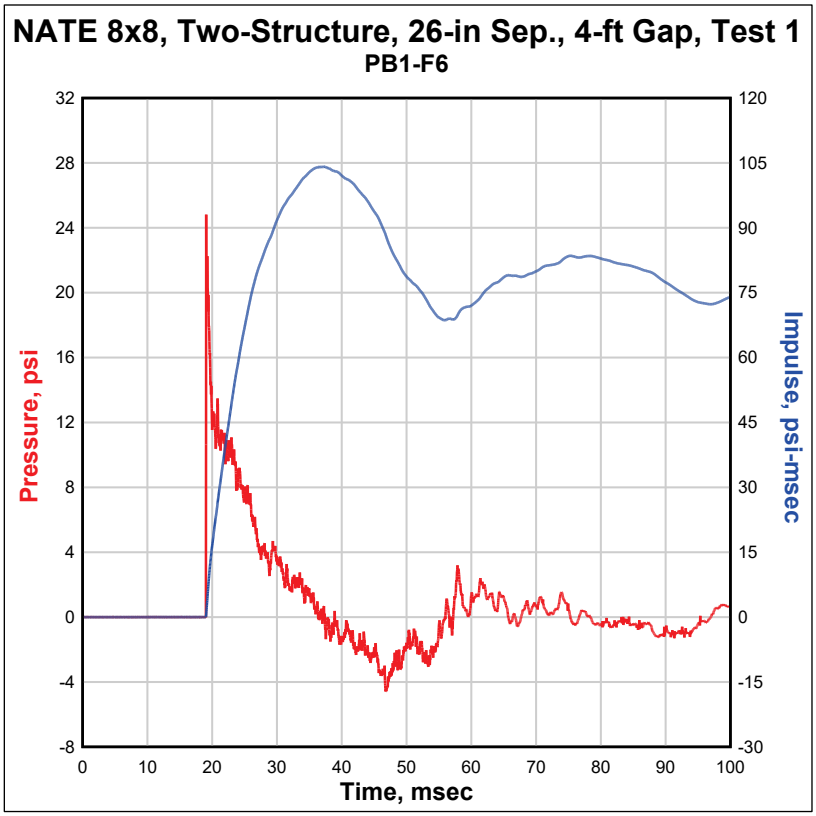
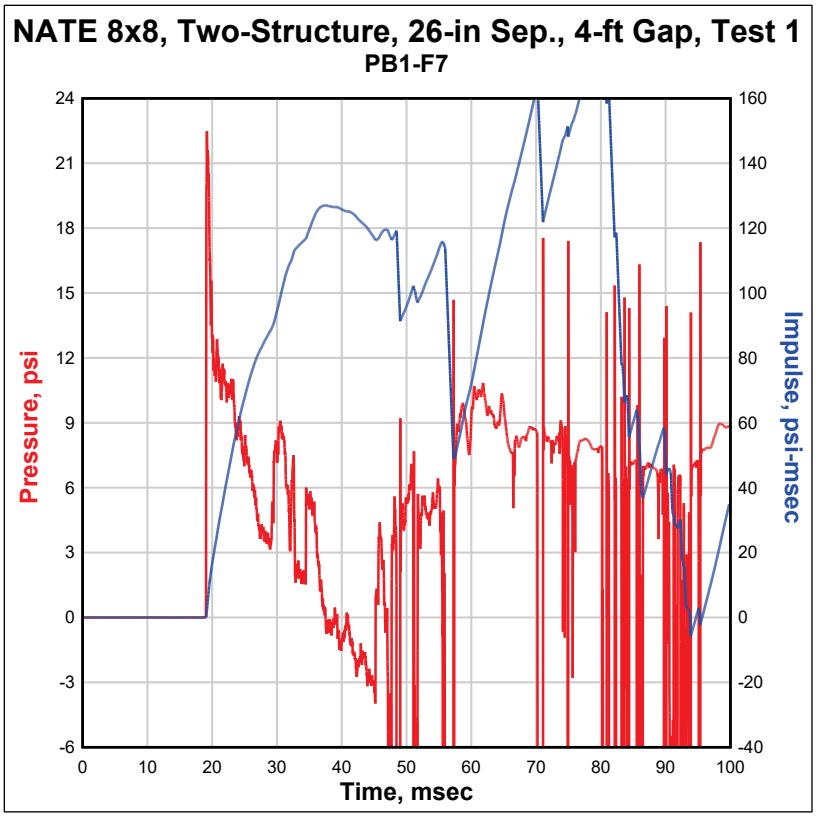
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
160
140
120
100
80
60
40
20
0
-20
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0
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30
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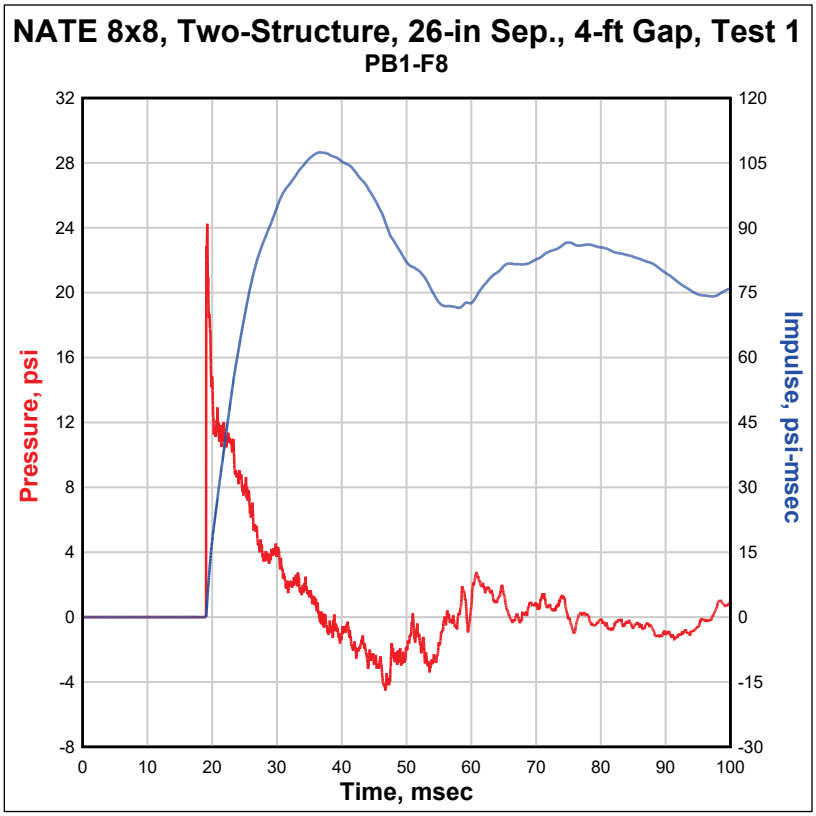
60
70
80
90
100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Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
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-15
-30
0
10
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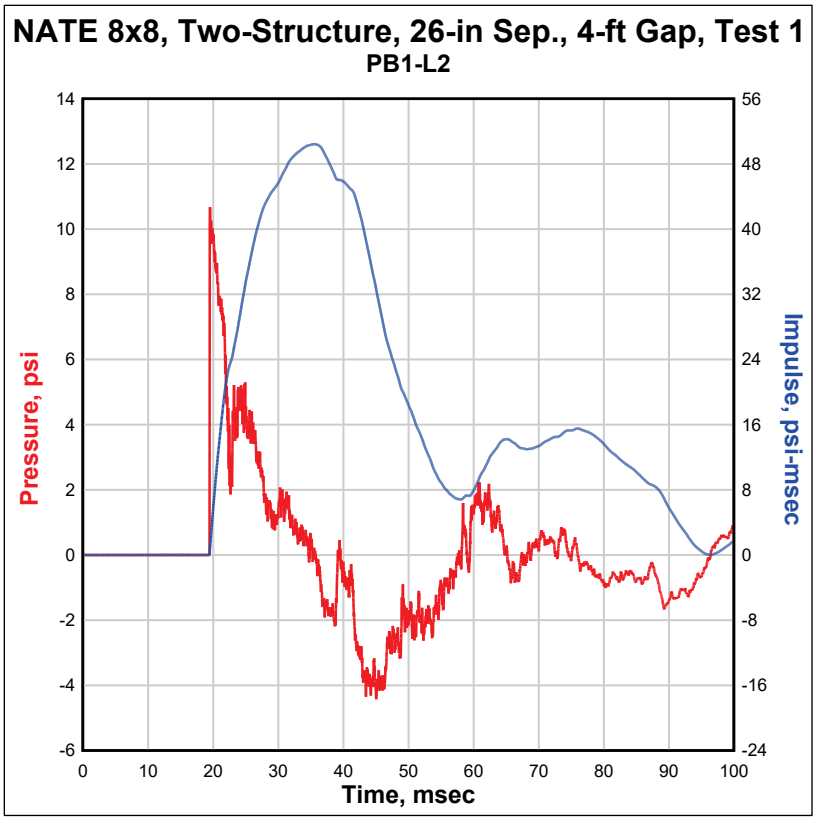
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
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8
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-8
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-24
0
10
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30
40
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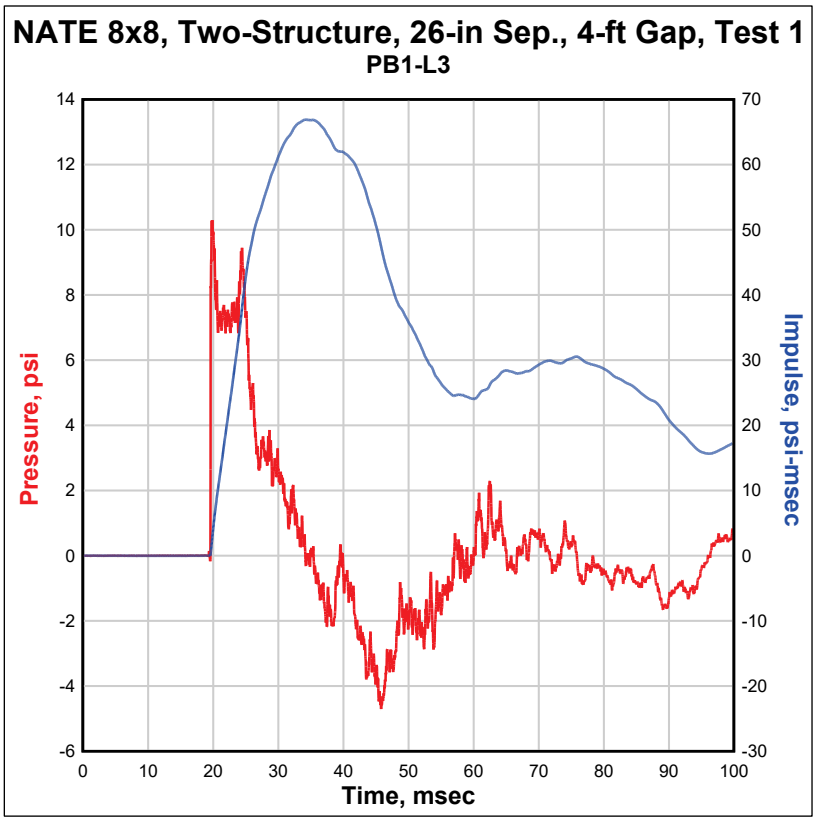
60
70
80
90
100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PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
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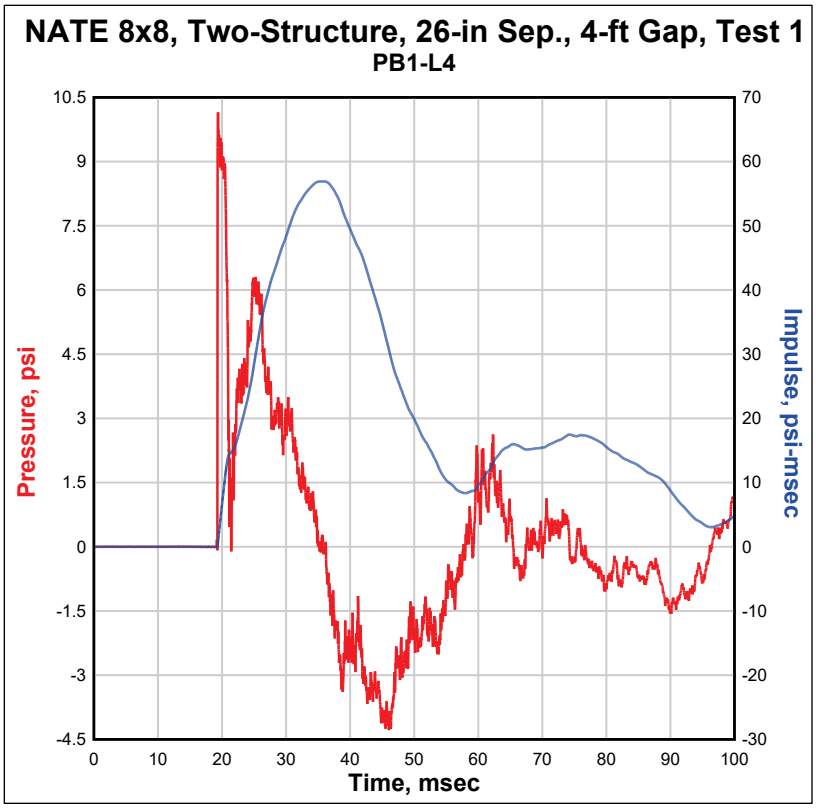
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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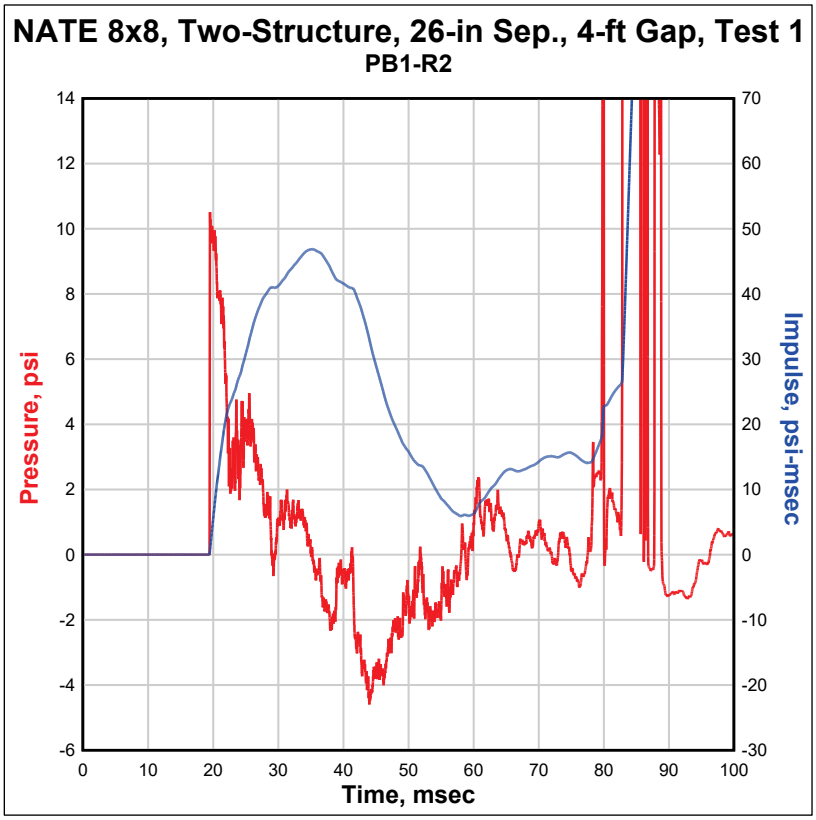
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
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10
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-10
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30
40
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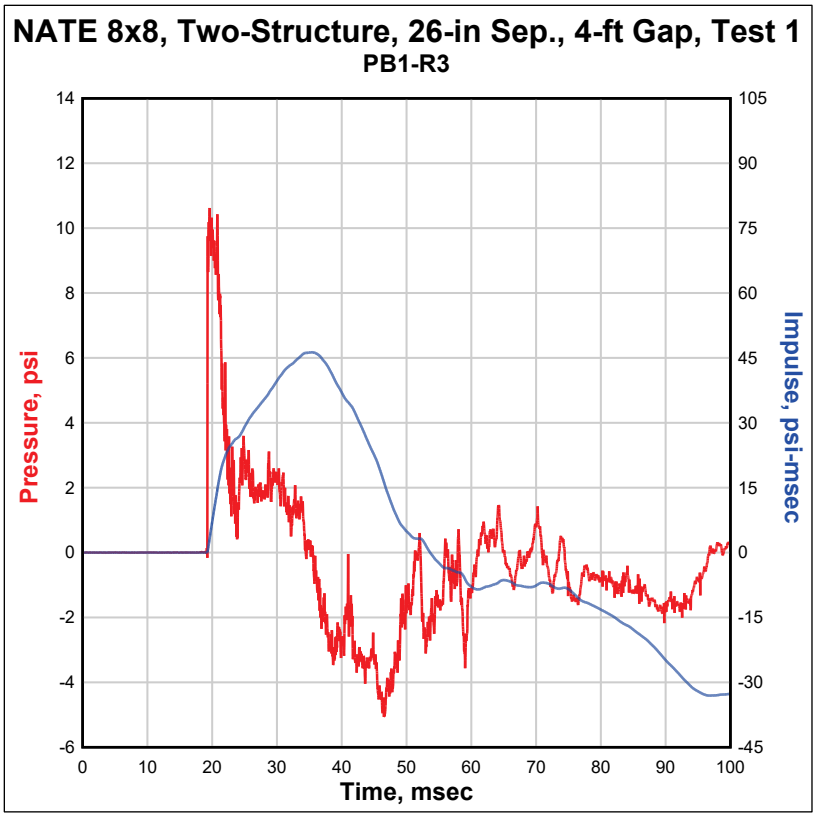
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
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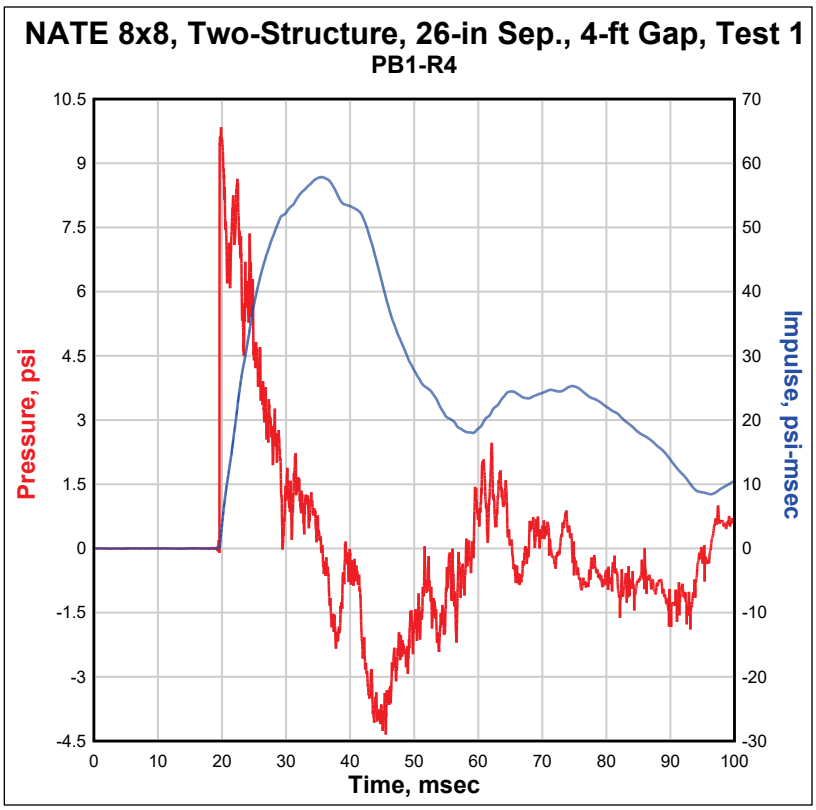
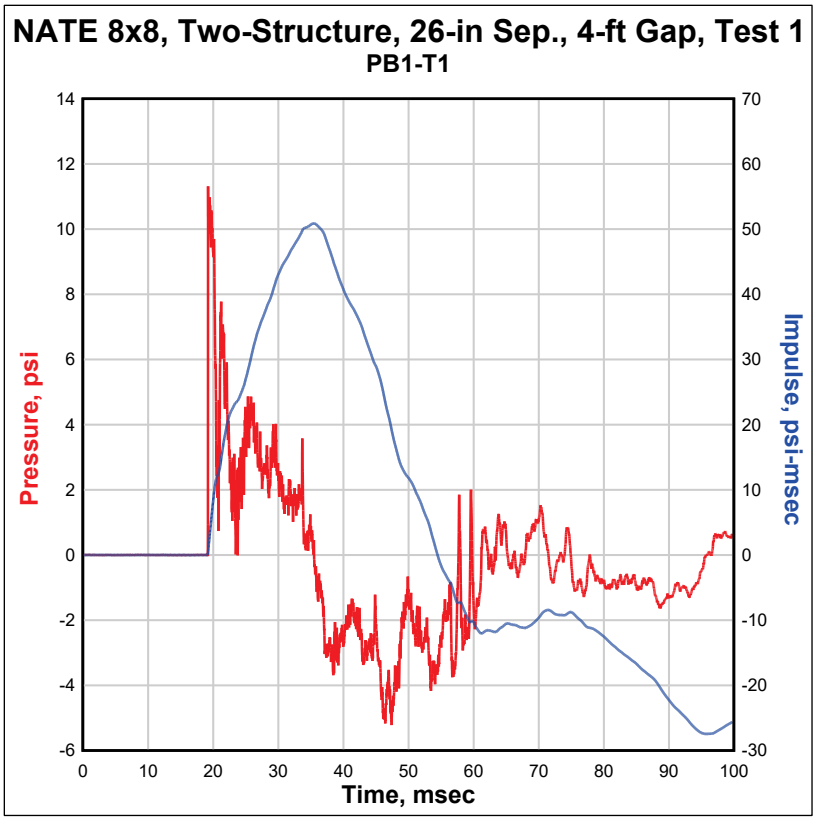
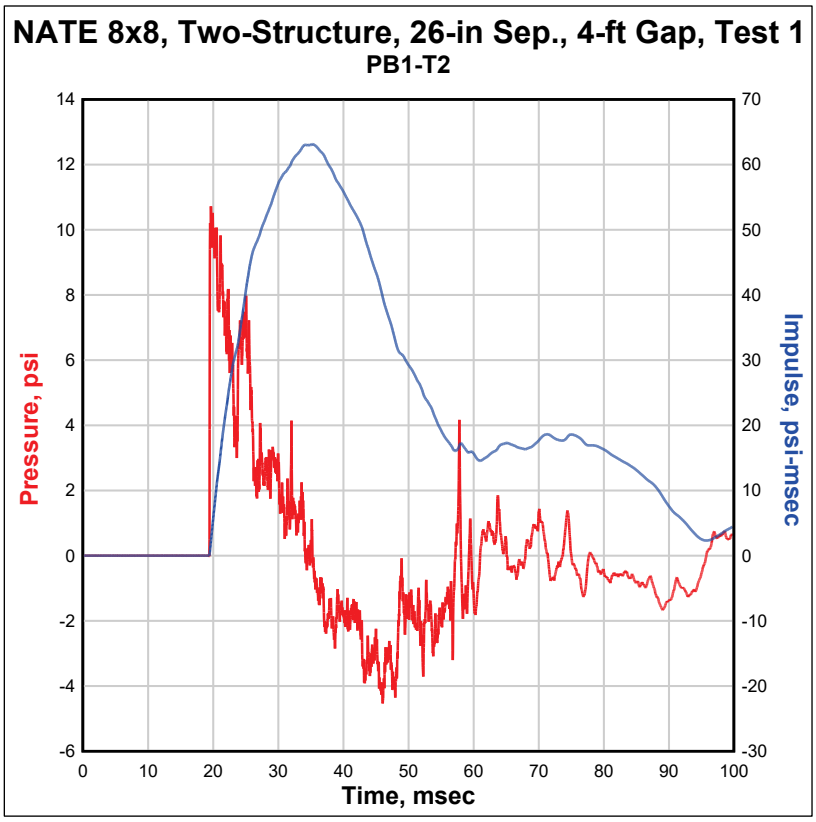
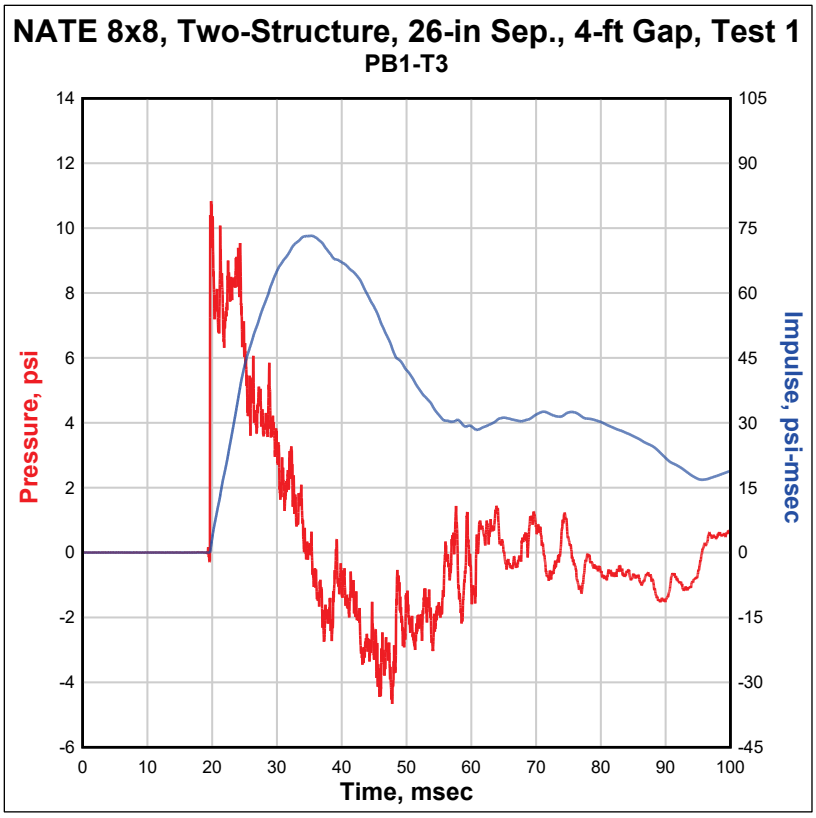
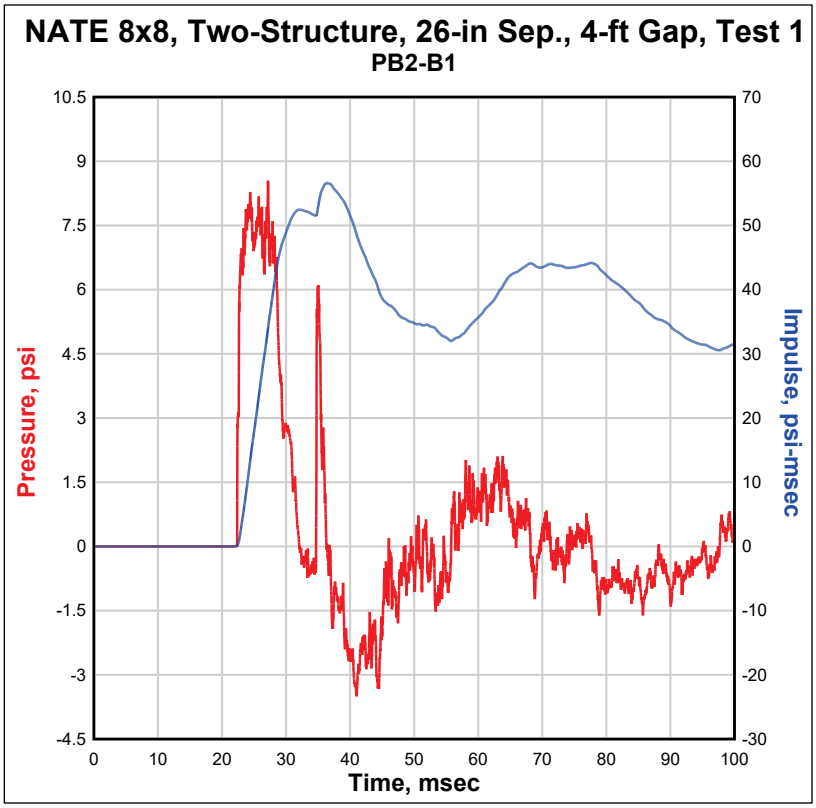
100

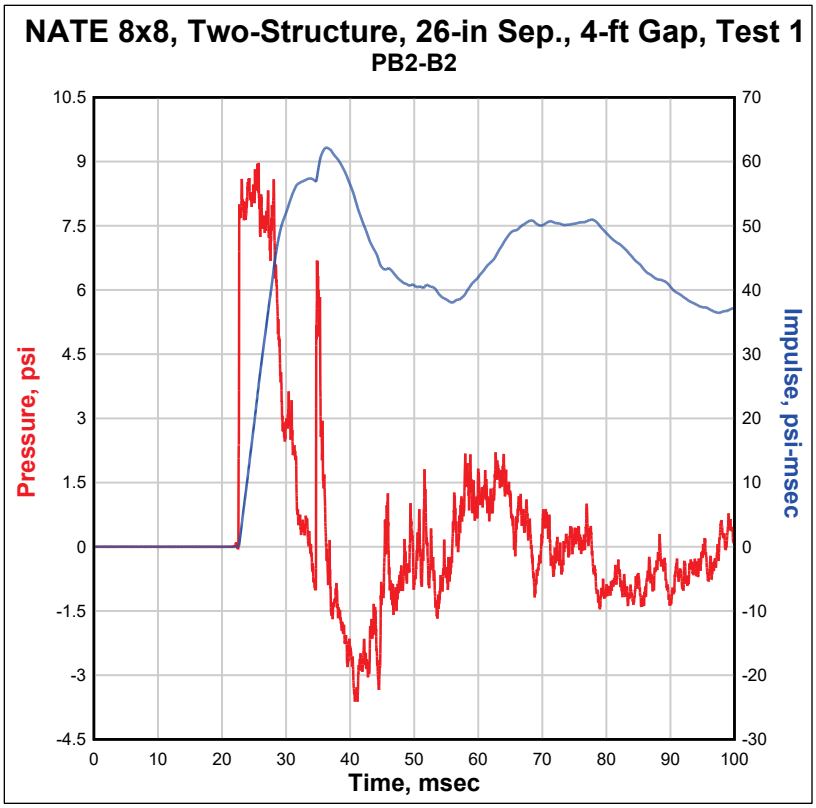

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

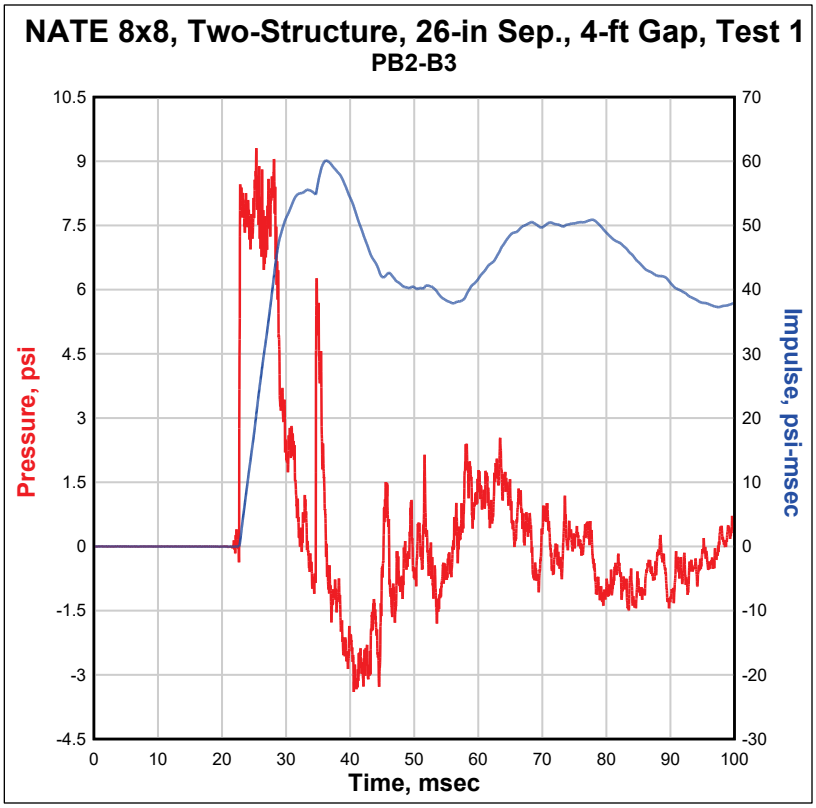

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

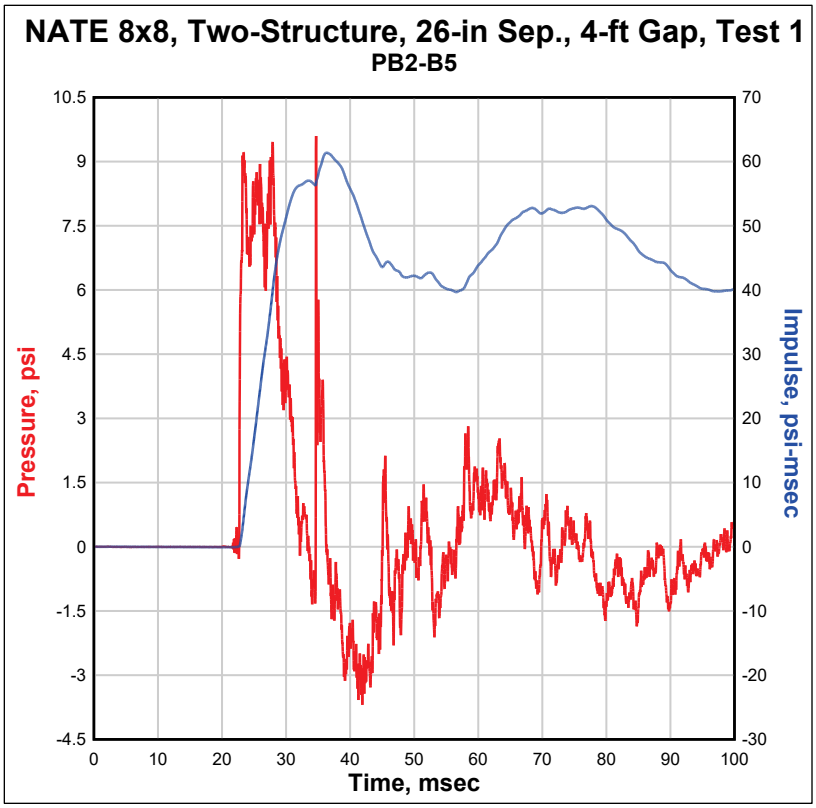

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

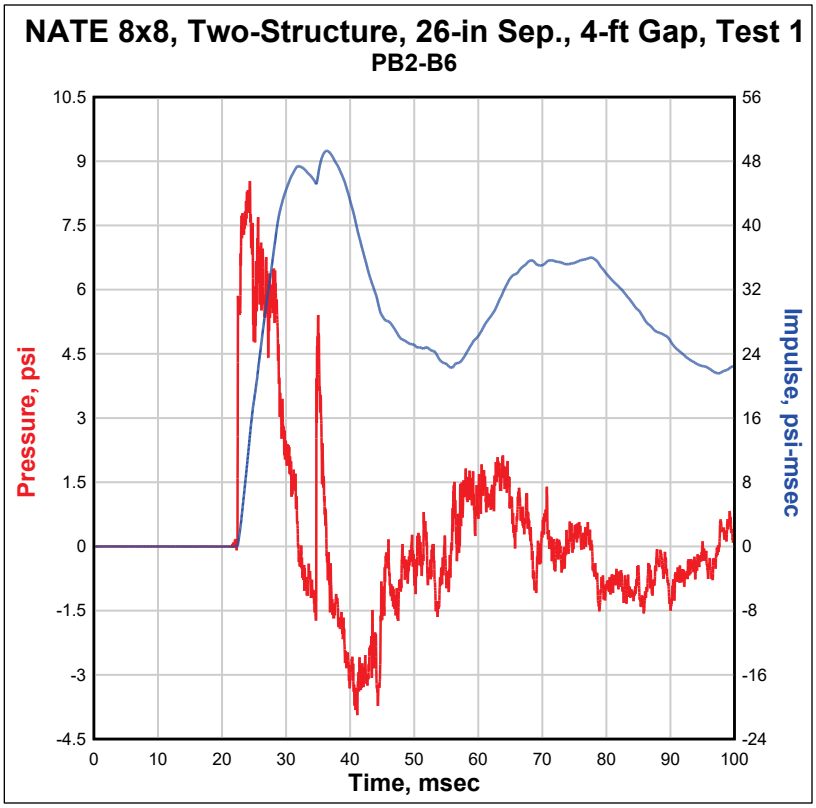

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

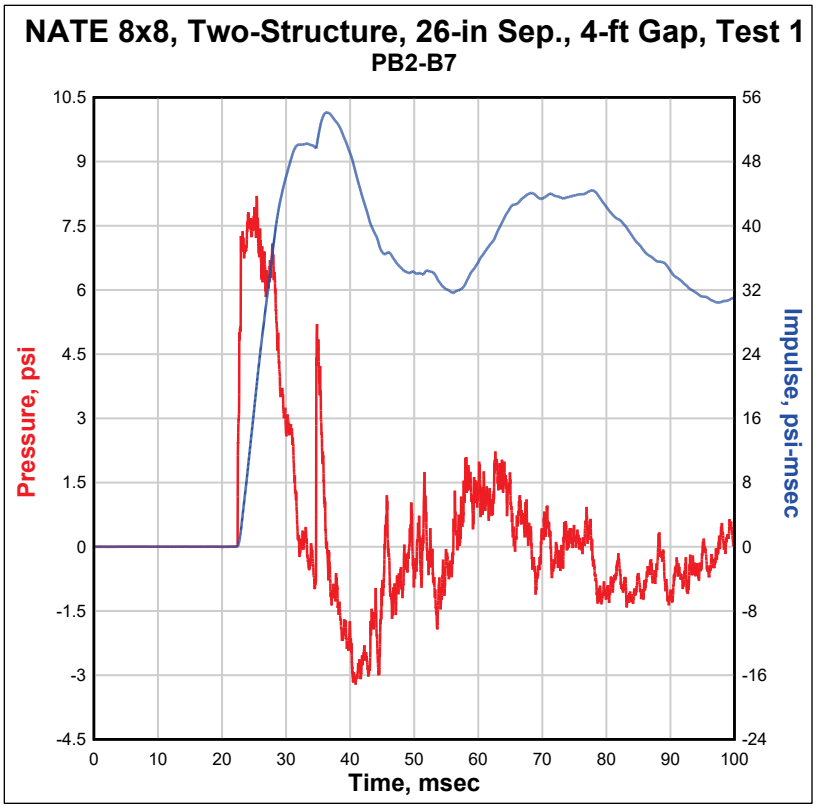

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

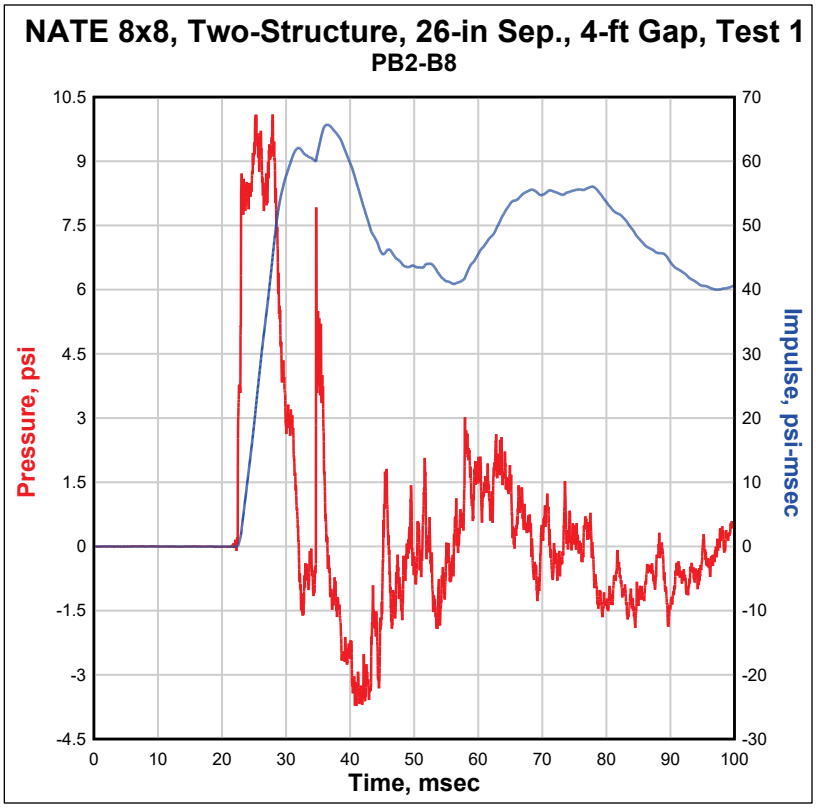

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

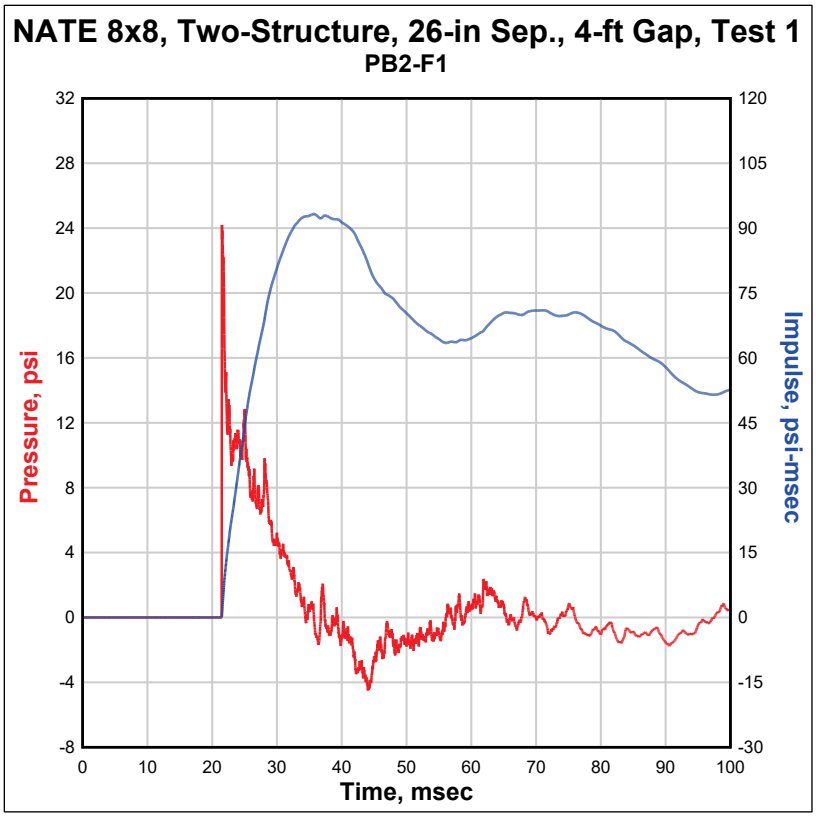

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

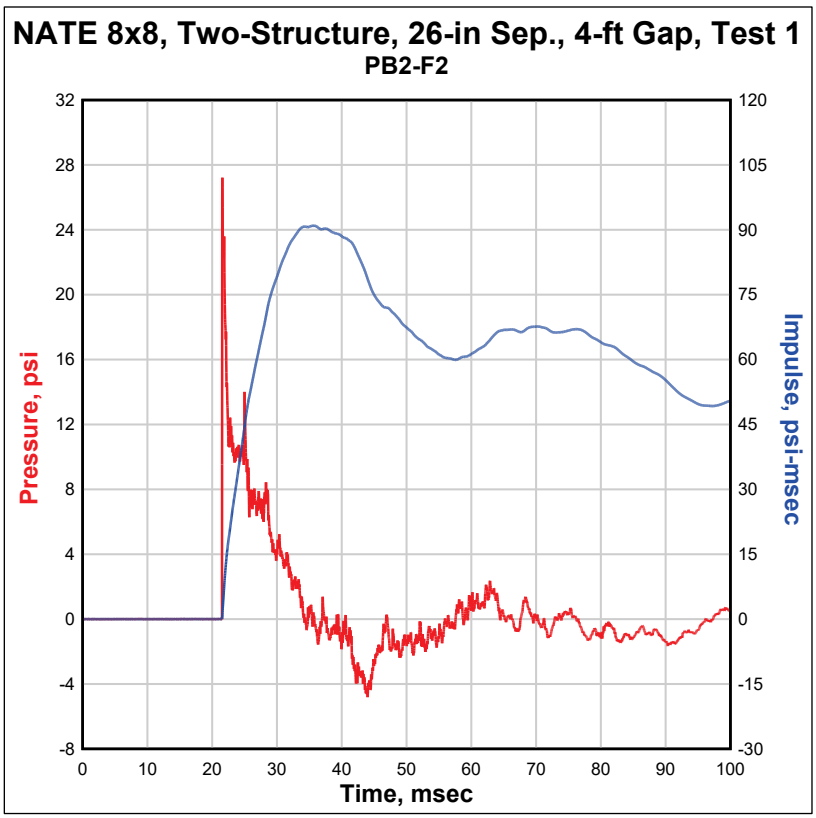

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

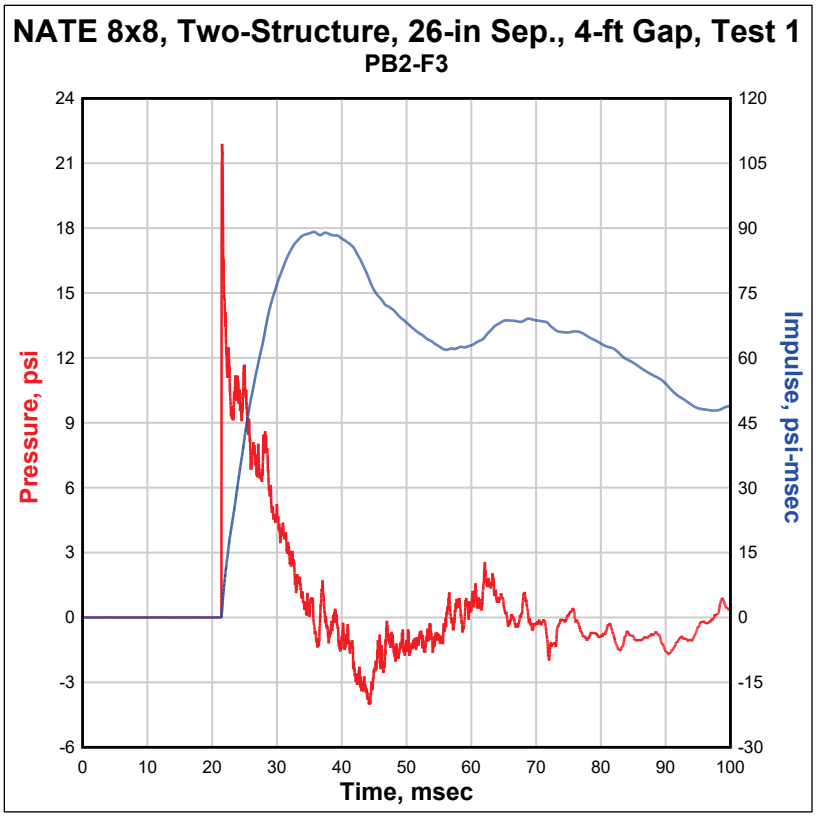

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

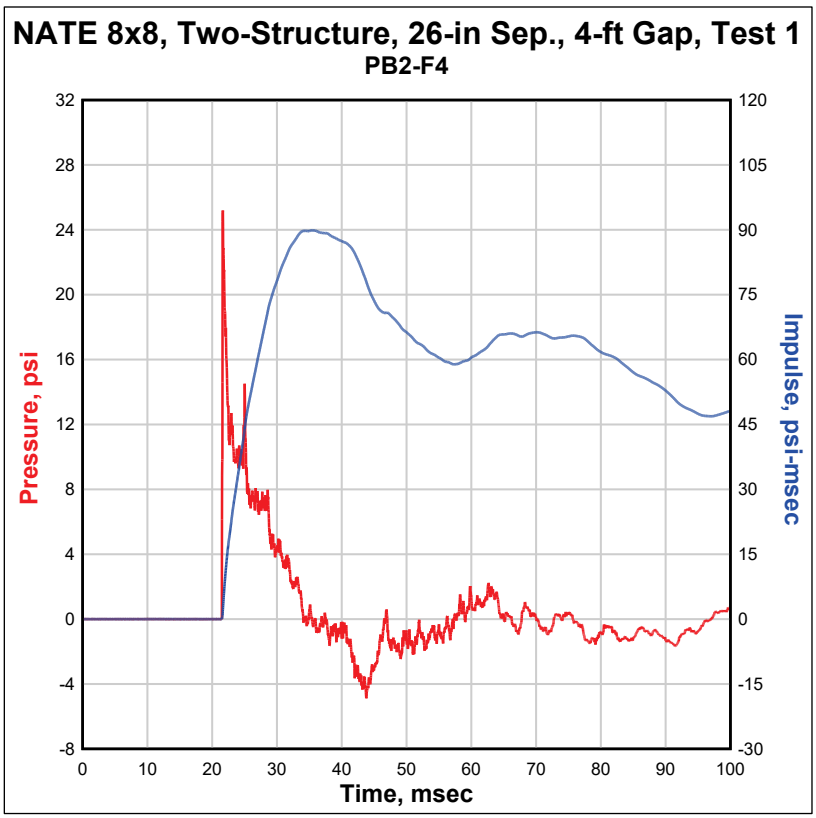

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

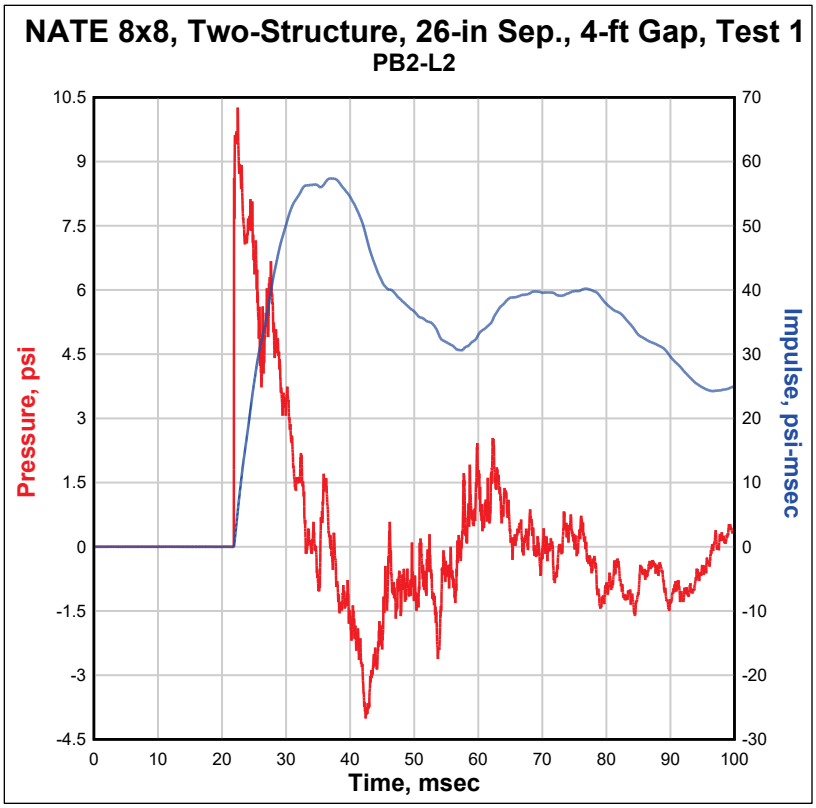

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

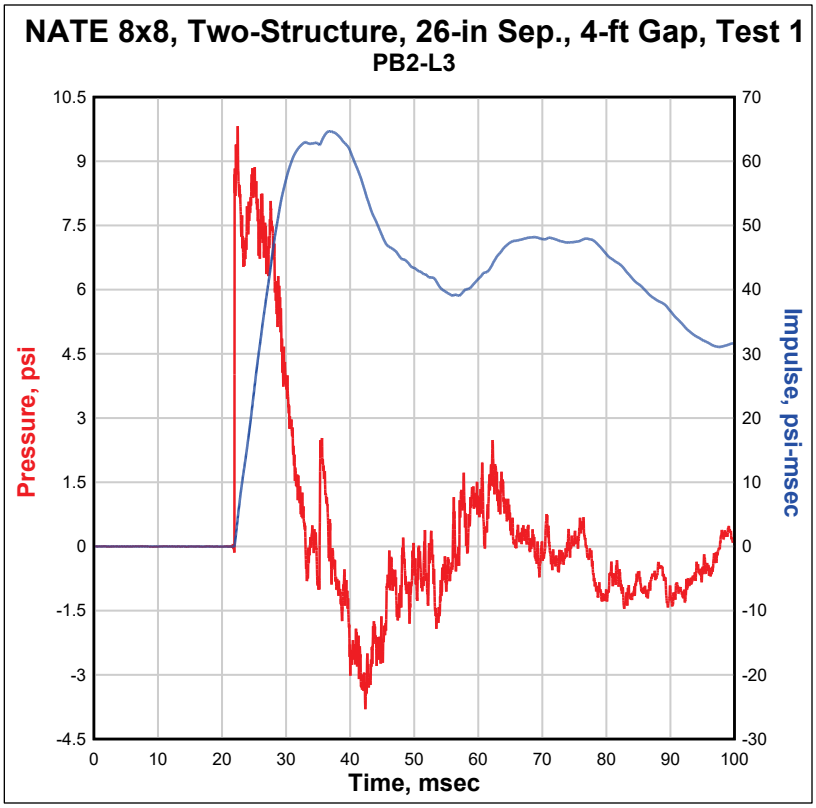

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

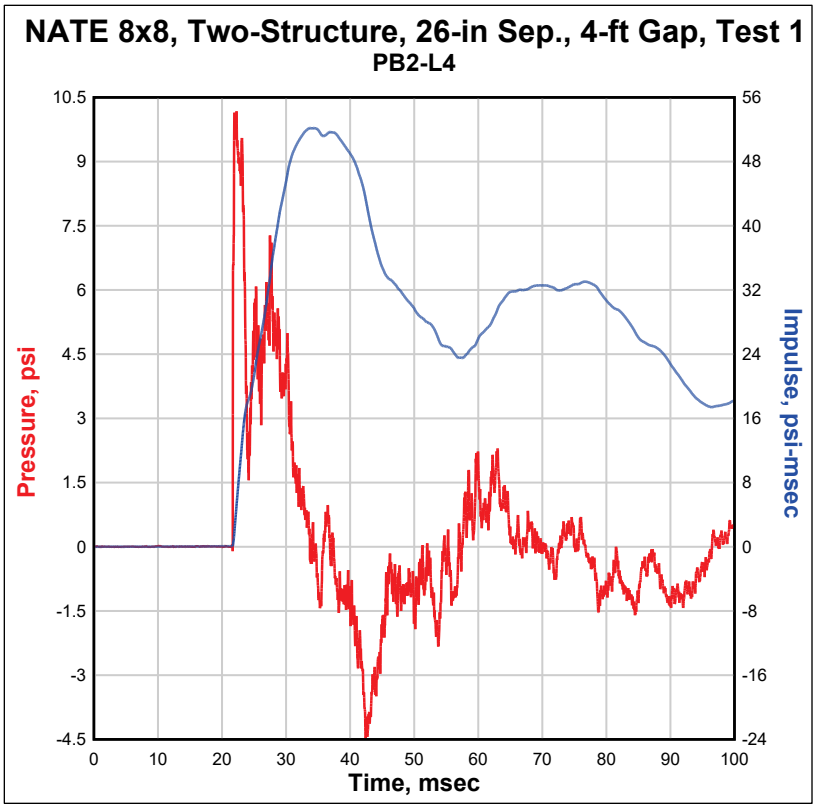

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

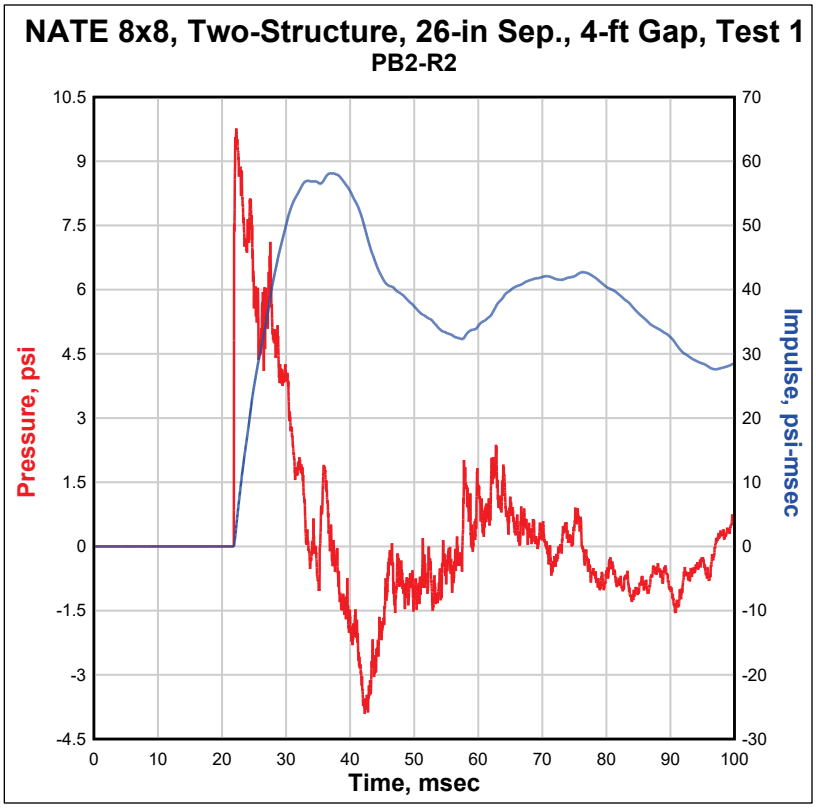

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

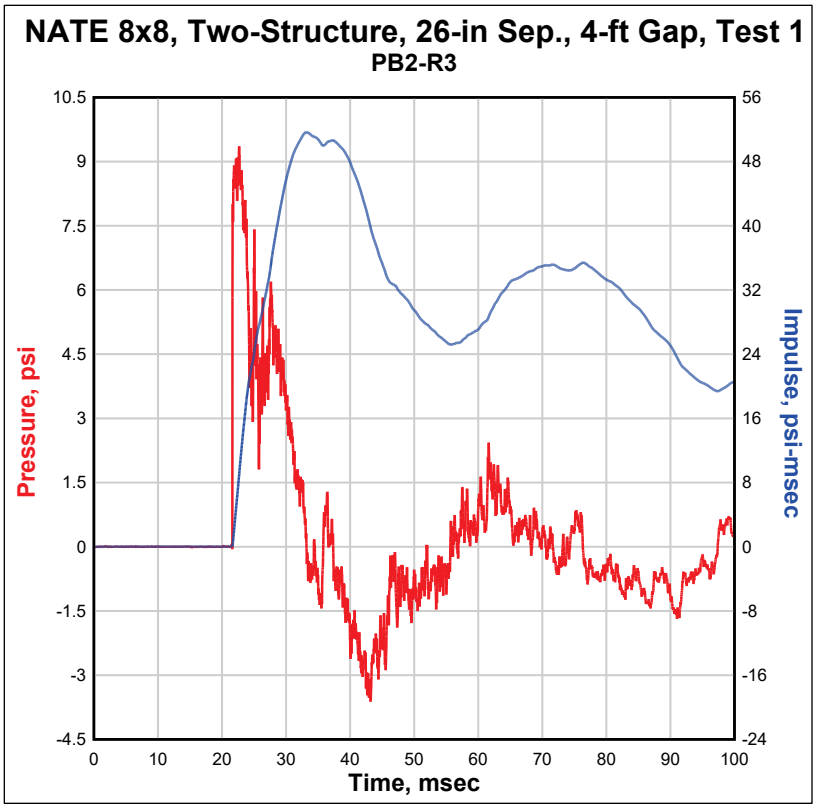

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

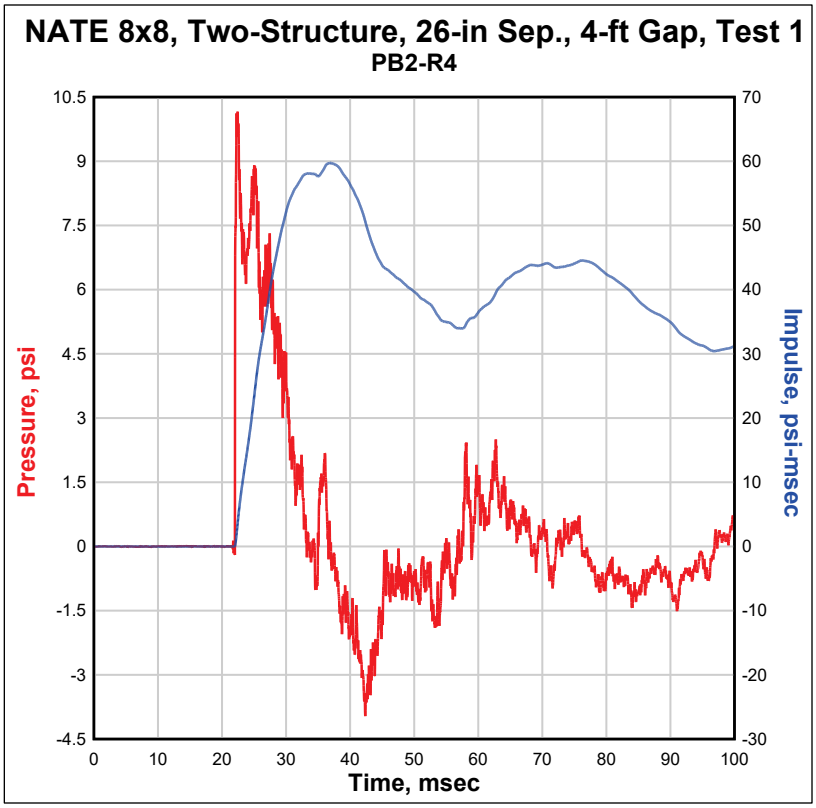

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

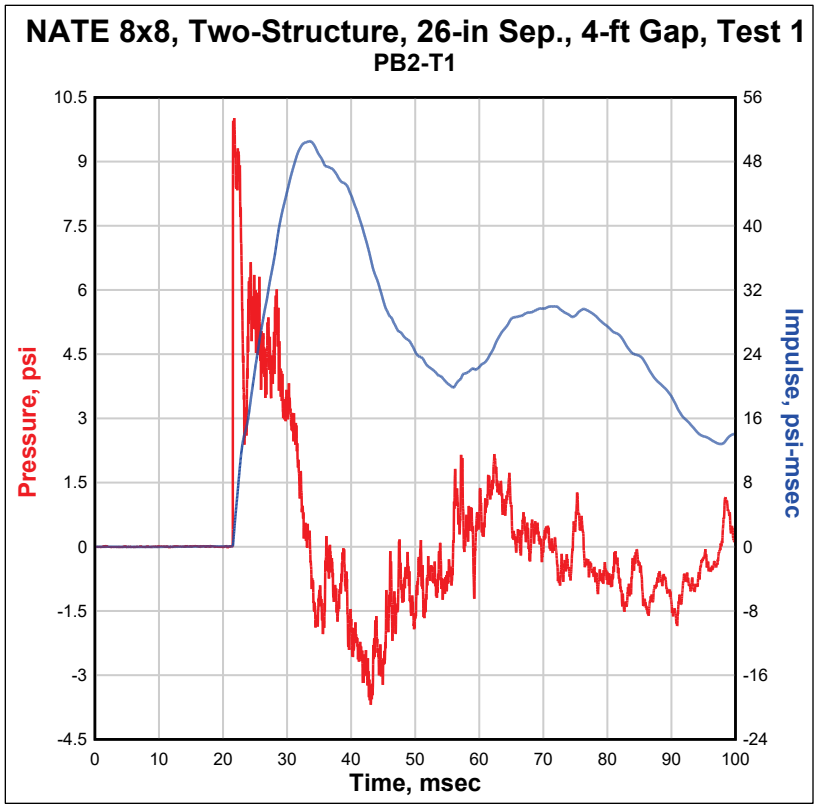

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

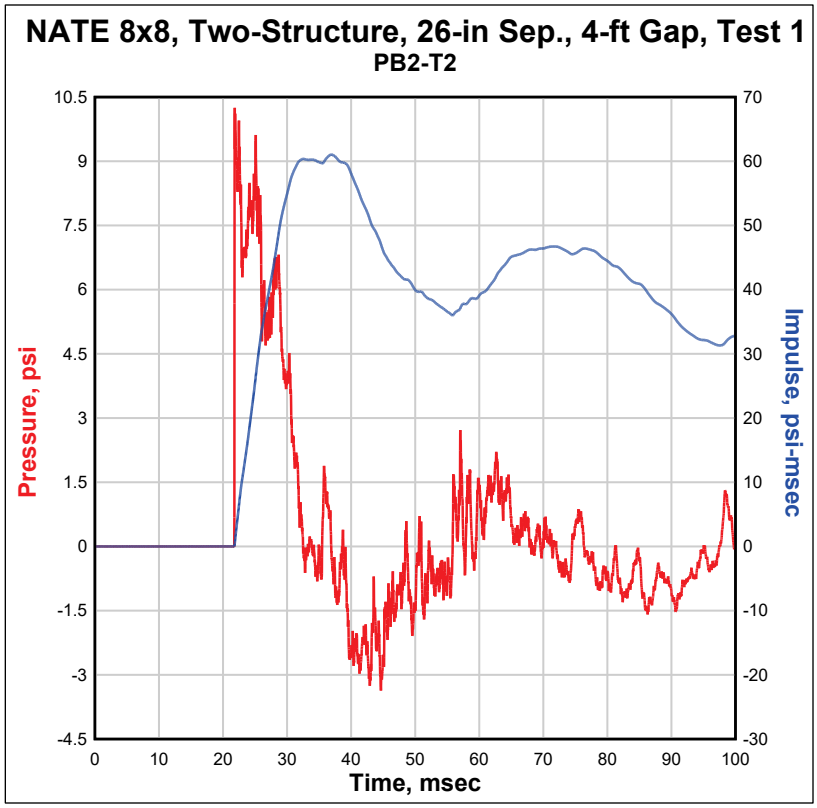

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

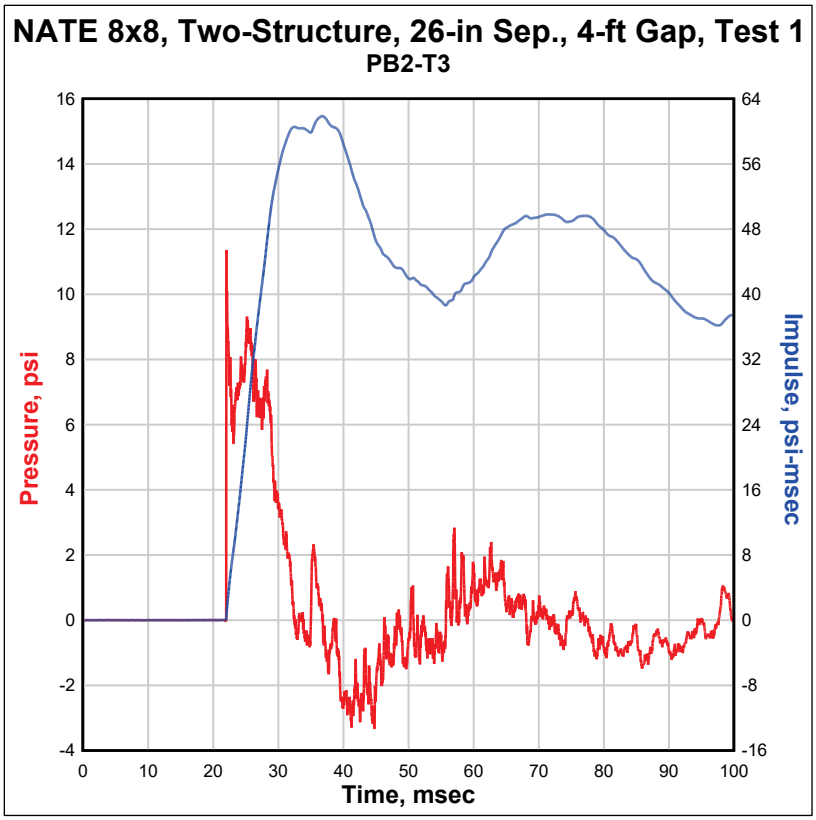

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

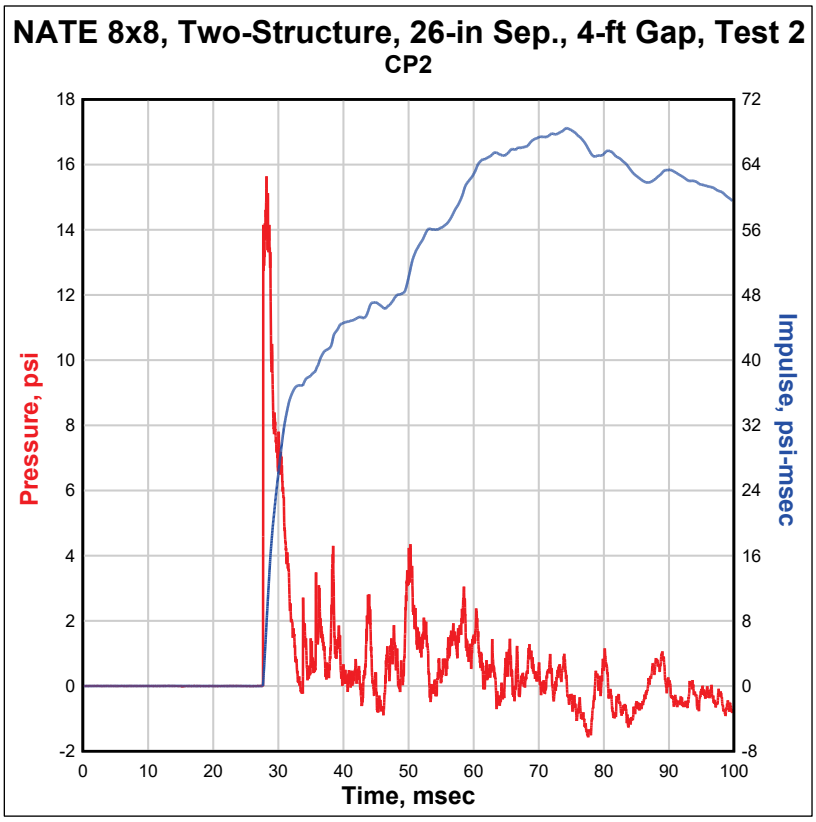

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

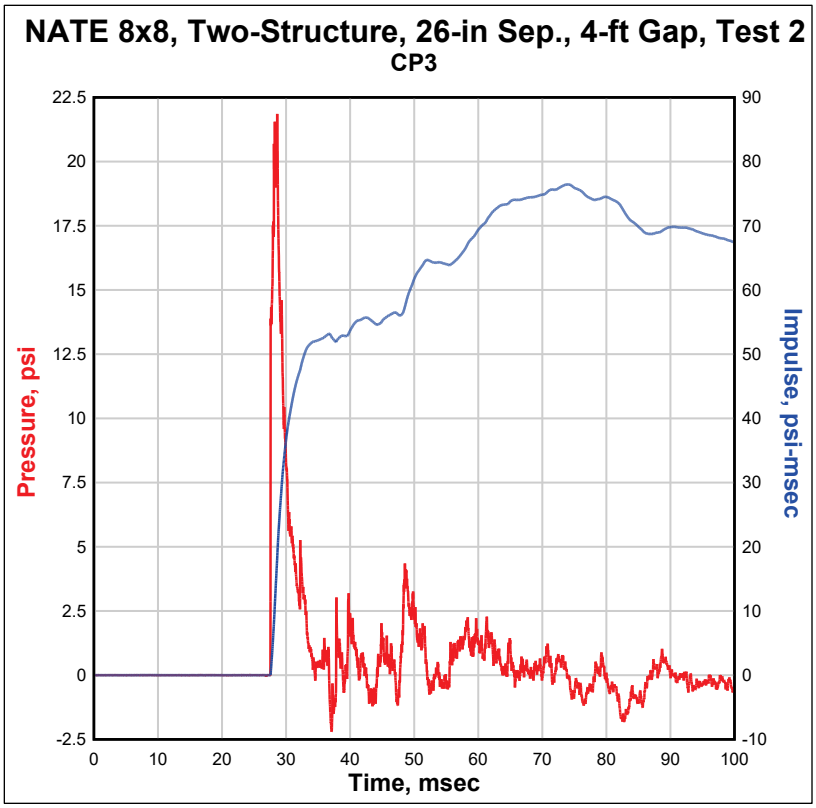

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

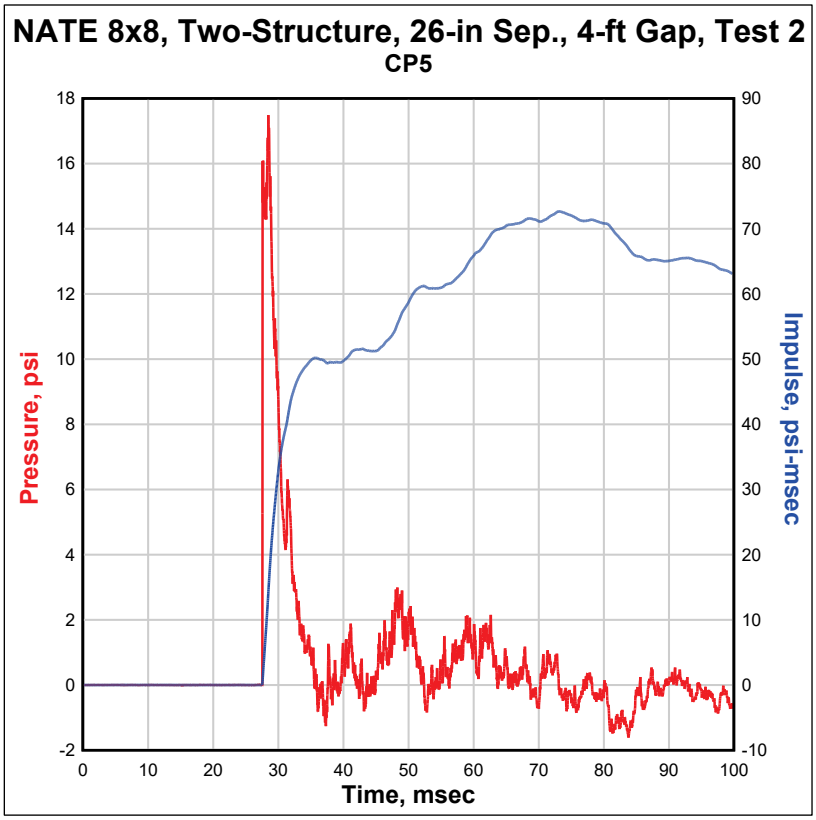

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

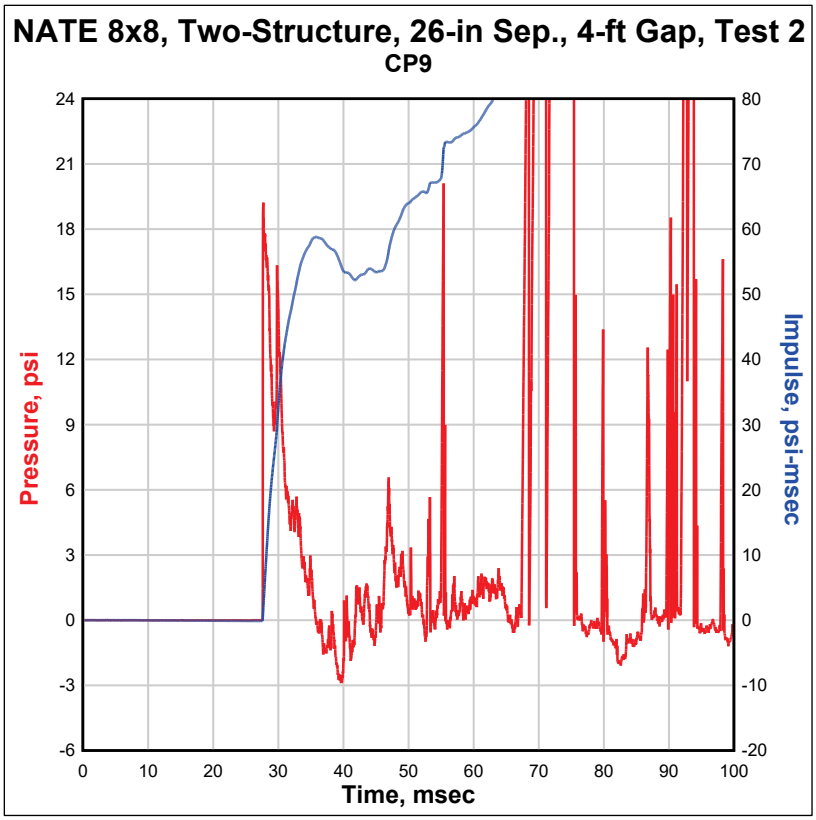

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

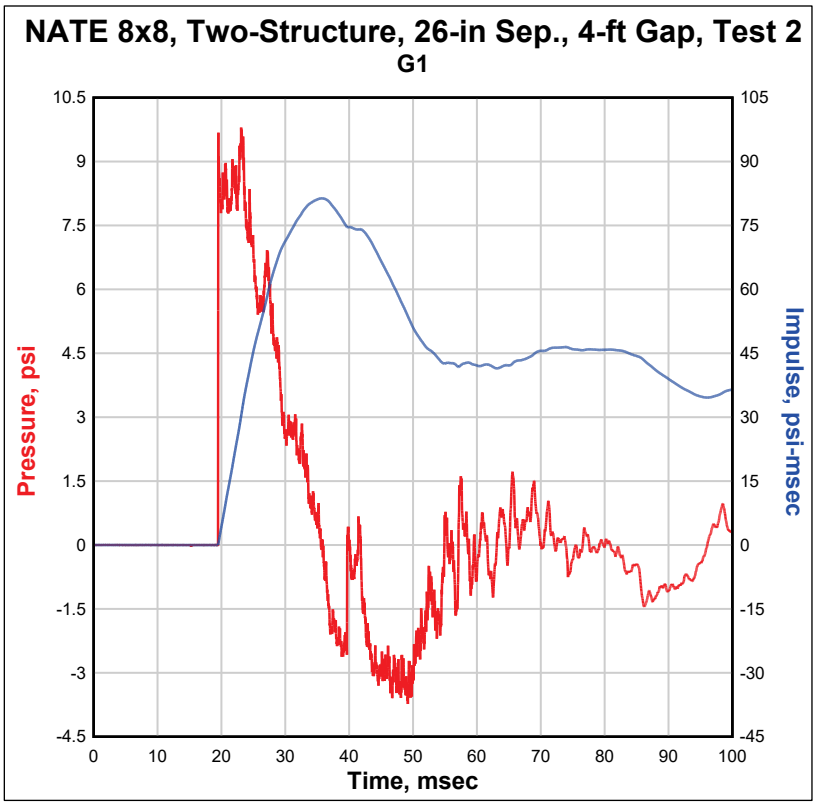

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 1
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

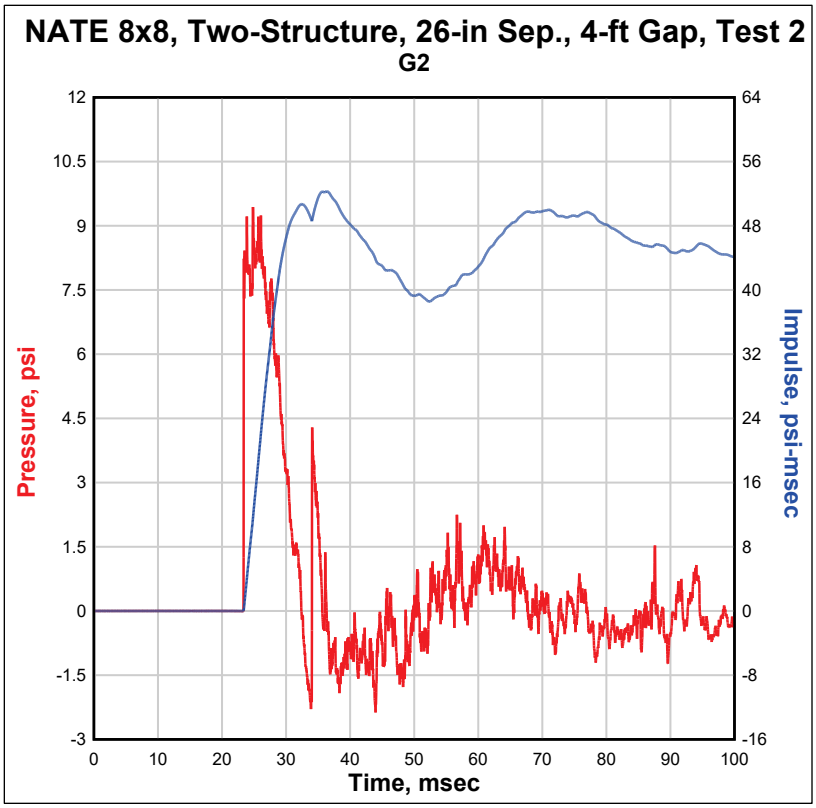

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

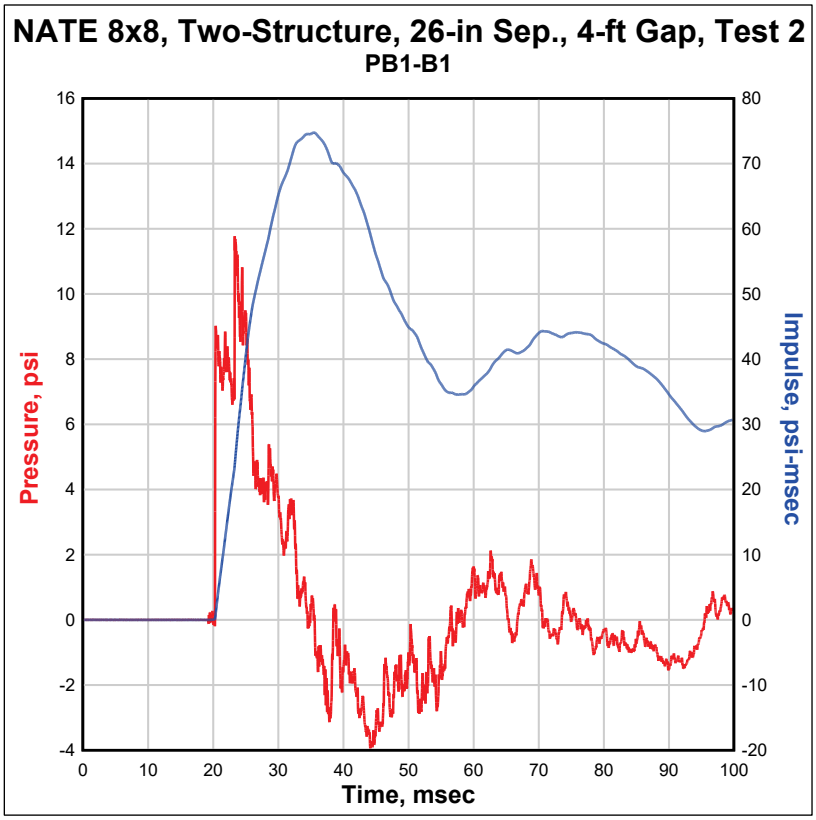

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

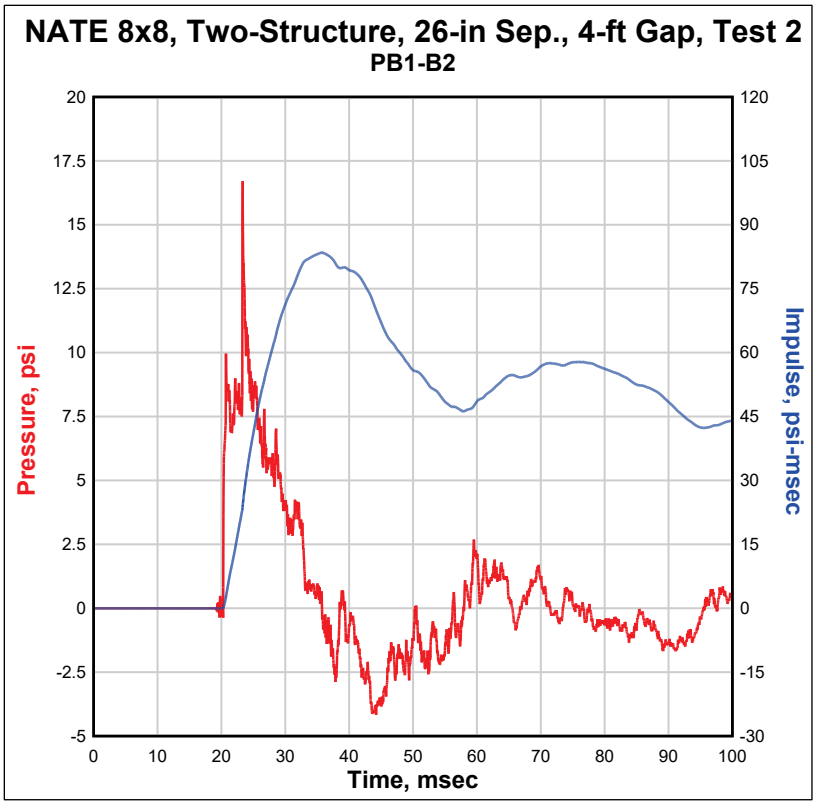

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

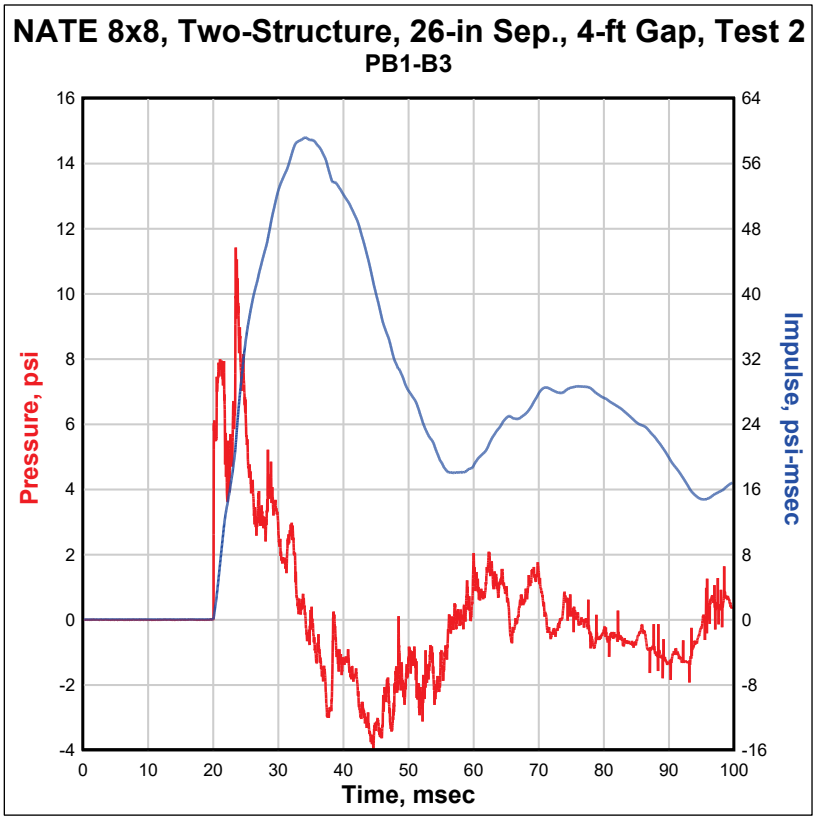

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

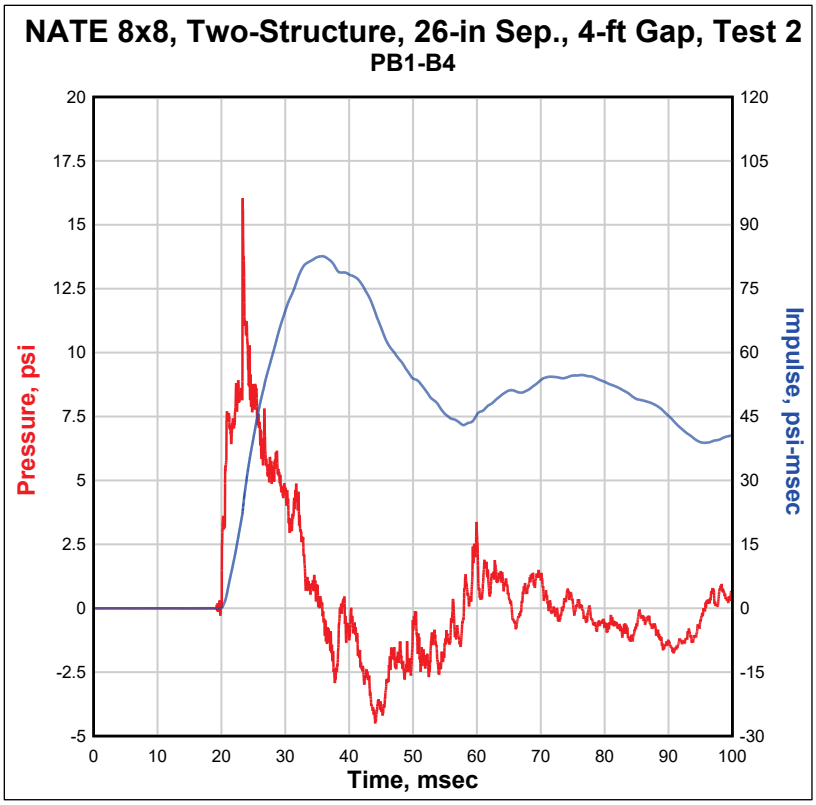

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

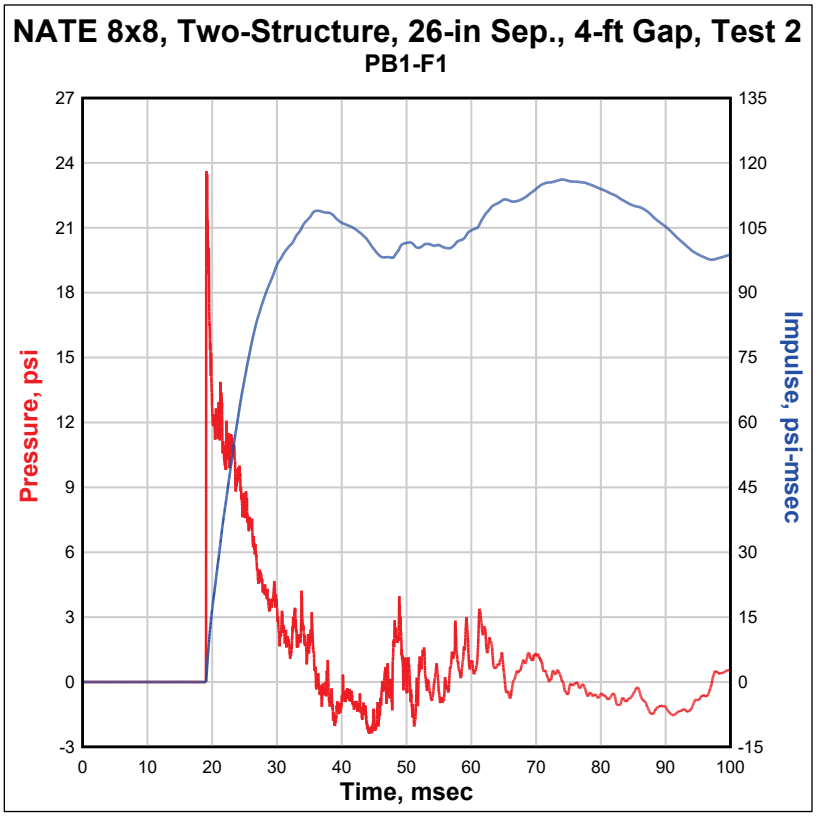

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

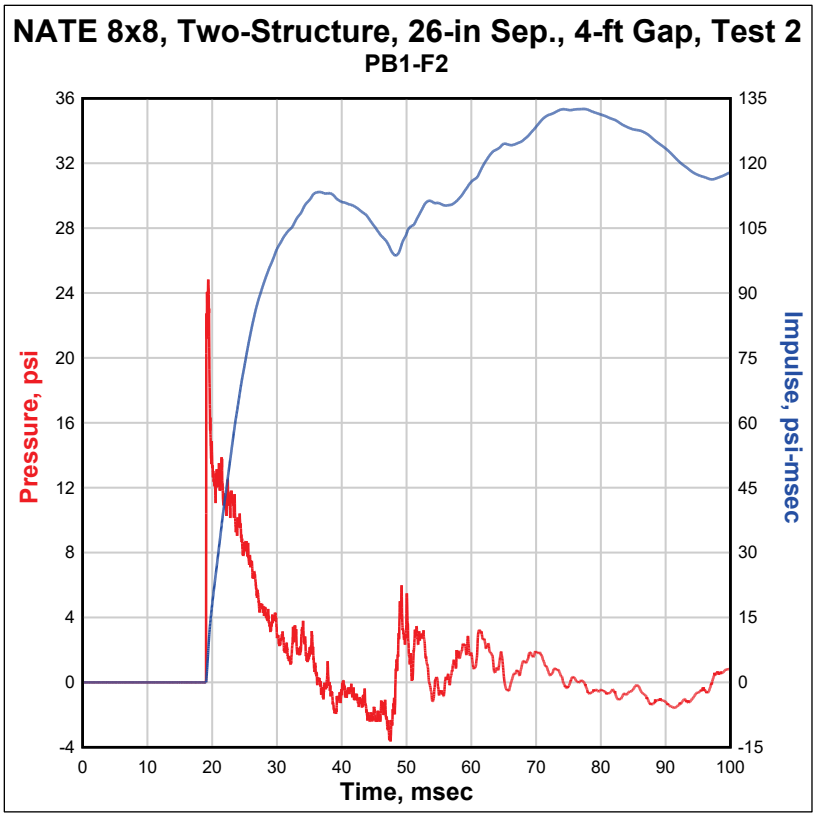

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

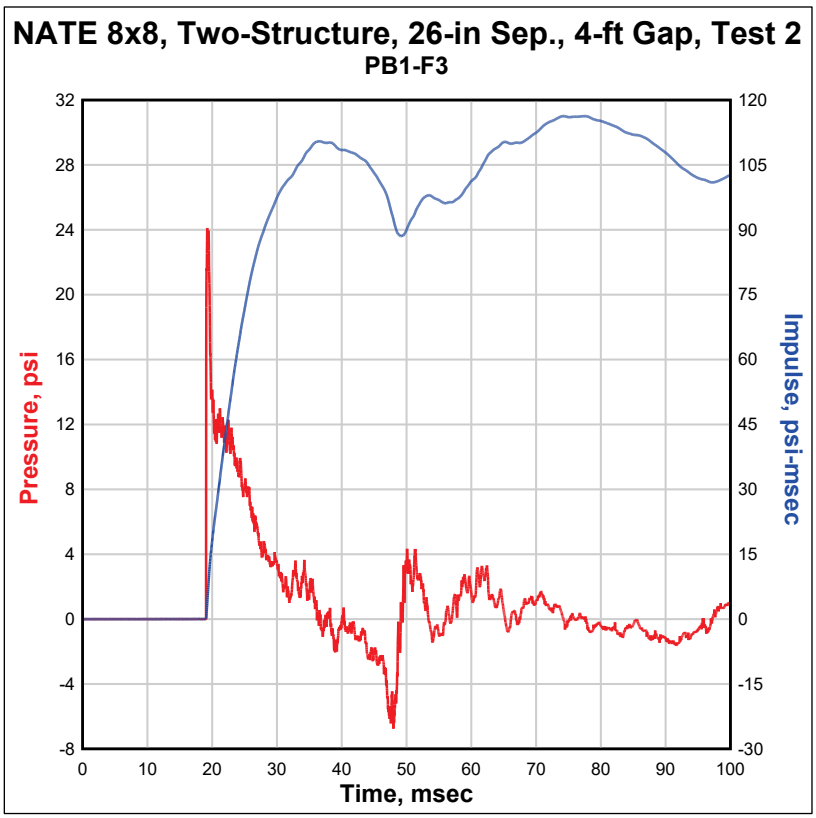

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

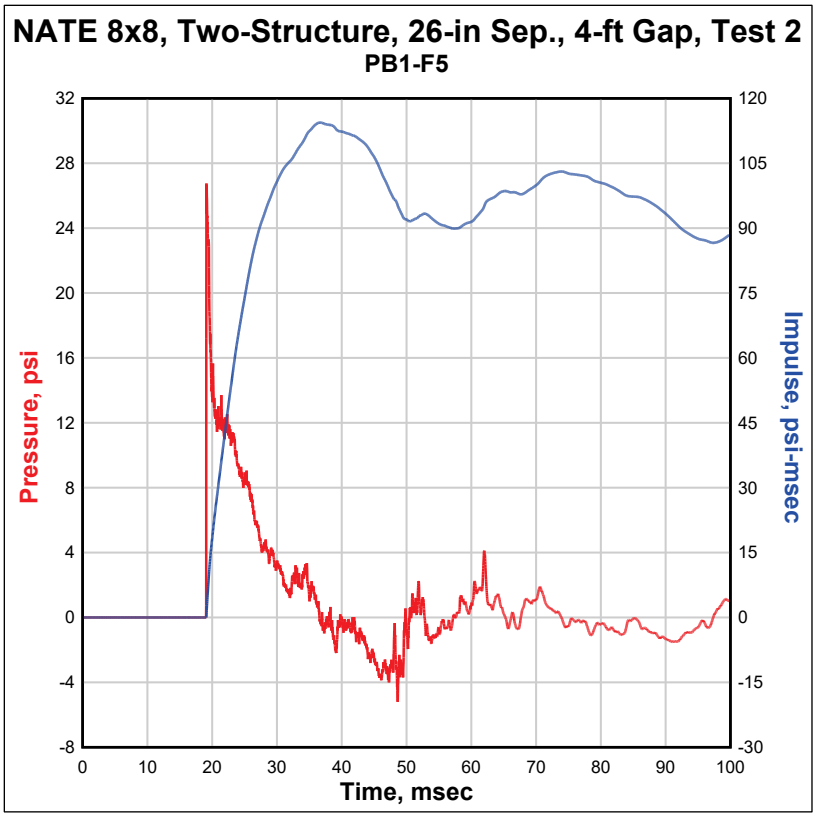

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

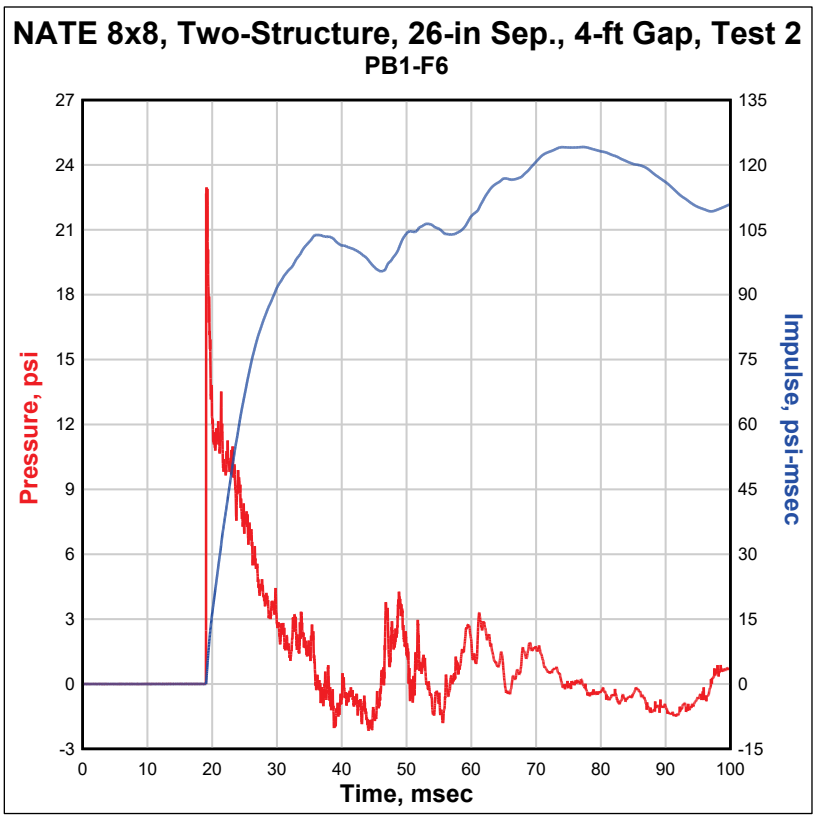

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

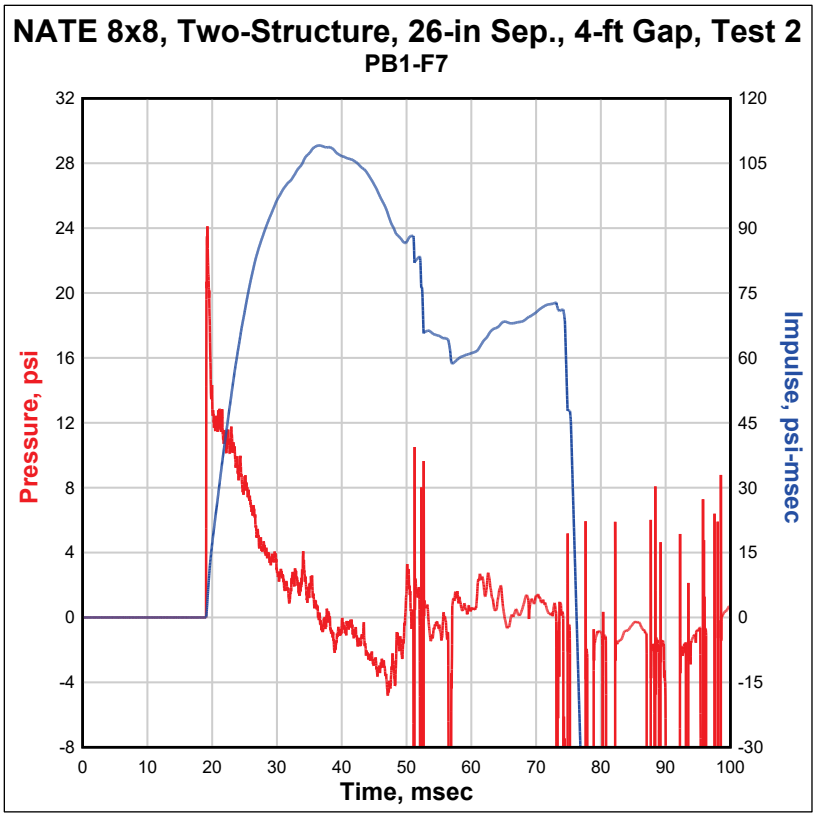

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
27
24
21
18
15
12
9
6
3
0
-3
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100

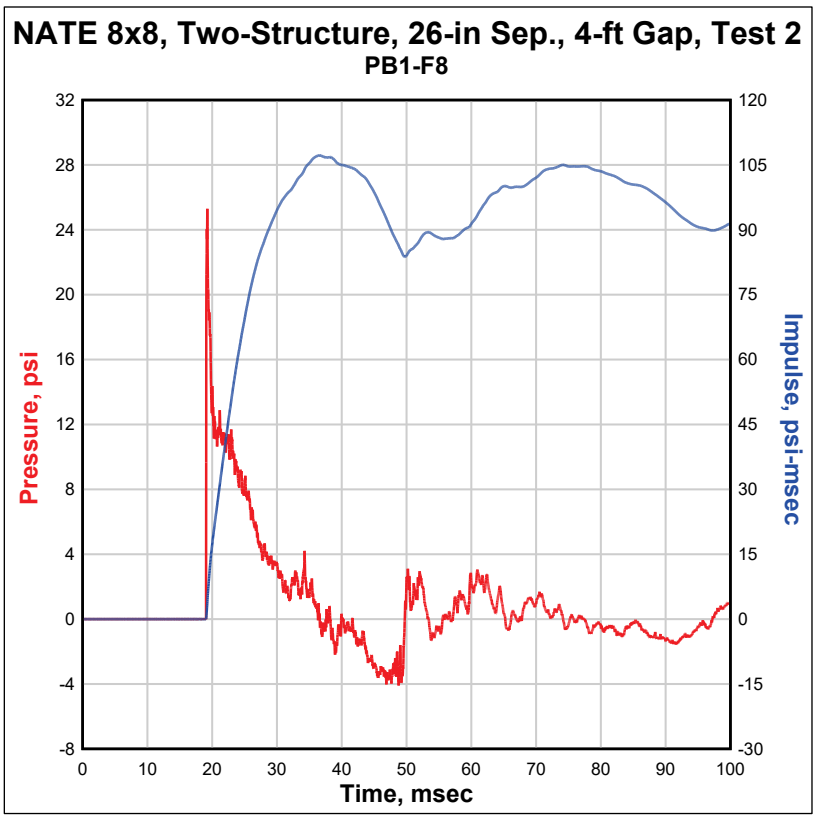

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100

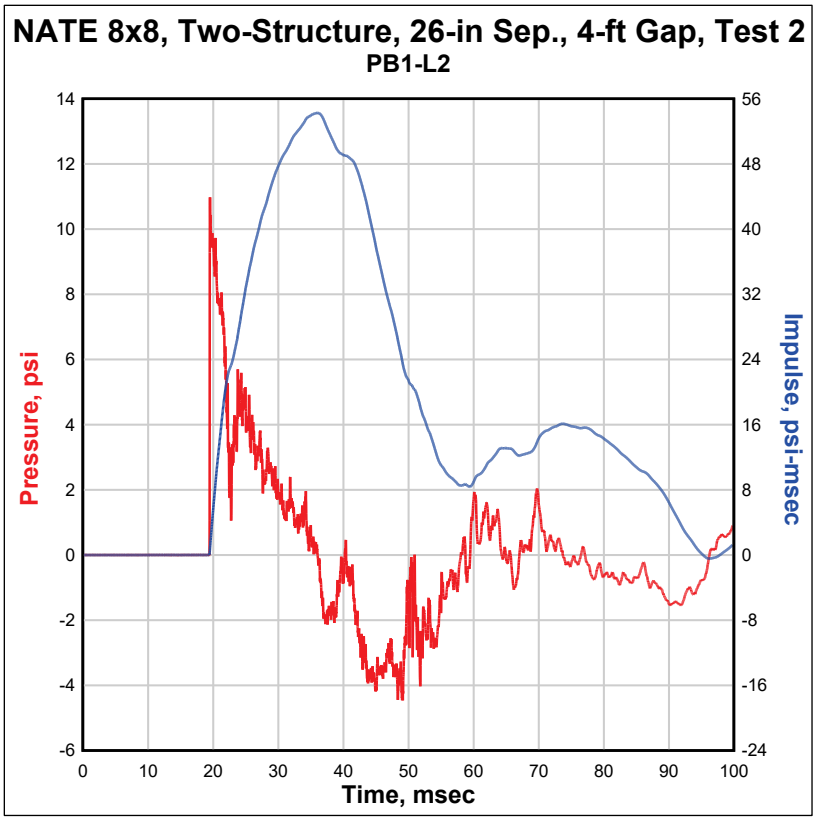

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

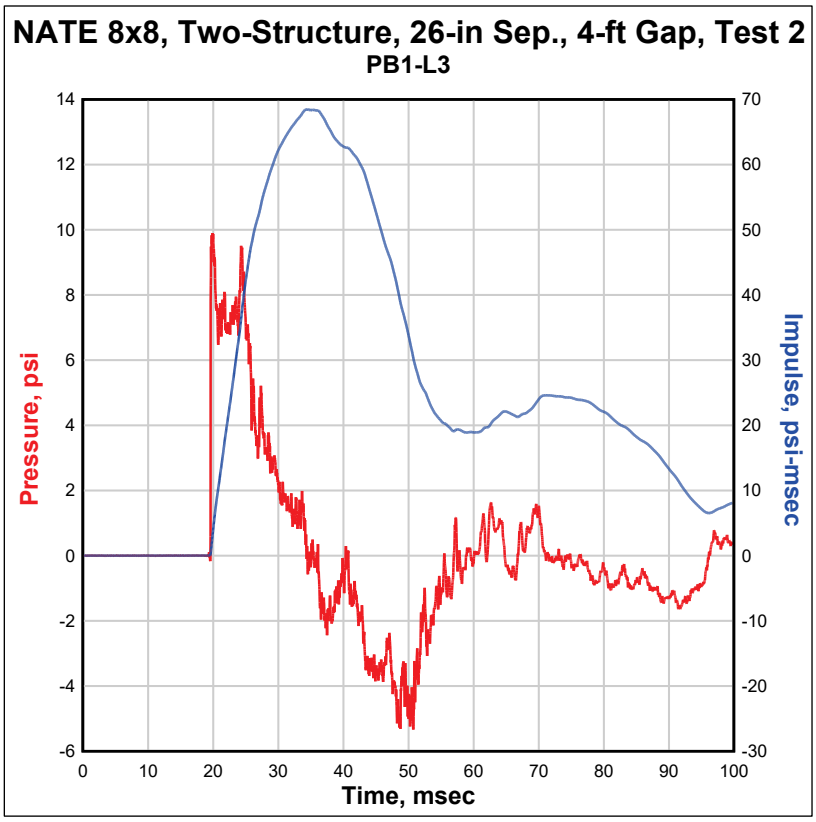

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

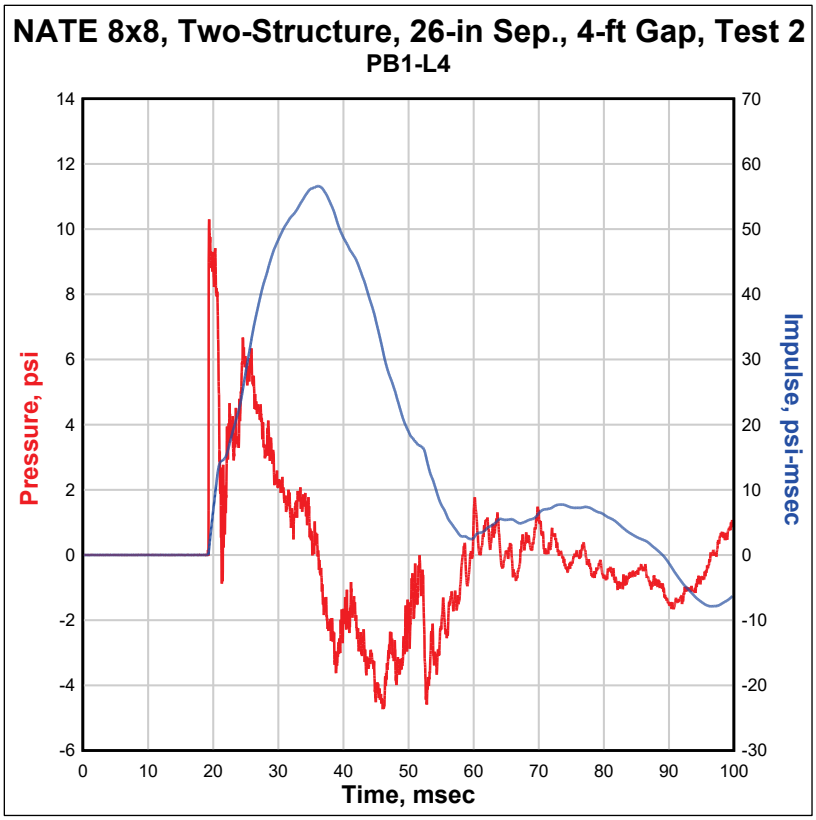

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
27
24
21
18
15
12
9
6
3
0
-3
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100

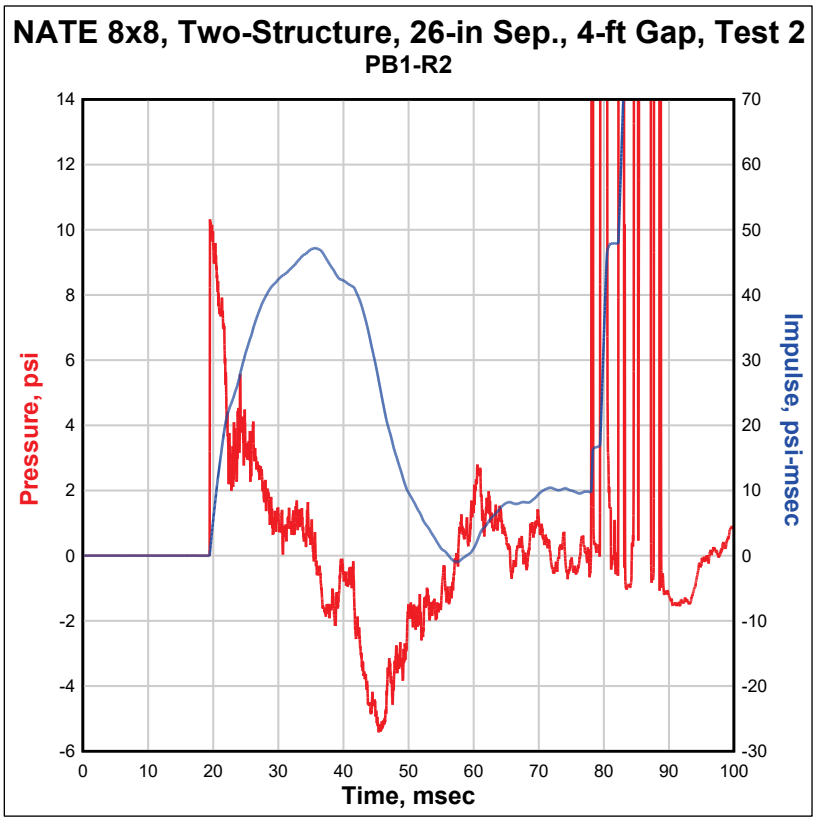

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

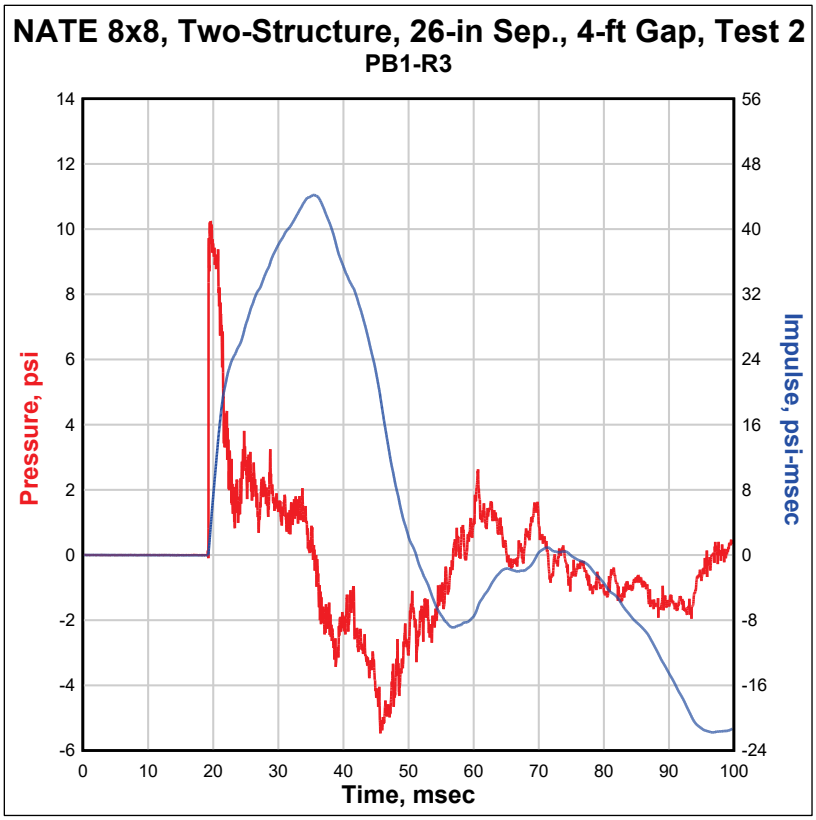

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
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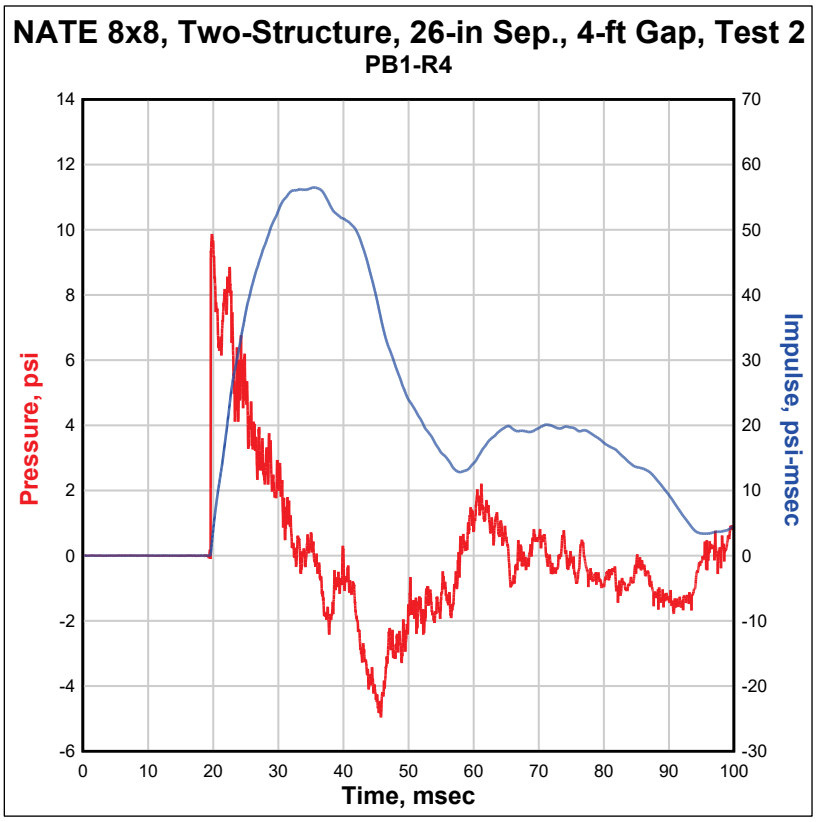
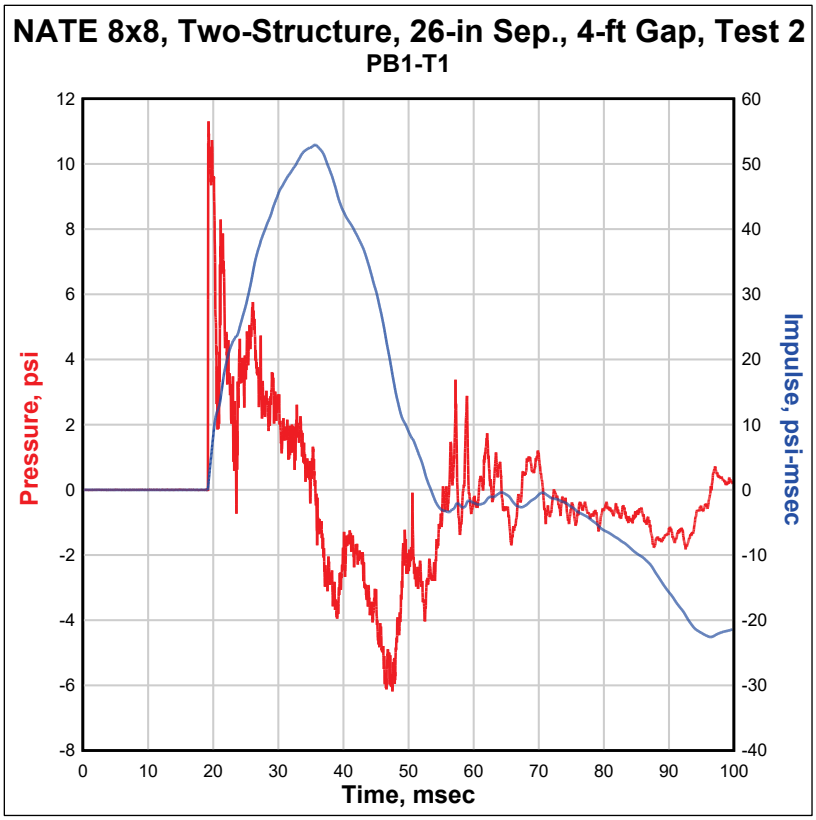
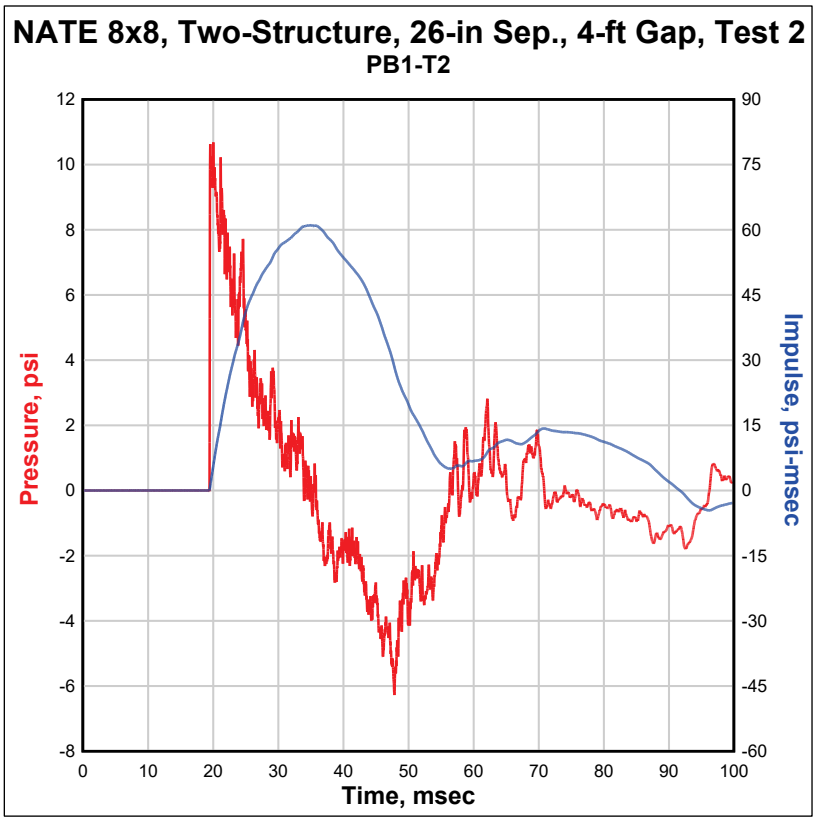
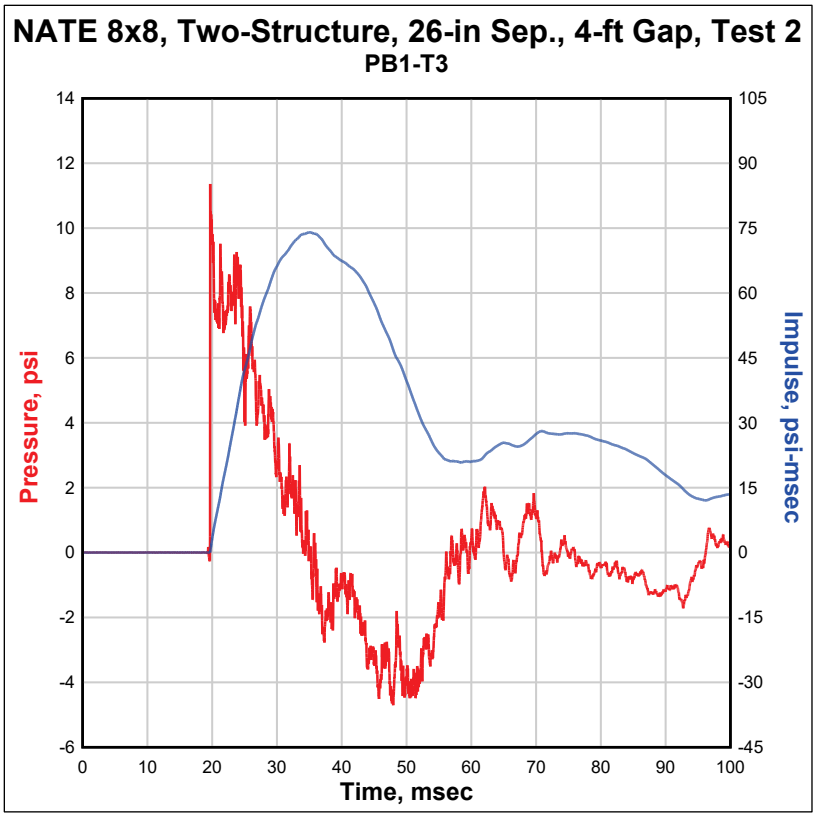
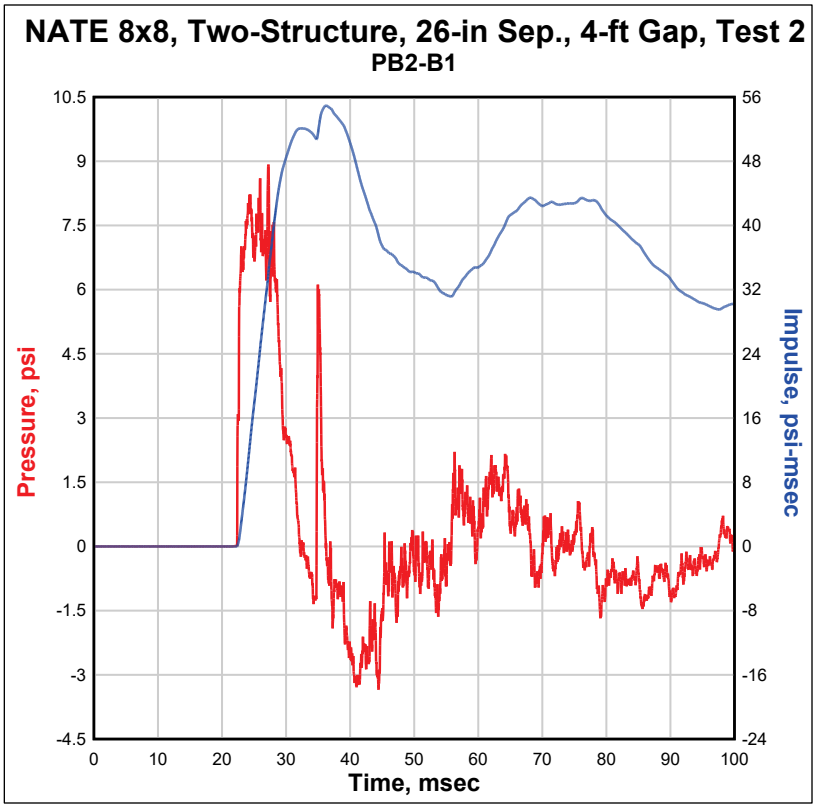
90
100

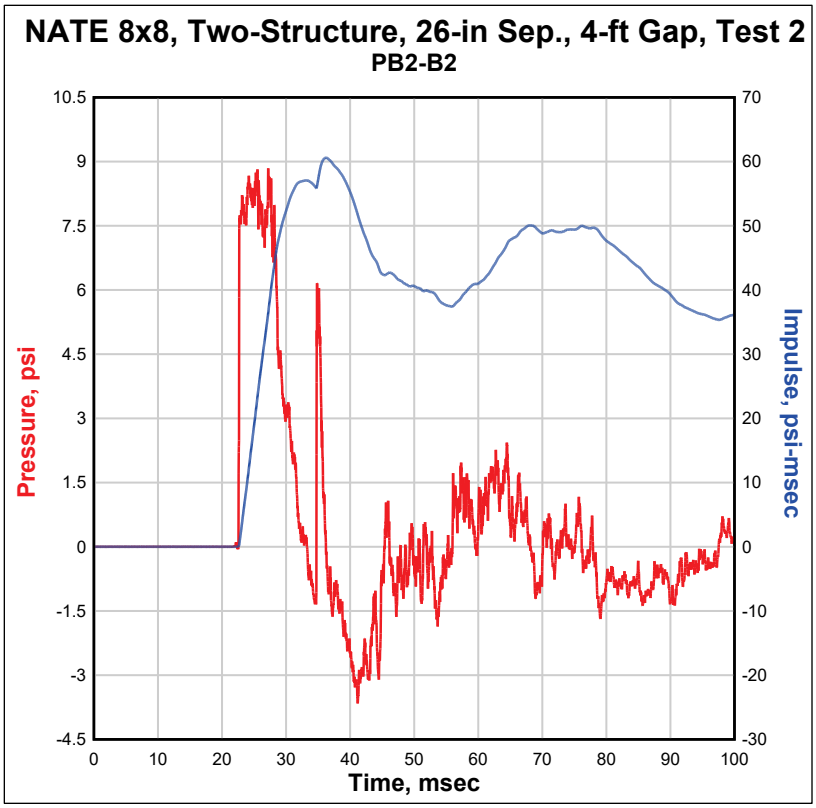

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

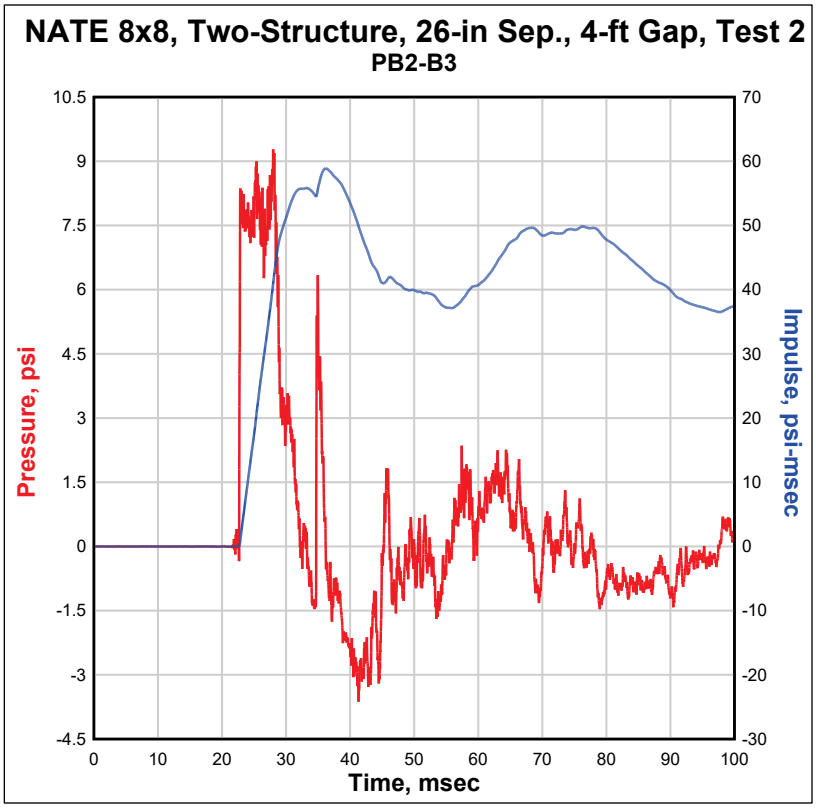

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
60
50
40
30
20
10
0
-10
-20
-30
-40
0
10
20
30
40
50
60
70
80
90
100

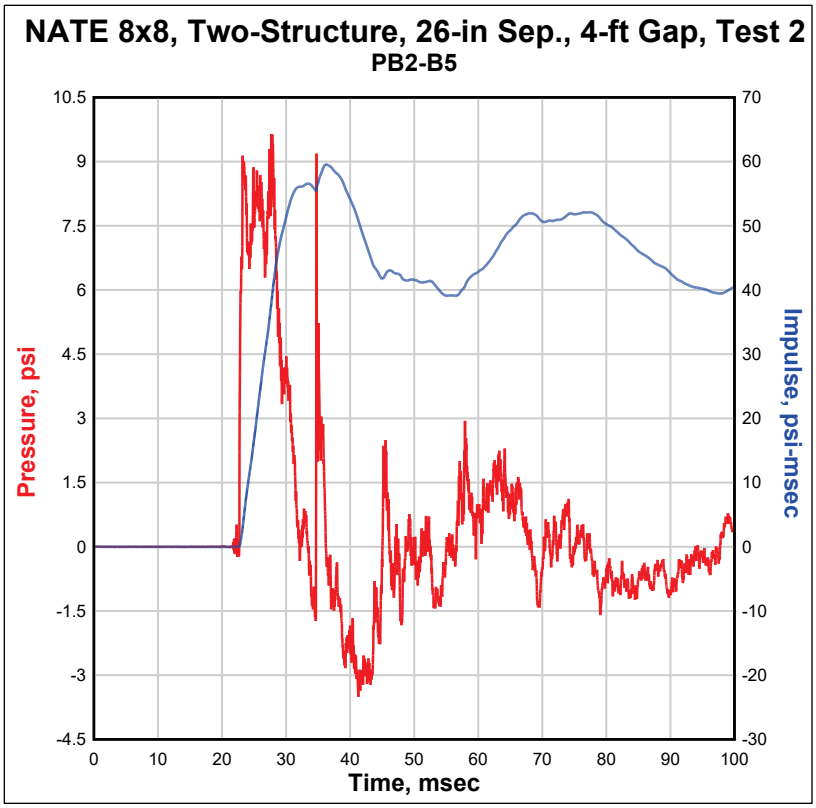

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
90
75
60
45
30
15
0
-15
-30
-45
-60
0
10
20
30
40
50
60
70
80
90
100

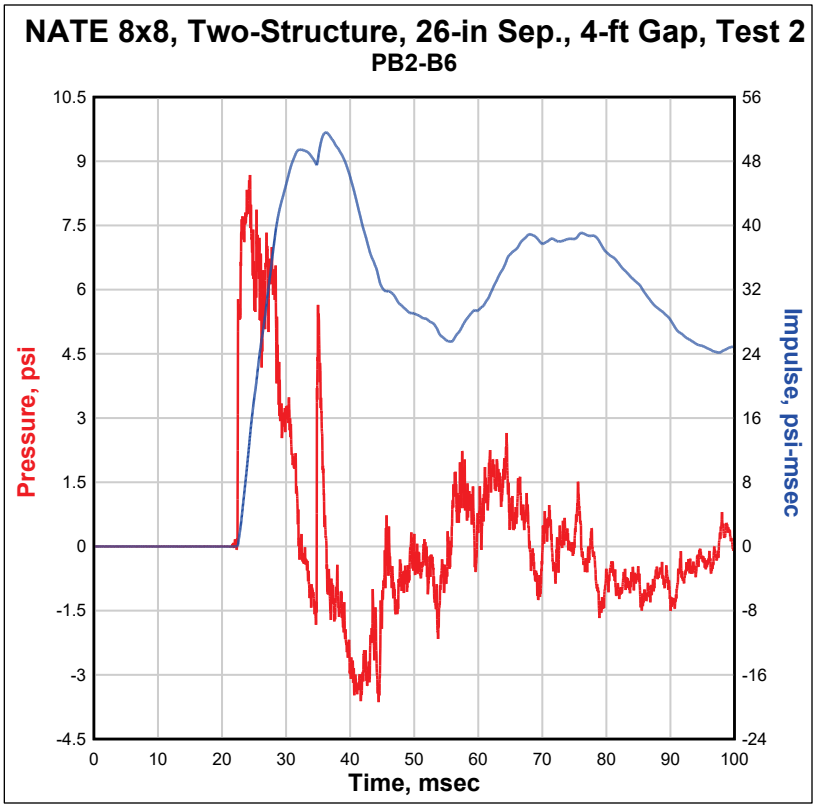

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

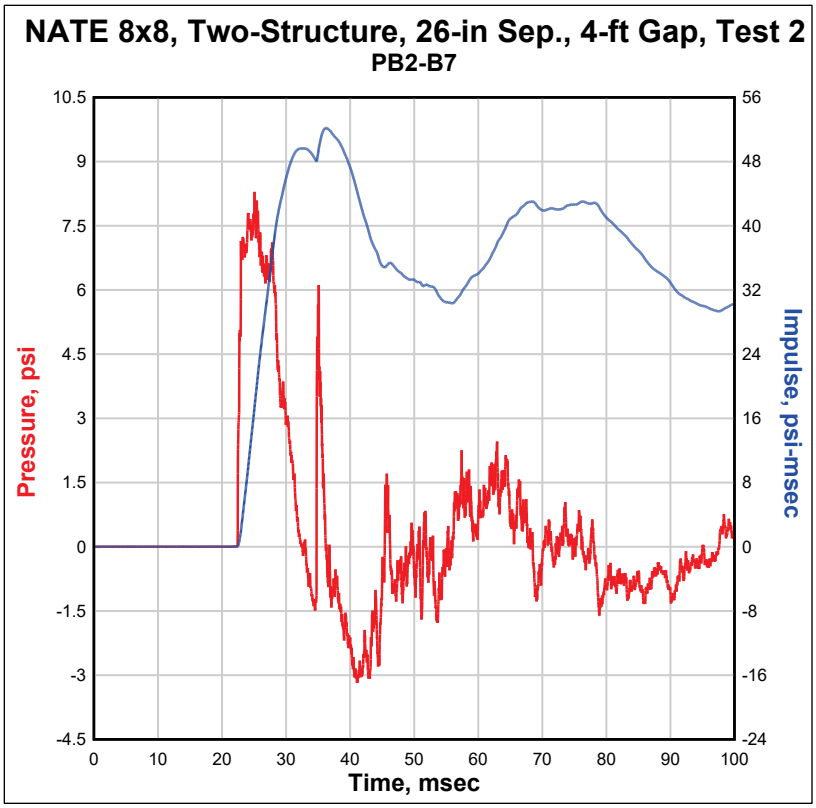

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

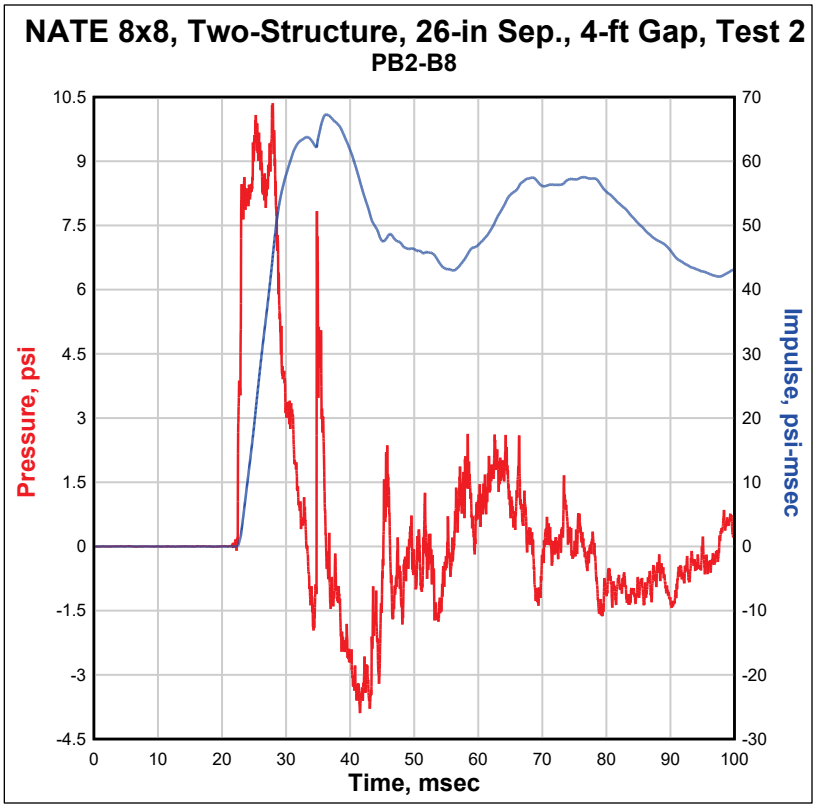

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

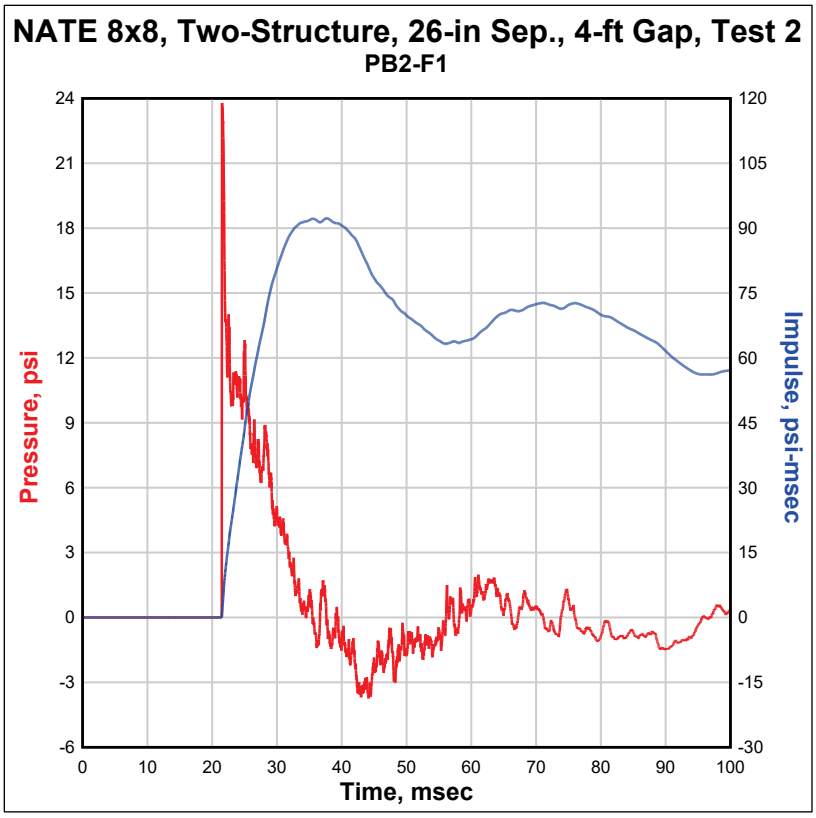

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
40
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60
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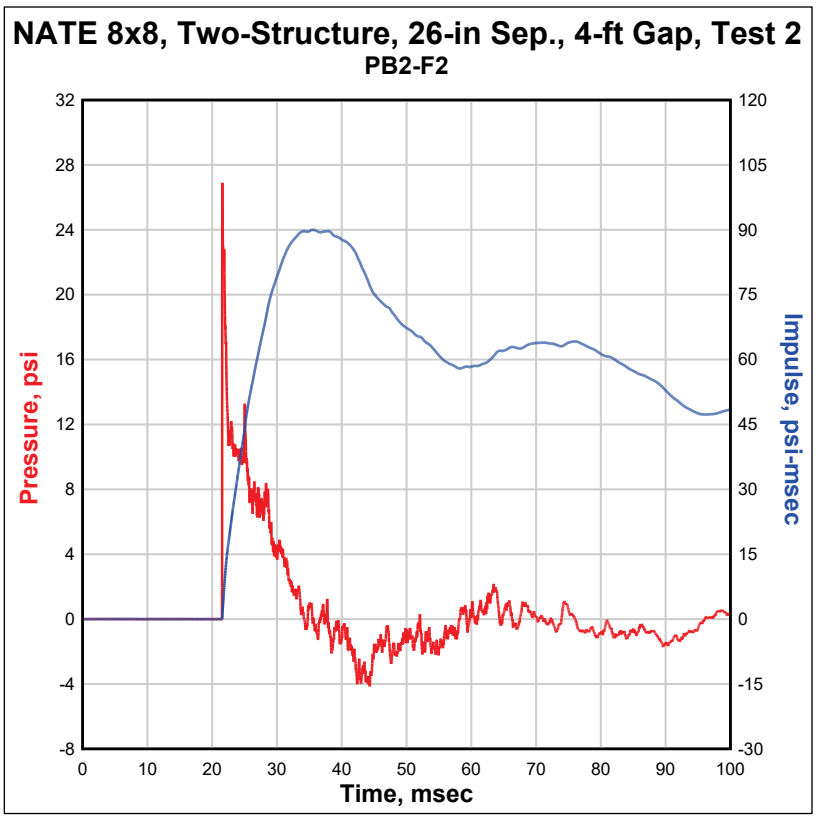
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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20
30
40
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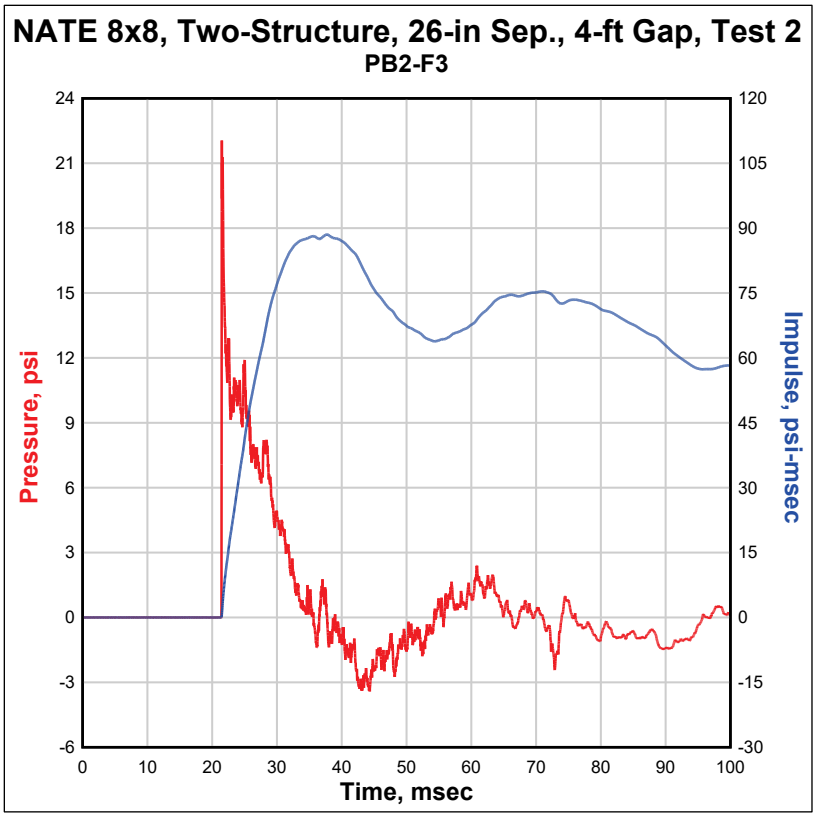
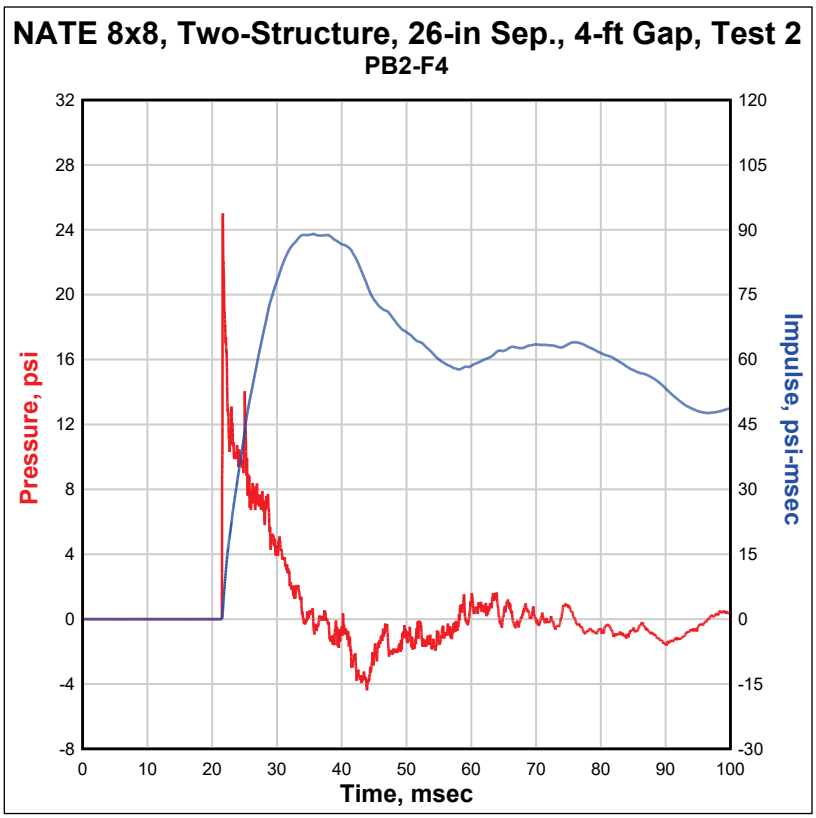
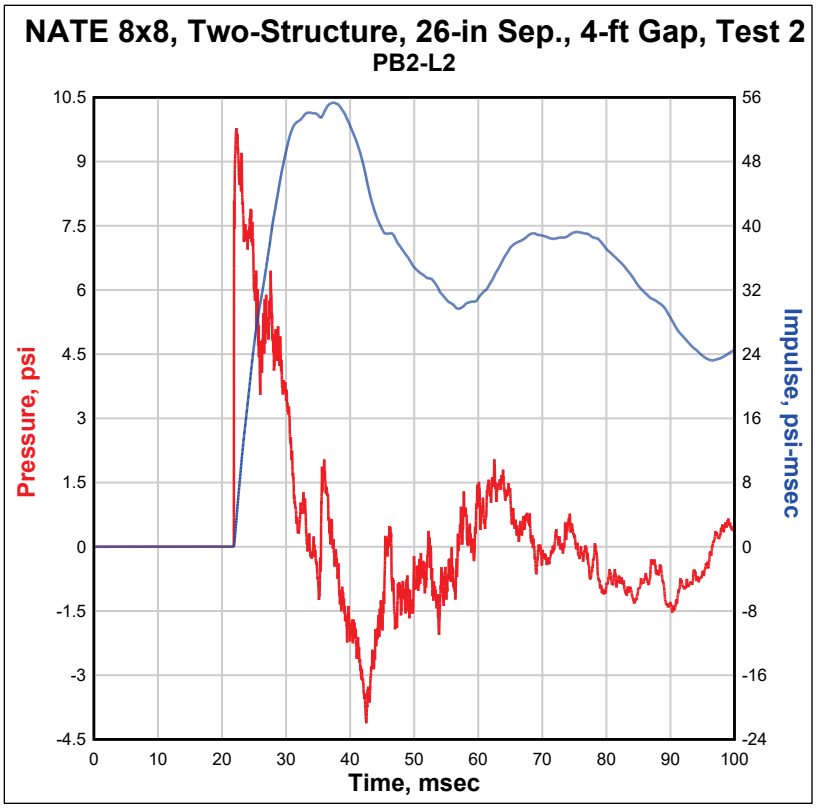
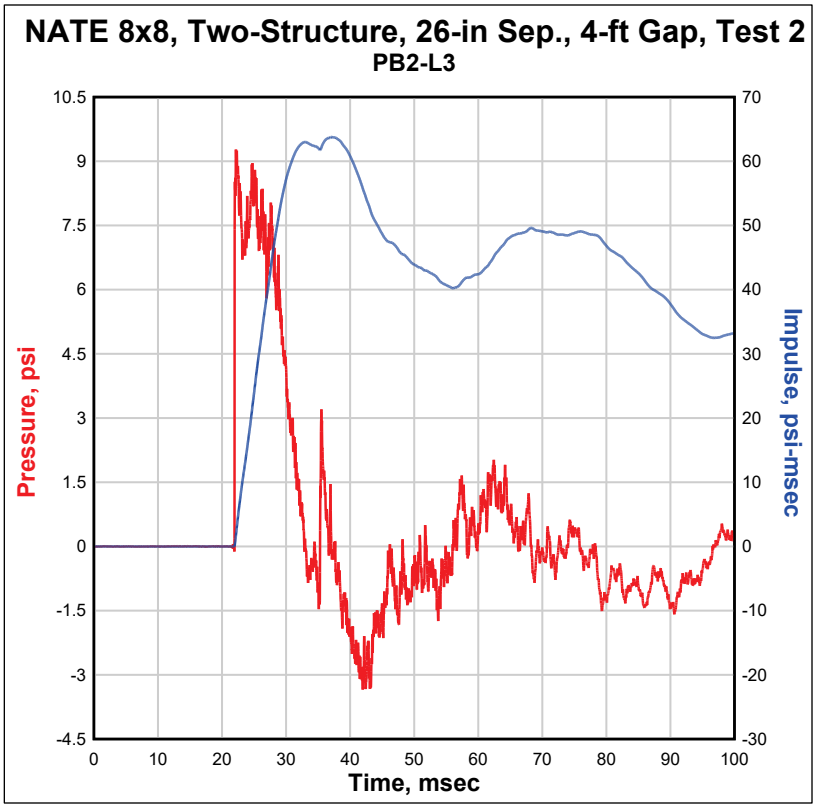
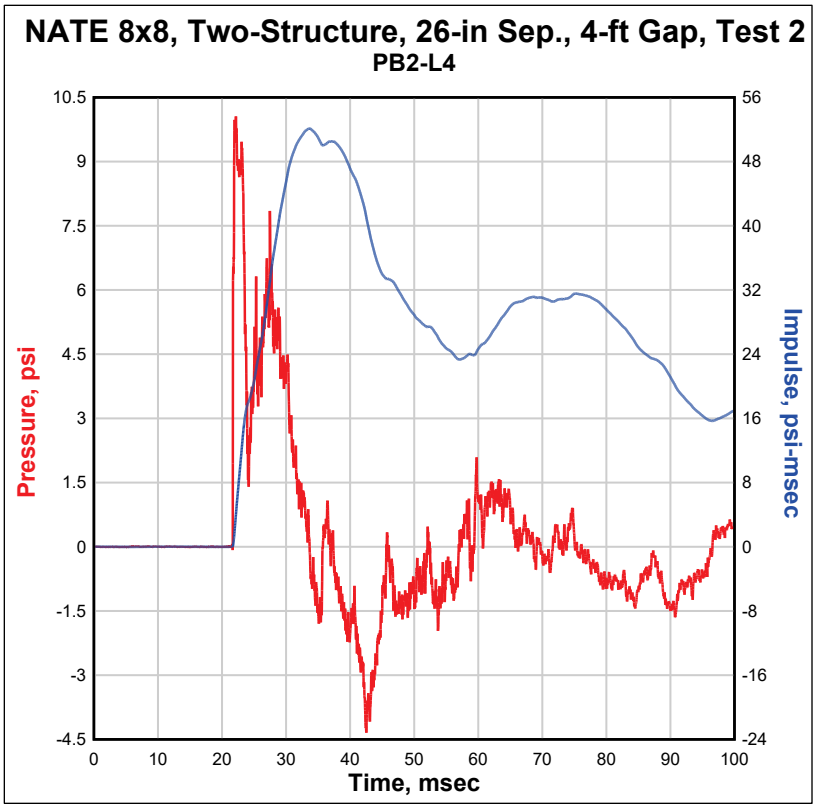
60
70
80
90
100

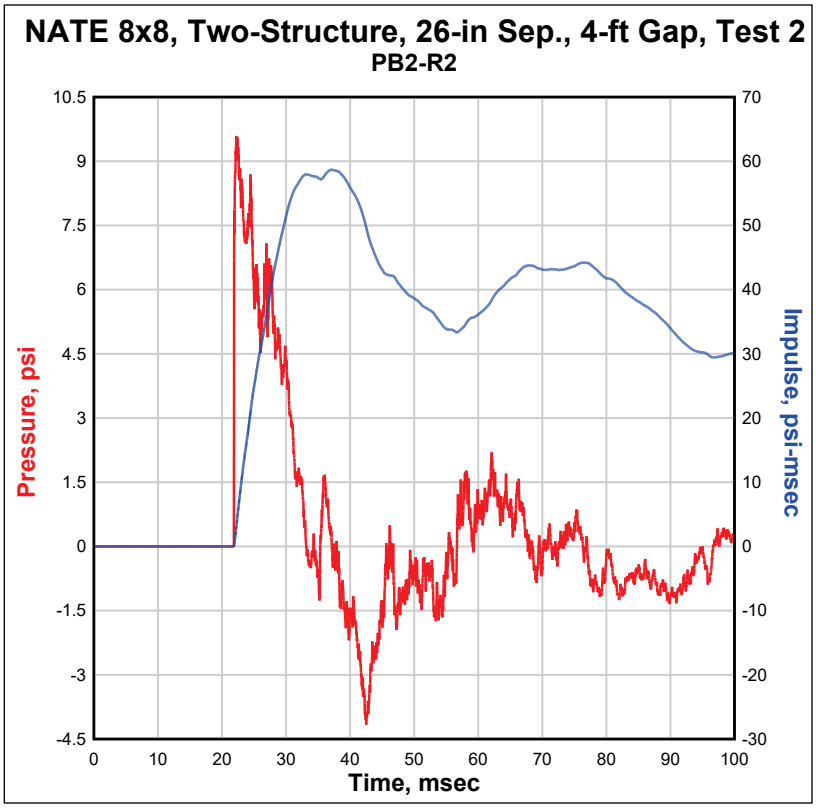

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

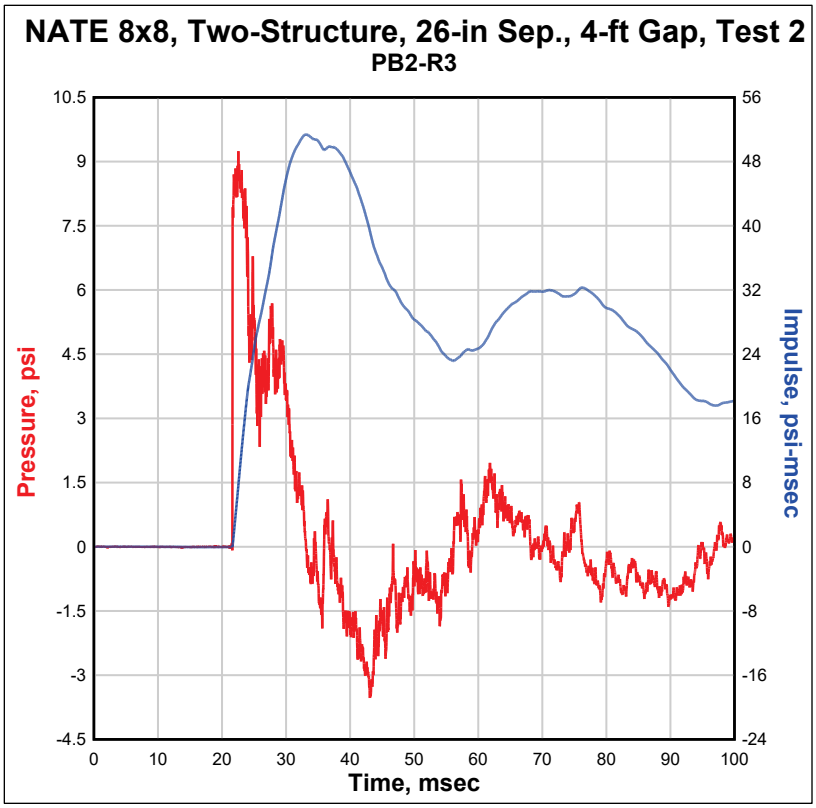

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

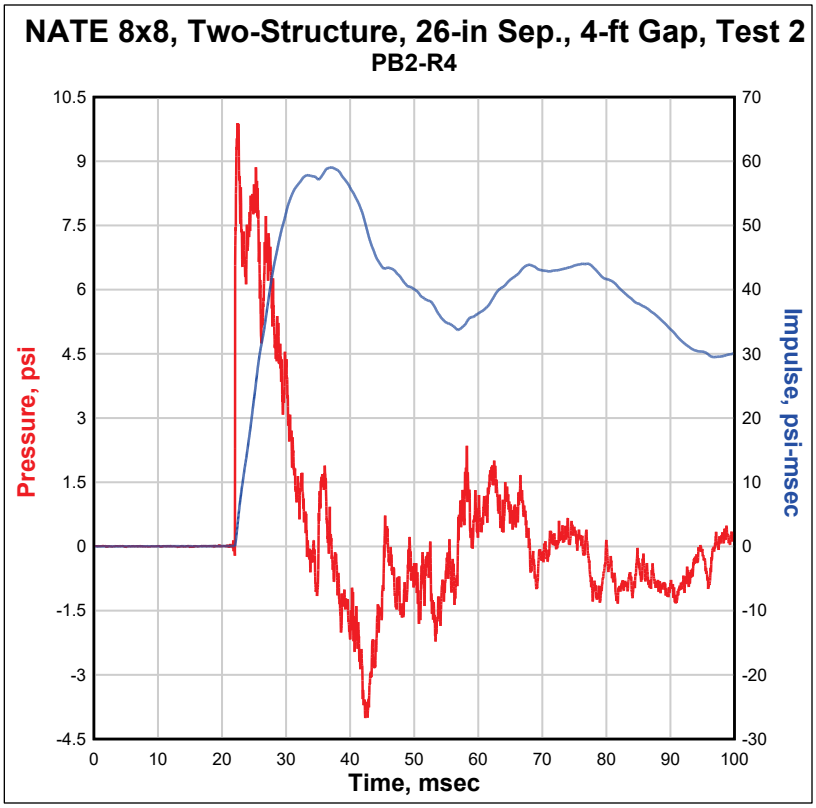

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

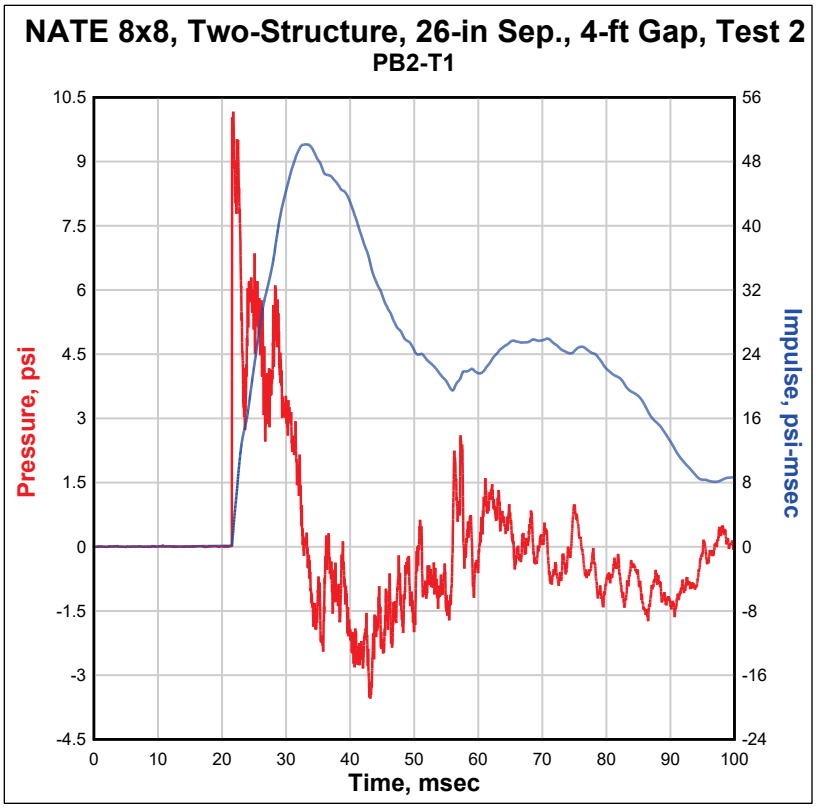

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

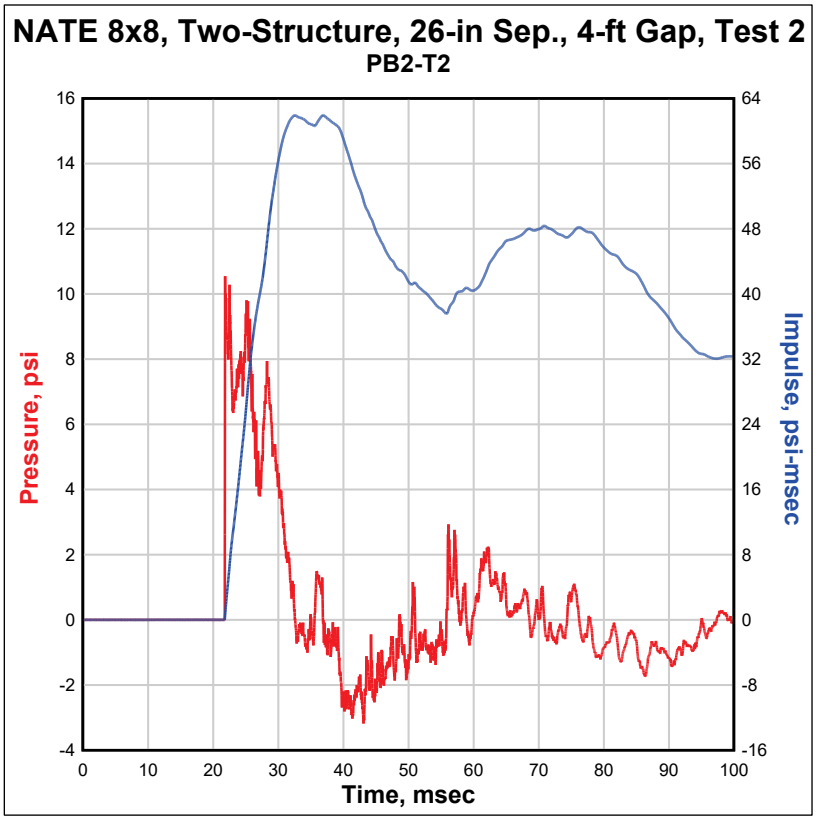

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

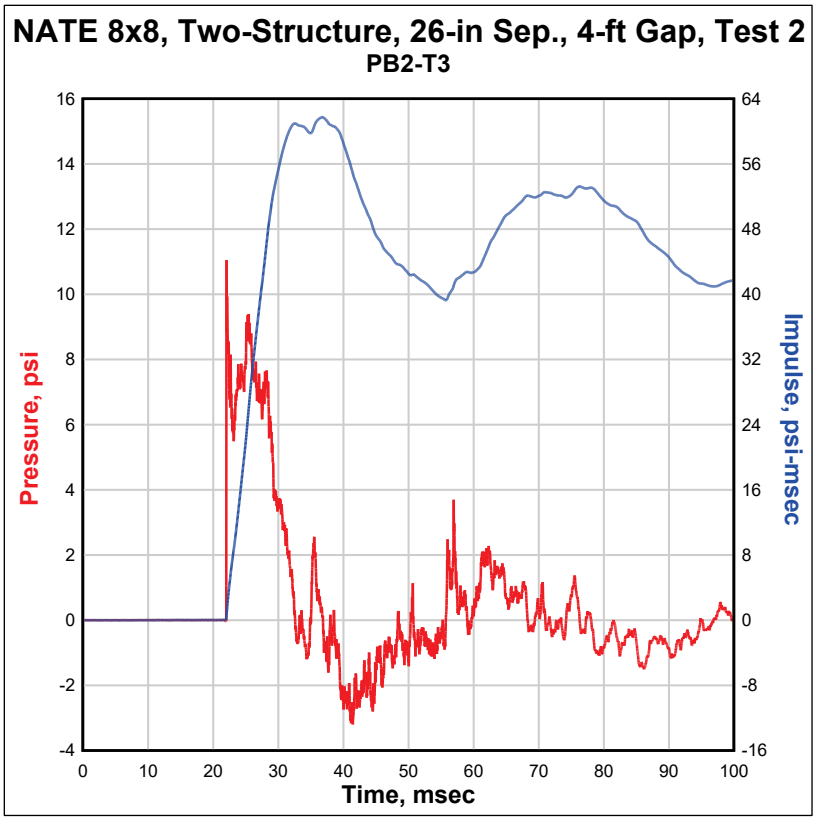

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

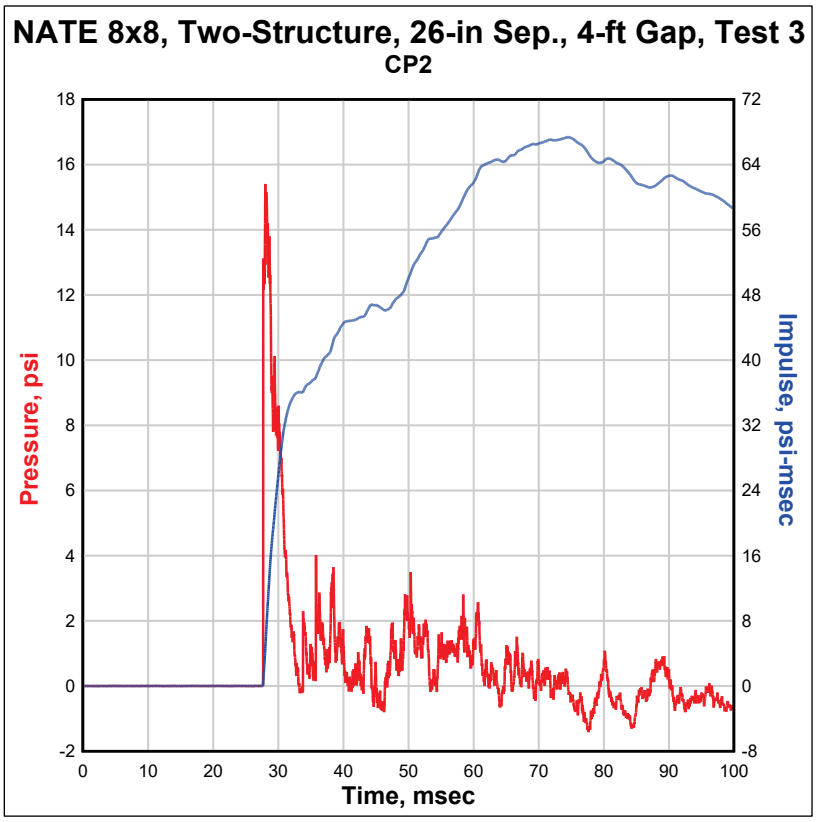

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

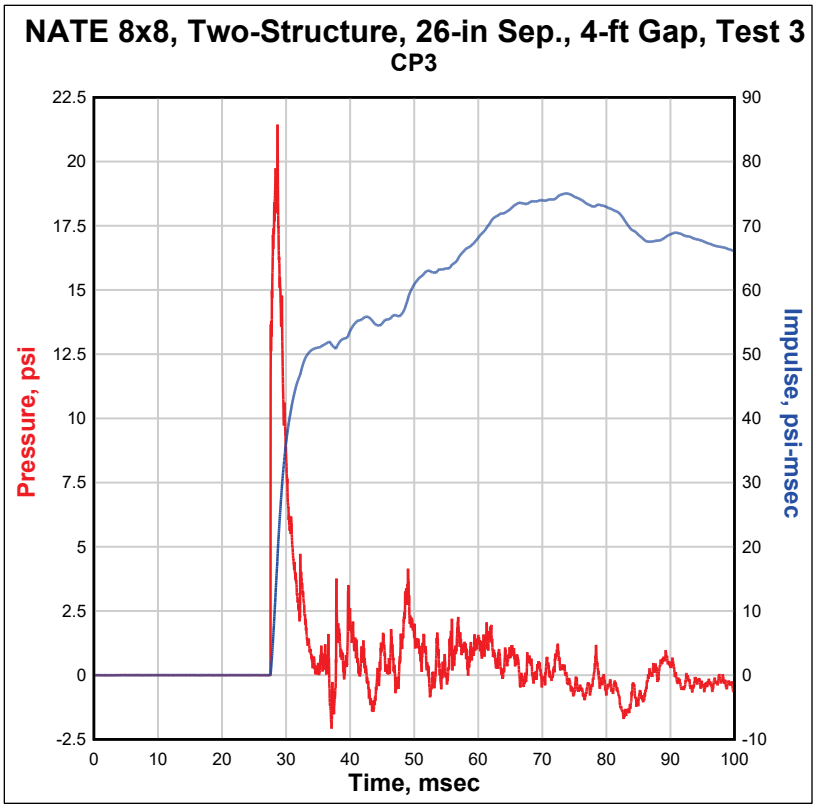

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

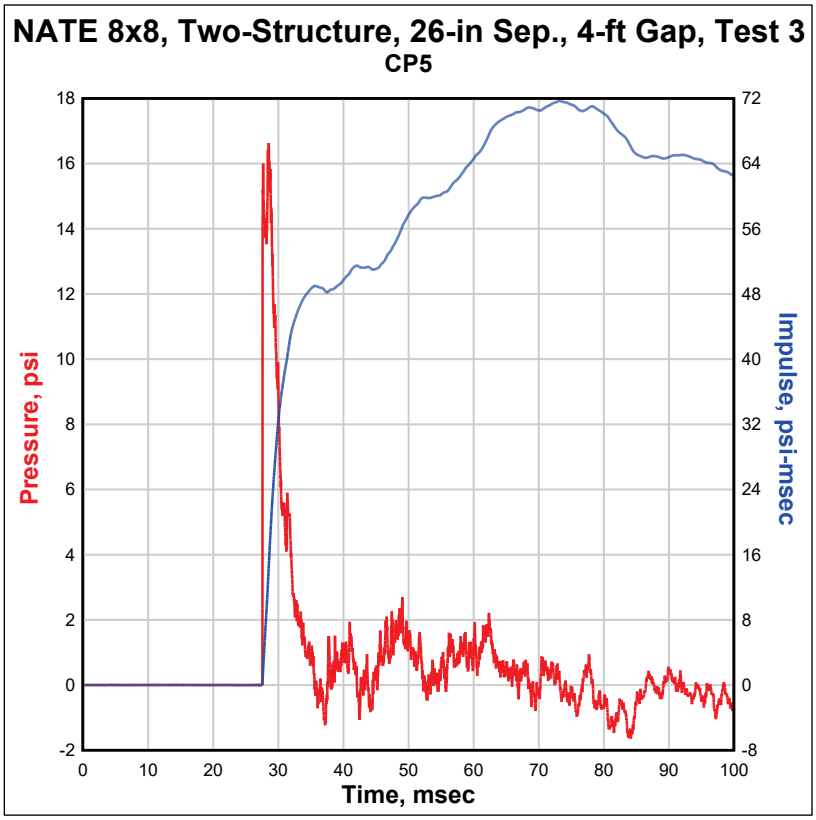

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

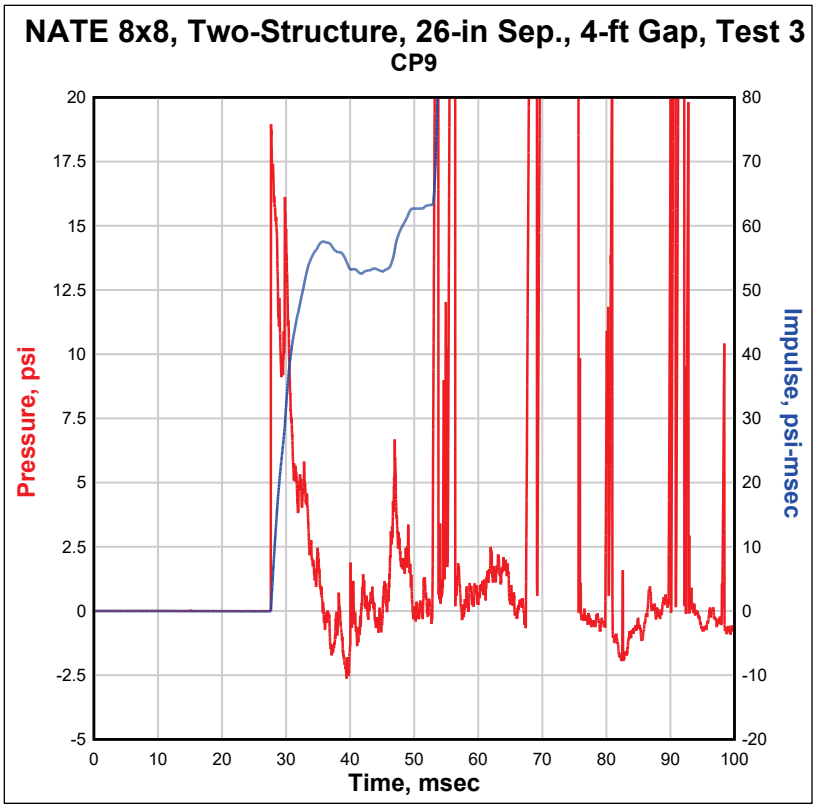

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

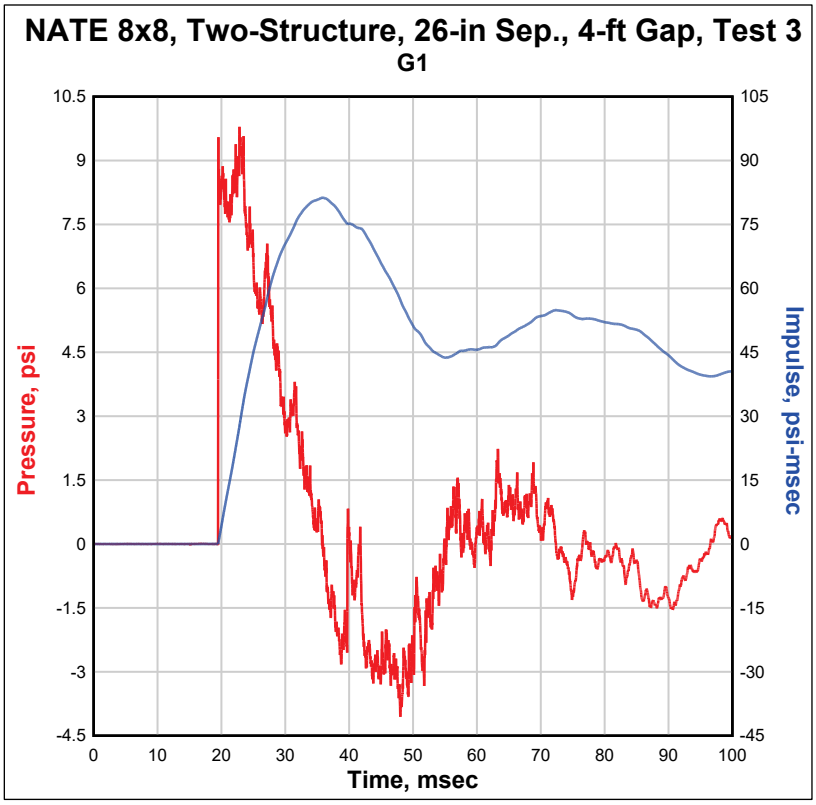

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 2
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

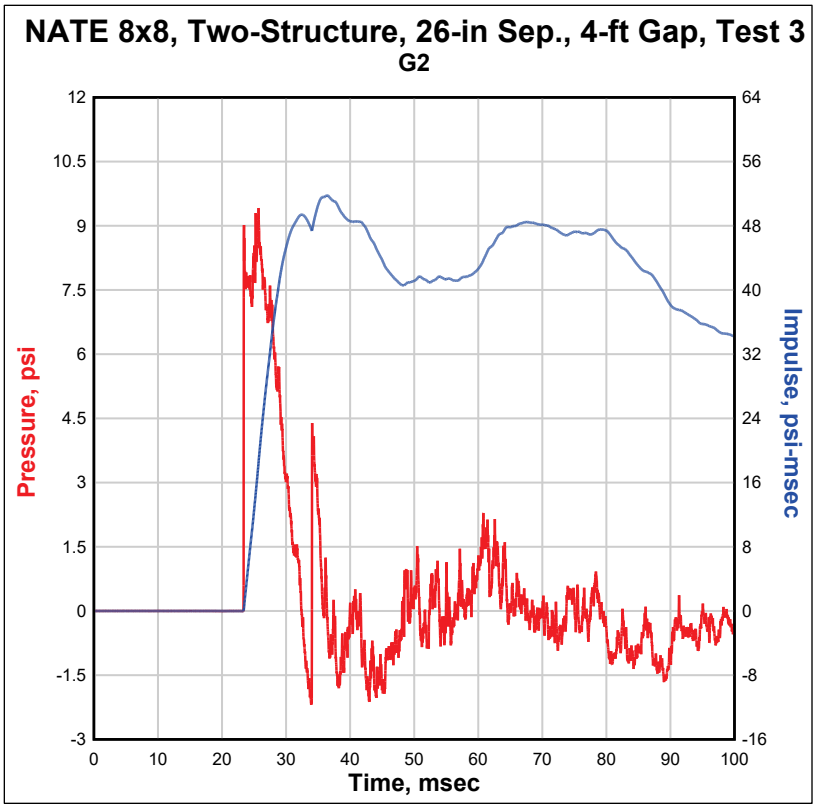

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

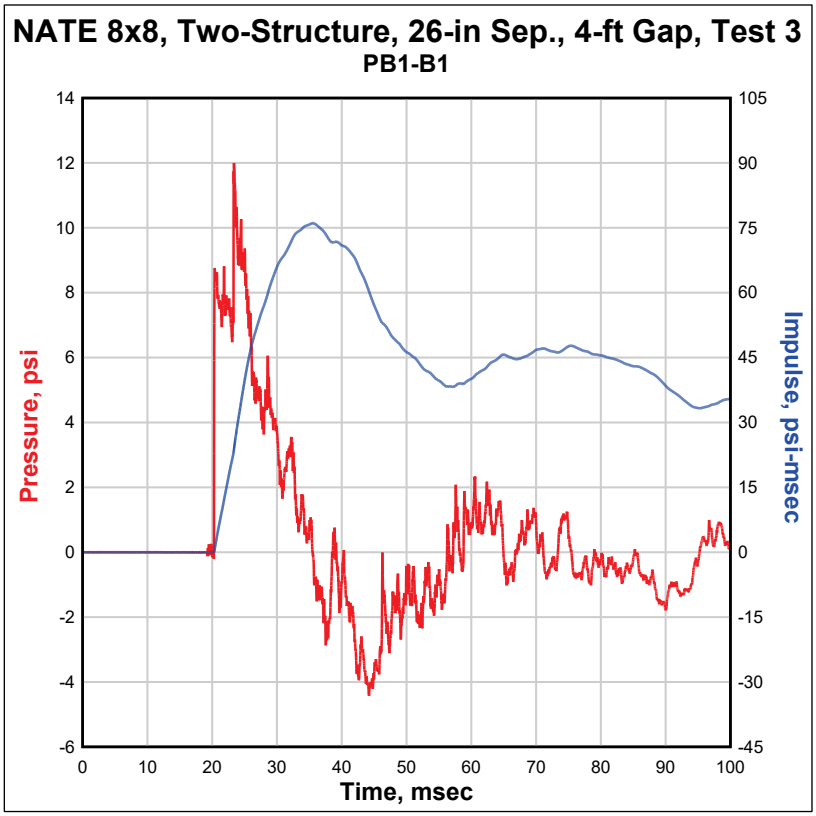

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

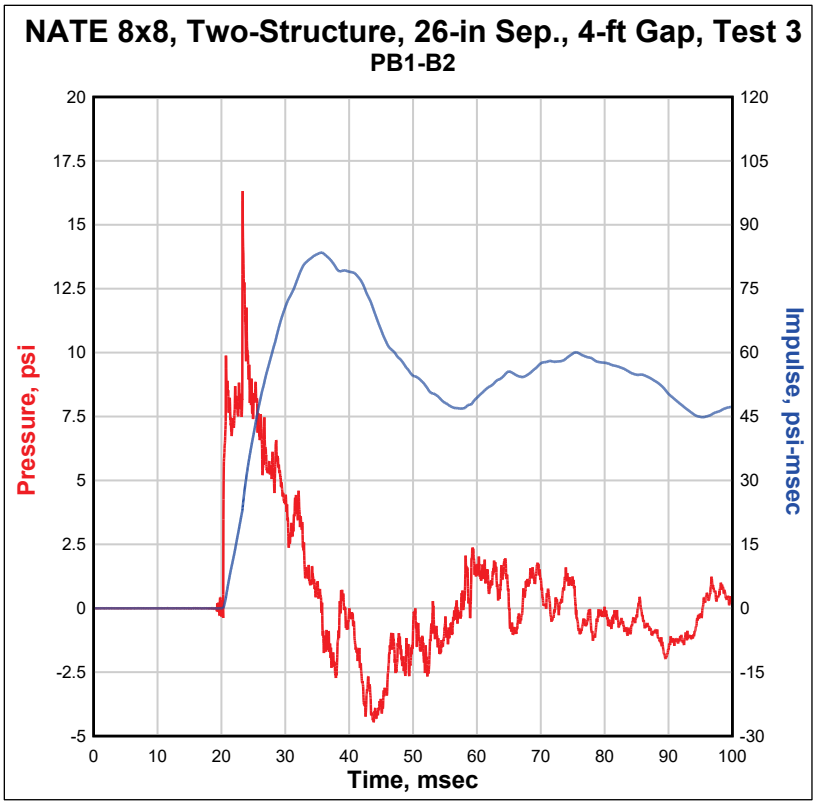

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

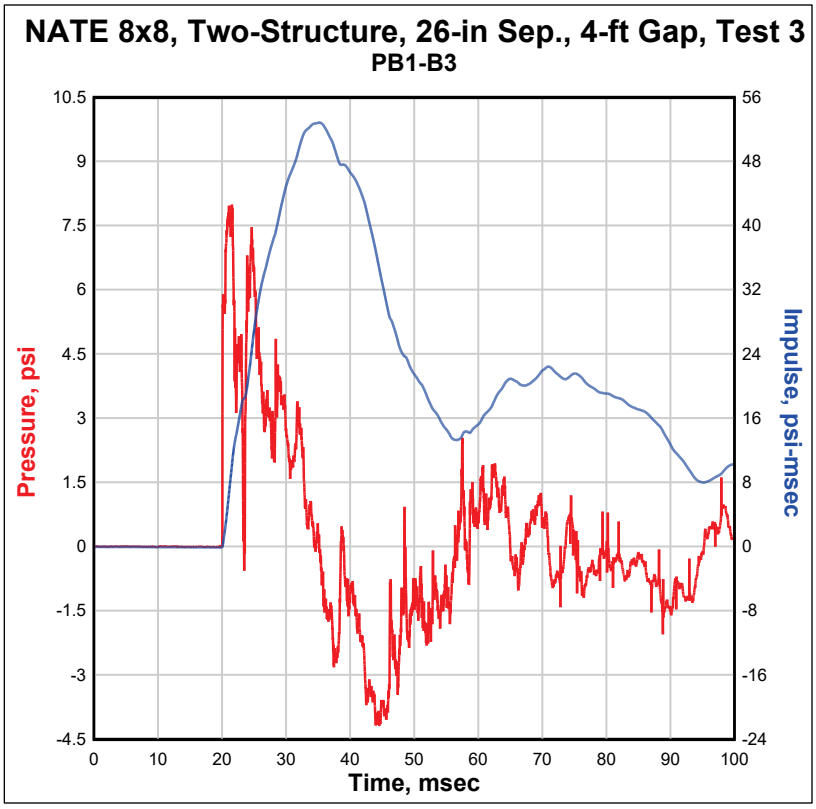

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

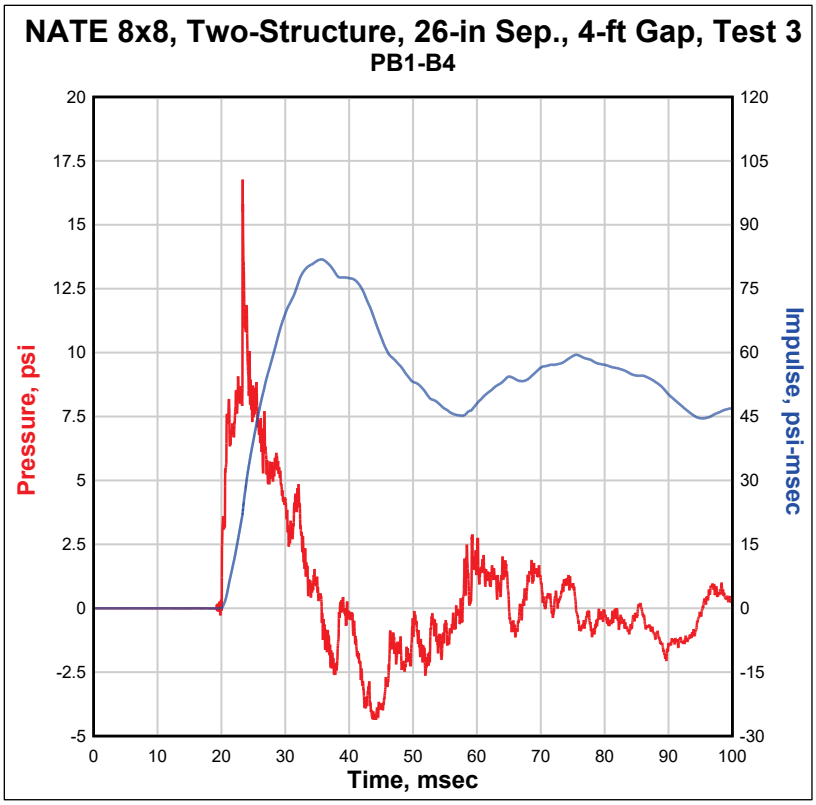

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

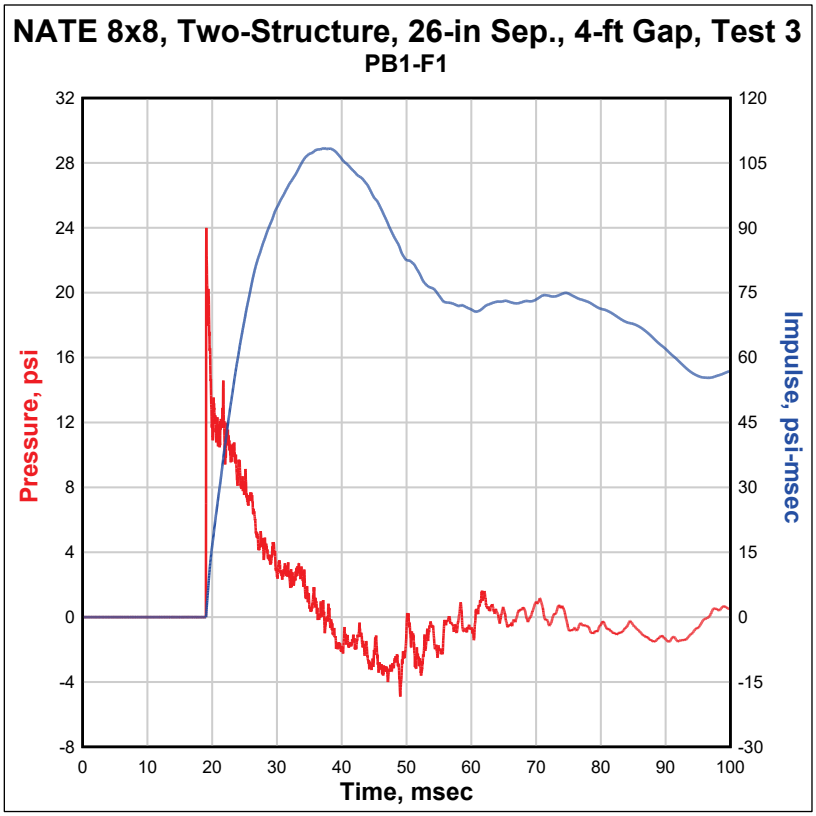

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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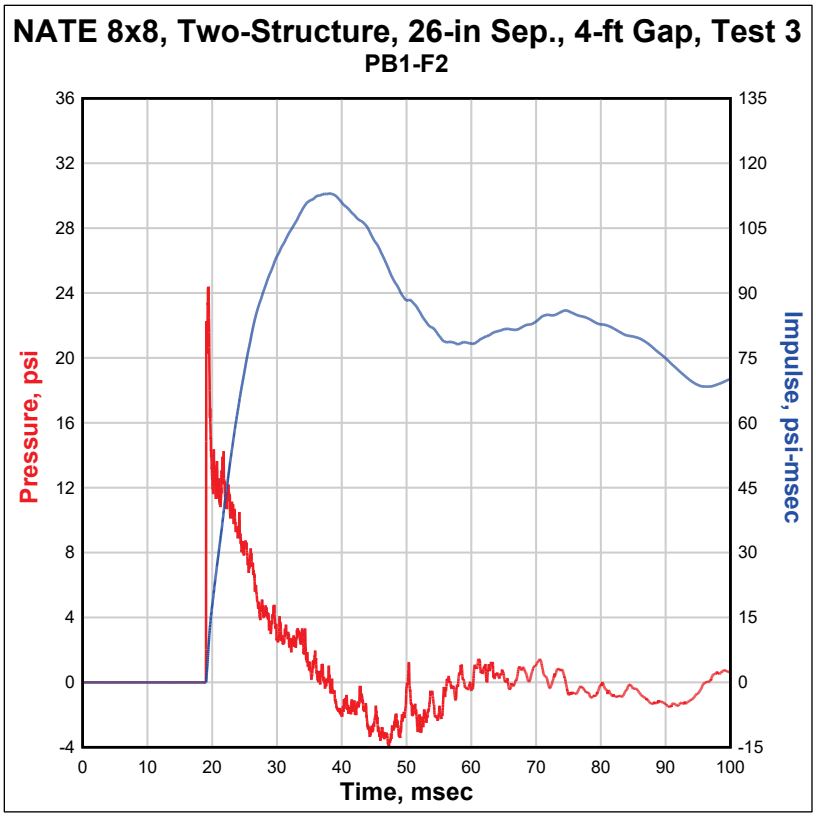
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
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-15
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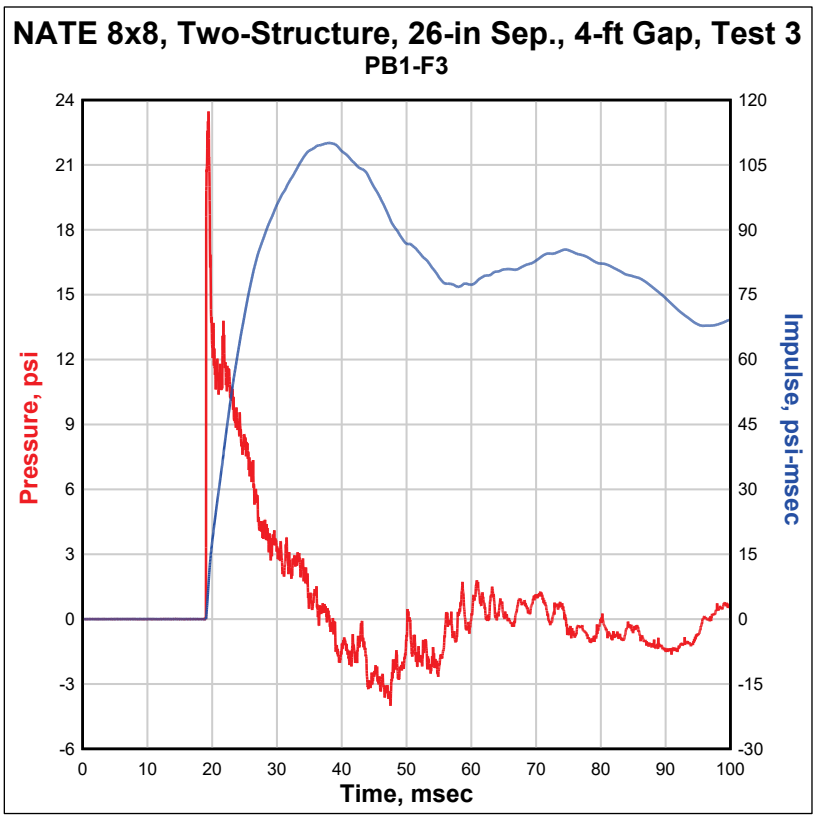
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
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-30
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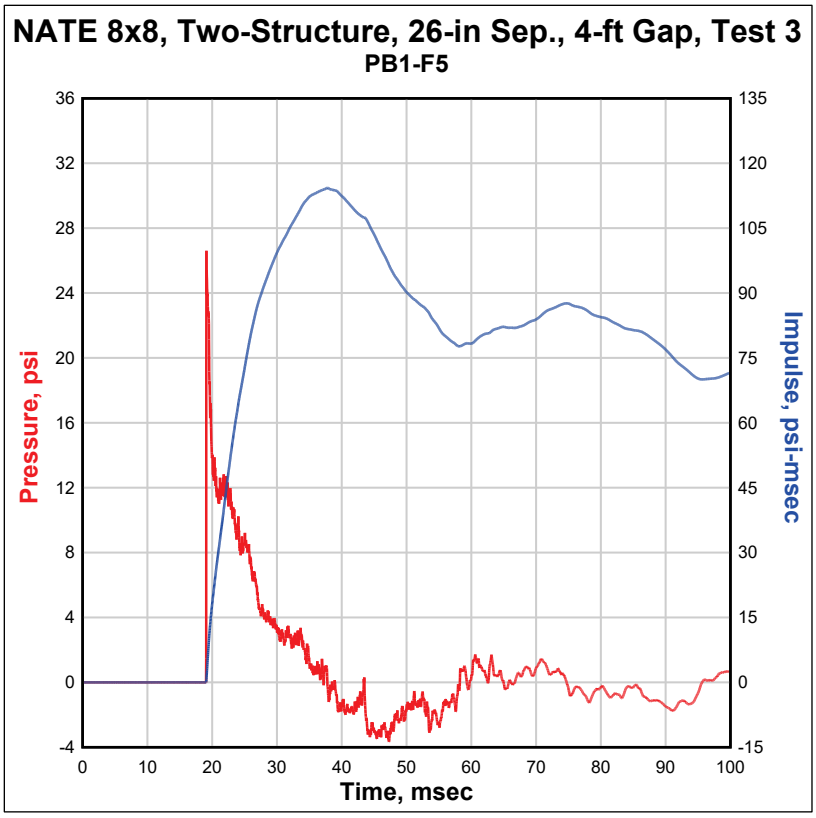
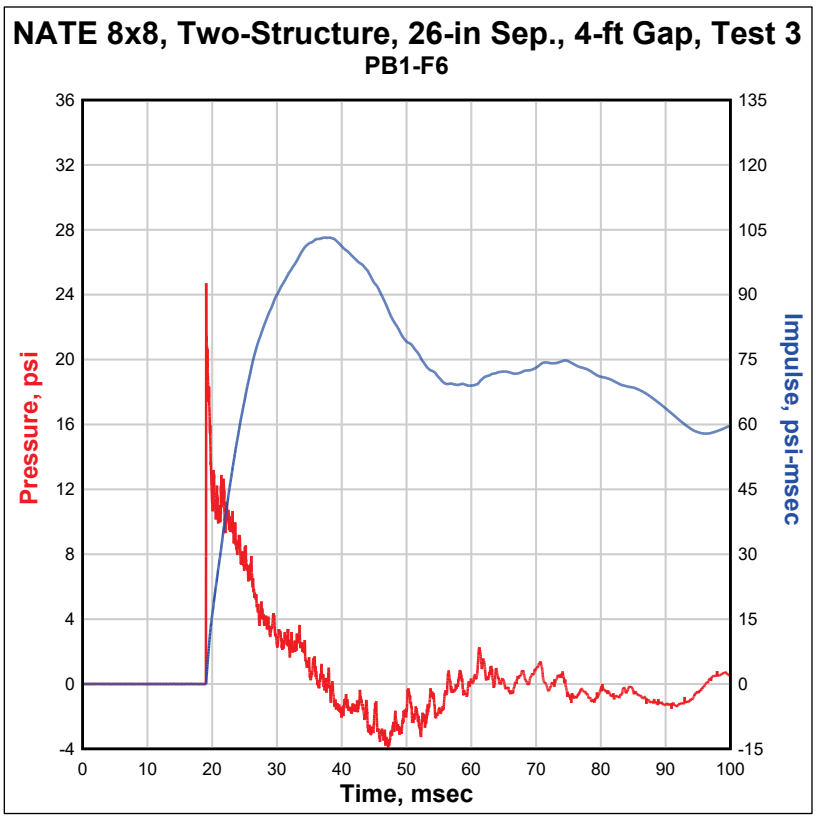
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
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-15
0
10
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30
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60
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90
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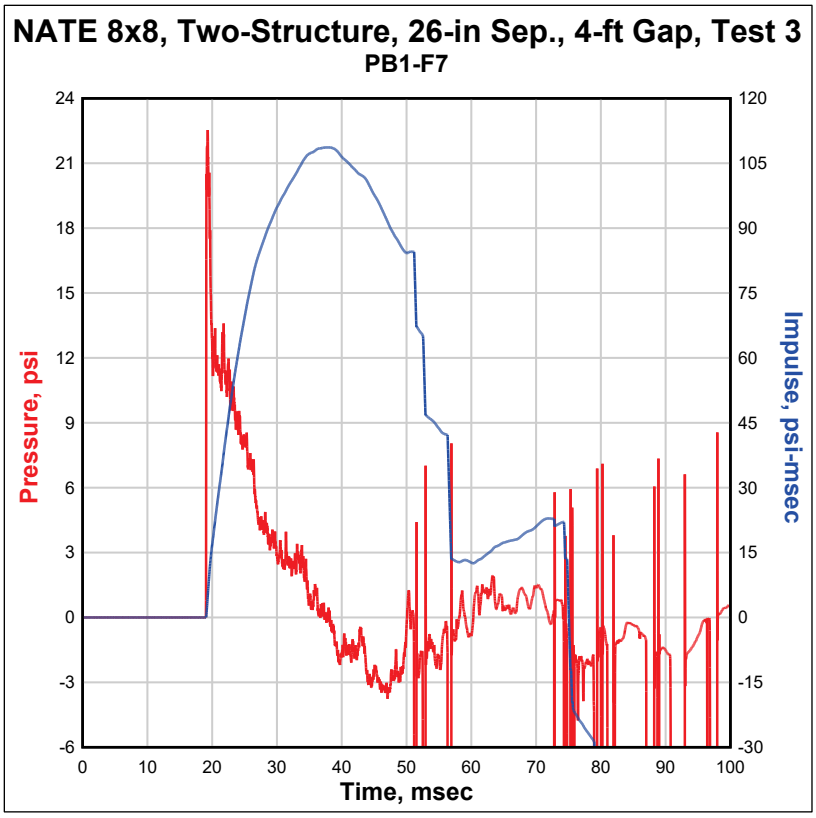
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
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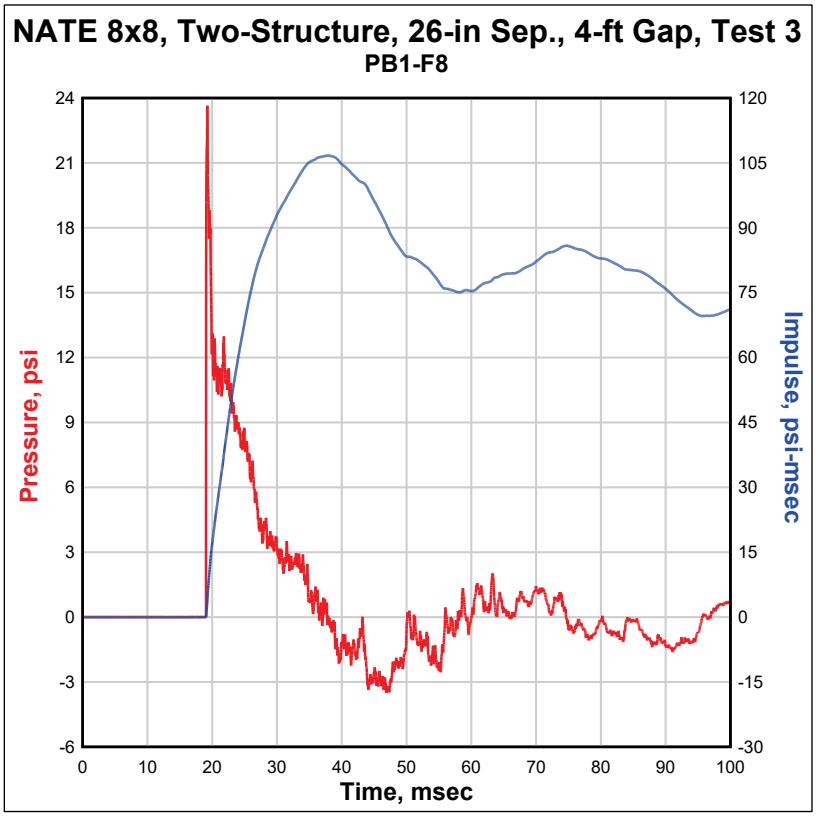
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
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-30
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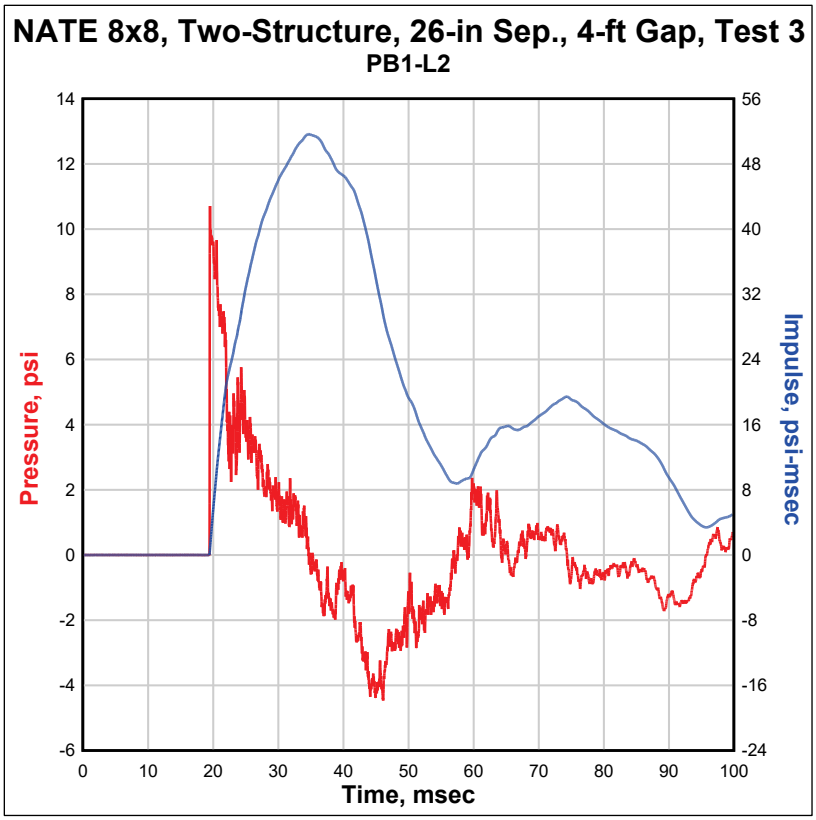
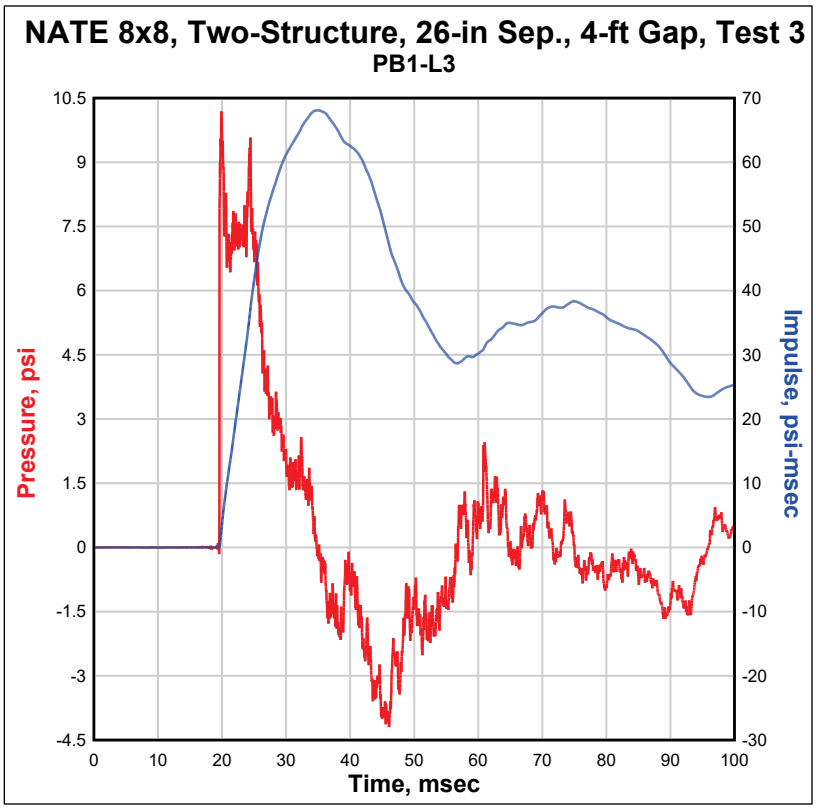
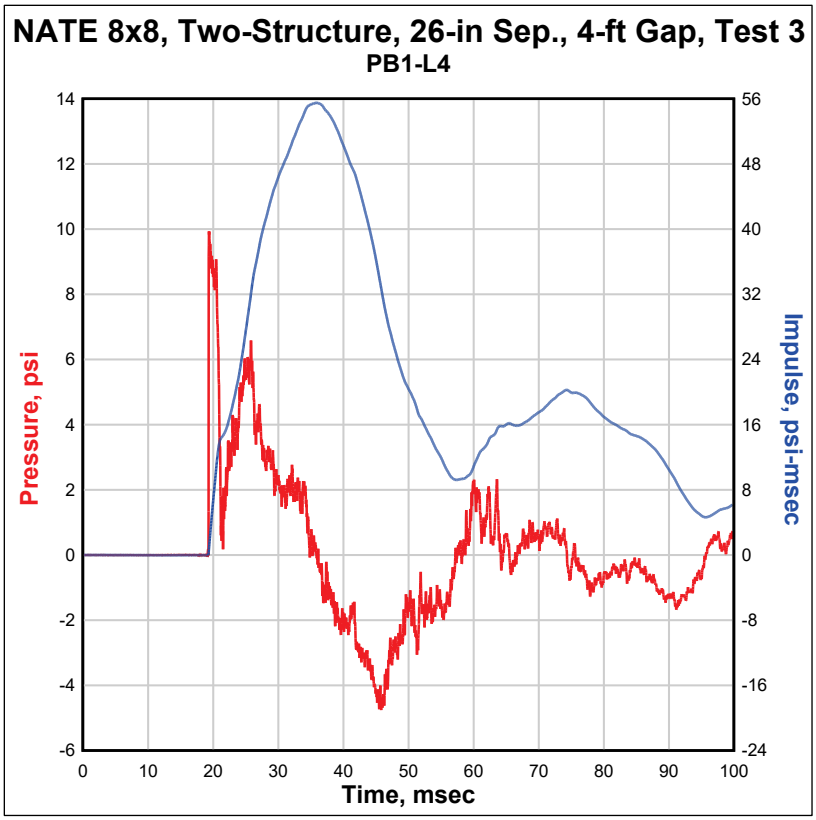
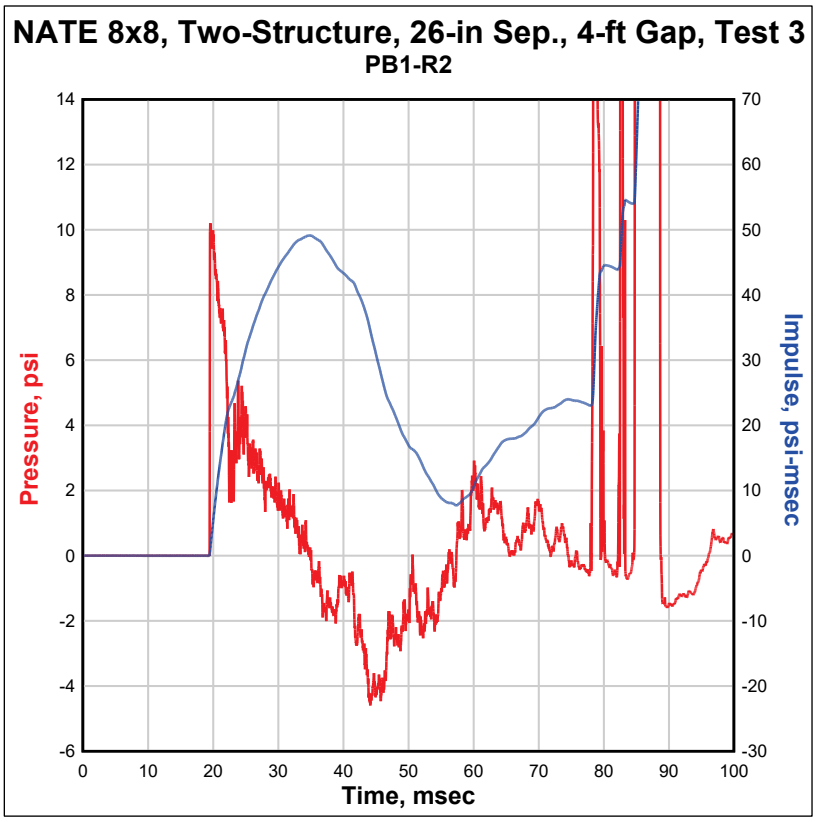
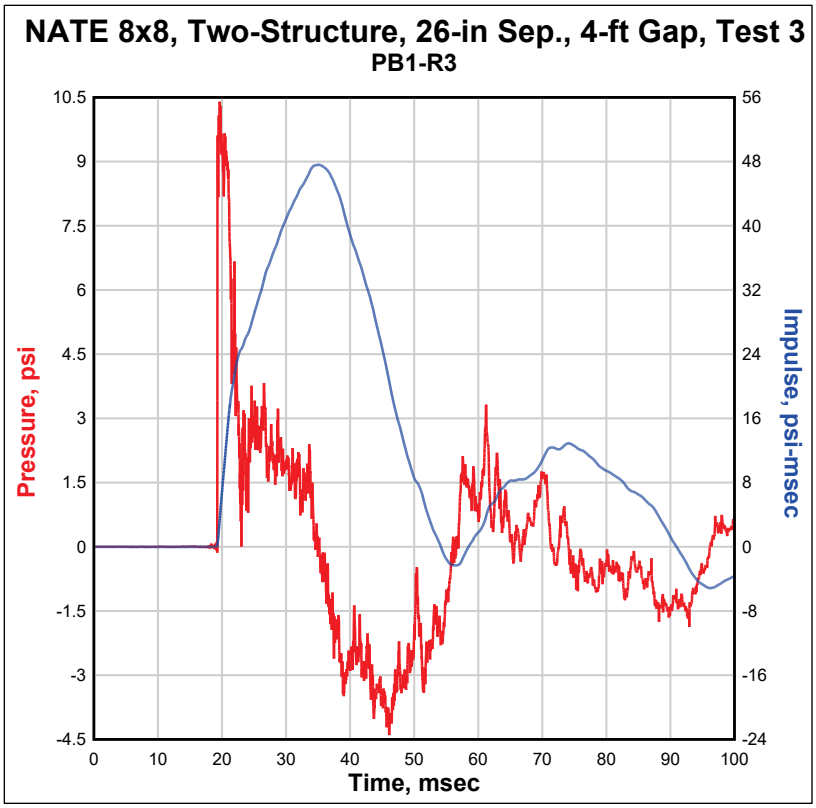
60
70
80
90
100

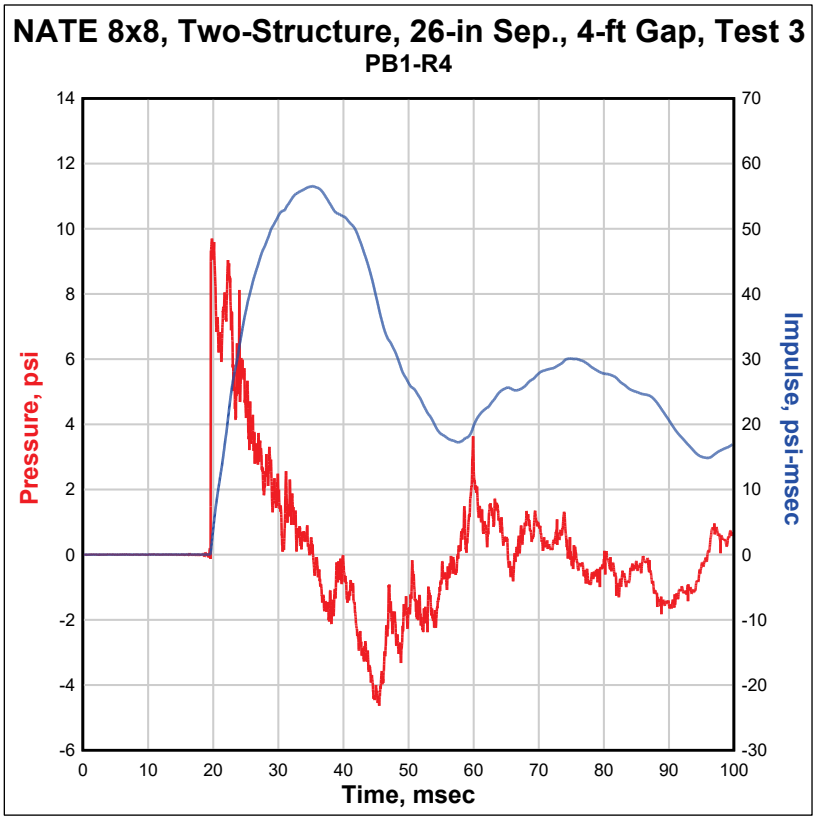

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

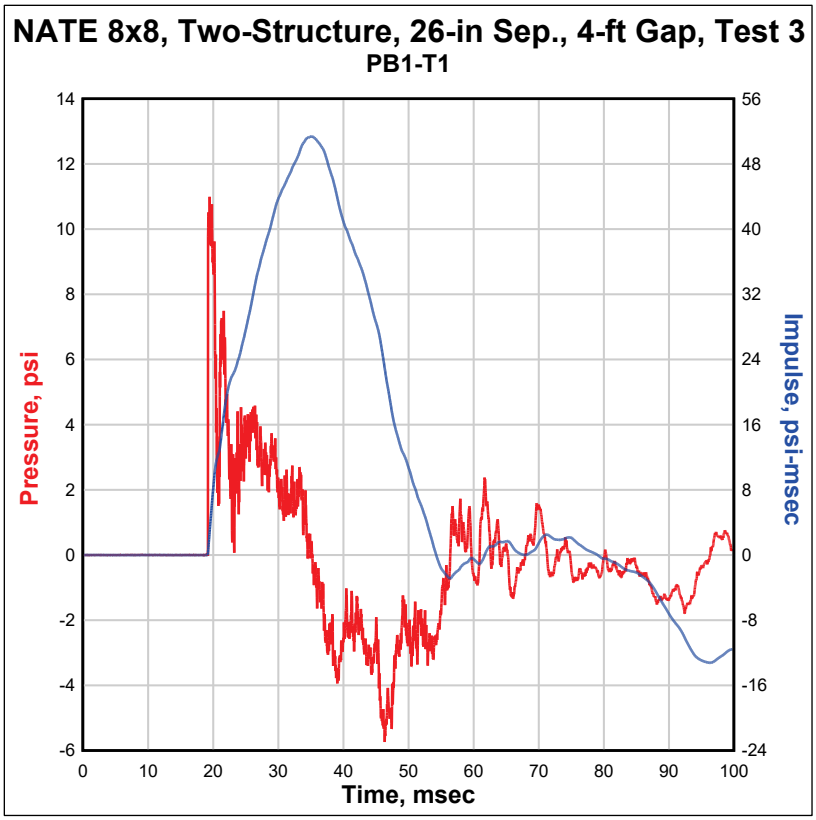

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

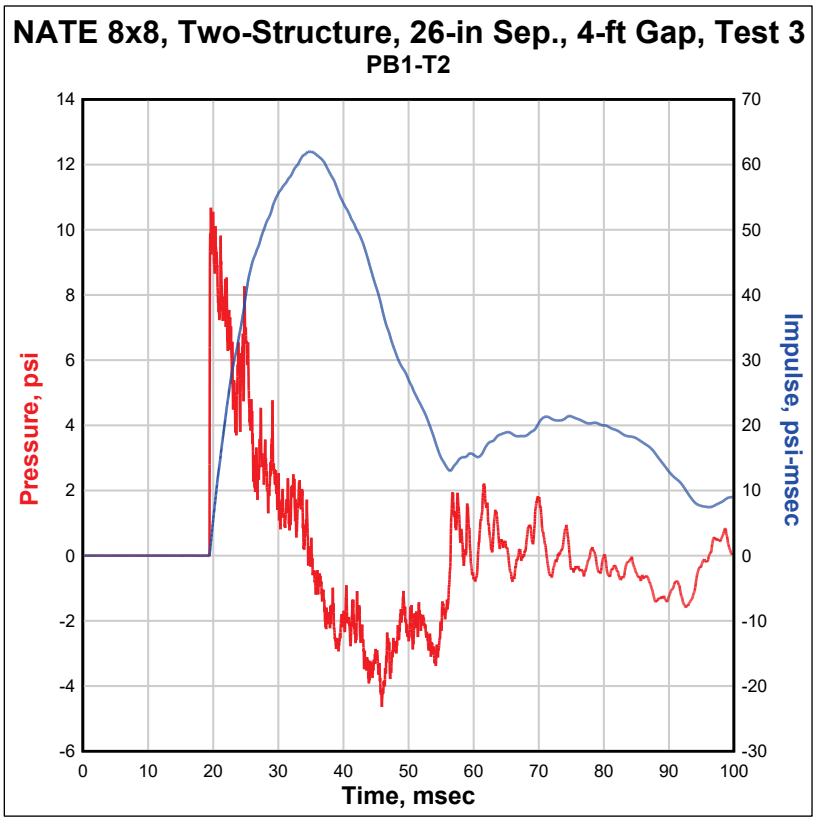

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
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0
-10
-20
-30
0
10
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30
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70
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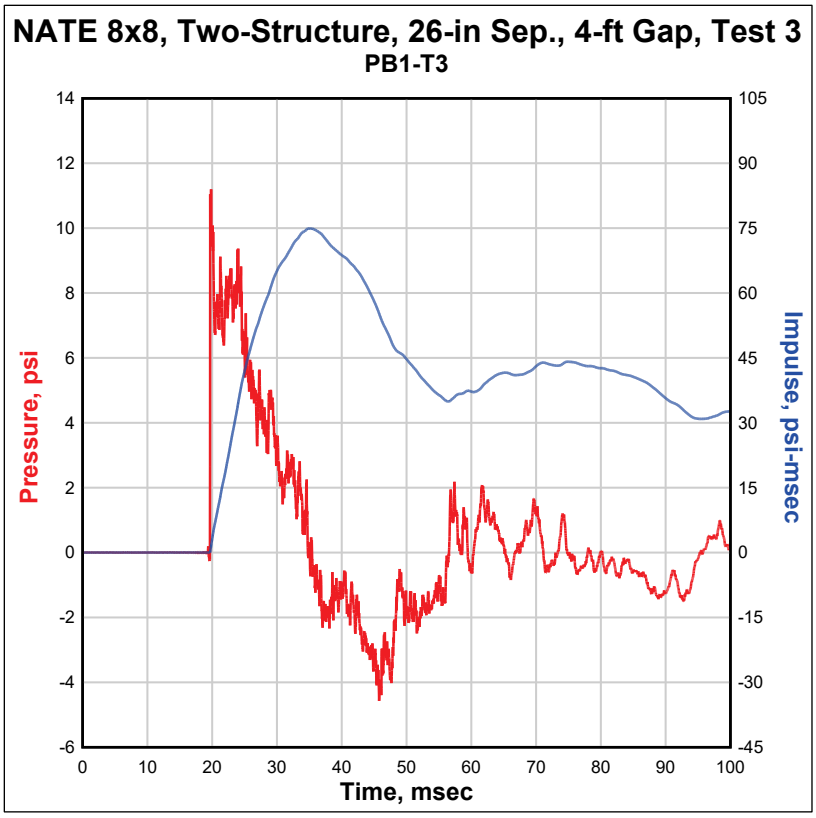
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
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0
-15
-30
-45
0
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40
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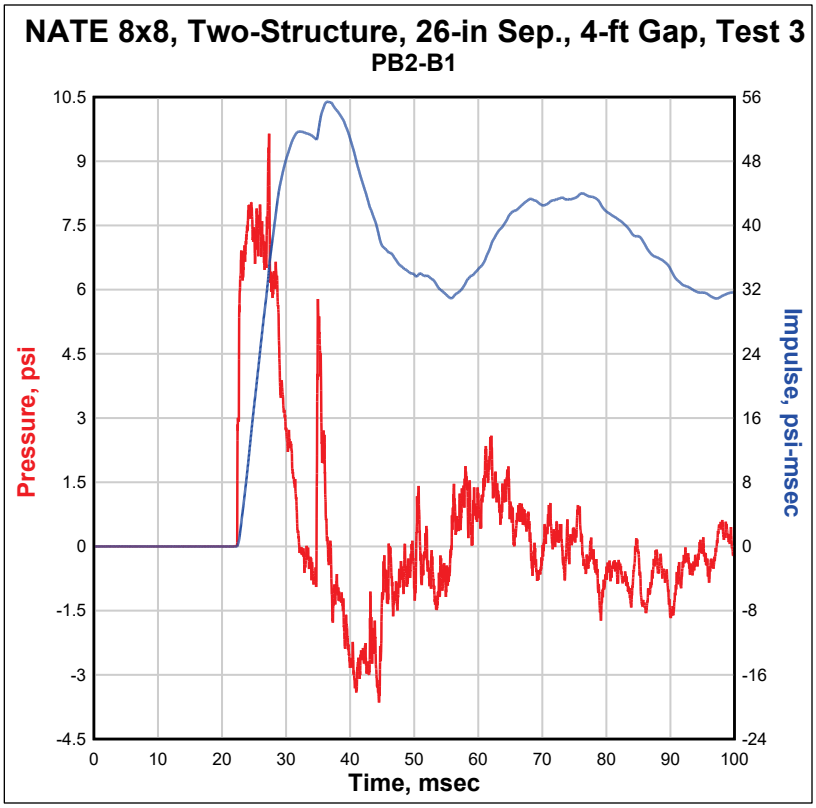
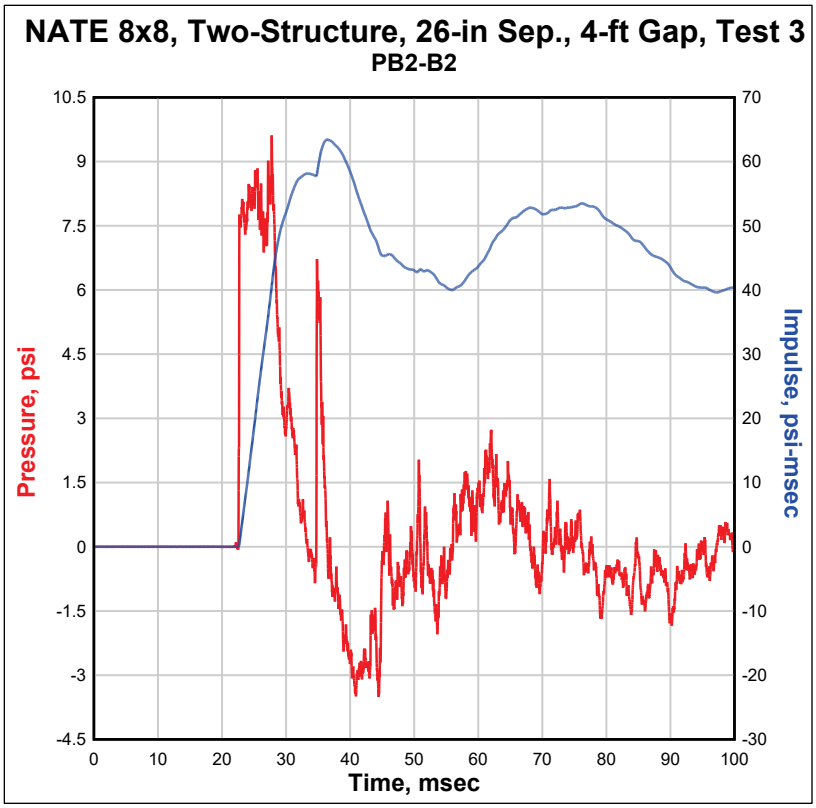
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
20
30
40
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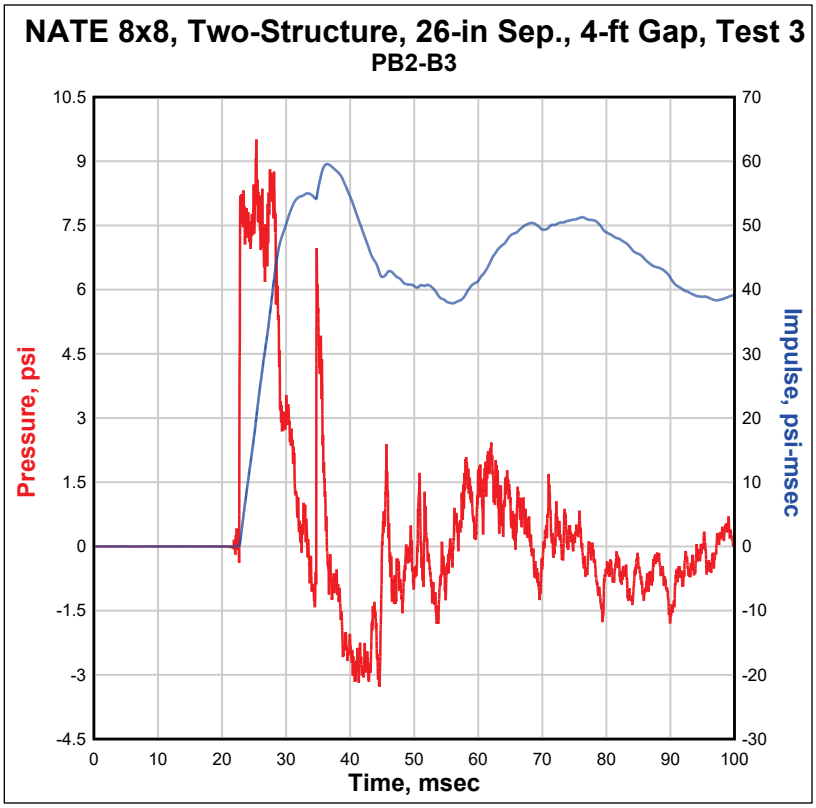
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
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30
40
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70
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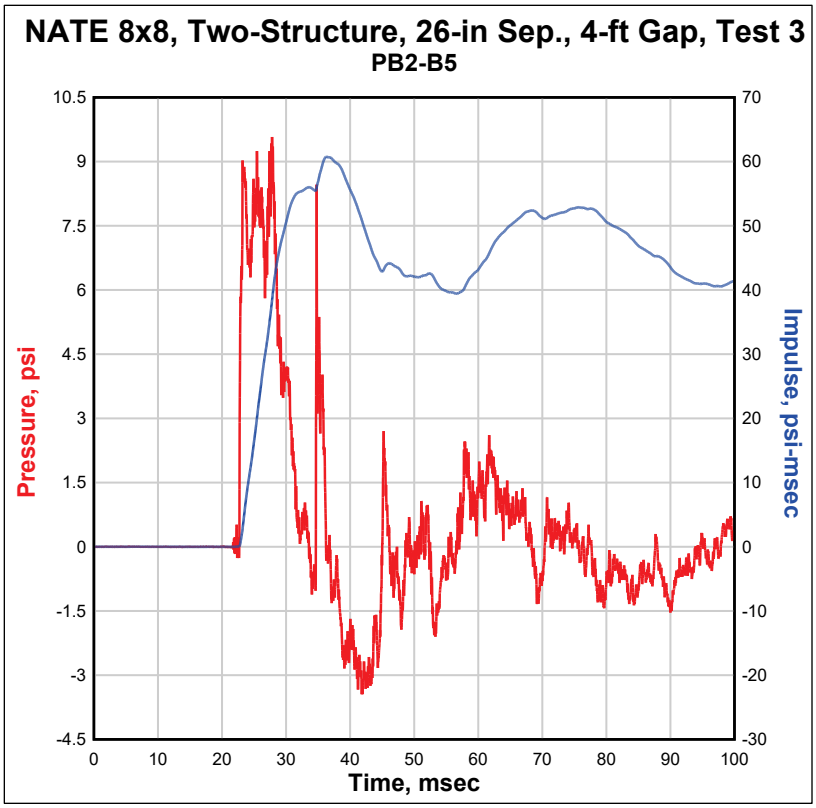
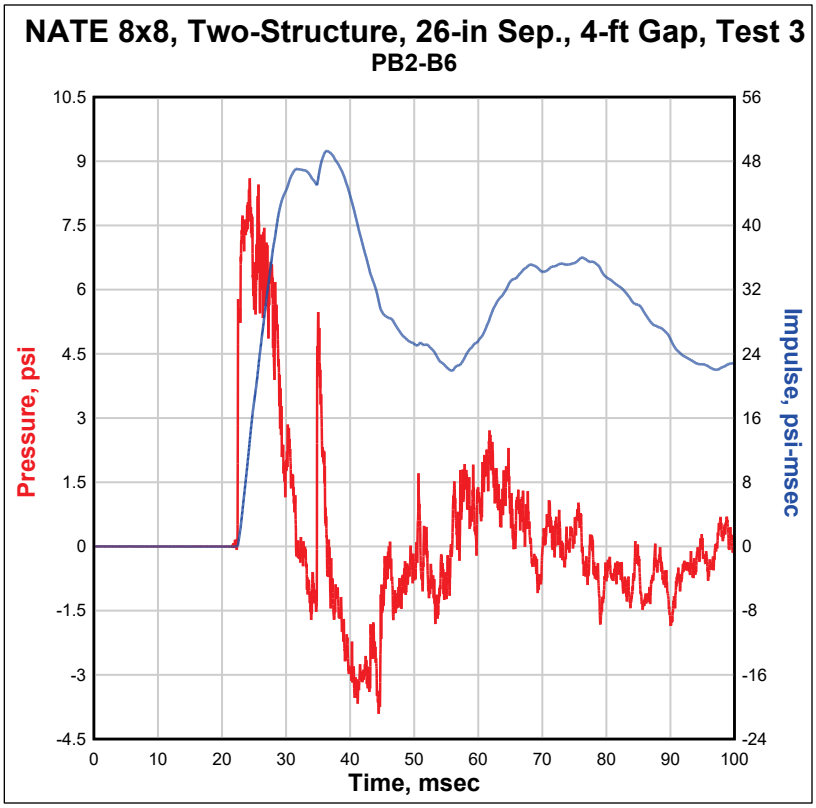
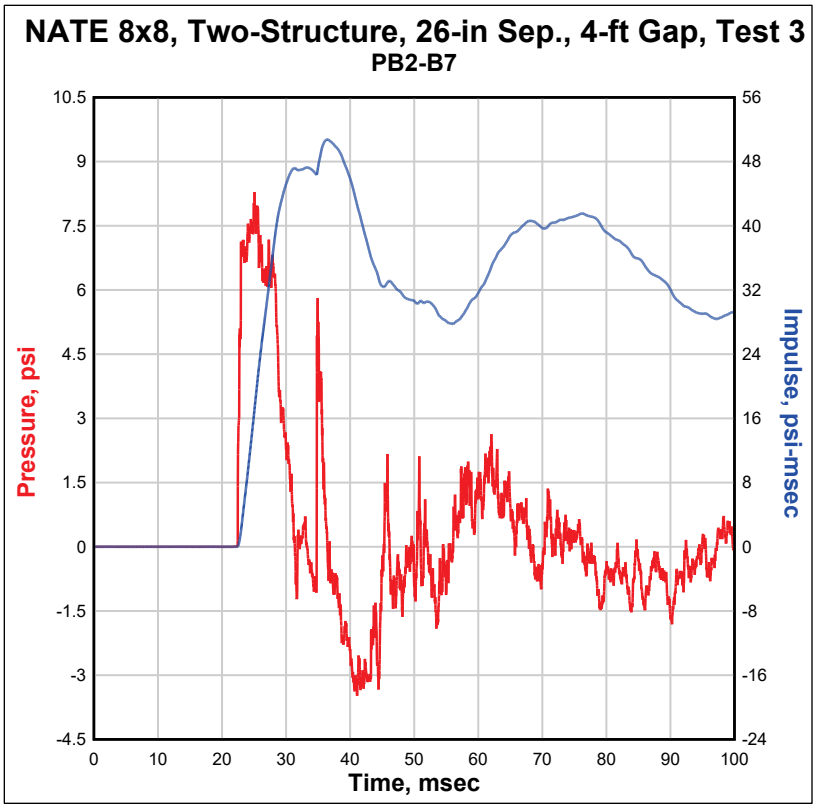
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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0
-8
-16
-24
0
10
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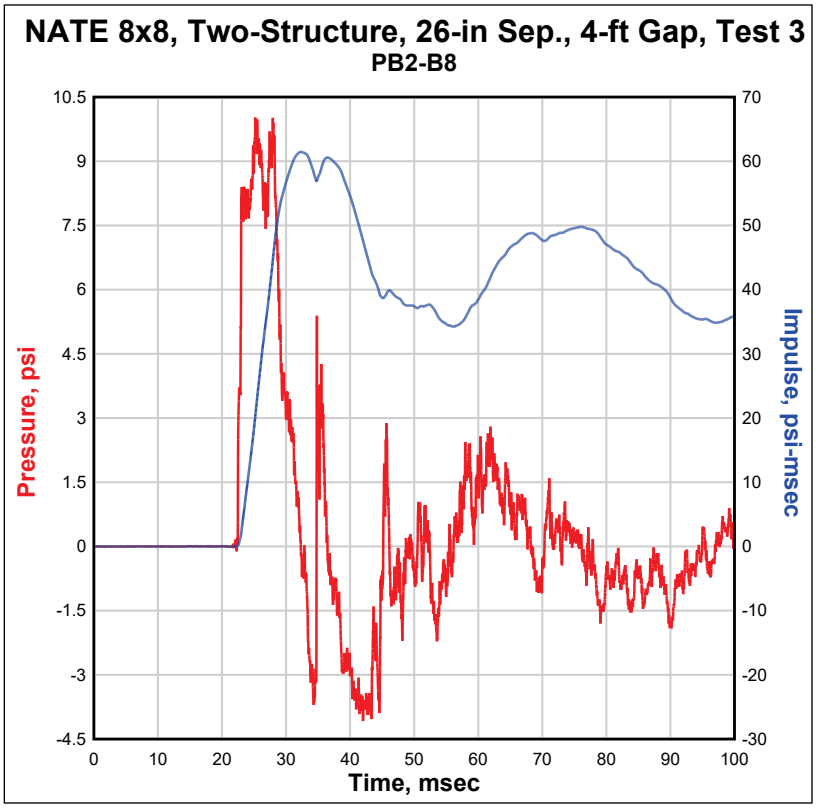
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
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30
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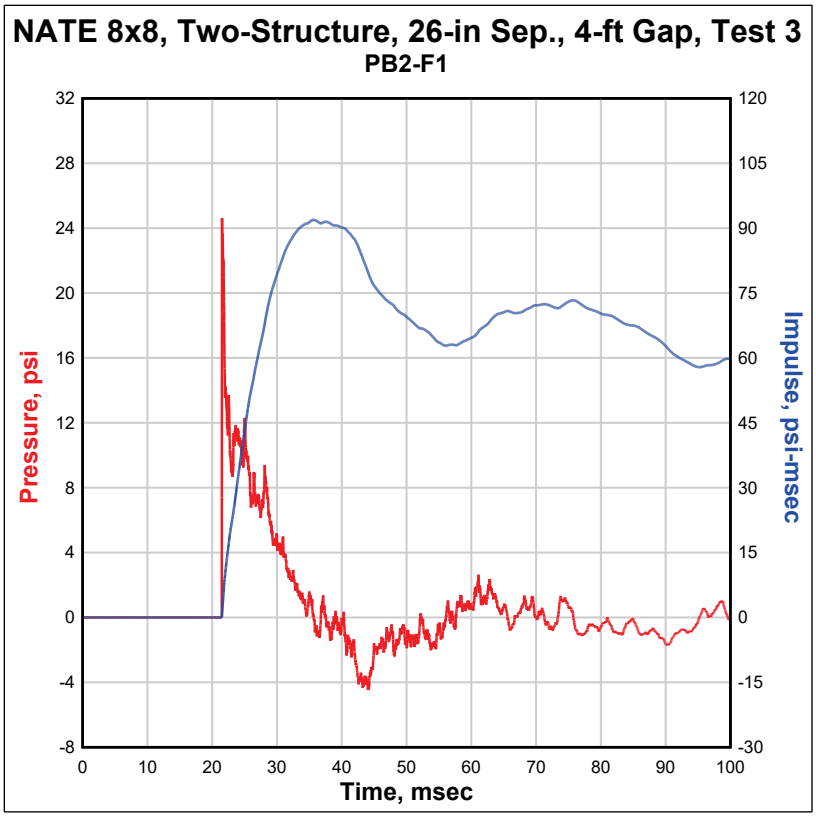
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
40
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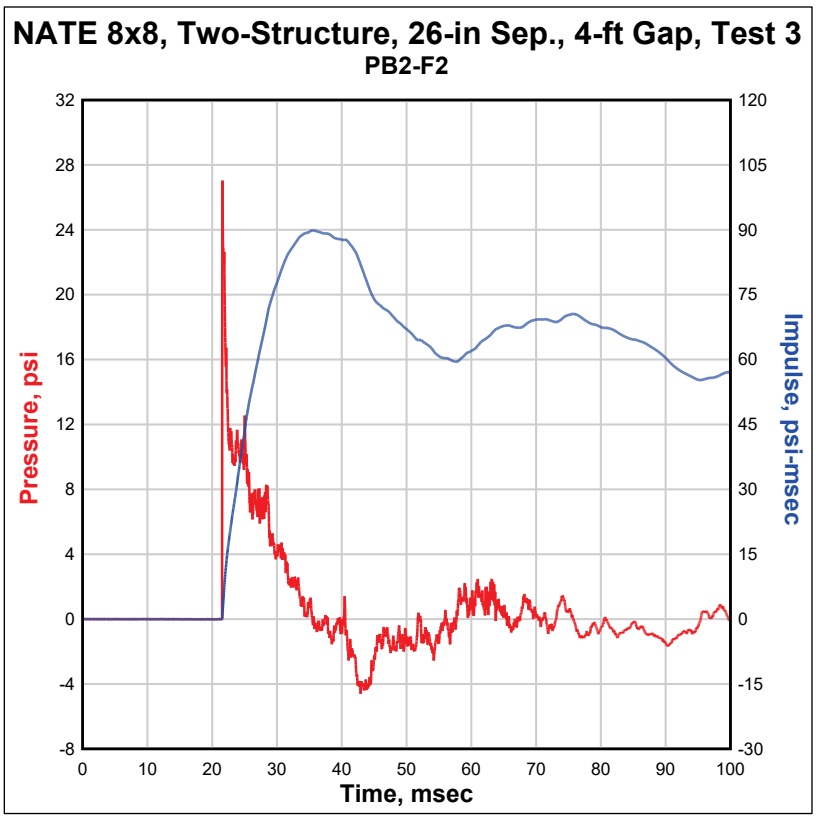
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
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70
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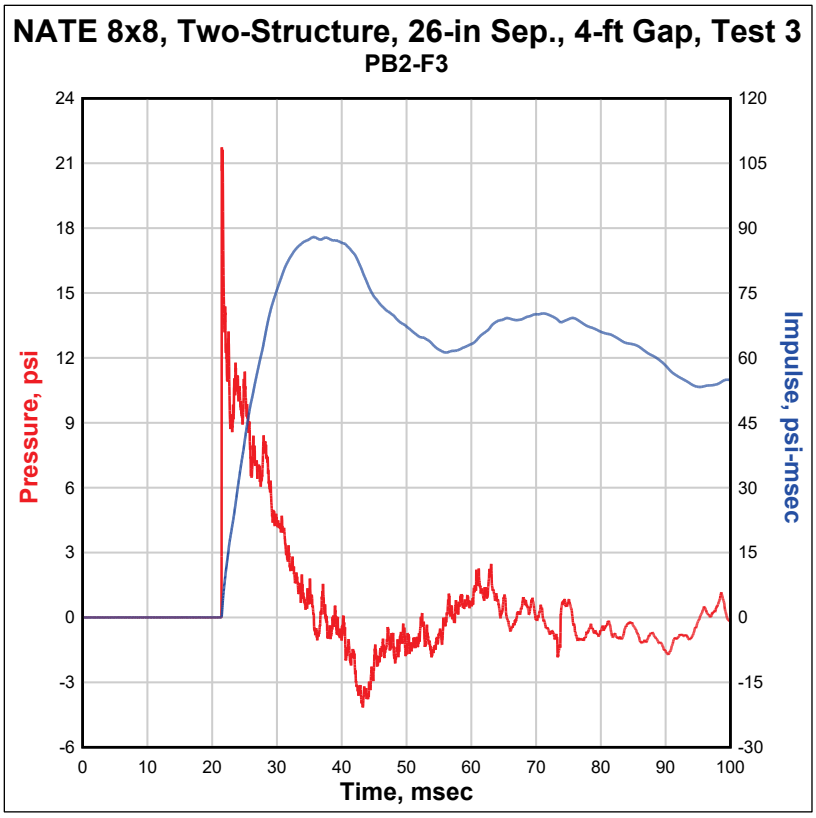
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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70
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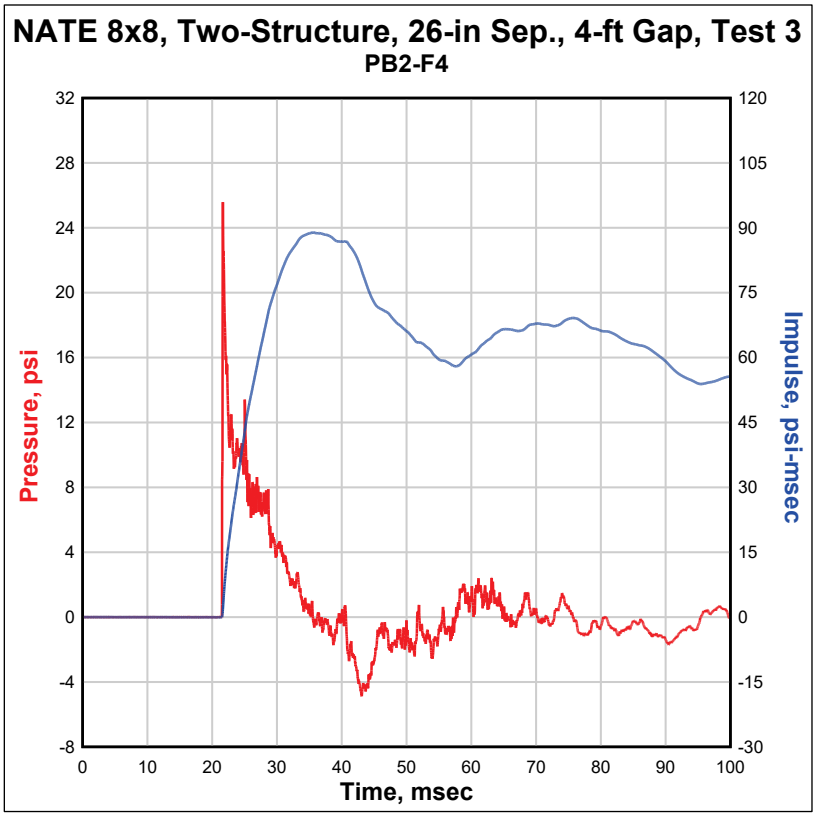
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
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15
0
-15
-30
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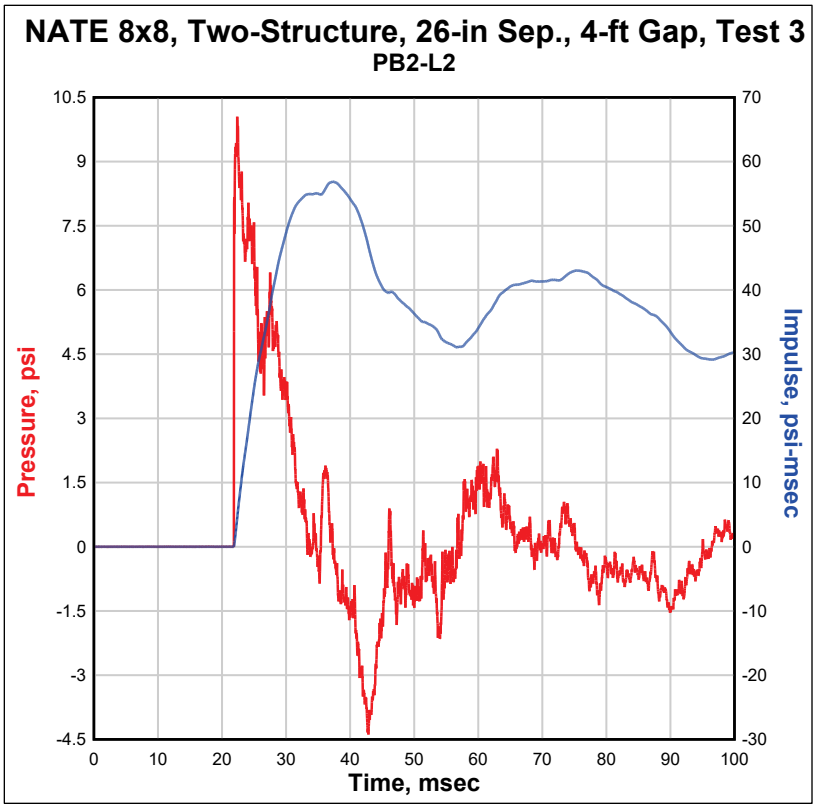
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
20
30
40
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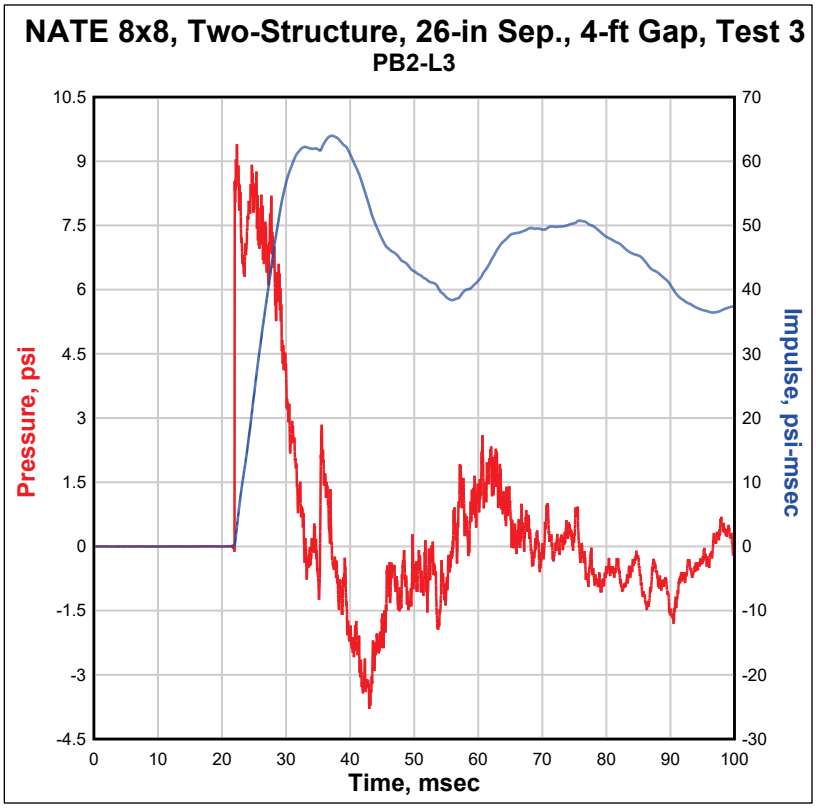
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
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-30
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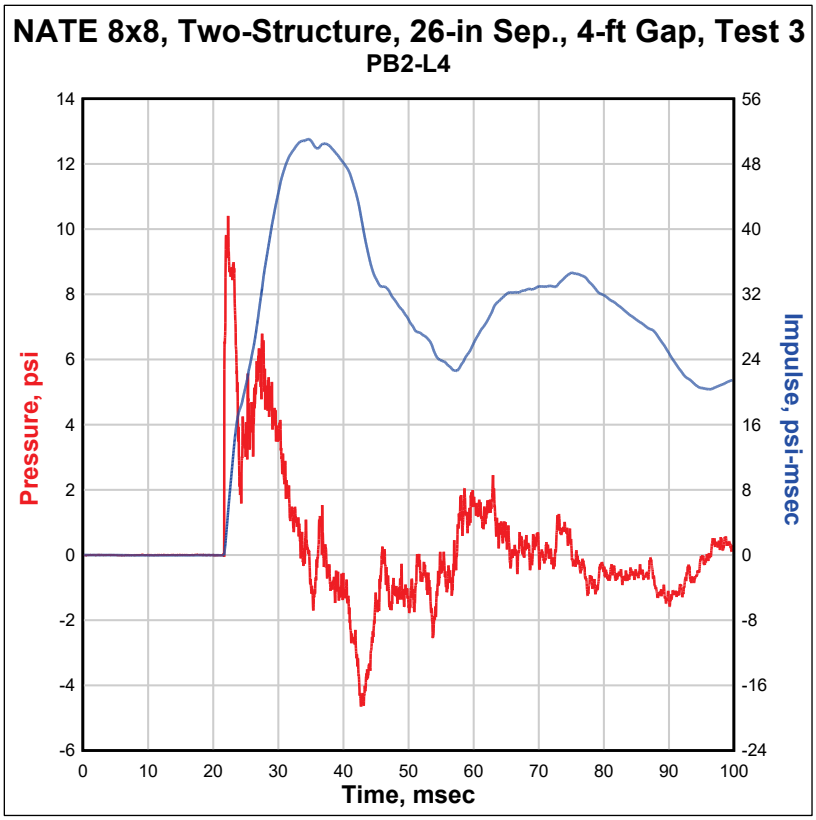
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
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-24
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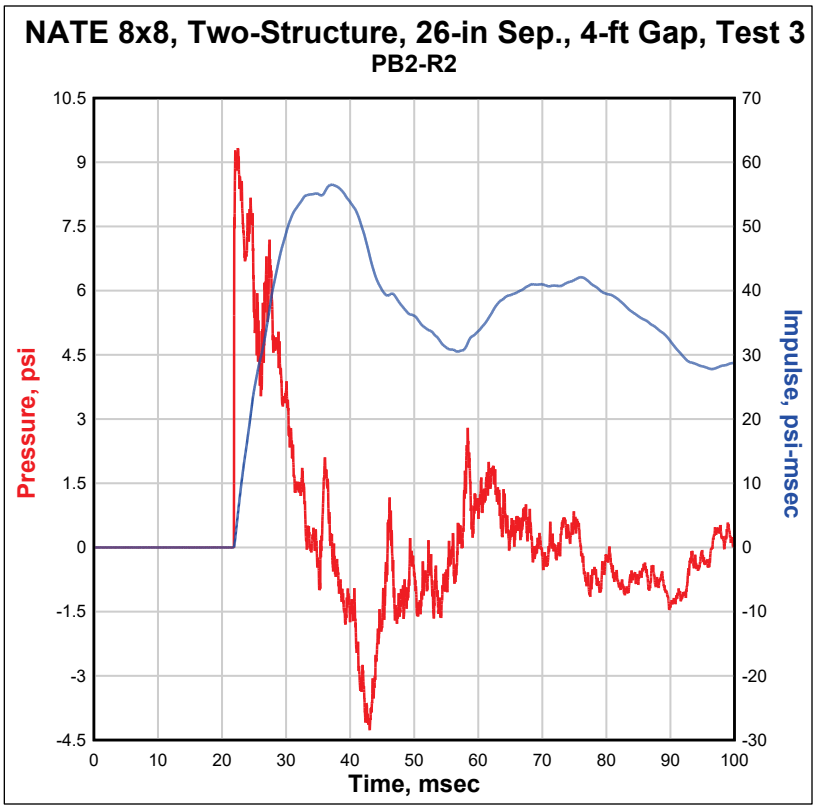
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
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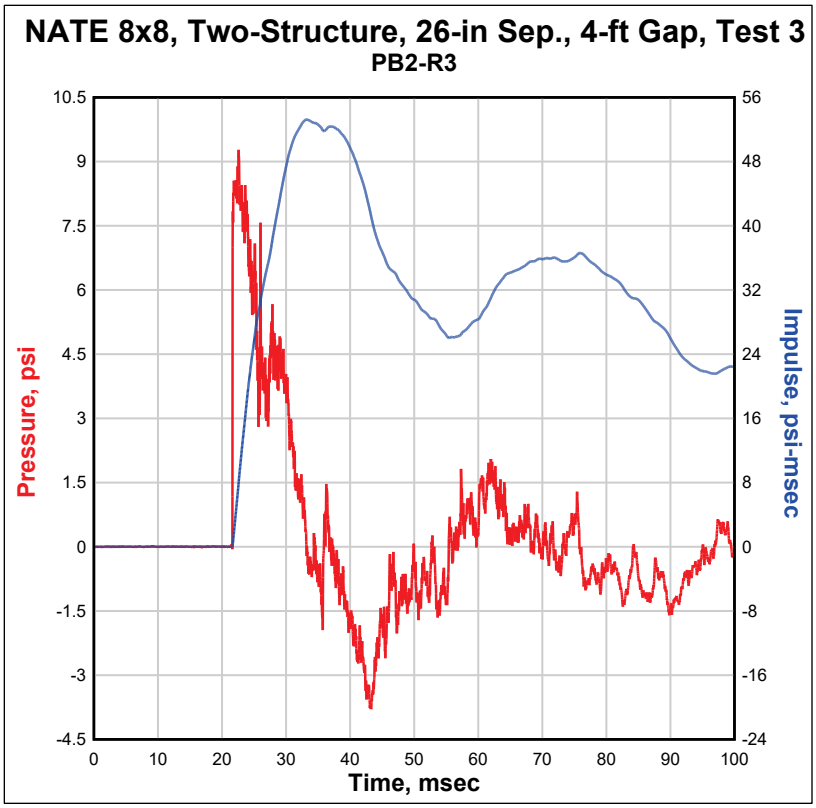
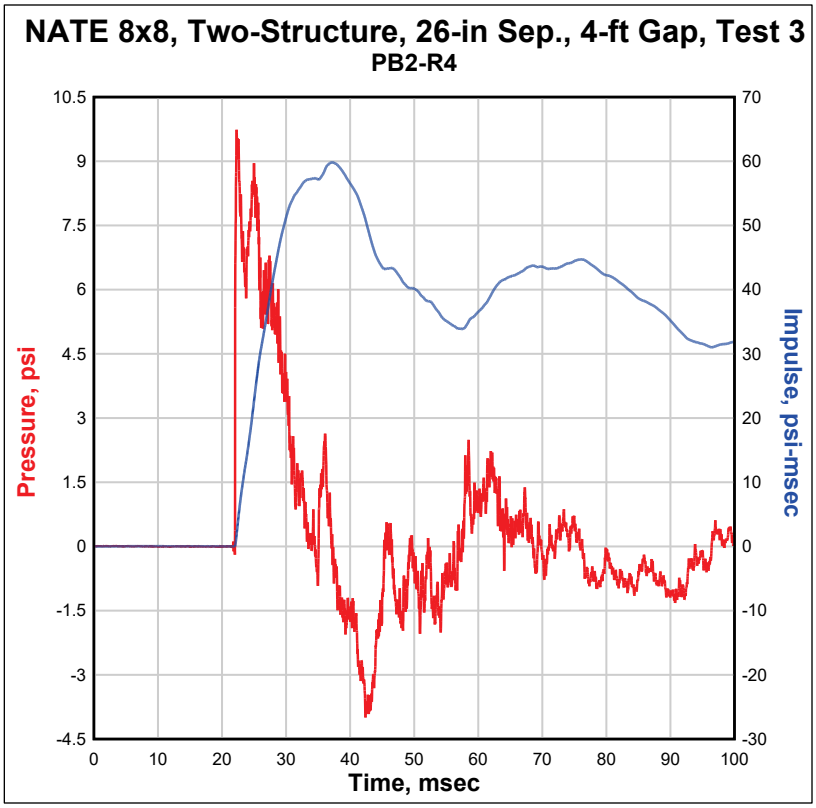
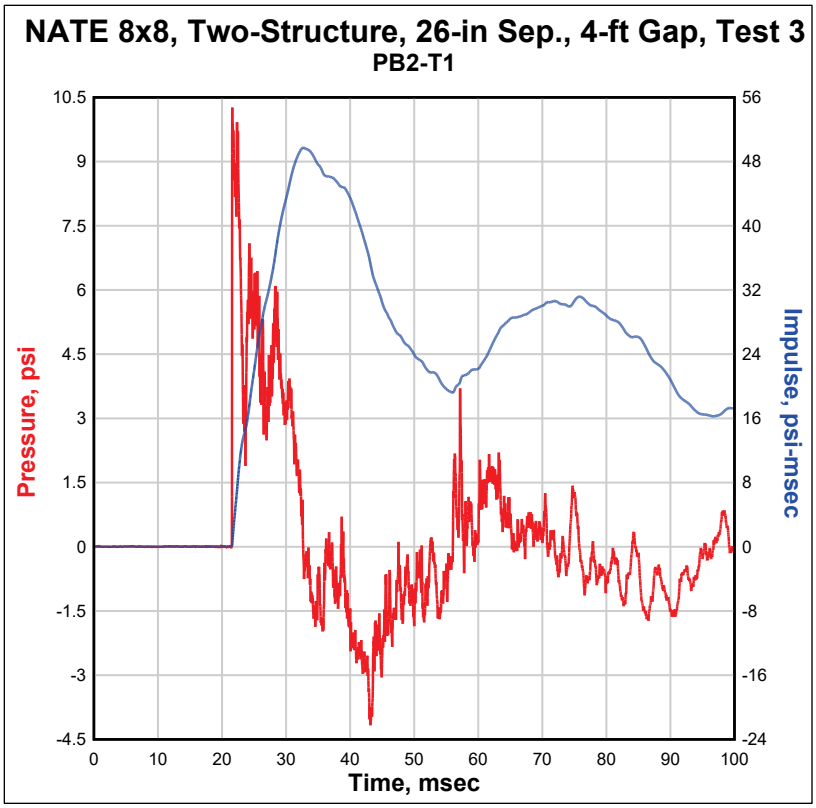
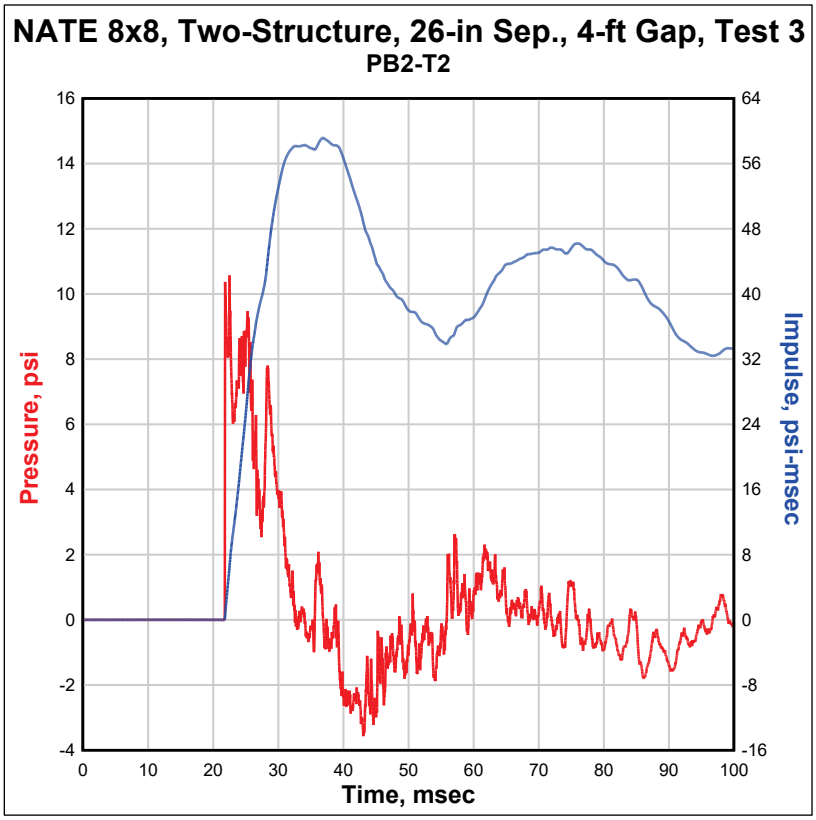
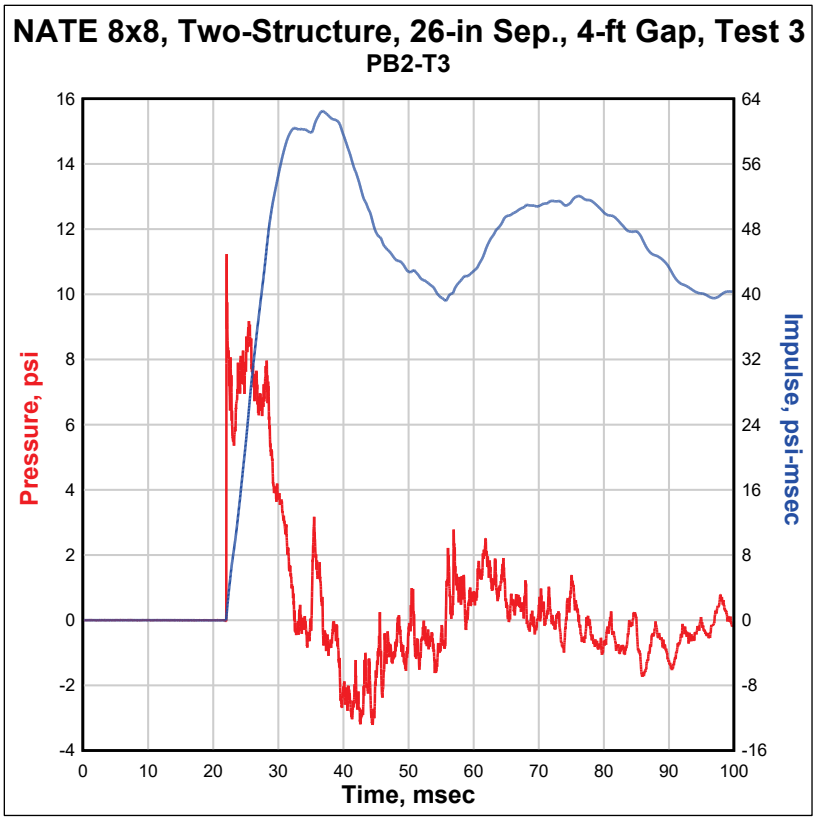

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 3
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
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20
30
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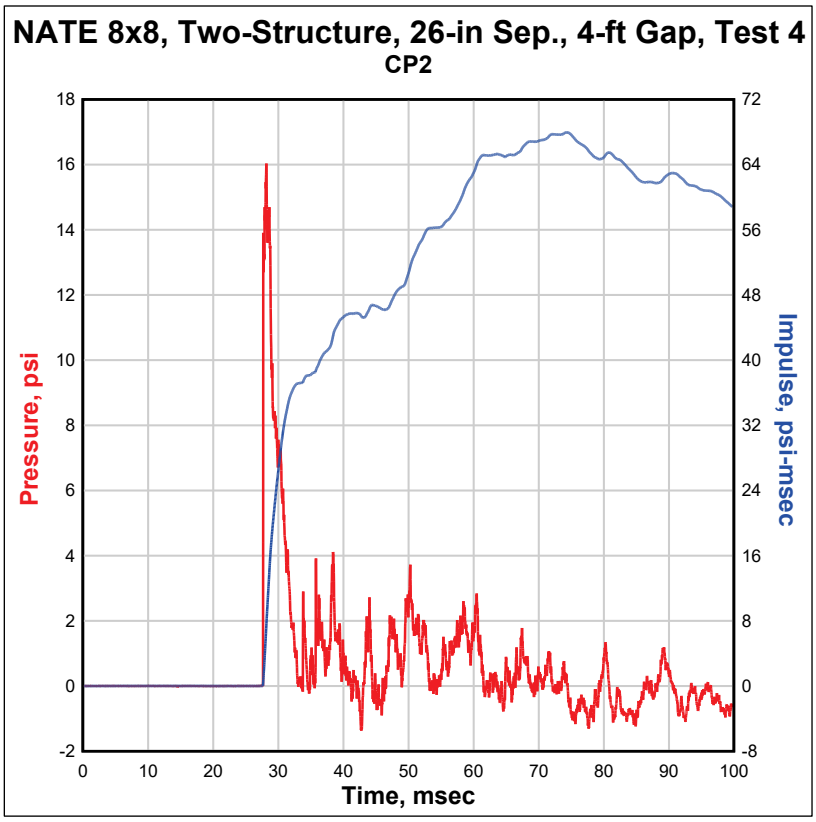
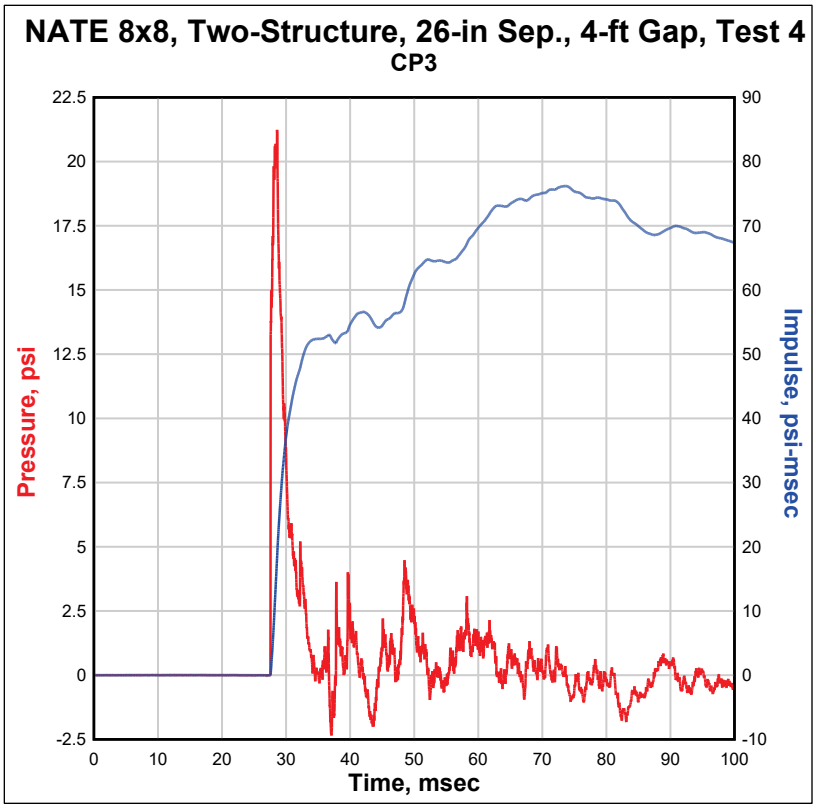
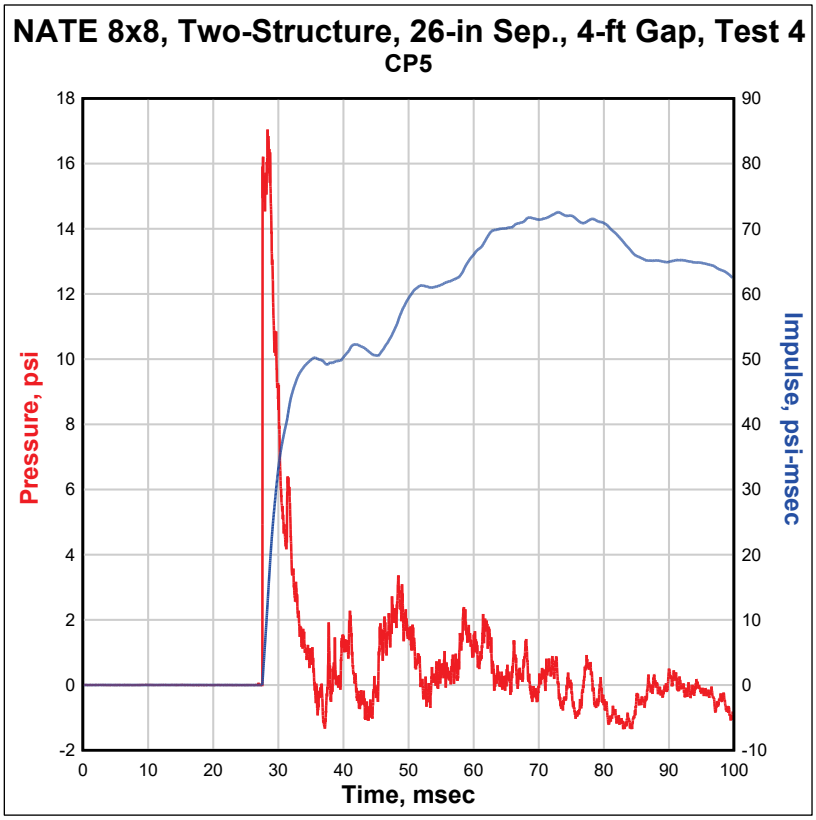
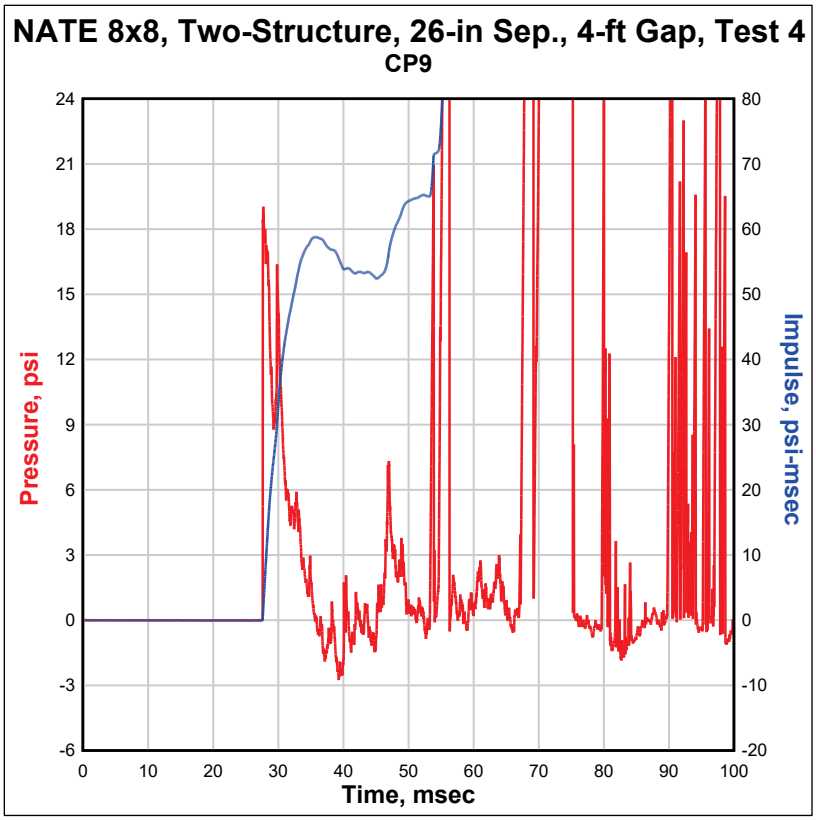
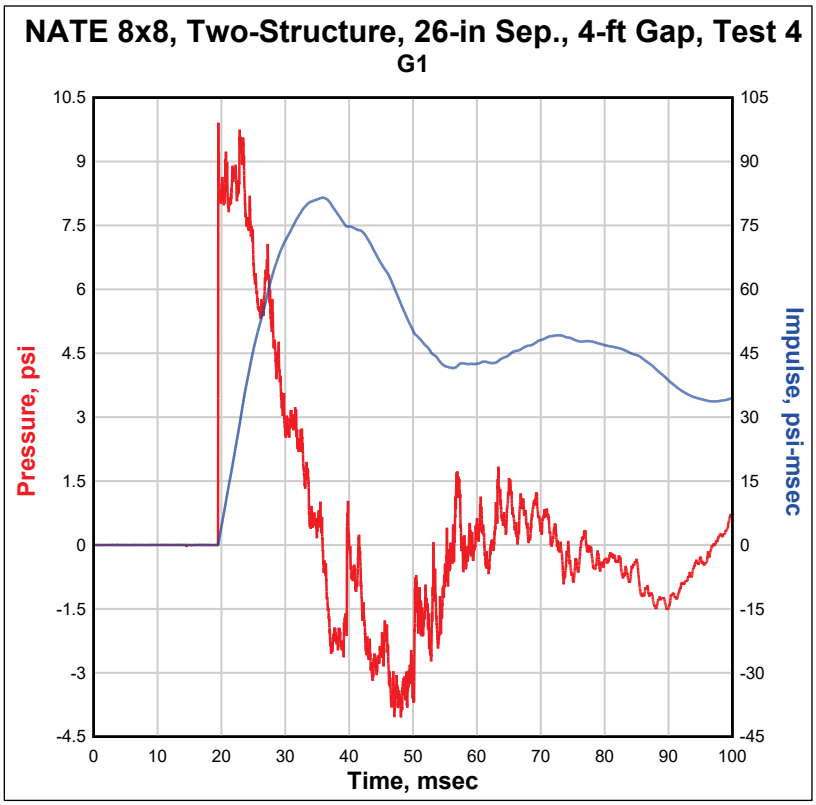
60
70
80
90
100

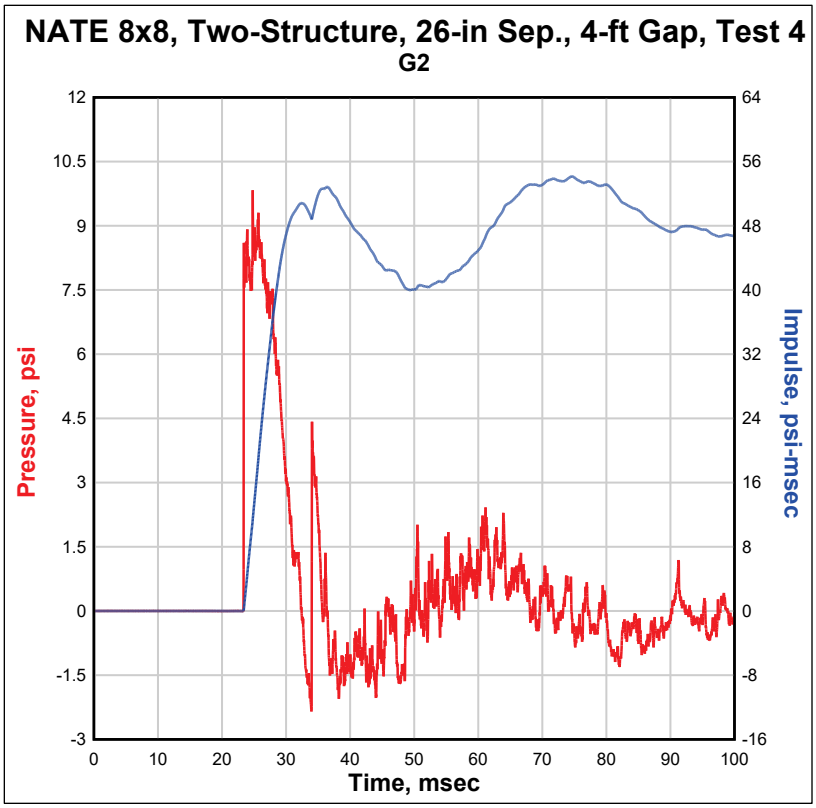

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

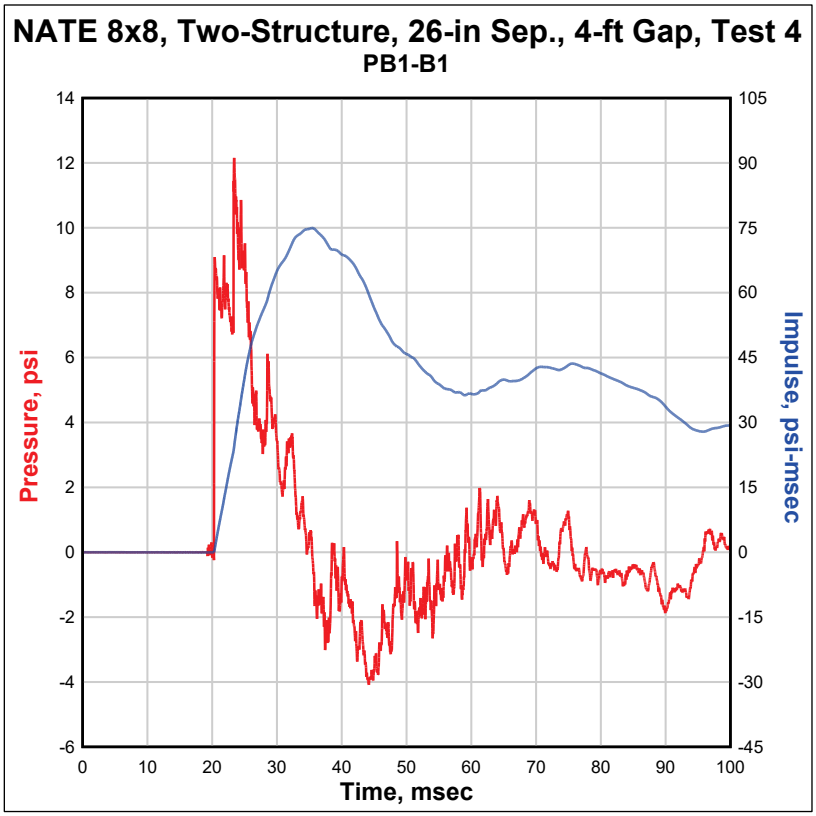

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

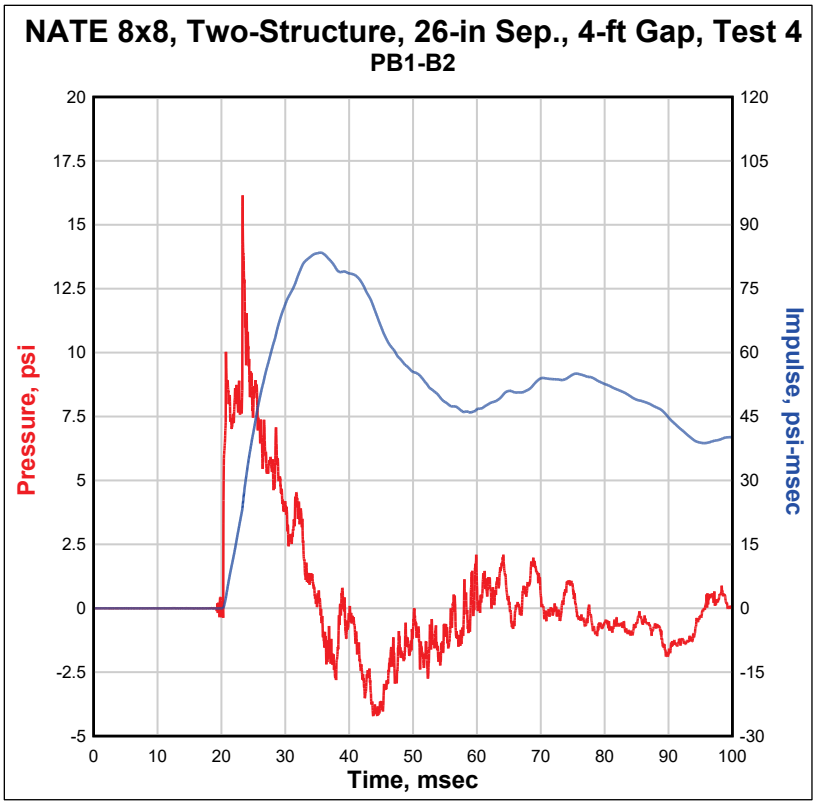

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

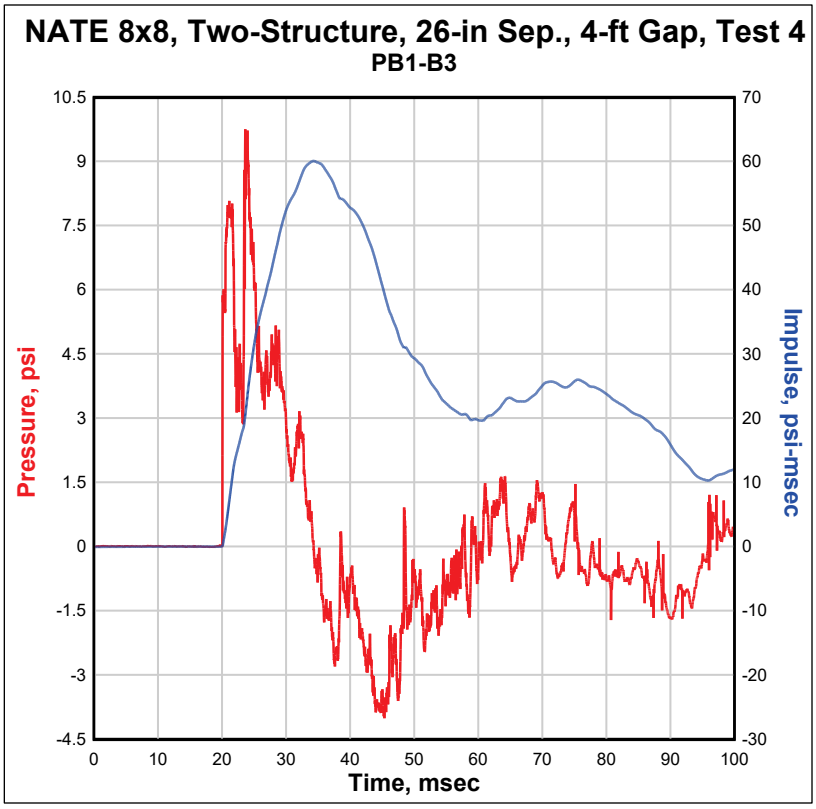

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

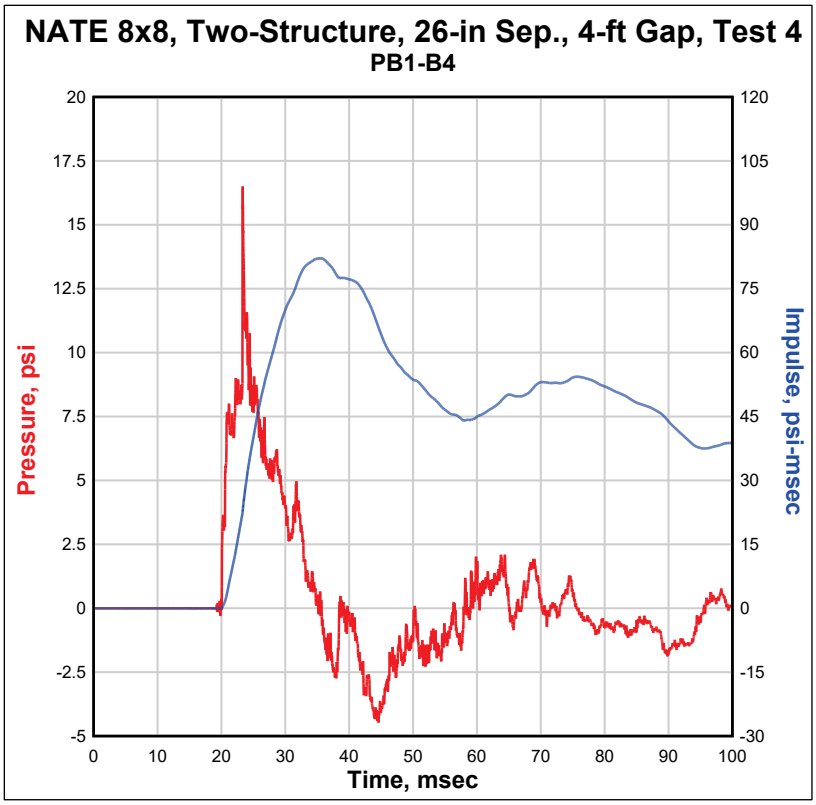

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

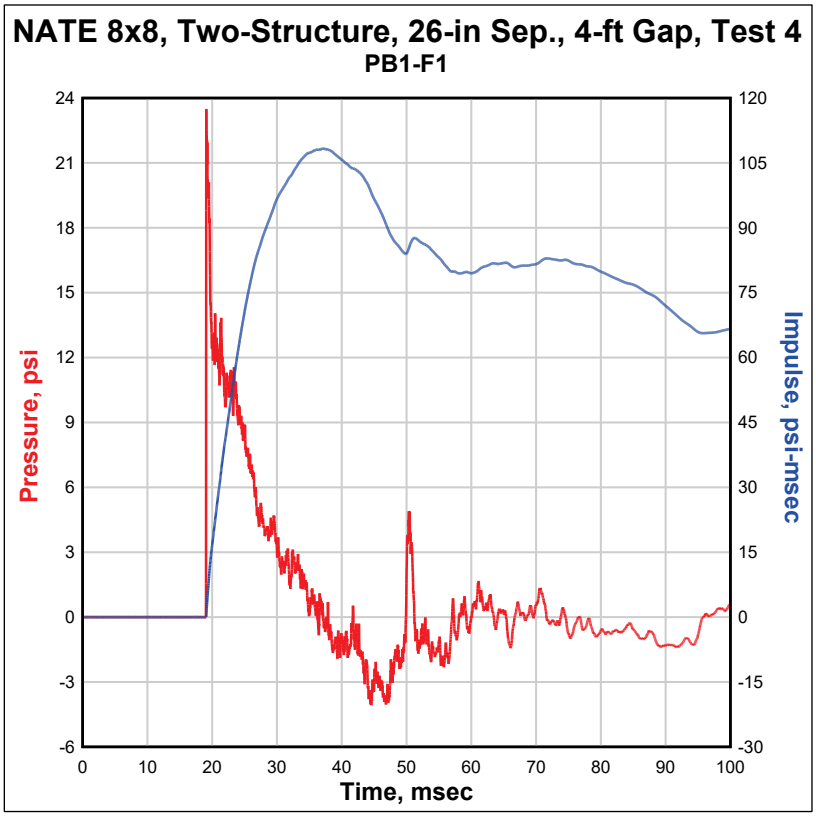

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

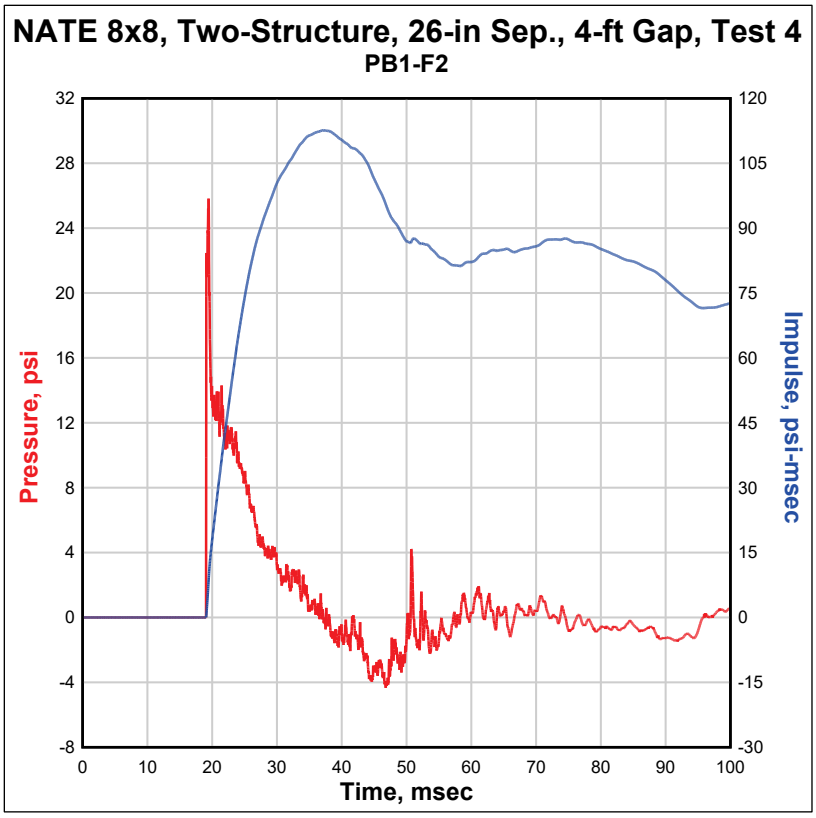

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

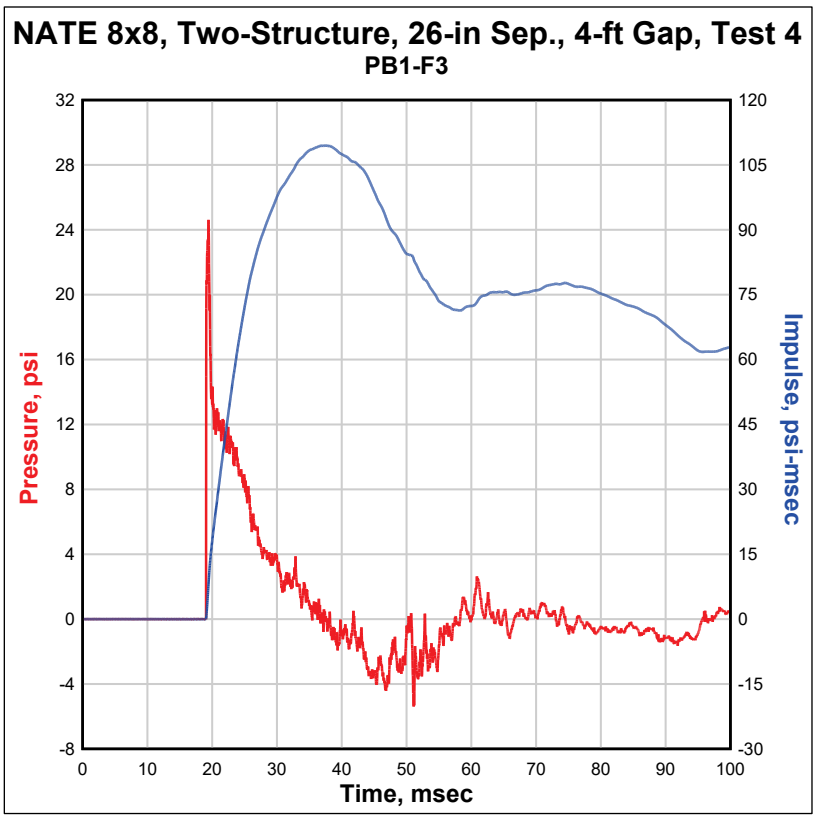

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
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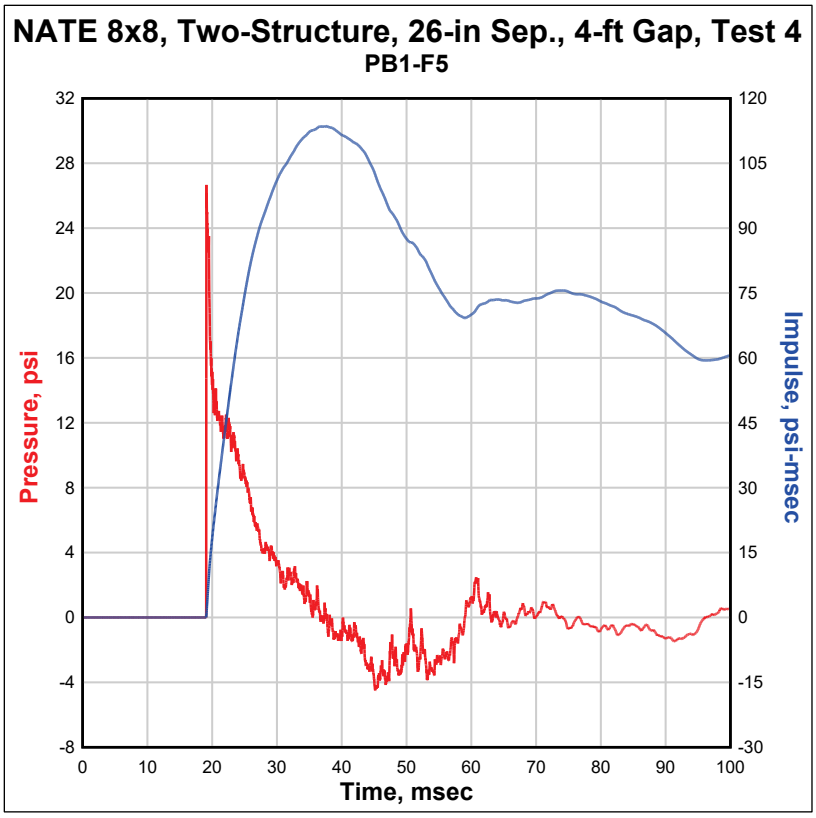
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
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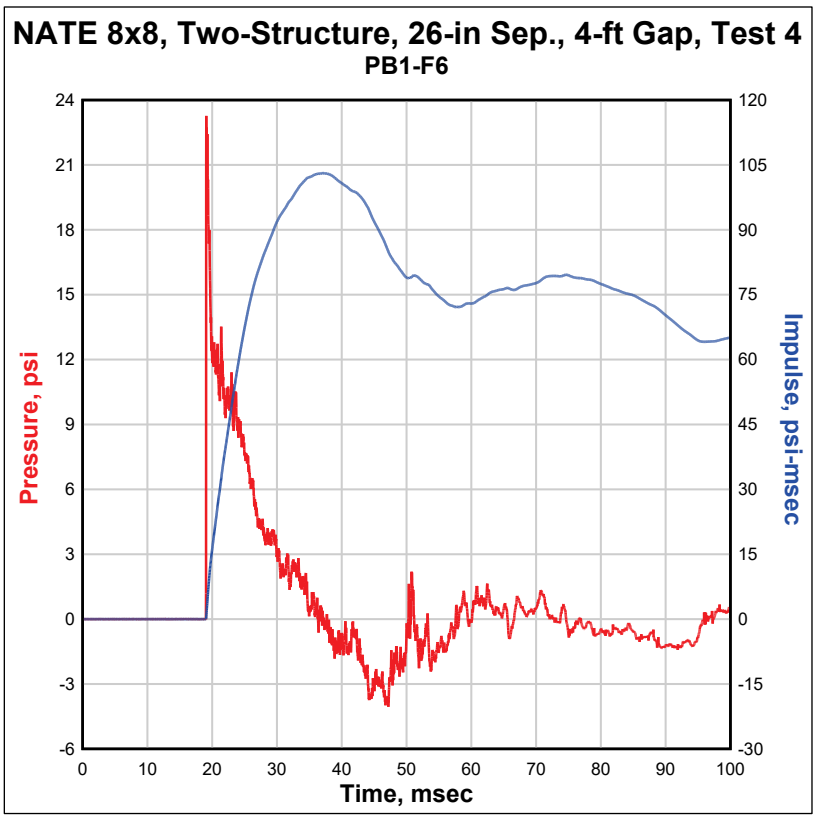
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
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30
40
50
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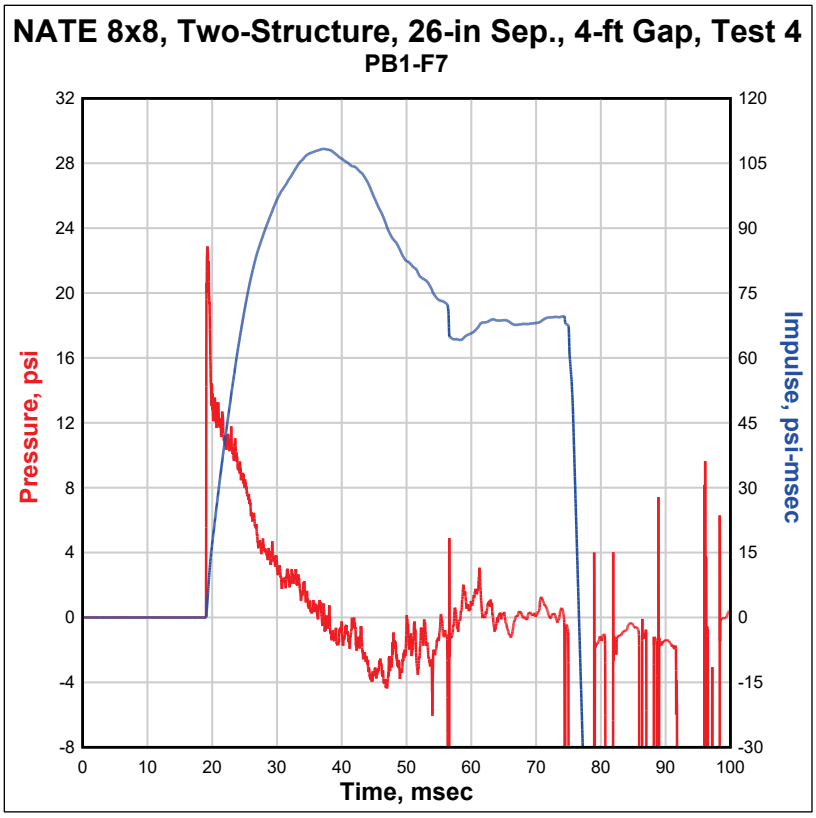
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
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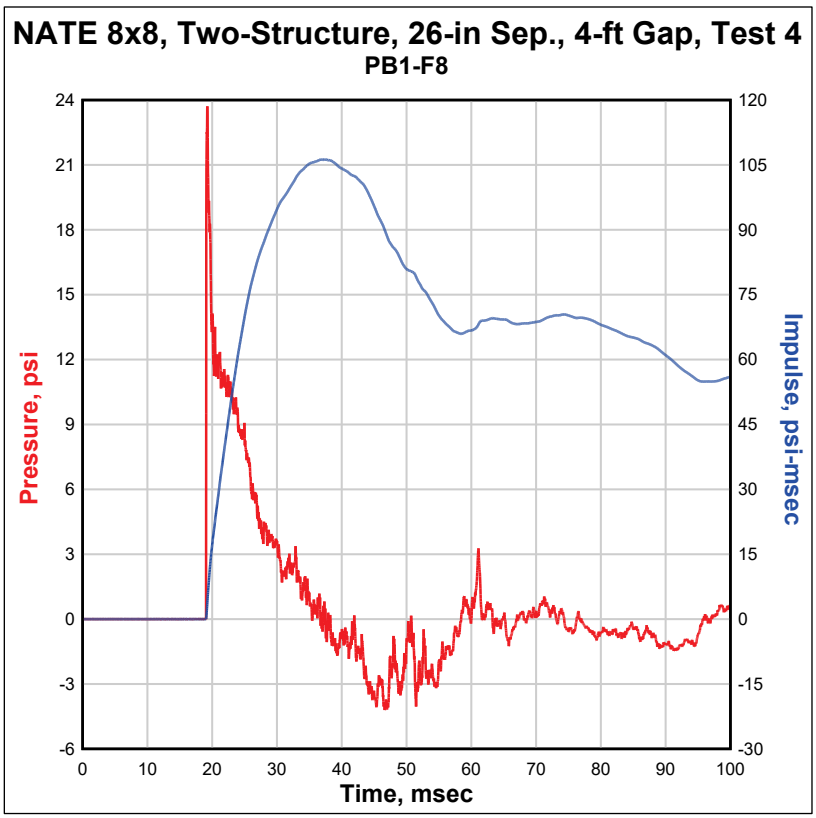
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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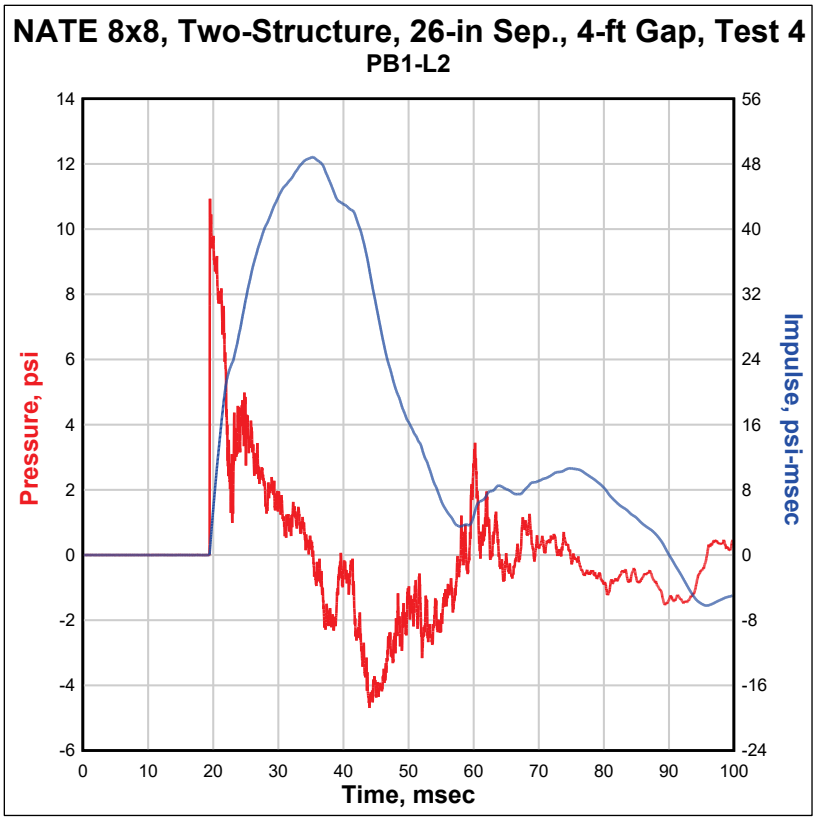
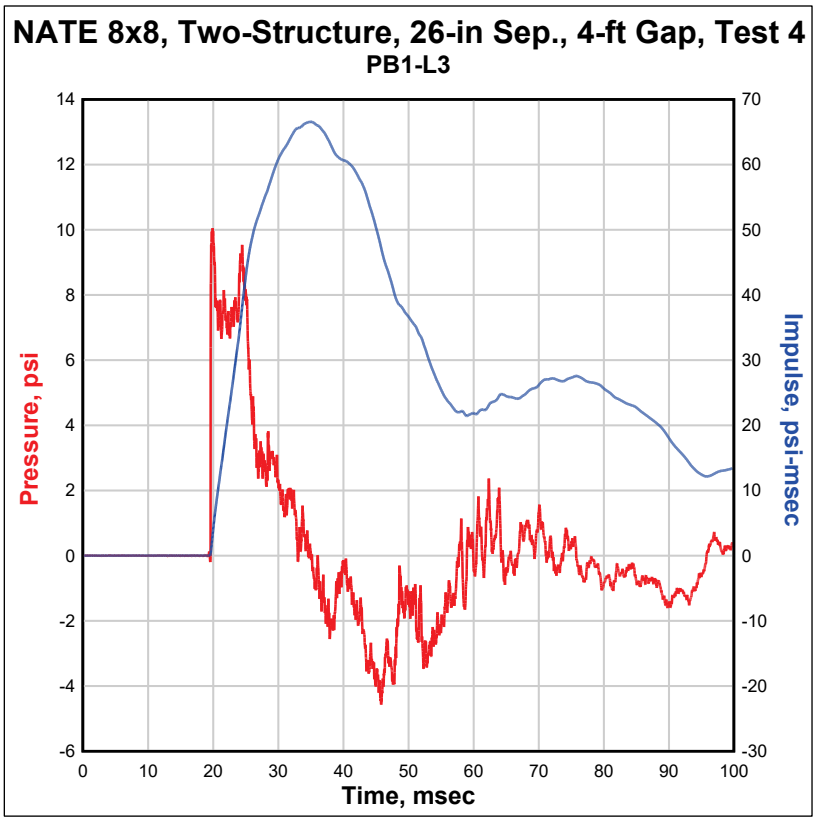
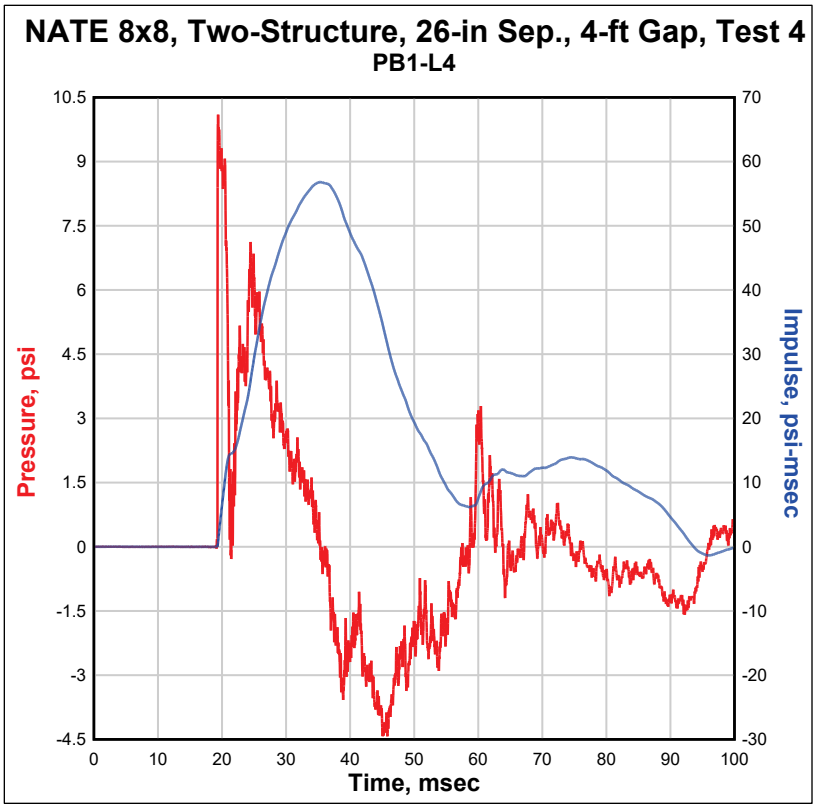
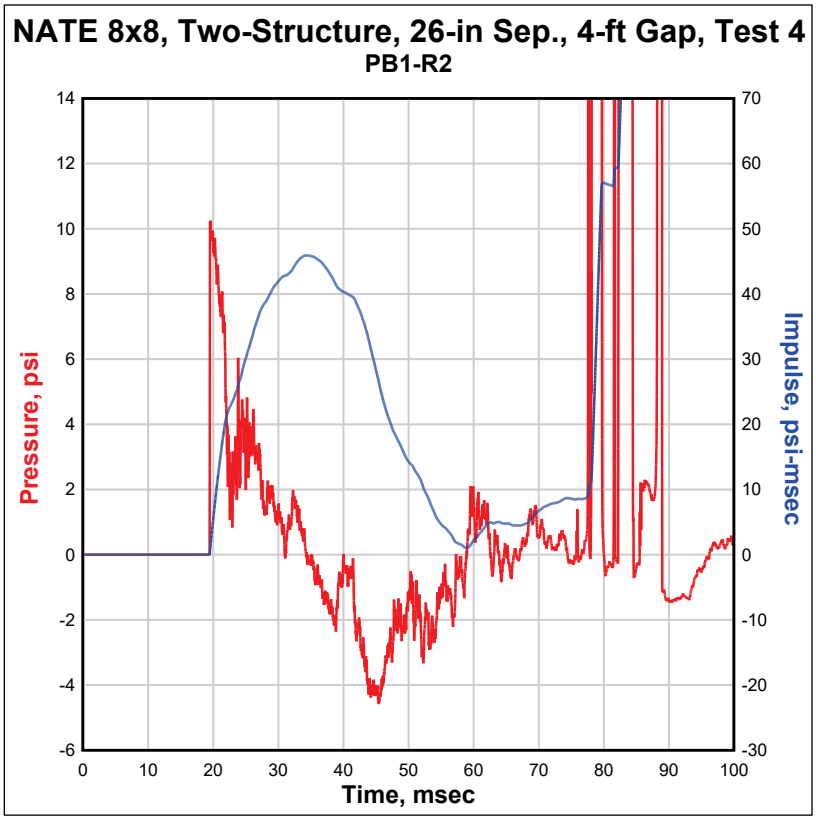
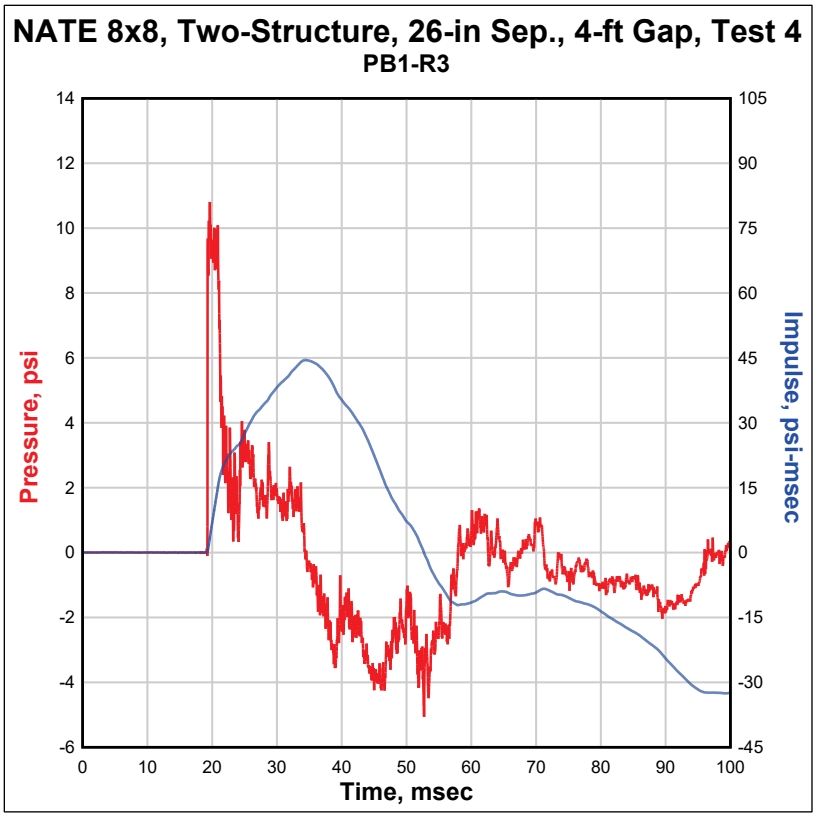
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
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0
-15
-30
-45
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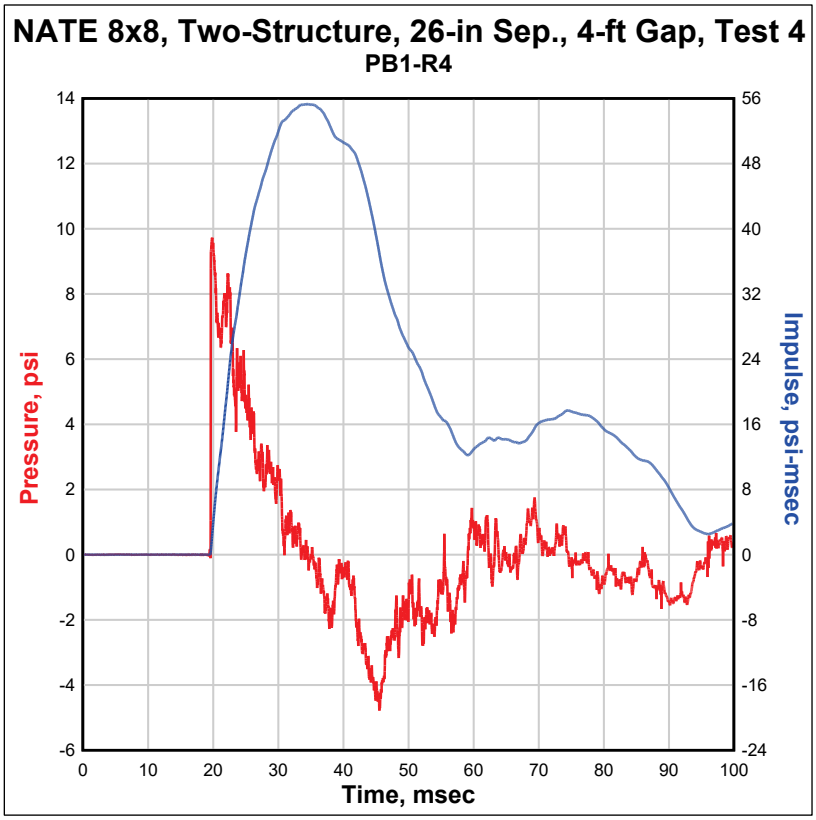
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
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30
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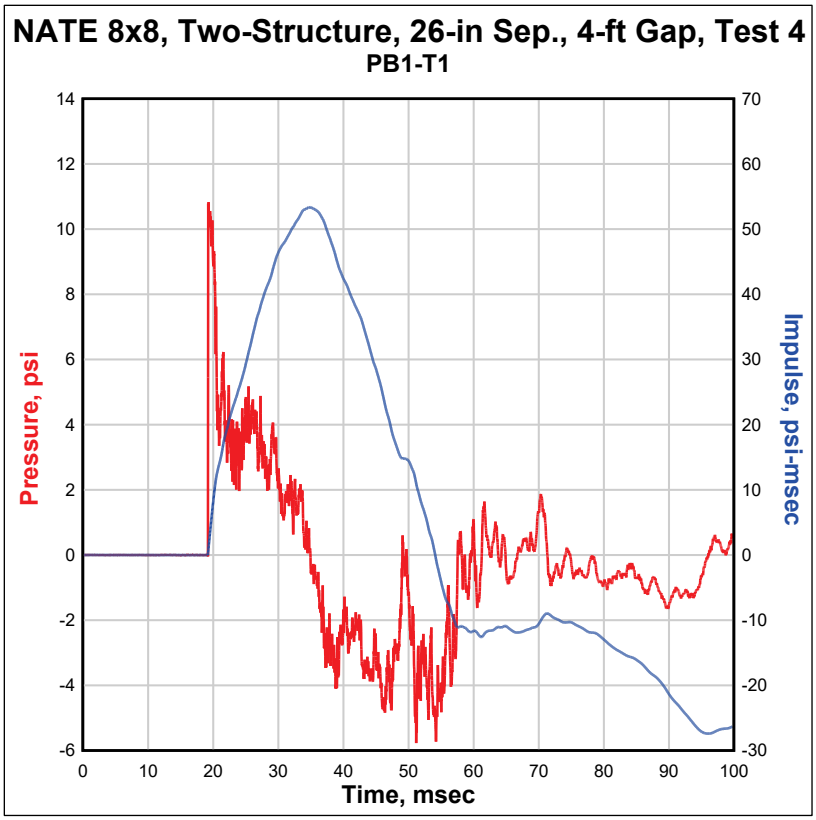
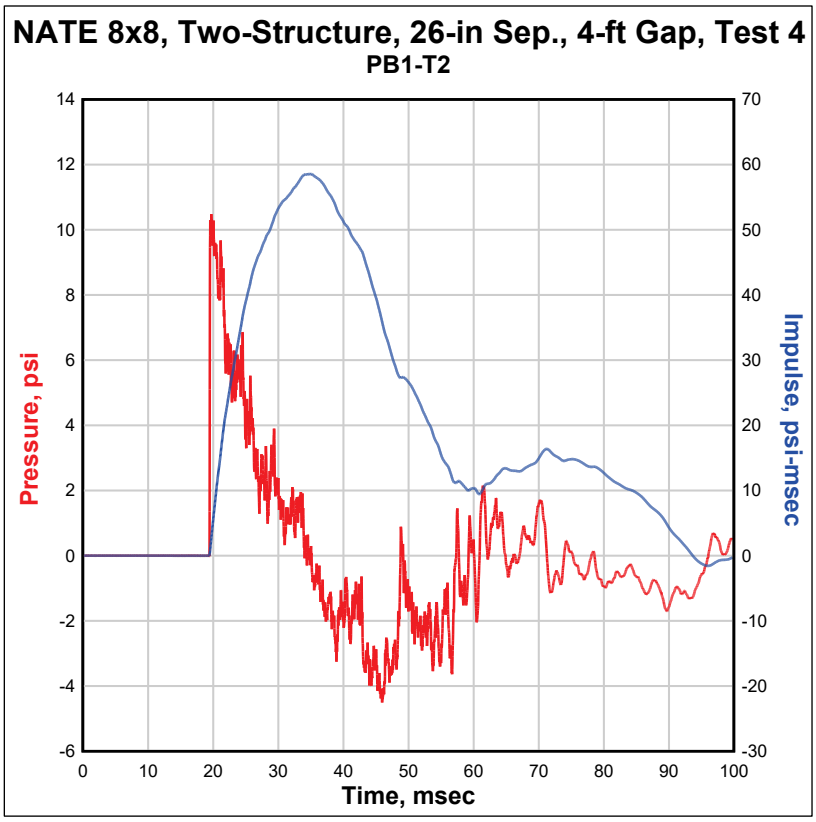
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
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30
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60
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90
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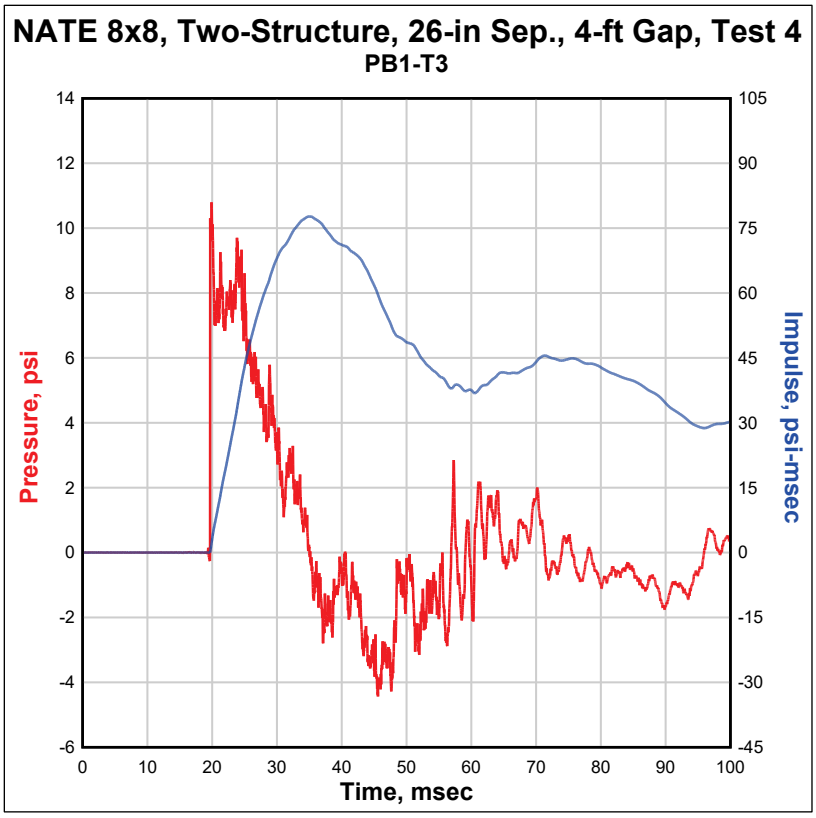
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
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60
70
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90
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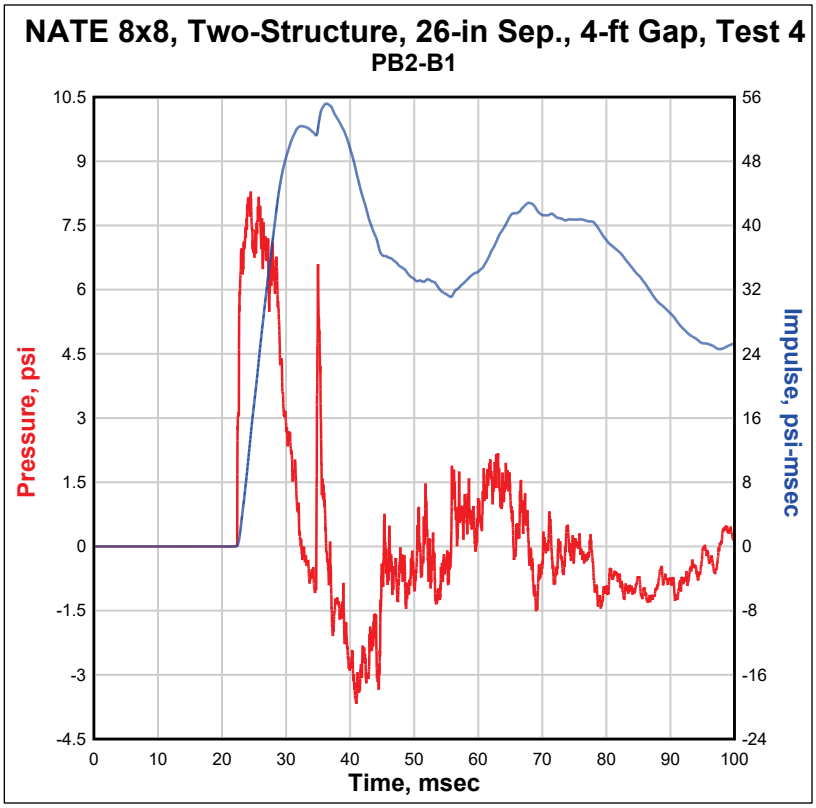
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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0
-8
-16
-24
0
10
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30
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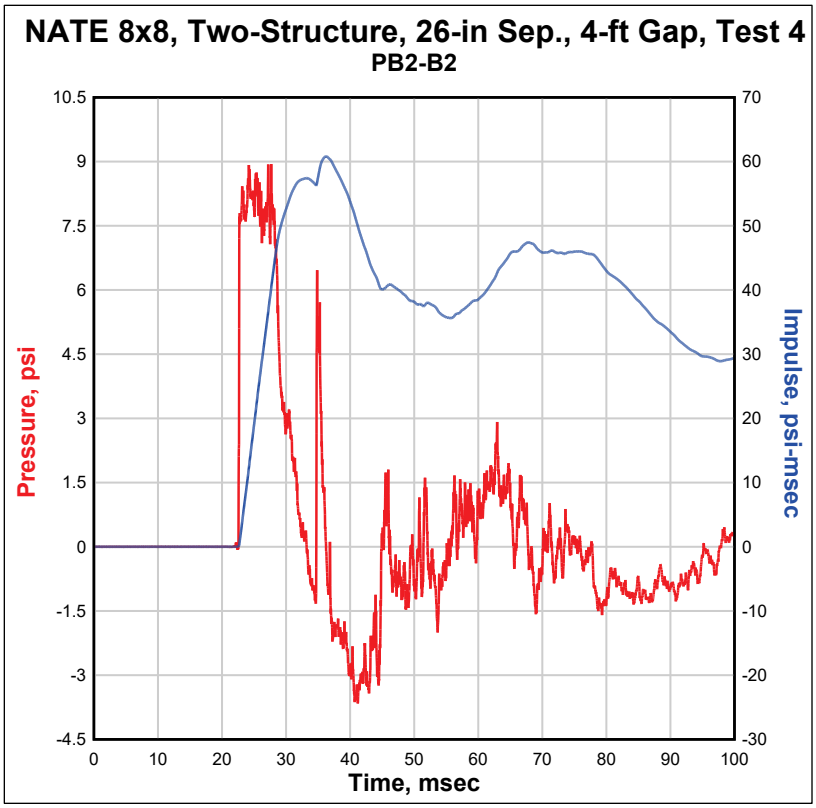
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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-10
-20
-30
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10
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60
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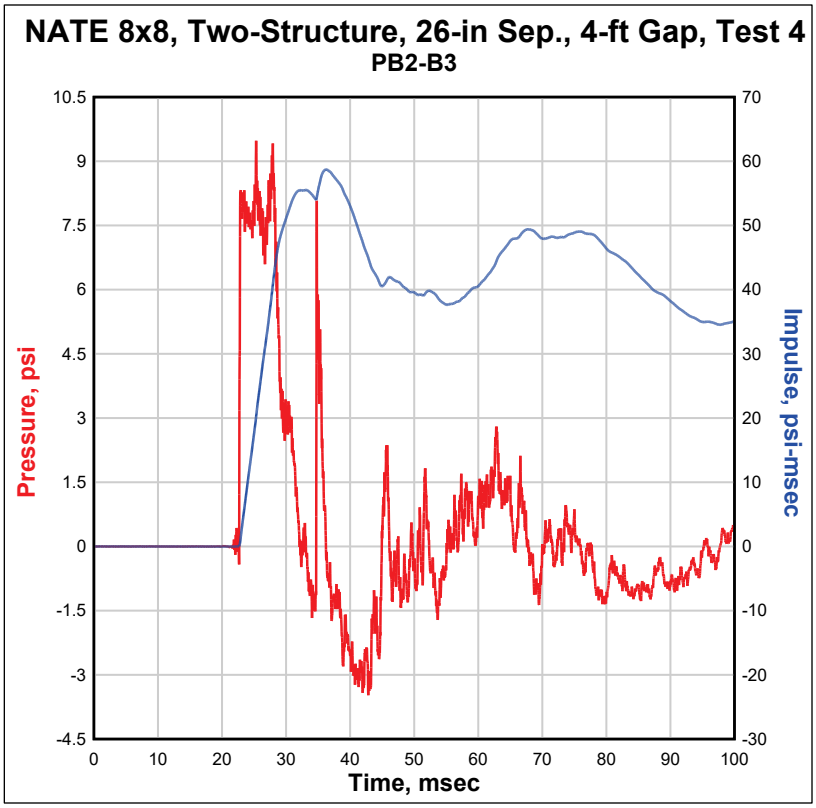
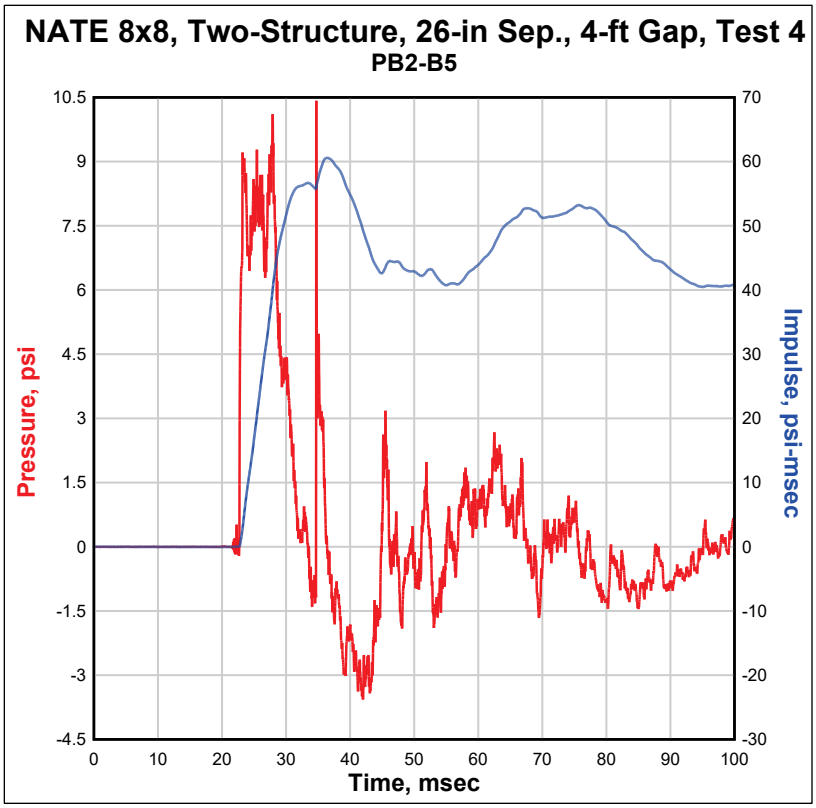
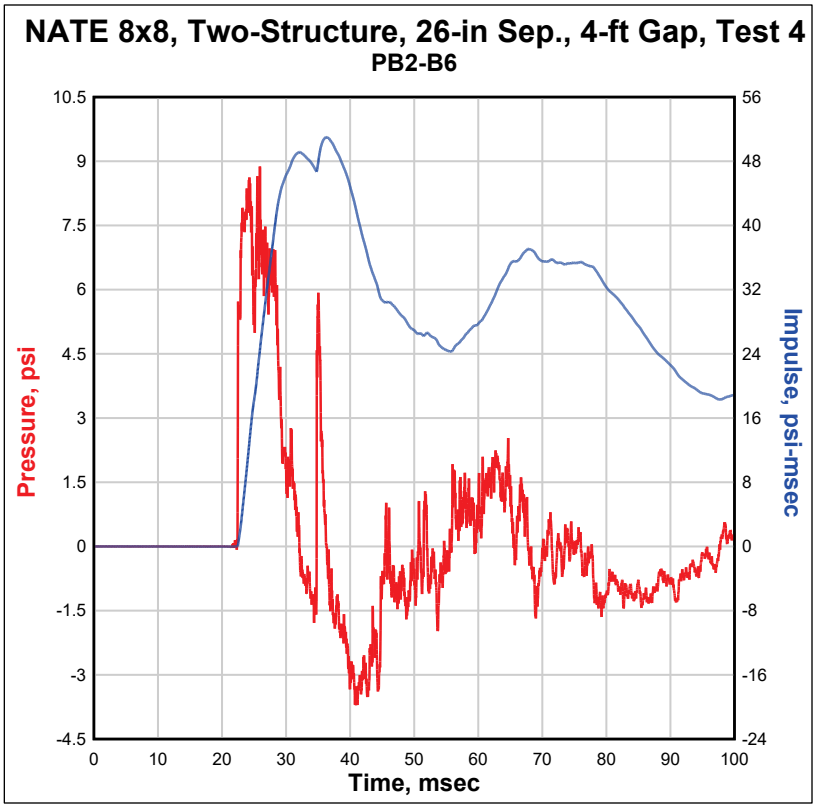
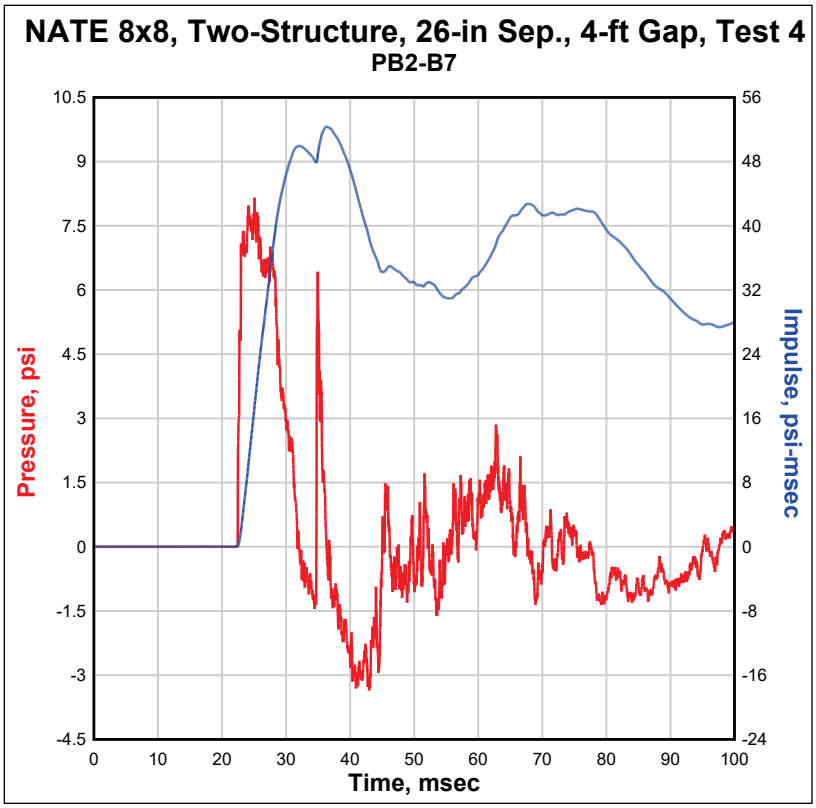
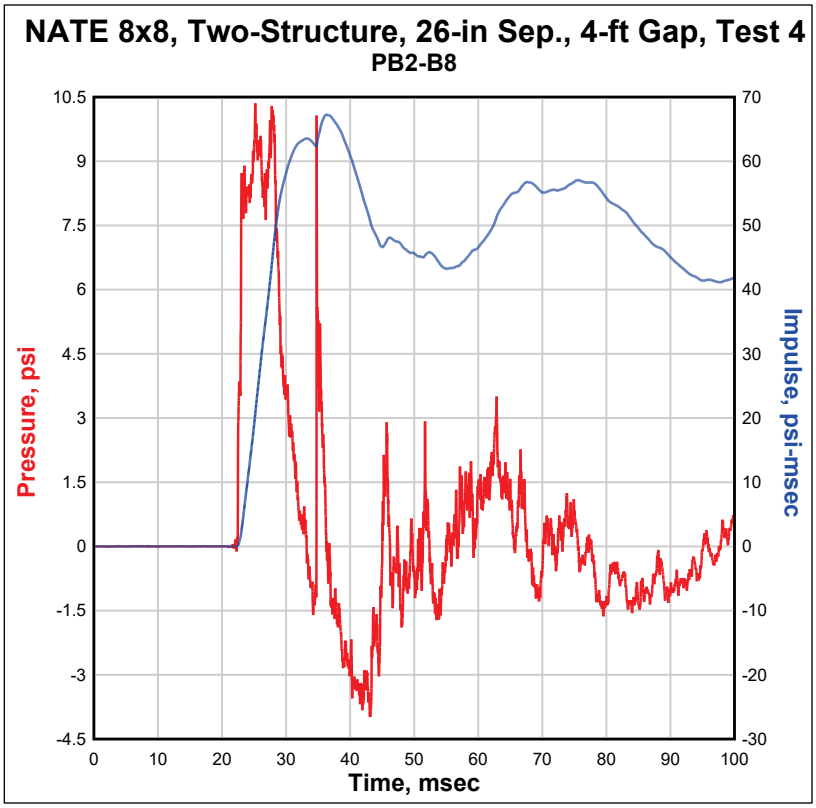
80
90
100

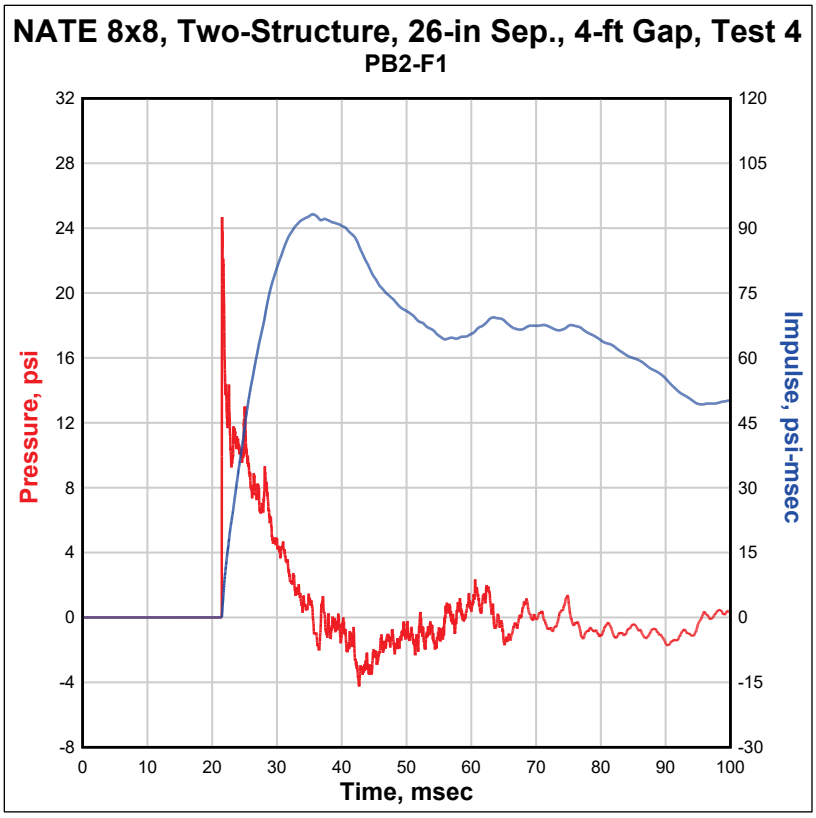

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

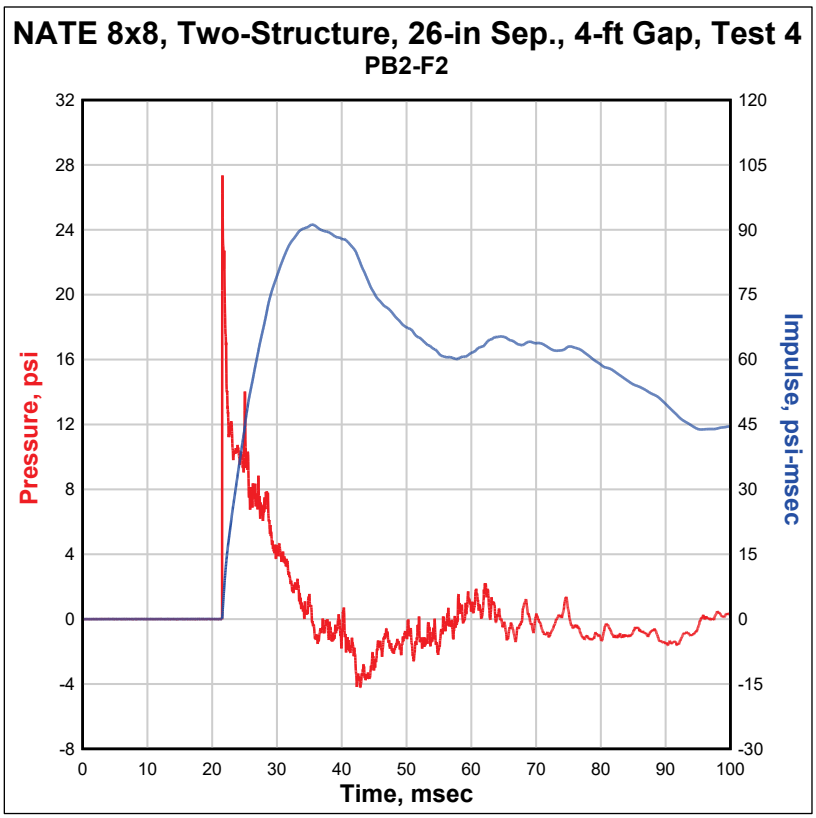

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
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15
0
-15
-30
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70
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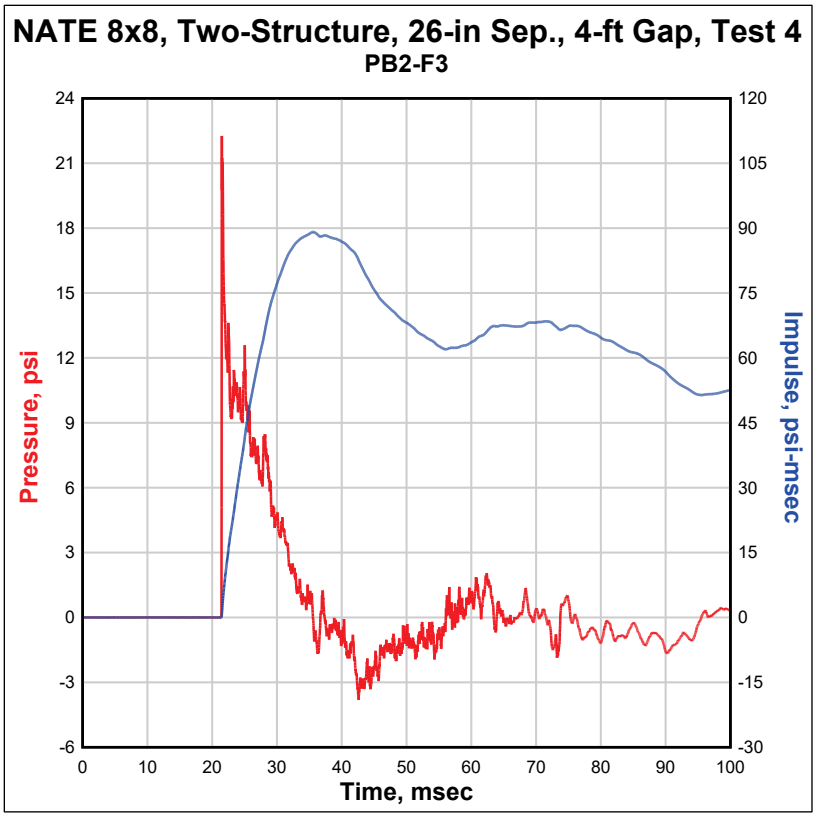
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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40
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90
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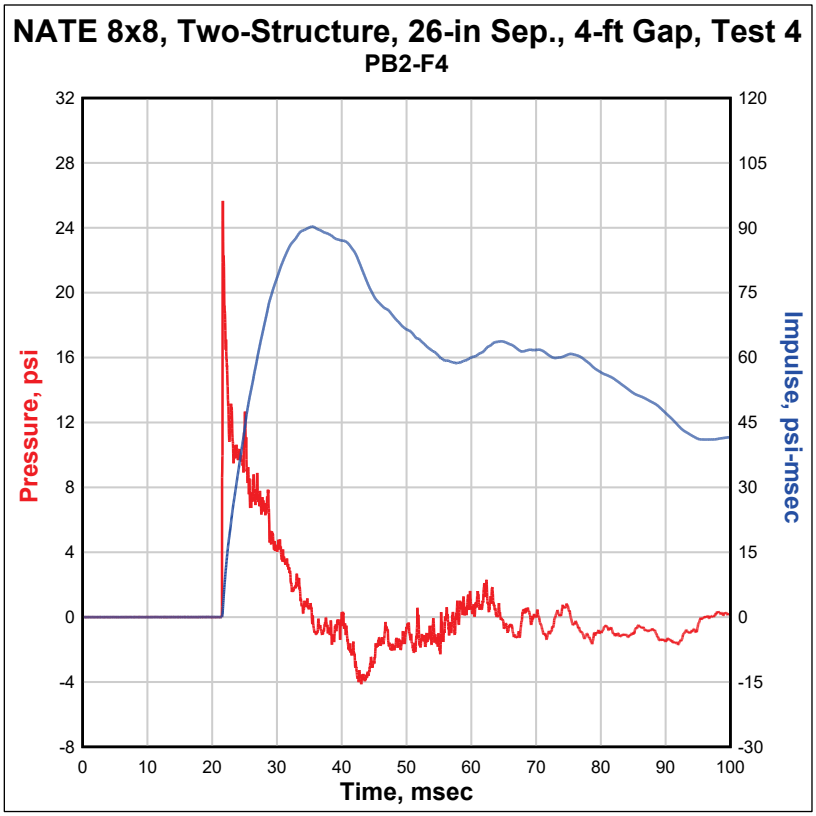
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
40
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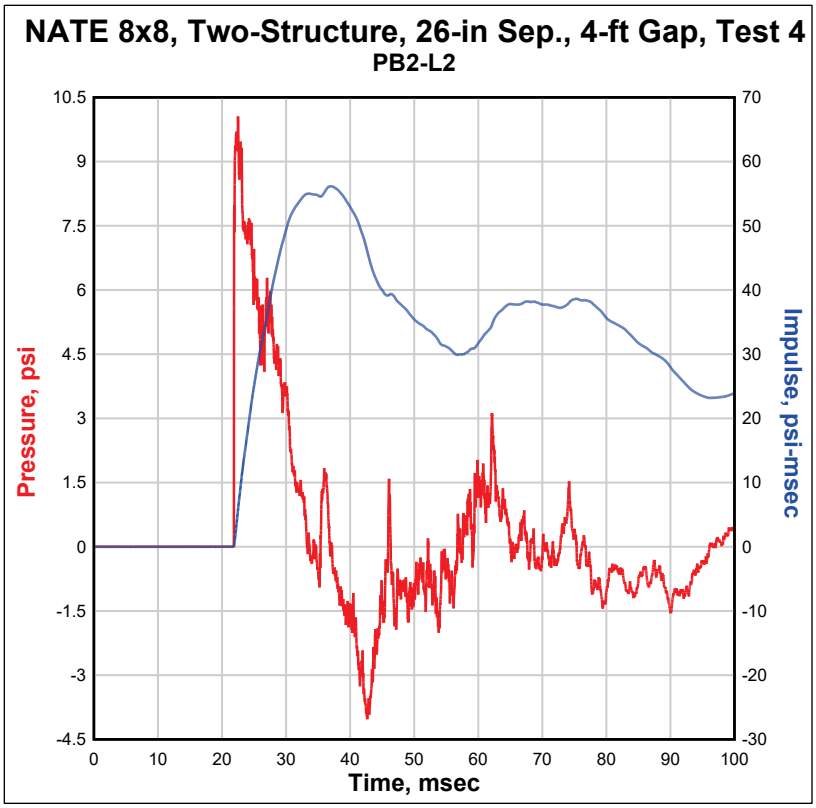
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
20
30
40
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60
70
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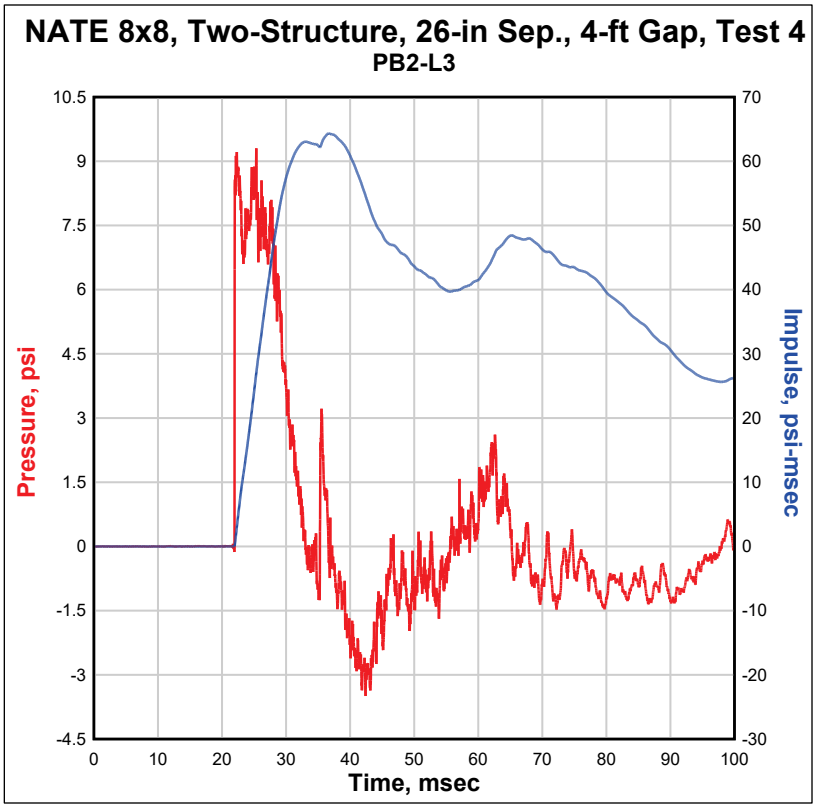
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
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30
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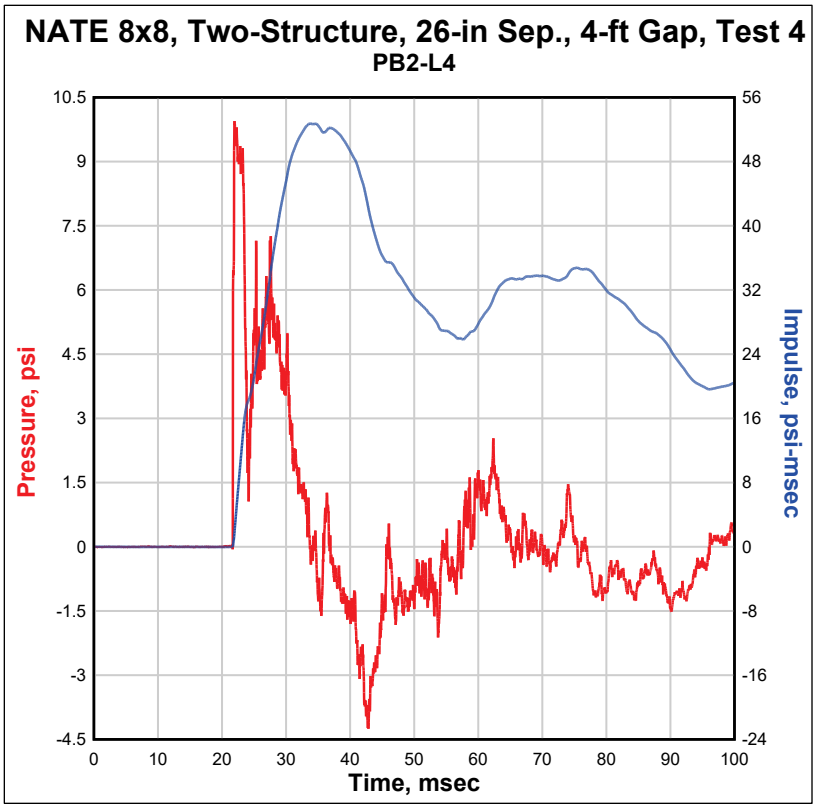
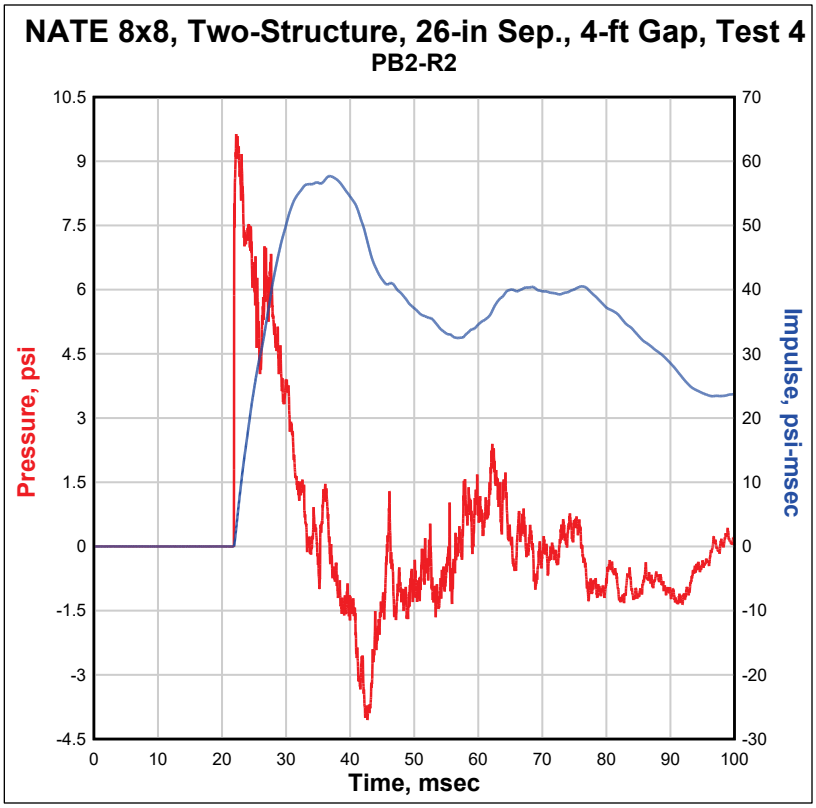
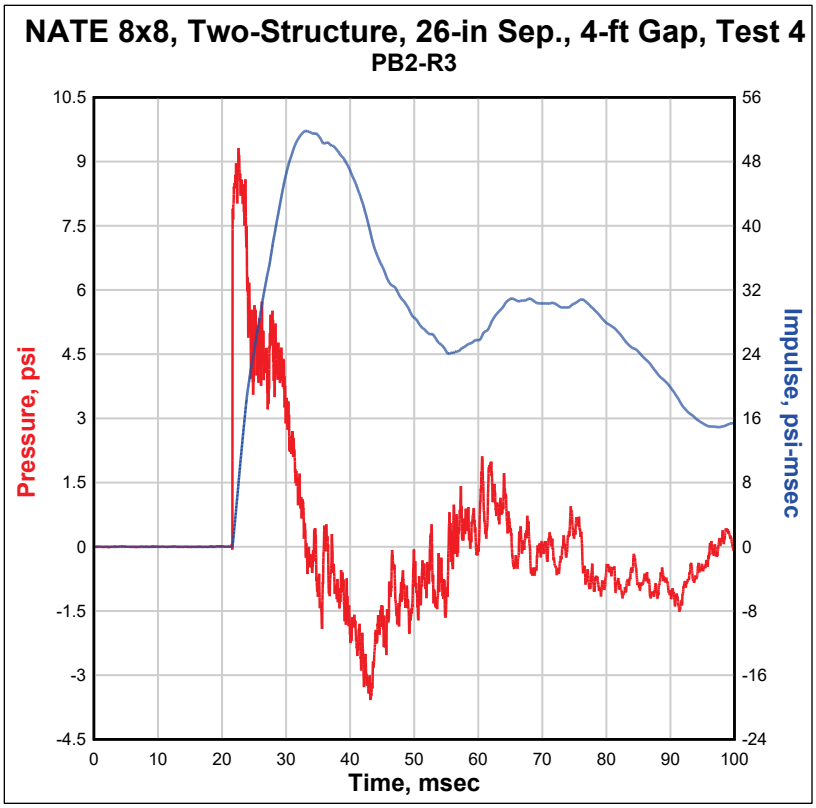
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
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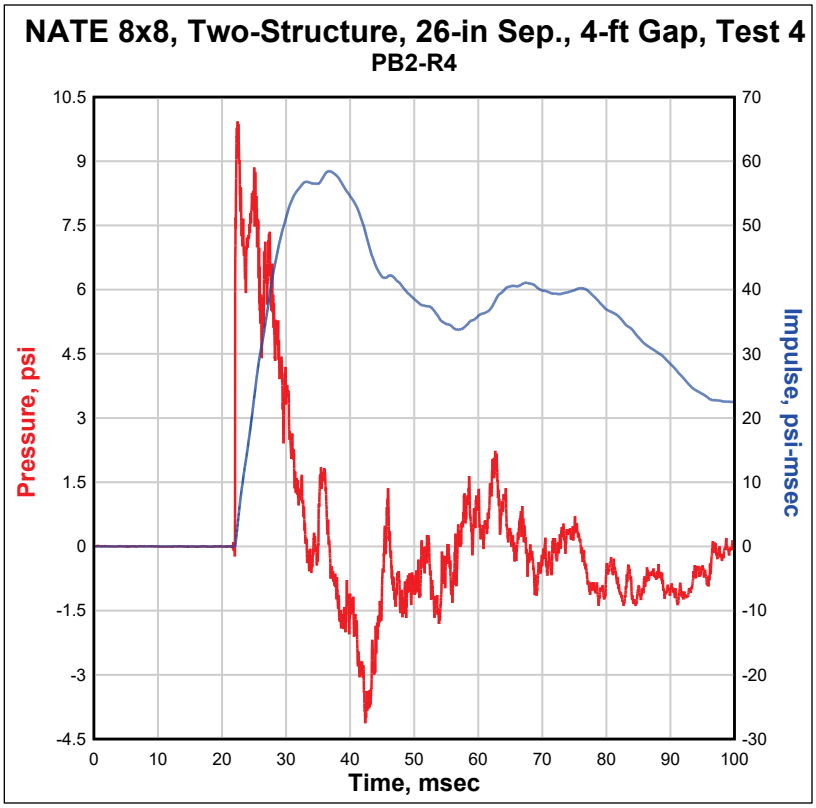
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
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30
40
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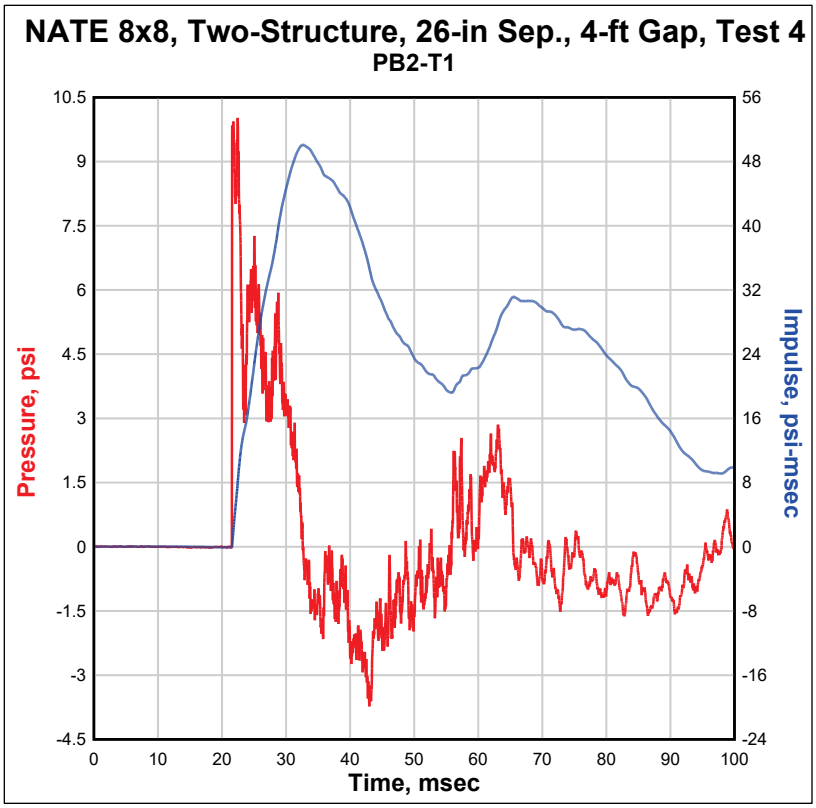
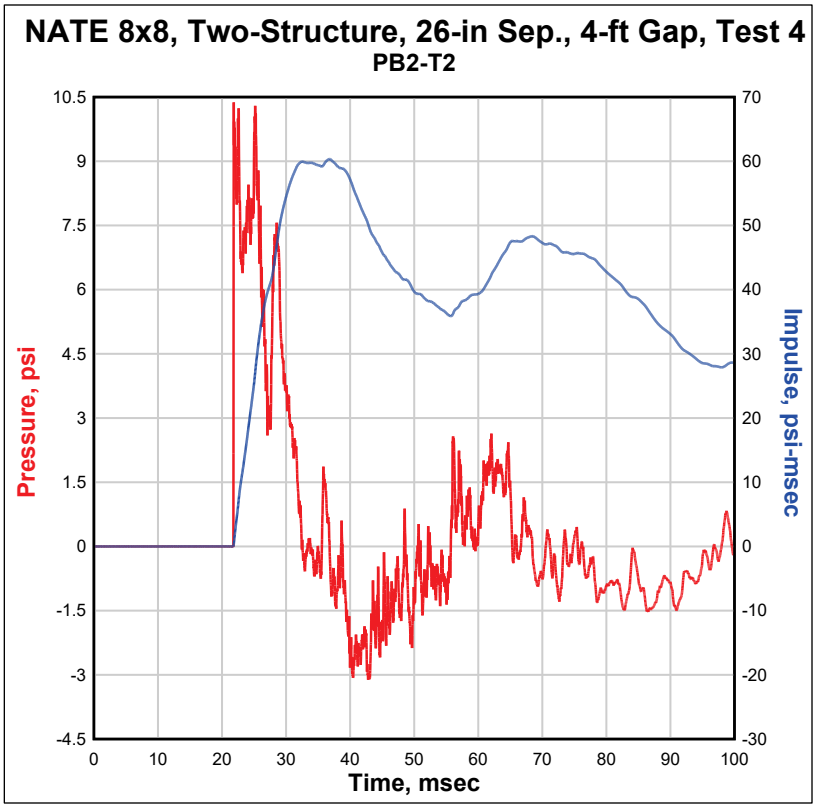
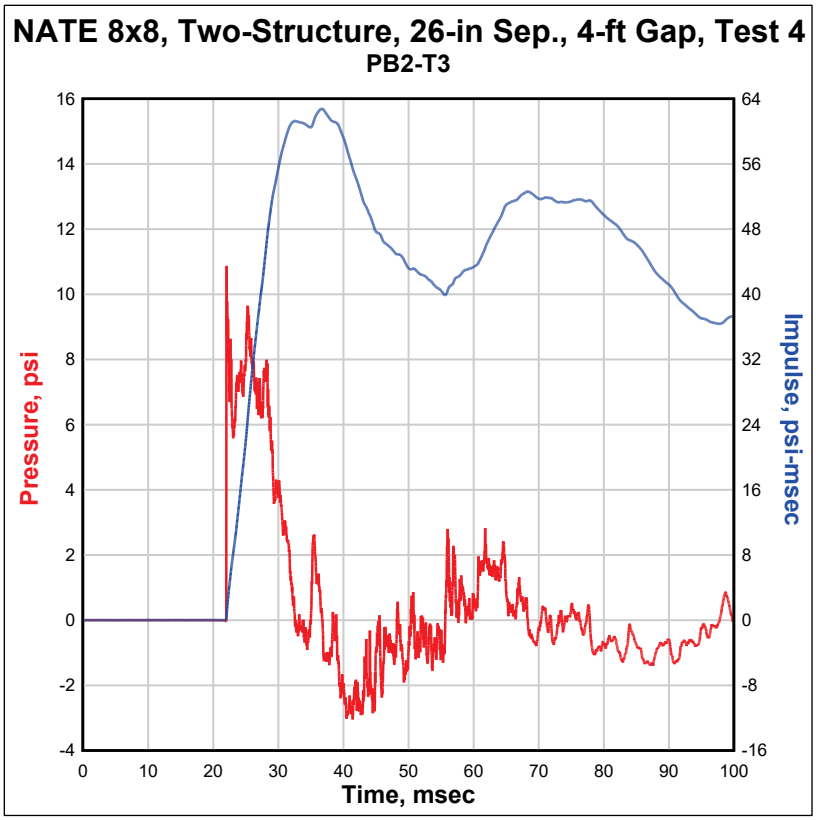
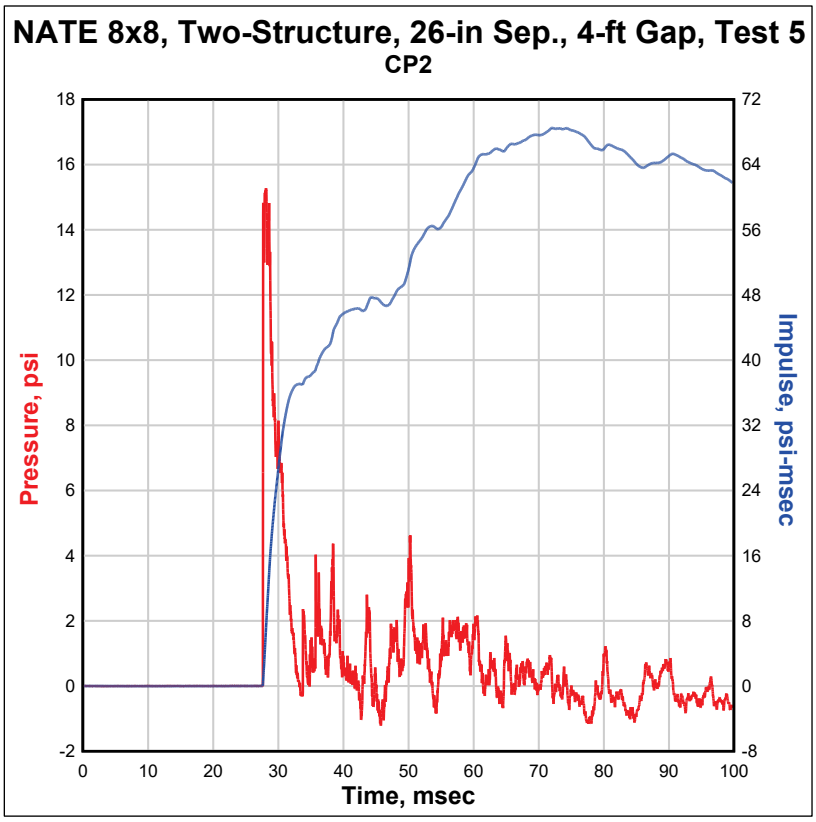
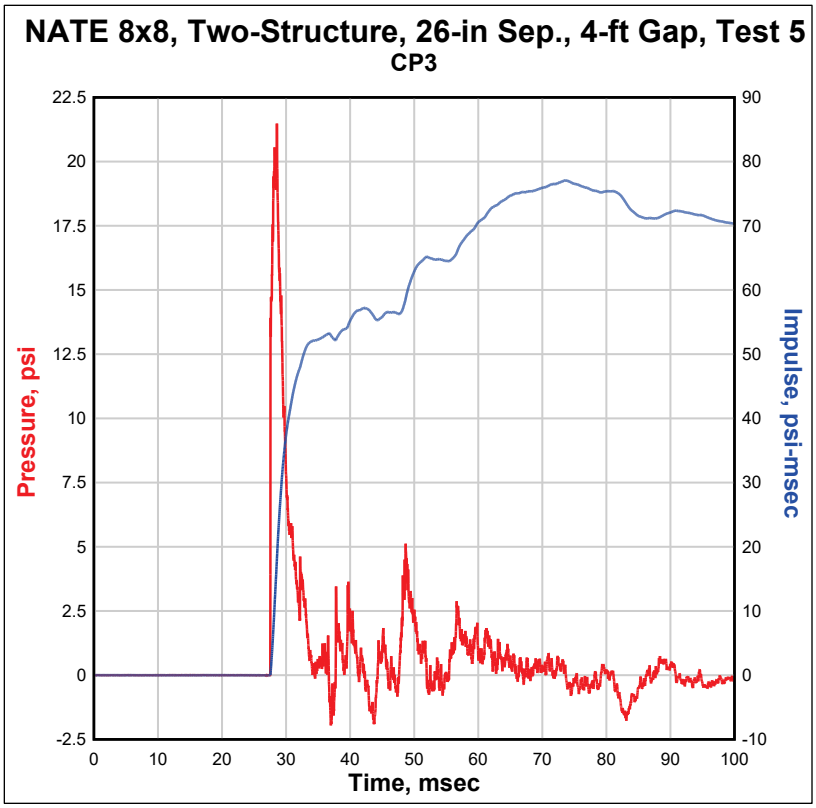
70
80
90
100

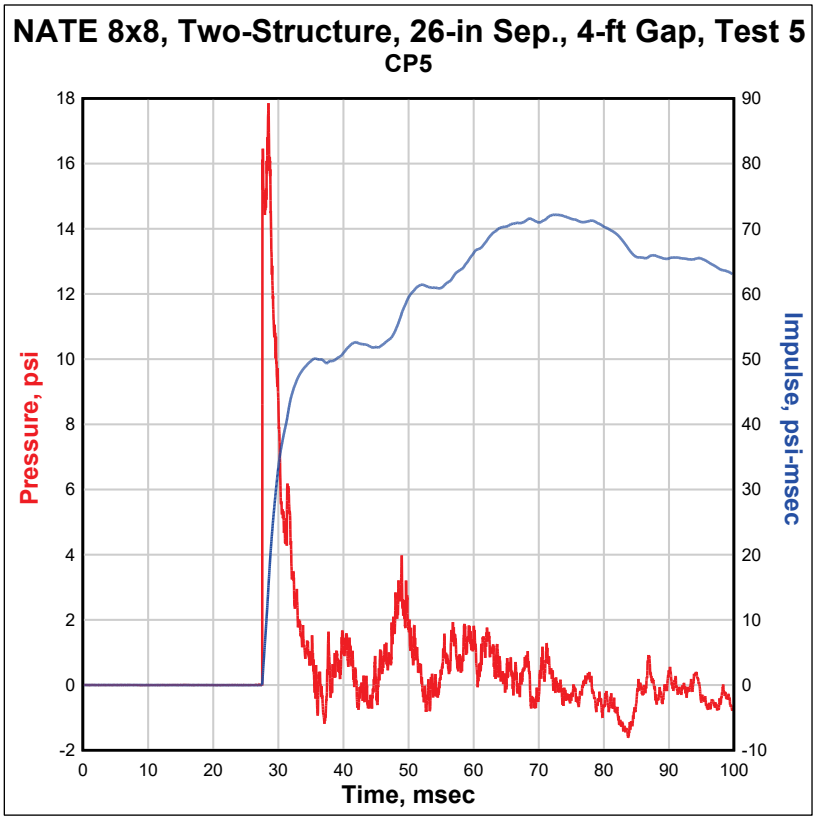

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

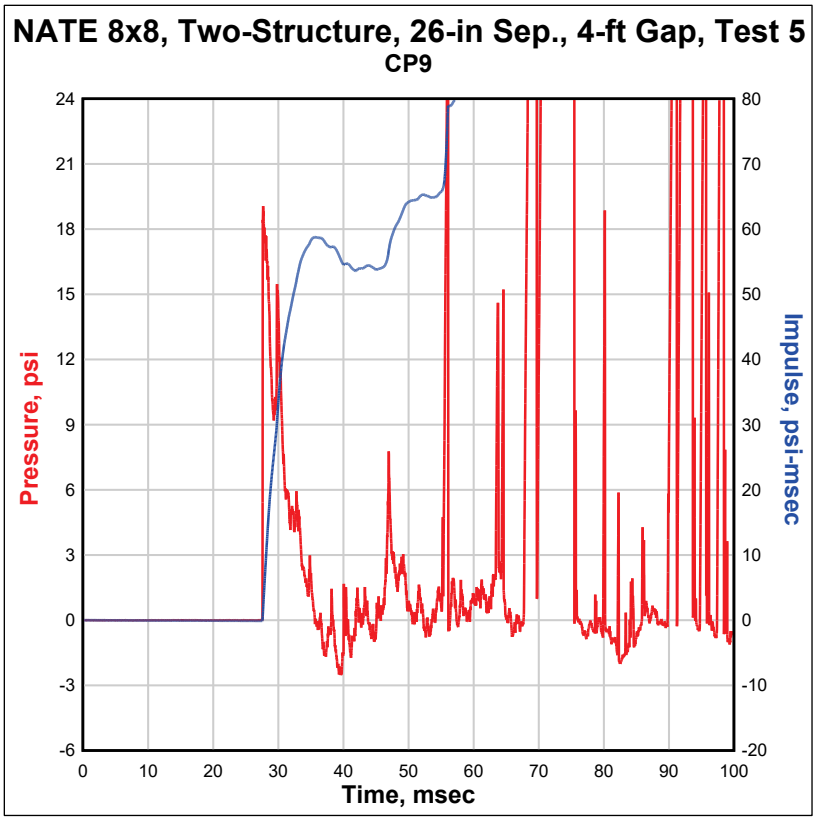

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 4
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
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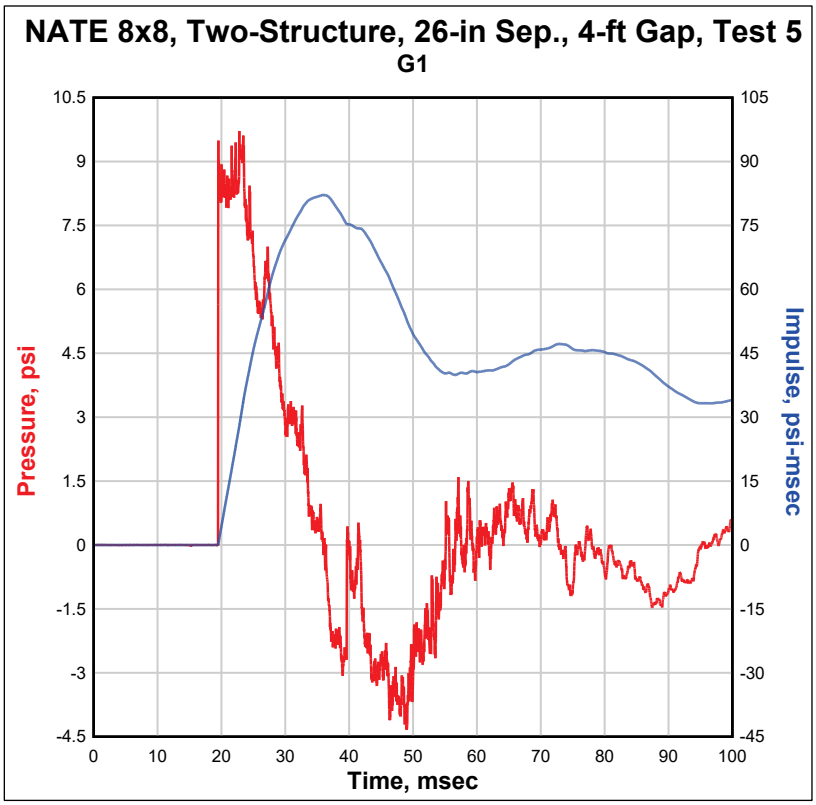
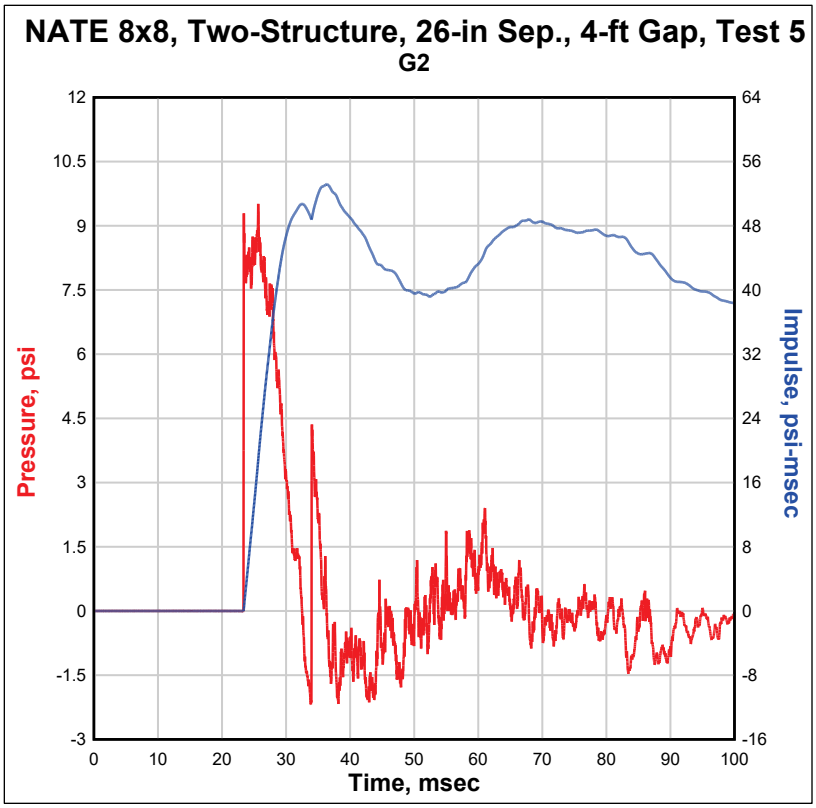
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
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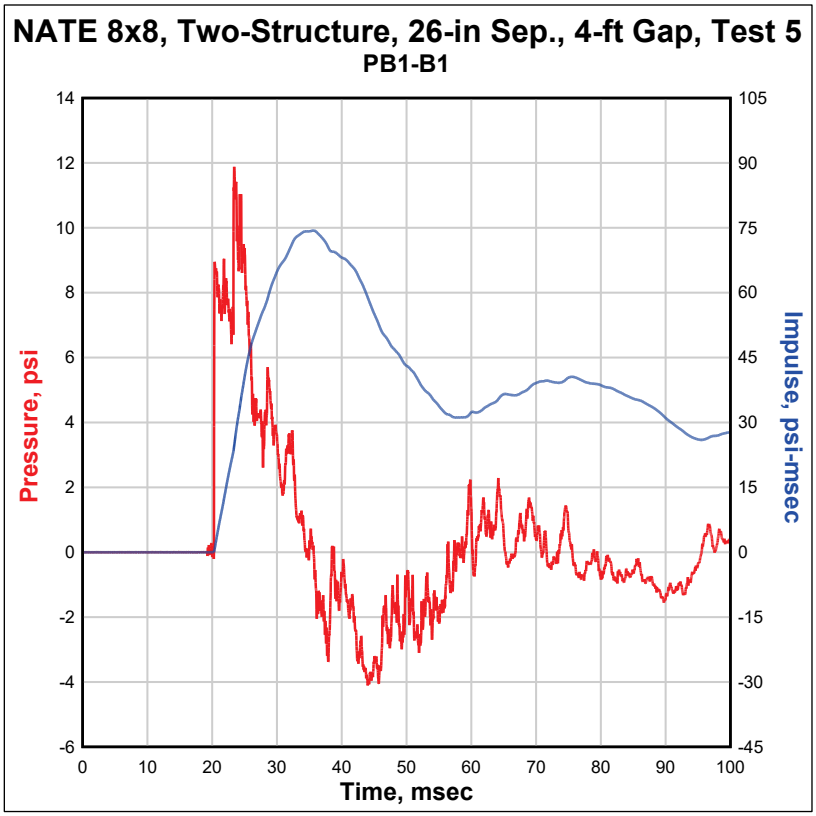
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
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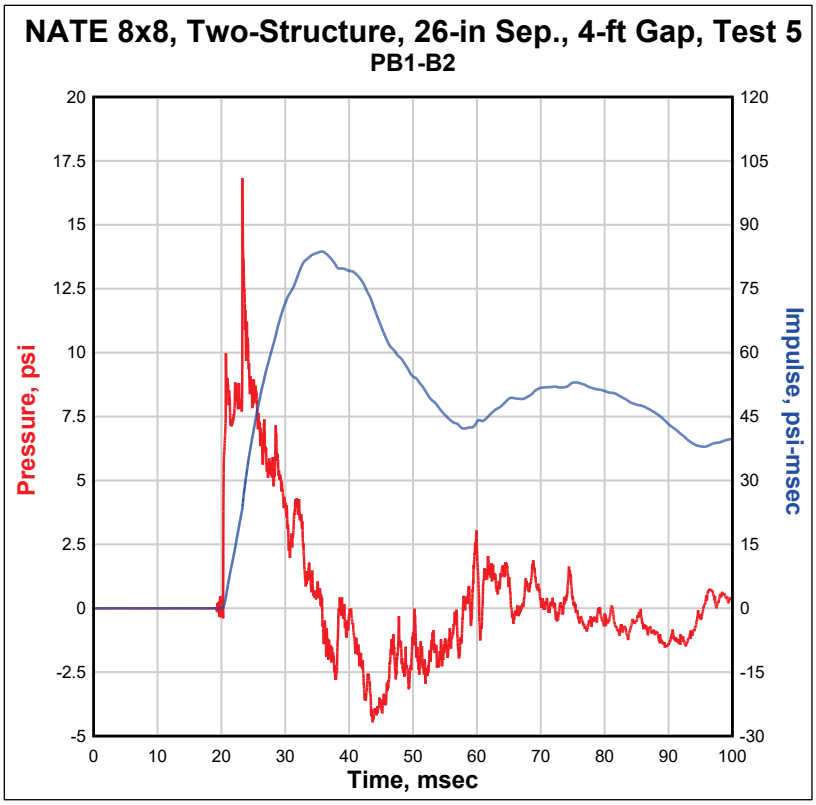
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
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30
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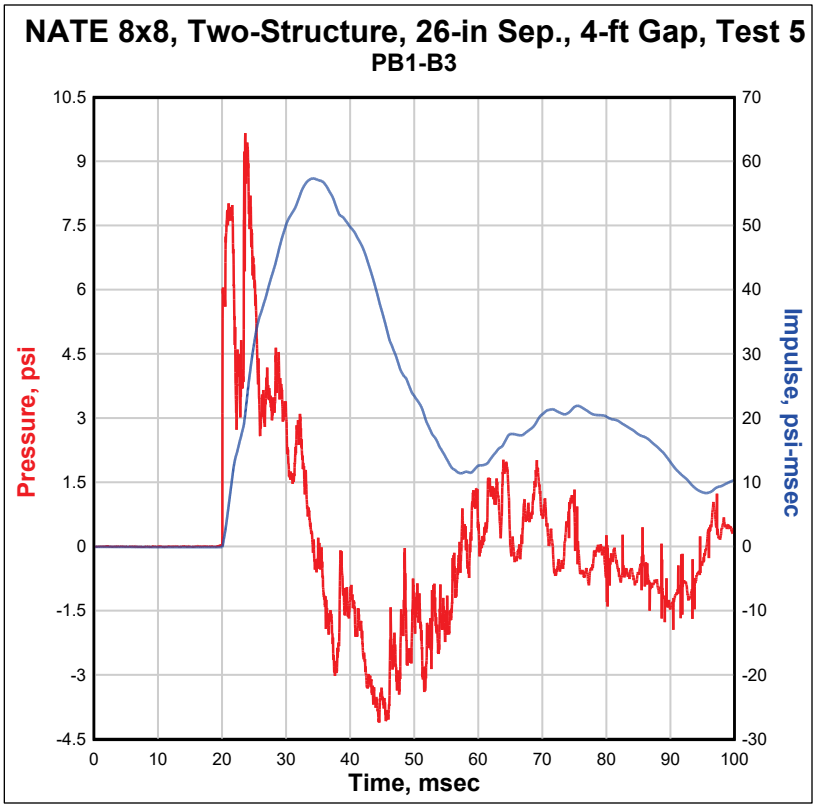
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
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-30
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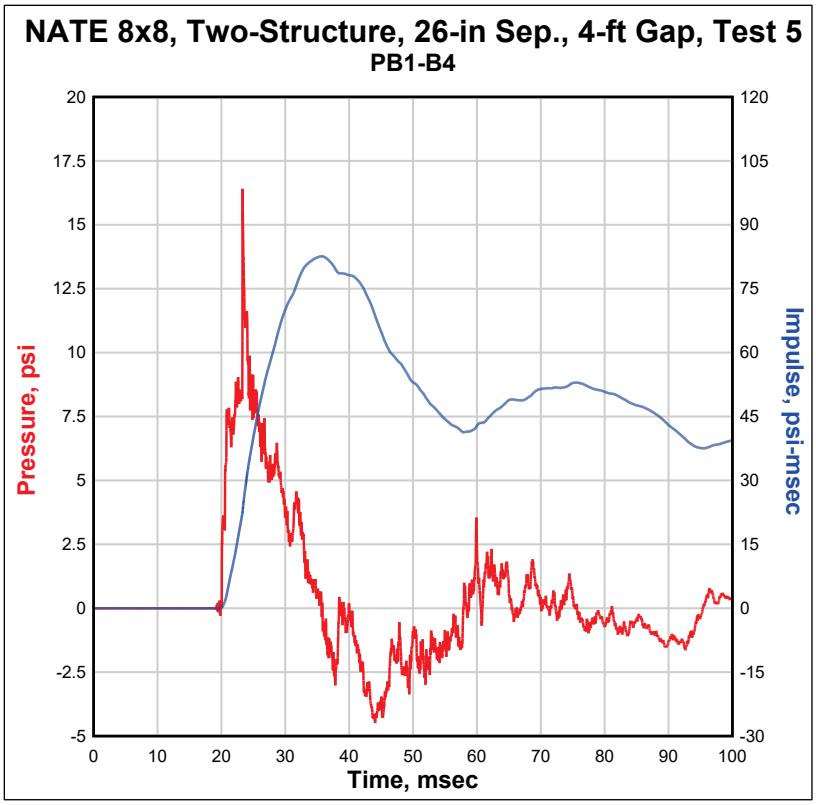
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
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0
-15
-30
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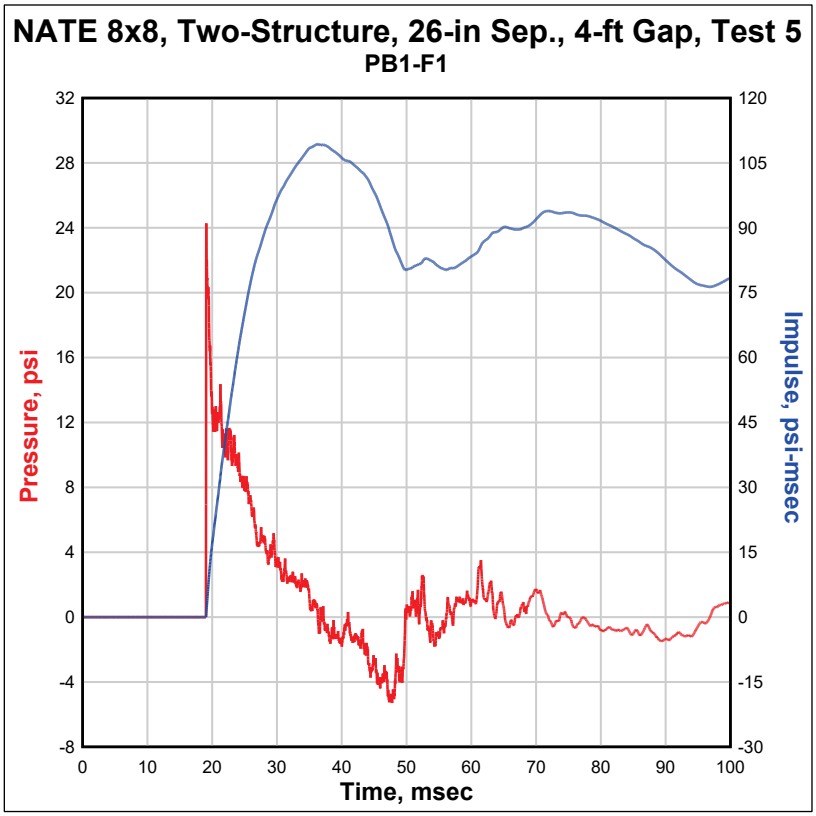
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
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30
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70
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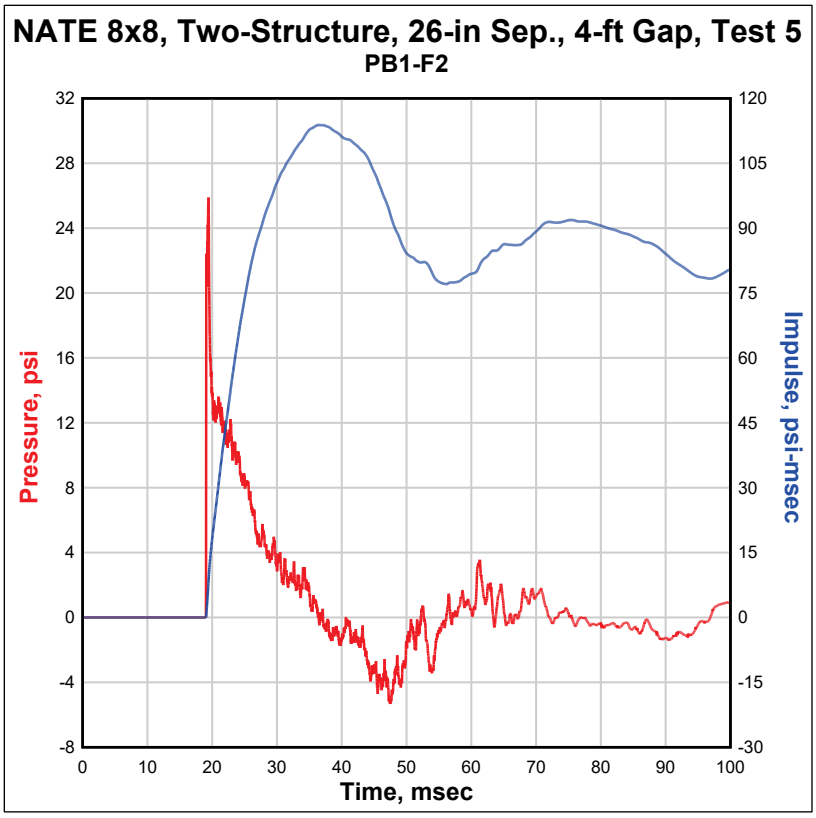
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
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0
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-30
0
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30
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70
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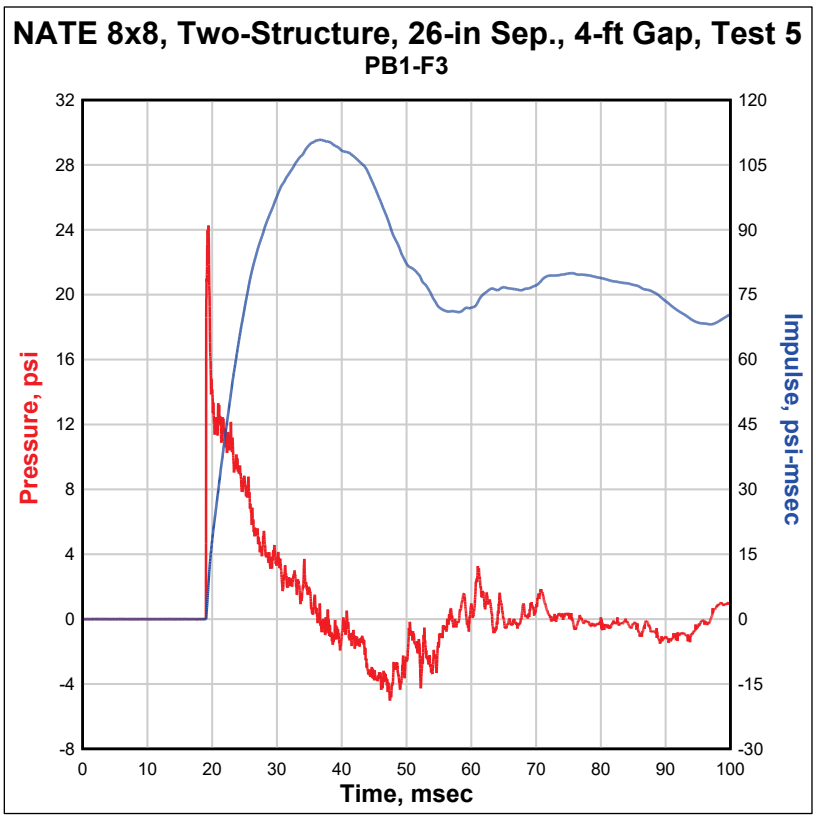
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
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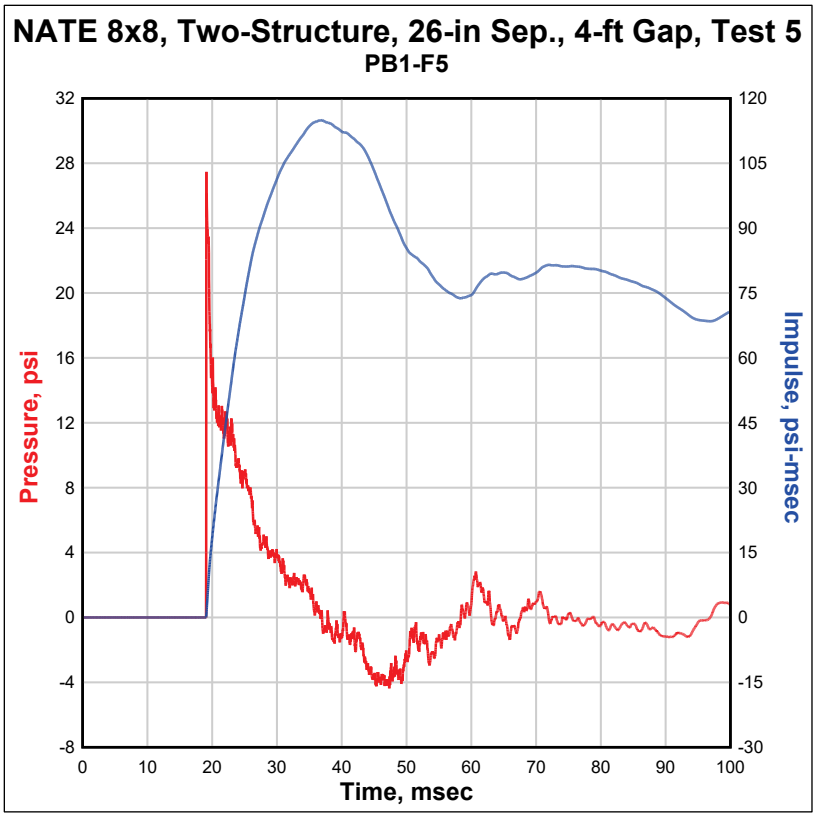
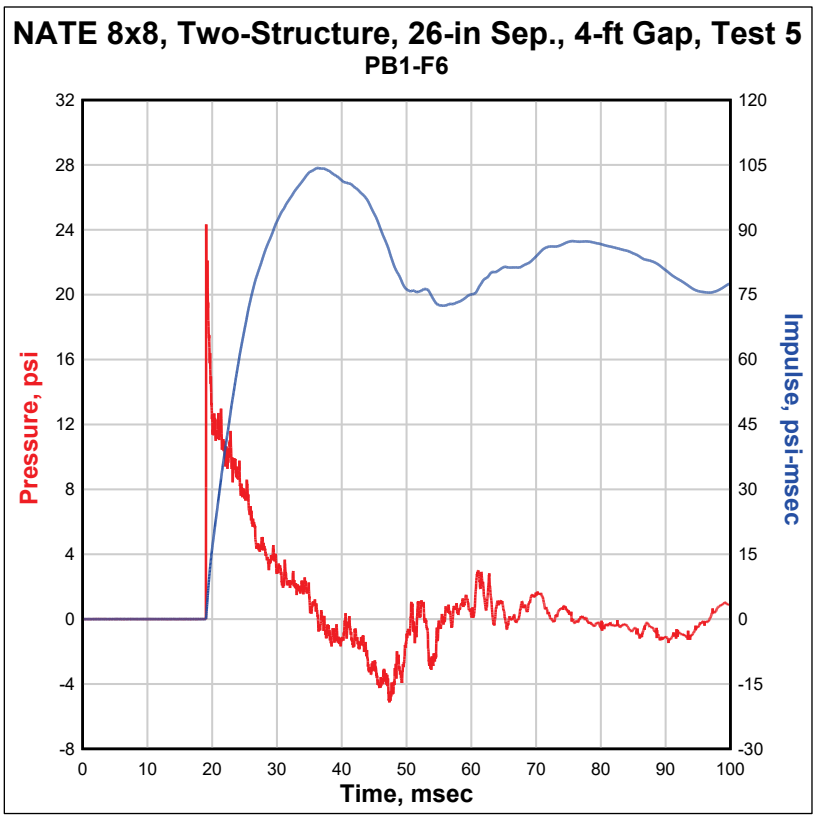
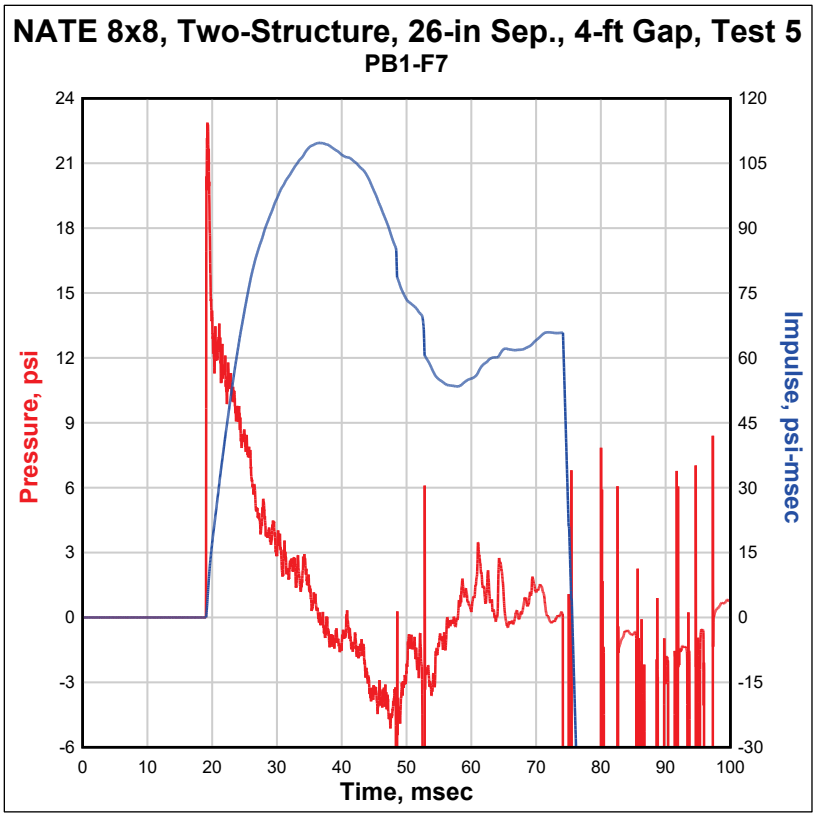
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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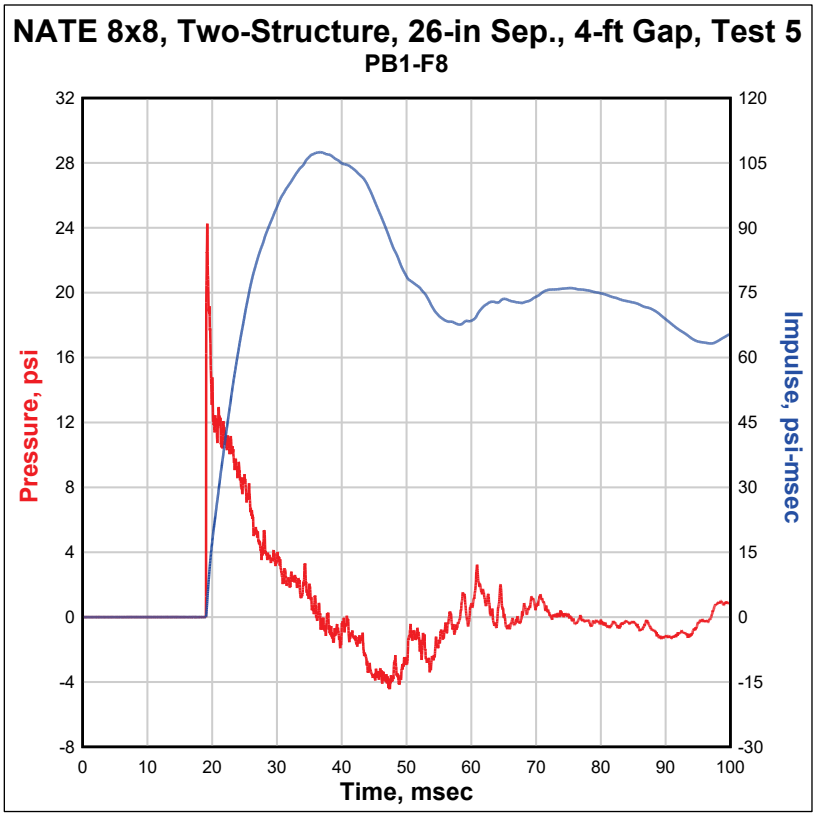
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
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30
15
0
-15
-30
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80
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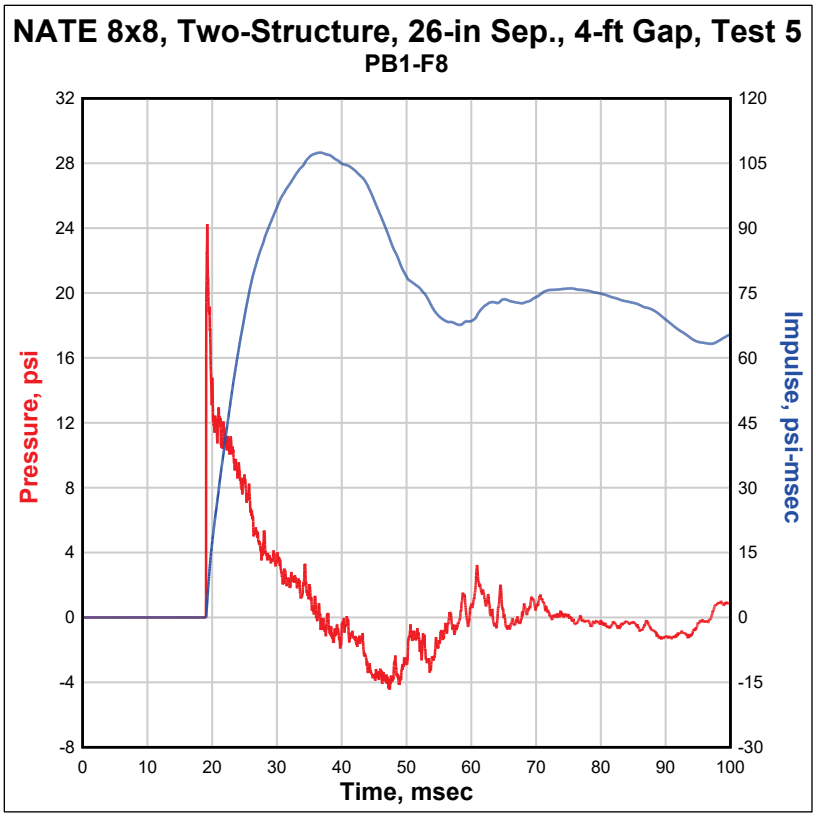
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
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30
15
0
-15
-30
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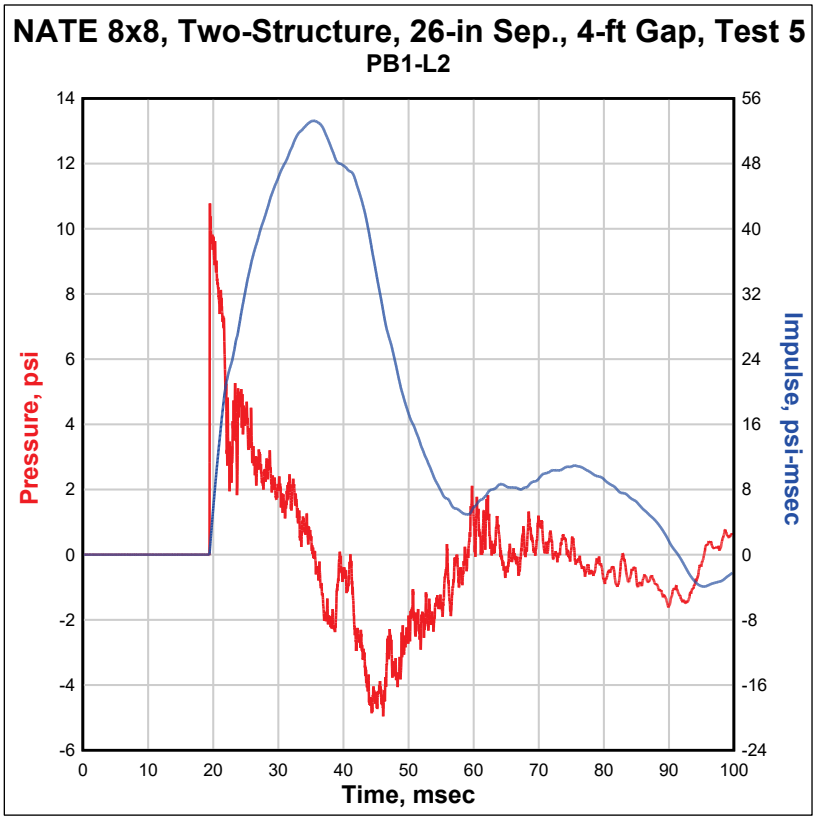
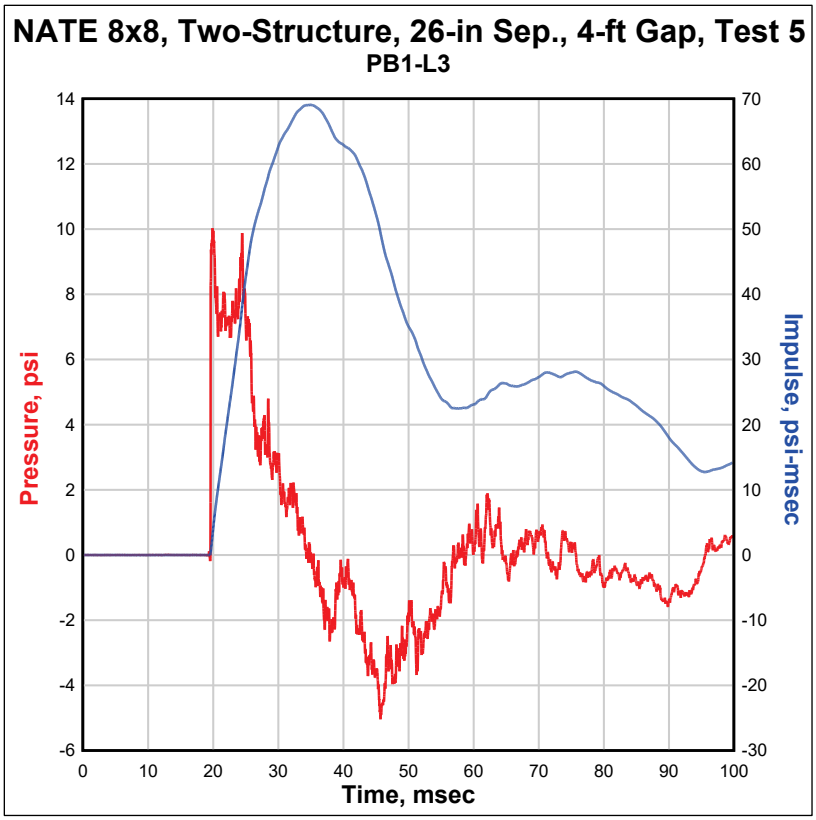

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
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30
20
10
0
-10
-20
-30
0
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30
40
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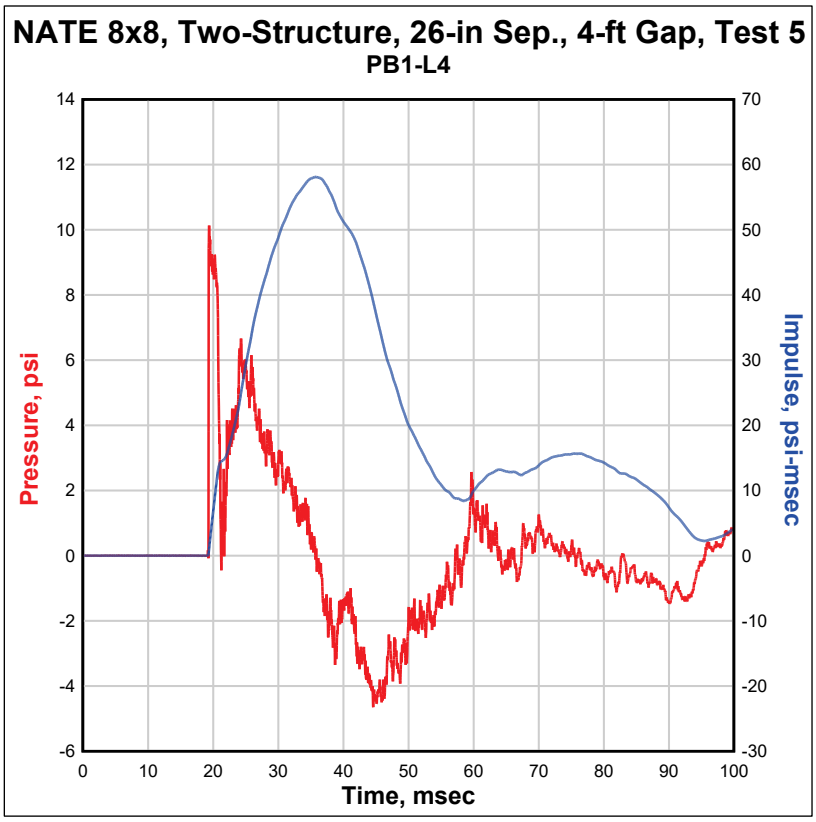
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
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40
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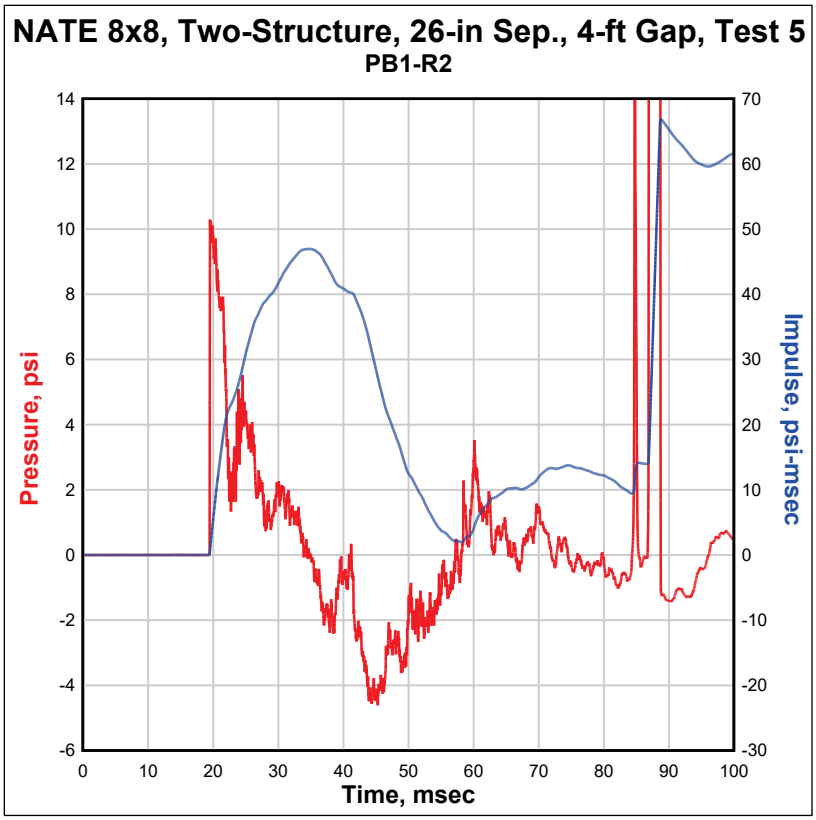
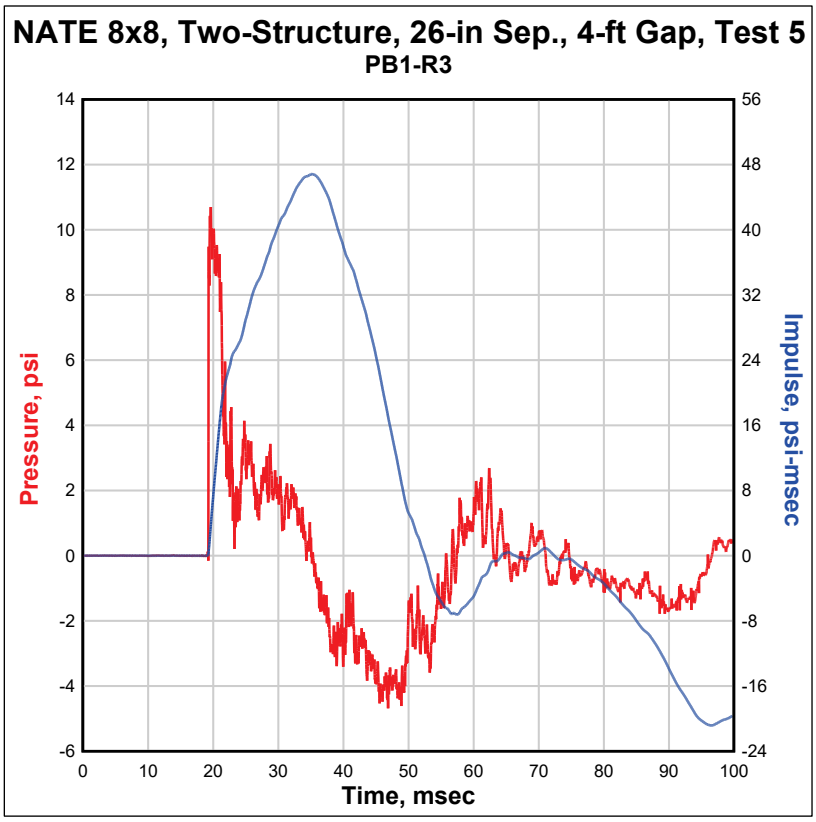
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
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30
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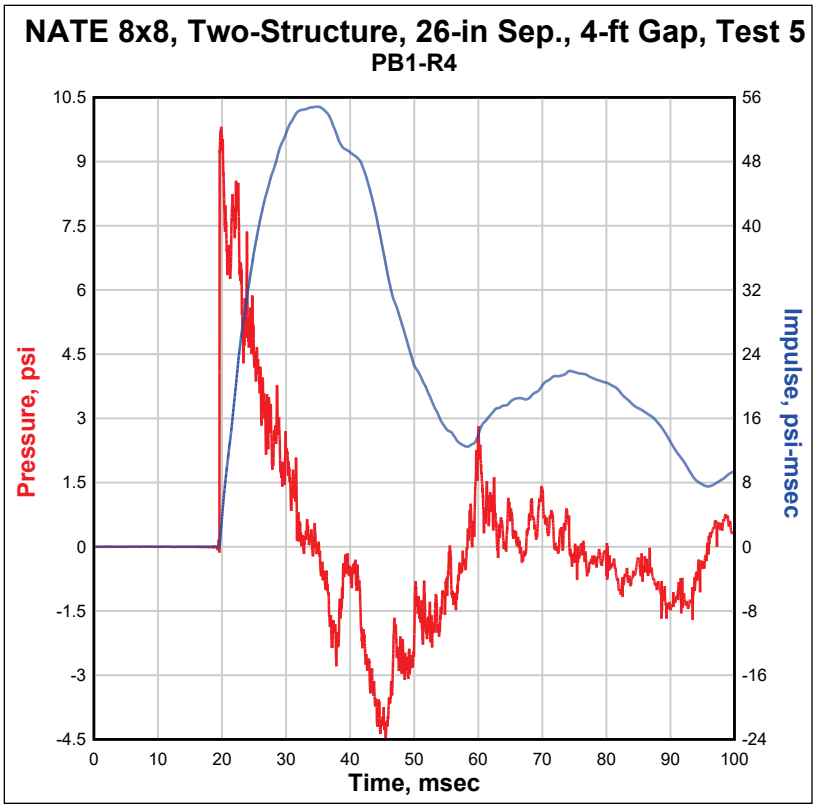
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
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-8
-16
-24
0
10
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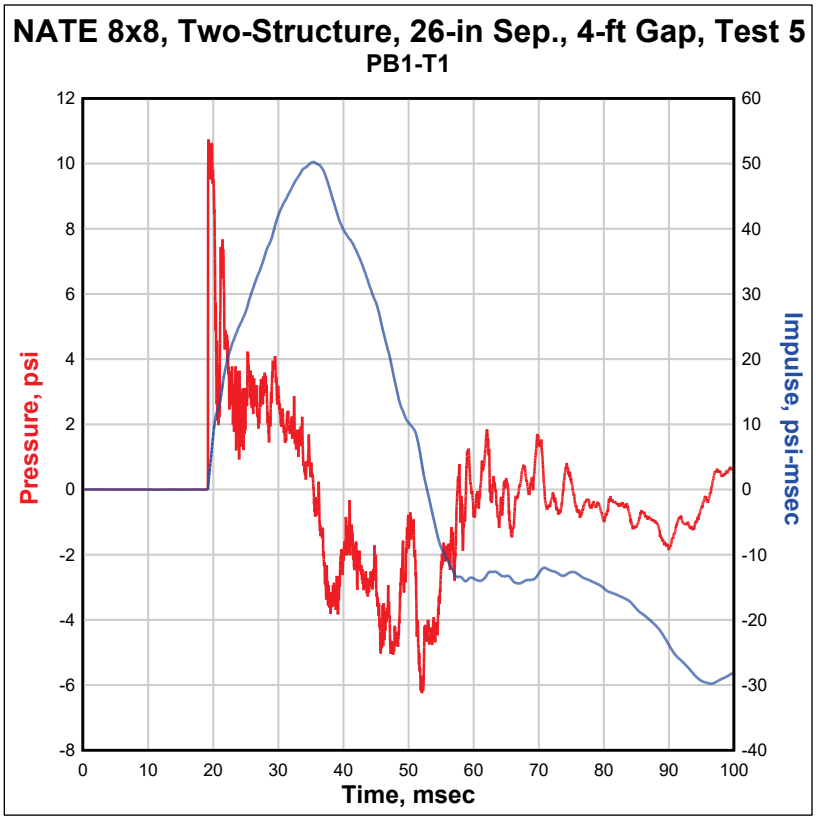
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
60
50
40
30
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-10
-20
-30
-40
0
10
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30
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70
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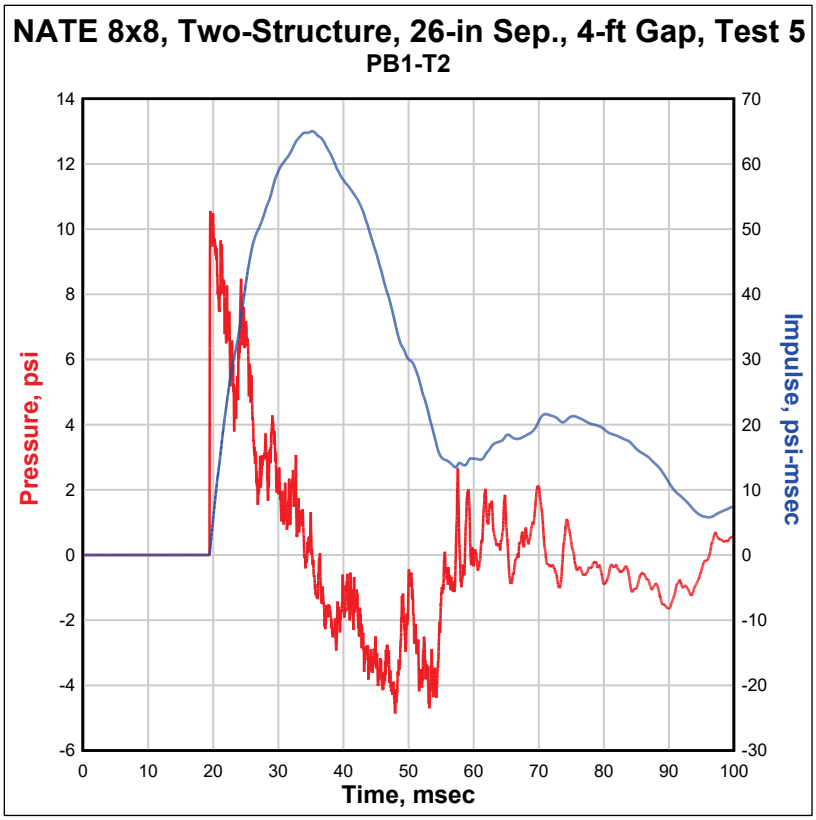
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
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0
-10
-20
-30
0
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30
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70
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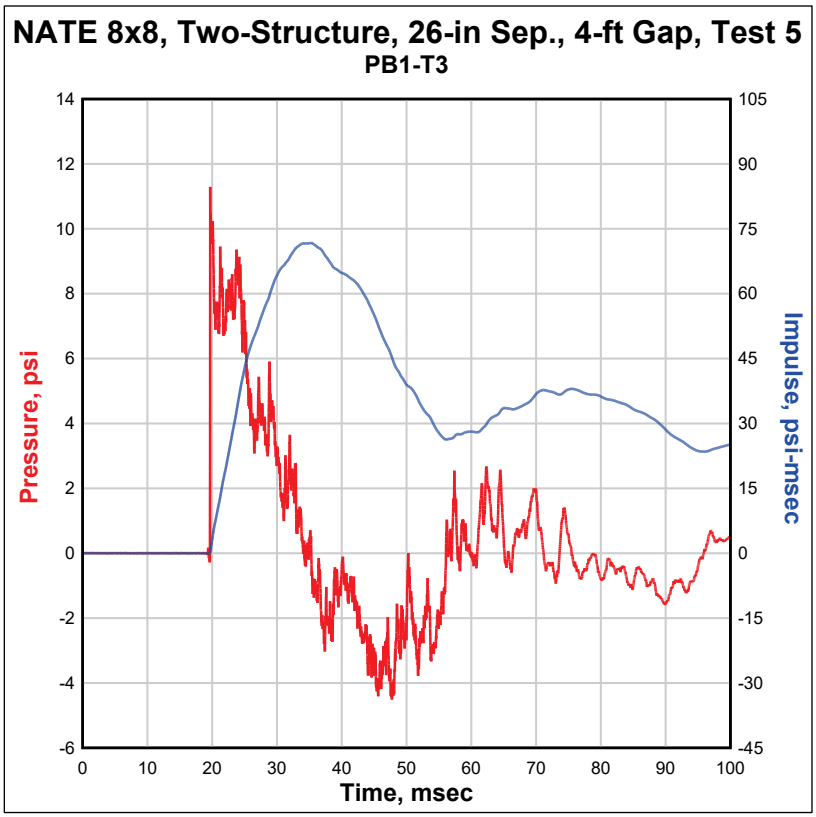
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
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0
-15
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-45
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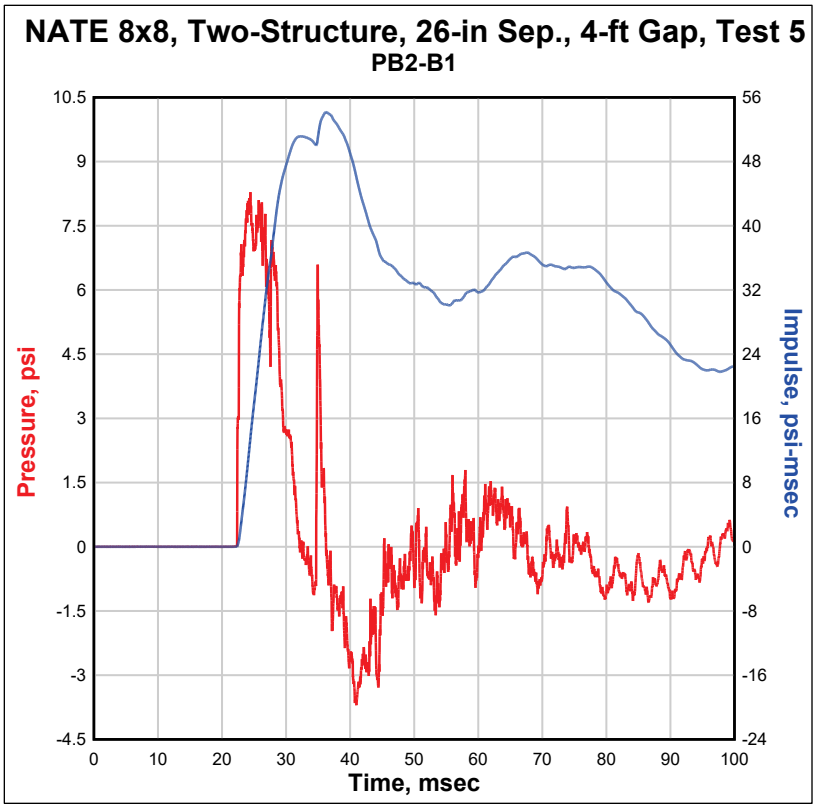
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
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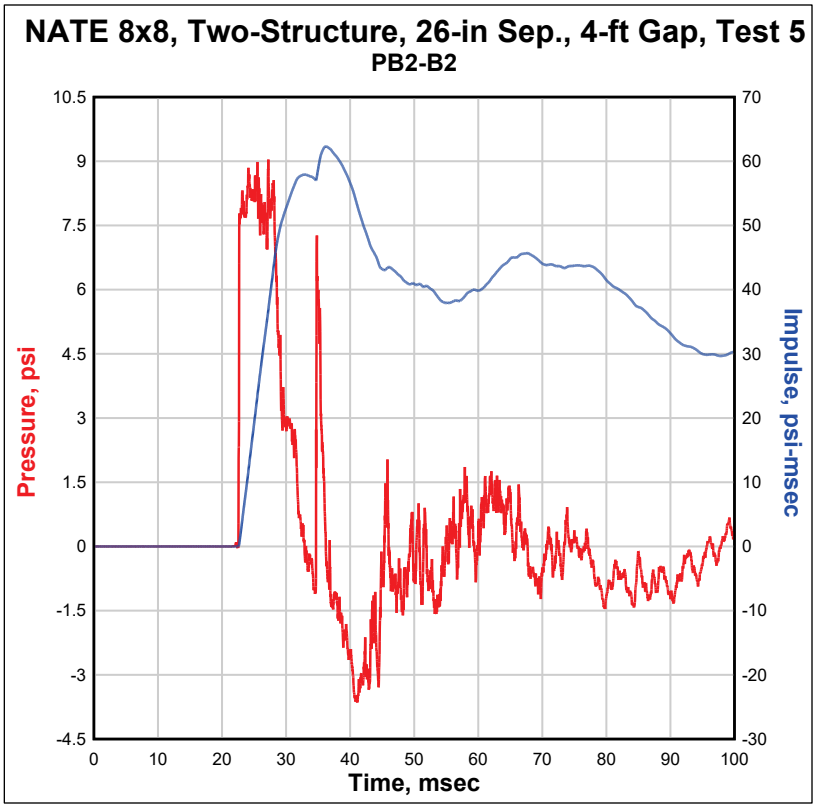
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
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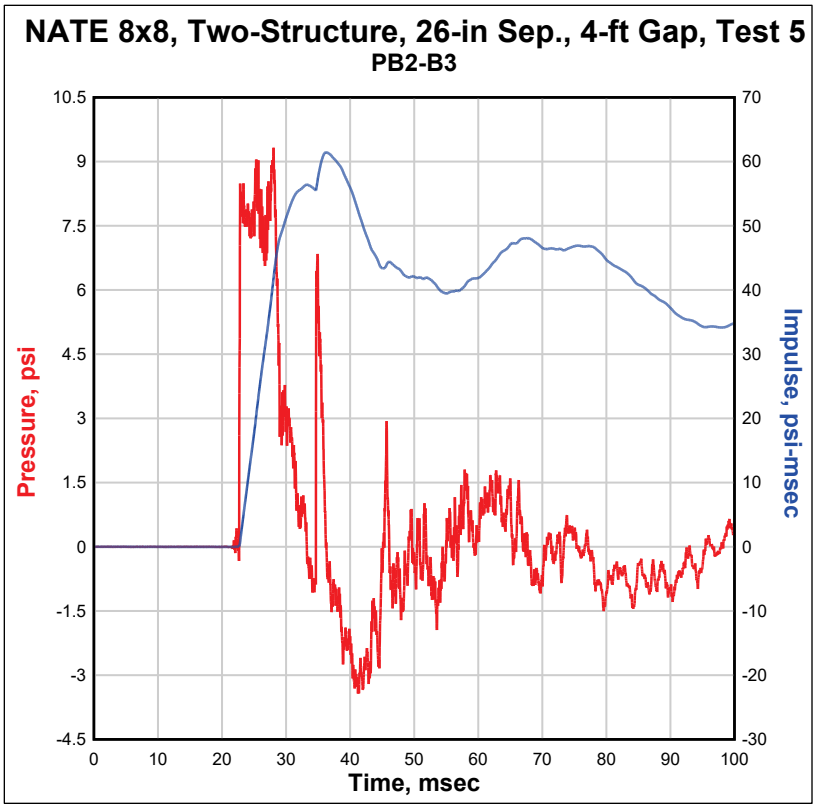
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
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0
-10
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-30
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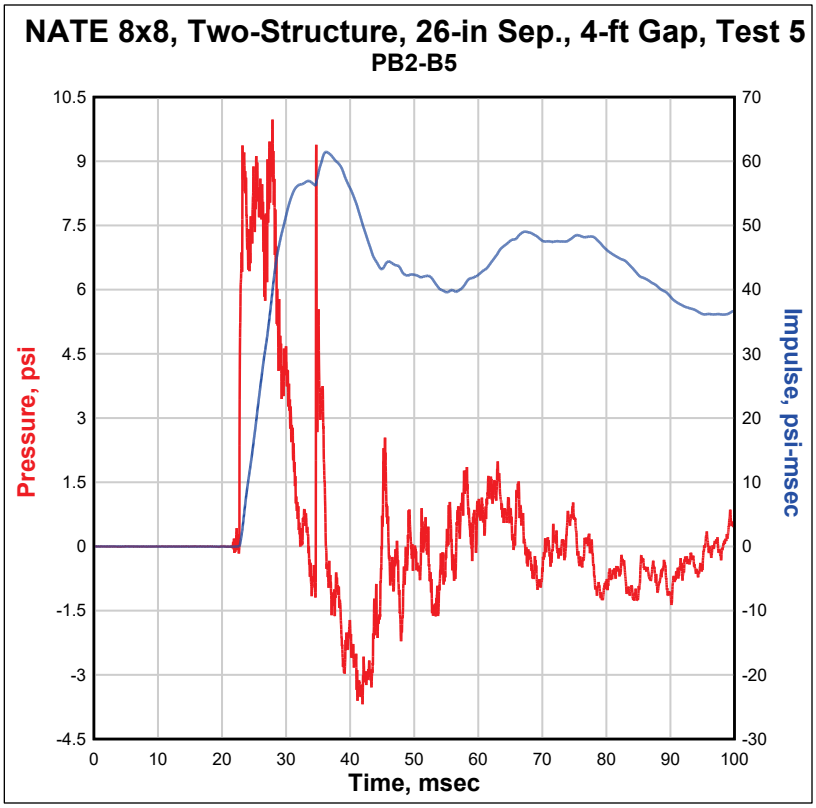
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
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0
-10
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-30
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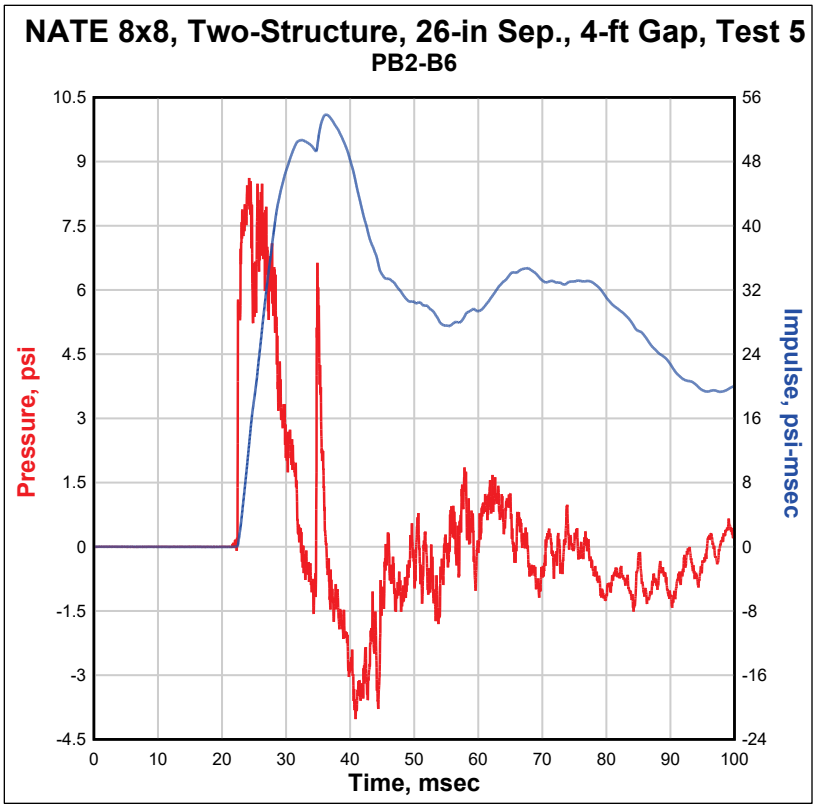
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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0
-8
-16
-24
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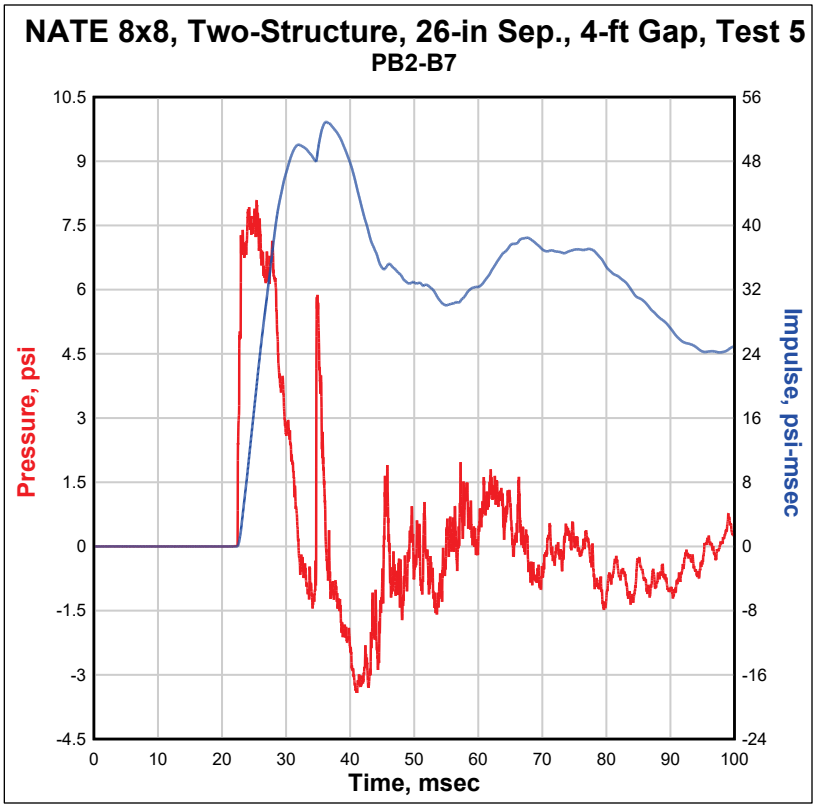
NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
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-8
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-24
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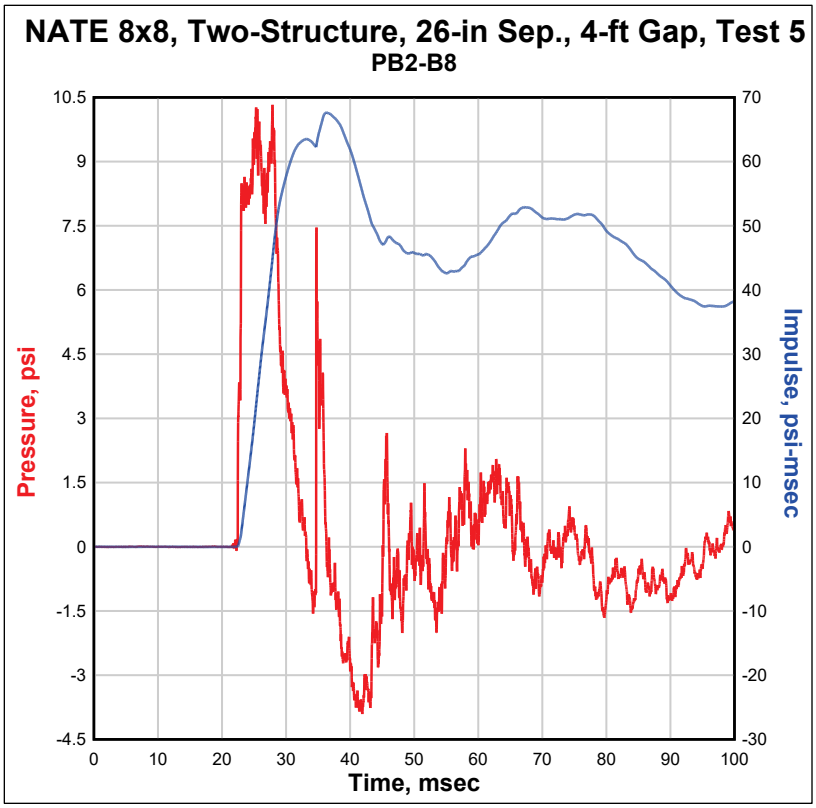
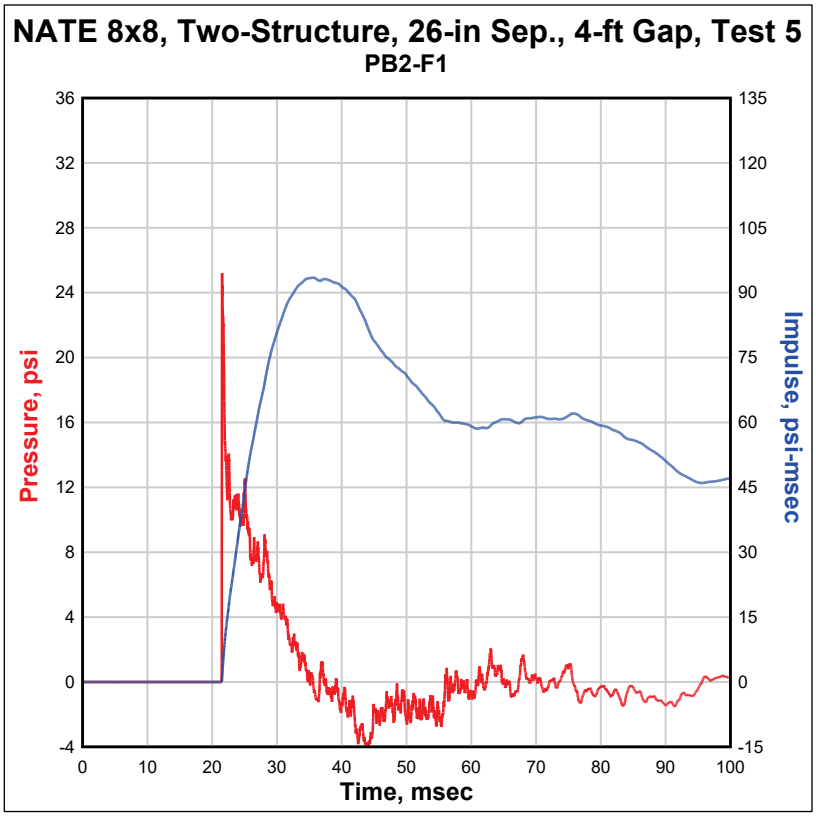
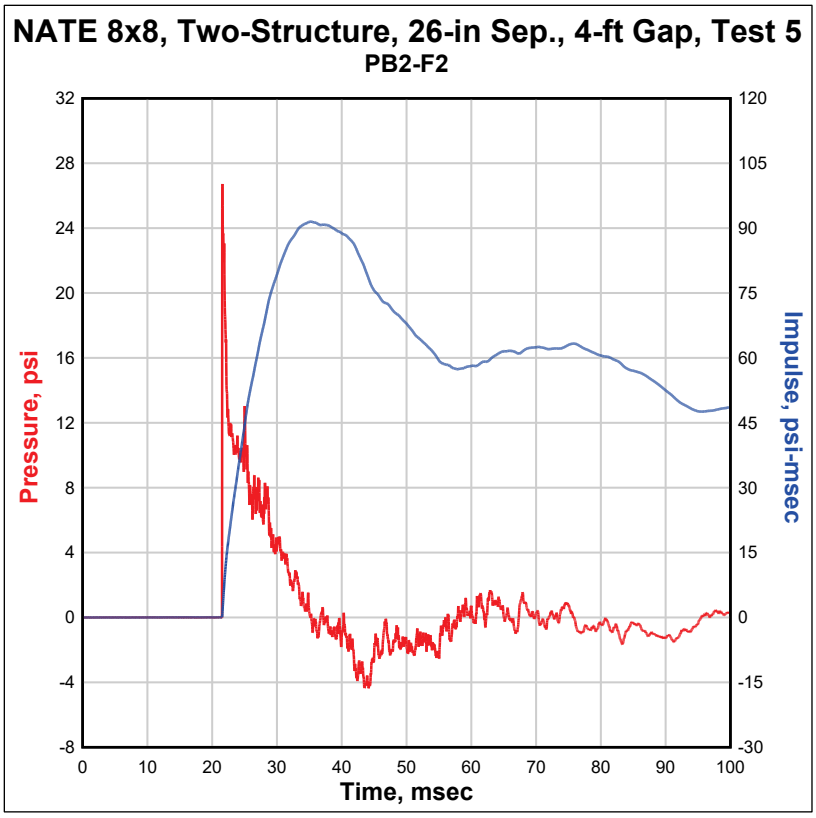
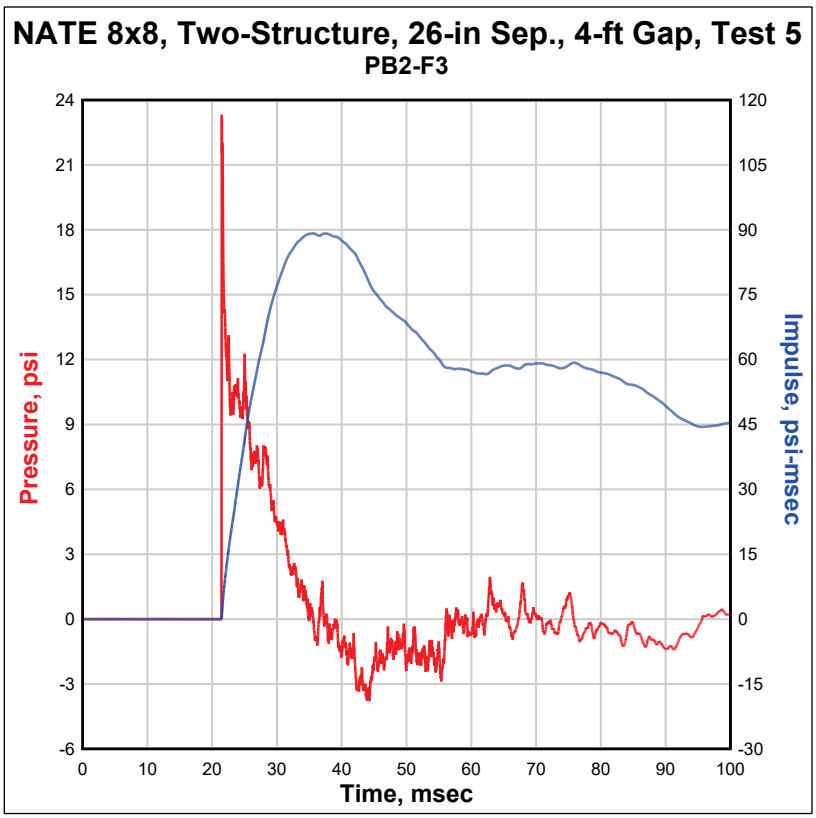
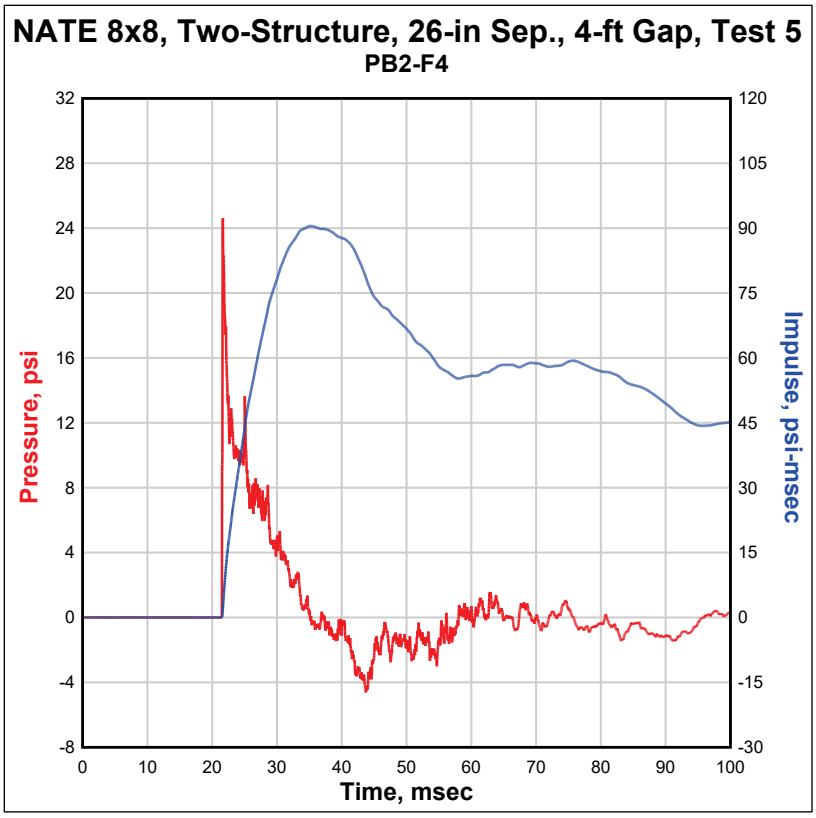
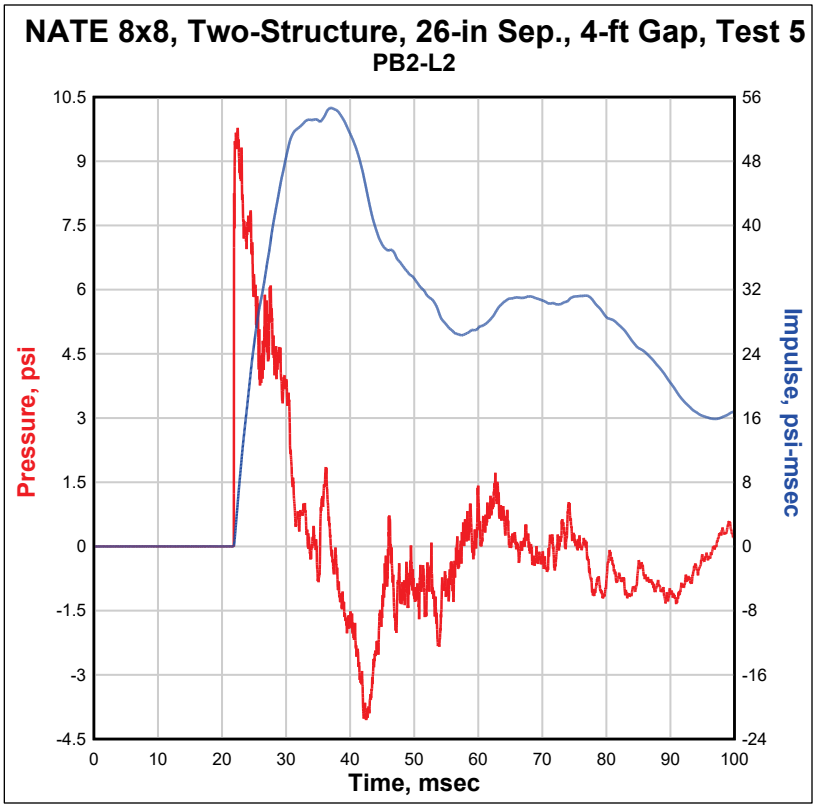

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

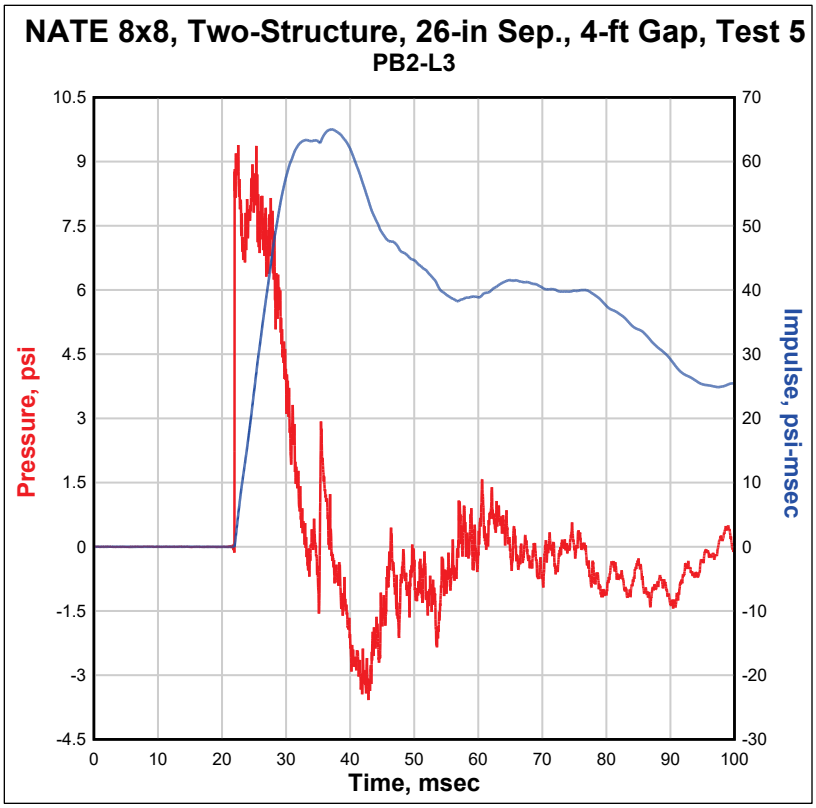

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100

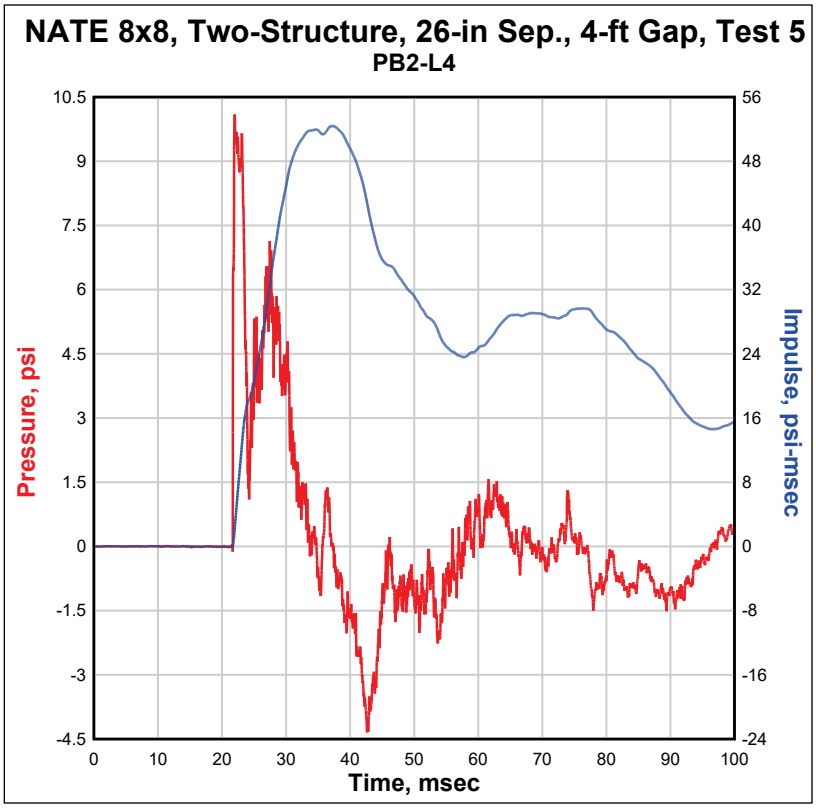

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

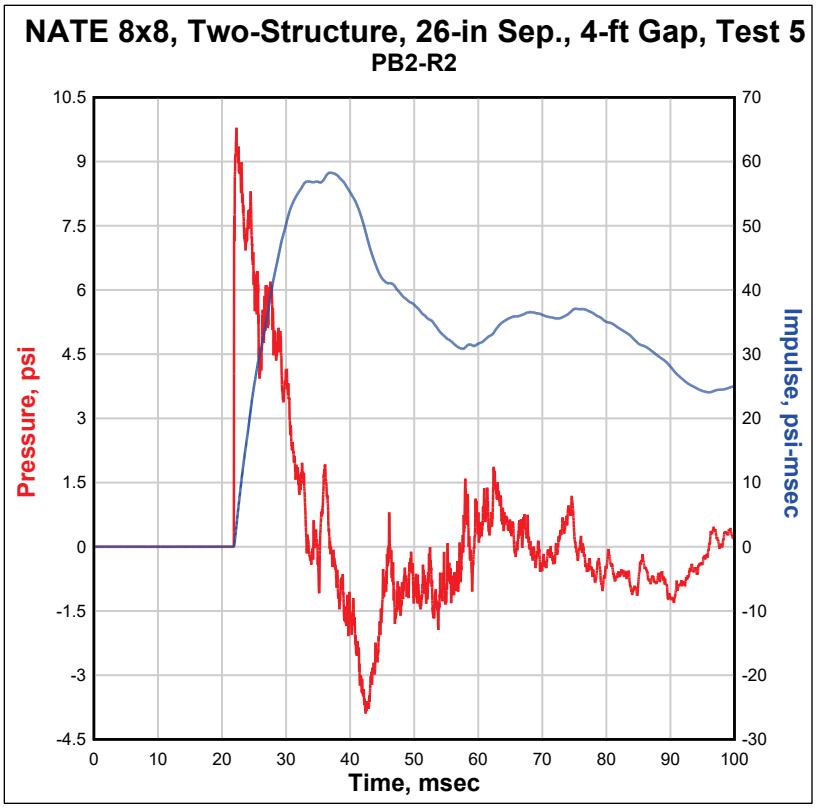

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

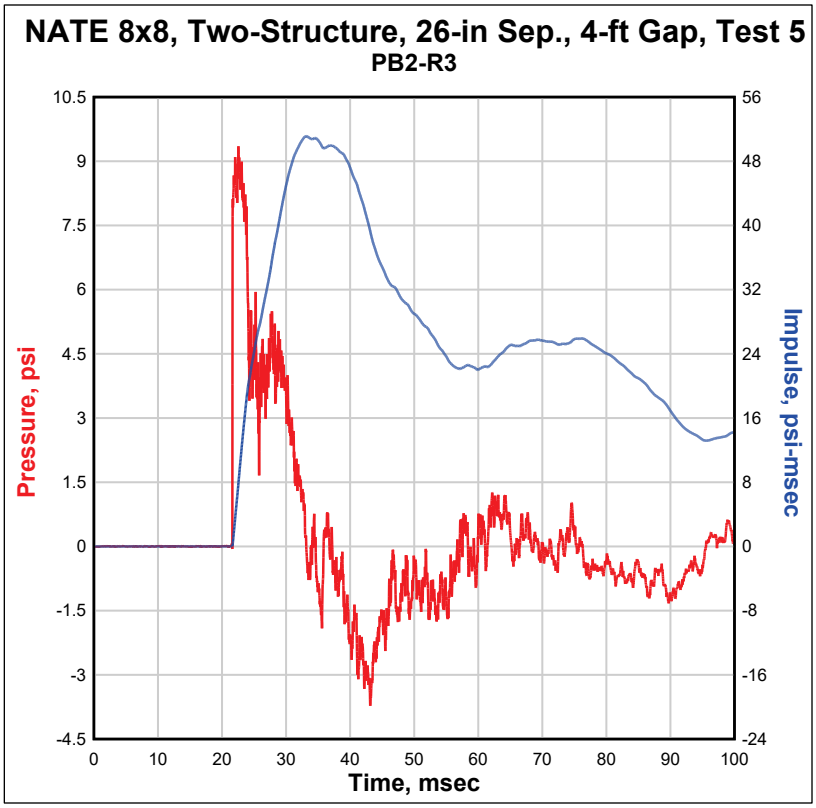

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

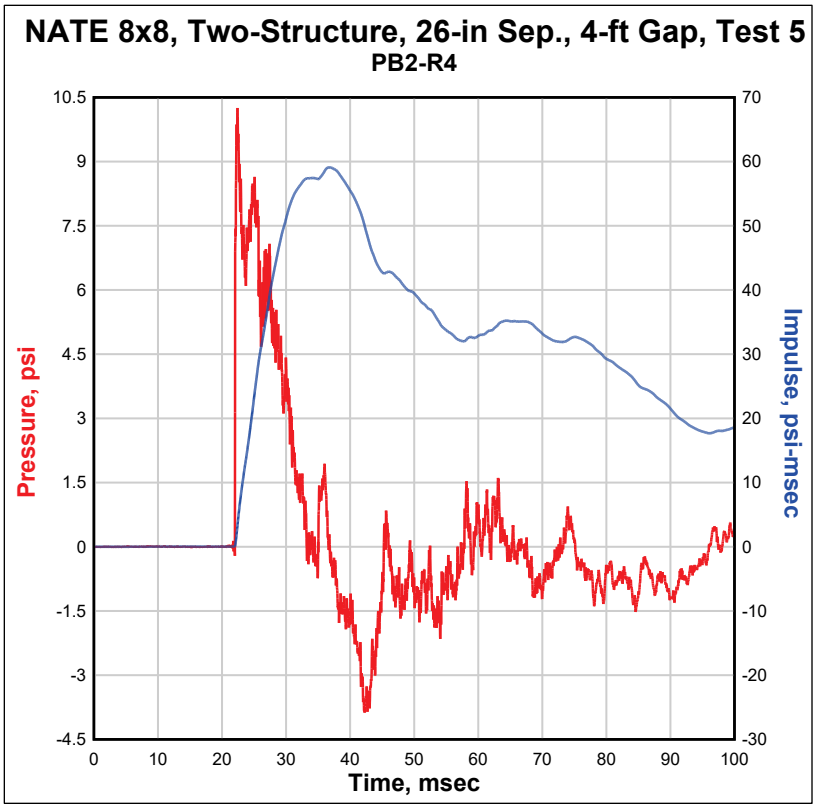

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

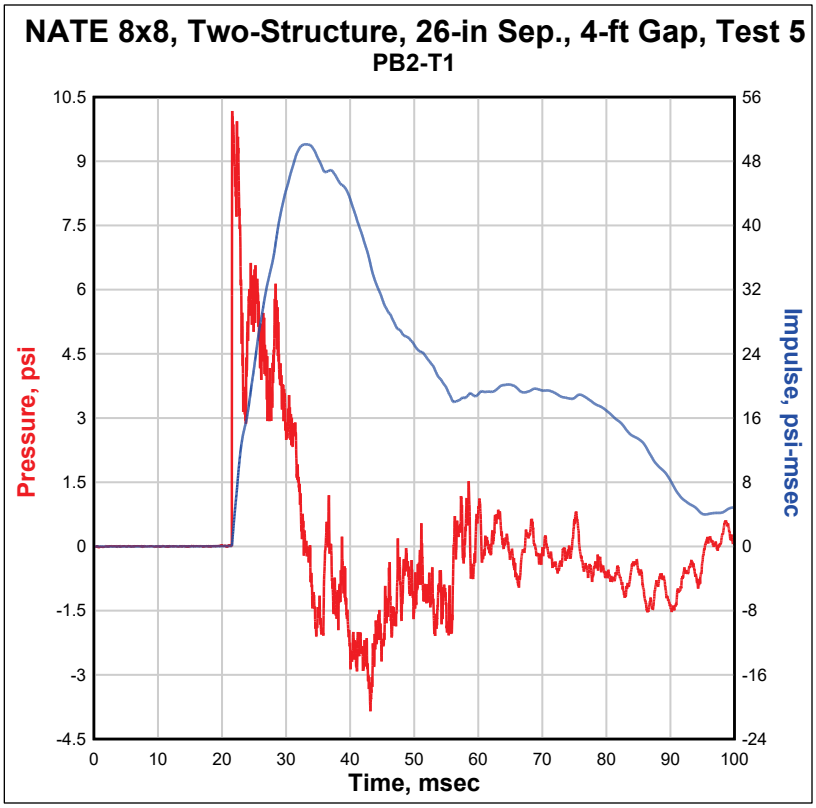

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

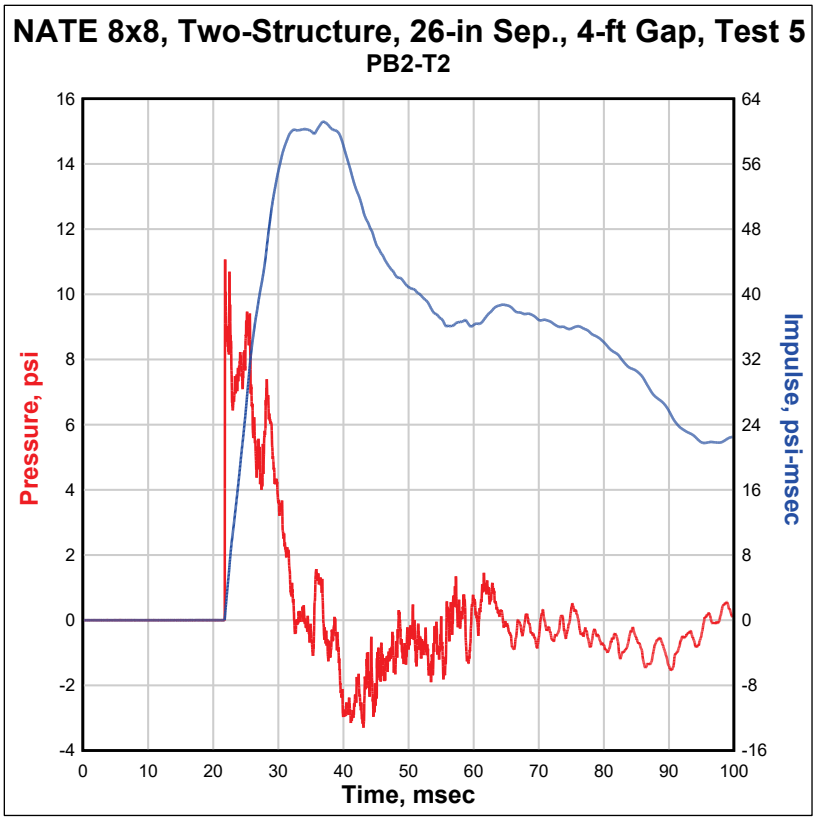

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

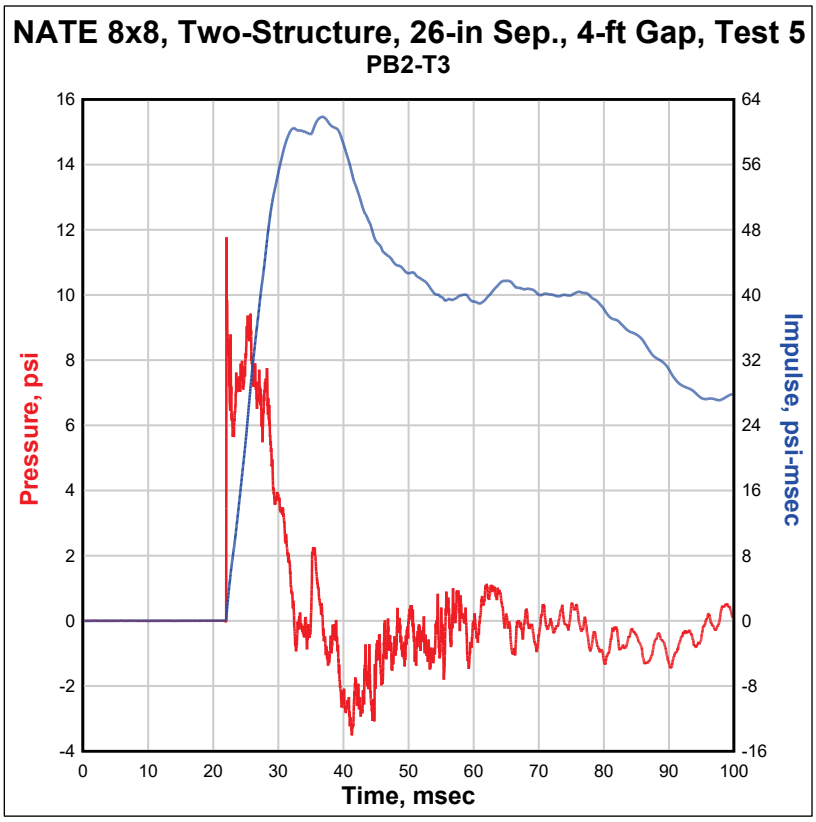

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

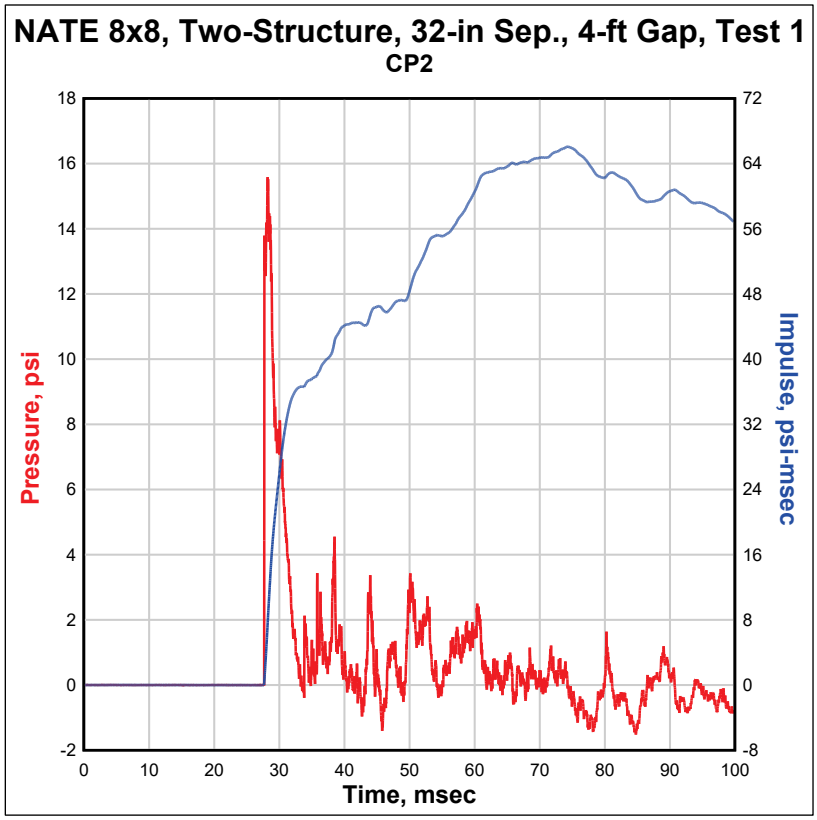

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

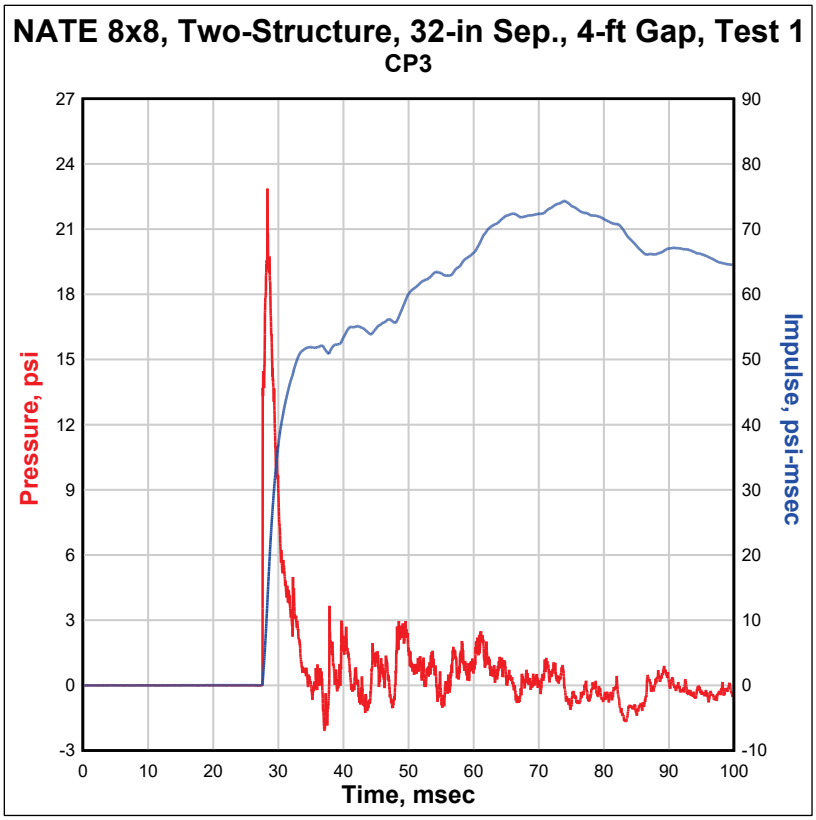

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

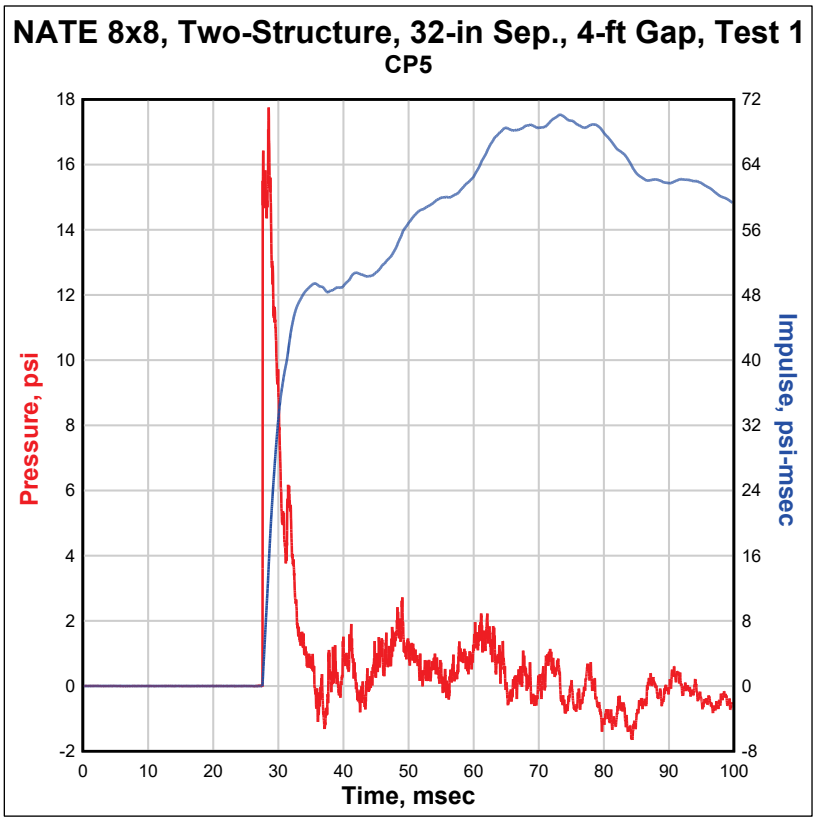

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

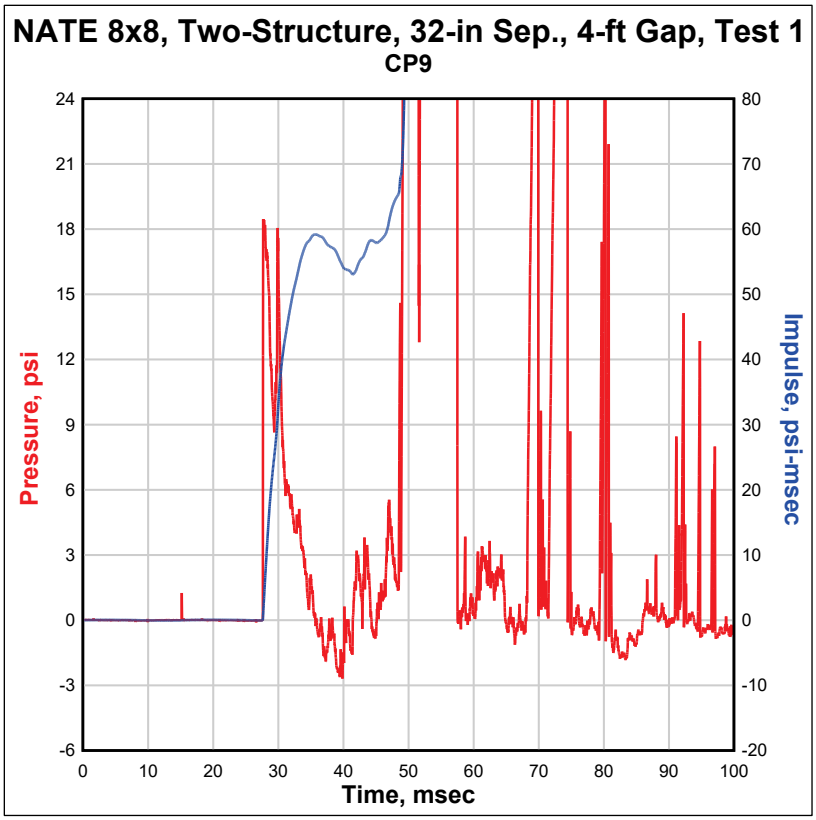

NATE 8x8, Two-Structure, 26-in Sep., 4-ft Gap, Test 5
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

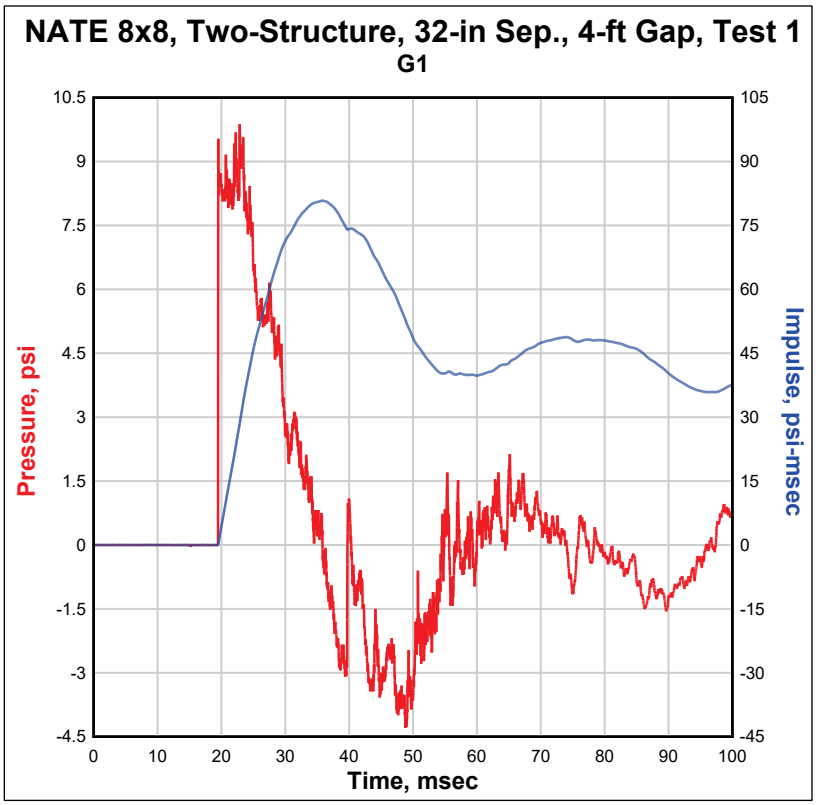
# Appendix B: Pressure and Impulse Data from Two-Structure Tests with 32-in. Spacing

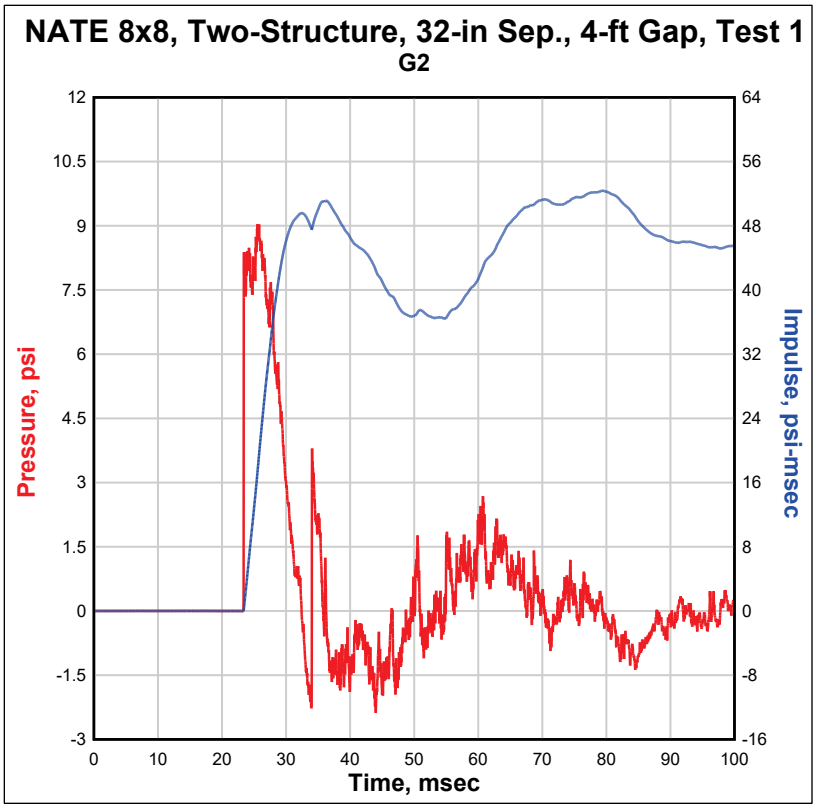


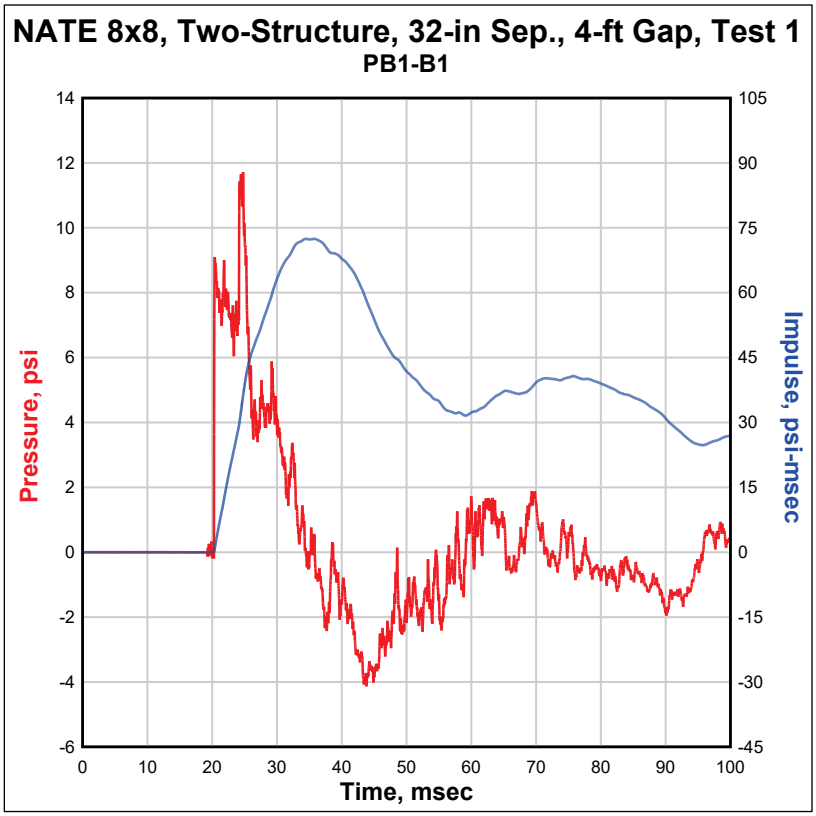

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
27
24
21
18
15
12
9
6
3
0
-3
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

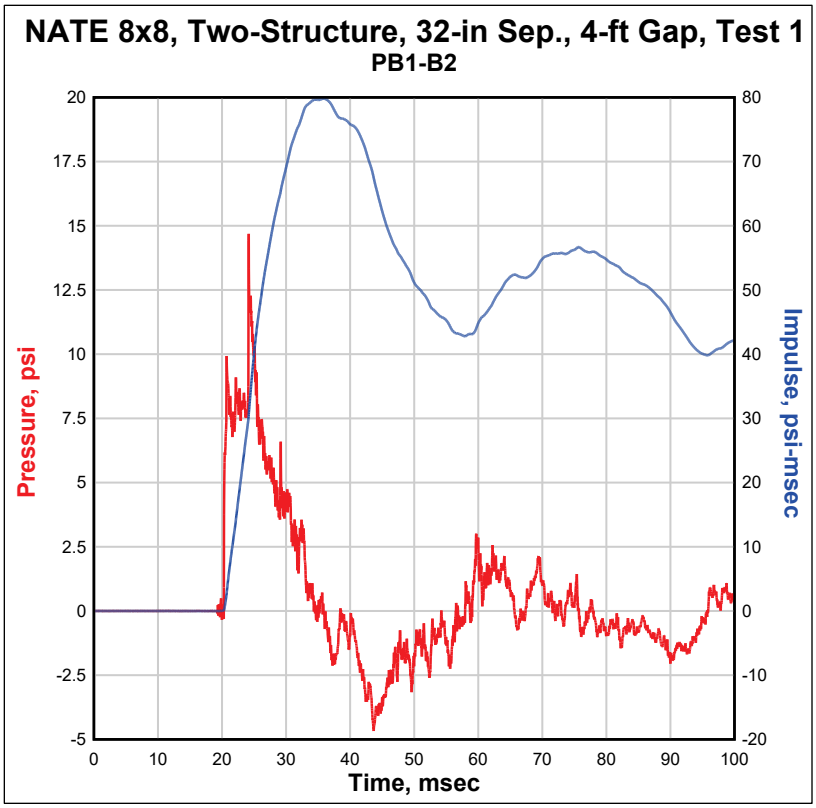

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

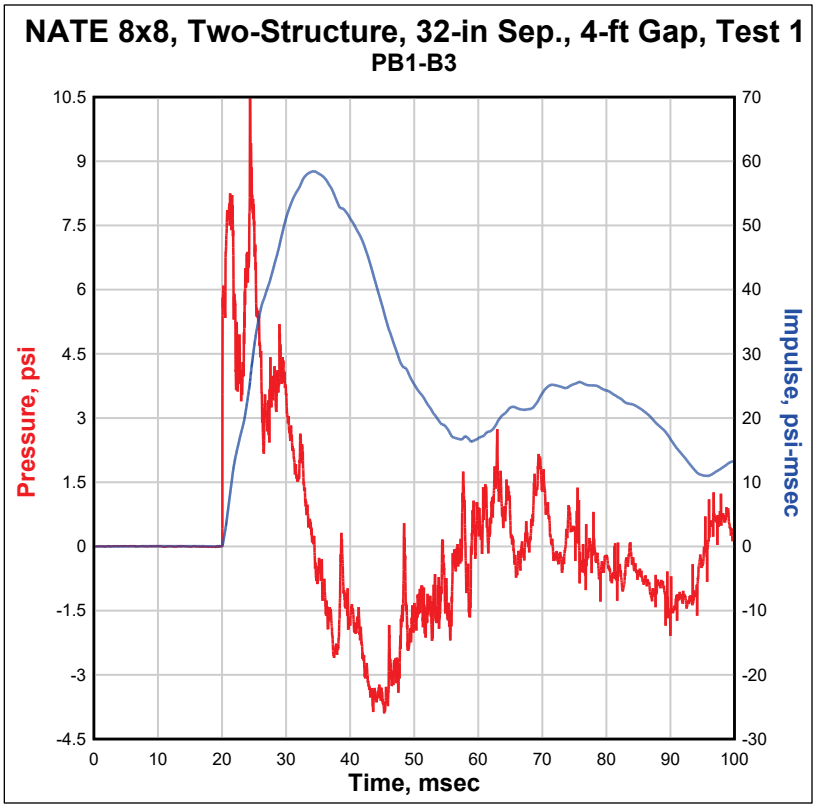

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

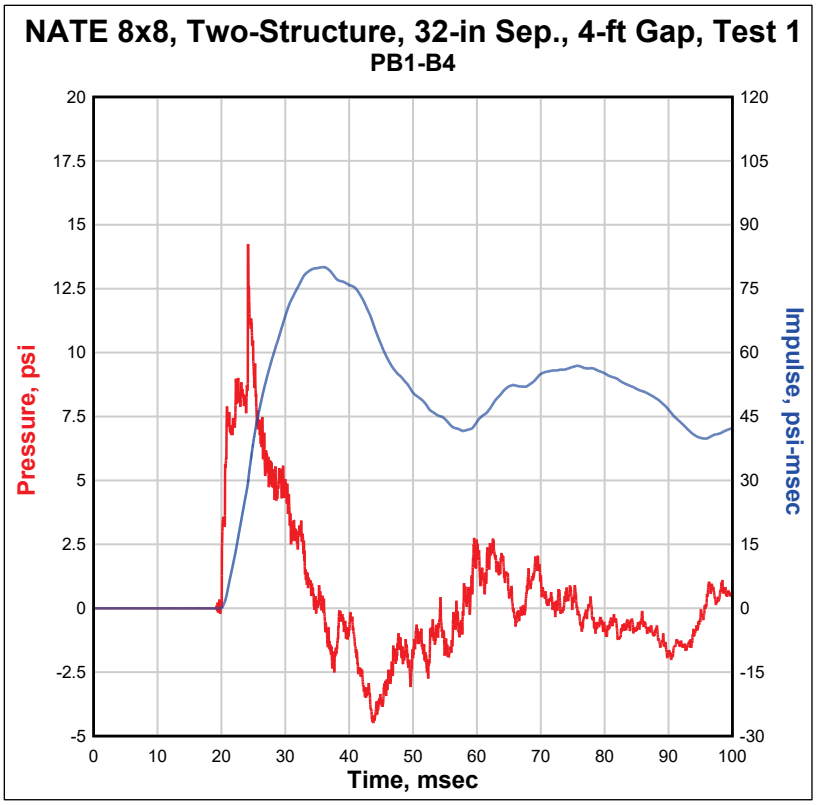

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

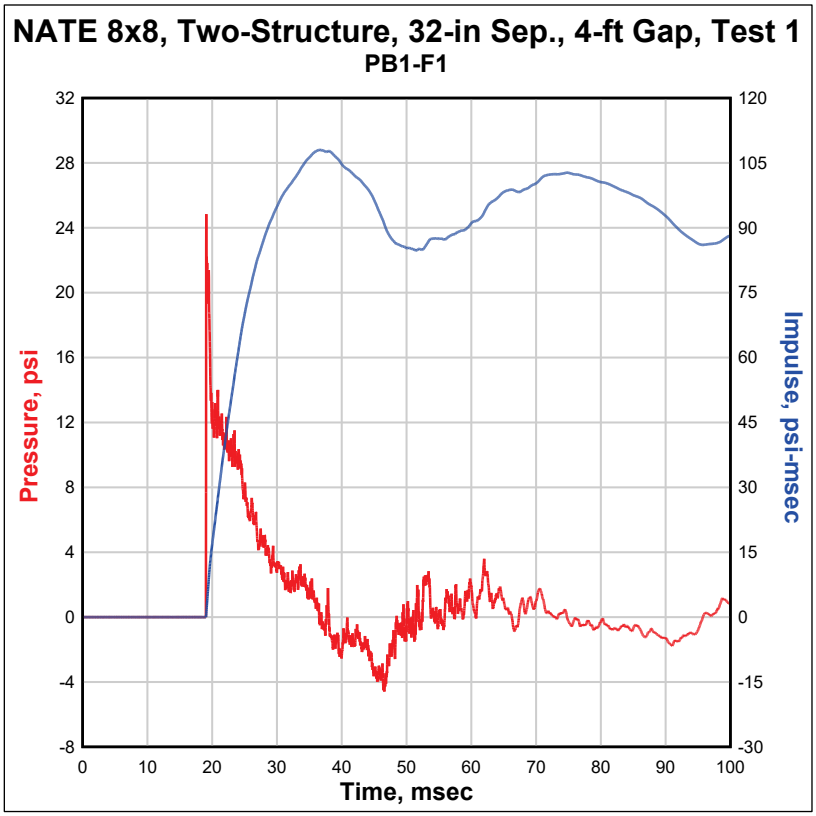

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

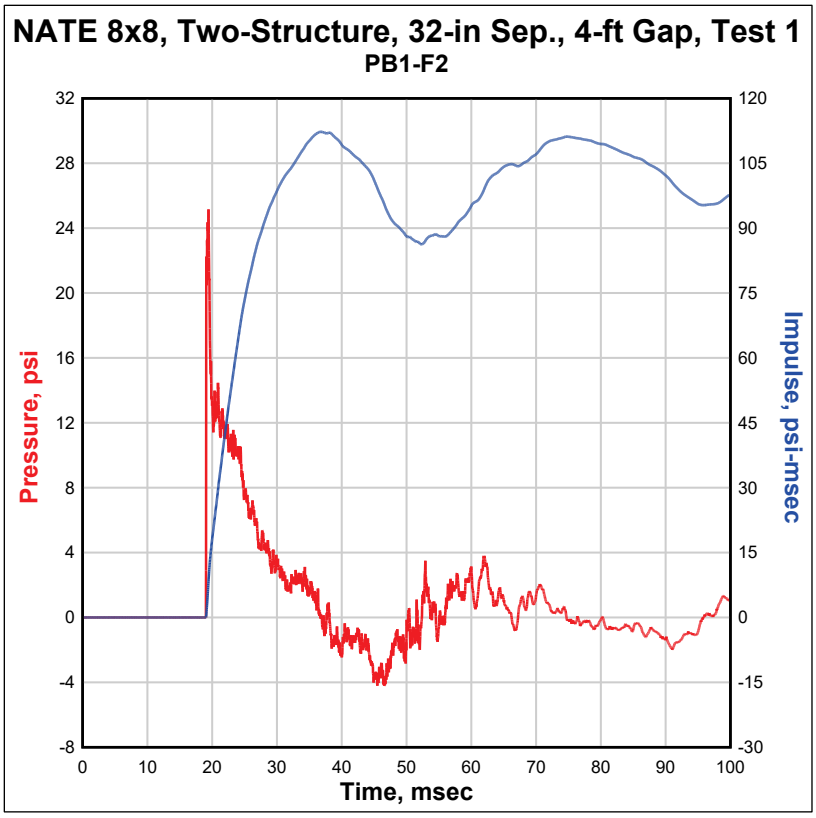

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

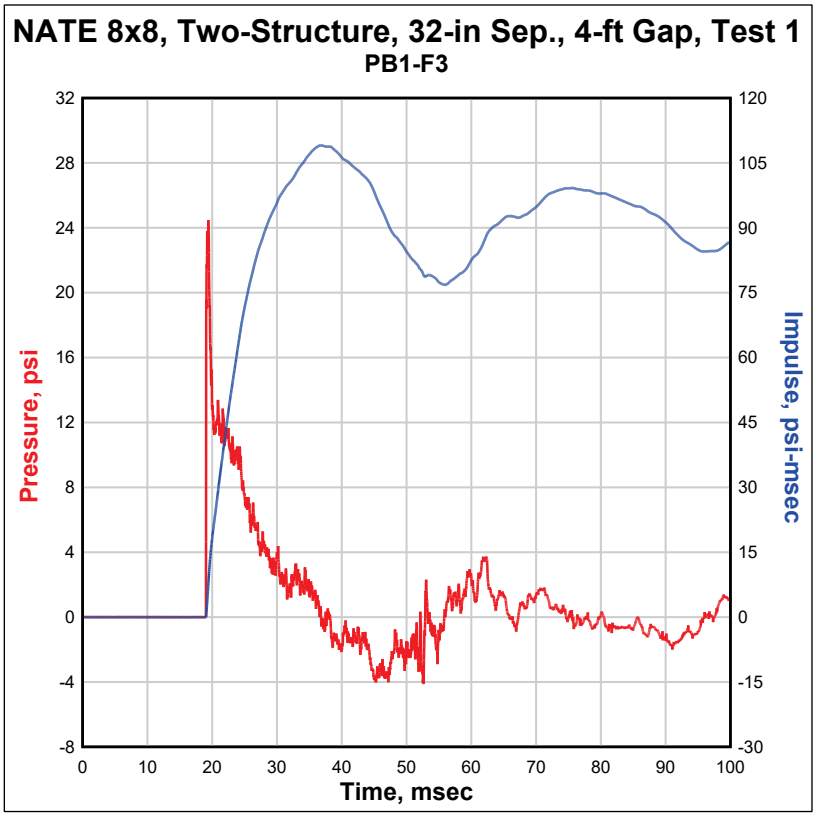

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

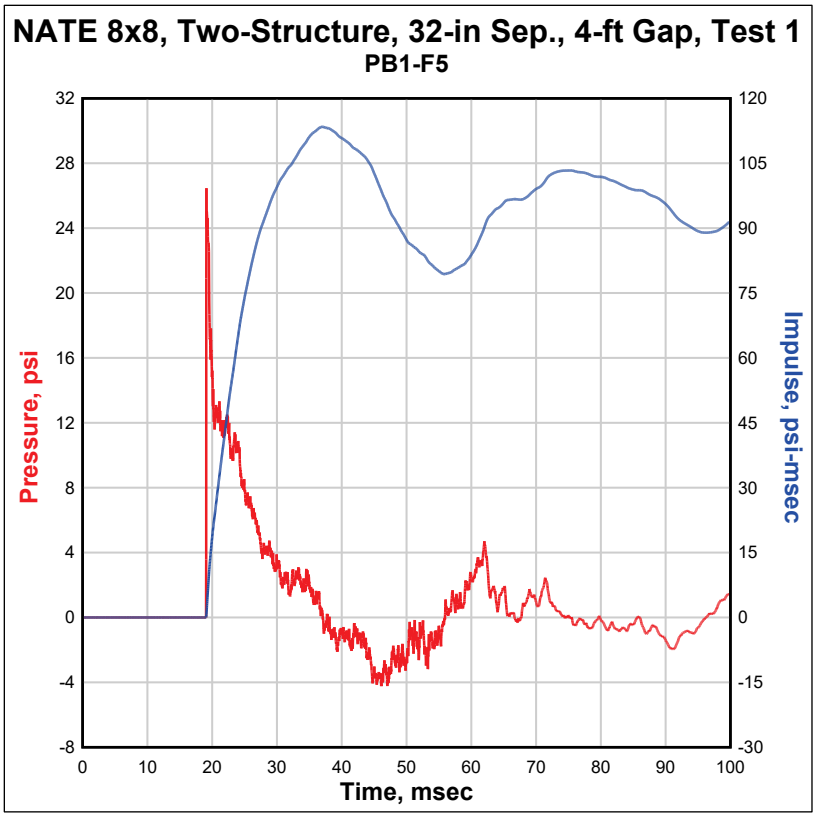

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

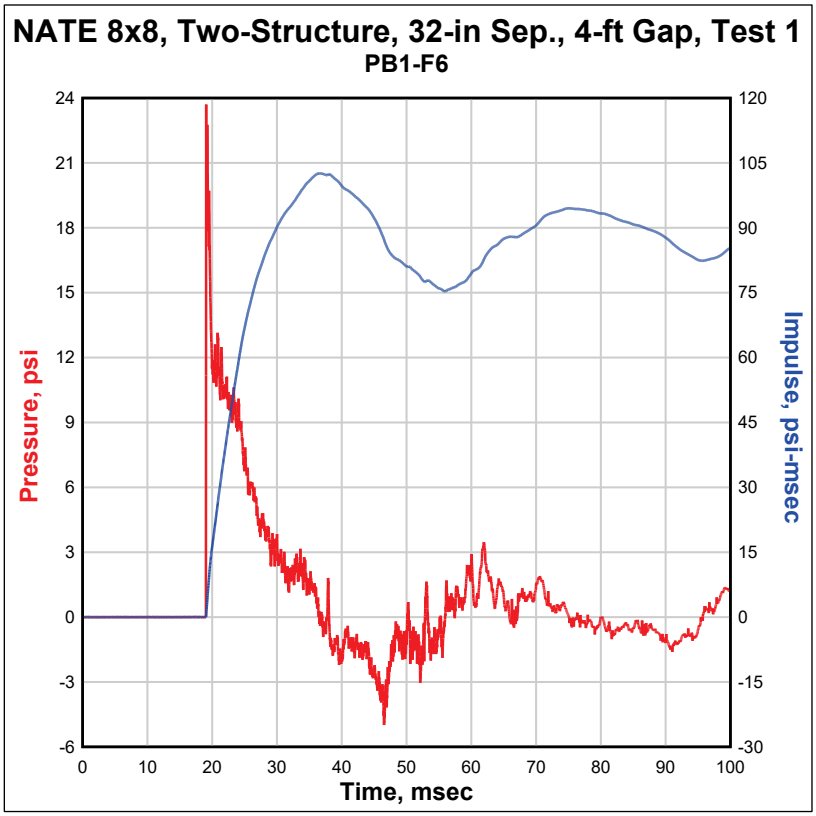

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

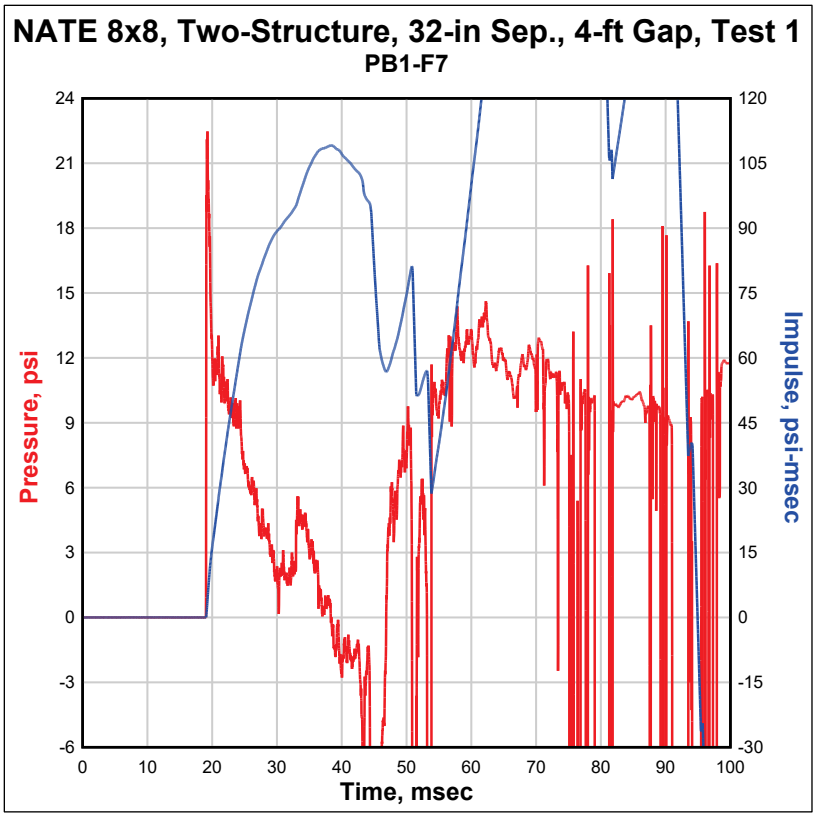

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
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-30
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20
30
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70
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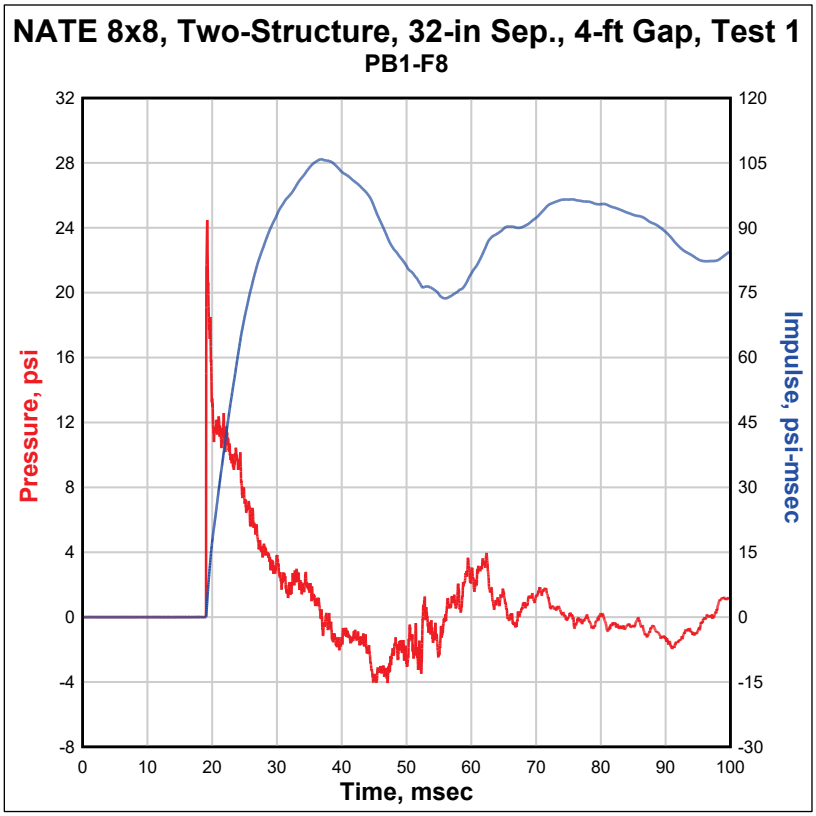
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
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60
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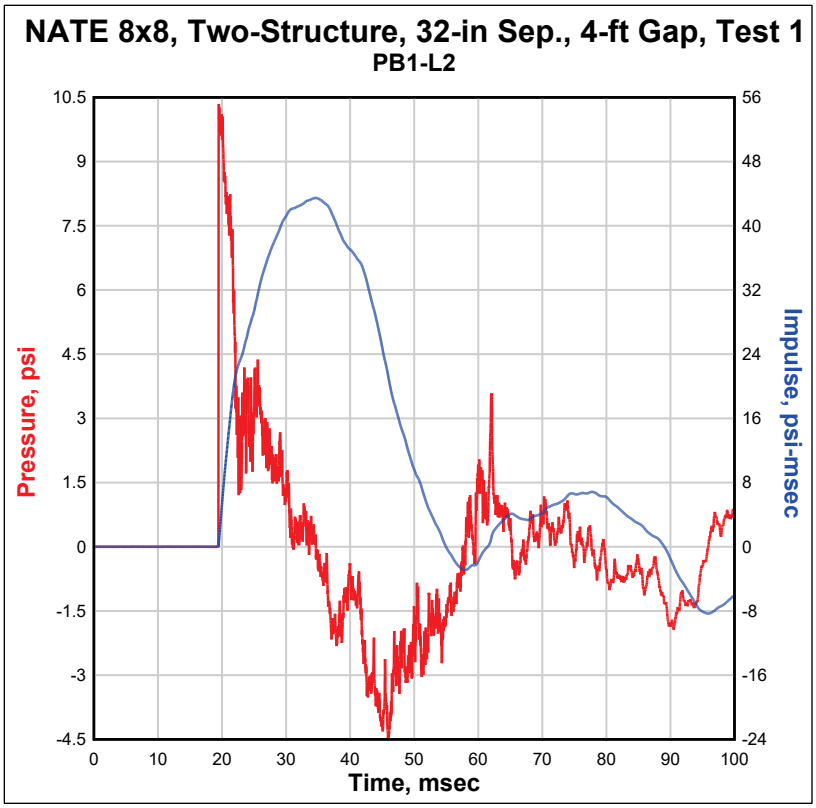
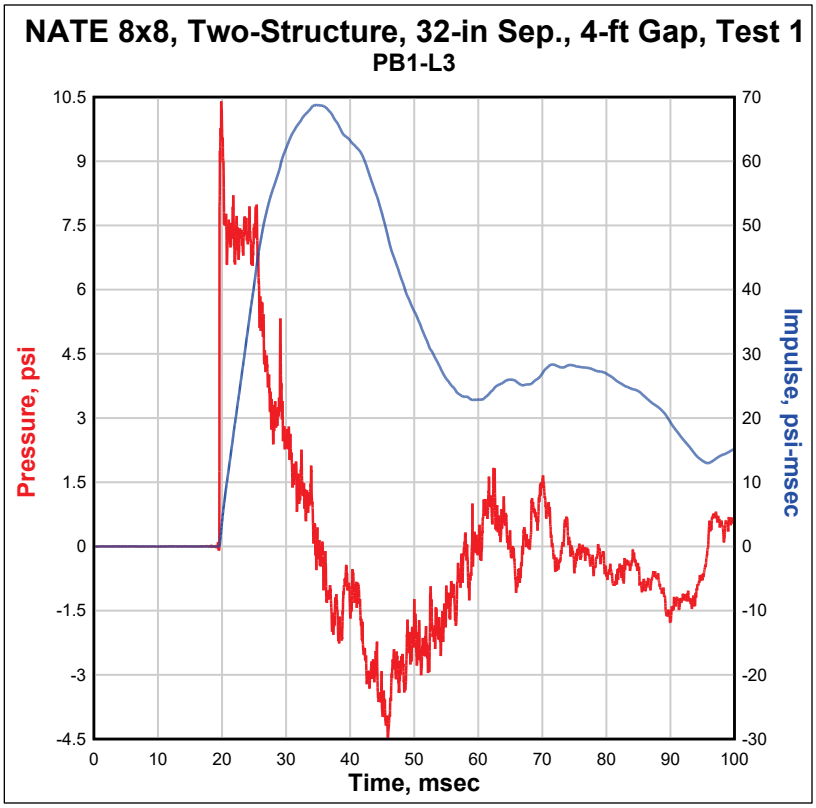
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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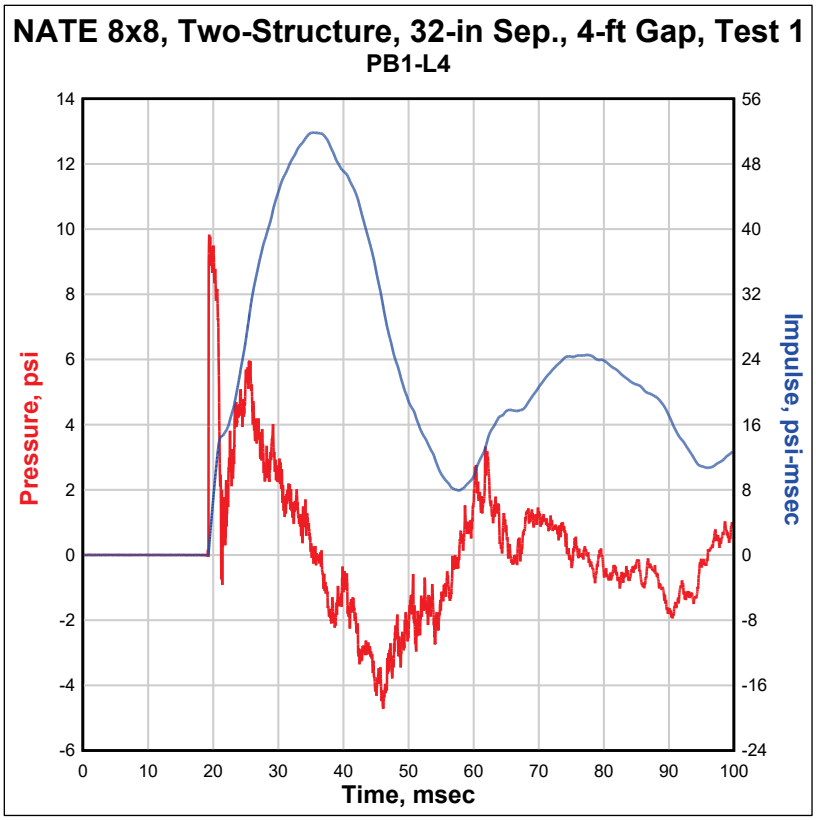
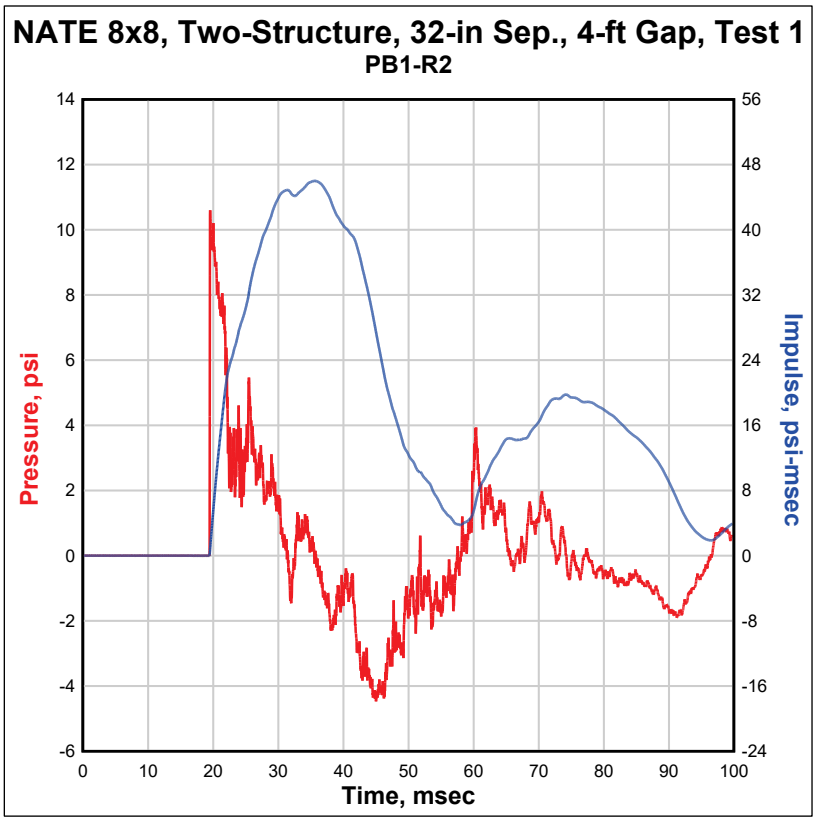
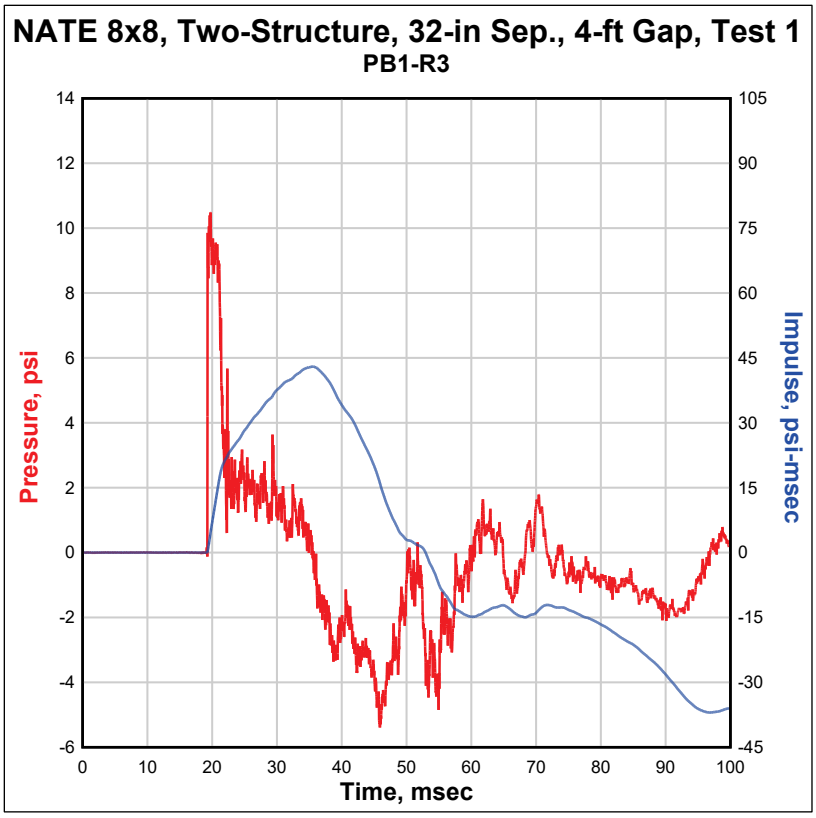
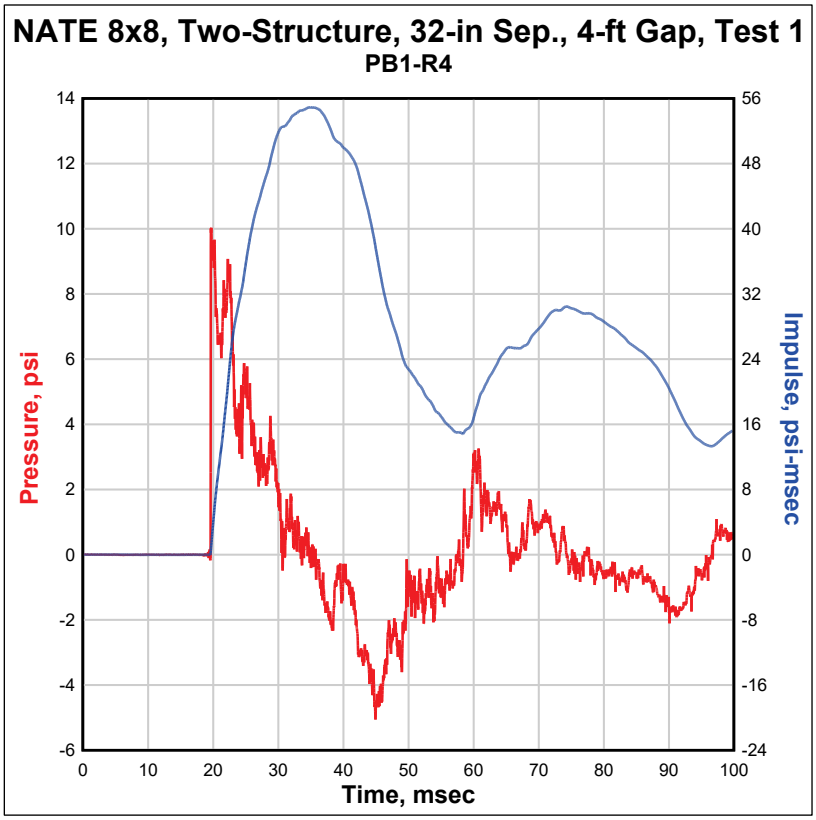
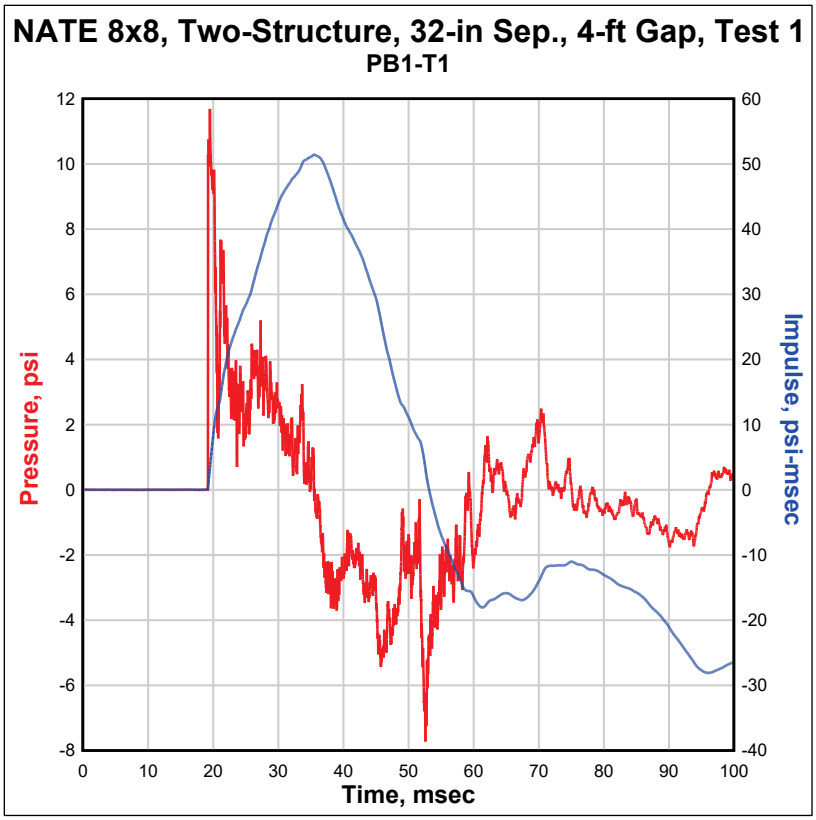
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

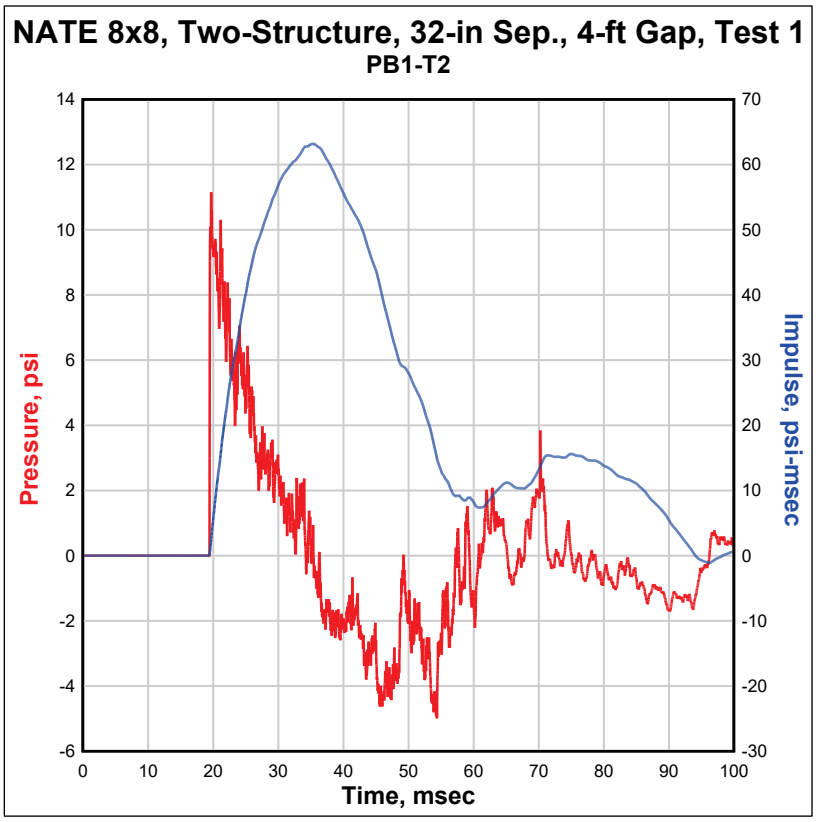

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

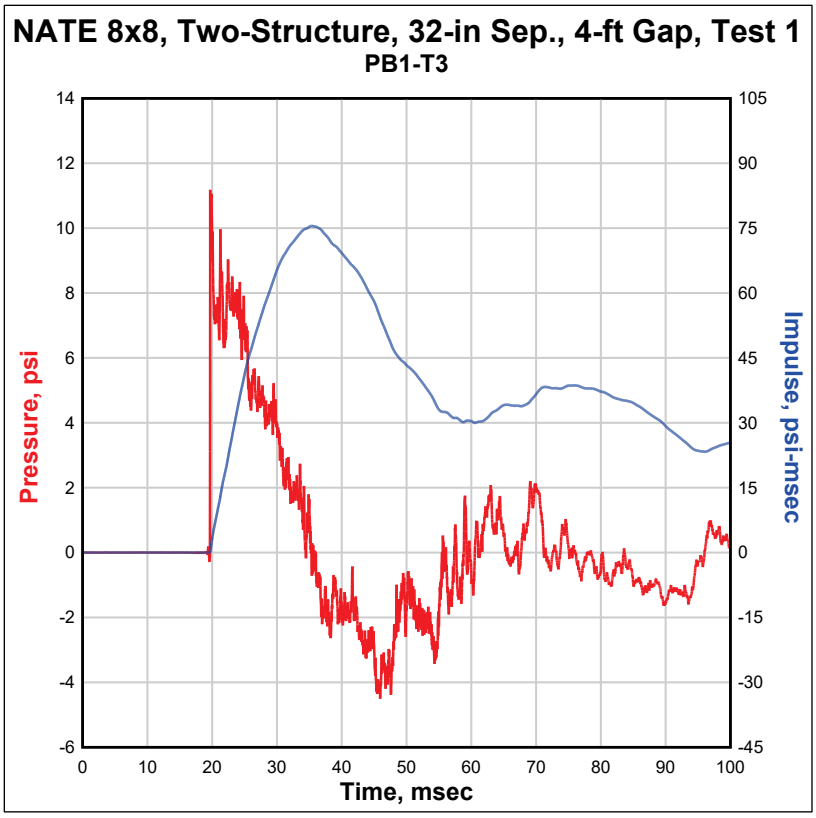

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
60
50
40
30
20
10
0
-10
-20
-30
-40
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
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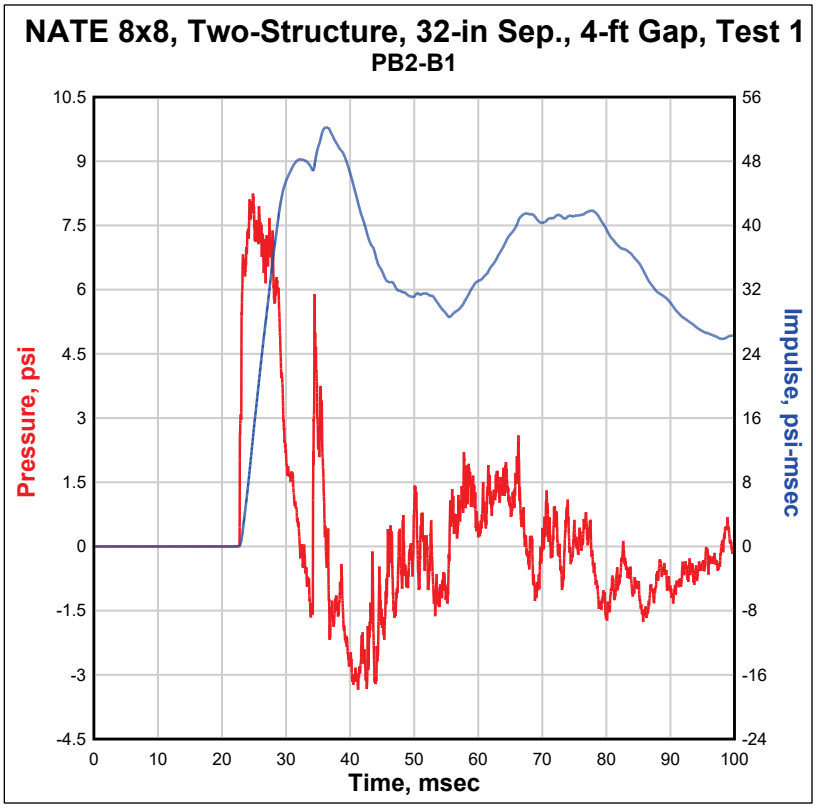
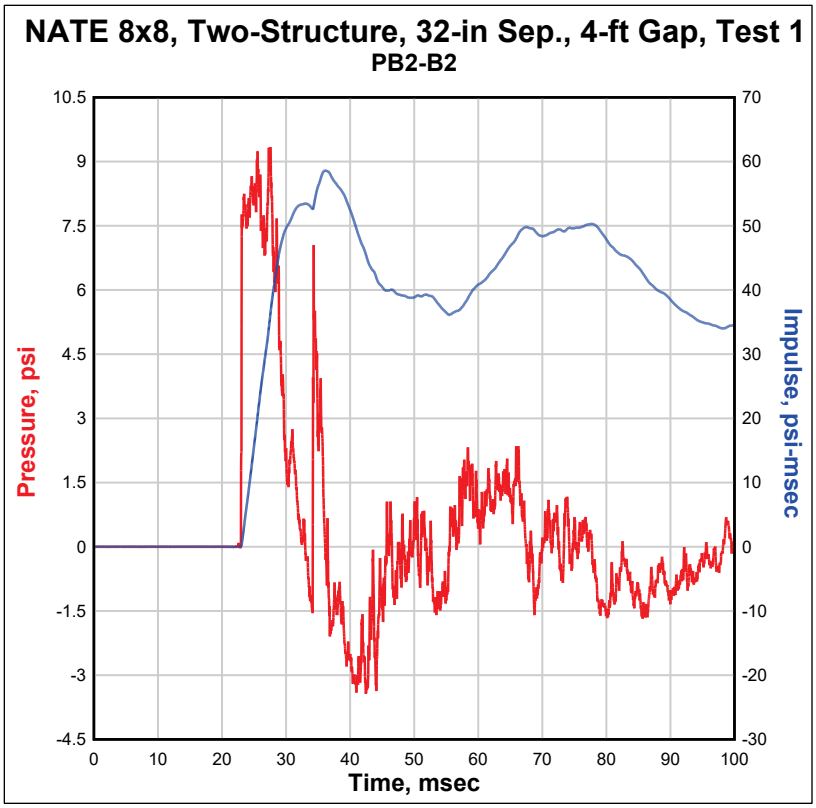
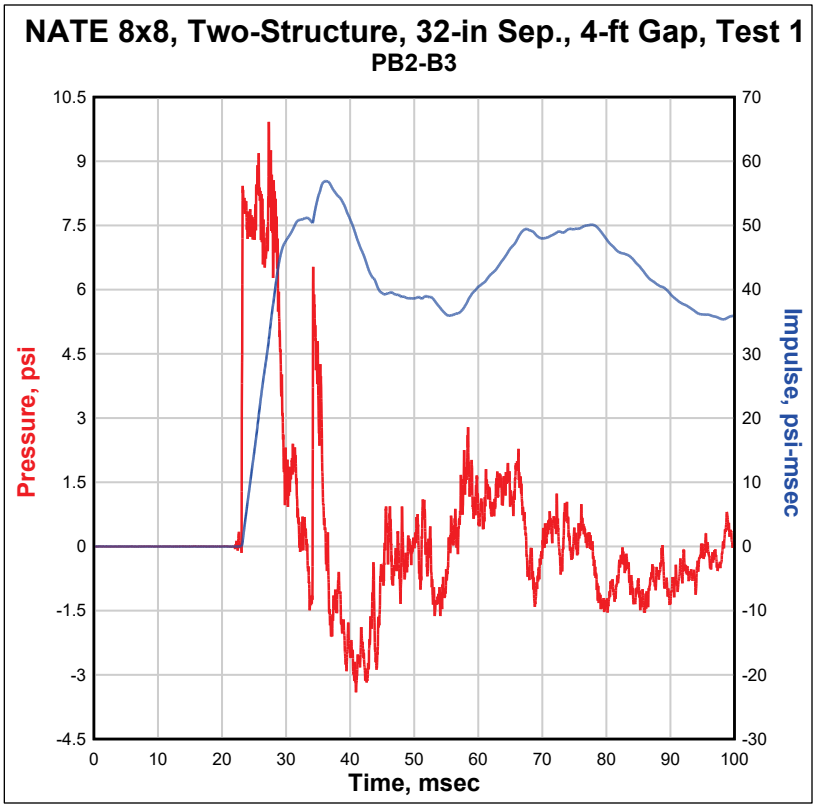
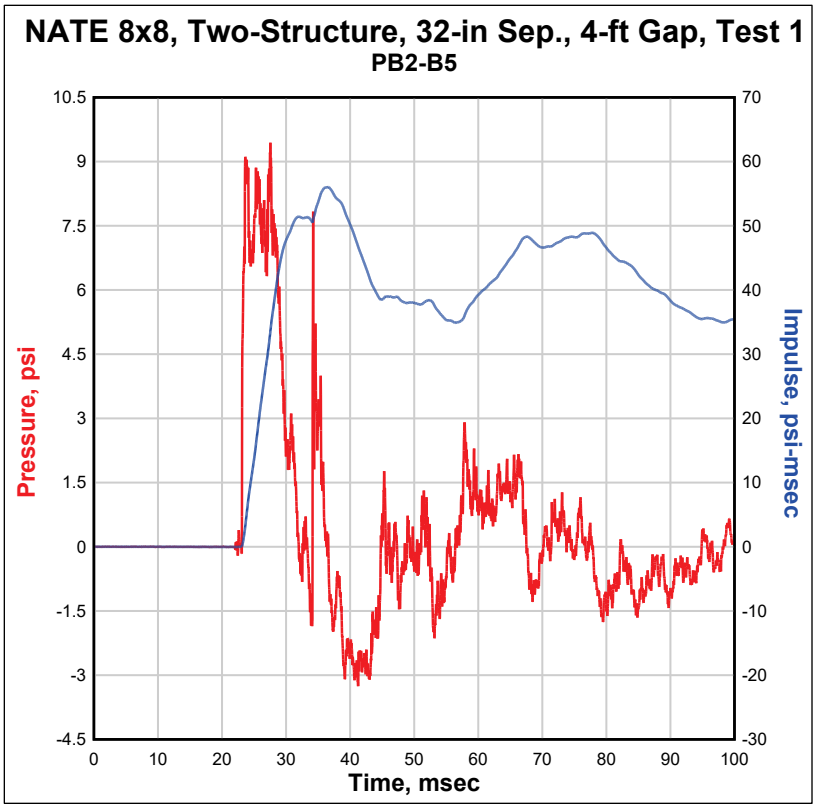
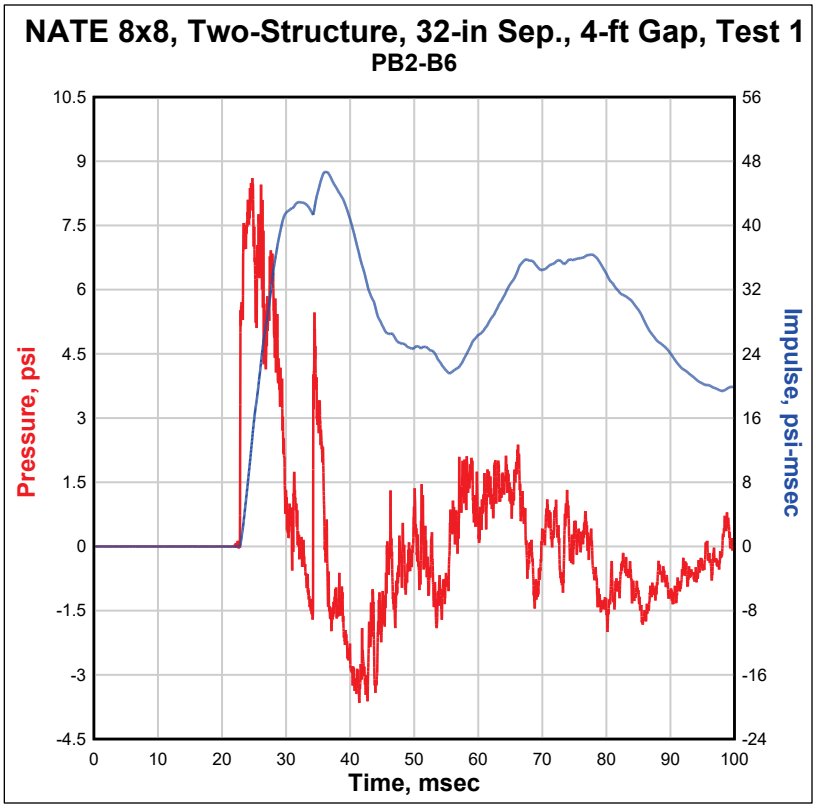
30
40
50
60
70
80
90
100

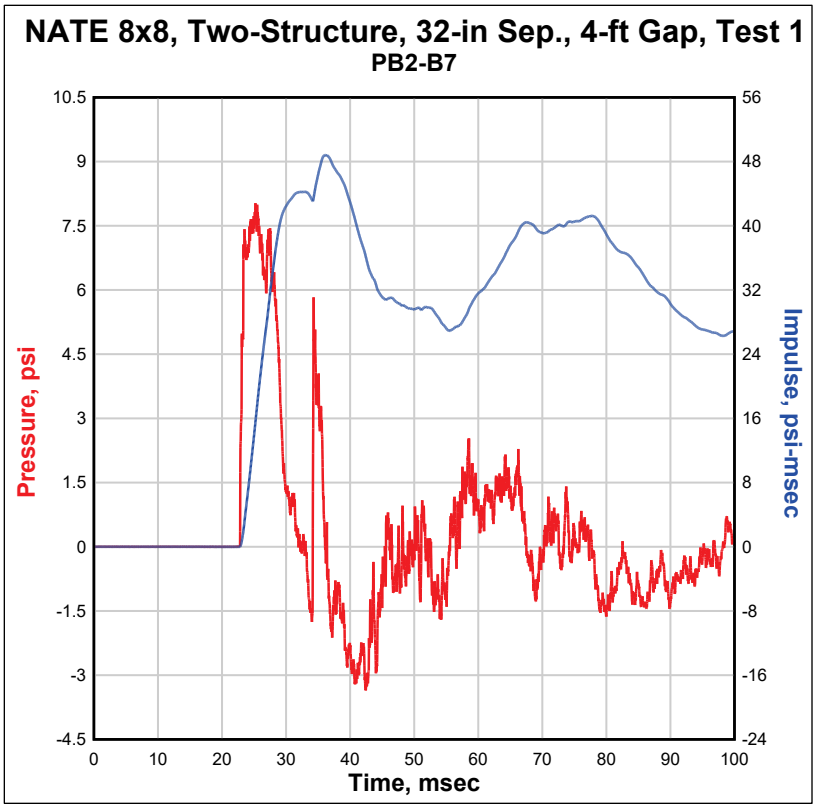

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

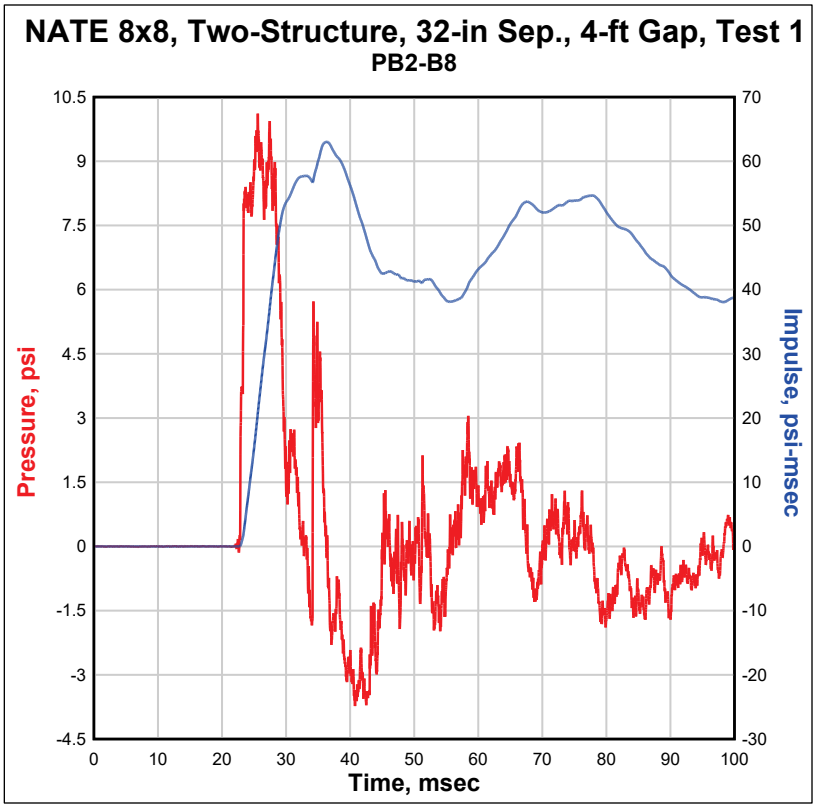

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
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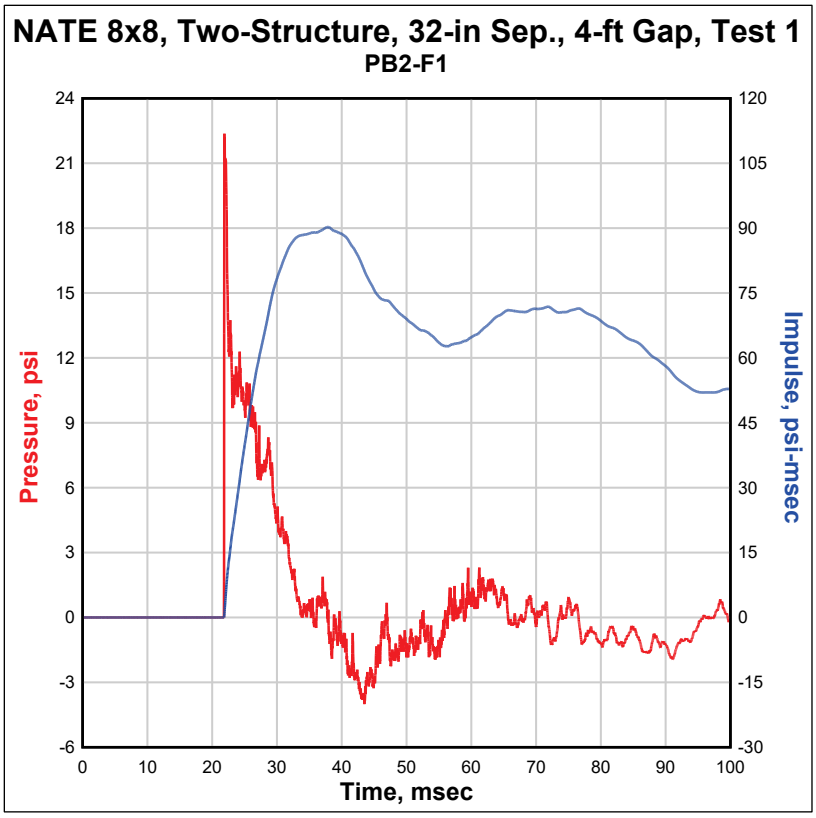
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
40
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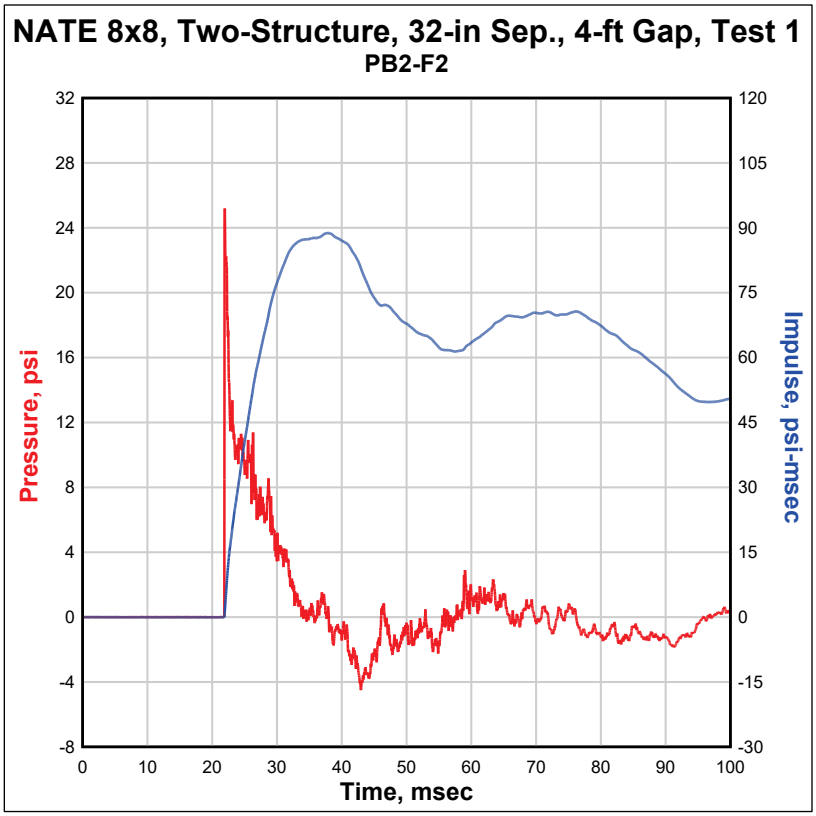
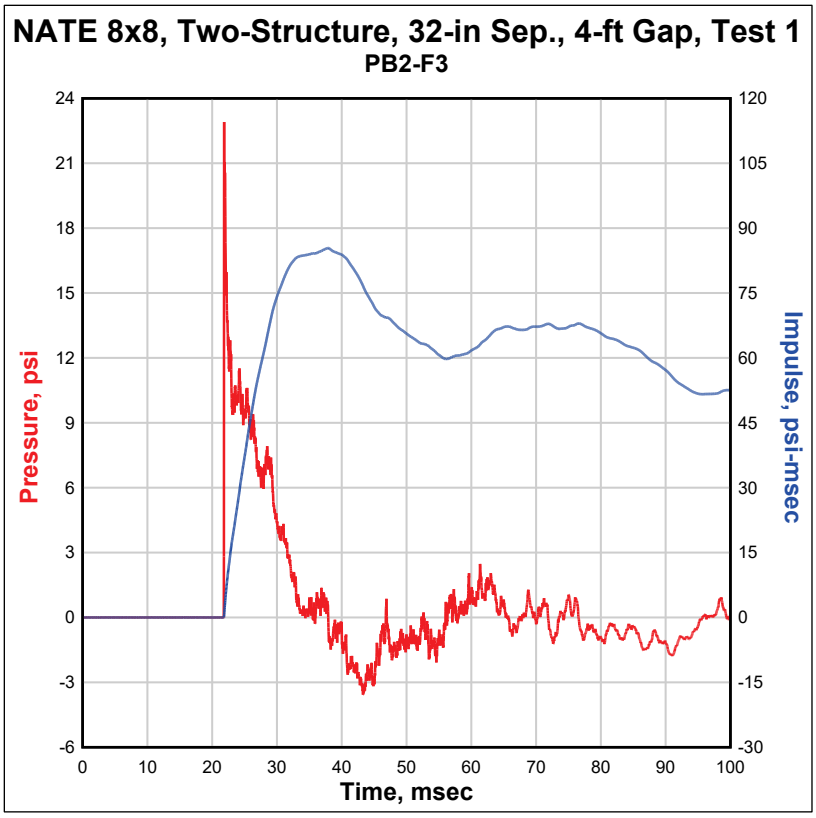
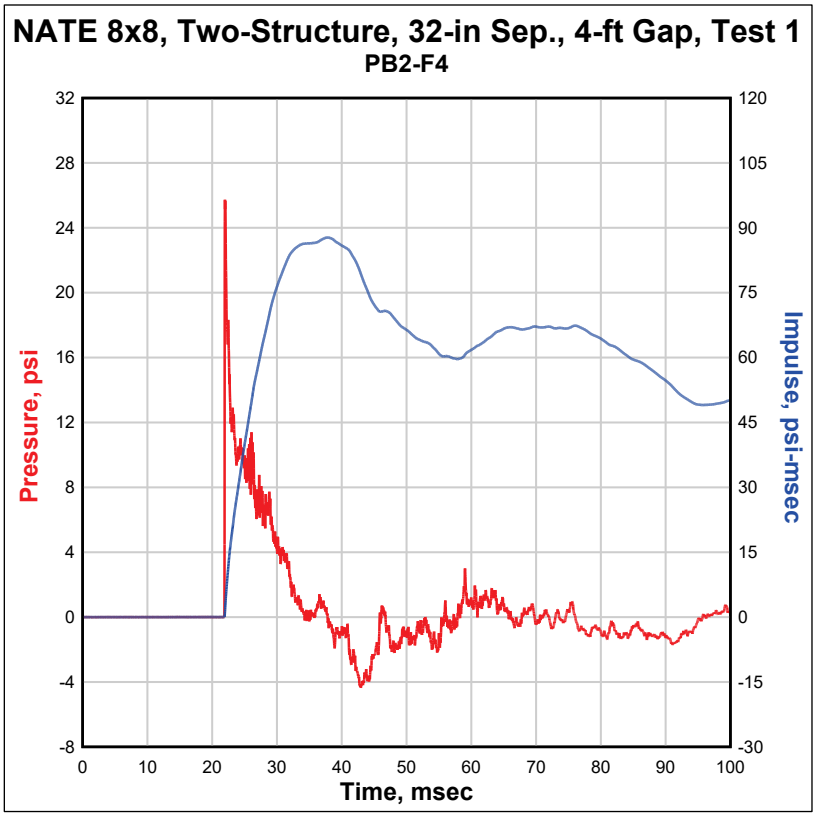
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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20
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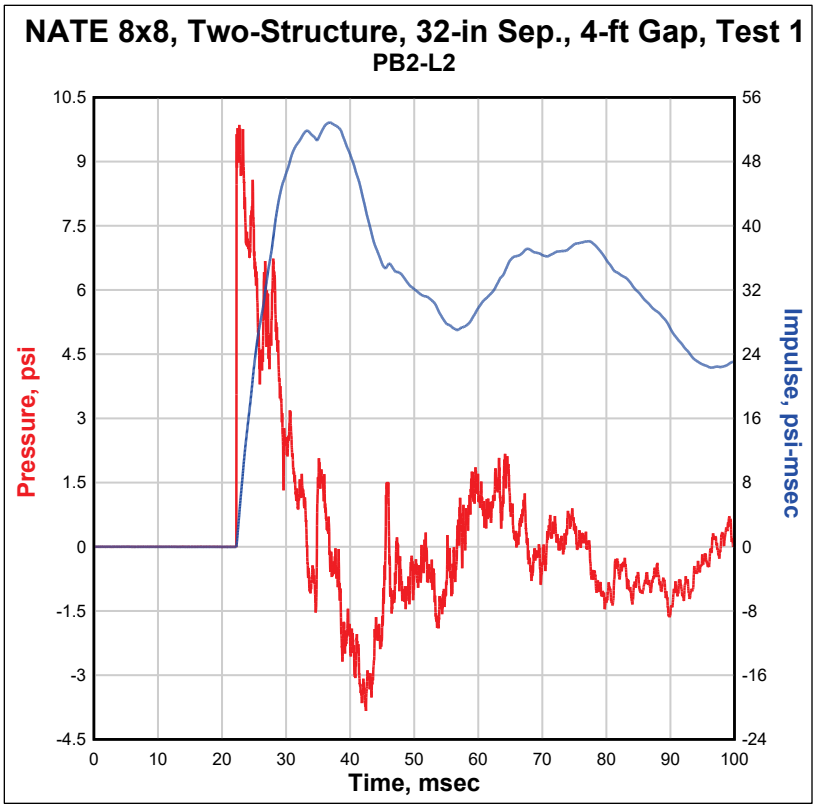
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
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60
70
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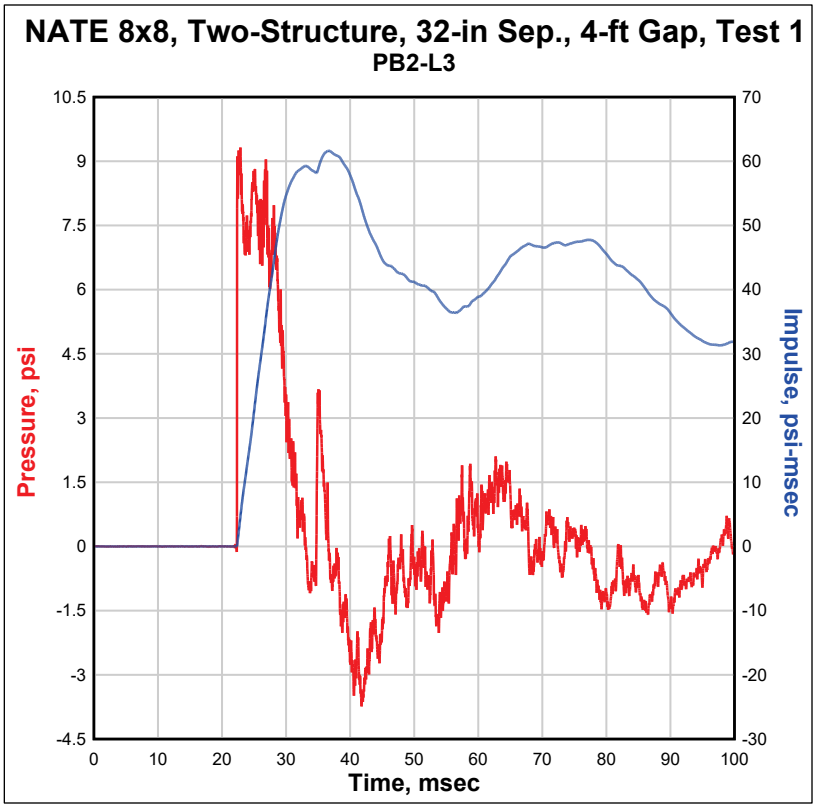
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
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10
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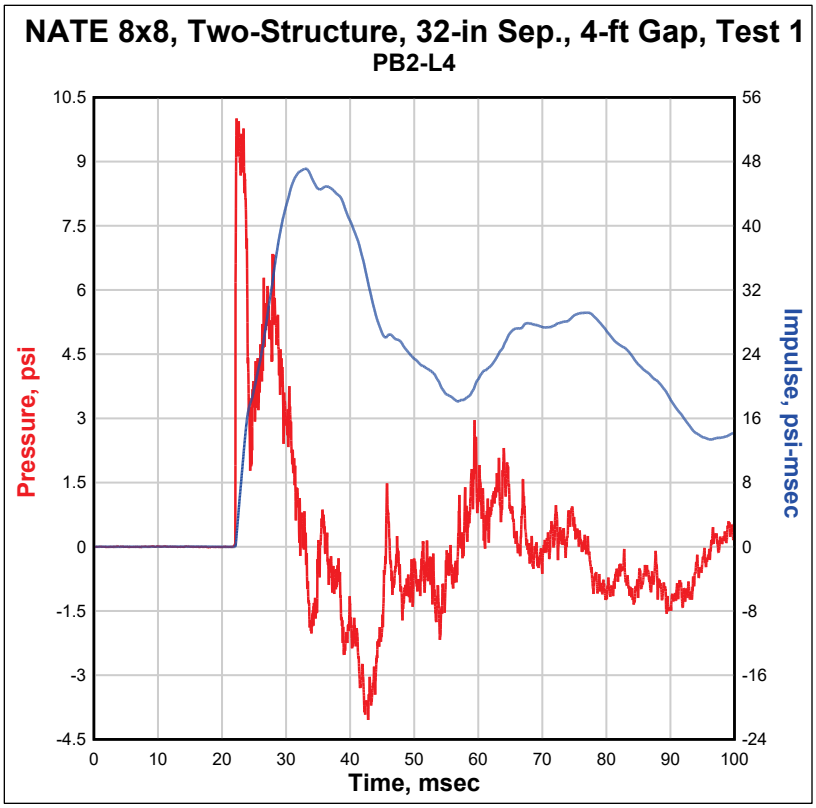
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
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10
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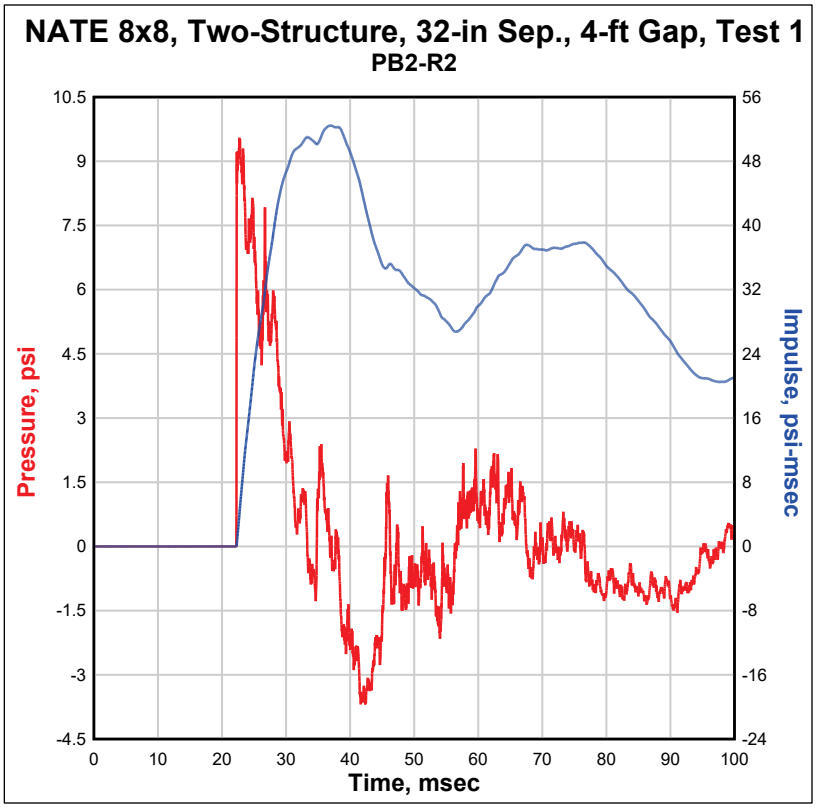
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
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10
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30
40
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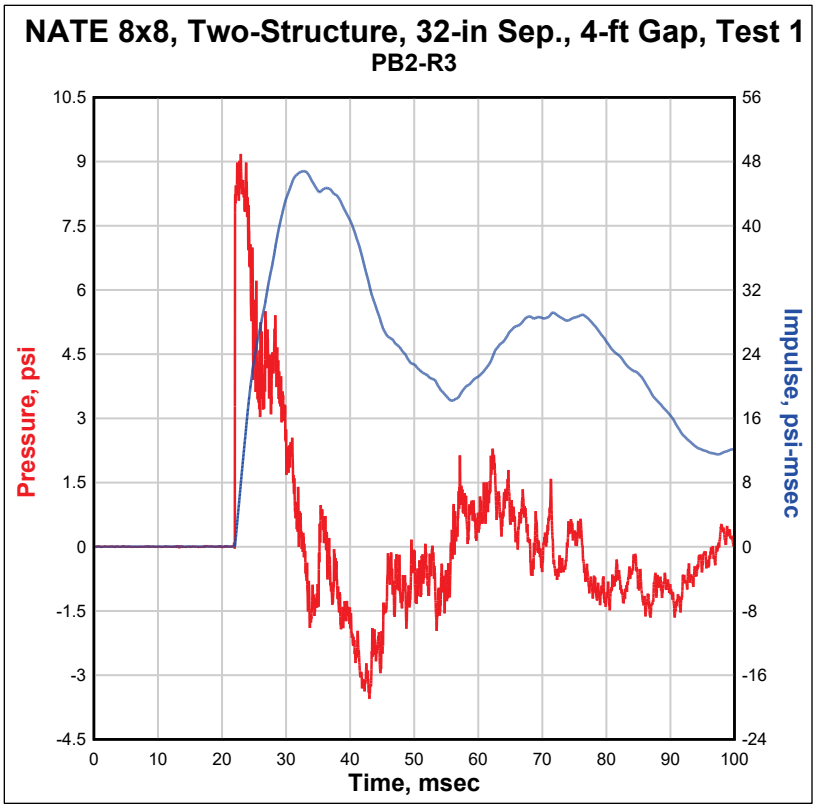
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
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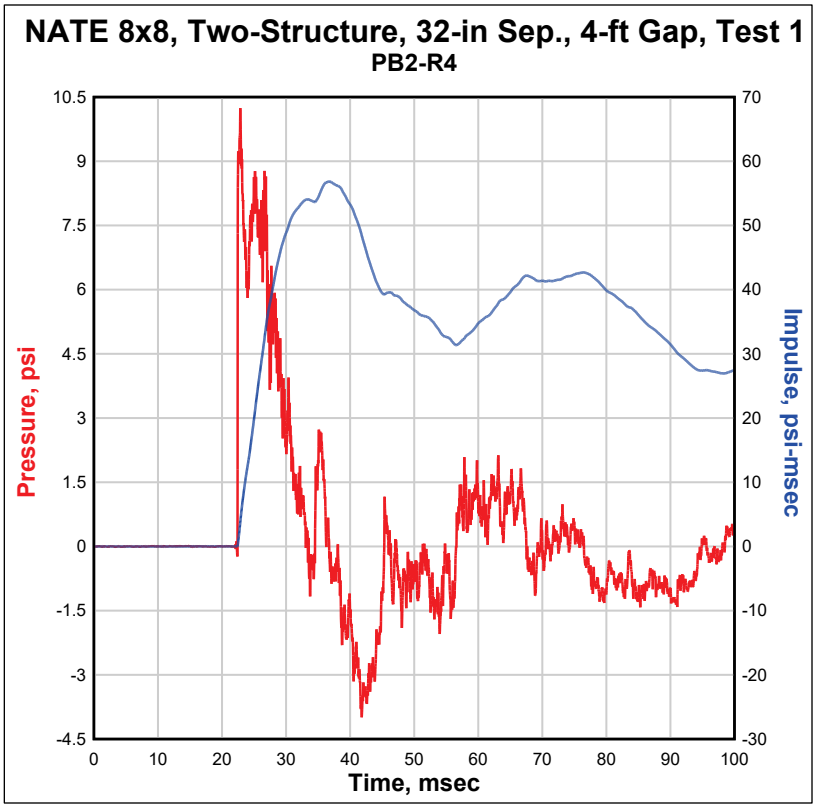
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
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-10
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90
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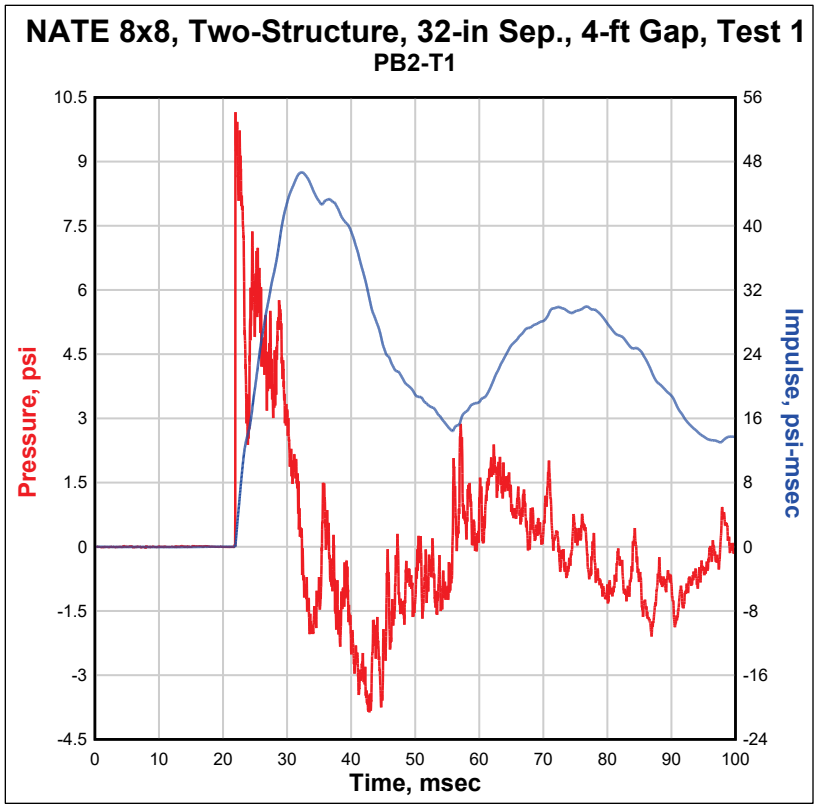
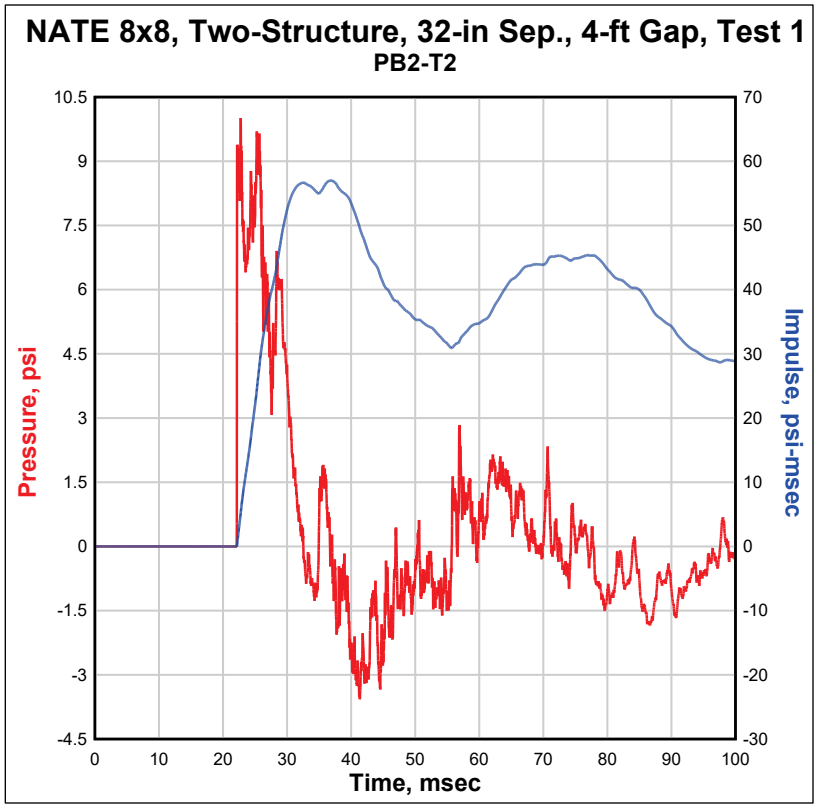
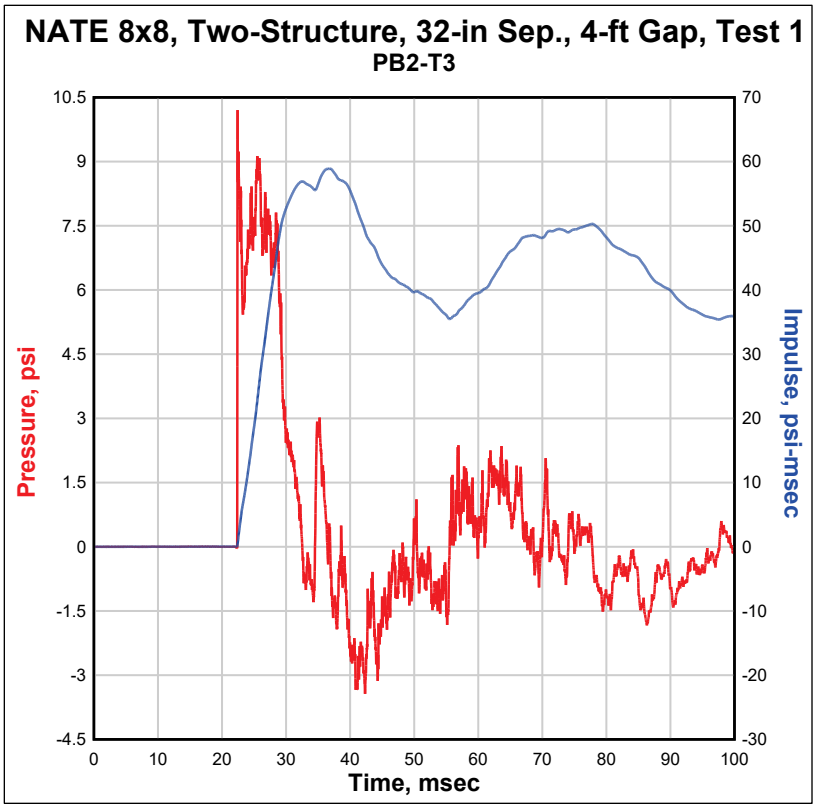
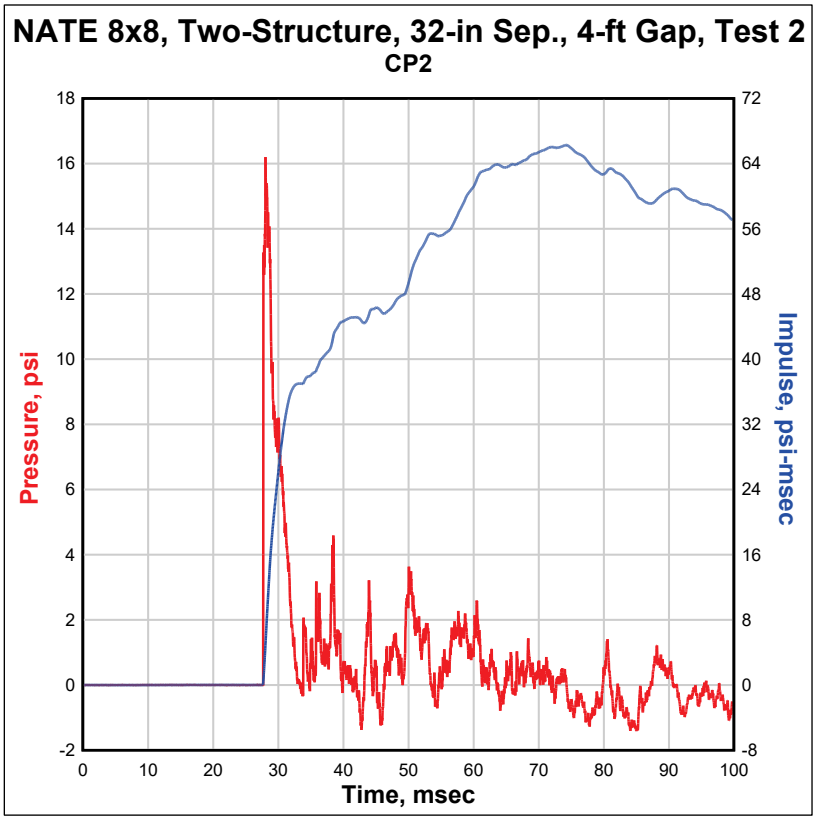
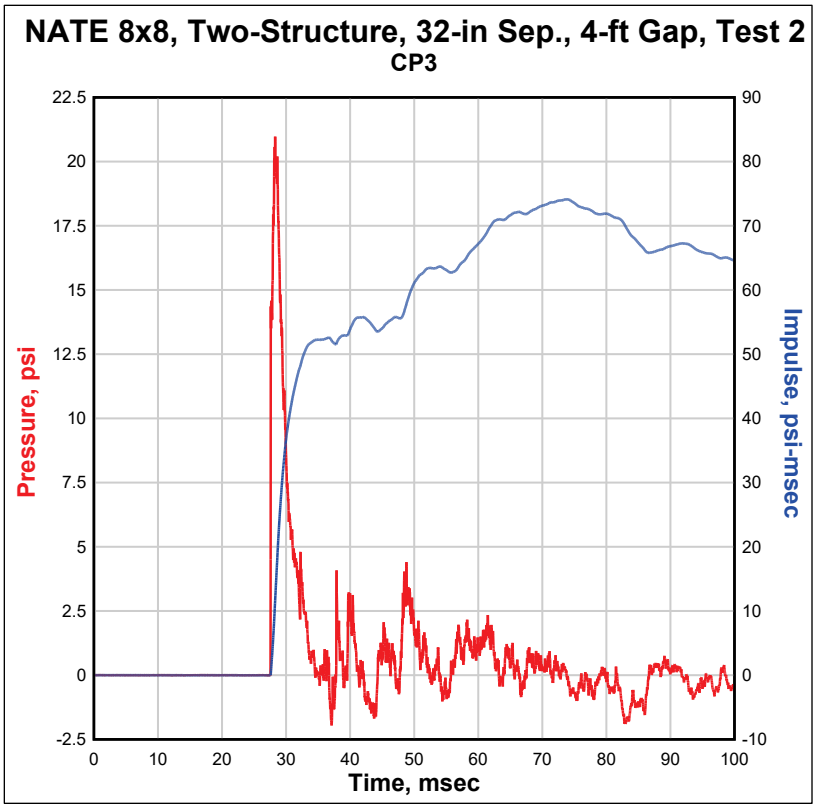
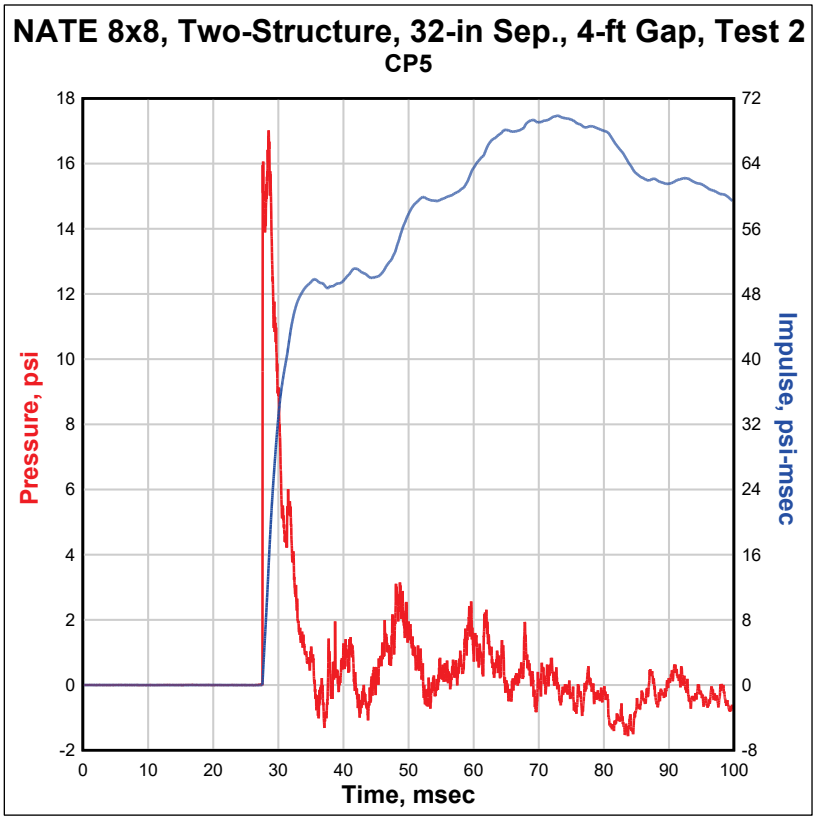

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

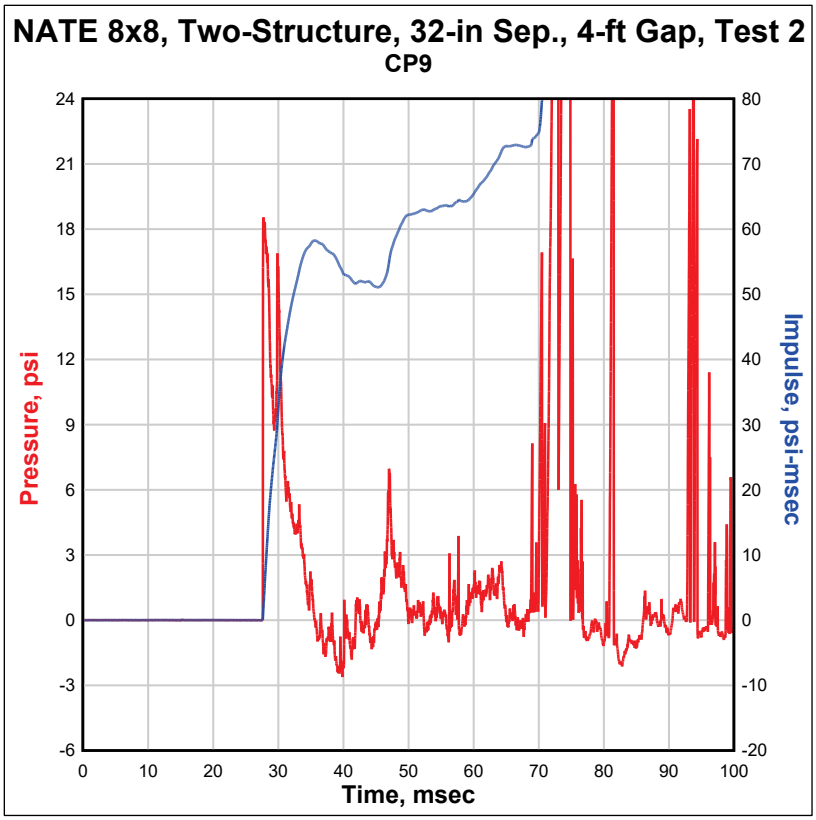

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

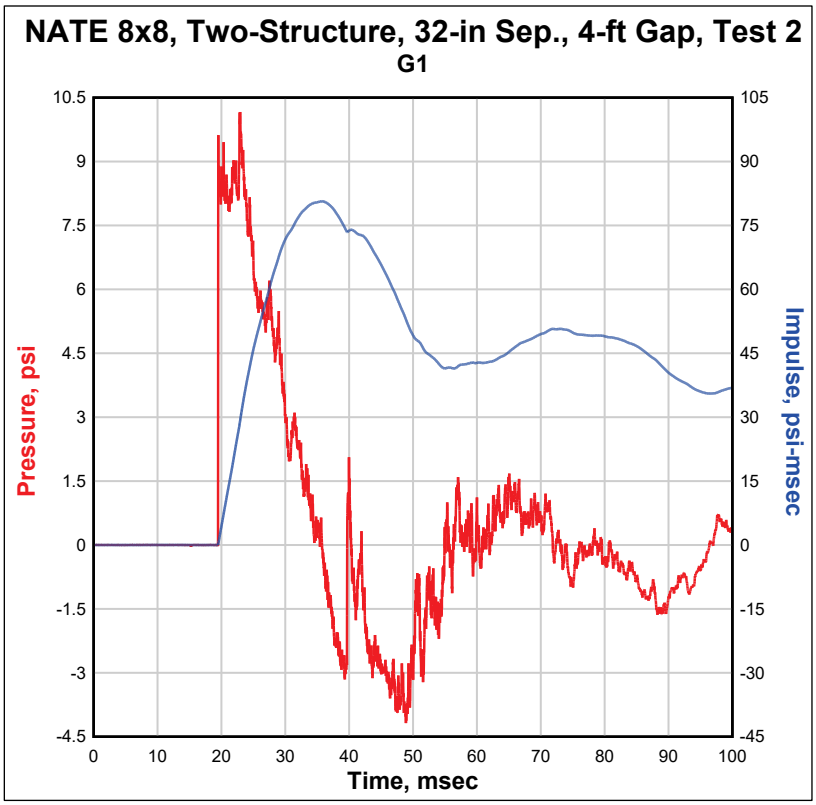

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 1
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

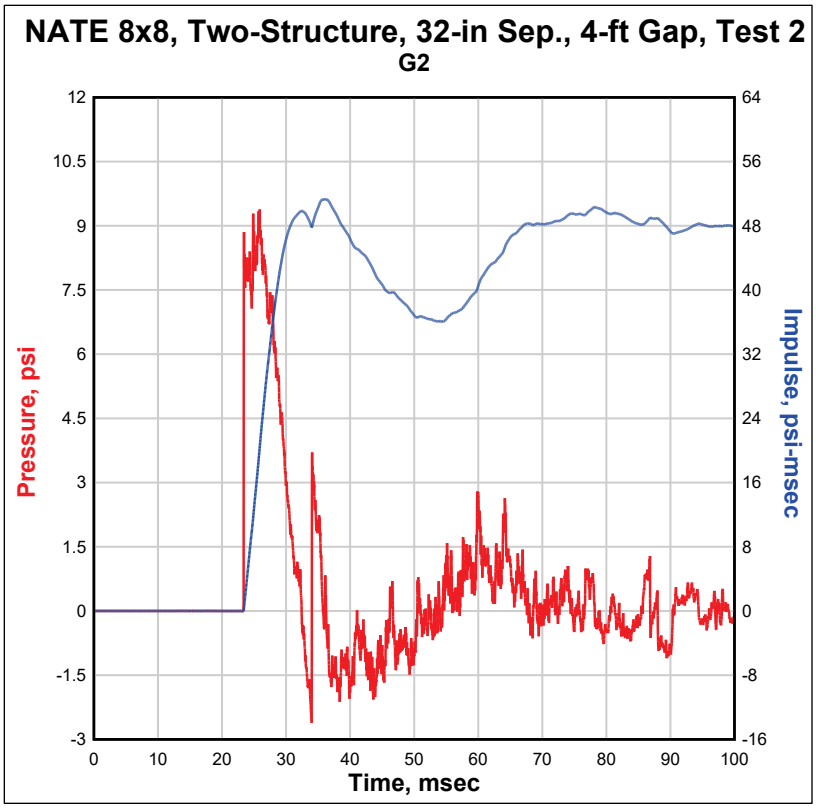

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

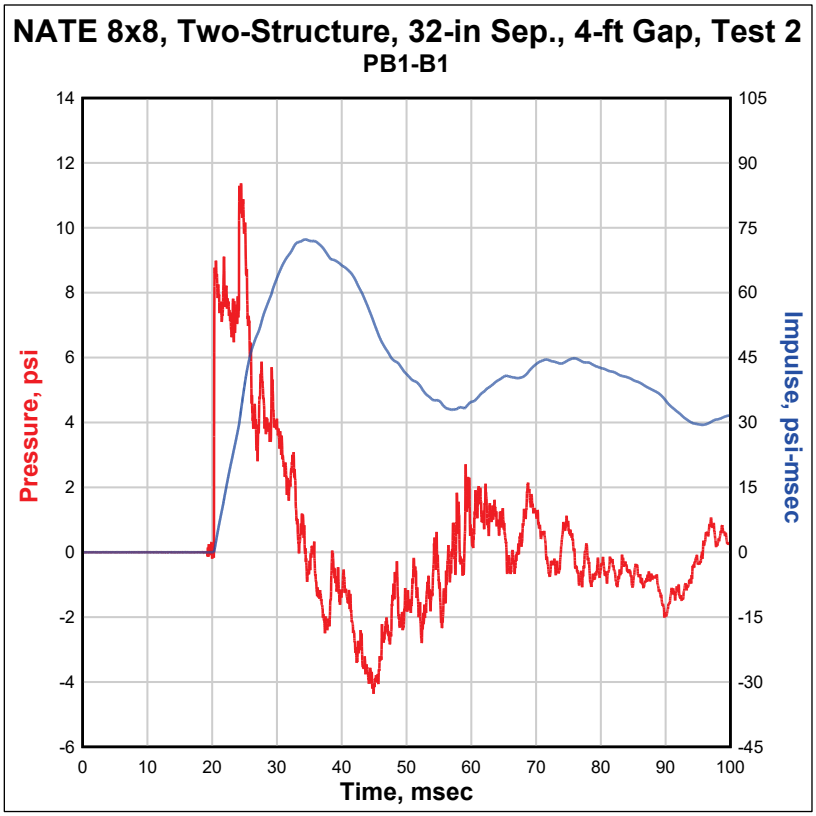

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

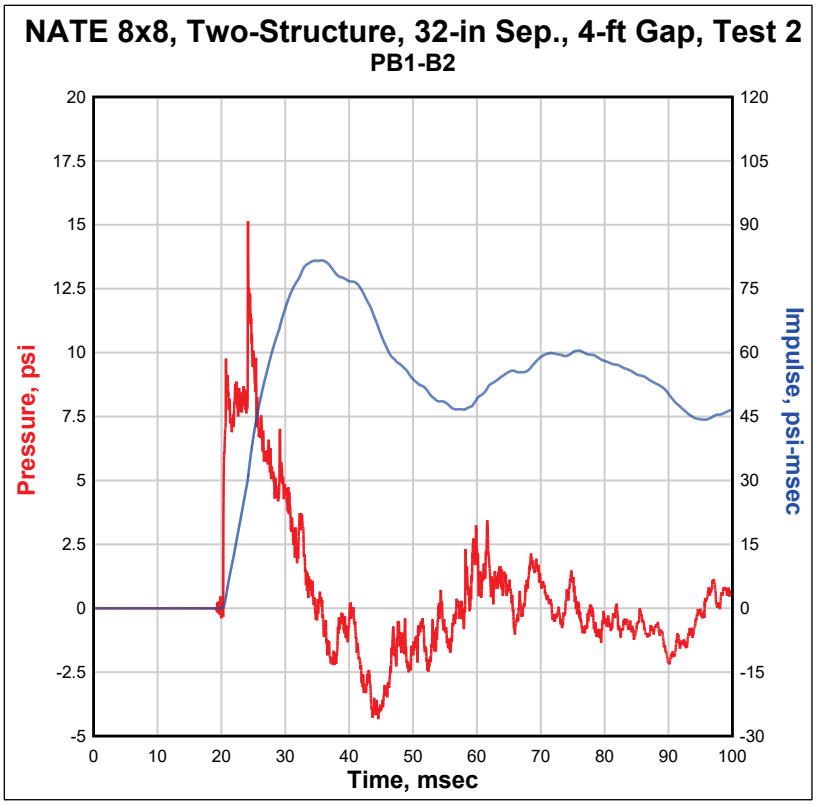

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

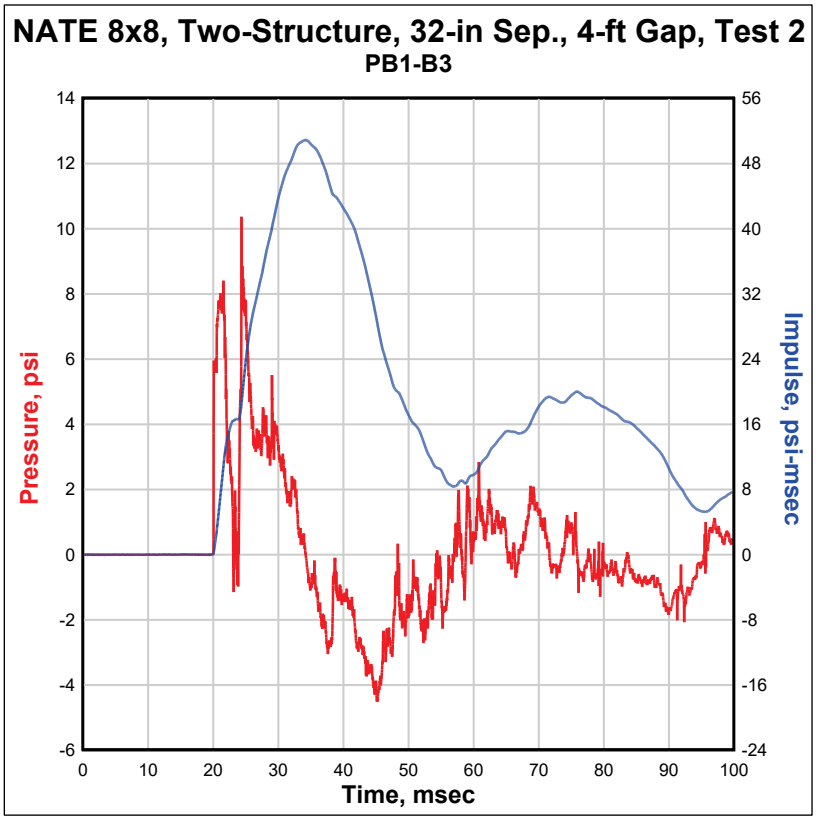

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

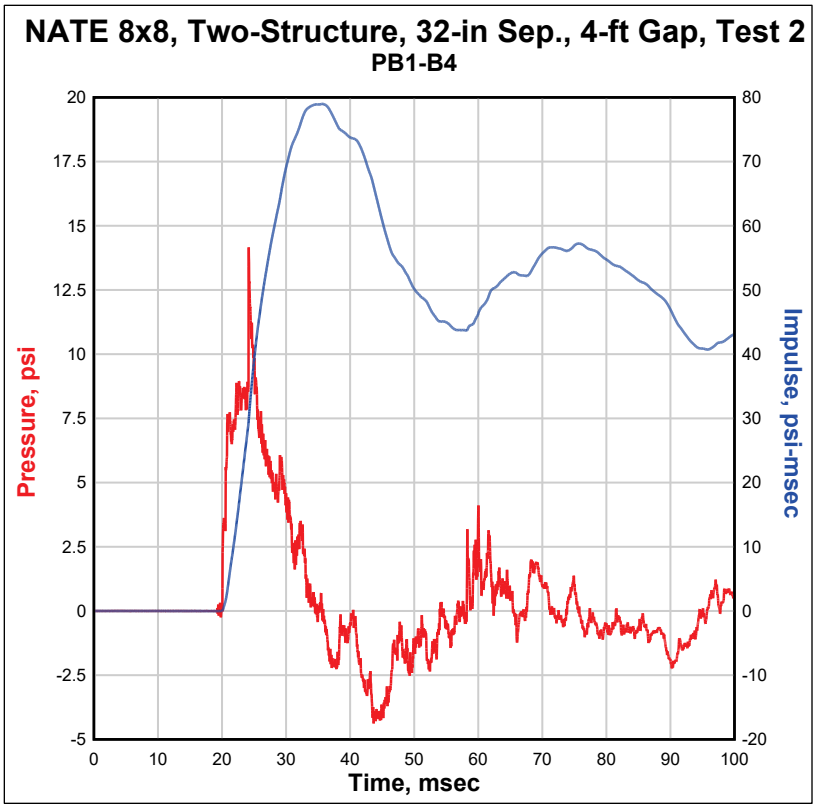

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

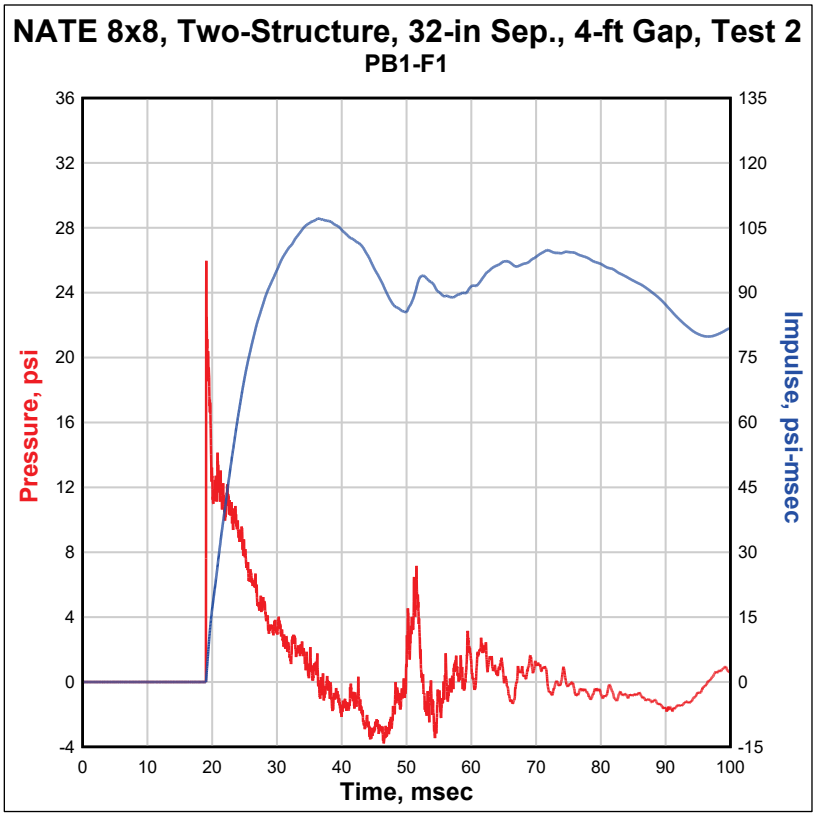

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

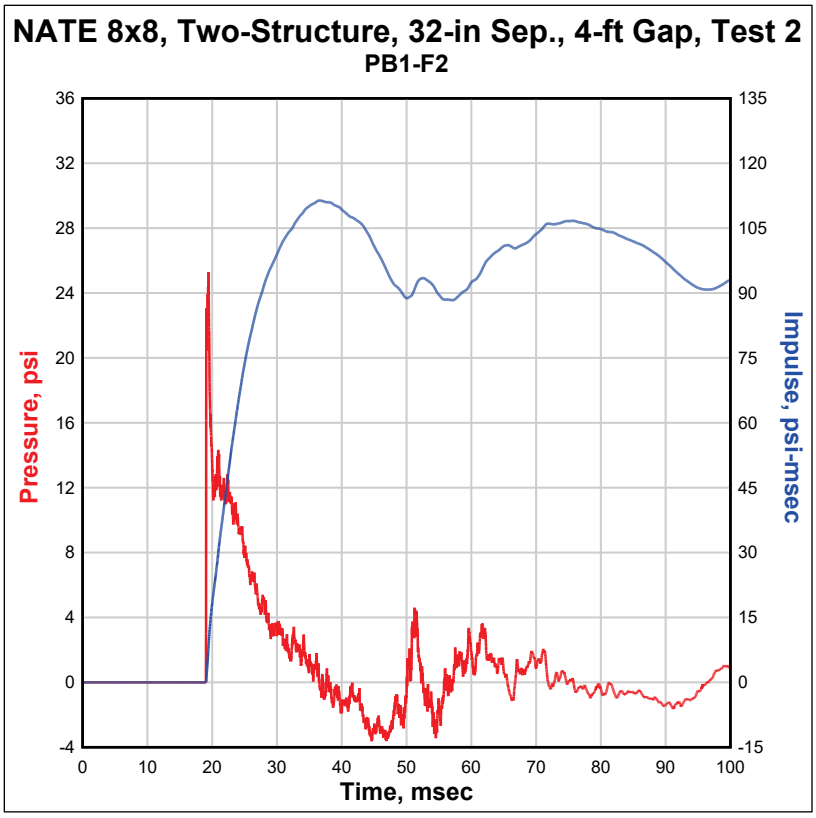

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

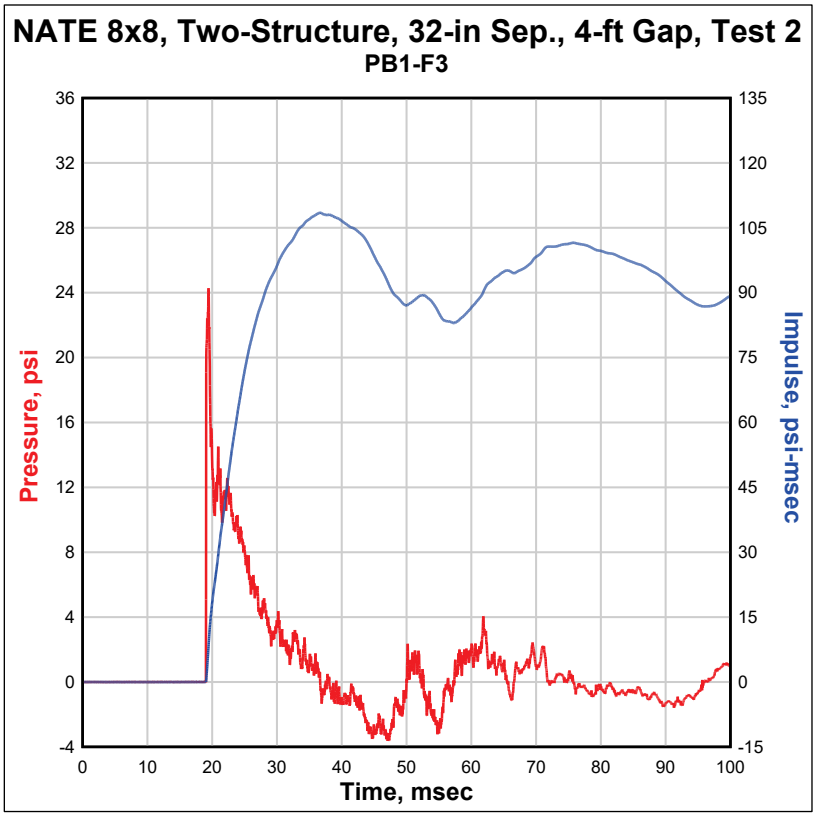

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

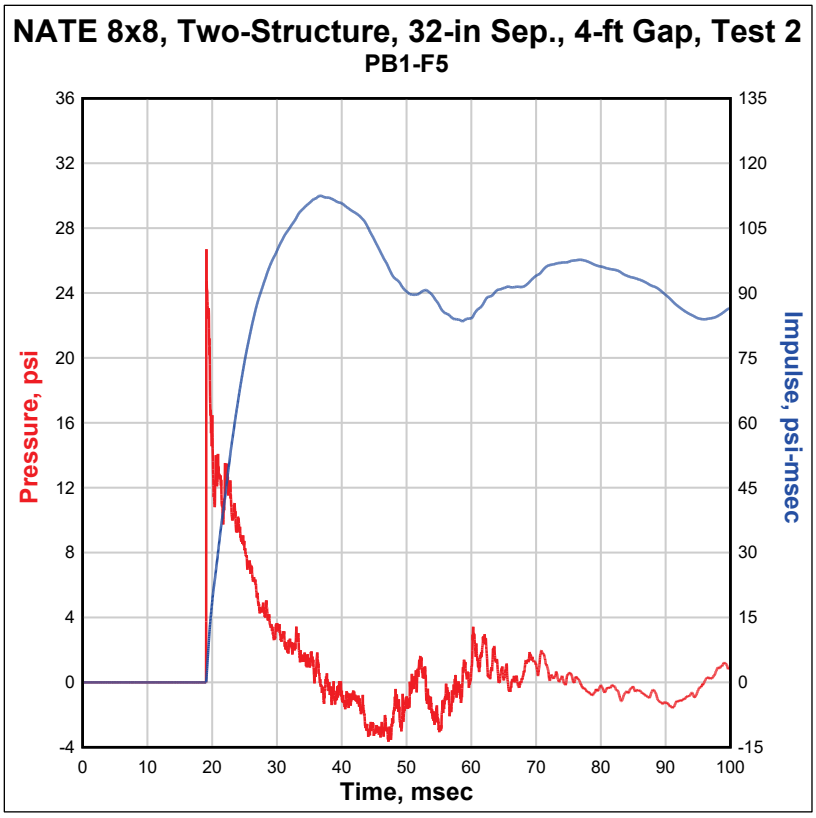

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

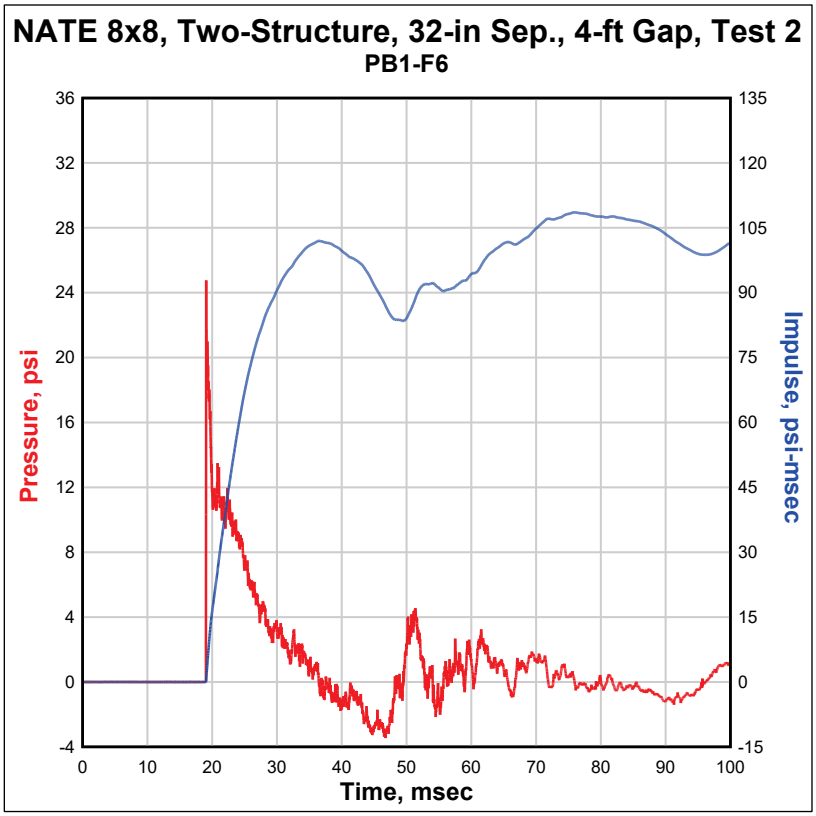

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

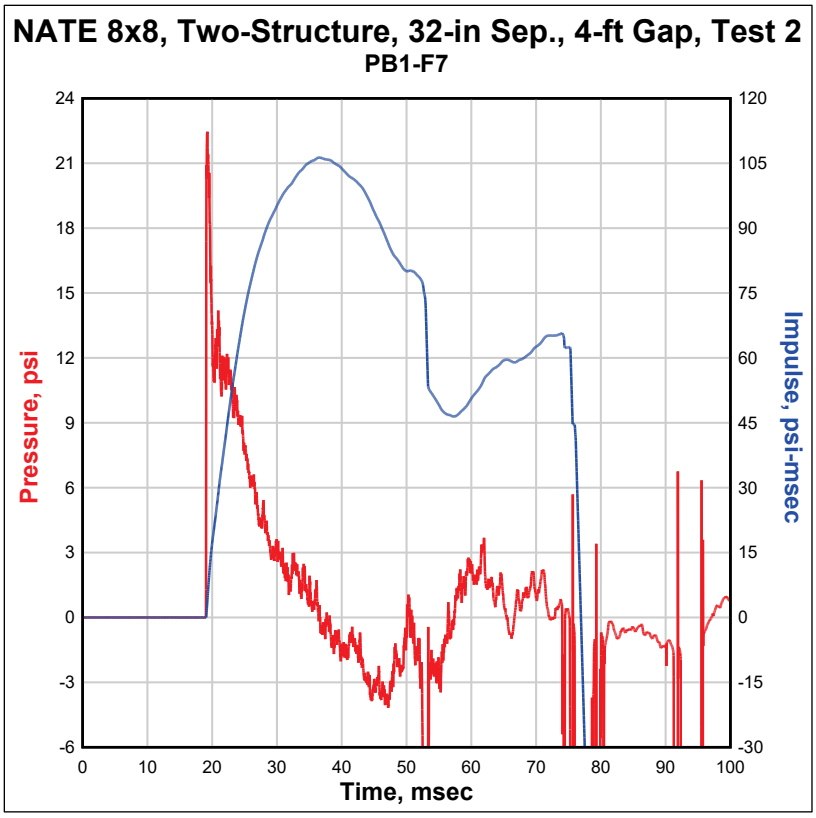

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
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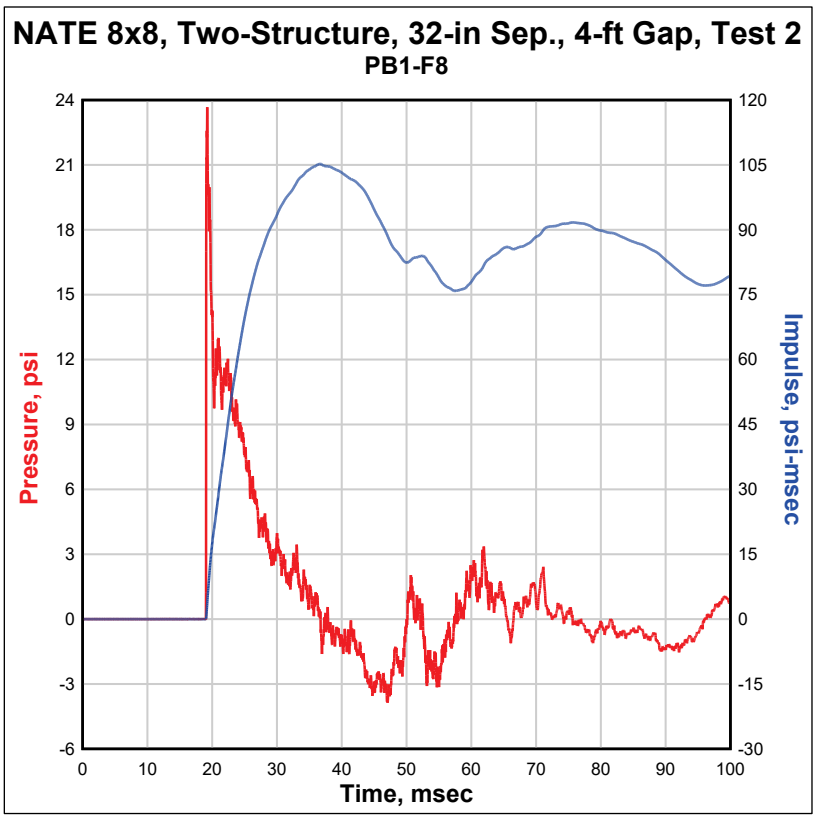
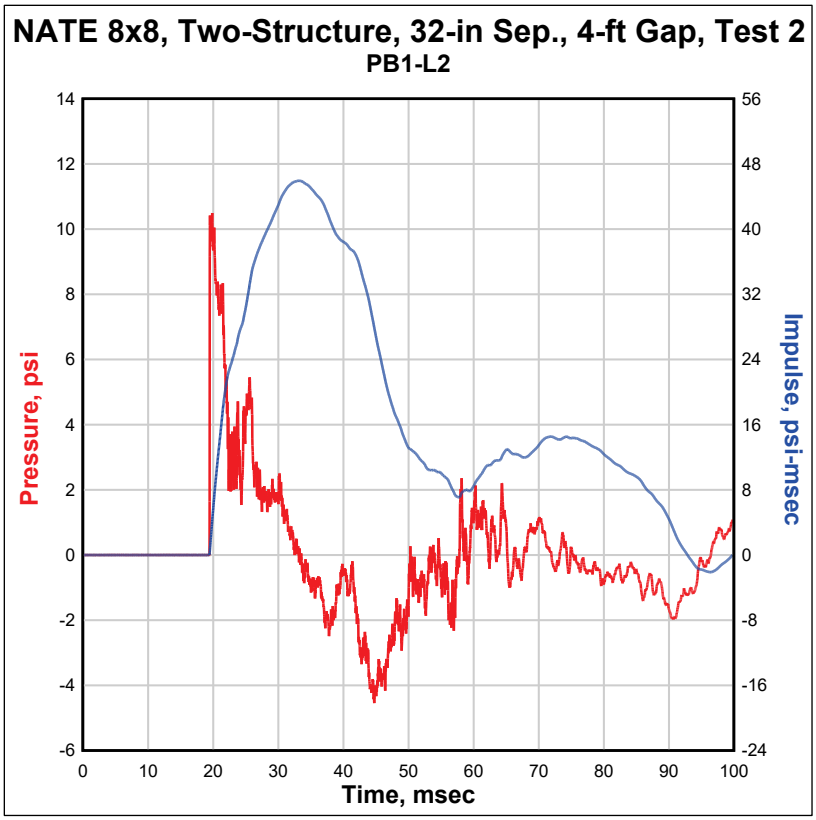
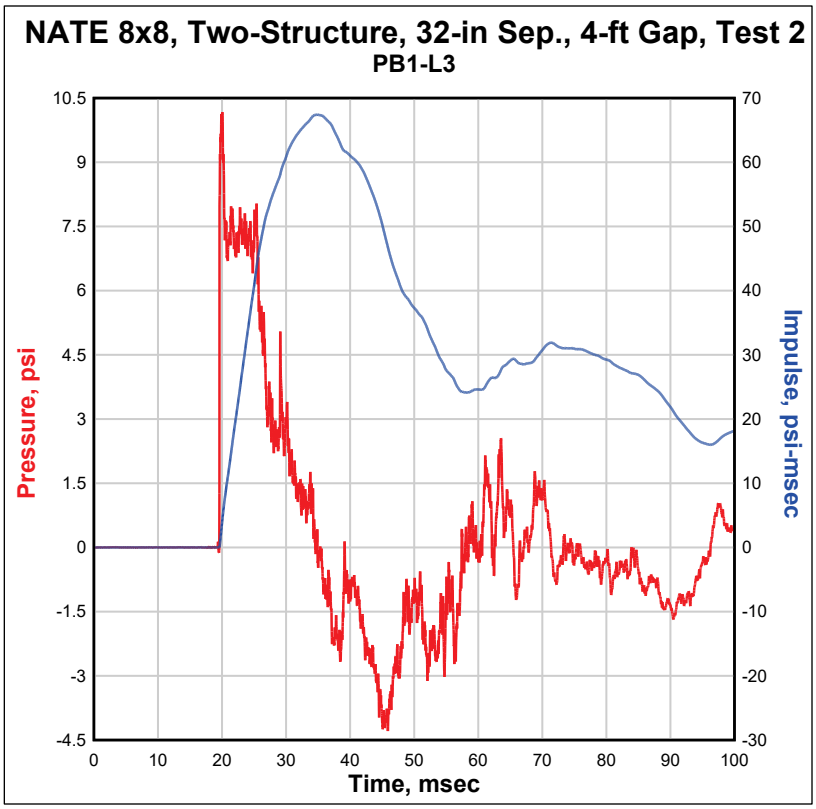
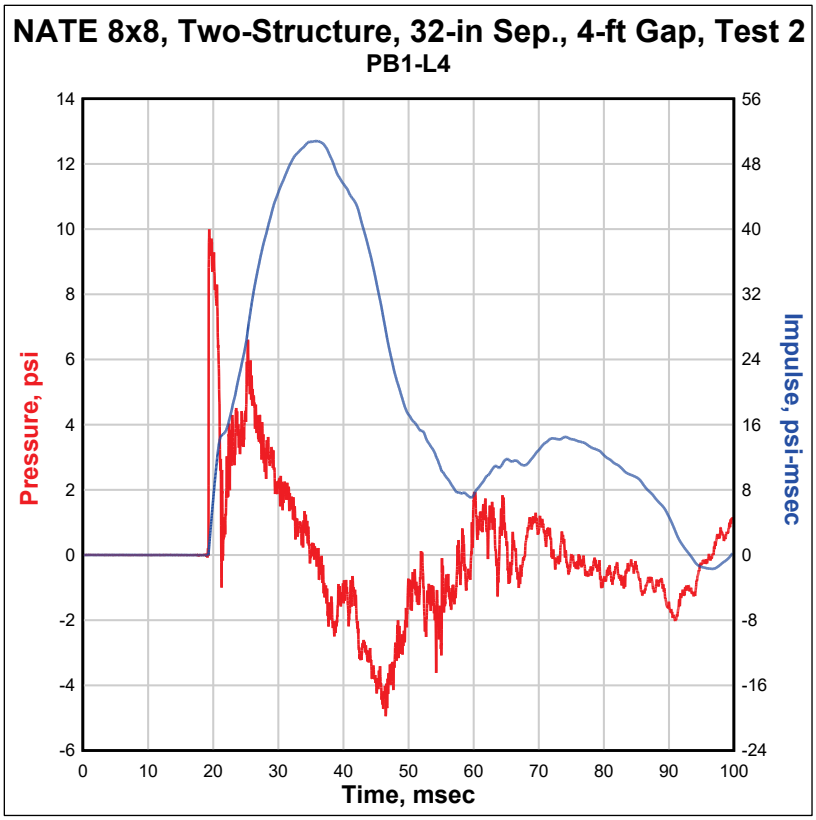
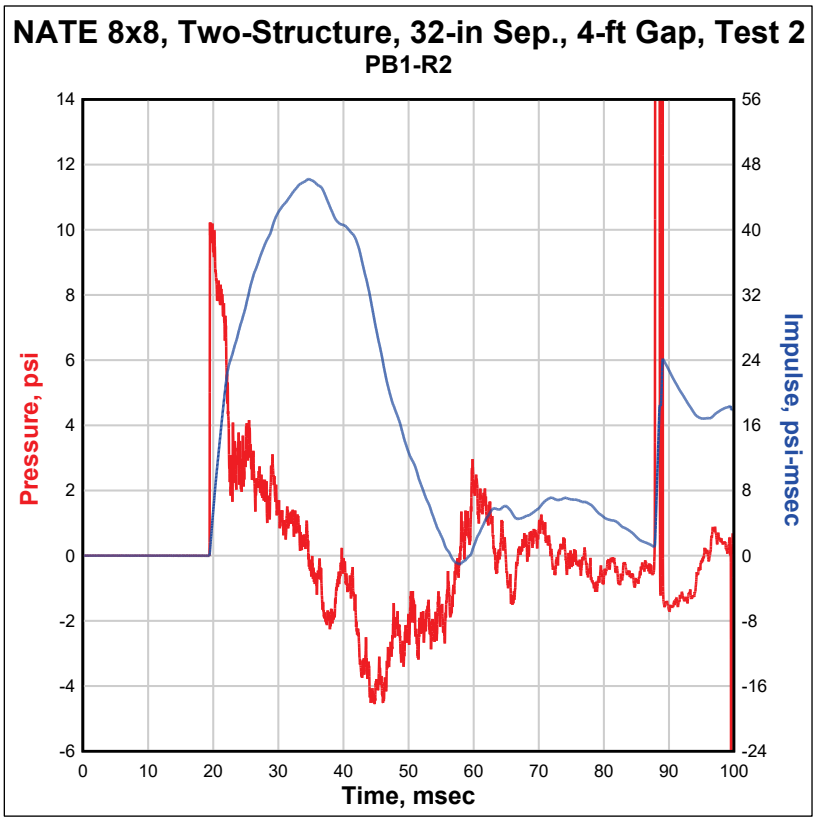
90
100

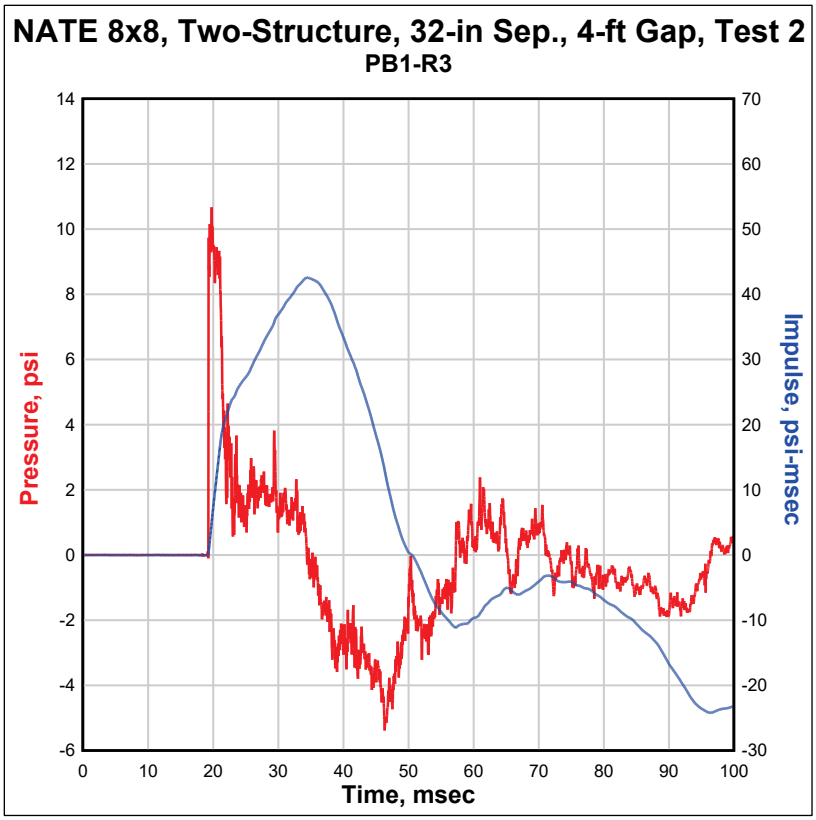

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

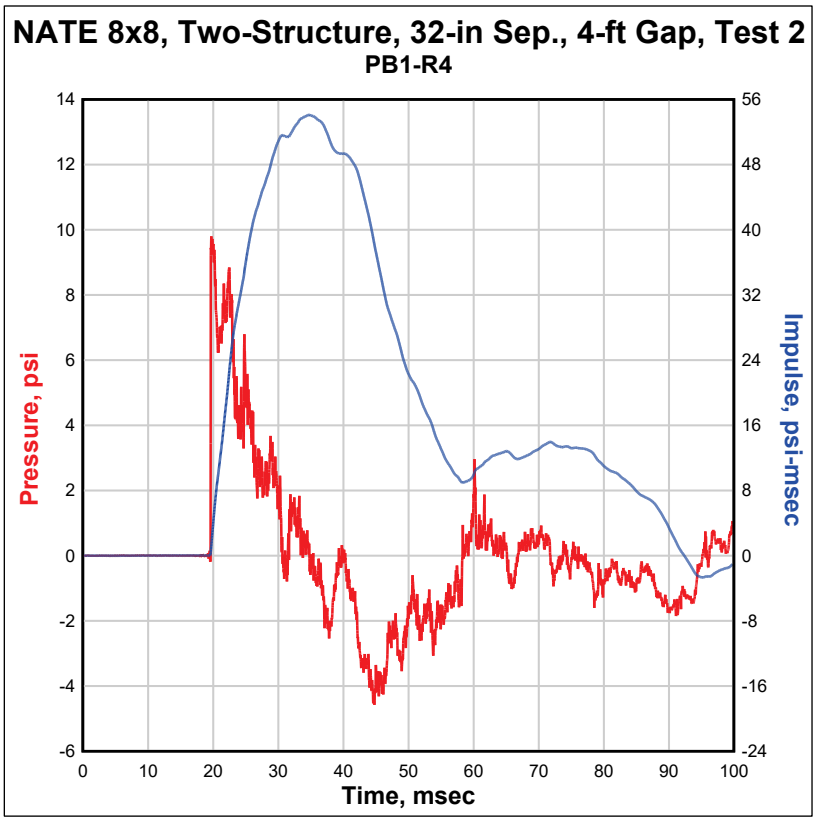

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
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20
30
40
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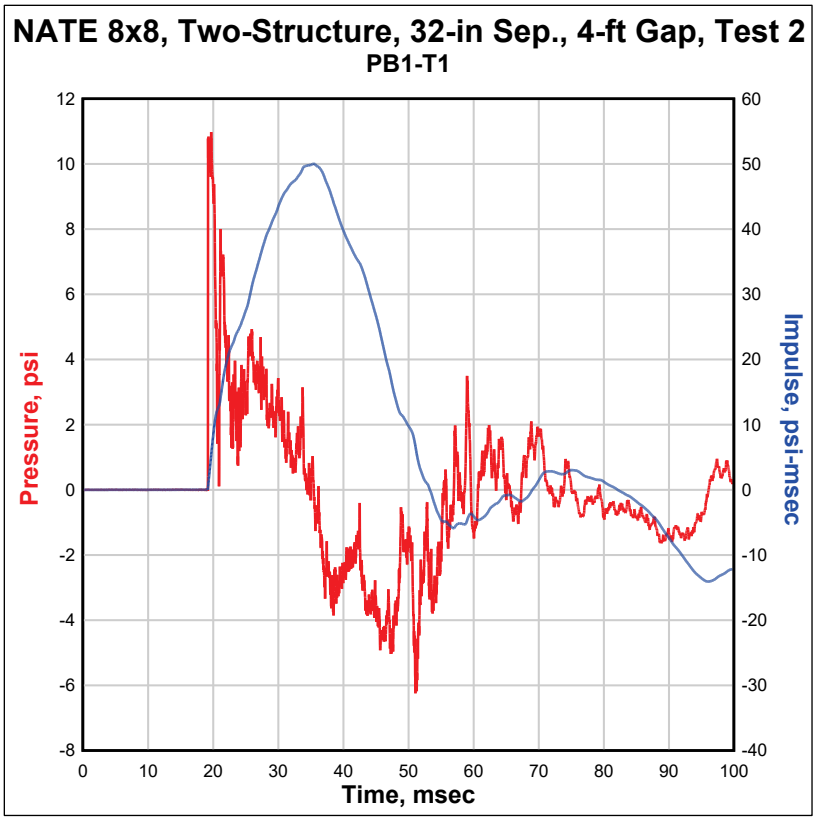
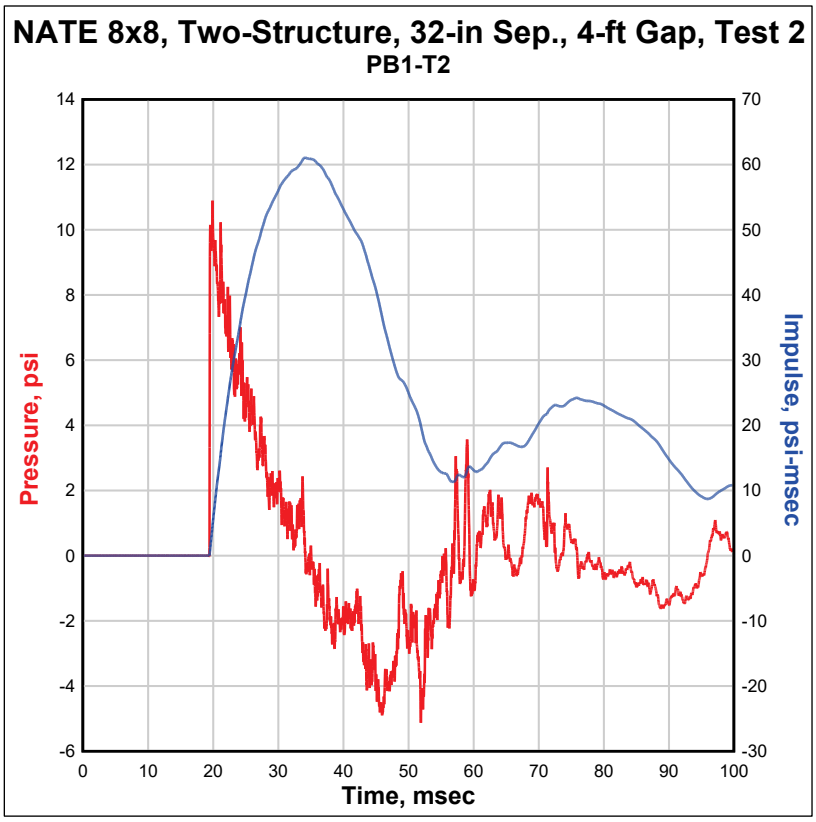
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
60
50
40
30
20
10
0
-10
-20
-30
-40
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
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30
40
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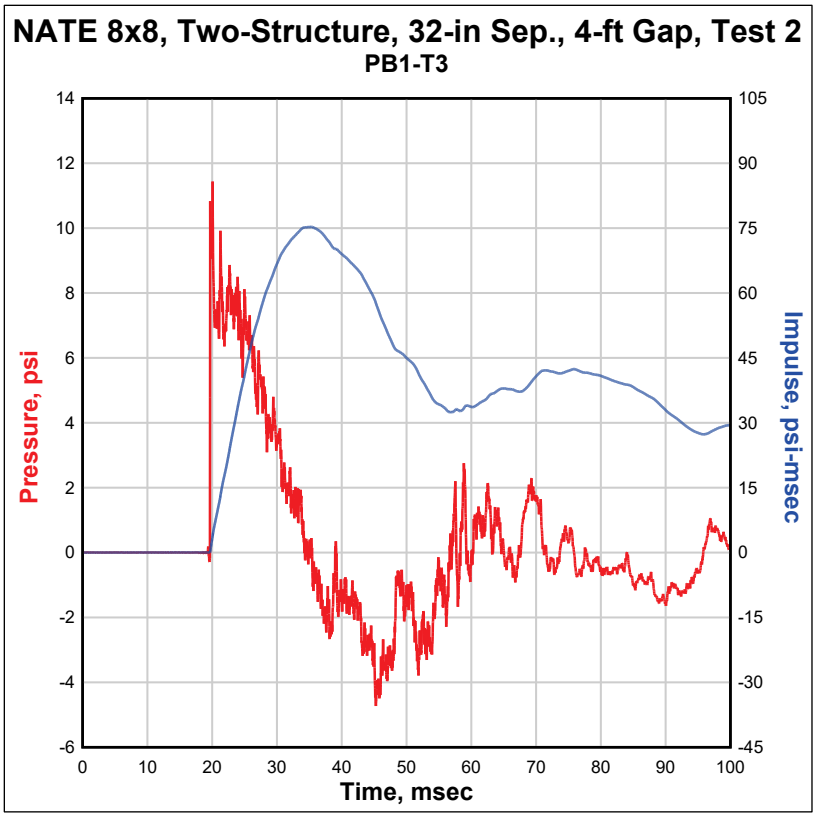
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
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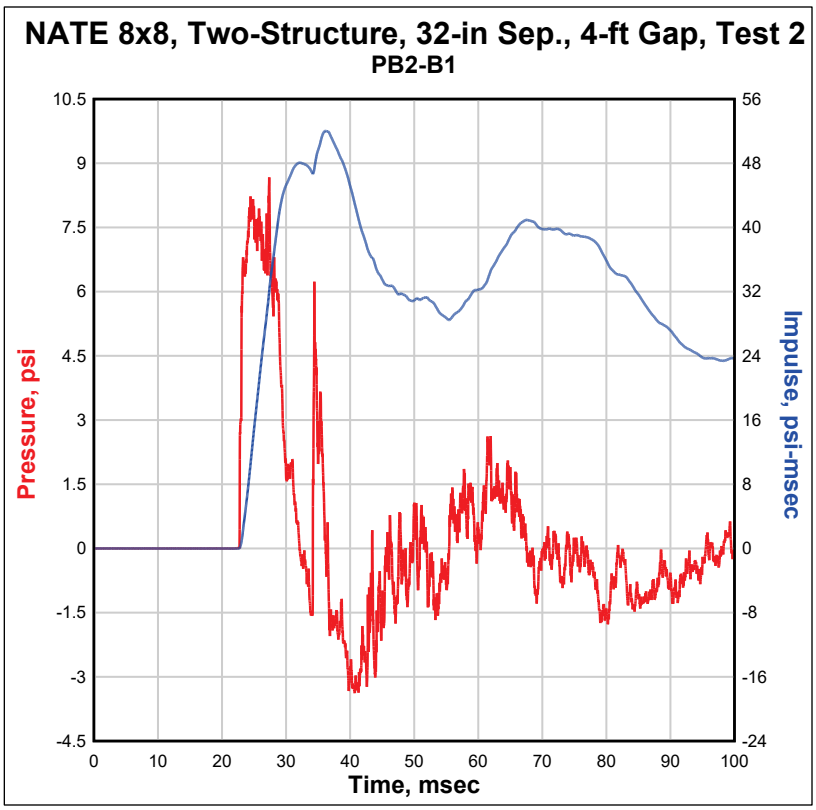
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
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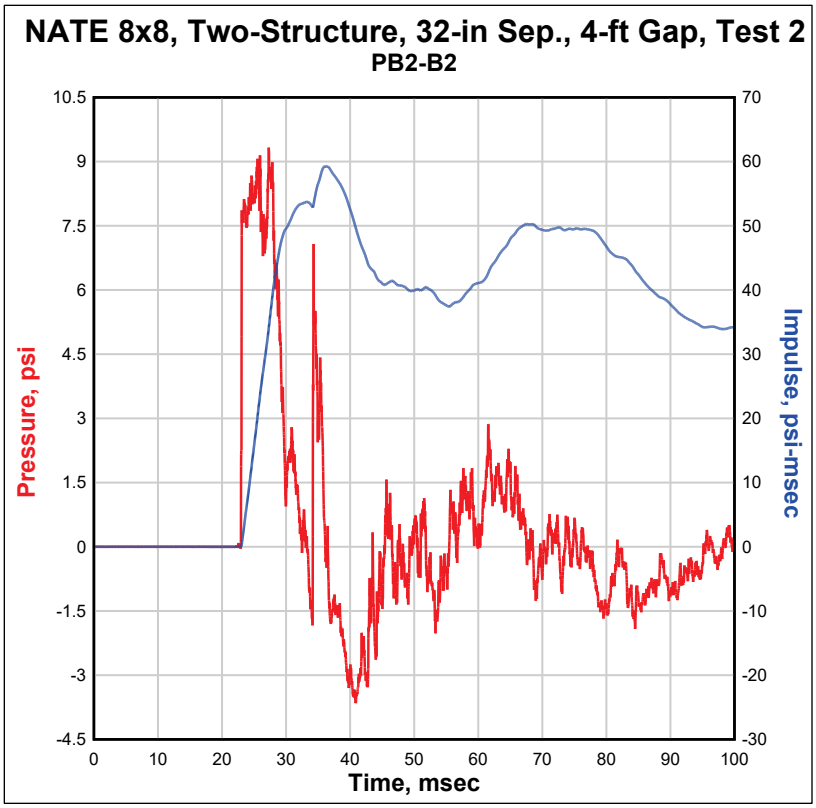
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
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60
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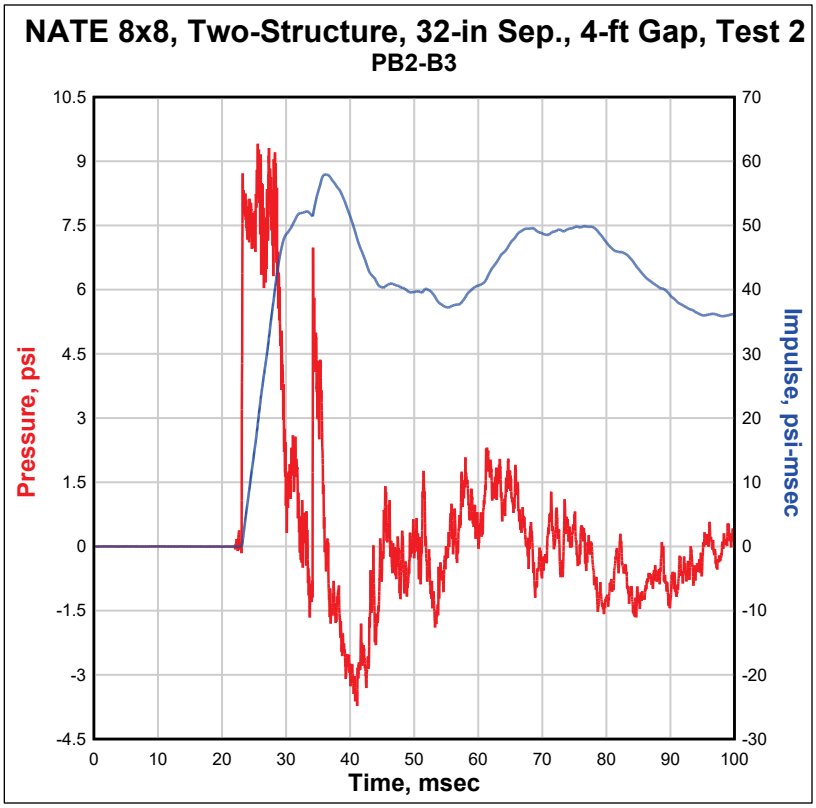
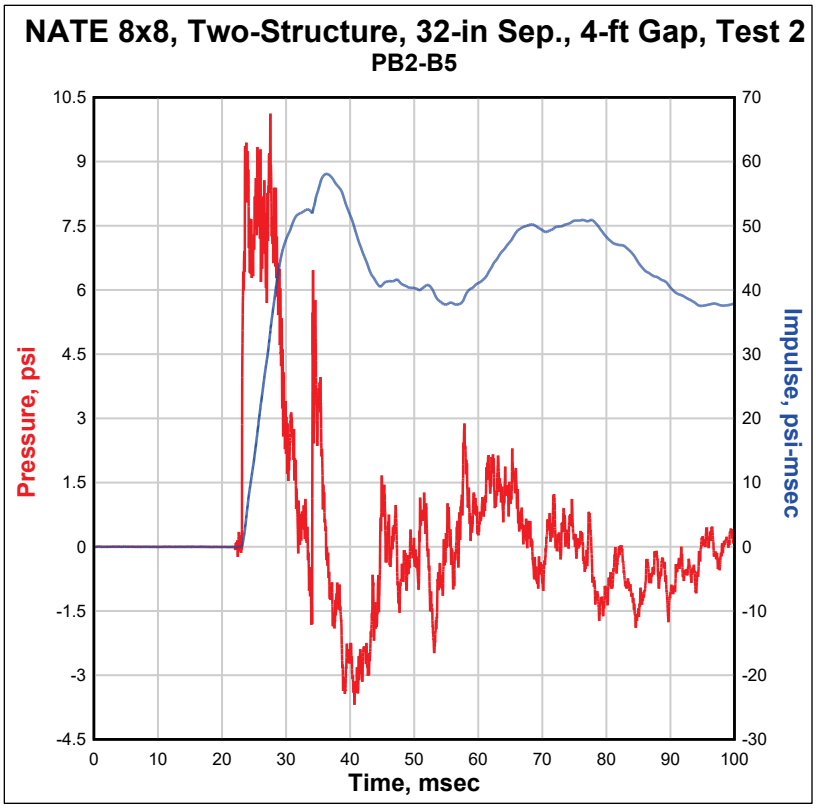
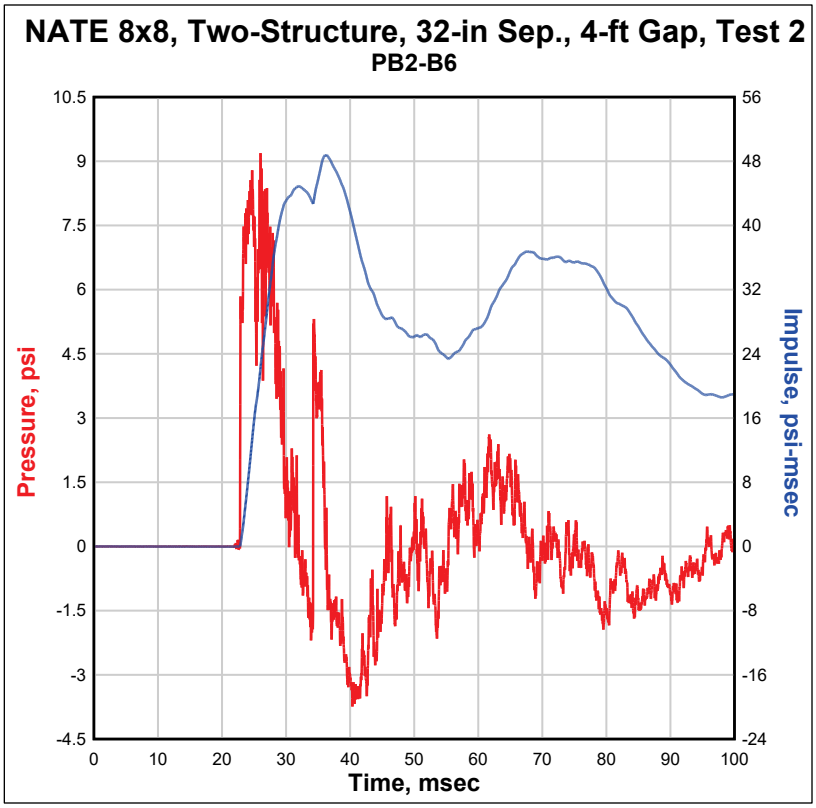
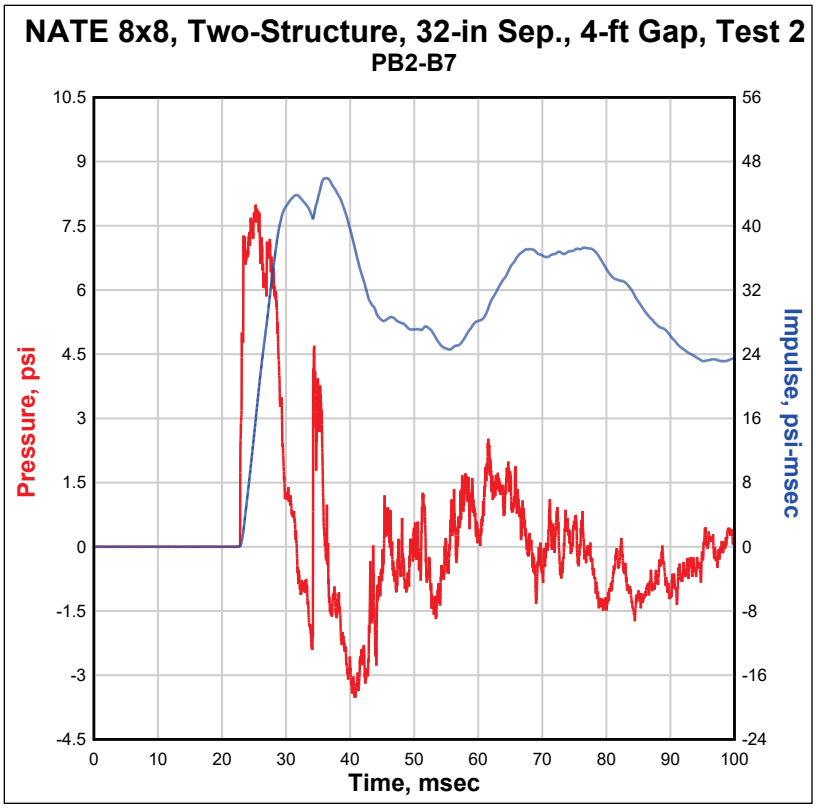
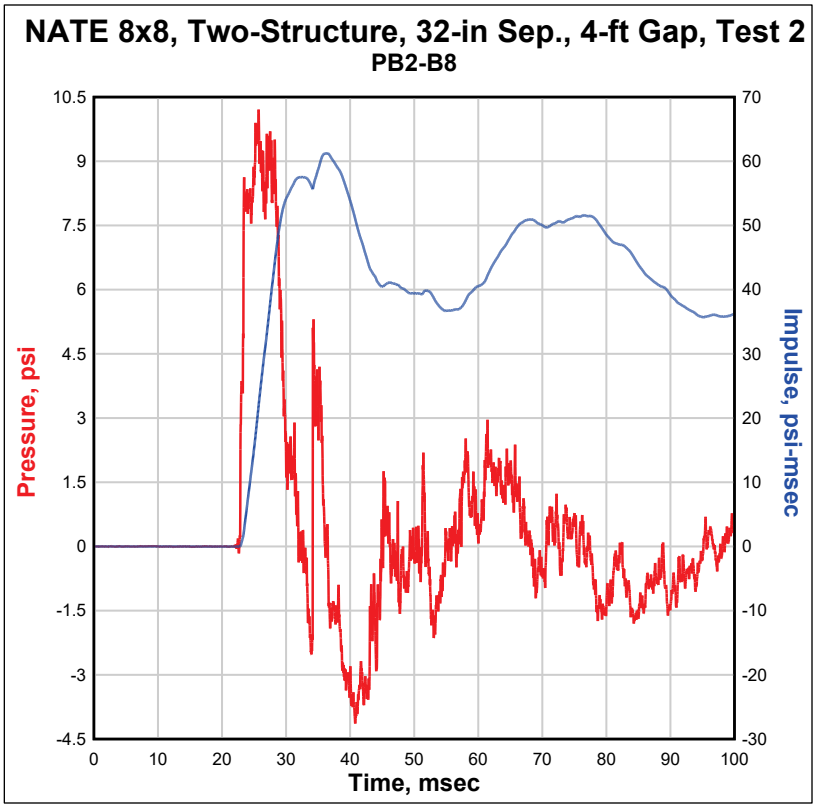
80
90
100

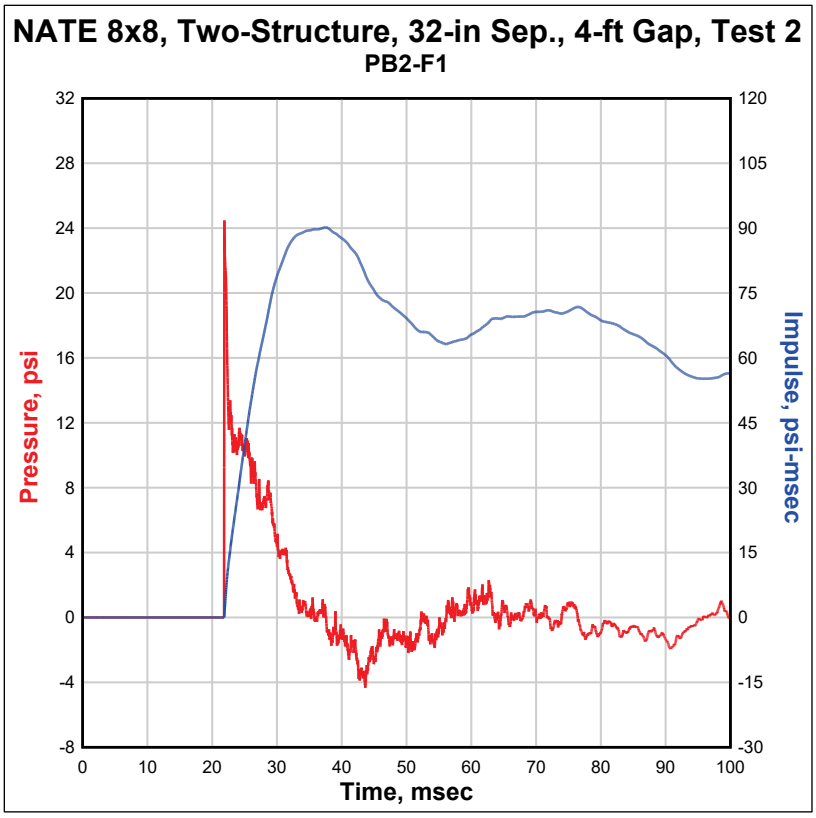

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

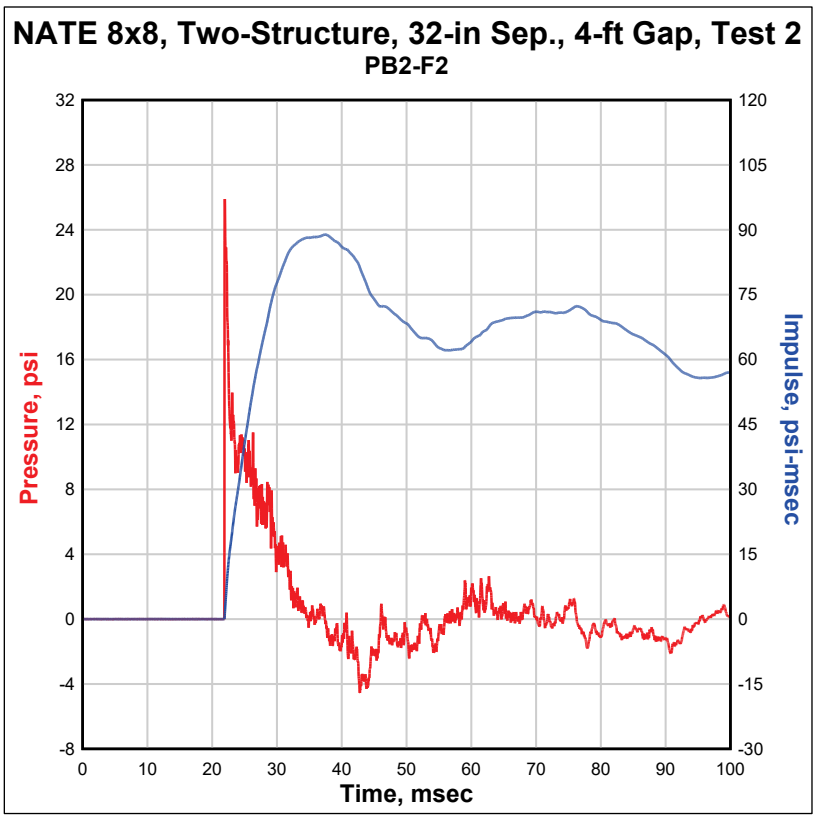

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

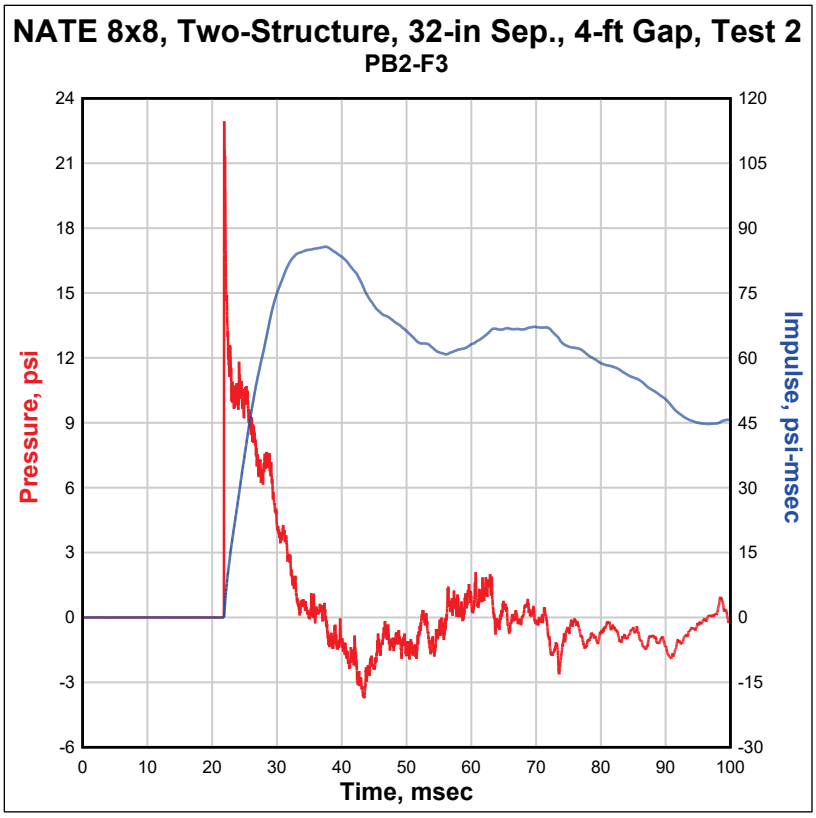

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

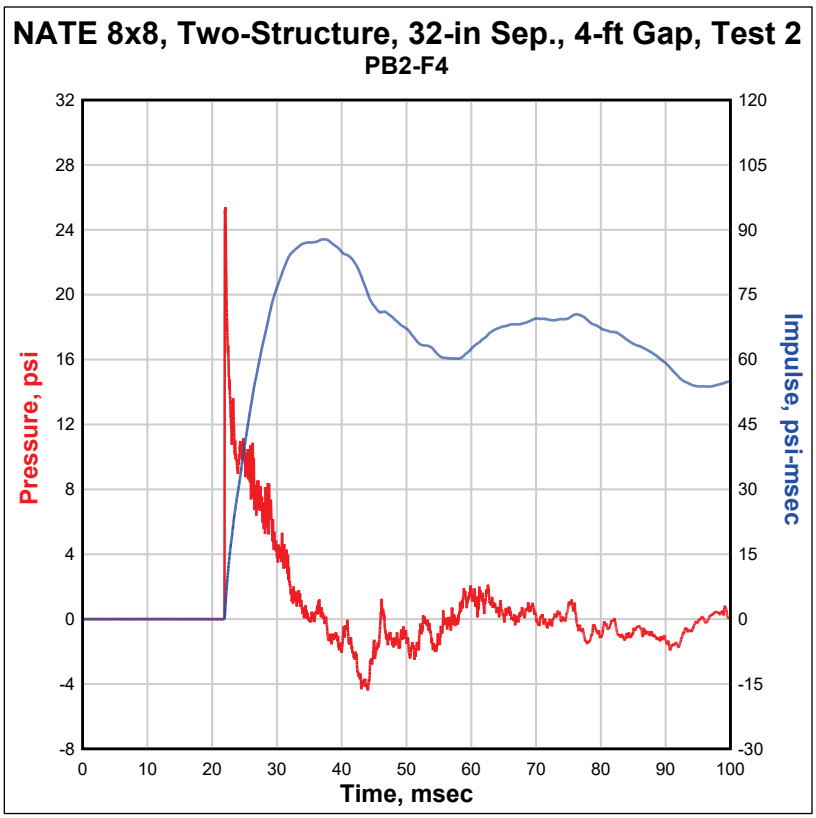

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

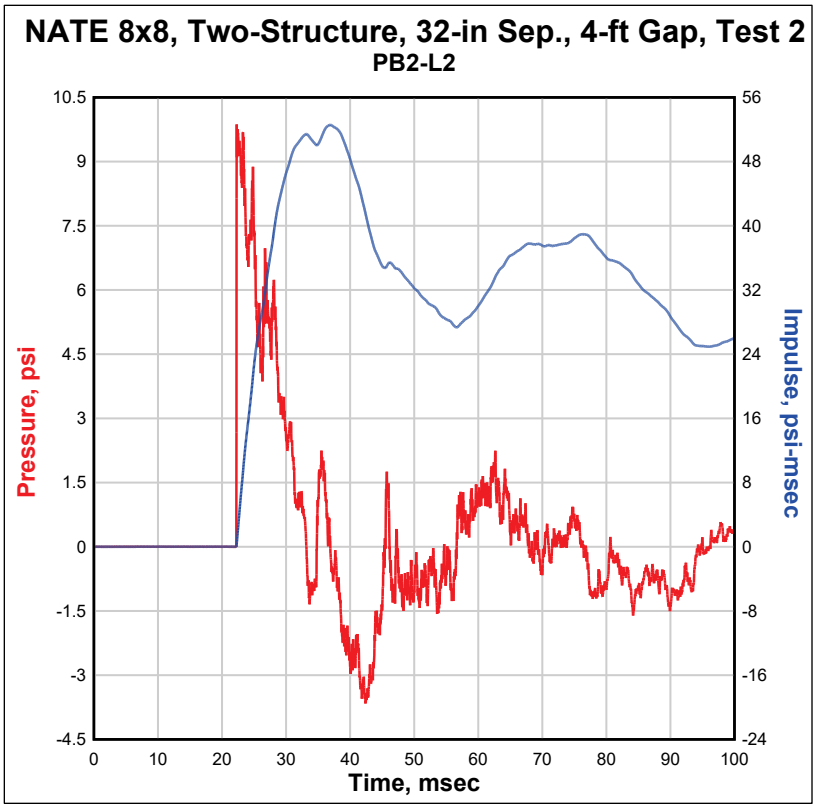

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

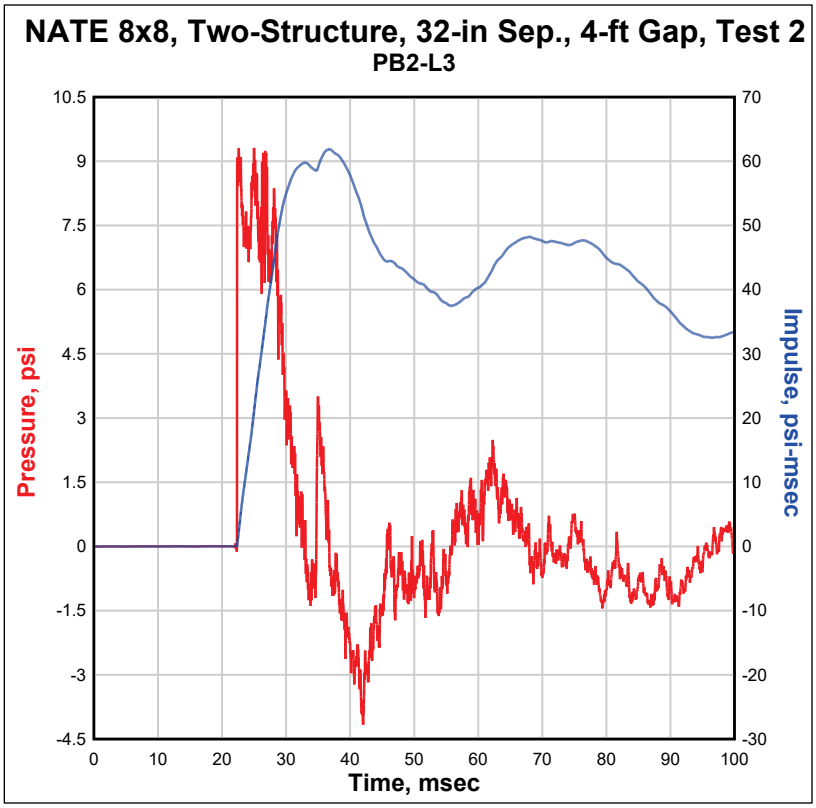

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

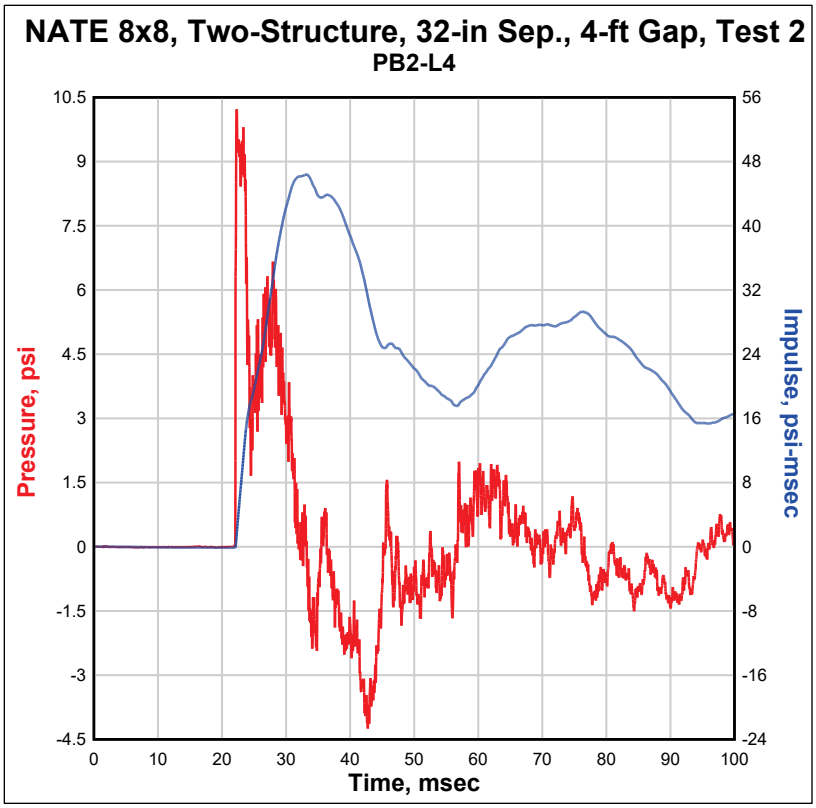

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

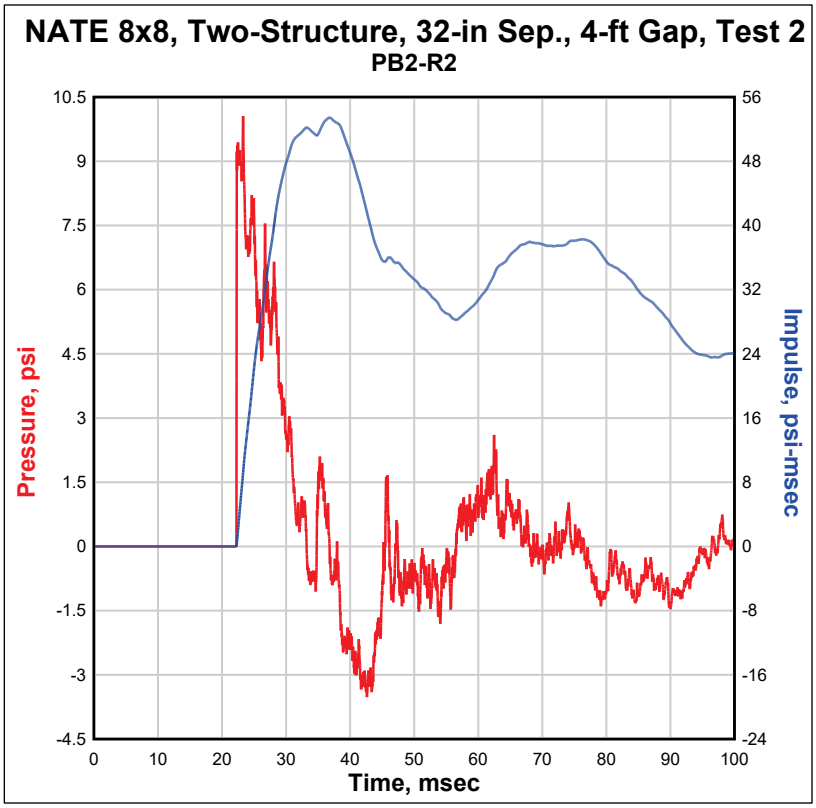

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

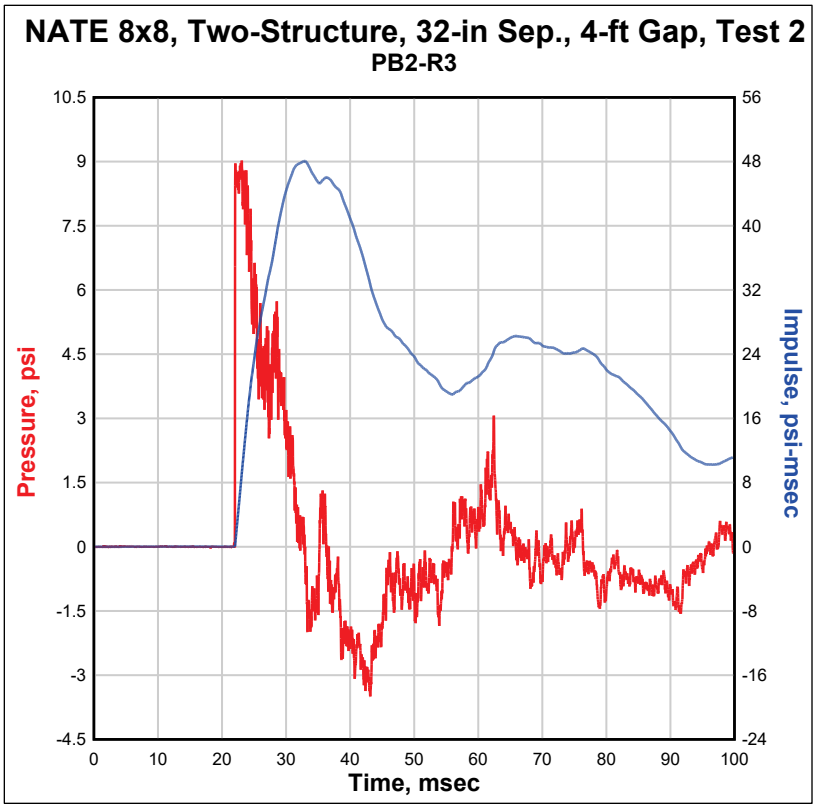

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

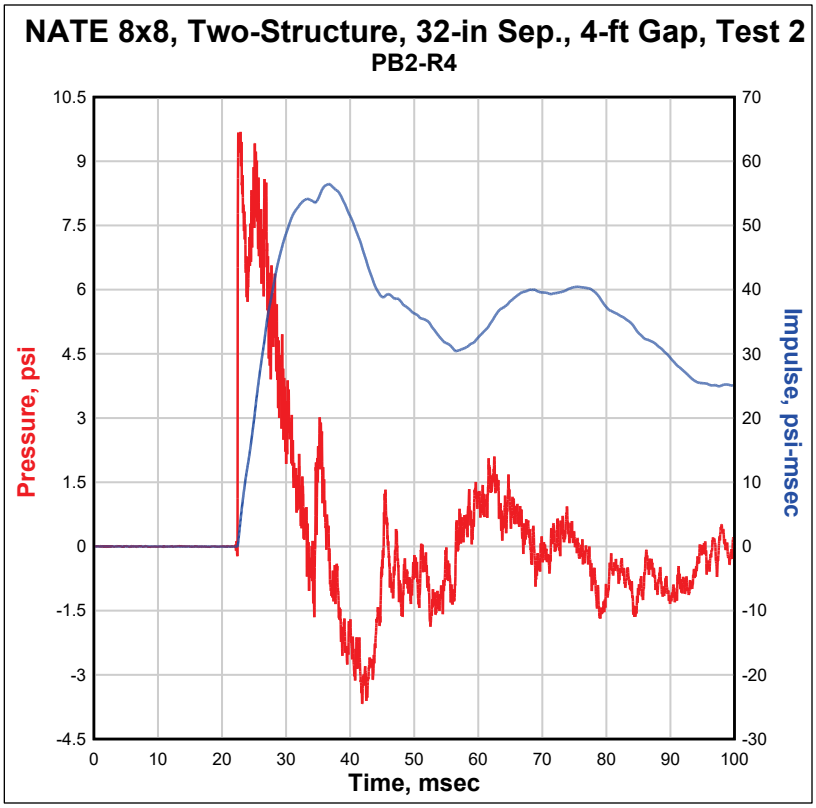

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

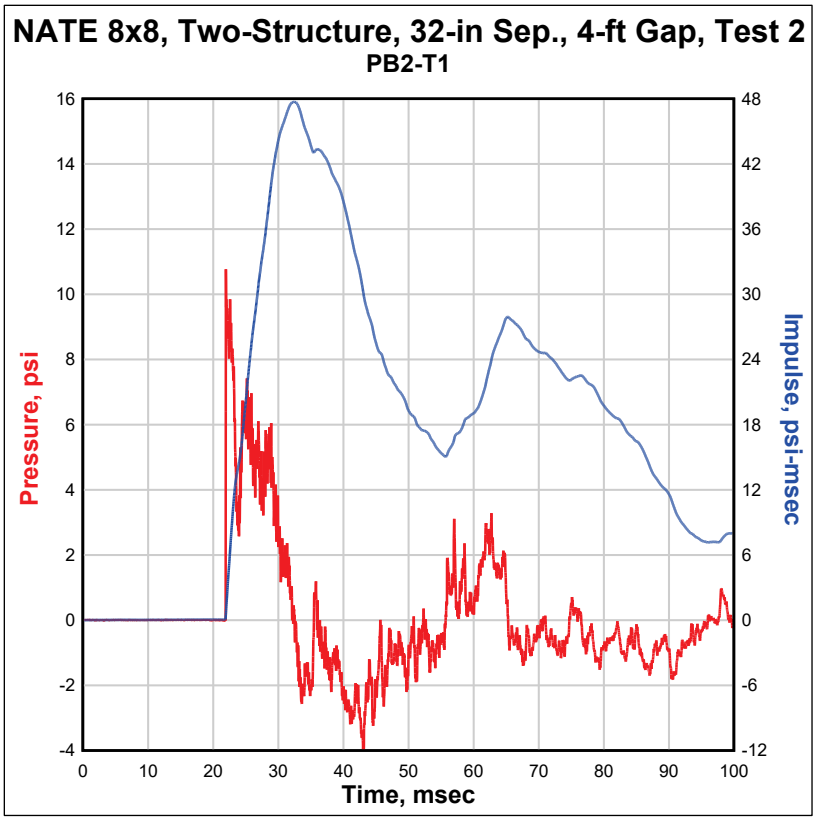

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

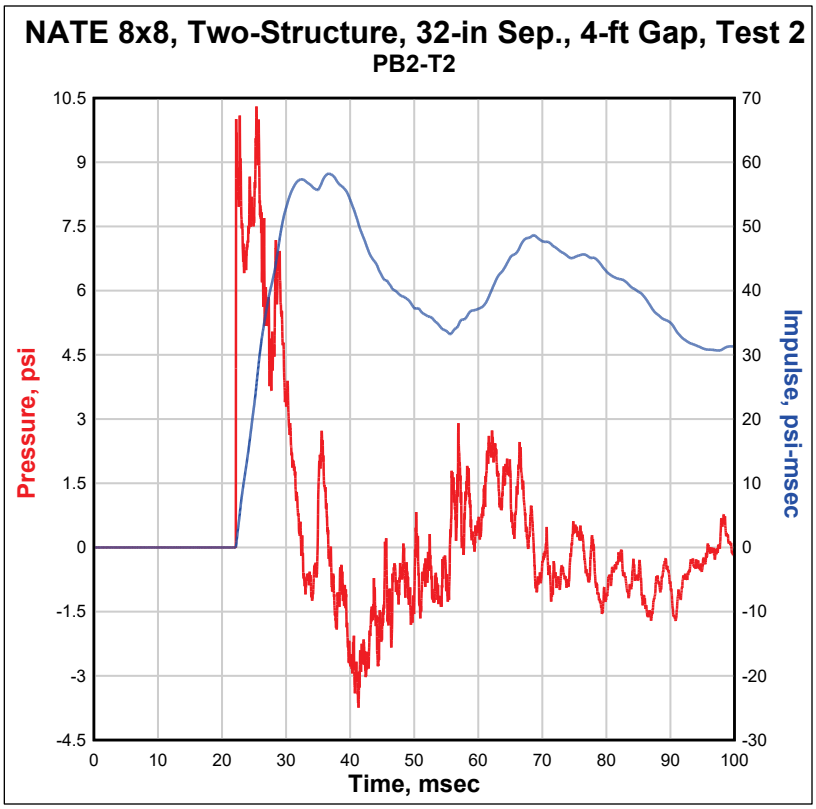

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

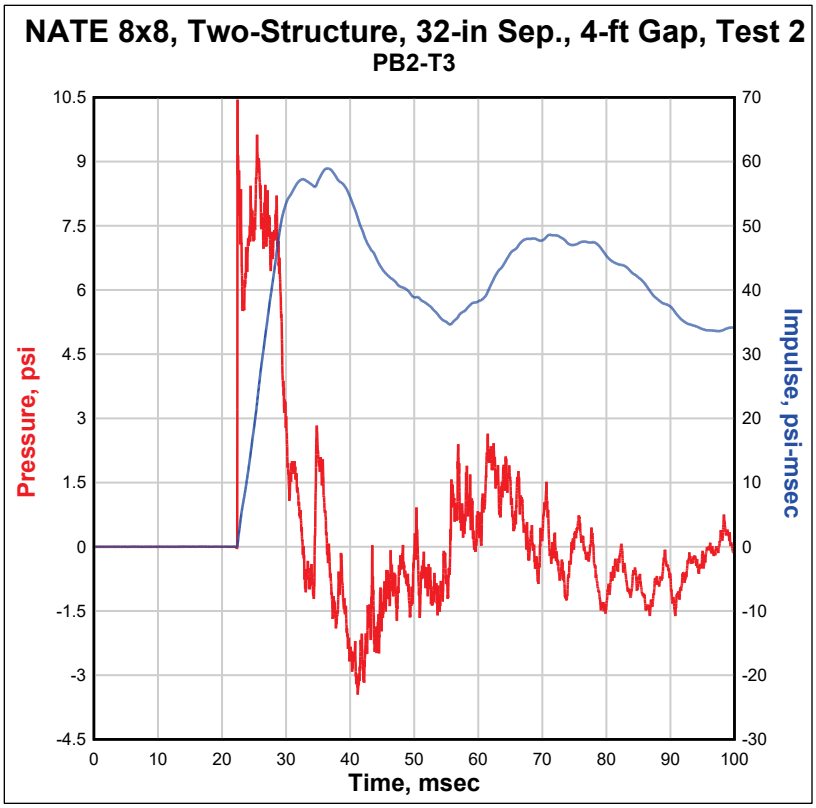

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

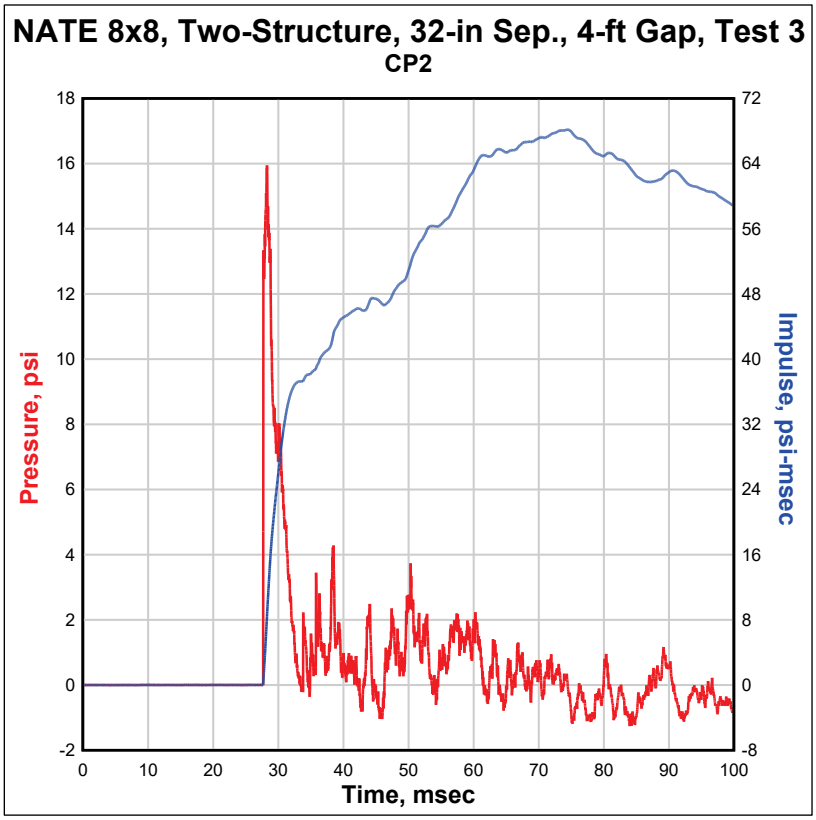

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

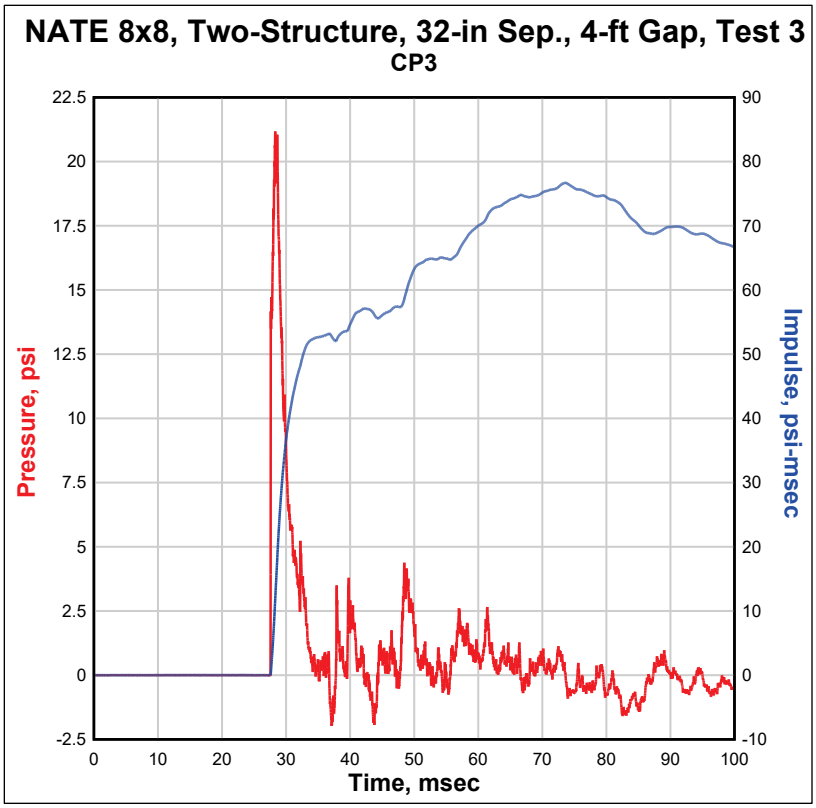

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

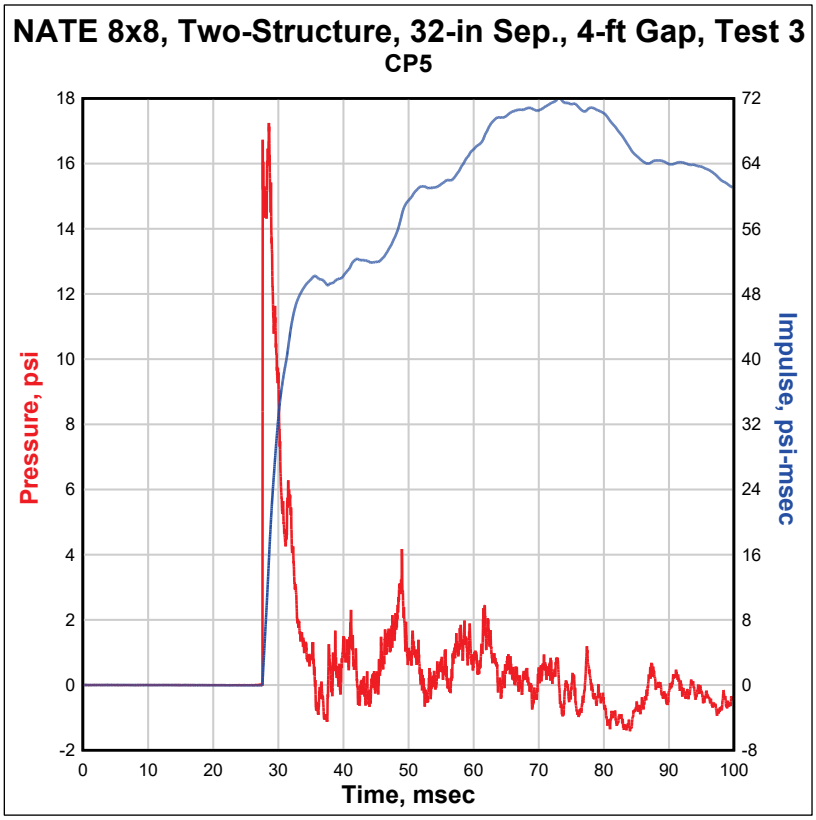

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
48
42
36
30
24
18
12
6
0
-6
-12
0
10
20
30
40
50
60
70
80
90
100

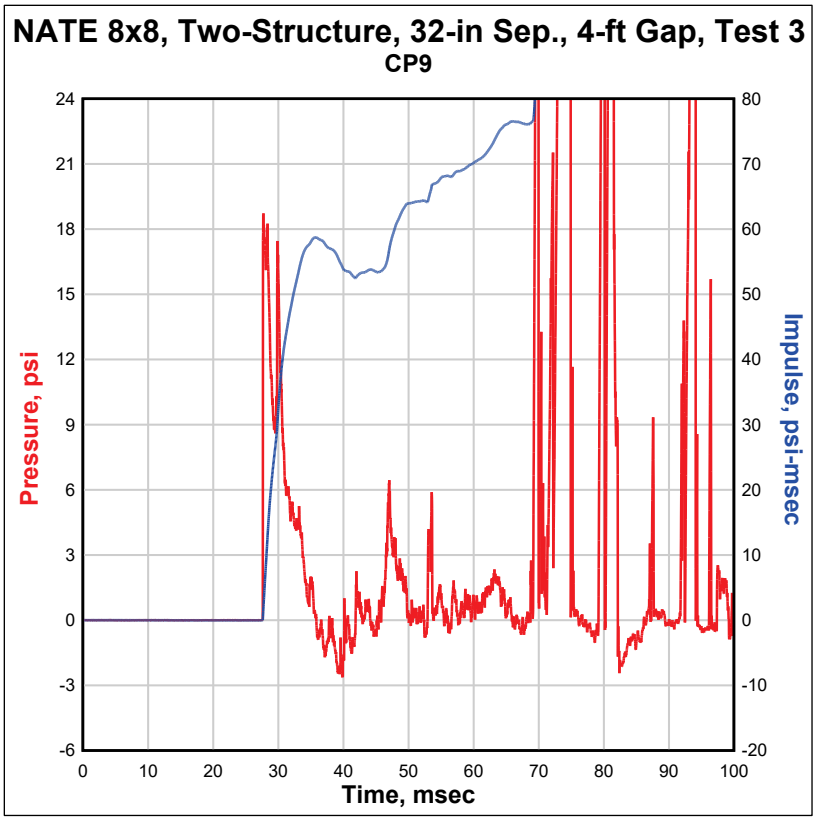

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

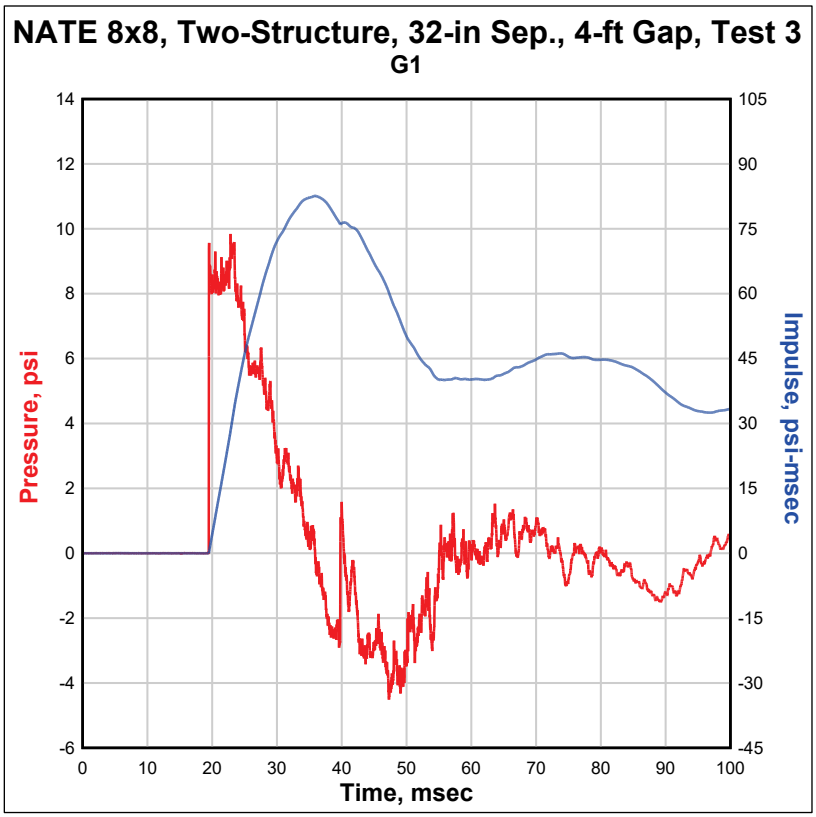

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 2
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

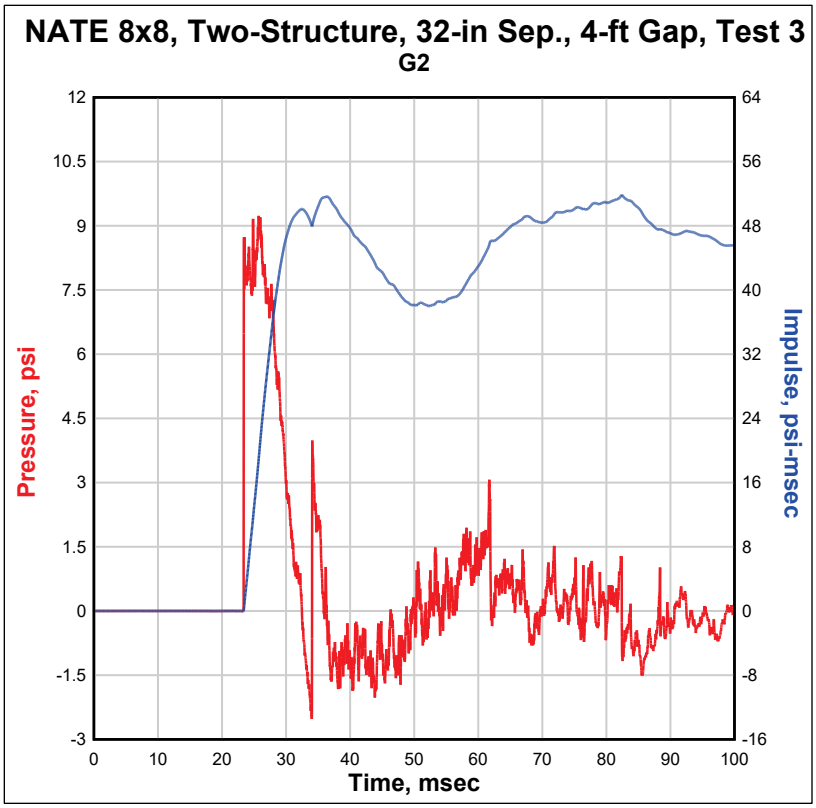

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

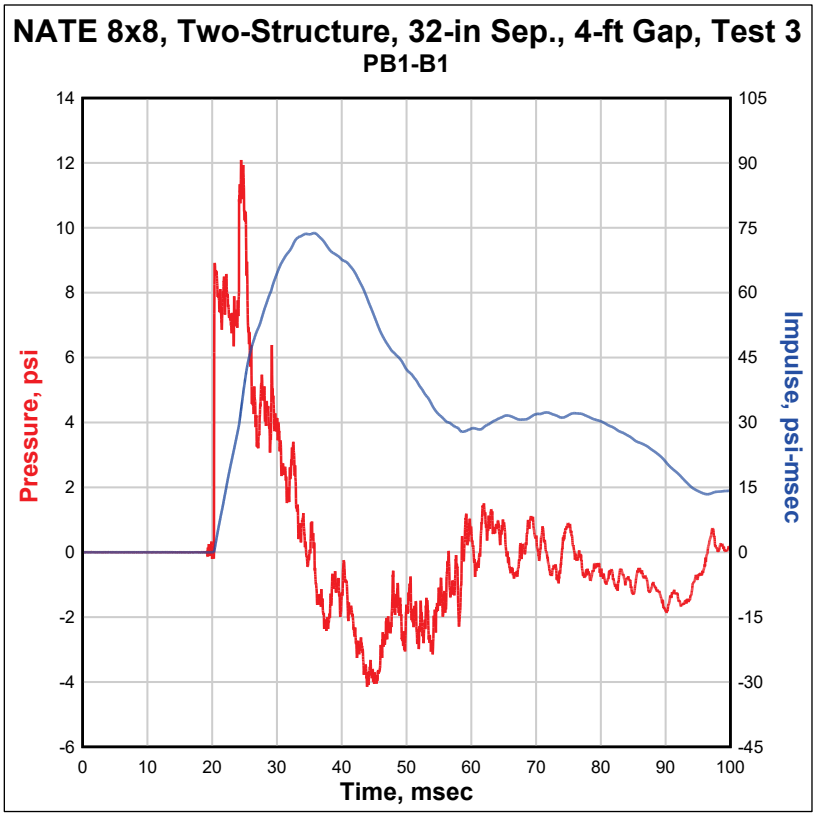

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

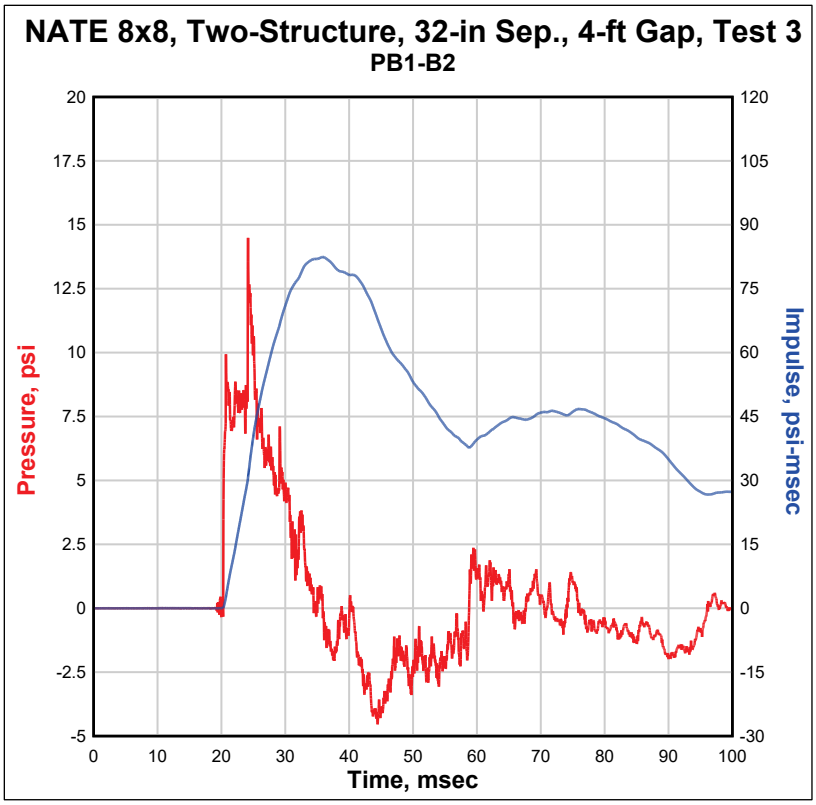

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
G1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
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-30
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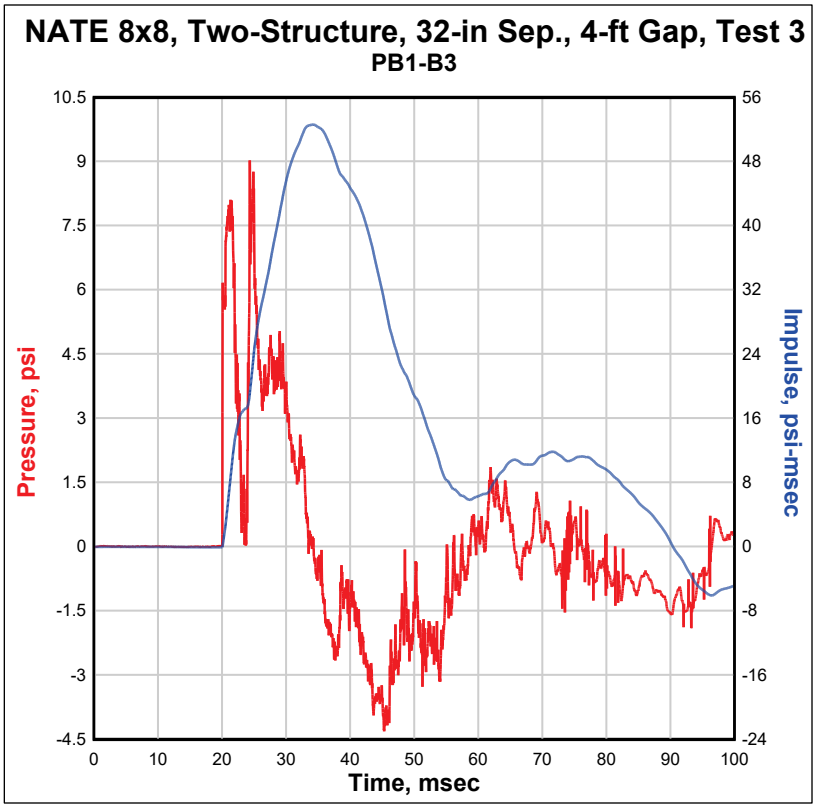
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
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60
70
80
90
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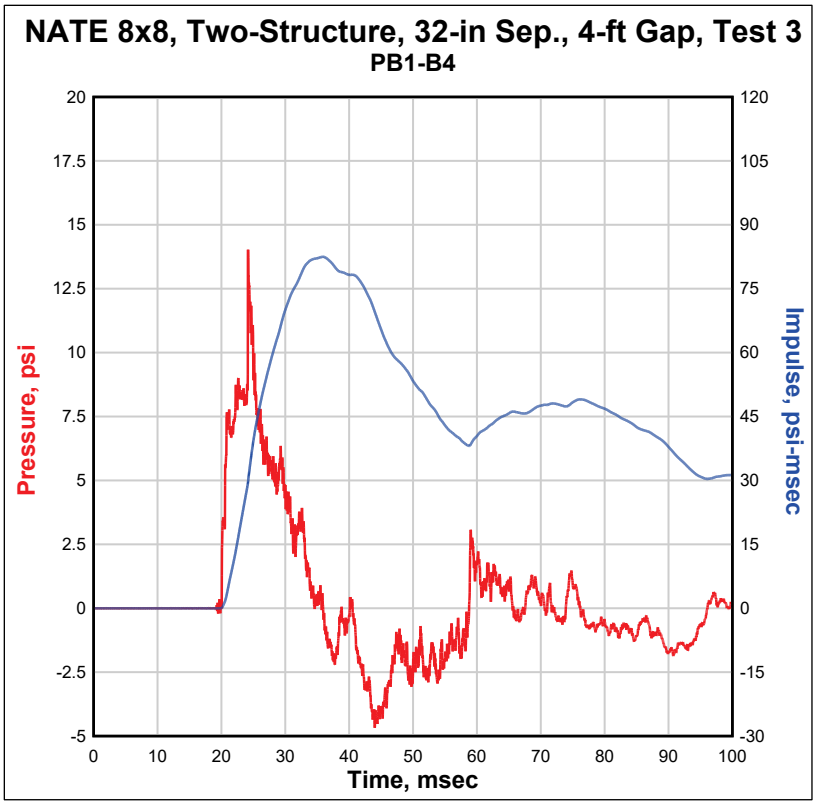
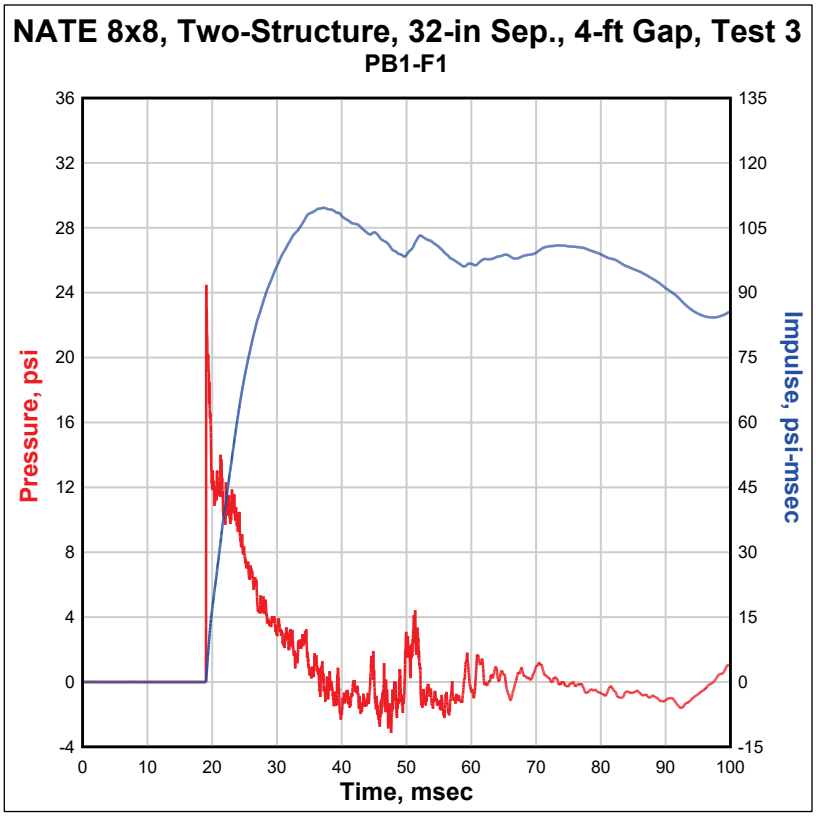

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
10
20
30
40
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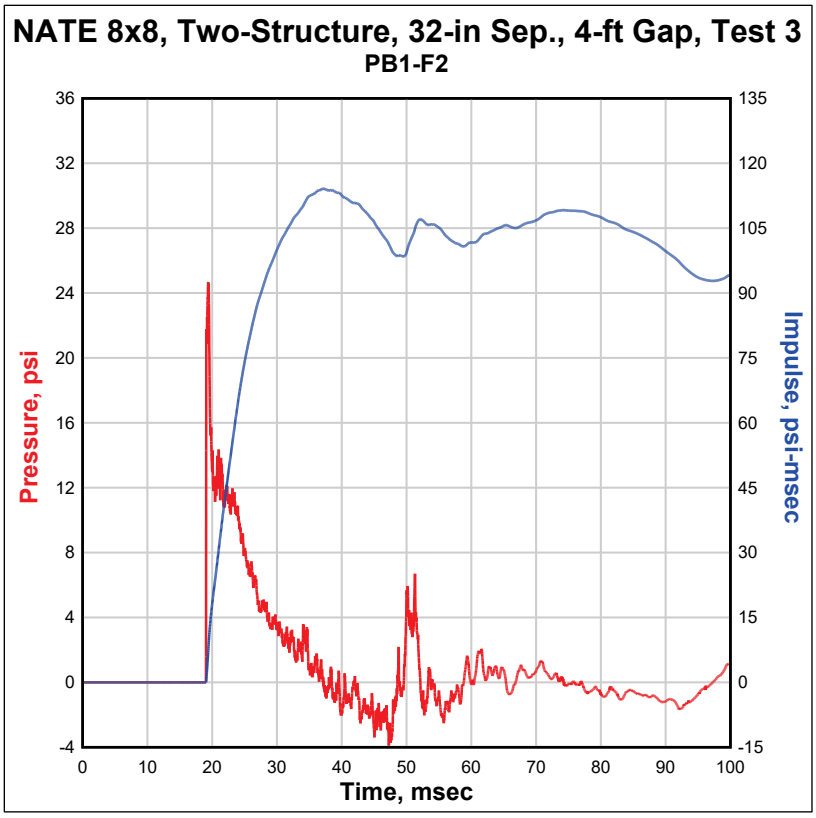
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
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20
30
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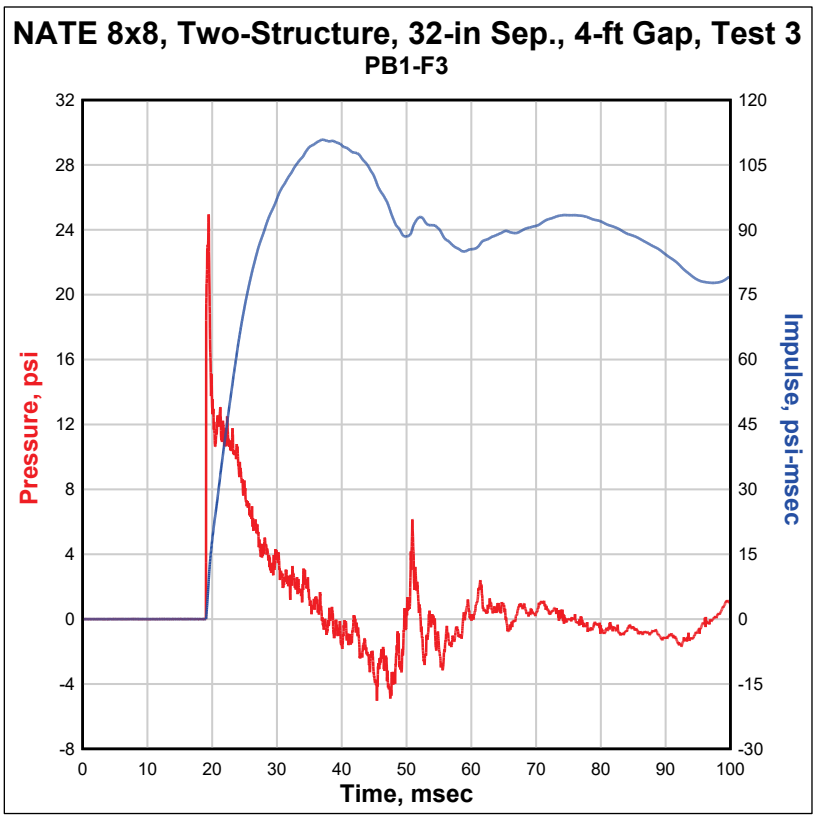
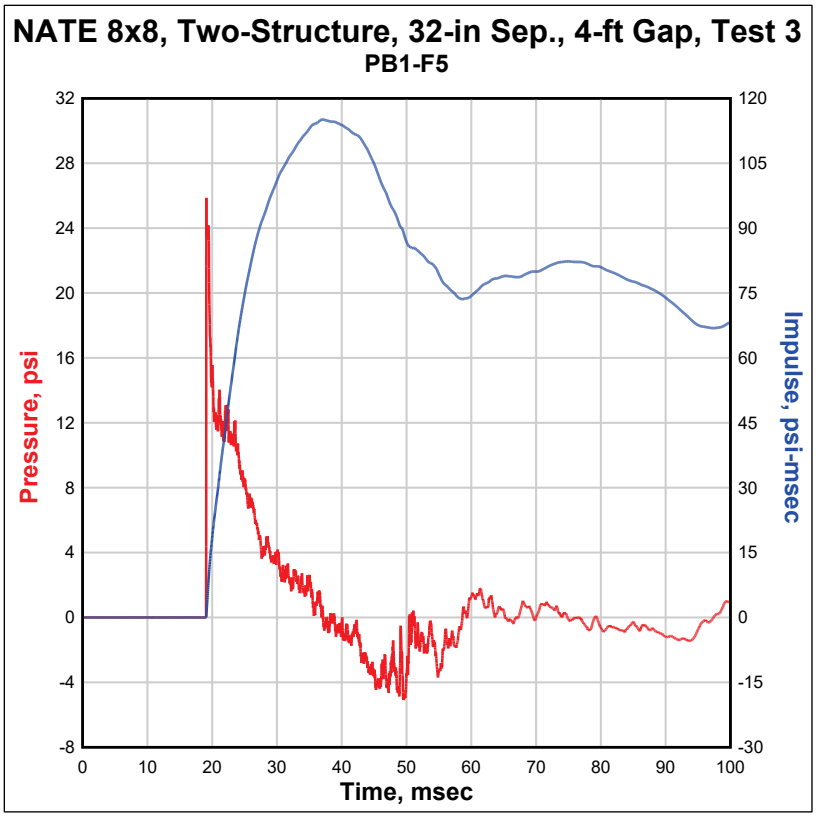

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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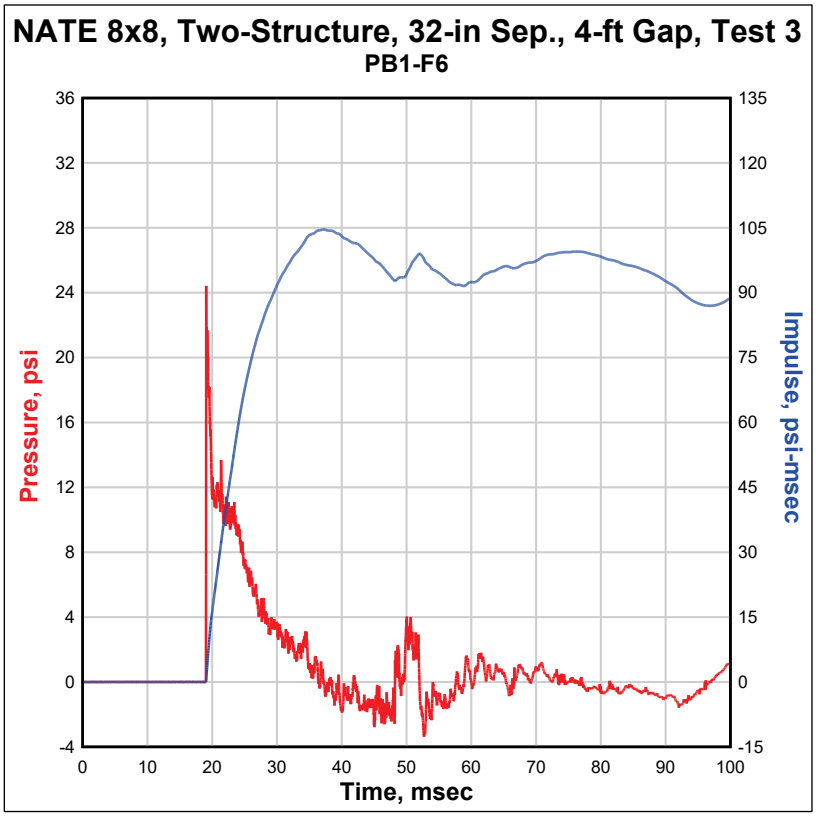
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
36
32
28
24
20
16
12
8
4
0
-4
135
120
105
90
75
60
45
30
15
0
-15
0
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30
40
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70
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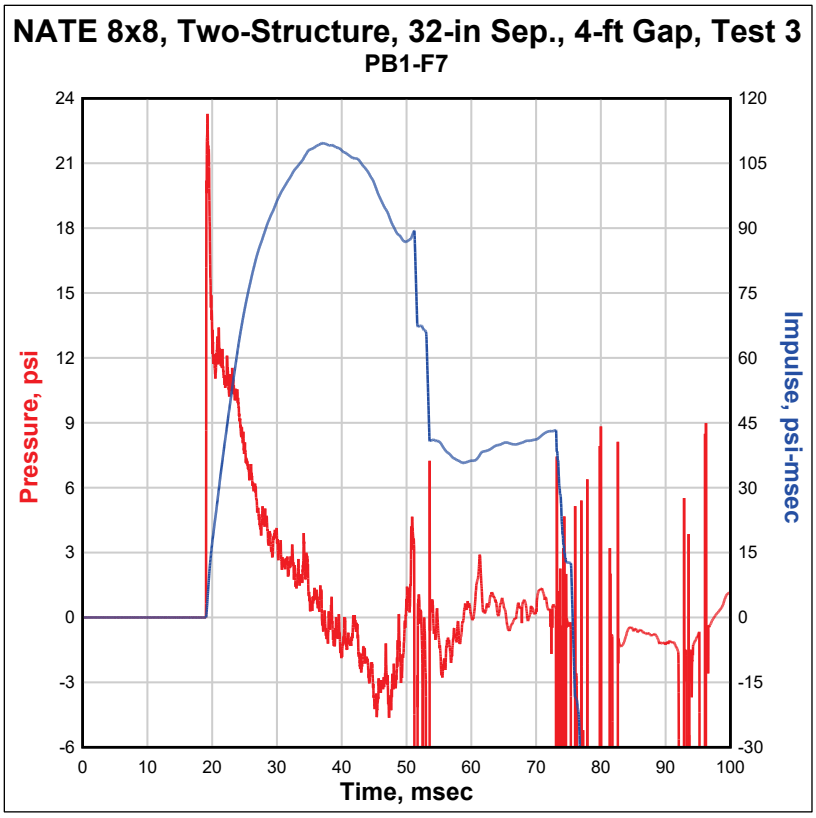
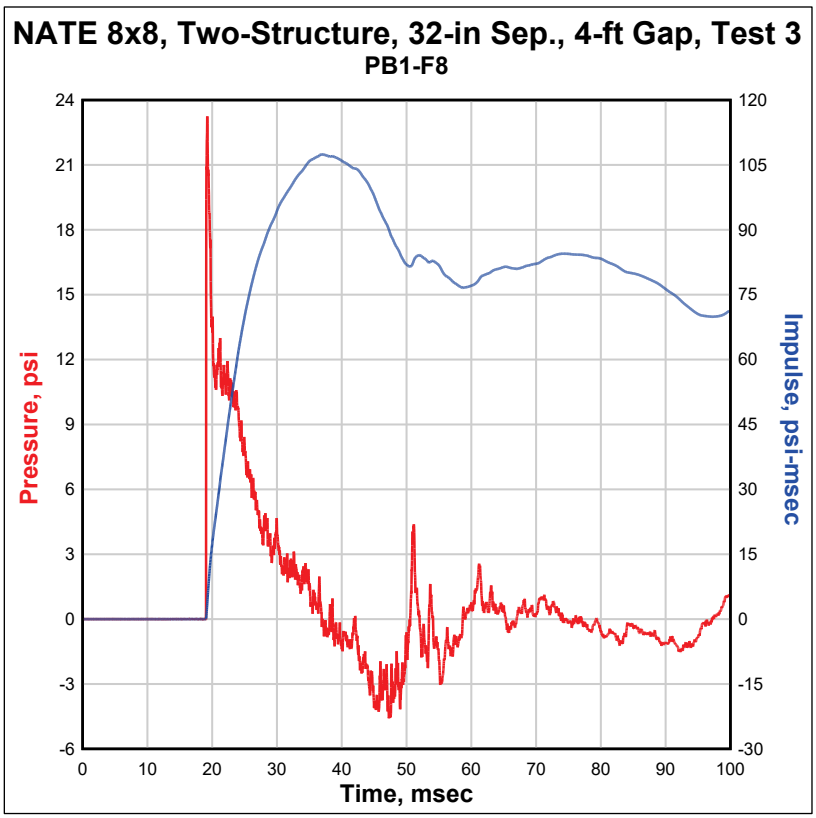
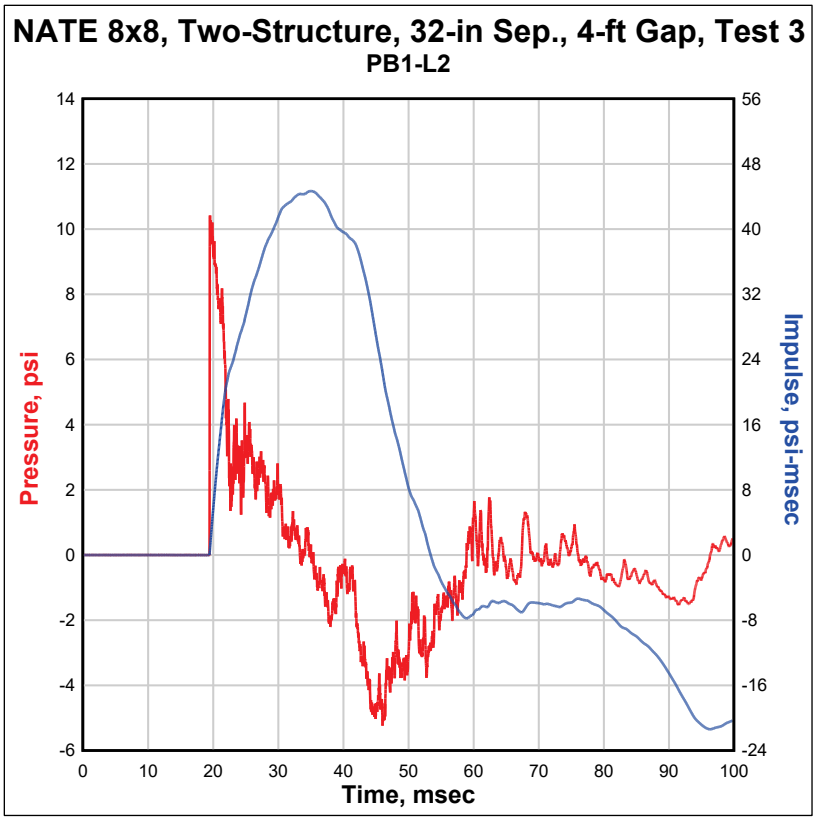
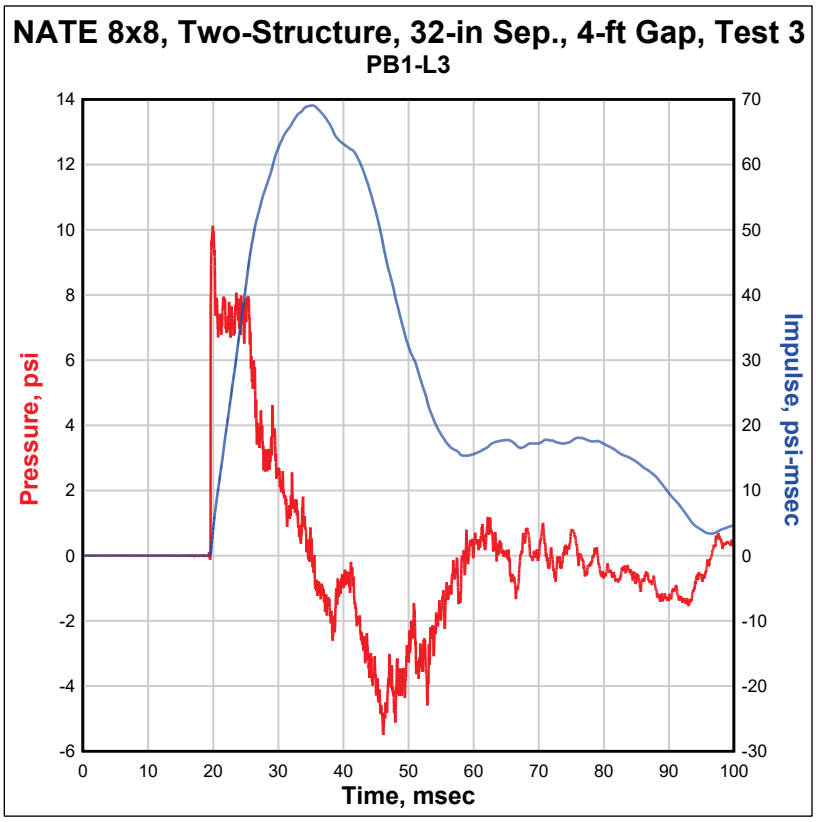
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
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30
40
50
60
70
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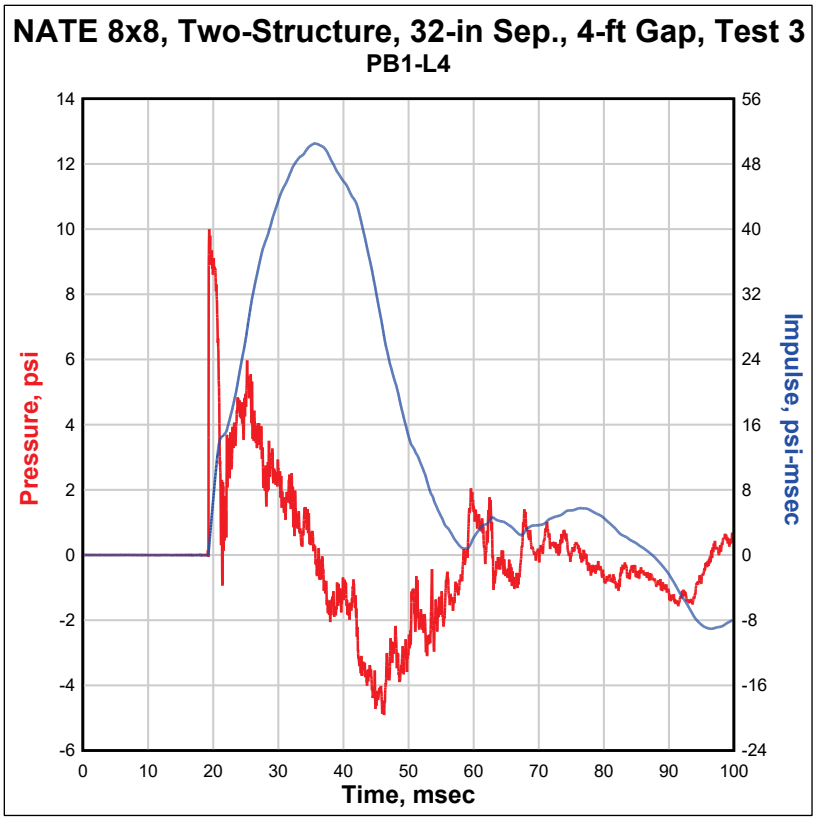
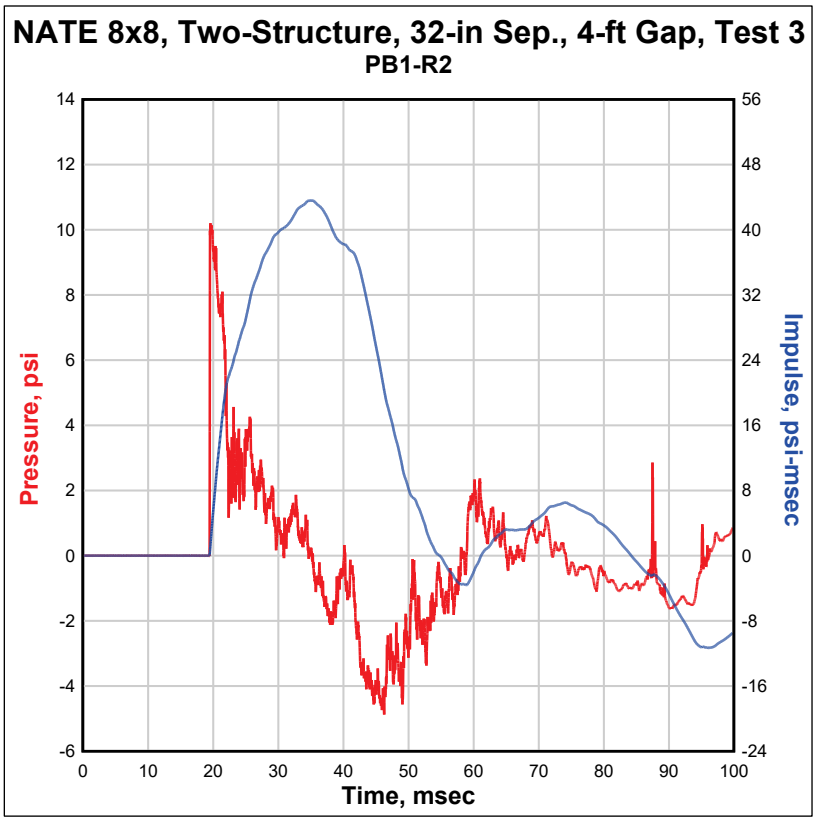
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
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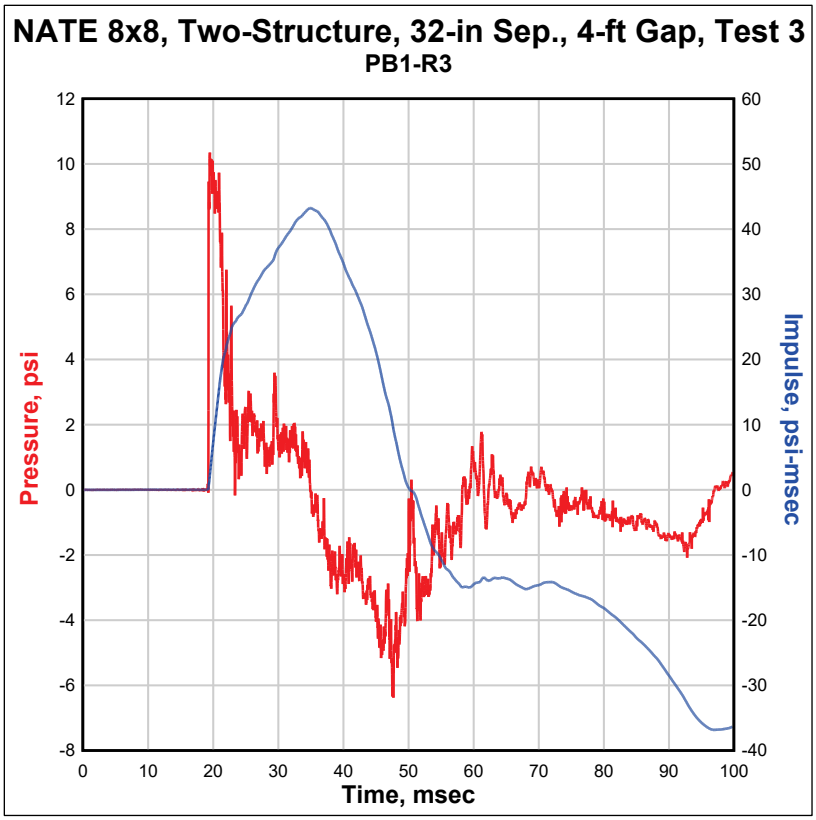
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
60
50
40
30
20
10
0
-10
-20
-30
-40
0
10
20
30
40
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70
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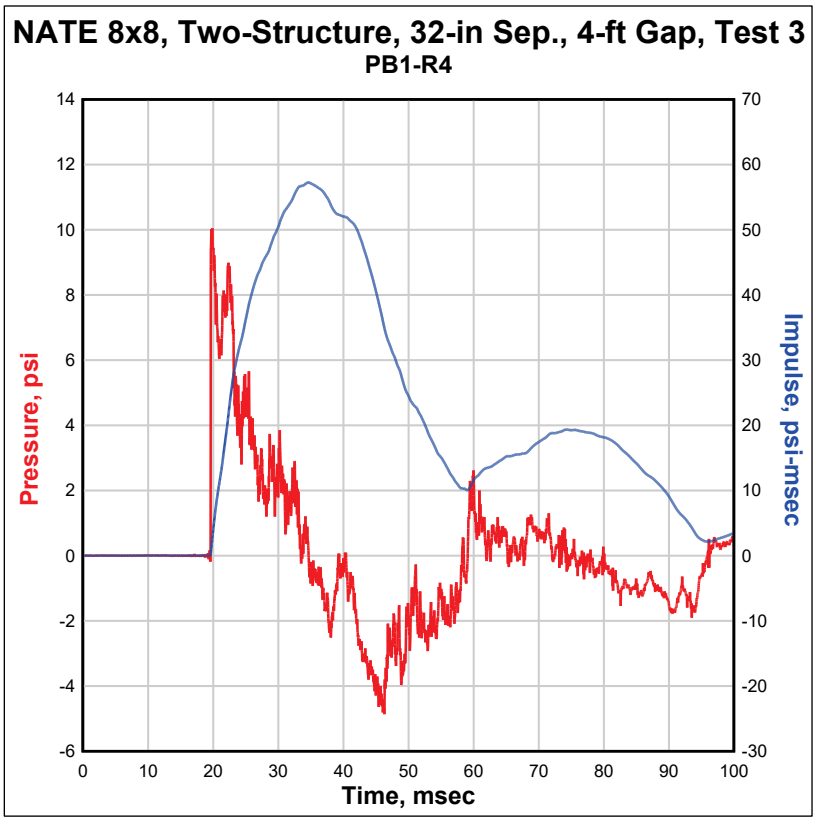
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
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30
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70
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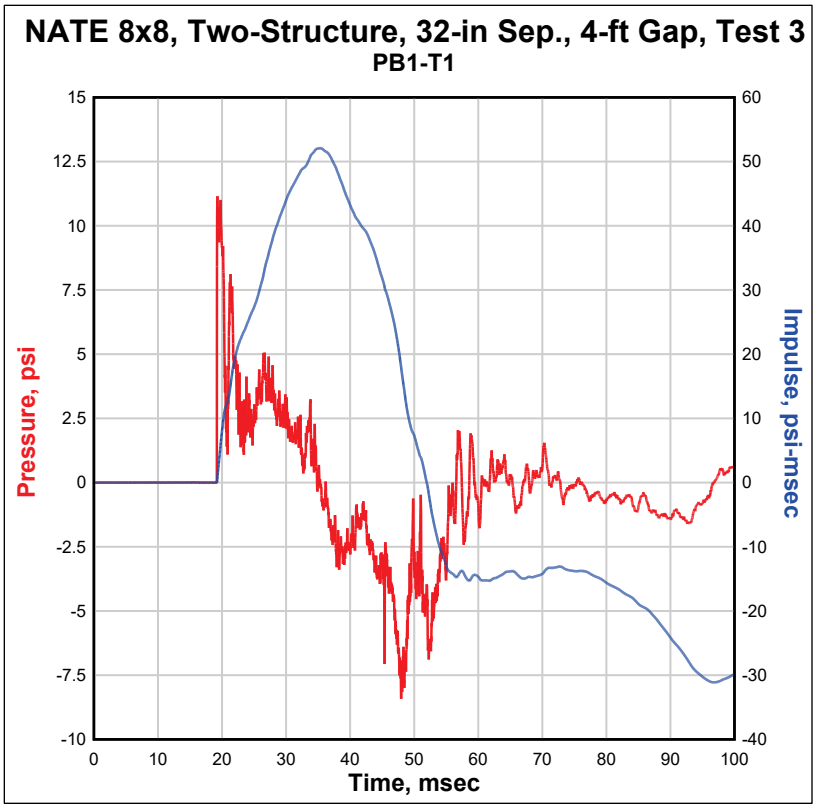
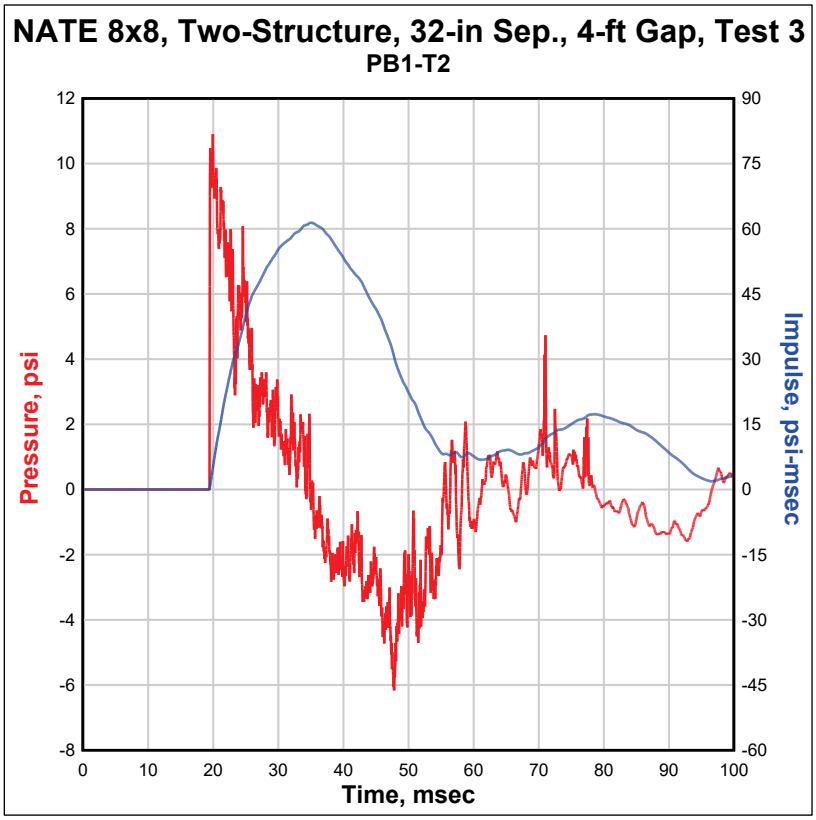
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
60
50
40
30
20
10
0
-10
-20
-30
-40
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
90
75
60
45
30
15
0
-15
-30
-45
-60
0
10
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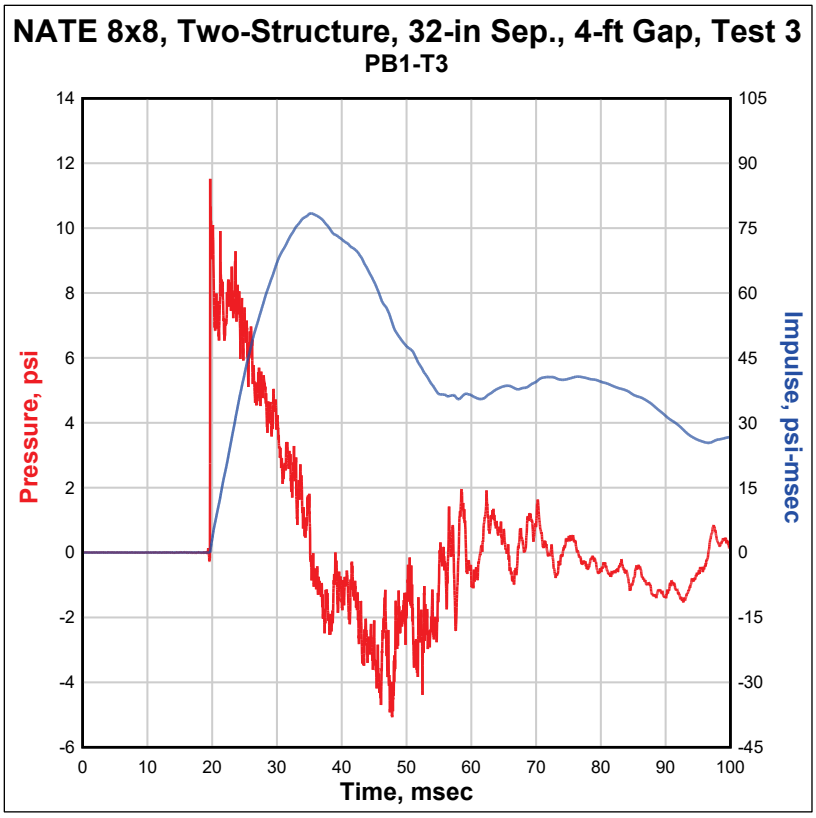
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
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30
40
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70
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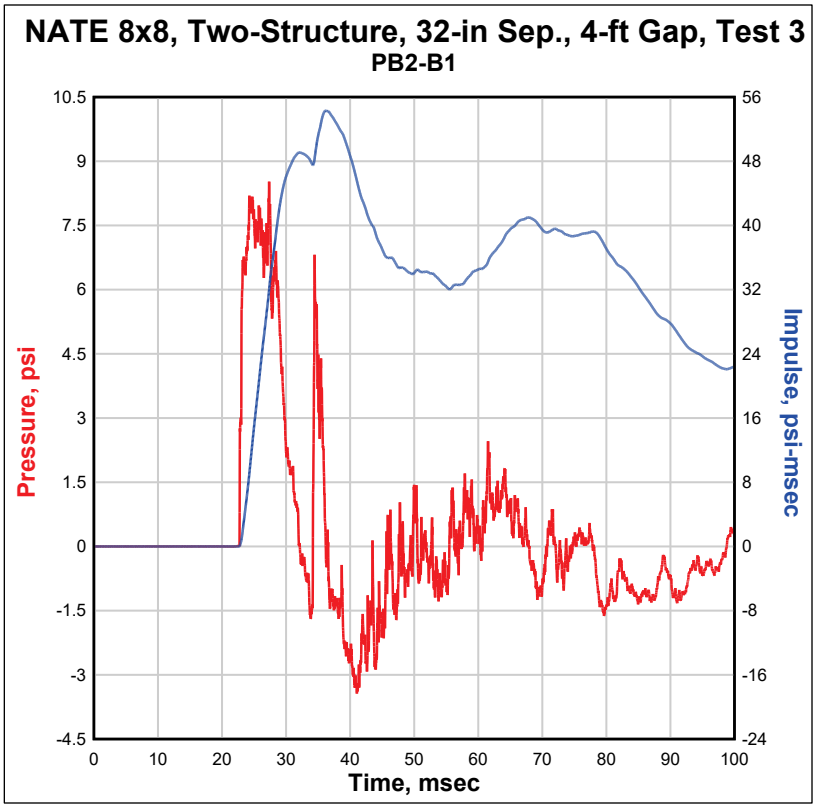
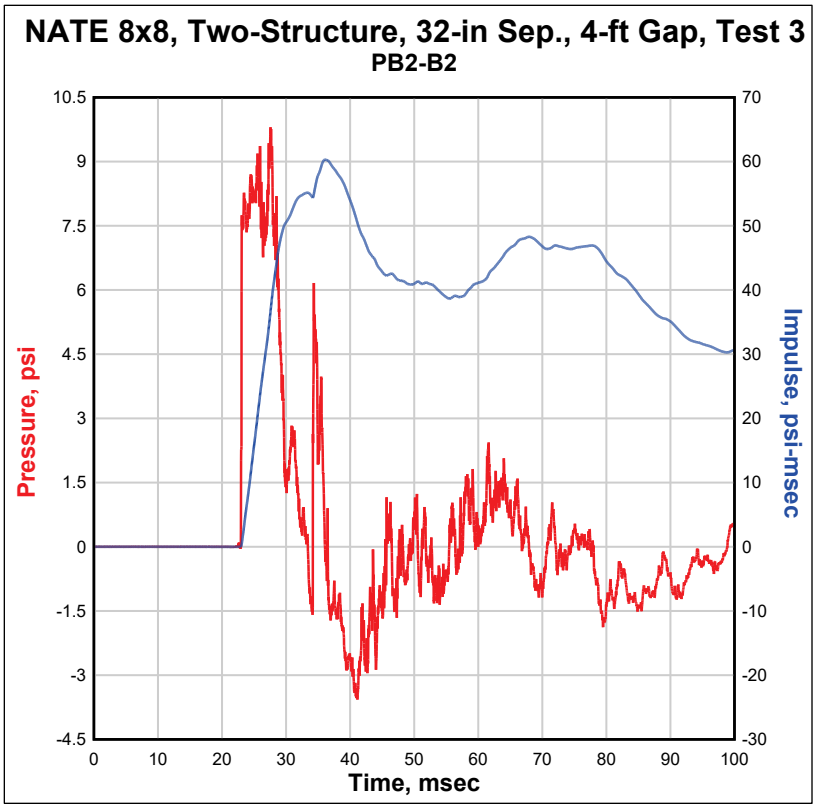
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
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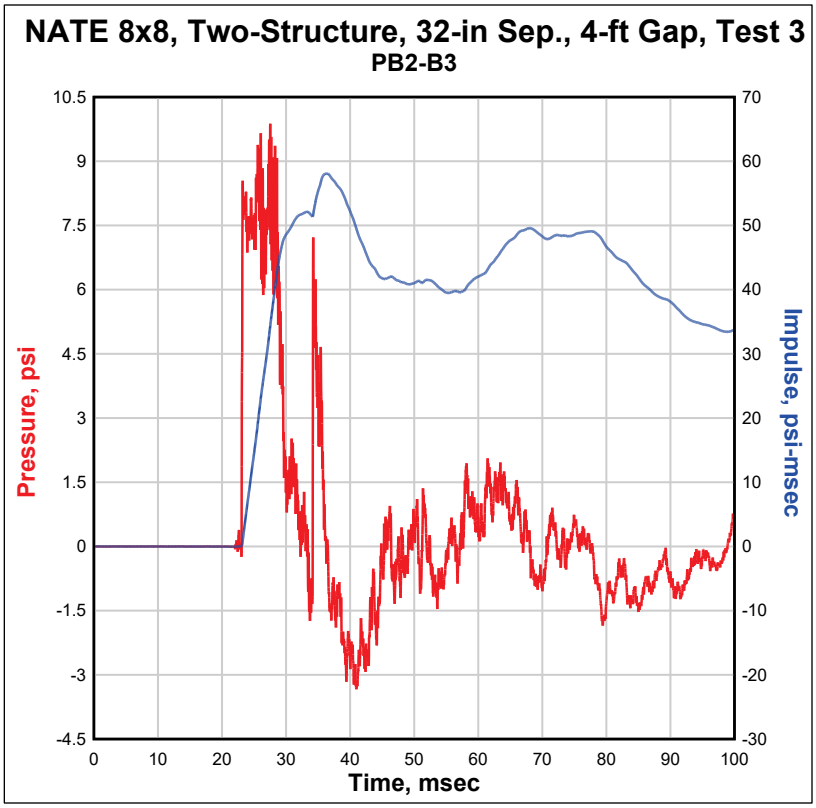
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
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30
40
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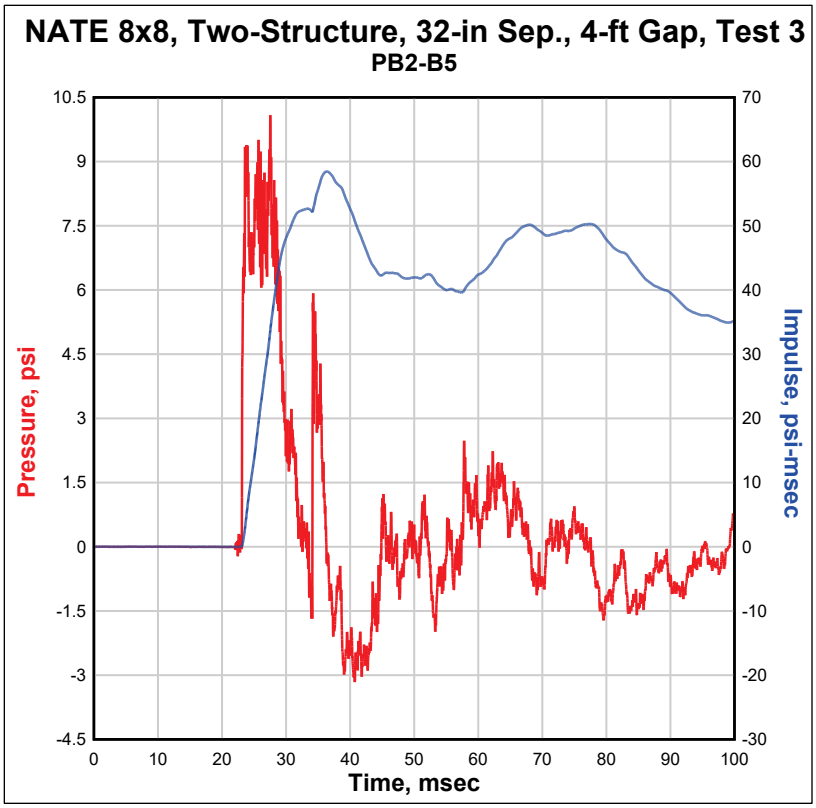
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
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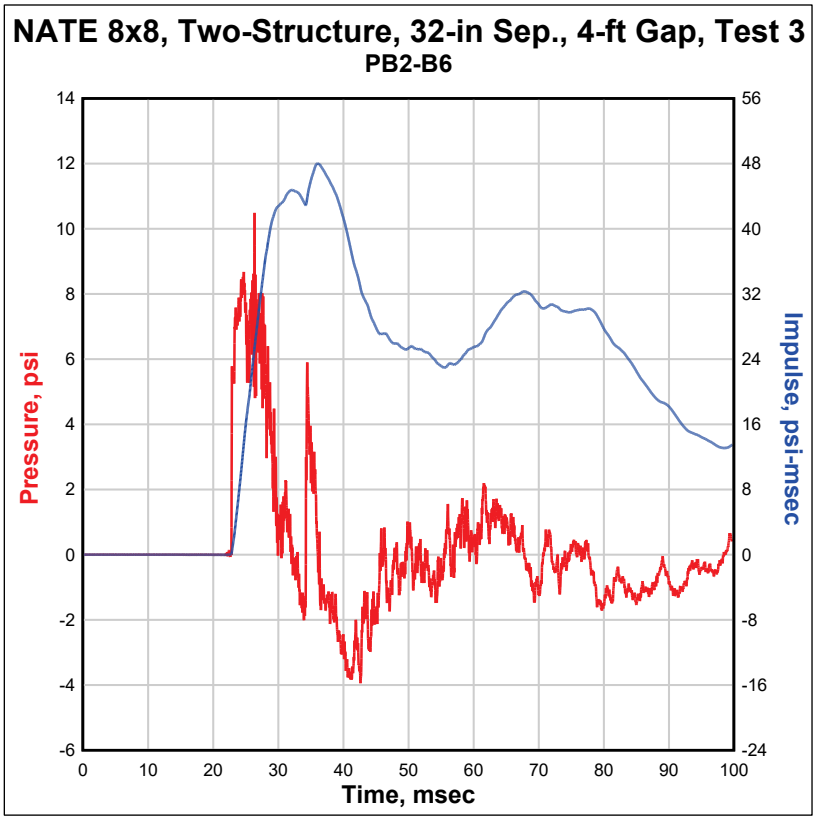
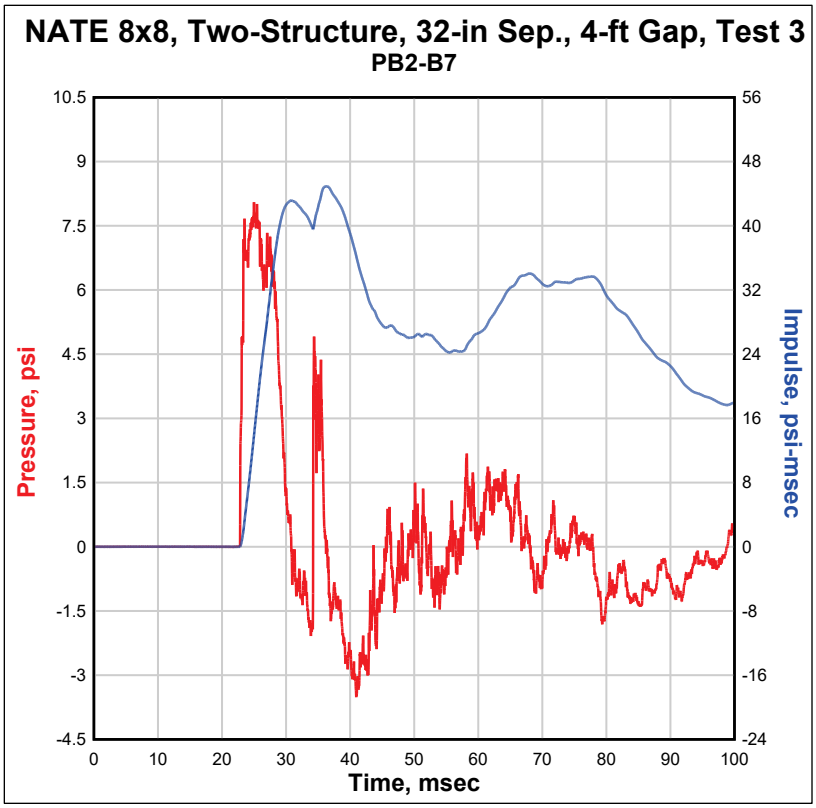
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
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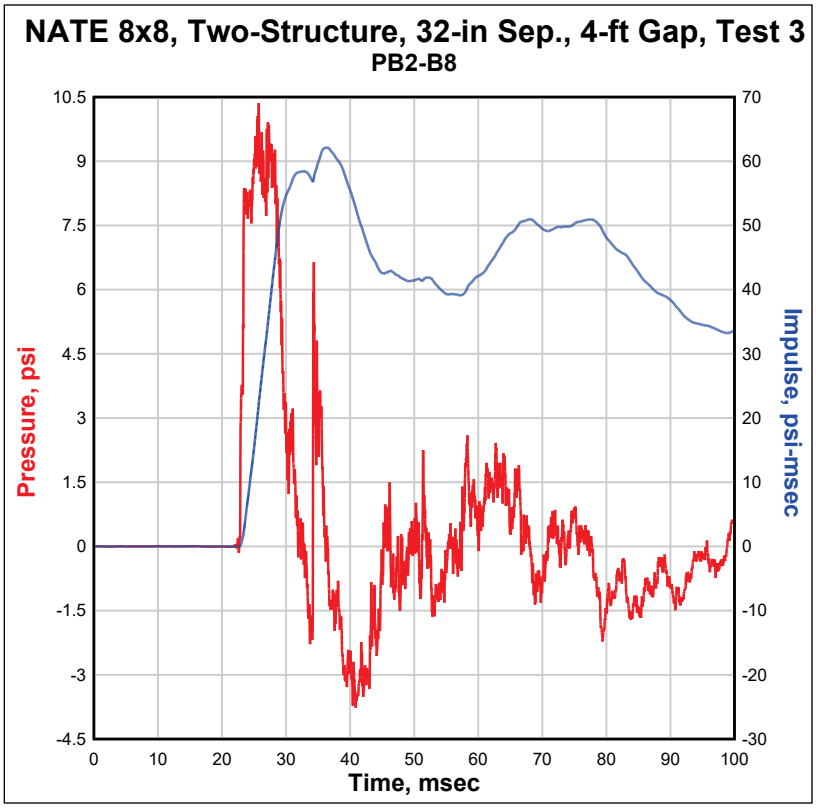
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
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0
-10
-20
-30
0
10
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30
40
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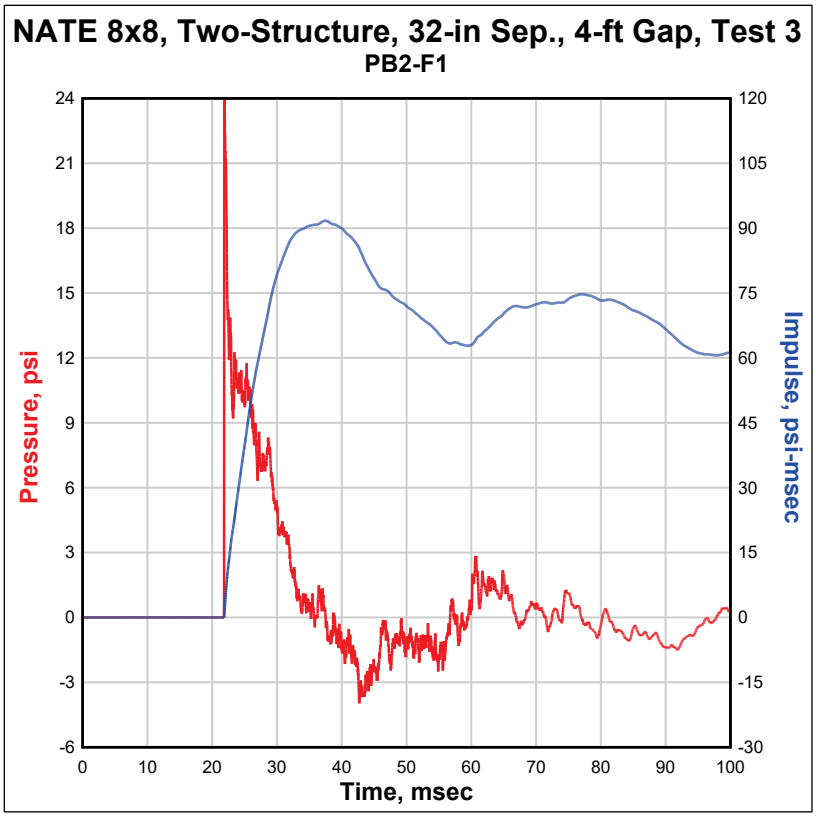
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
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40
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70
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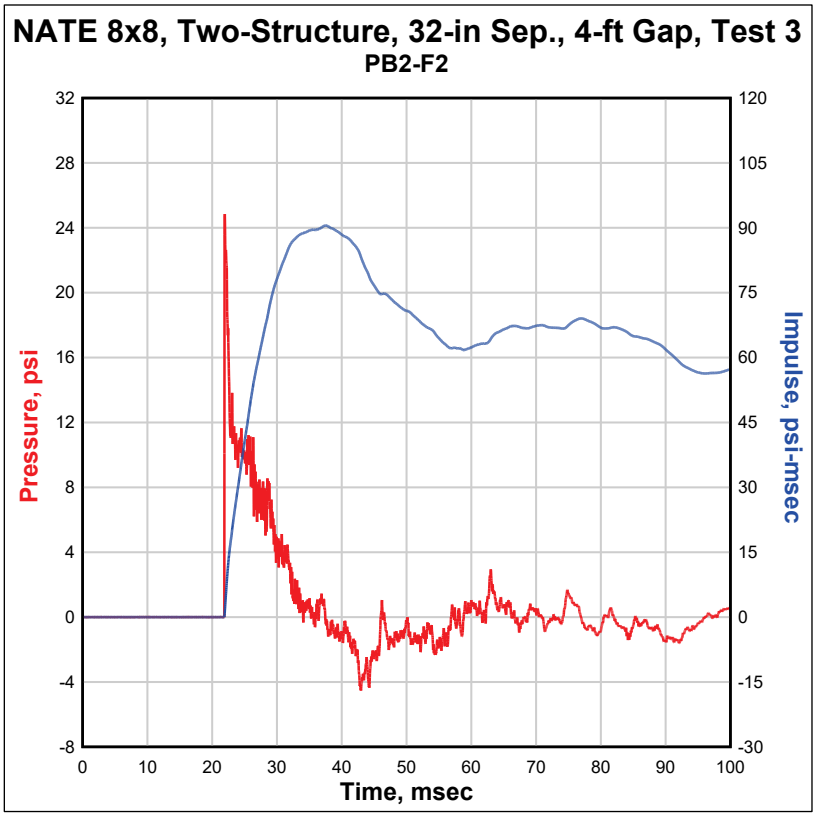
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
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0
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-30
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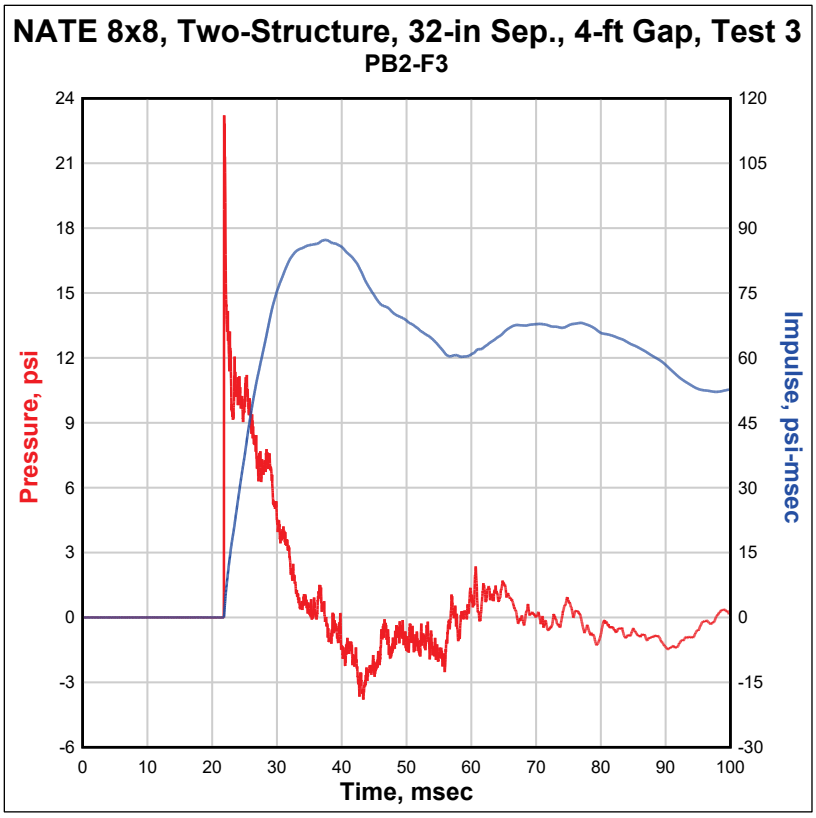
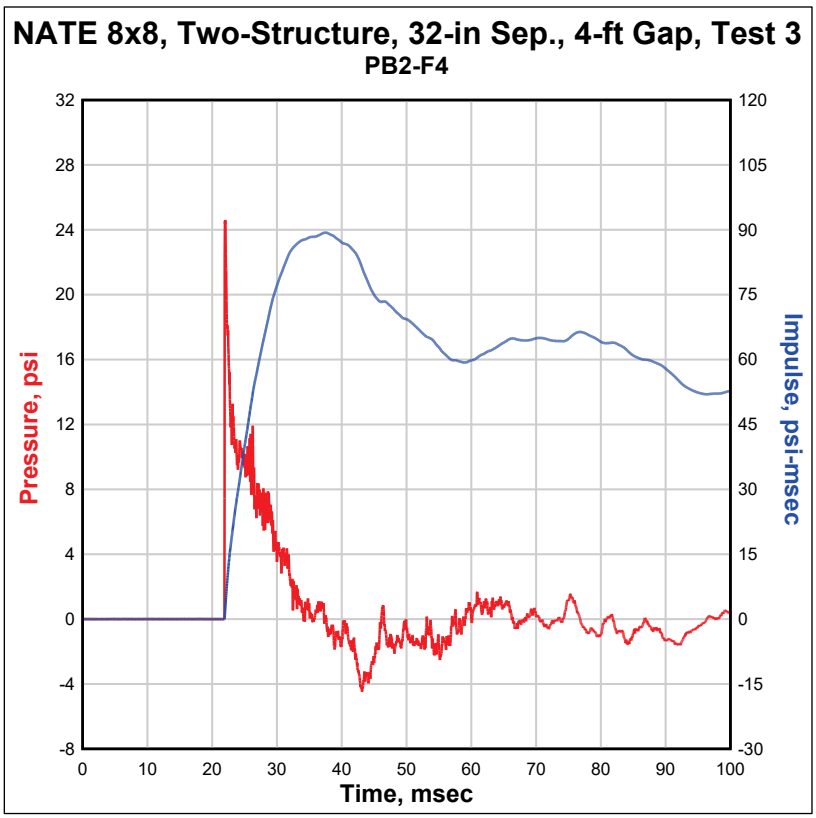
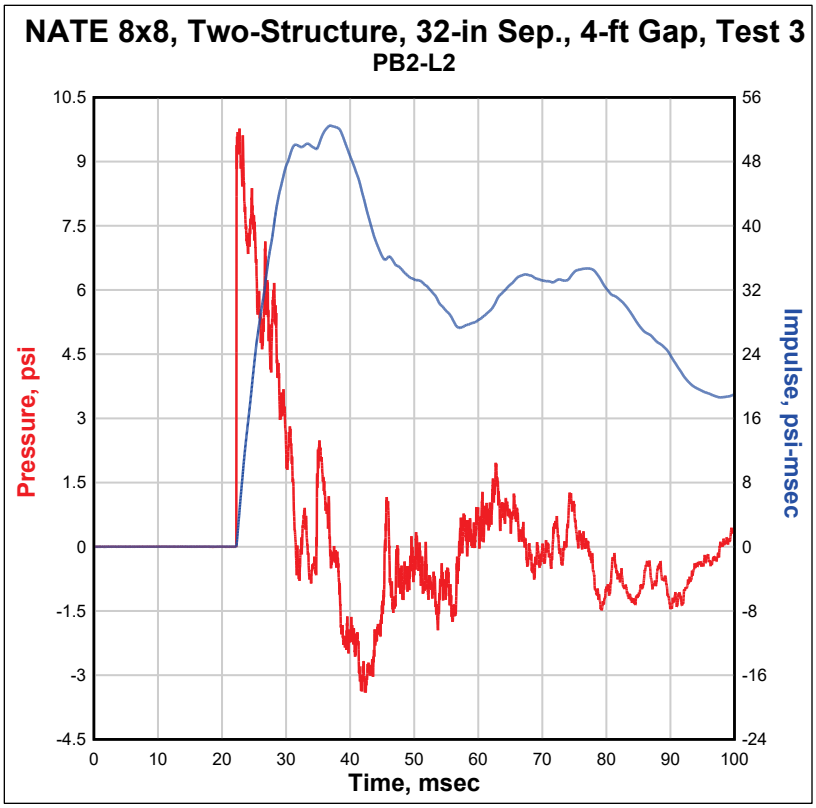
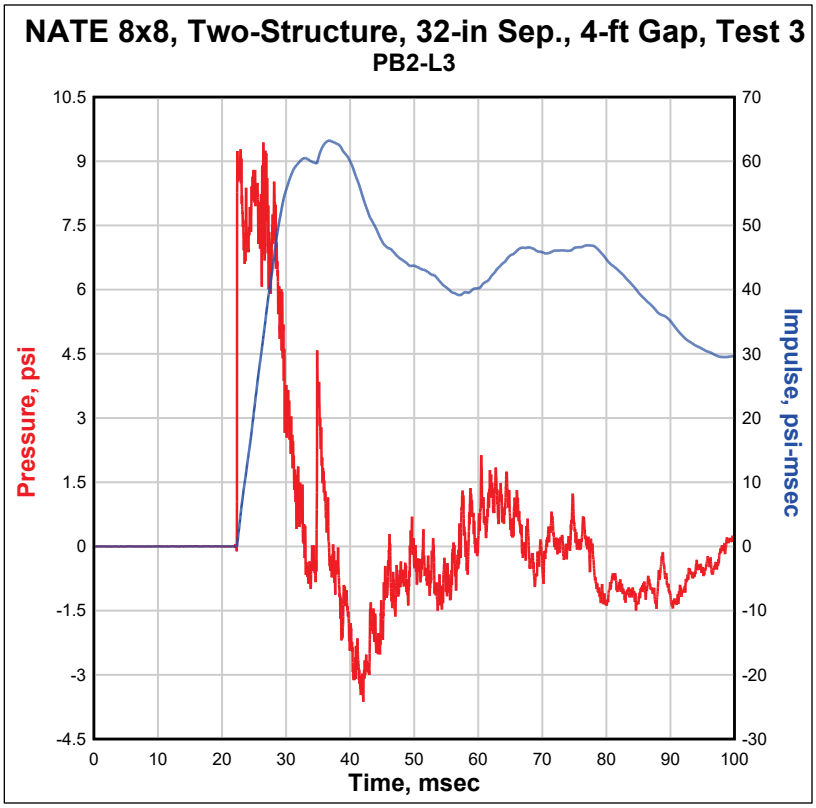
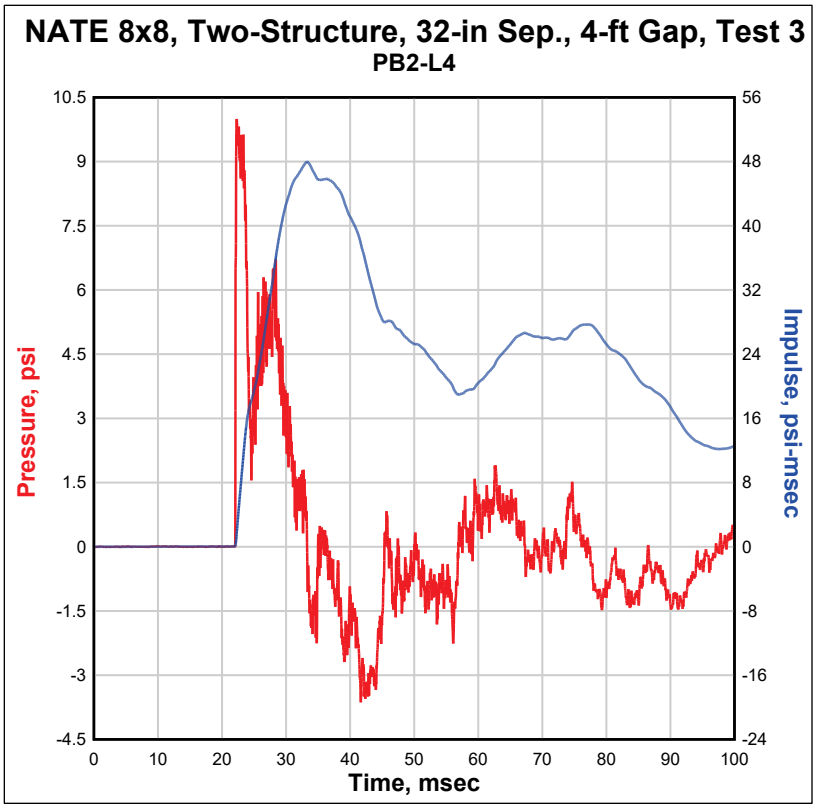
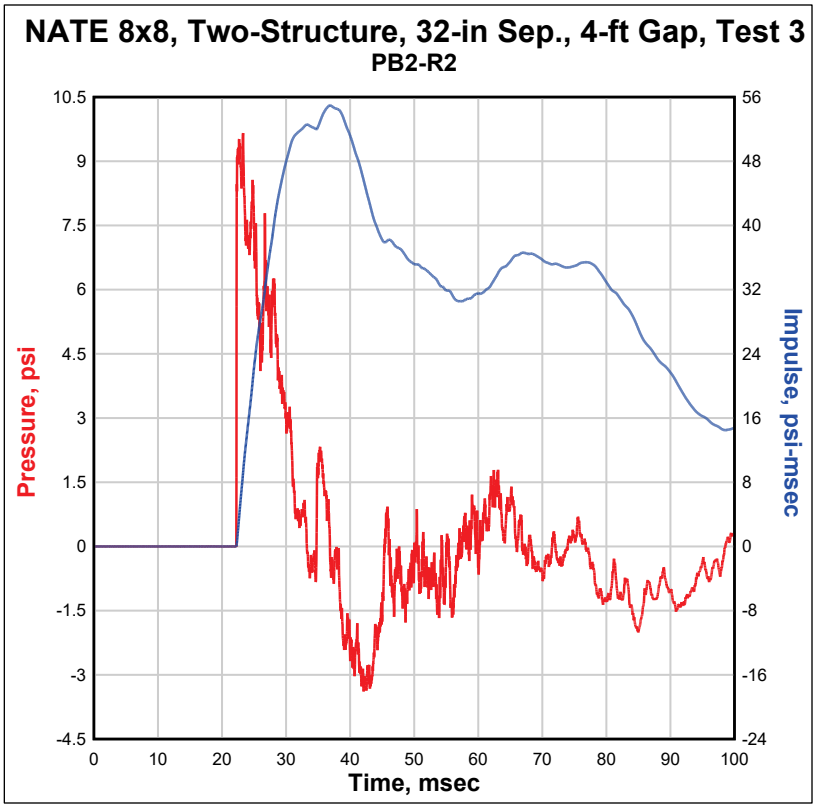

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

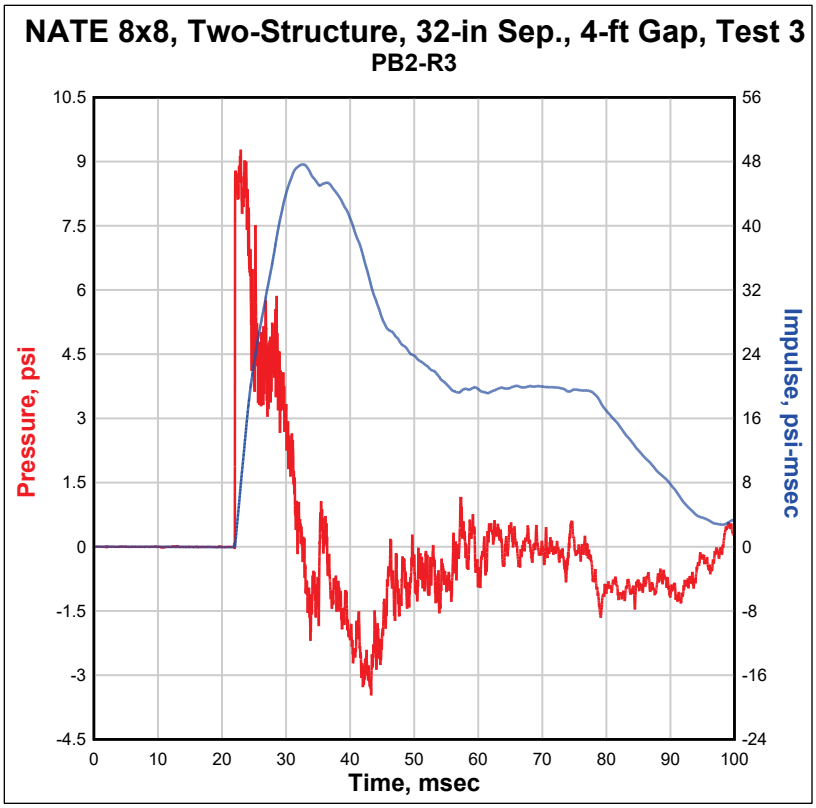

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

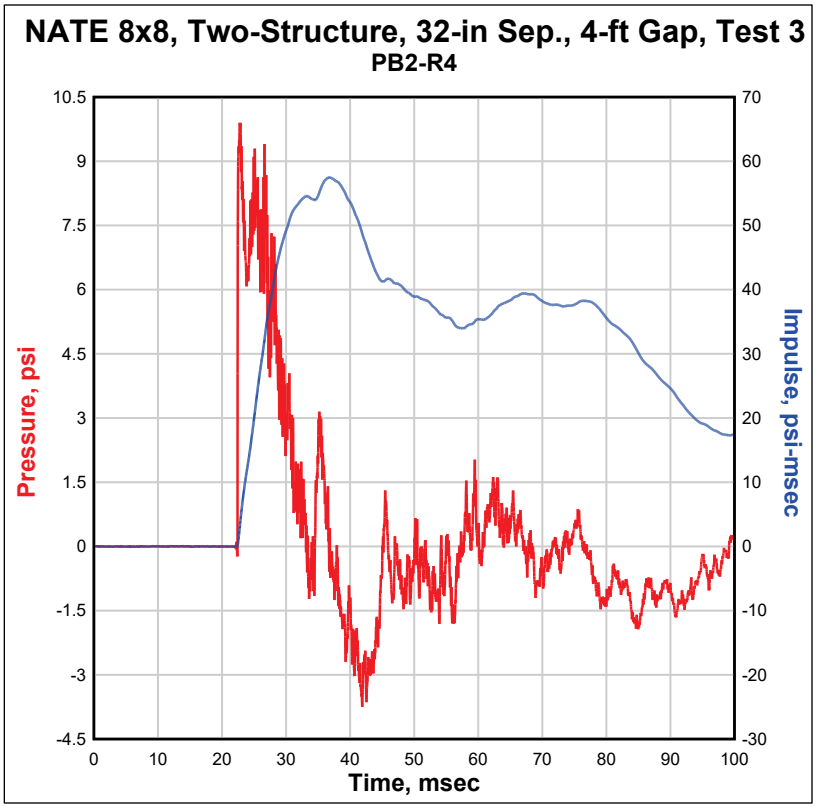

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

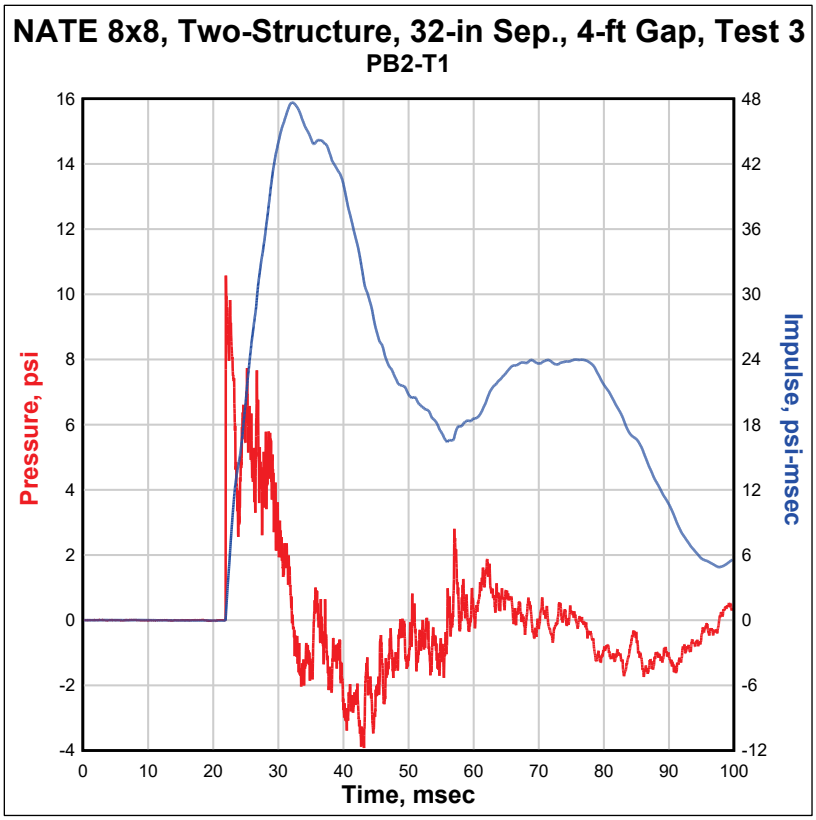

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

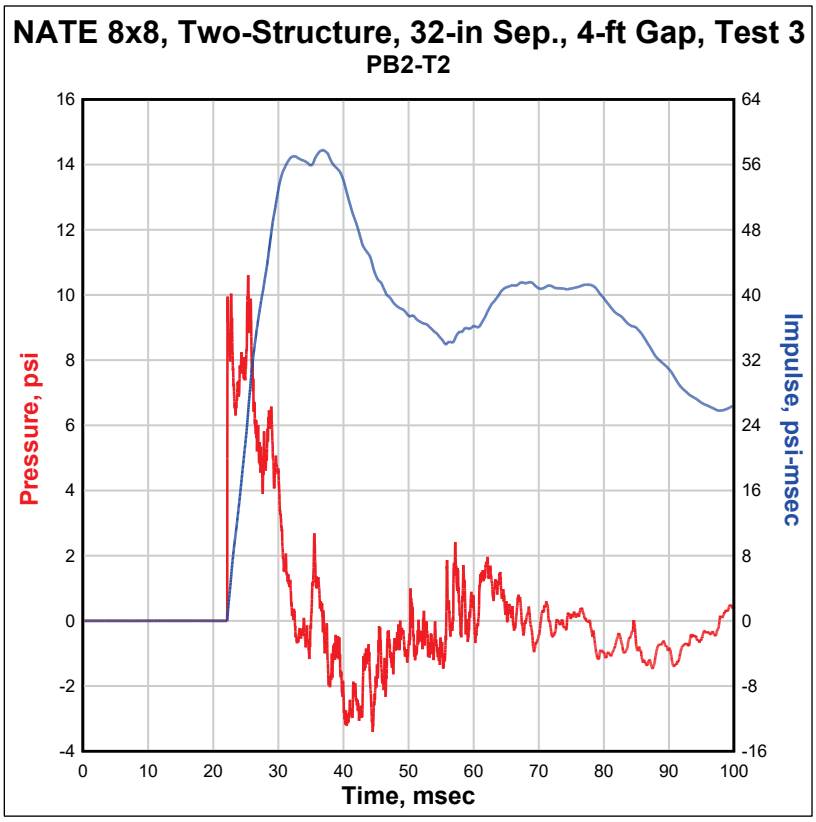

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

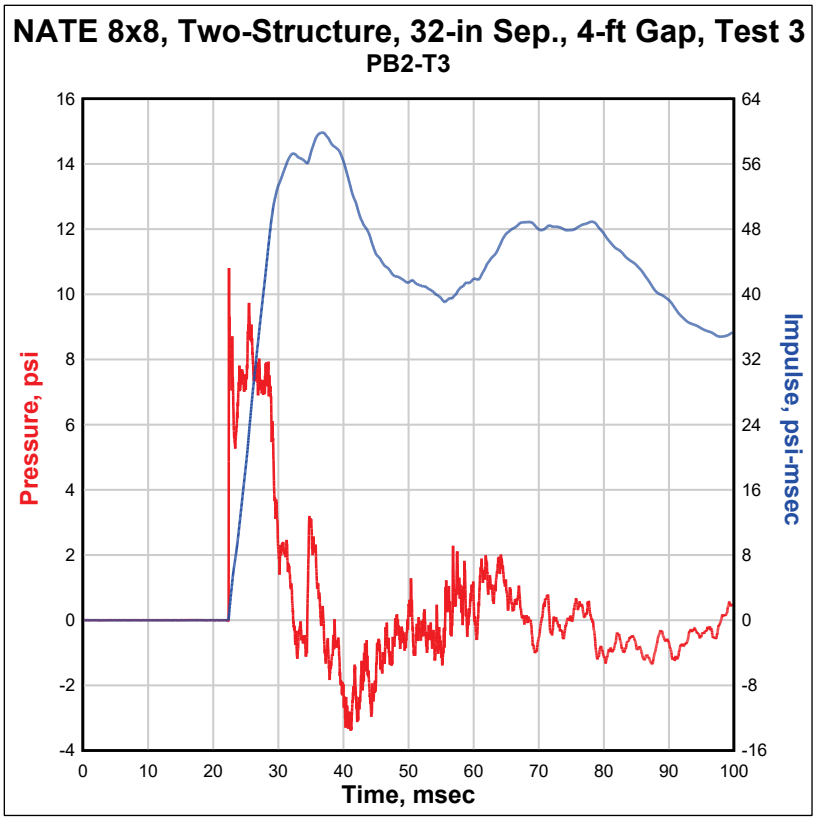

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

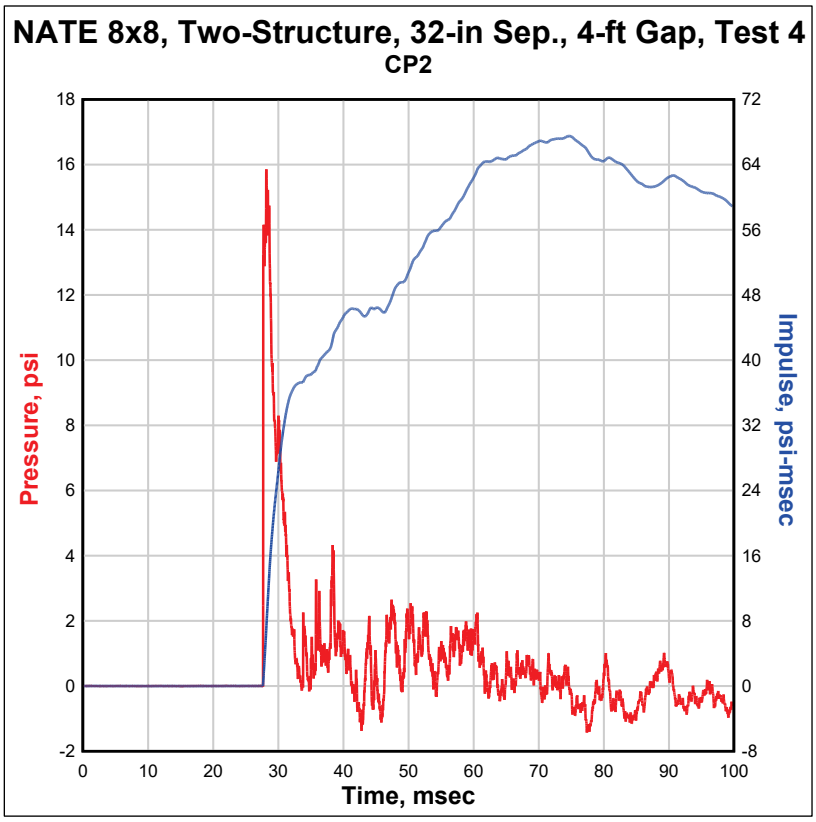

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100

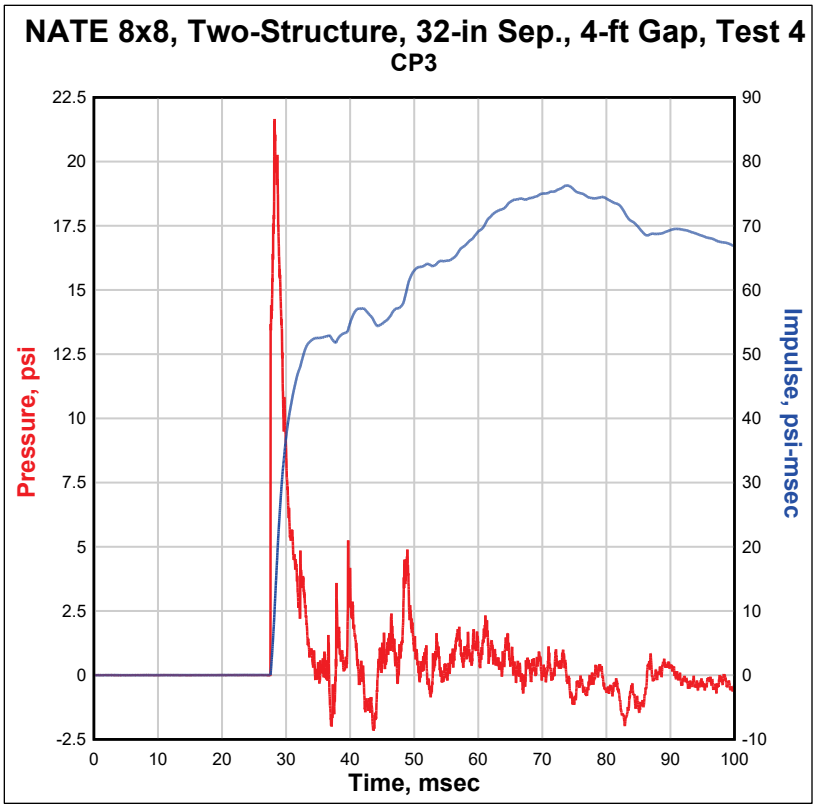

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

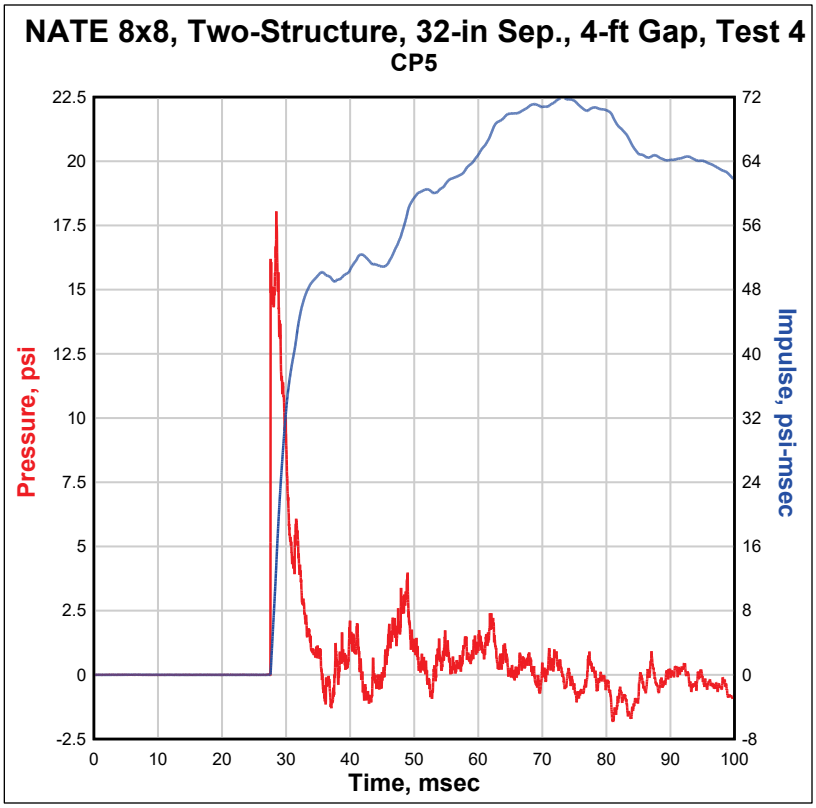

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
48
42
36
30
24
18
12
6
0
-6
-12
0
10
20
30
40
50
60
70
80
90
100

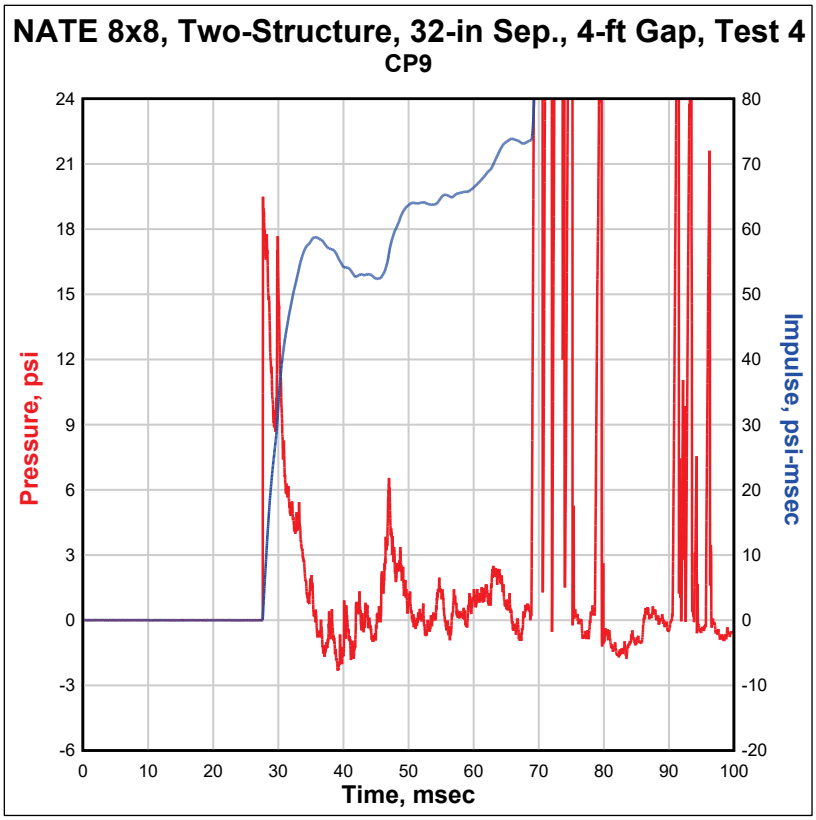

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

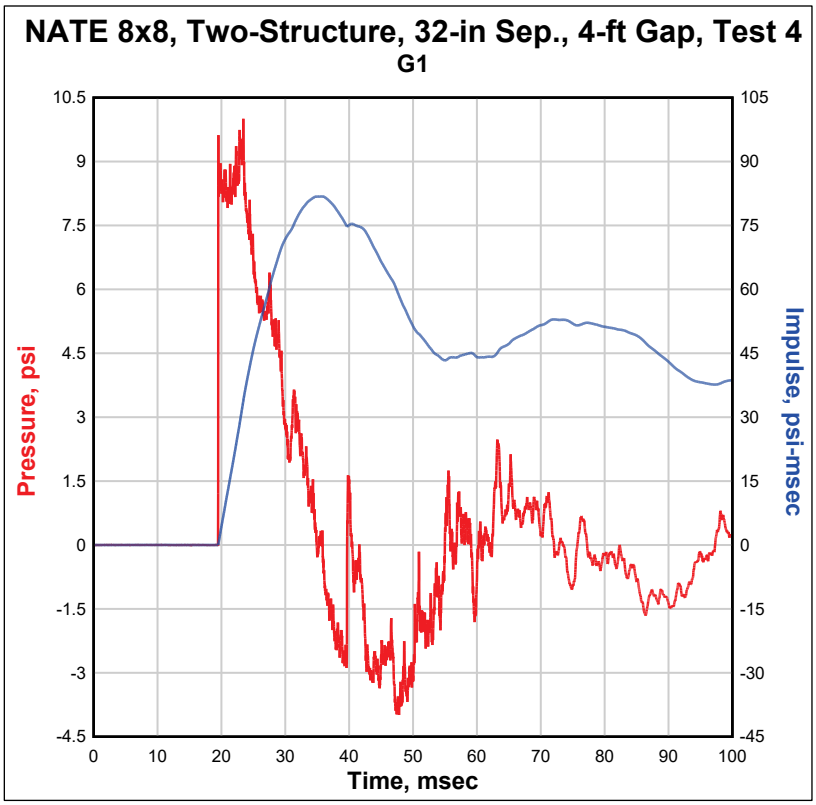

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 3
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
16
14
12
10
8
6
4
2
0
-2
-4
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

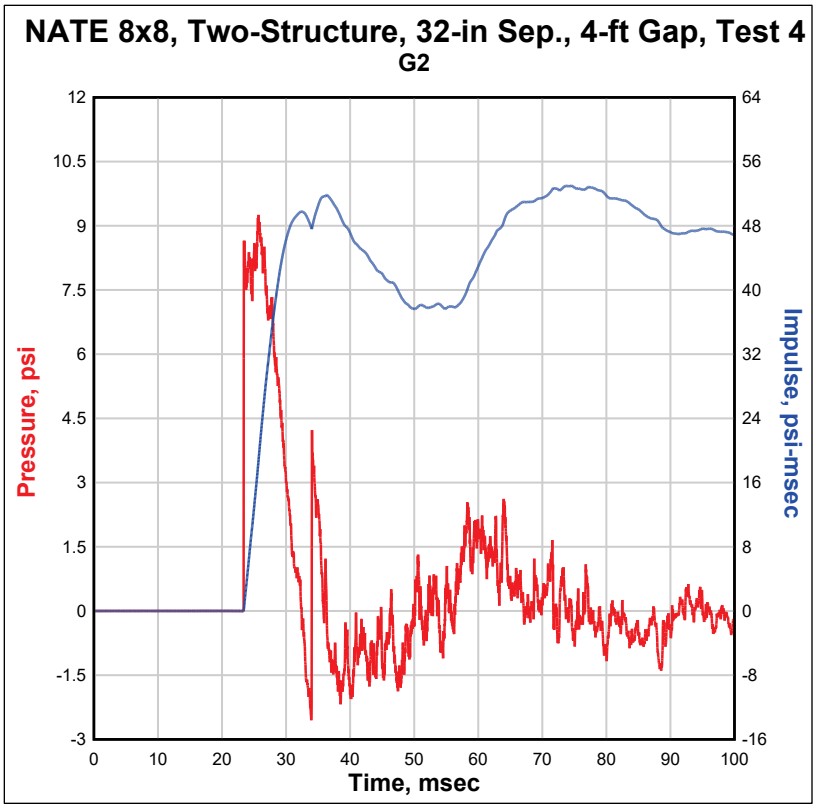

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

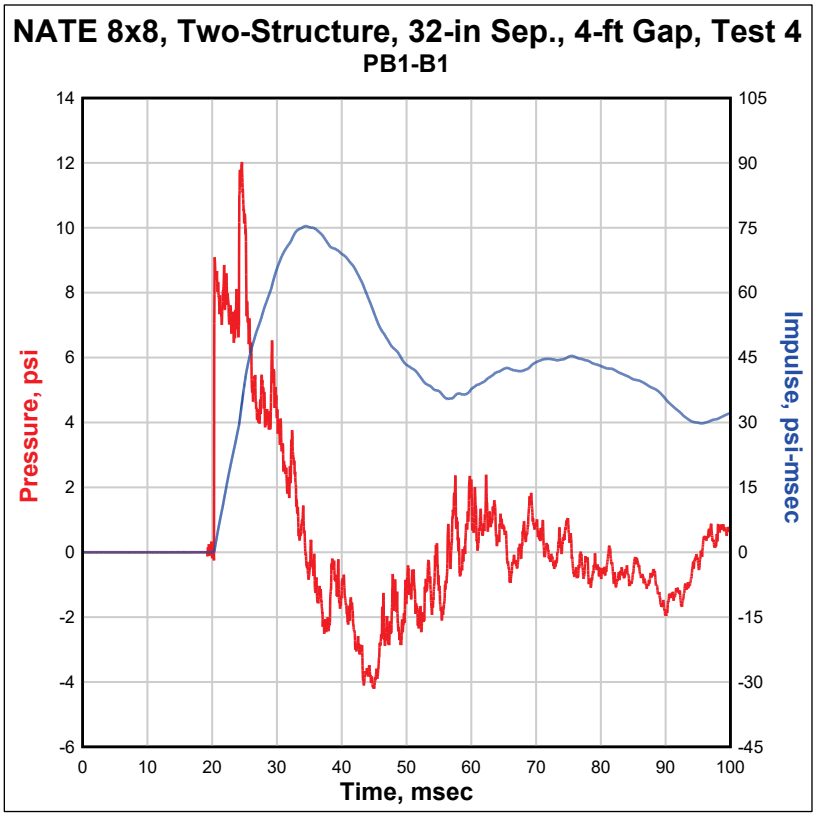

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

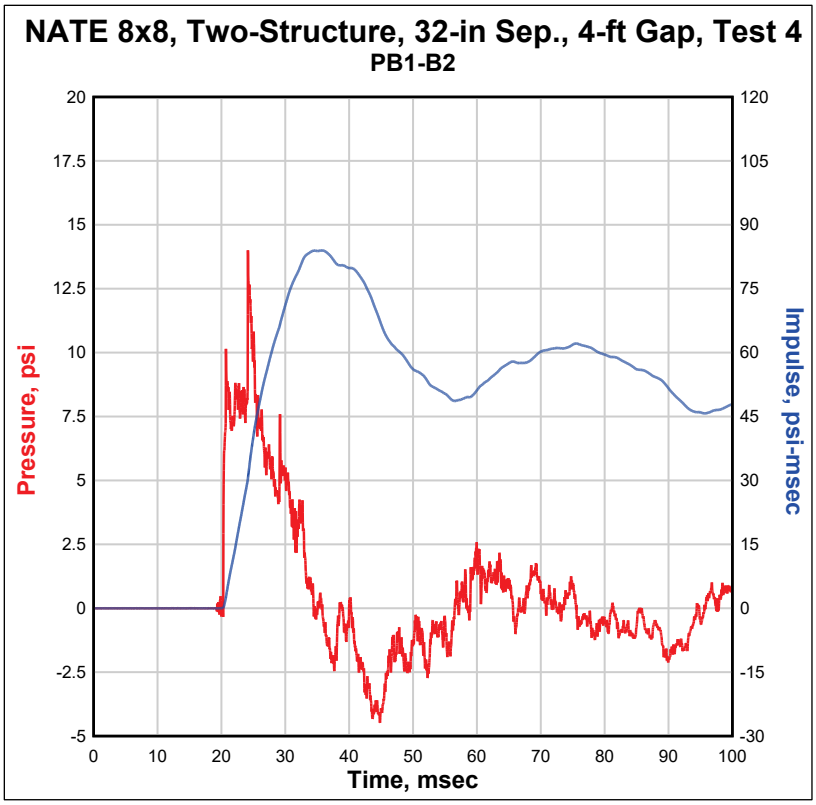

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

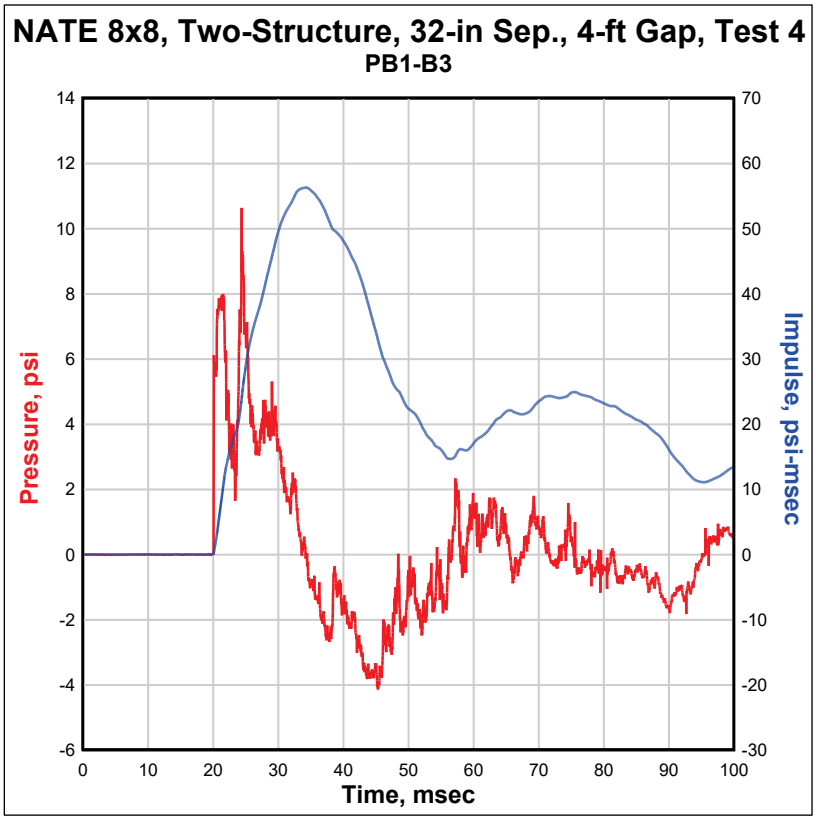

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

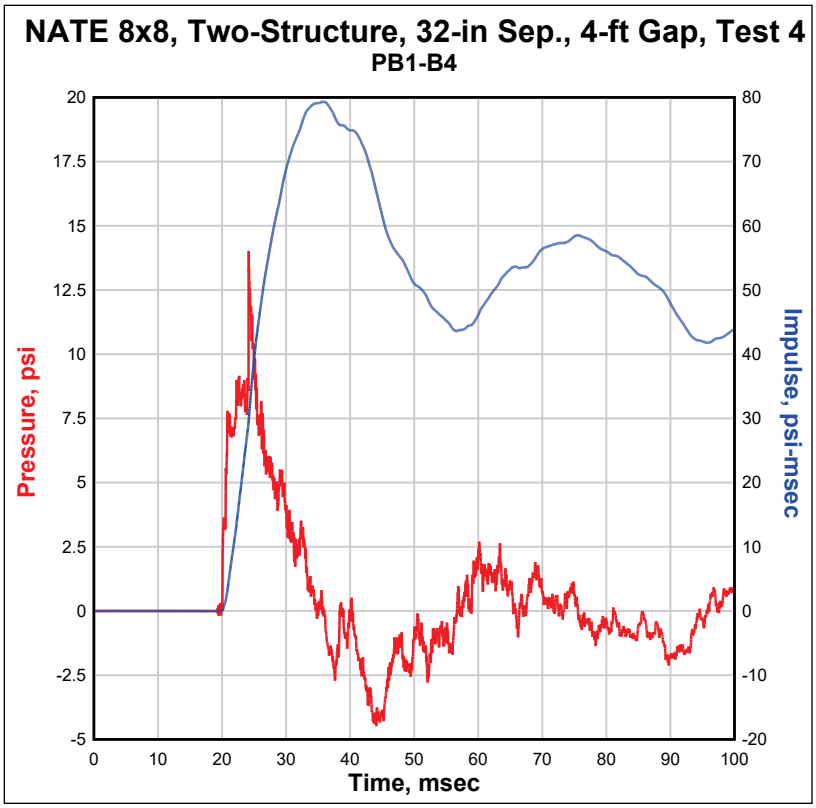

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

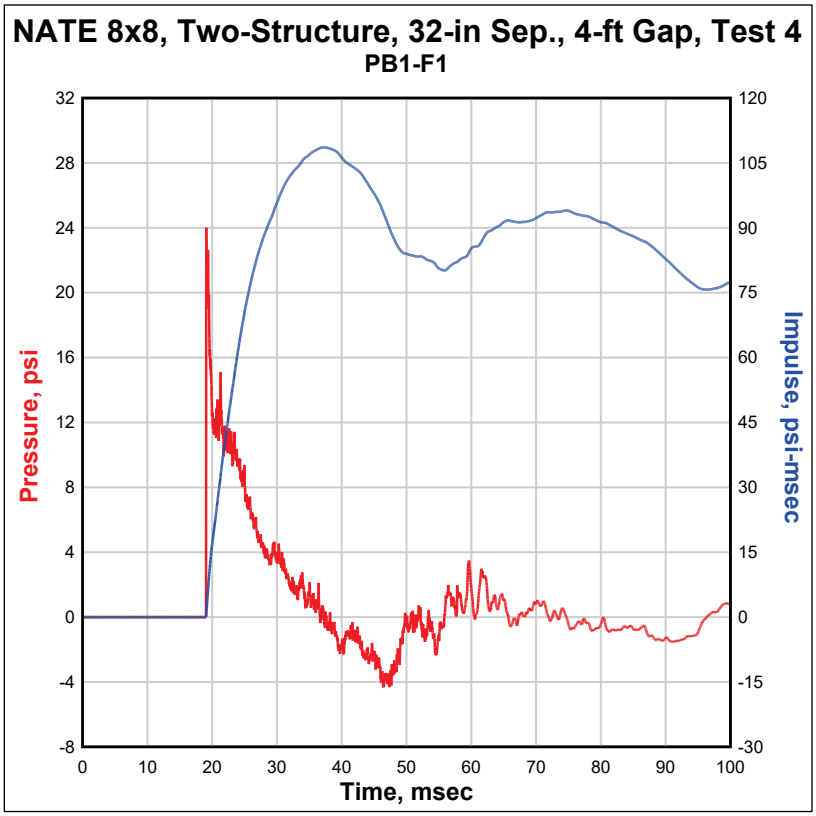

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

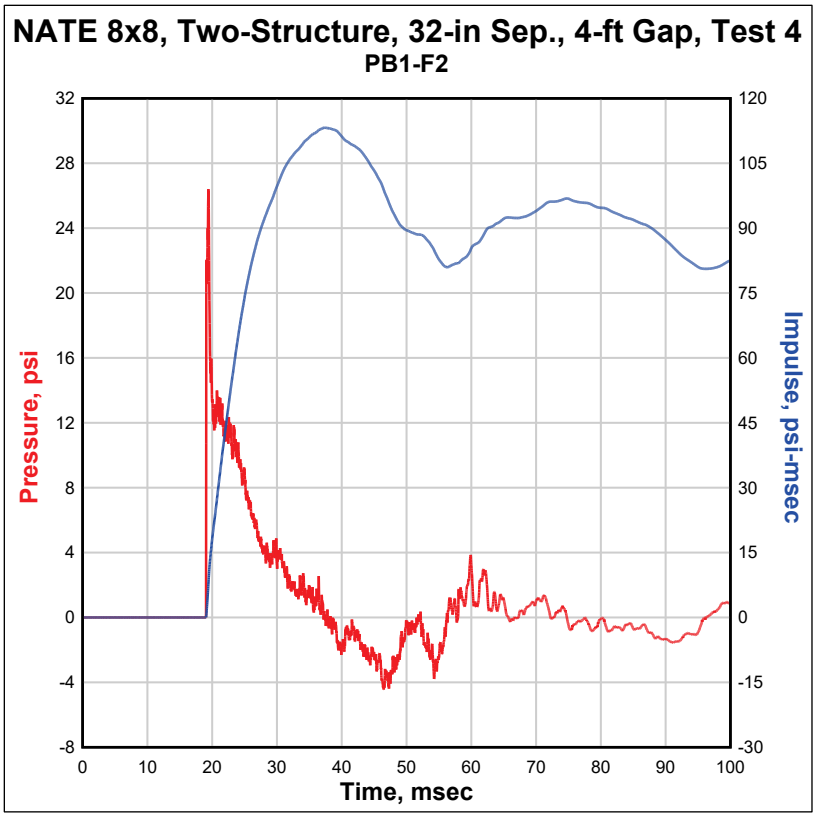

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

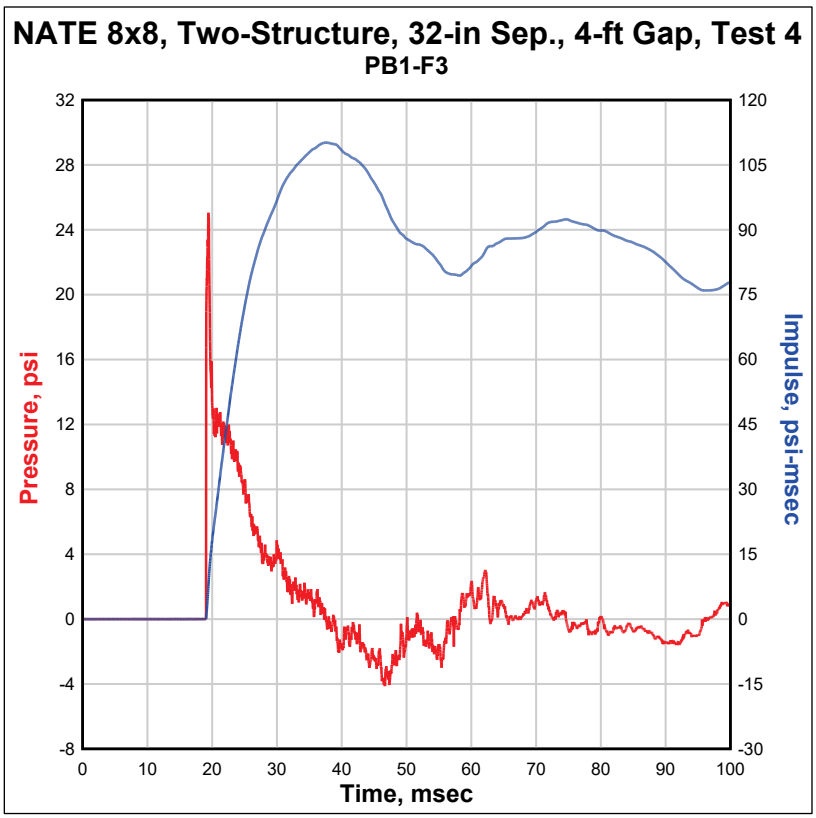

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
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30
40
50
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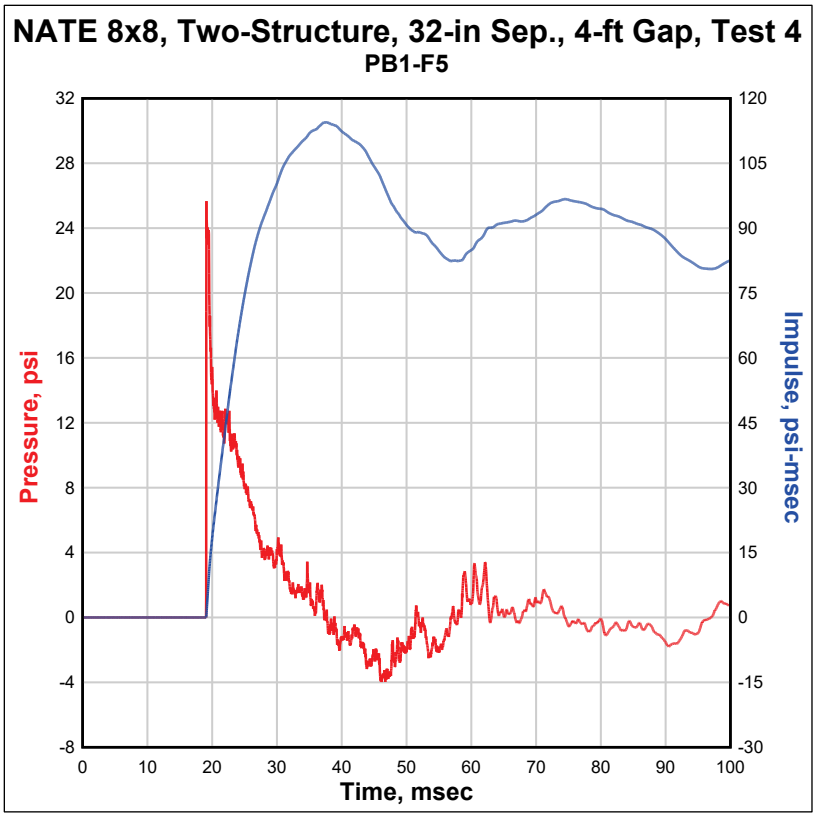
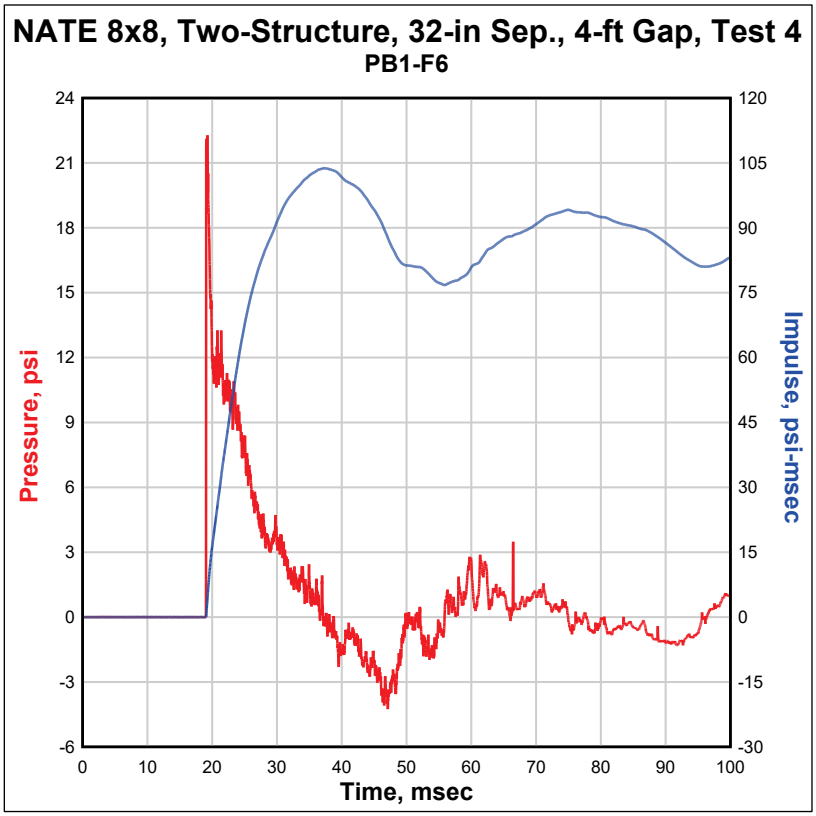
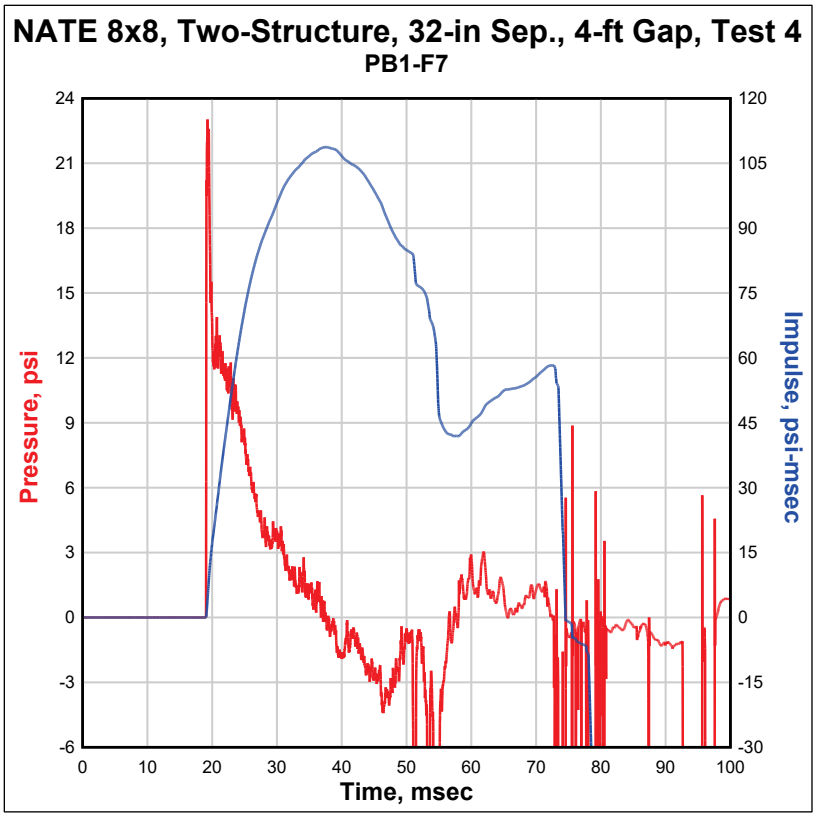
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
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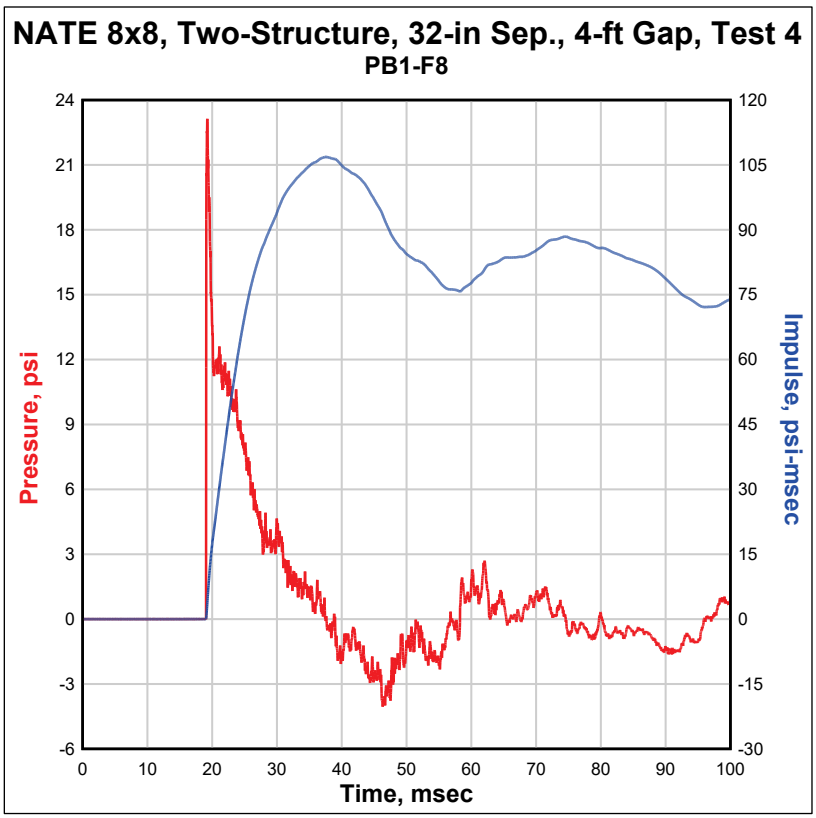
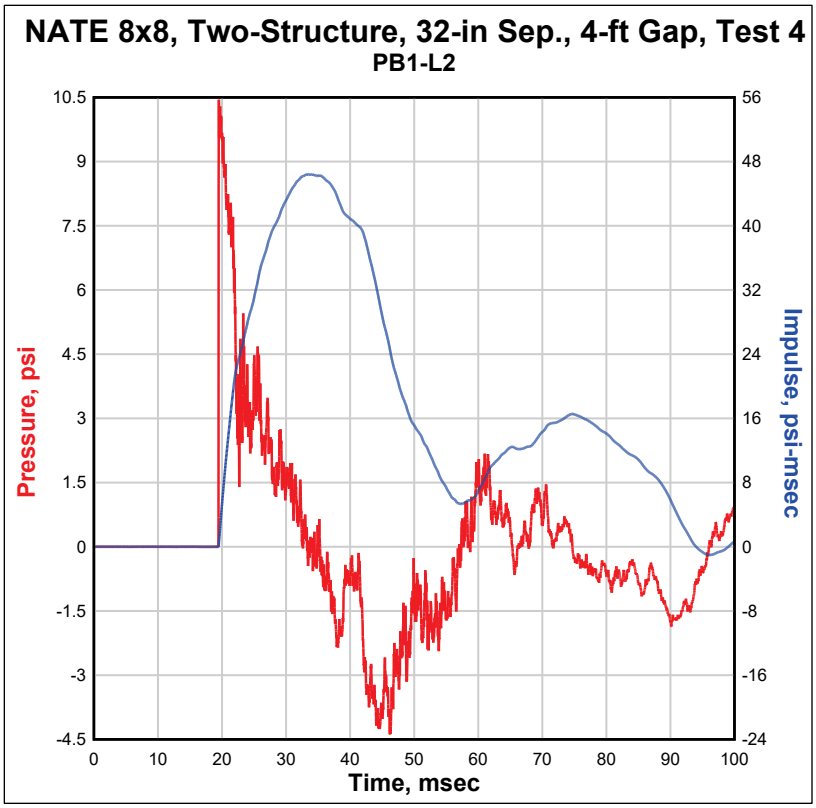
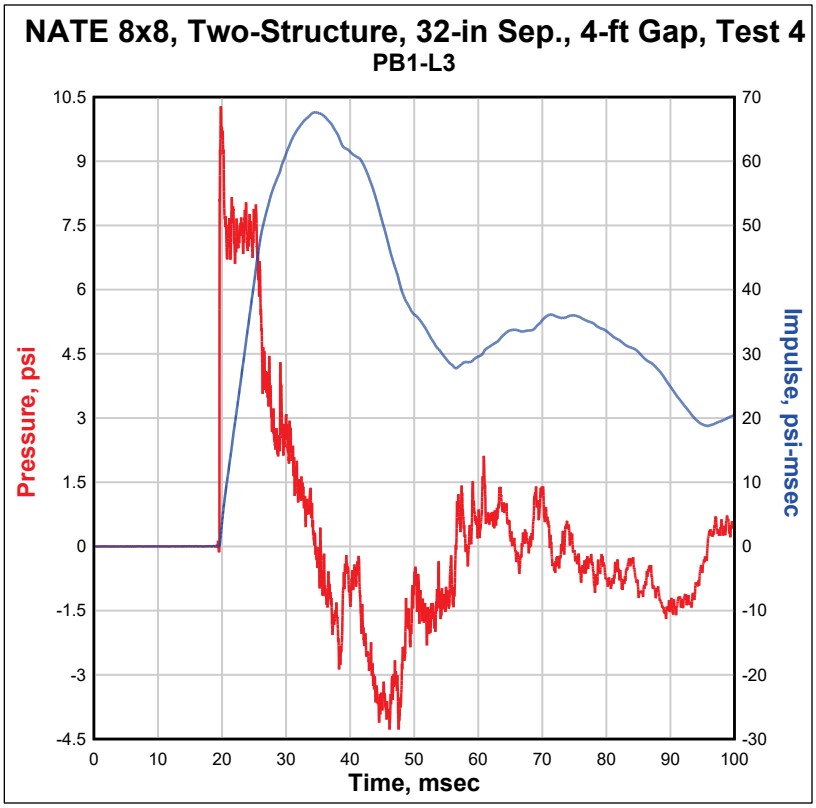
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
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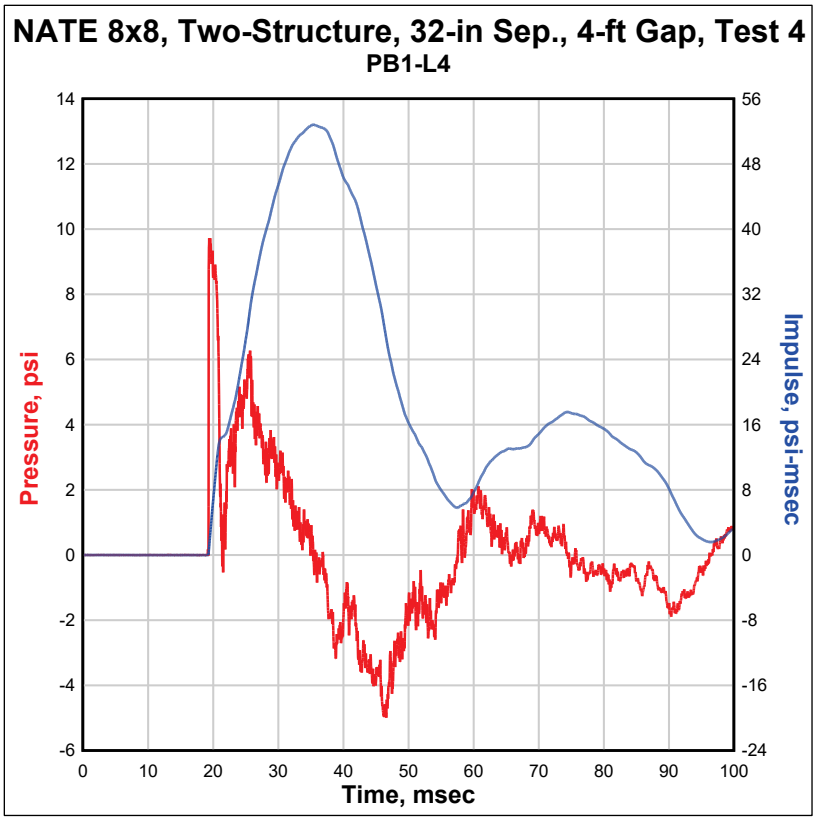
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
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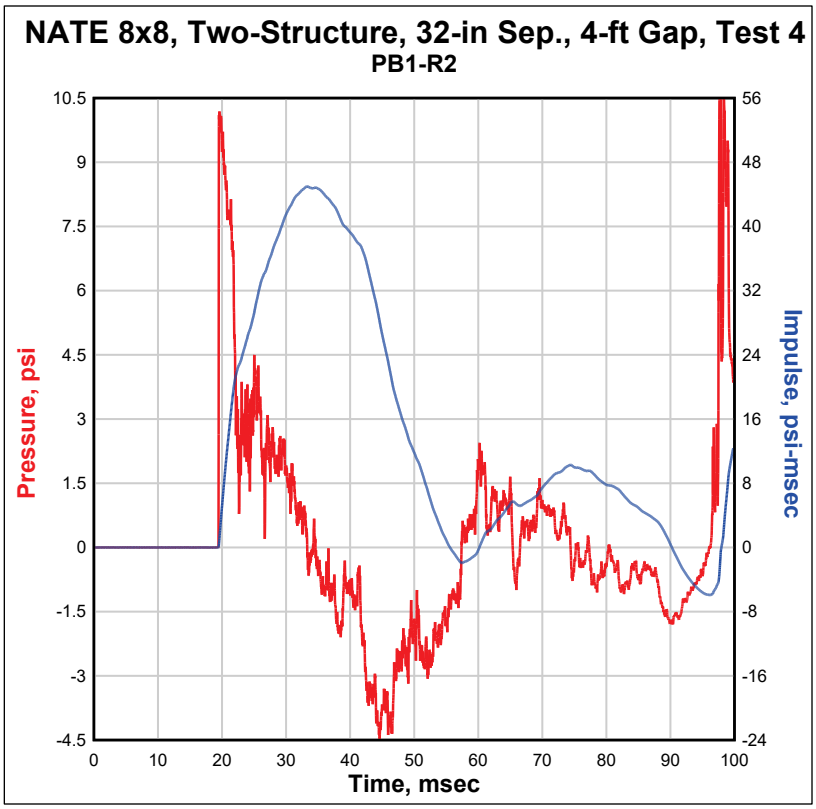
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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-16
-24
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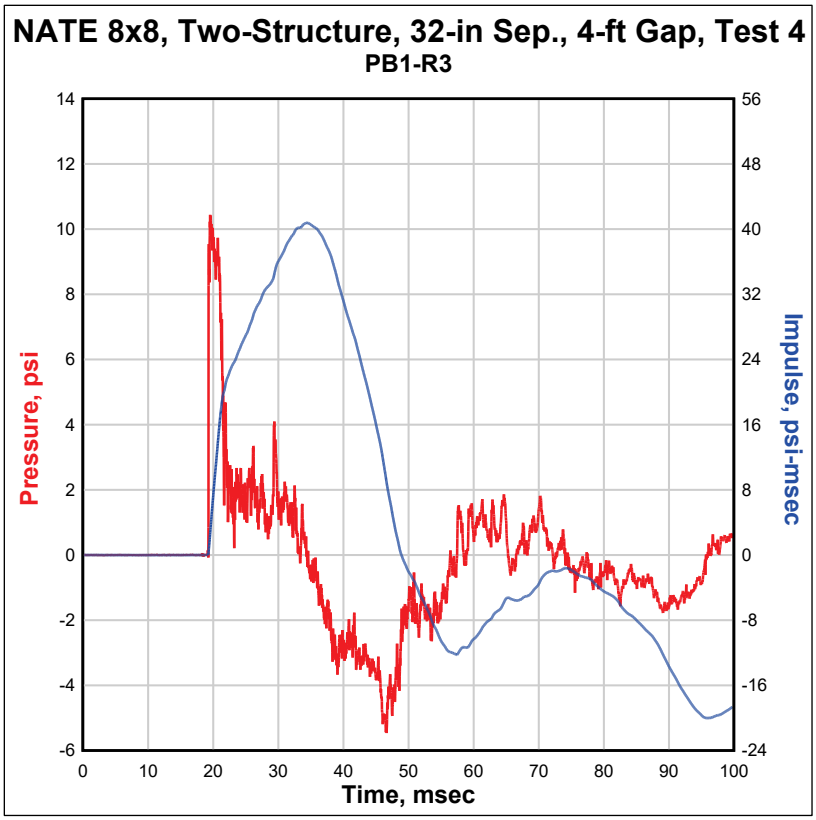
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
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32
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-24
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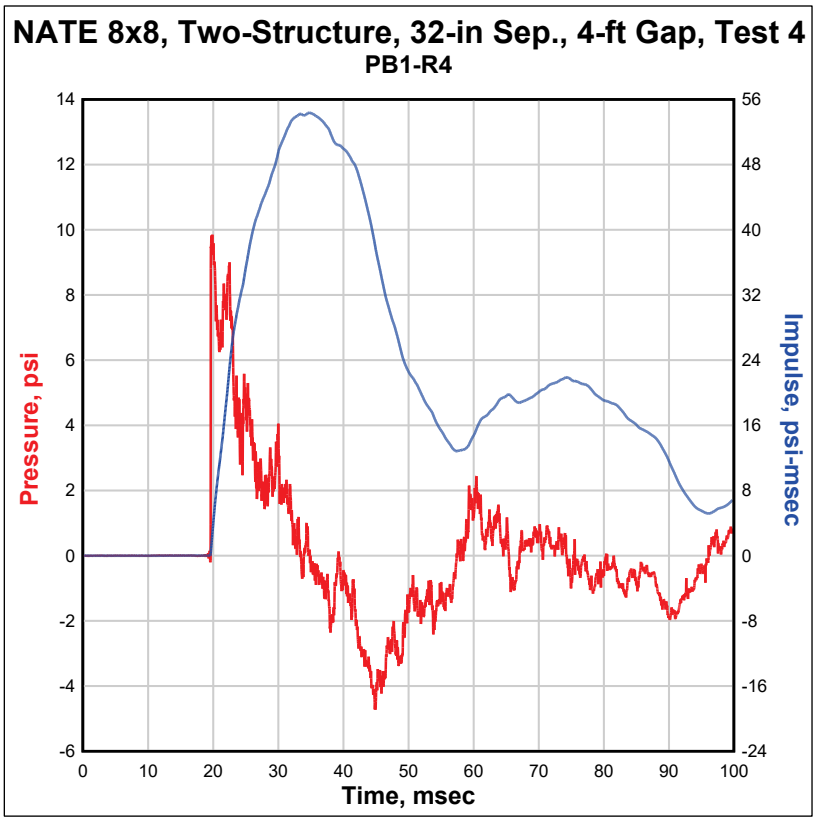
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
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-8
-16
-24
0
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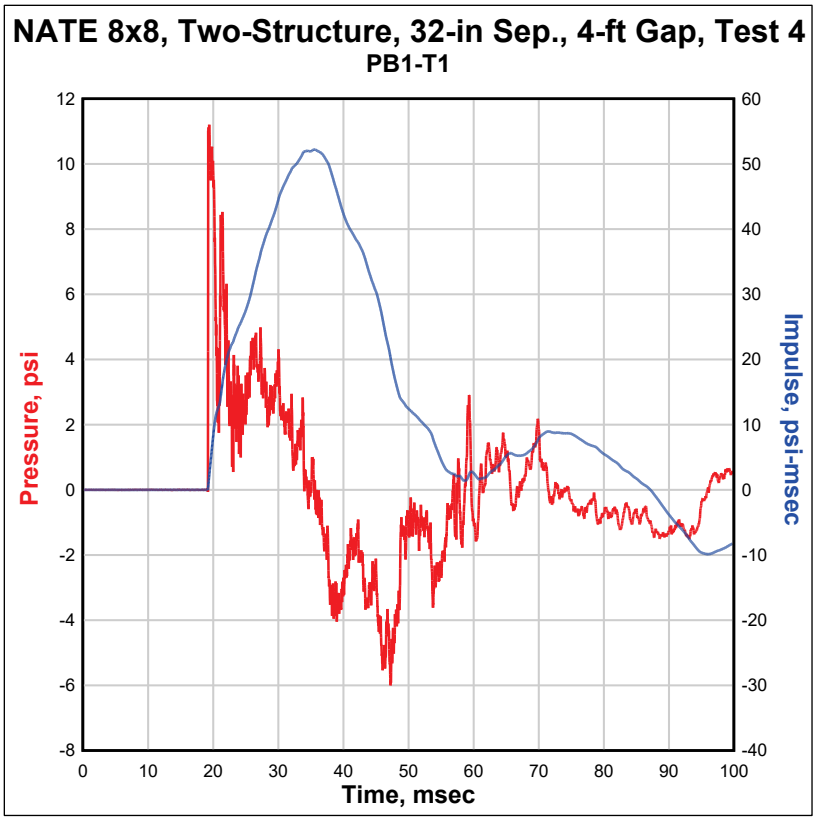
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
12
10
8
6
4
2
0
-2
-4
-6
-8
60
50
40
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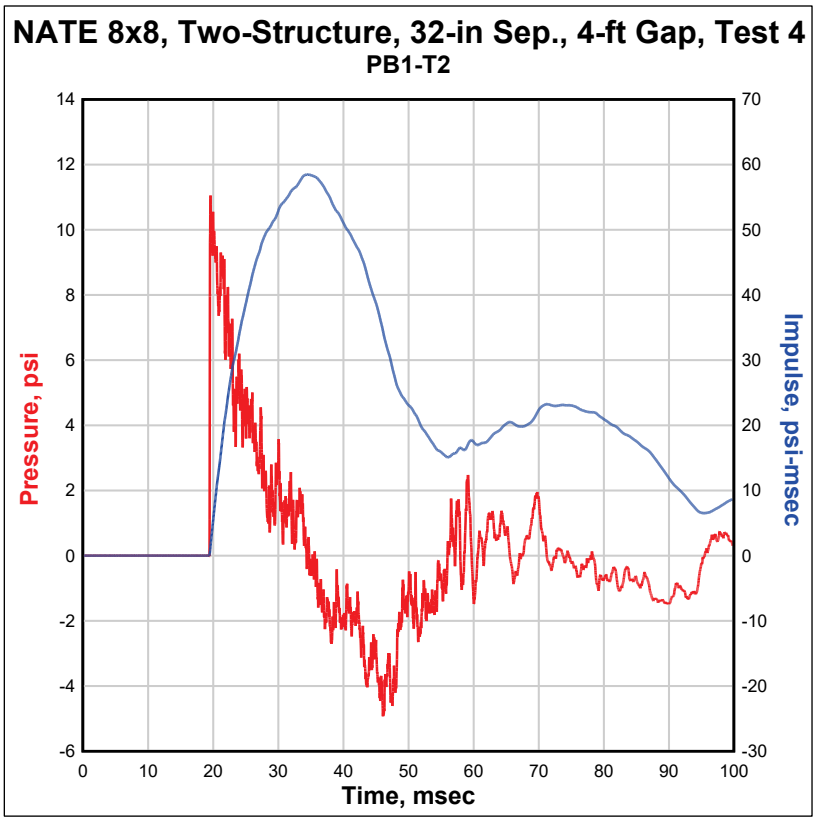
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
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-10
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-30
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30
40
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60
70
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90
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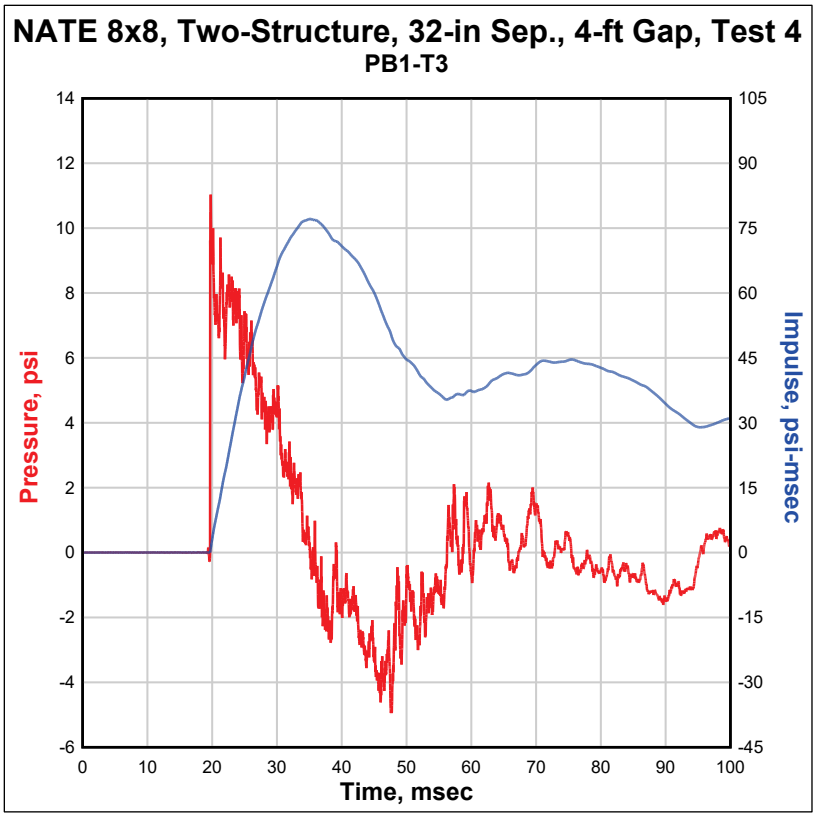
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
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0
-15
-30
-45
0
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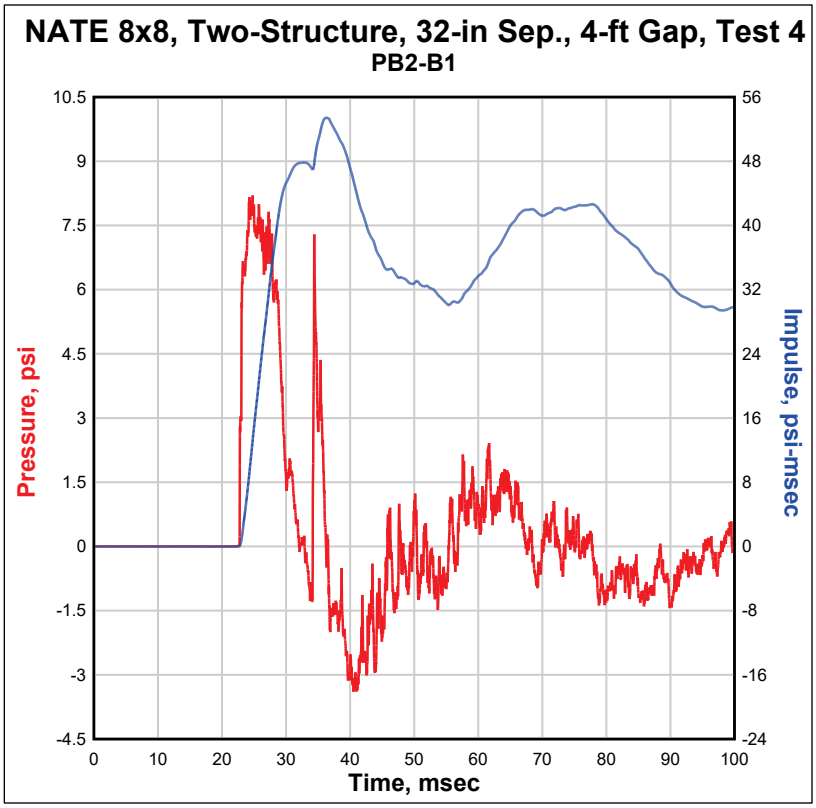
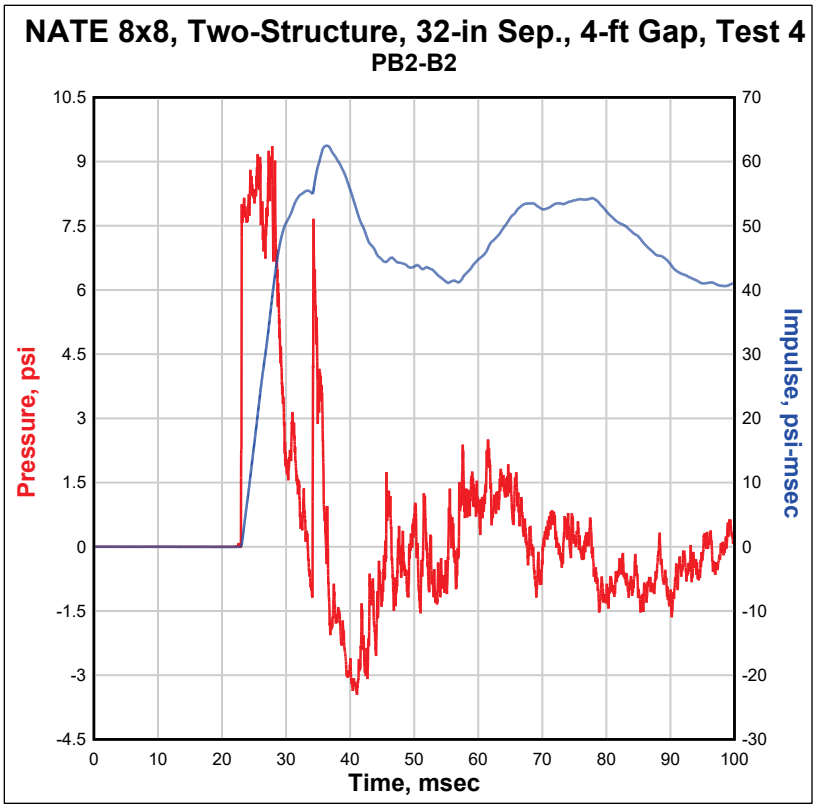
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
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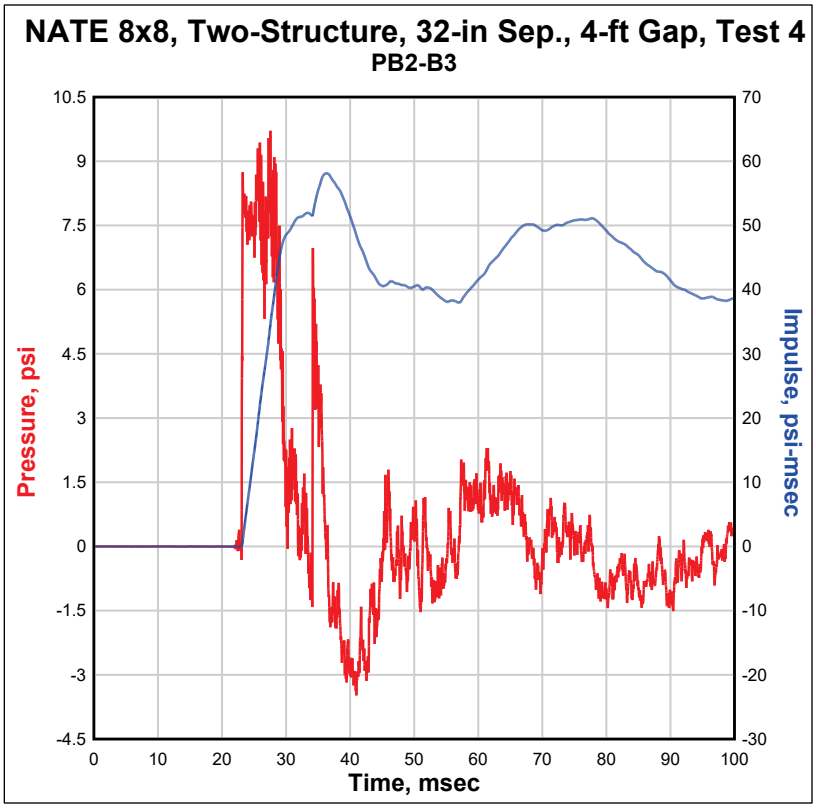
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
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20
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0
-10
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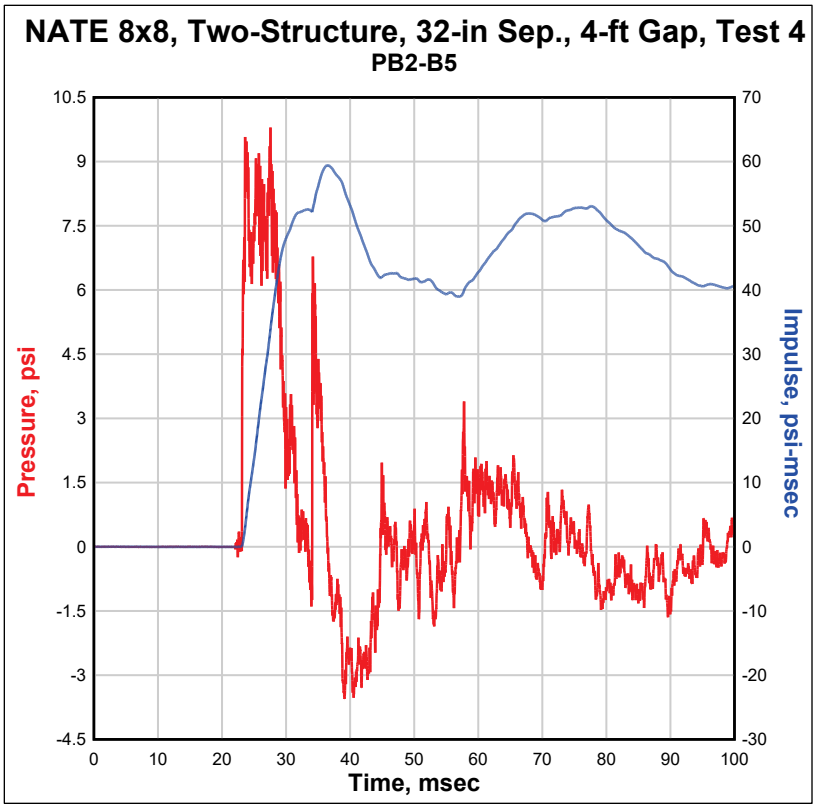
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B5
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
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20
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40
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60
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80
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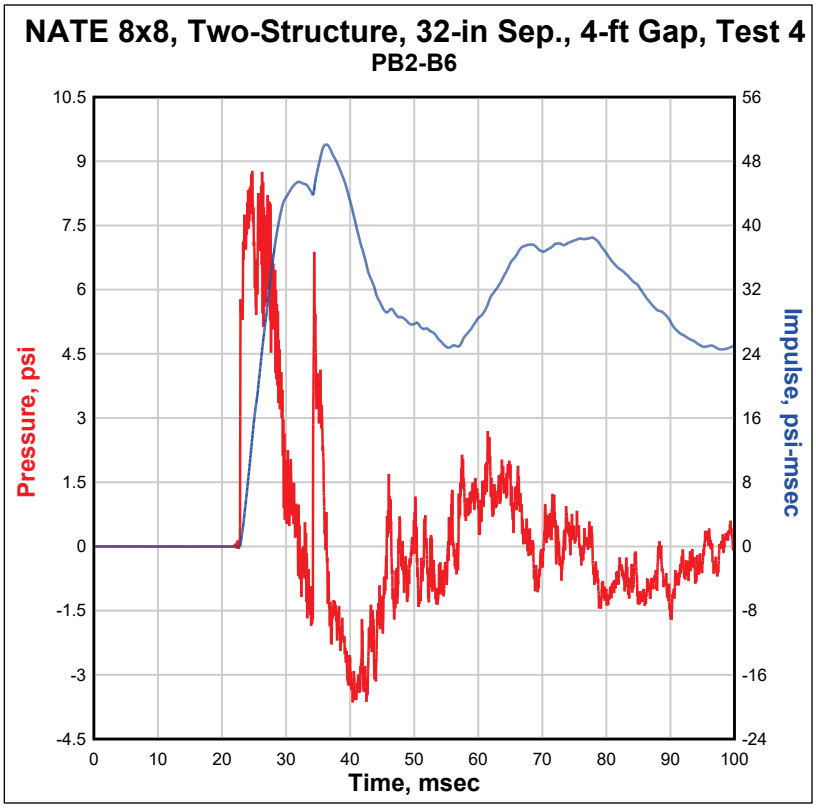
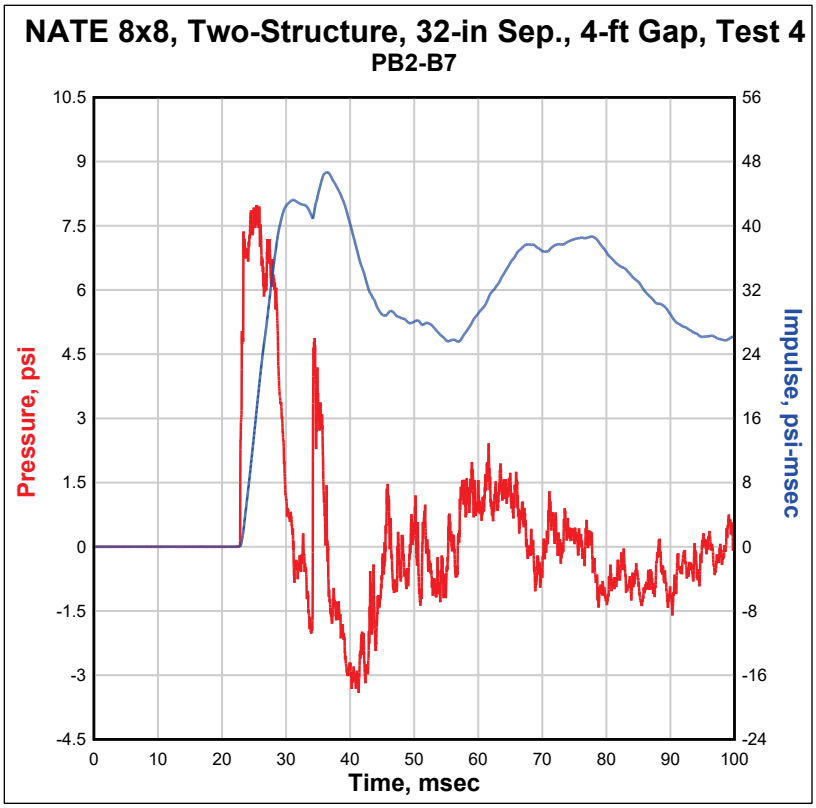
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B6
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B7
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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-8
-16
-24
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10
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30
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70
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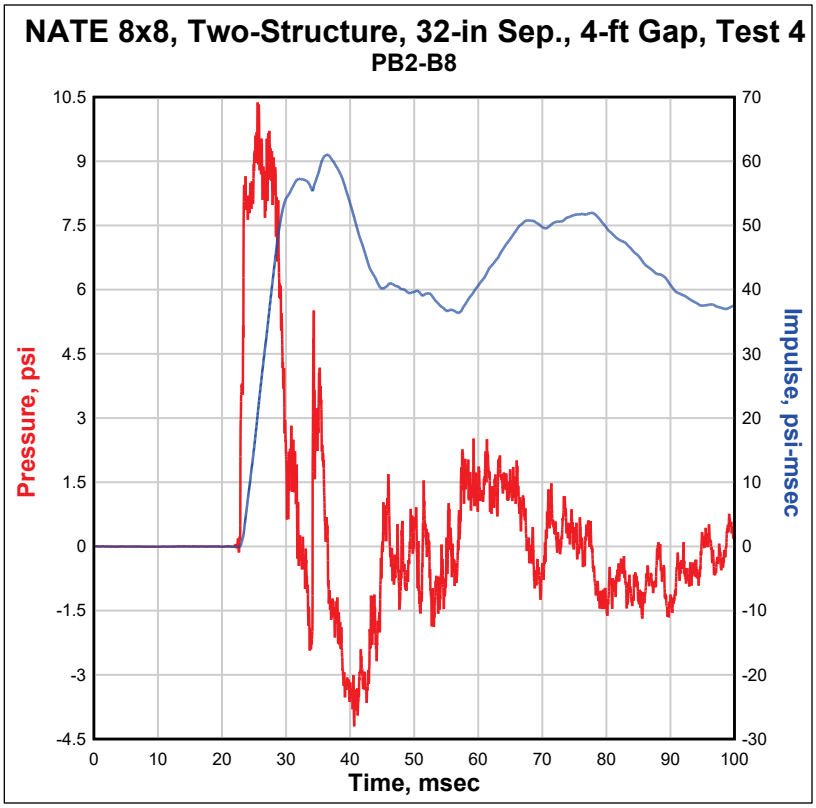
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-B8
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
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30
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0
-10
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-30
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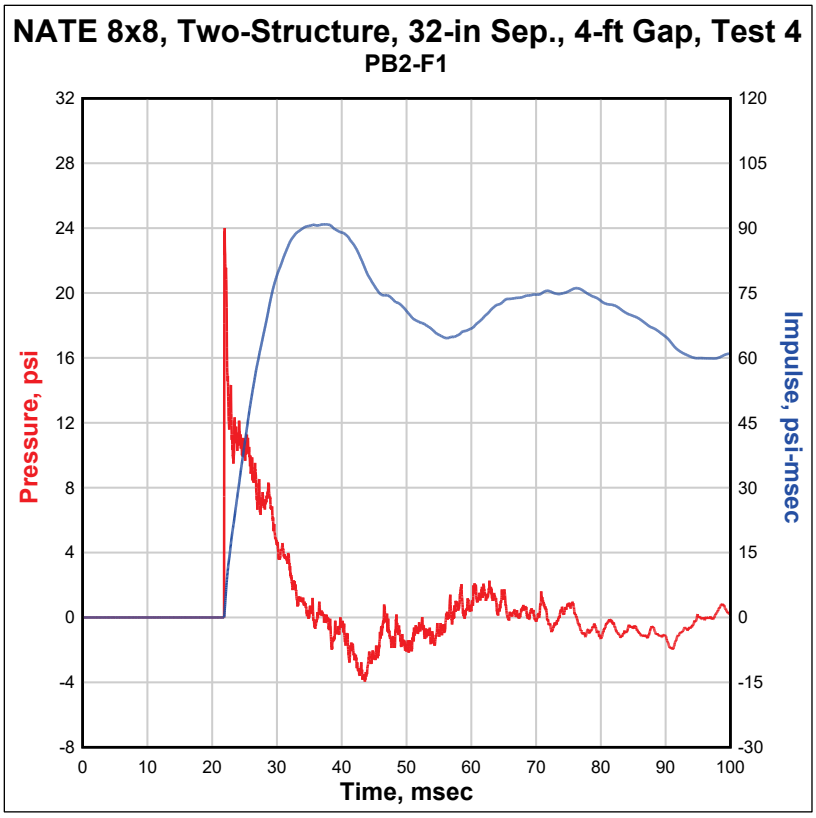
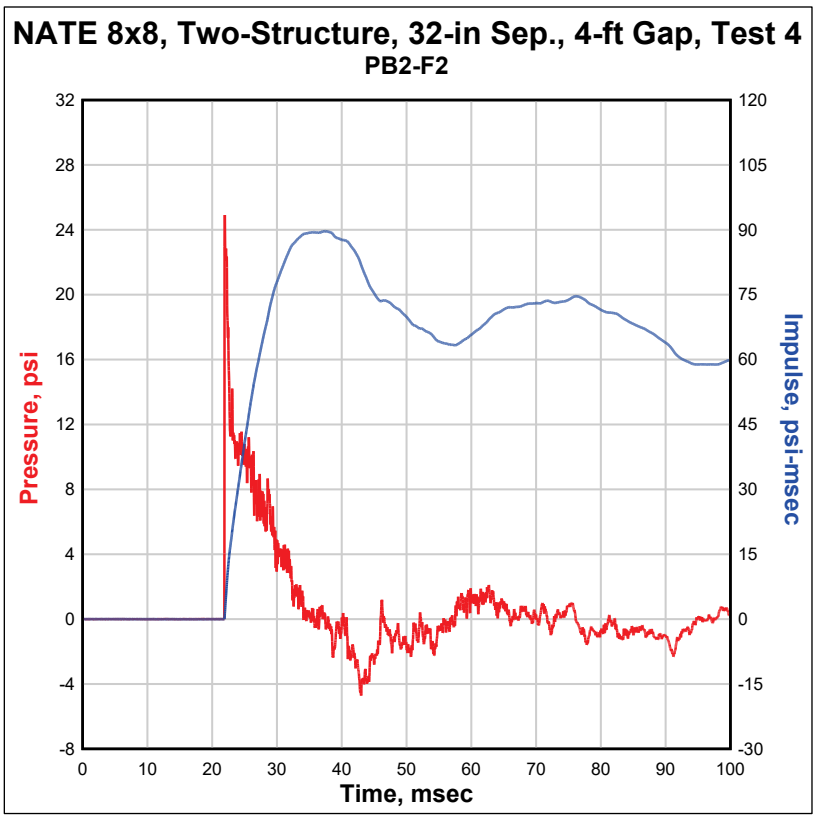
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
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60
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30
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0
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-30
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30
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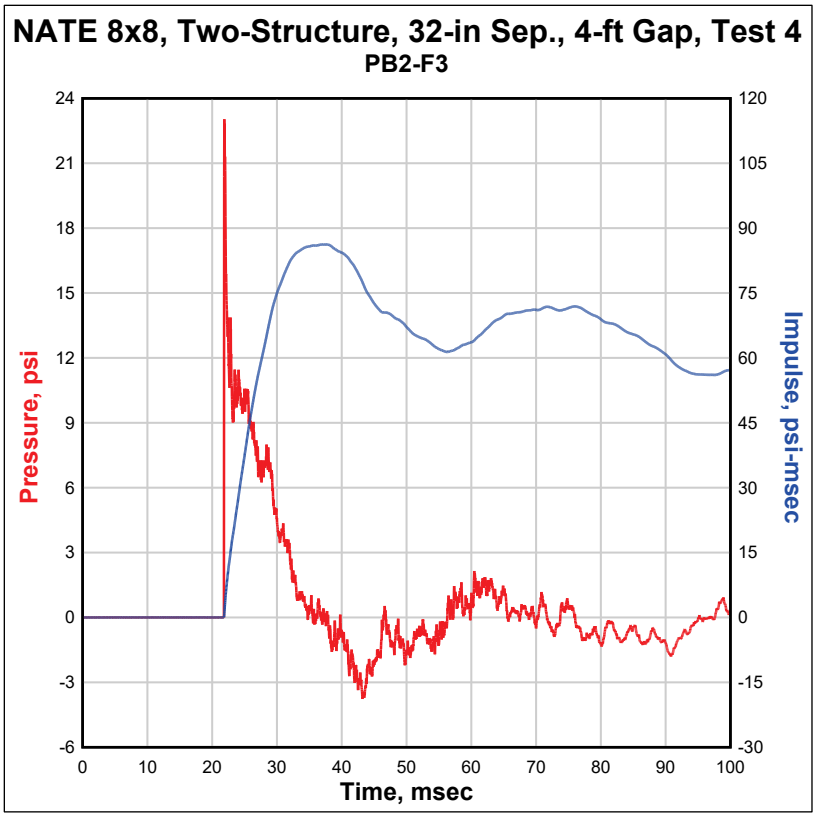
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-F3
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
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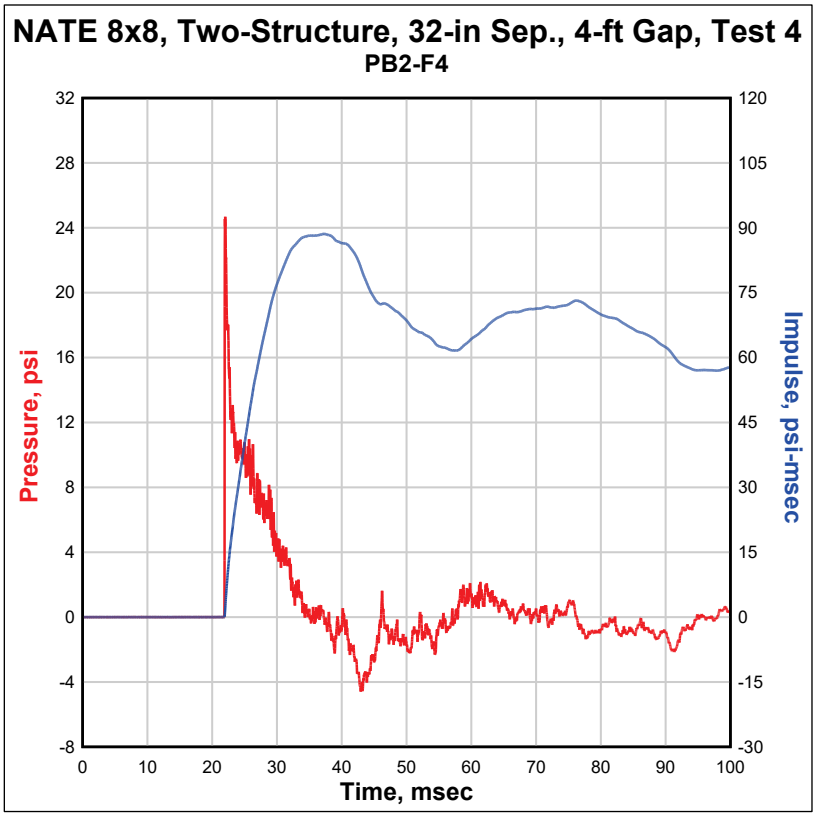
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-F4
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
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60
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30
15
0
-15
-30
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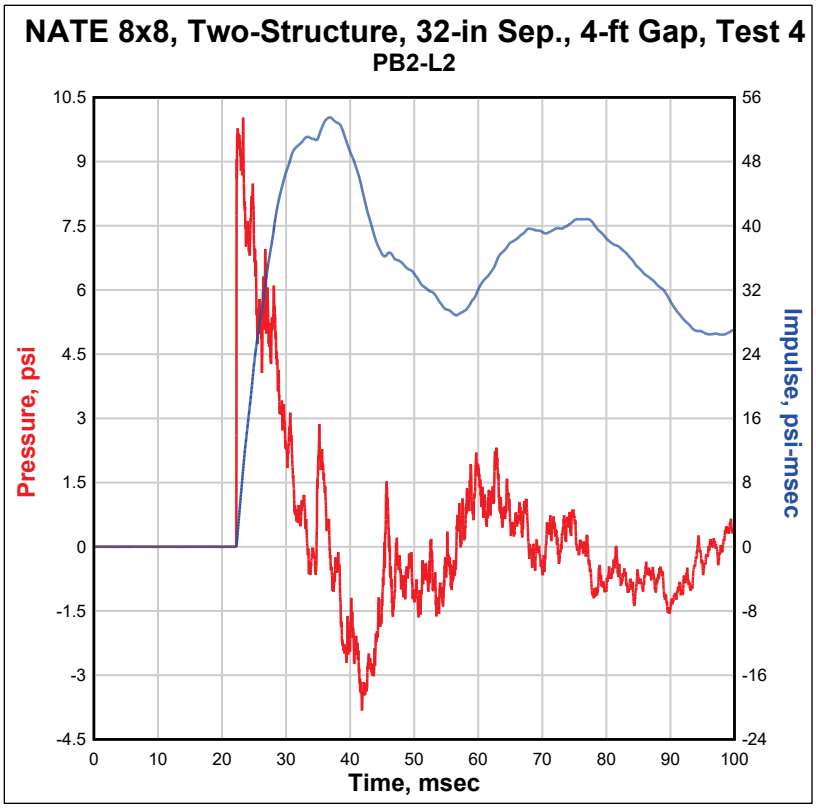
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-L2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
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-8
-16
-24
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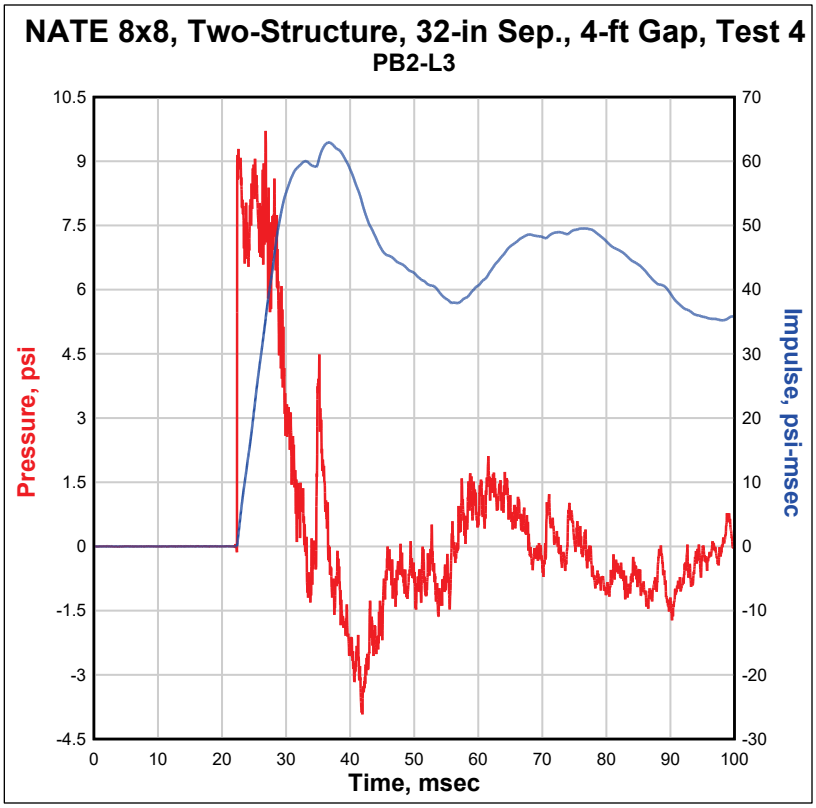
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
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-10
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-30
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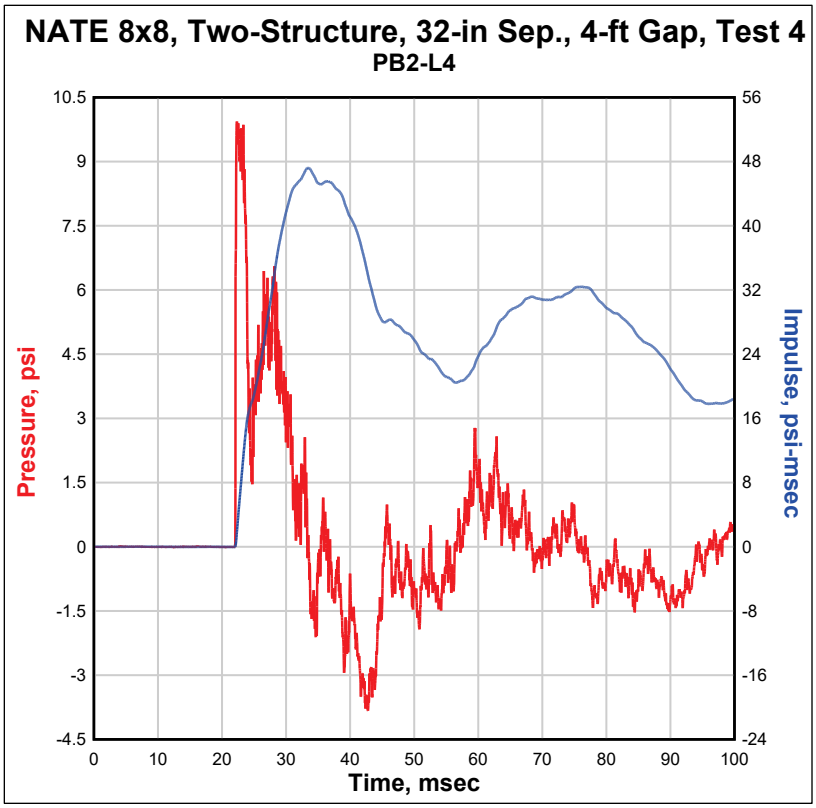
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-L4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
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7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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-8
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-24
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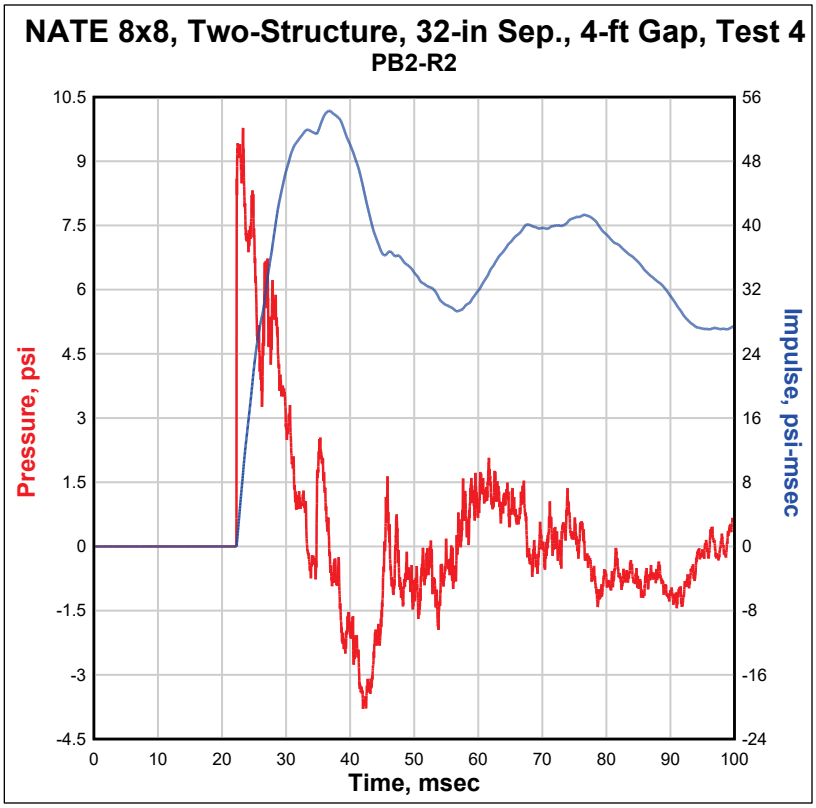
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-R2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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-24
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40
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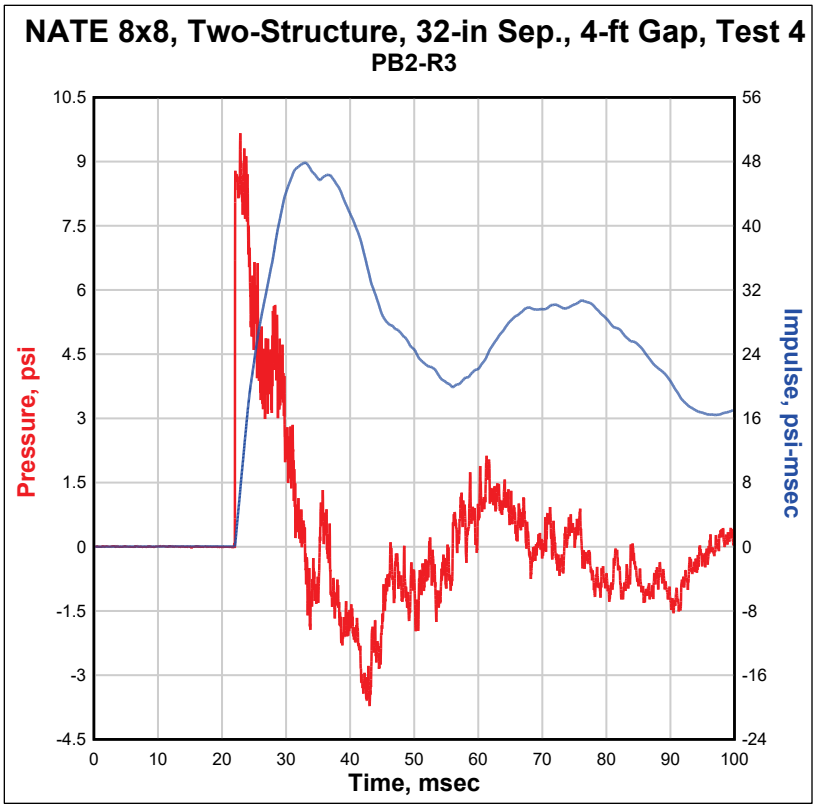
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-R3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
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-8
-16
-24
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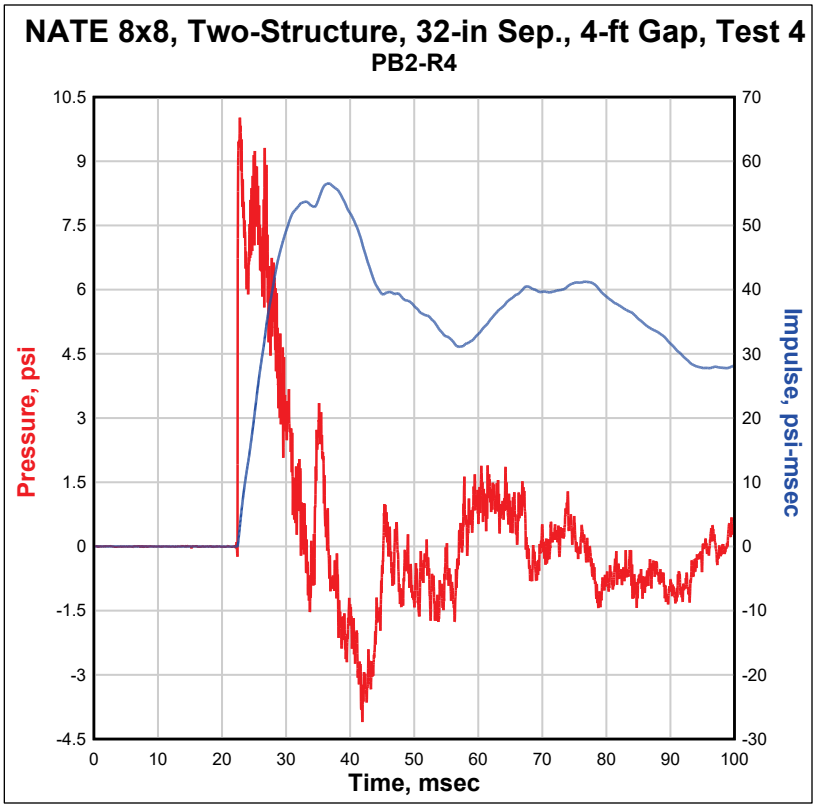
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
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-10
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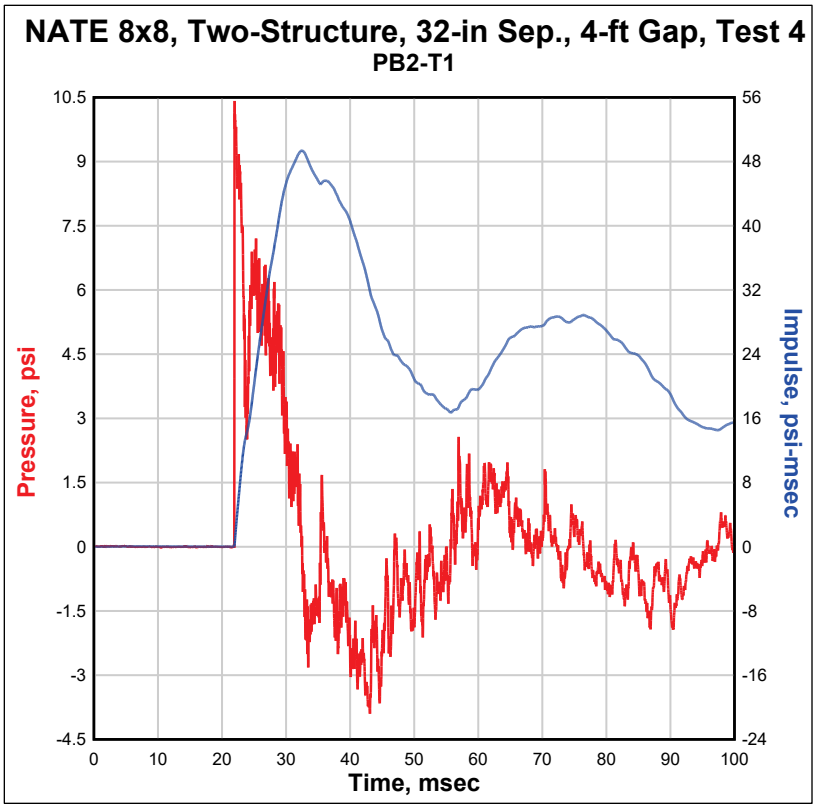
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-T1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
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-8
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-24
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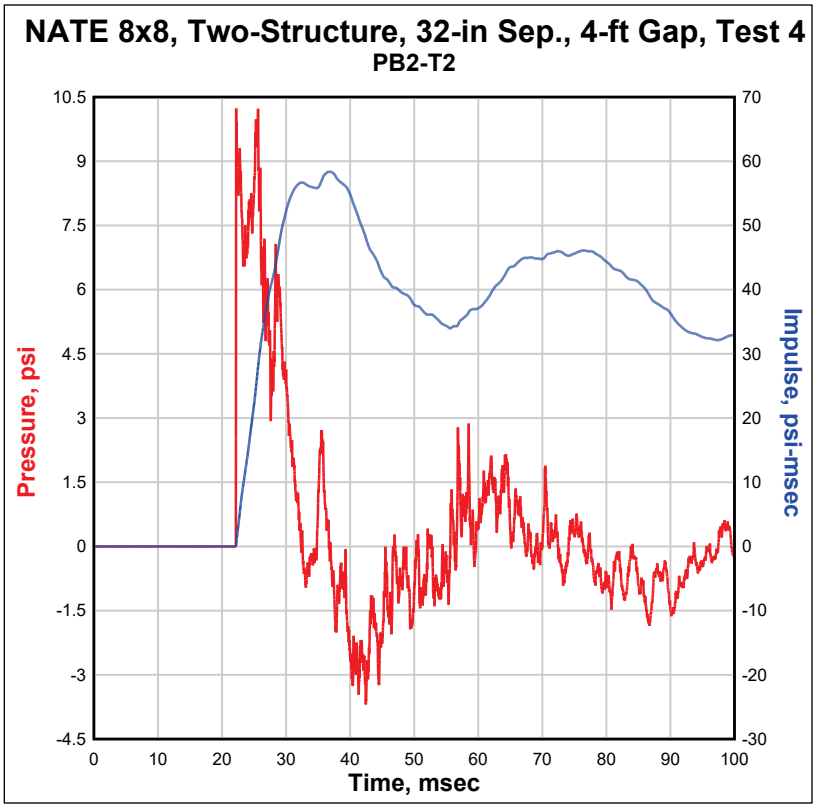
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-T2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
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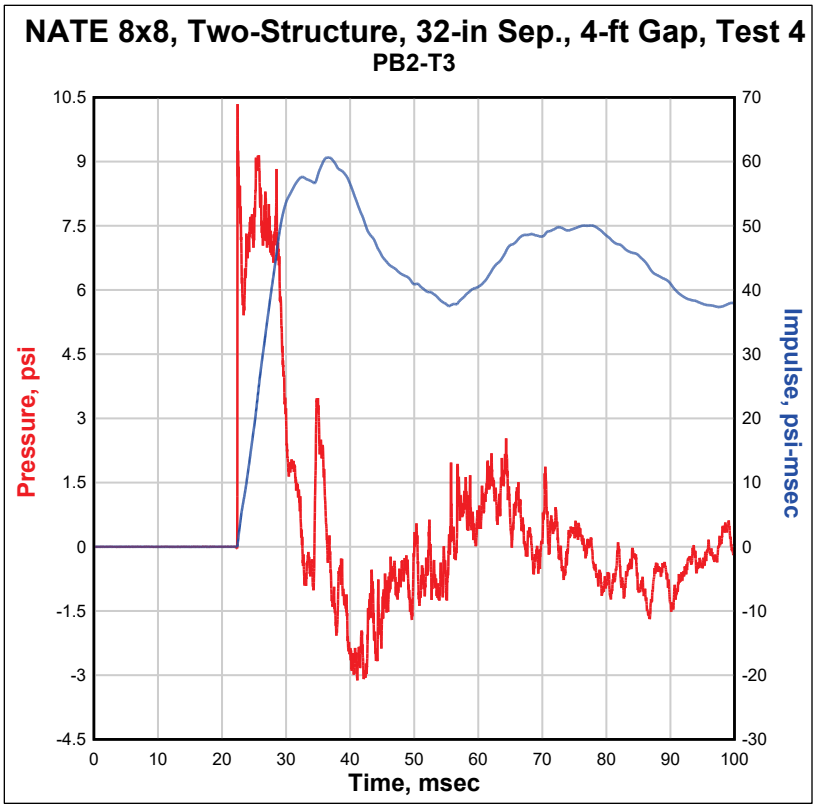
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 4
PB2-T3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
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-10
-20
-30
0
10
20
30
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90
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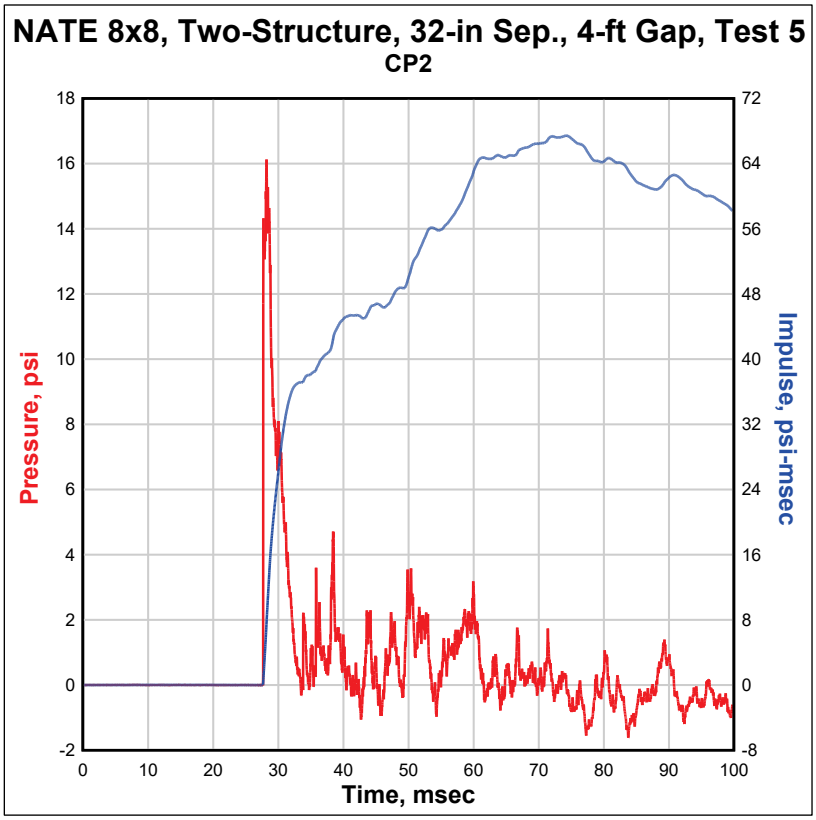
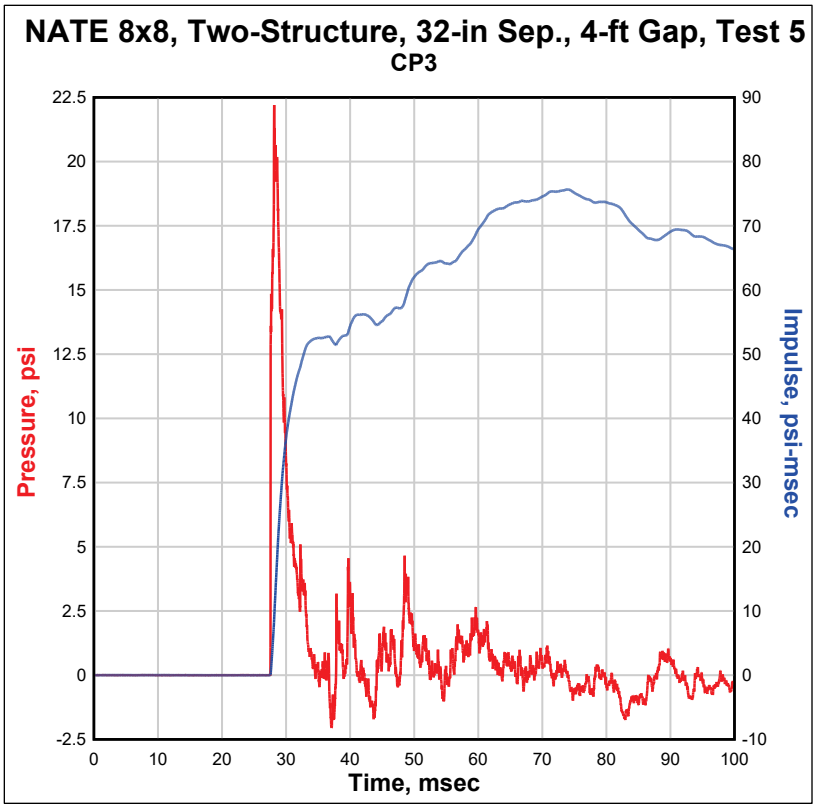
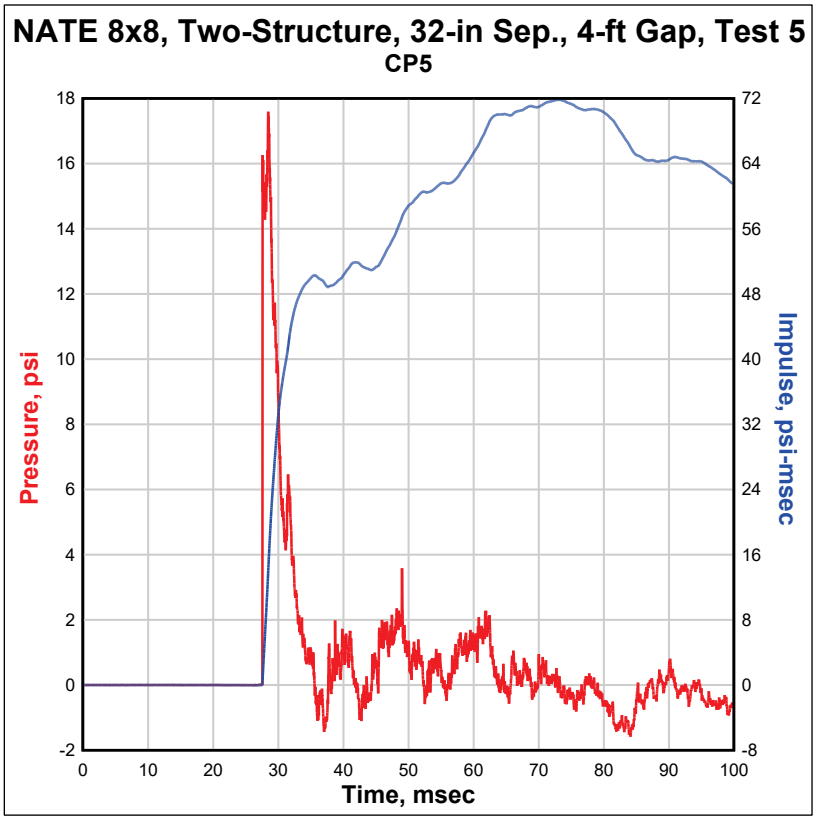
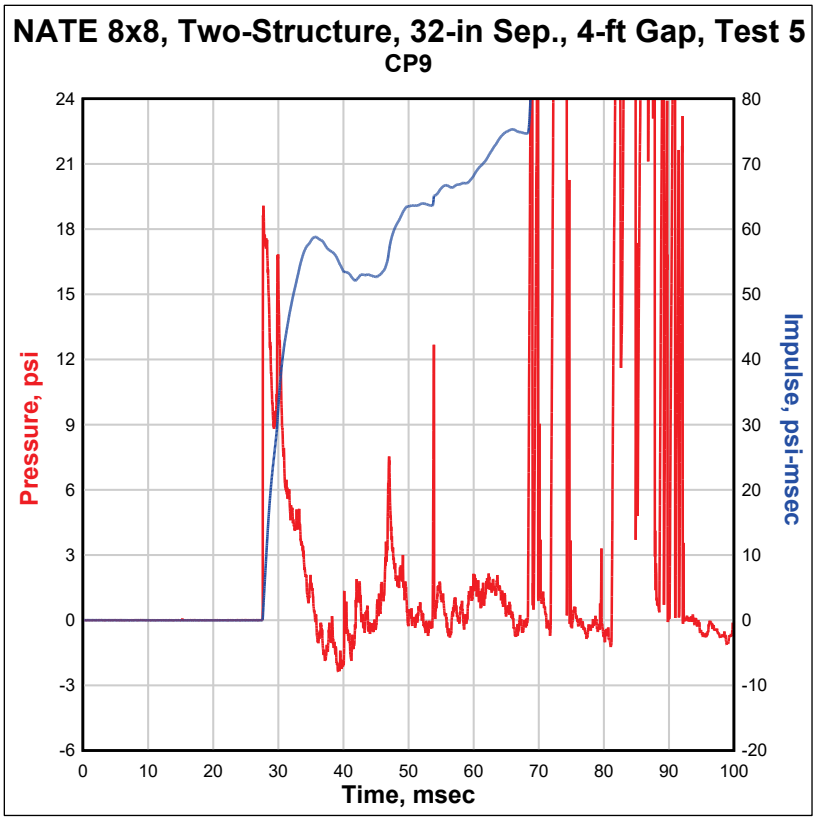
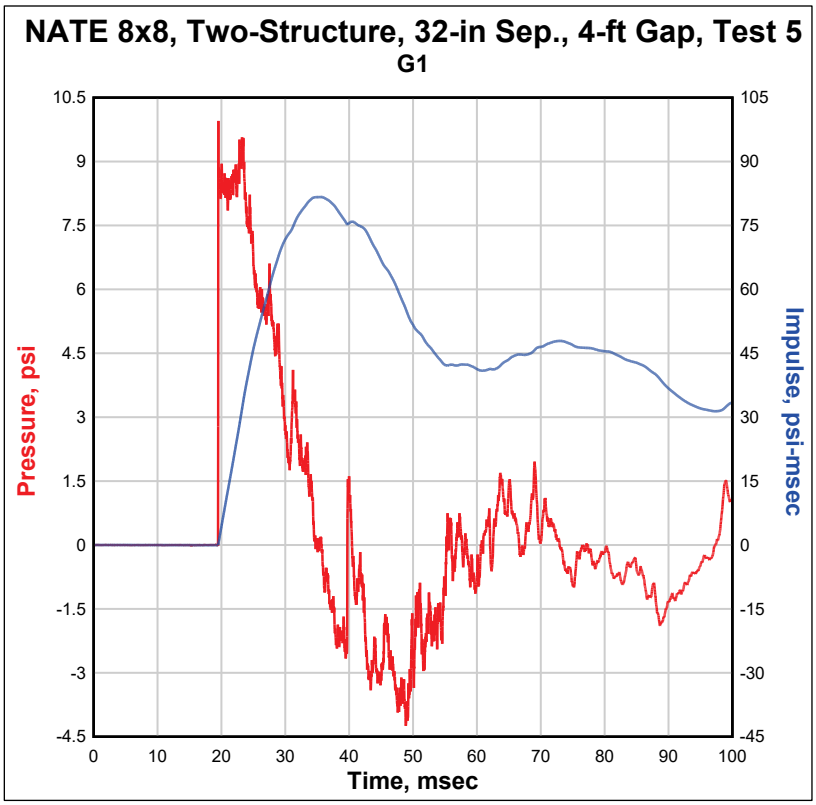
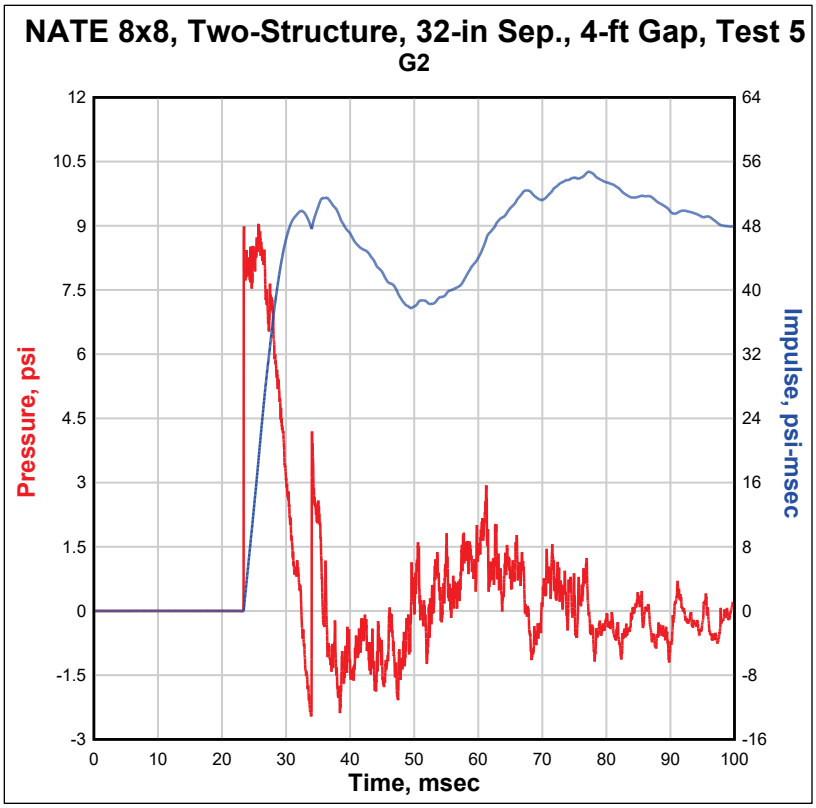

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
CP2
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

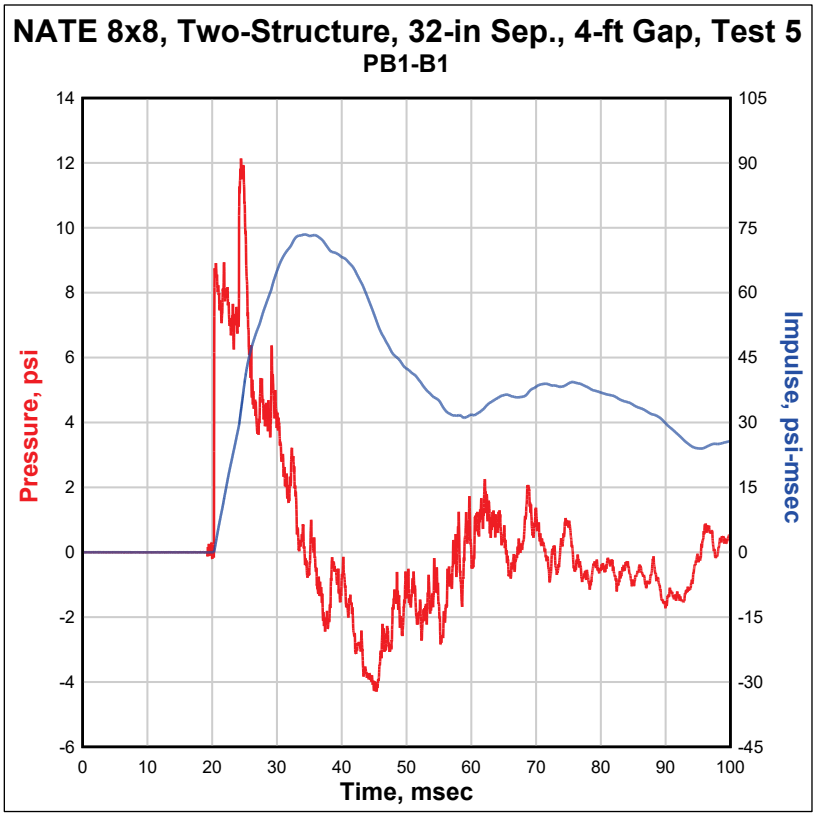

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
CP3
Pressure, psi
Impulse, psi-msec
Time, msec
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80
90
100

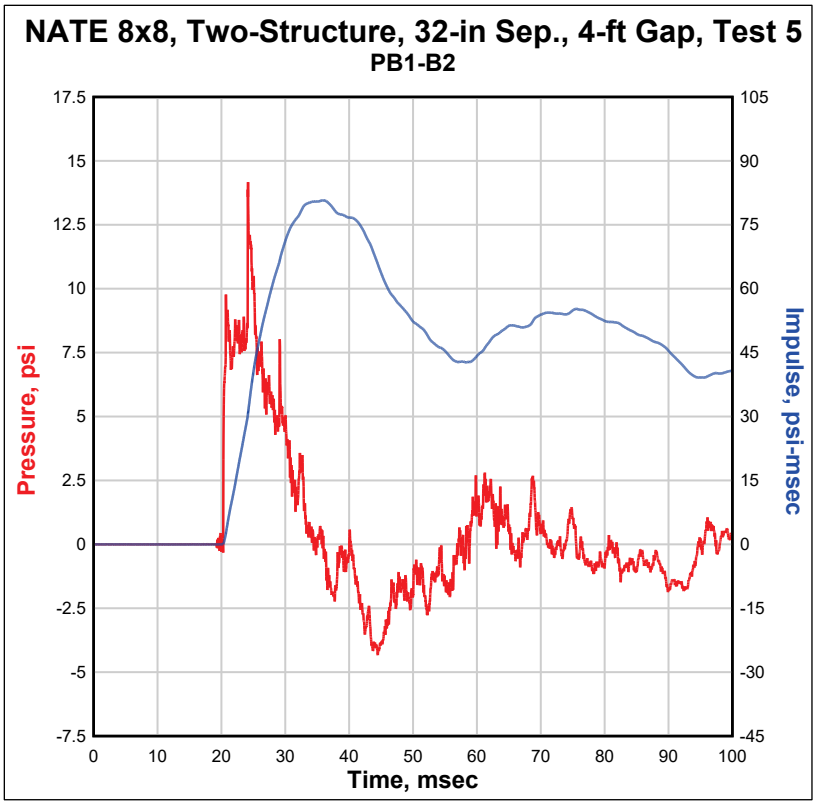

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
CP5
Pressure, psi
Impulse, psi-msec
Time, msec
18
16
14
12
10
8
6
4
2
0
-2
72
64
56
48
40
32
24
16
8
0
-8
0
10
20
30
40
50
60
70
80
90
100

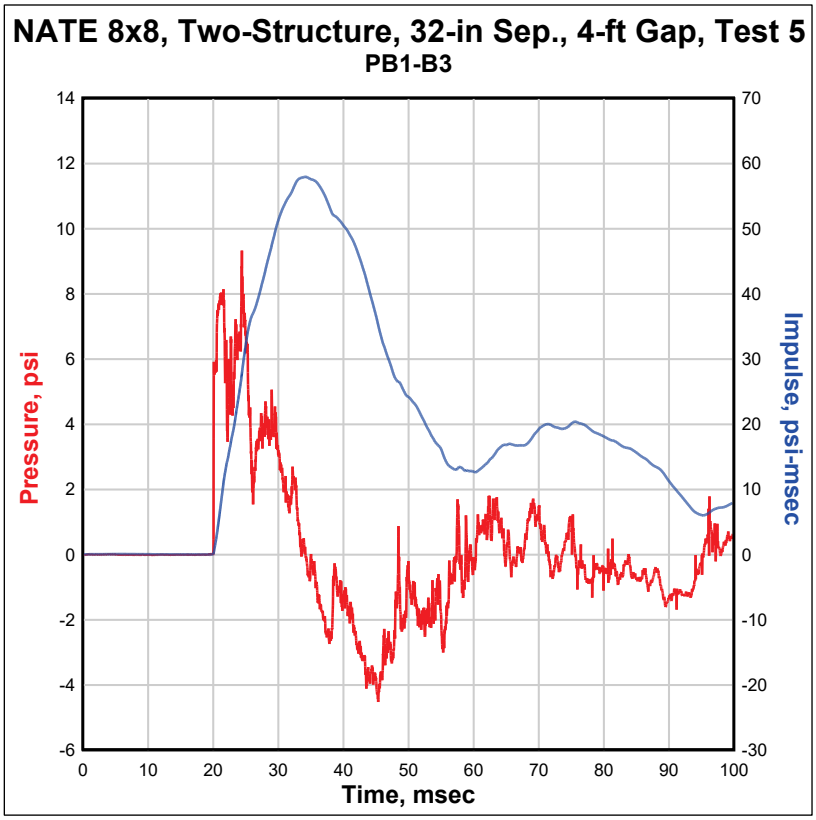

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
CP9
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

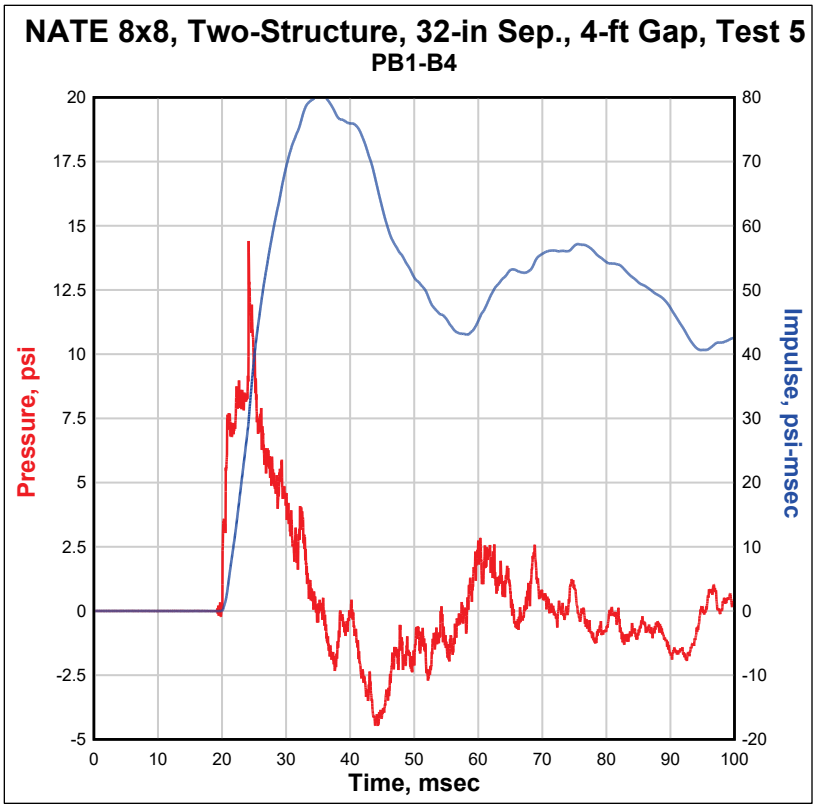

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
G1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

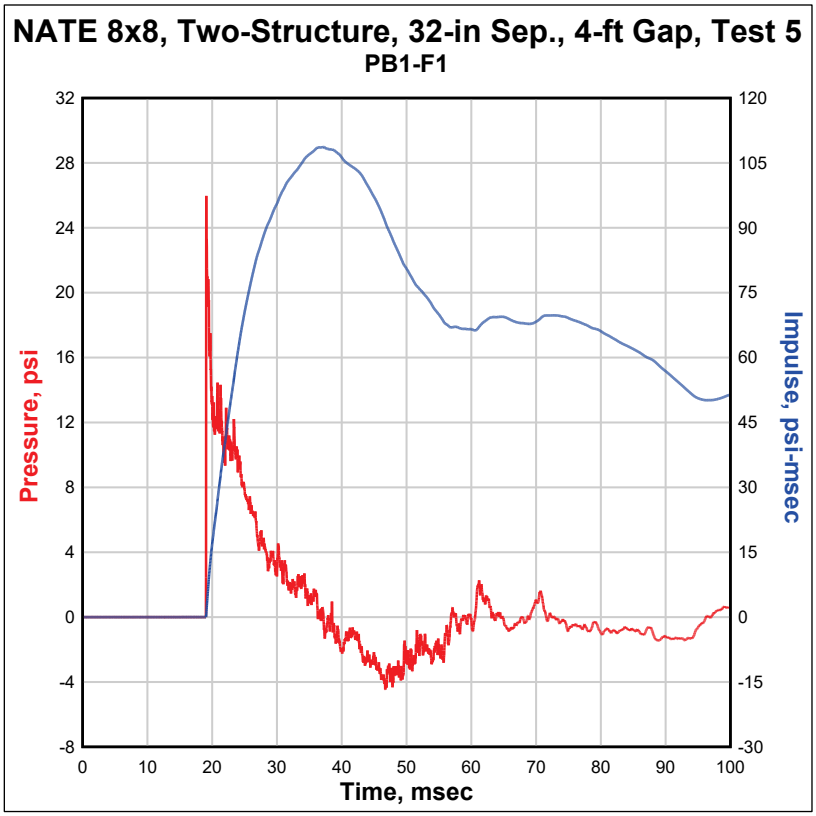

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
G2
Pressure, psi
Impulse, psi-msec
Time, msec
12
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
64
56
48
40
32
24
16
8
0
-8
-16
0
10
20
30
40
50
60
70
80
90
100

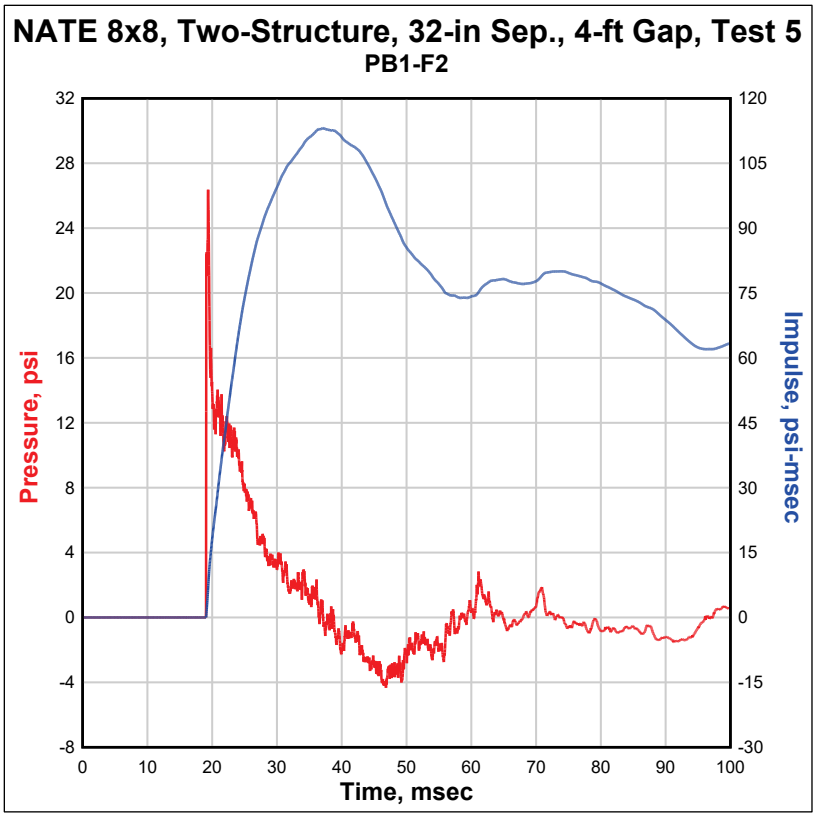

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-B1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

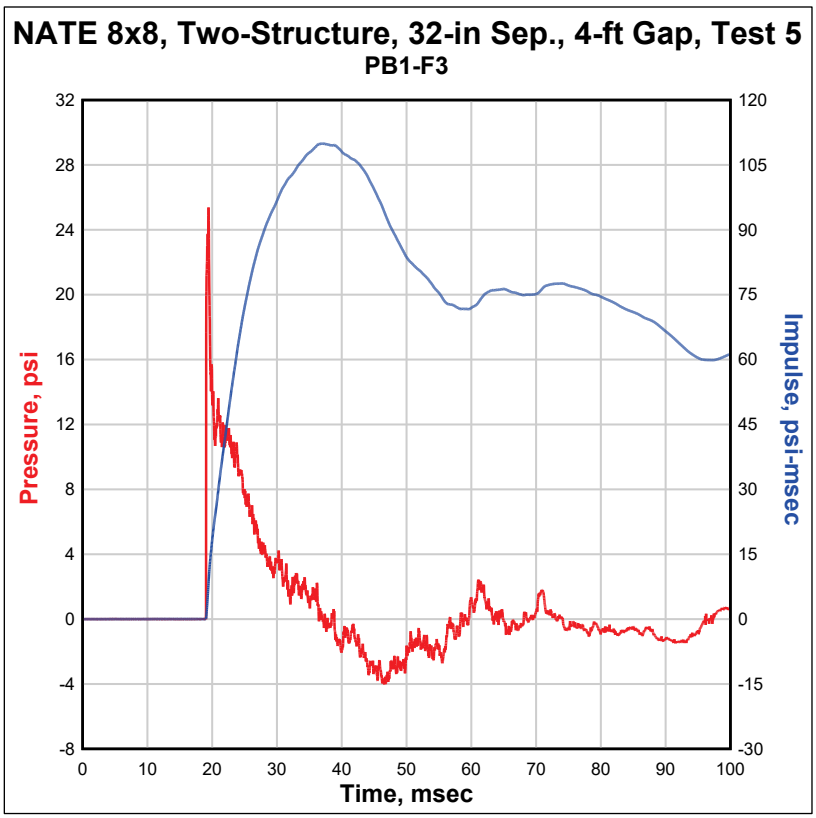

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-B2
Pressure, psi
Impulse, psi-msec
Time, msec
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100

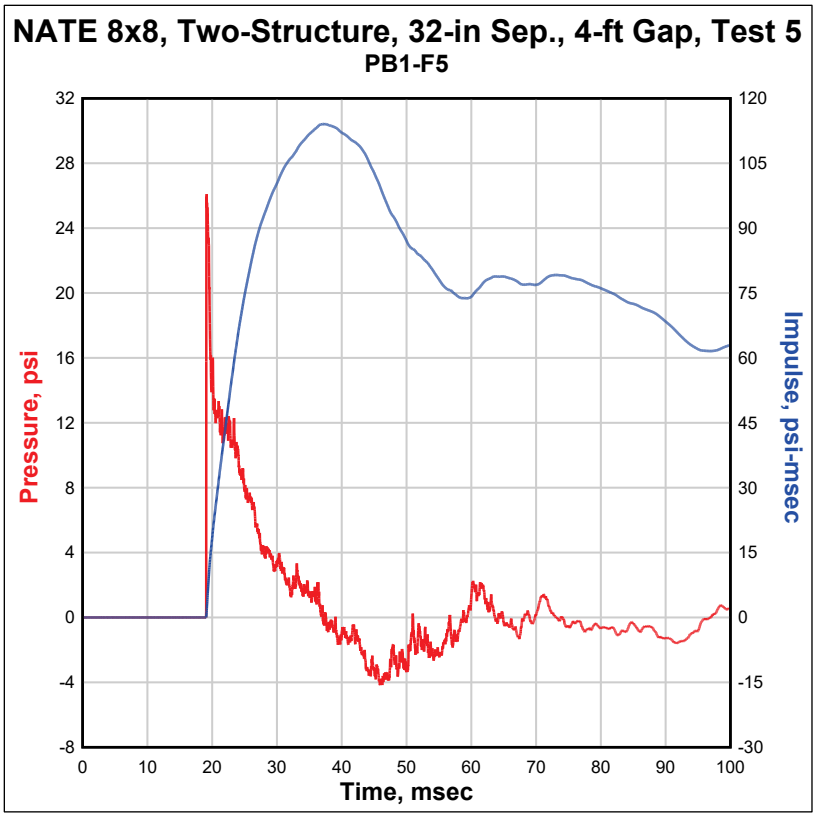

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-B3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100

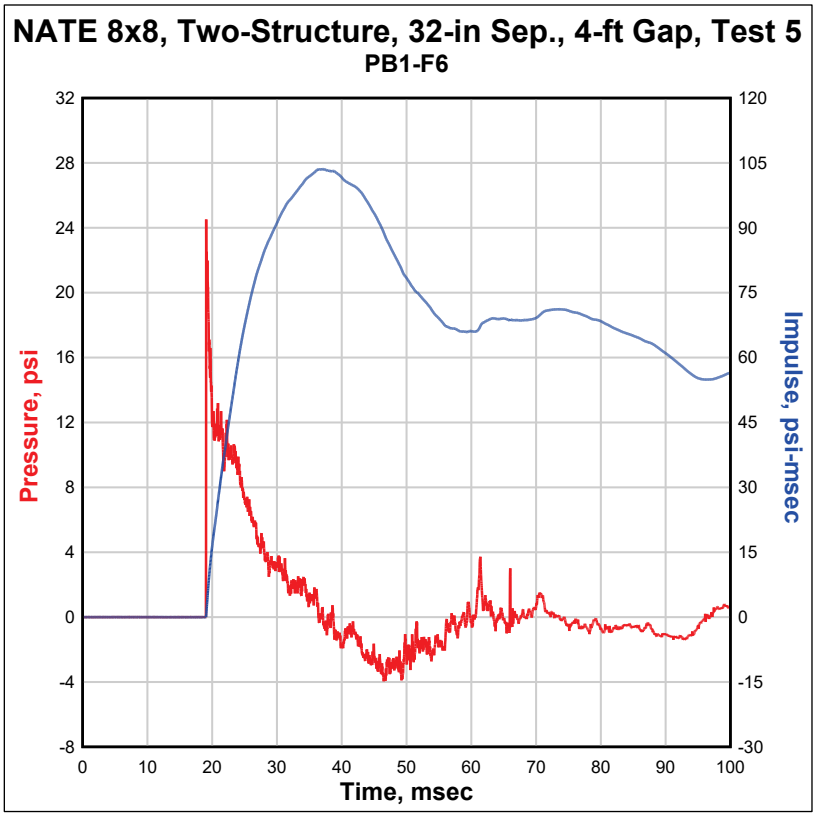

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-B4
Pressure, psi
Impulse, psi-msec
Time, msec
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

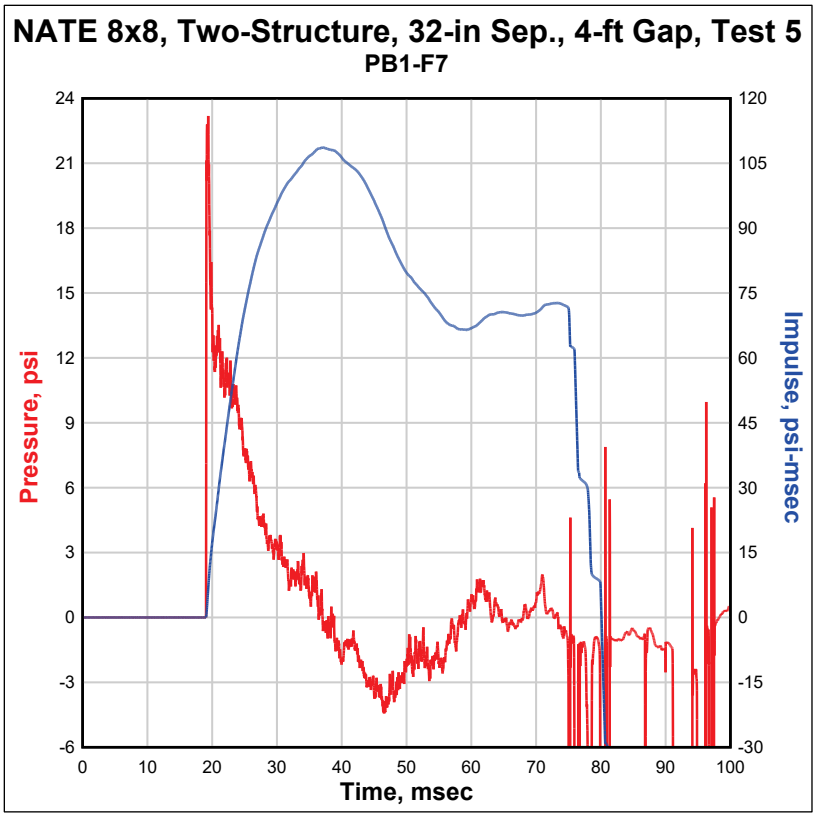

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F1
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

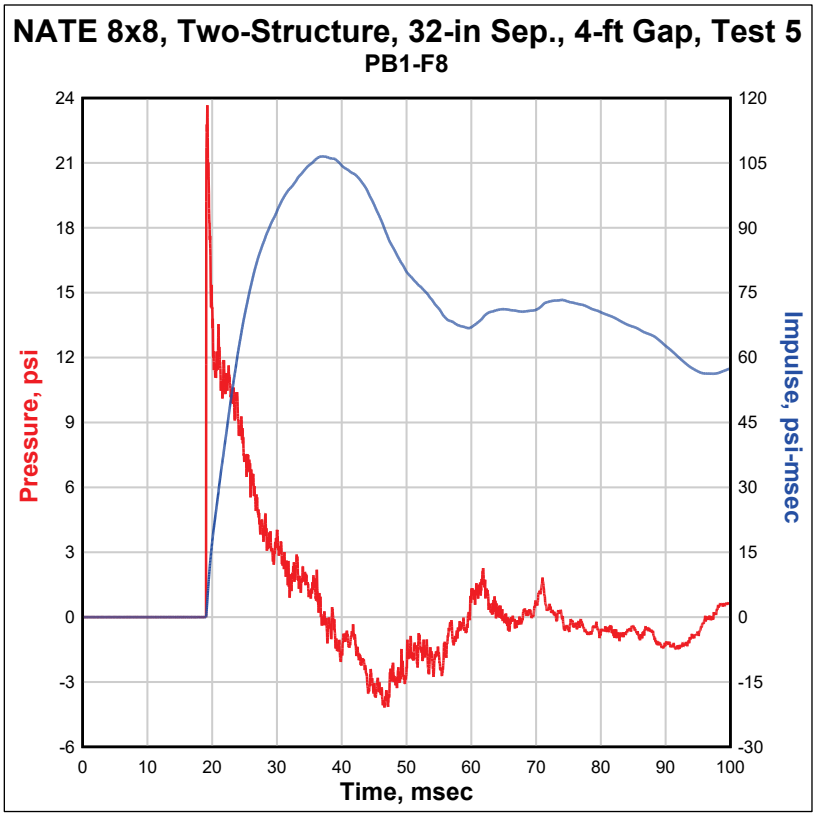

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F2
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

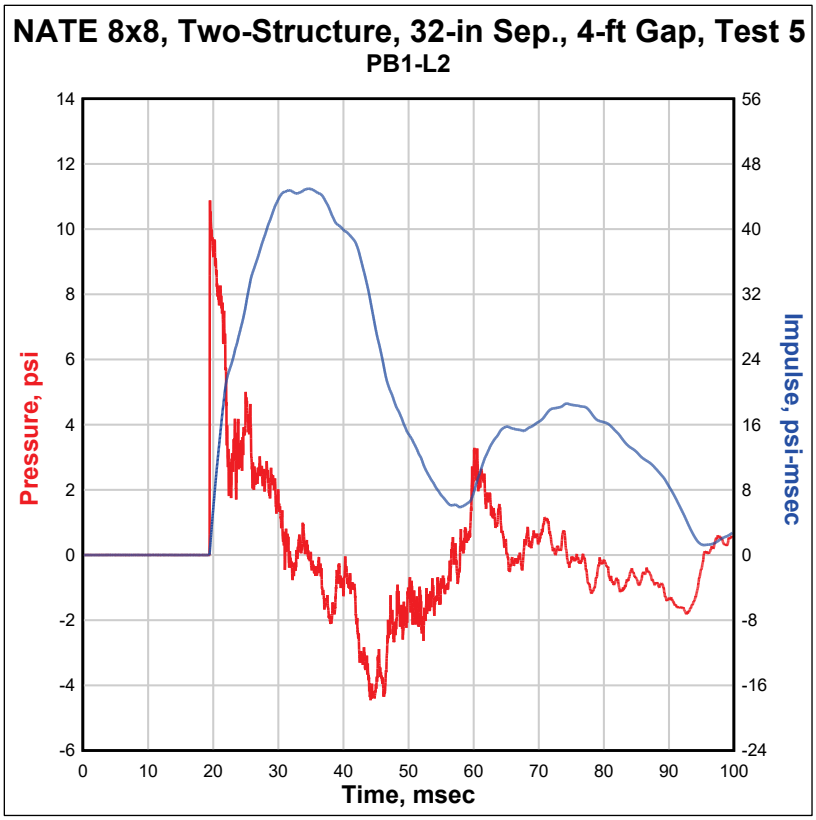

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F3
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

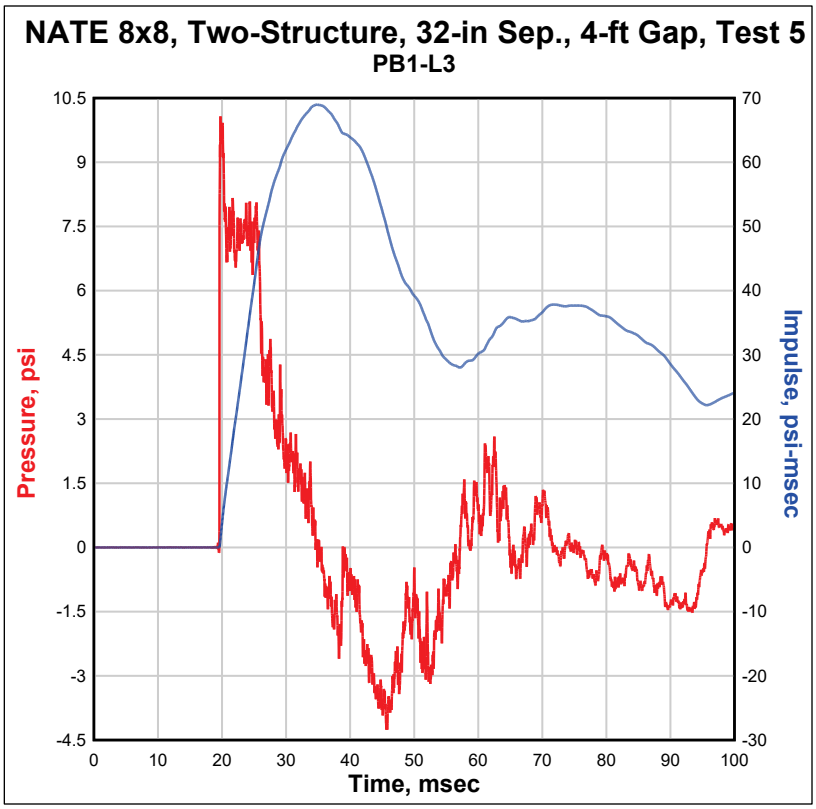

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F5
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

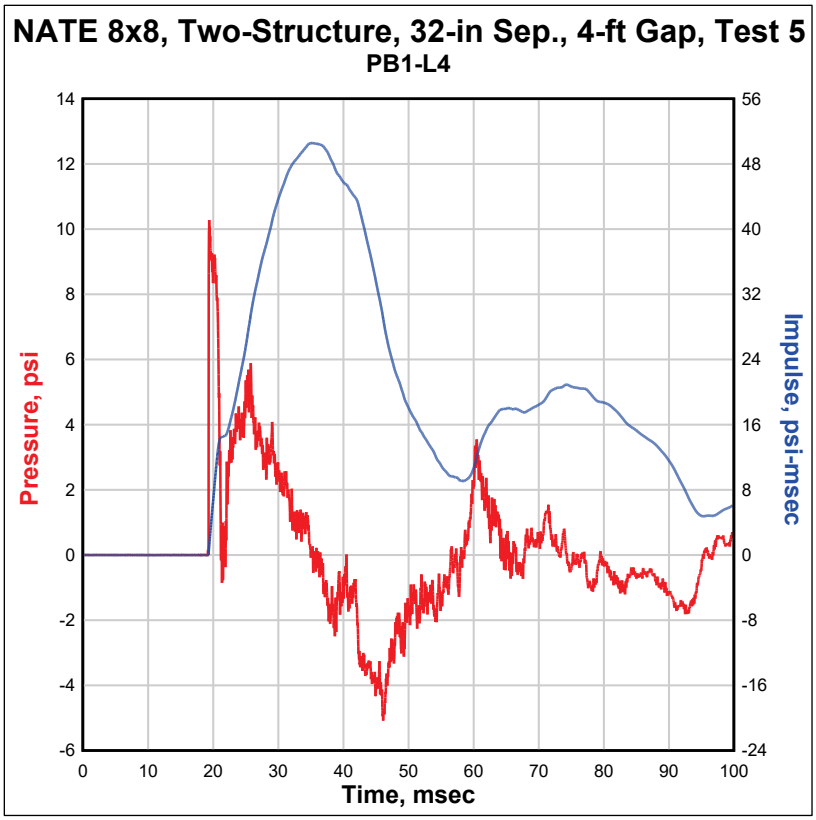

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F6
Pressure, psi
Impulse, psi-msec
Time, msec
32
28
24
20
16
12
8
4
0
-4
-8
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

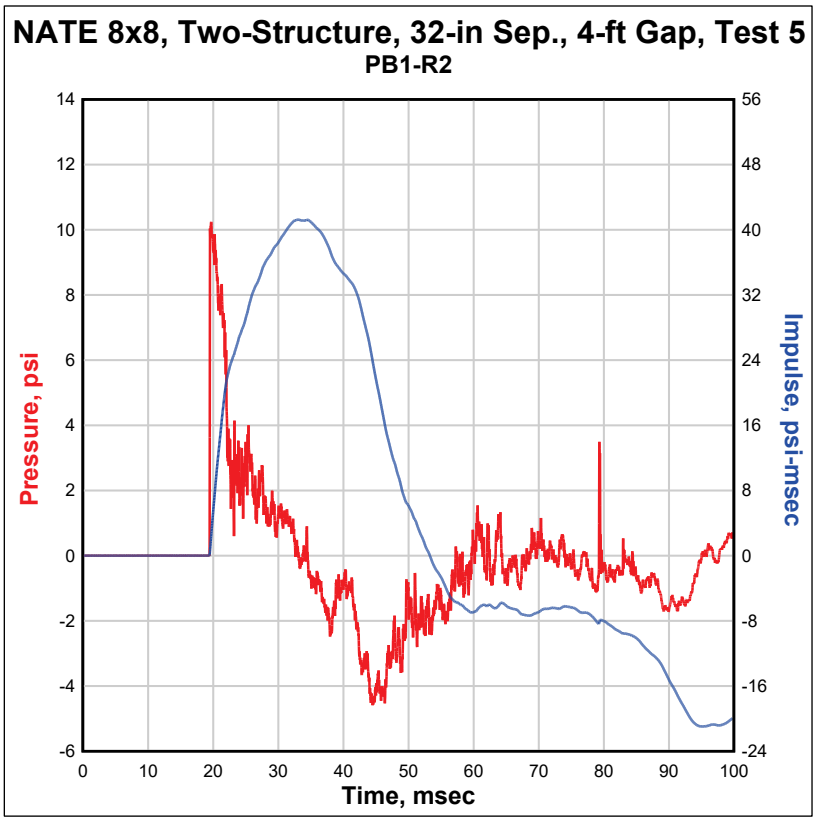

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F7
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

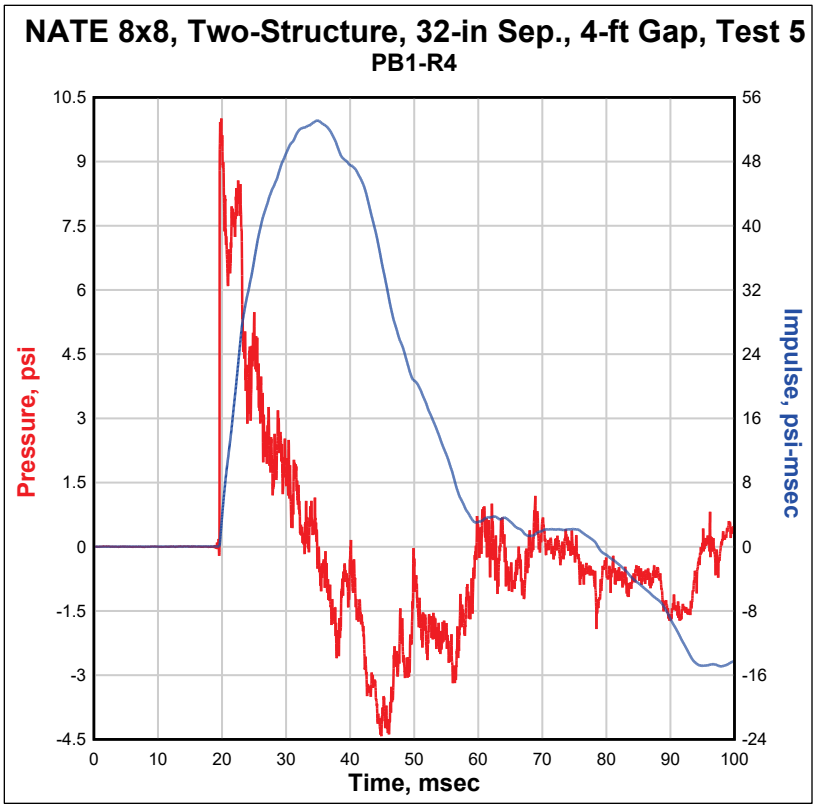

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-F8
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
9
6
3
0
-3
-6
120
105
90
75
60
45
30
15
0
-15
-30
0
10
20
30
40
50
60
70
80
90
100

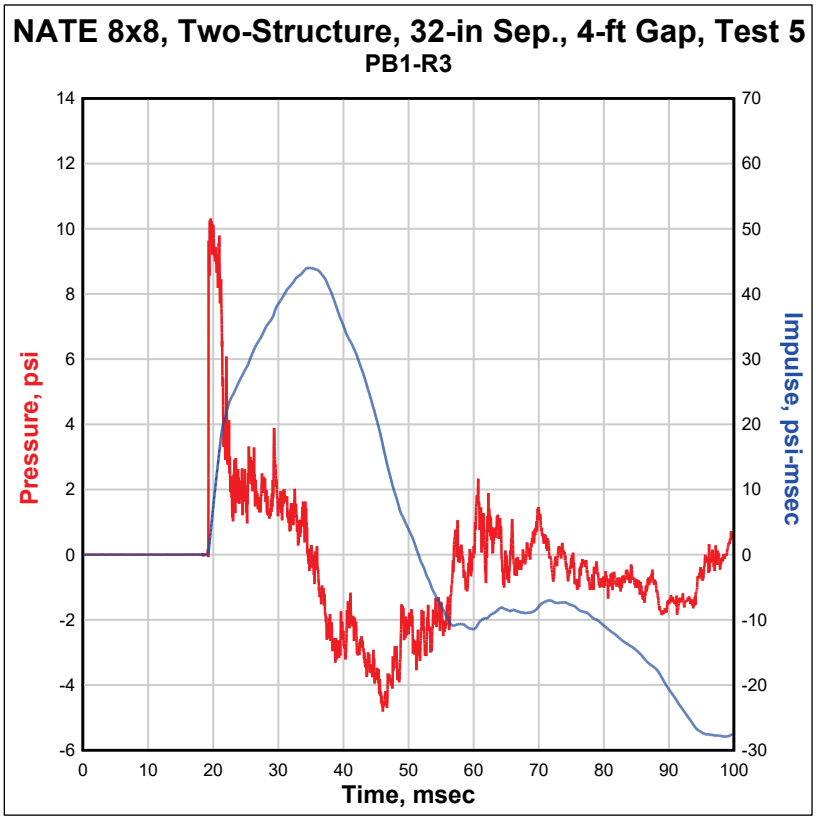

NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-L2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-L3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-L4
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-R2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-R4
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-R3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
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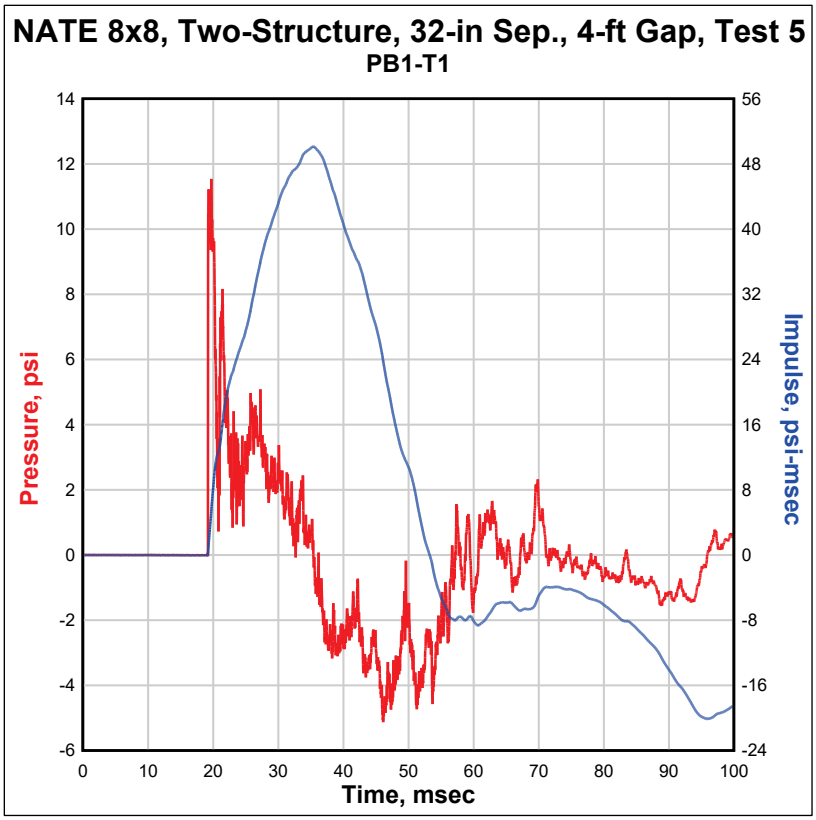
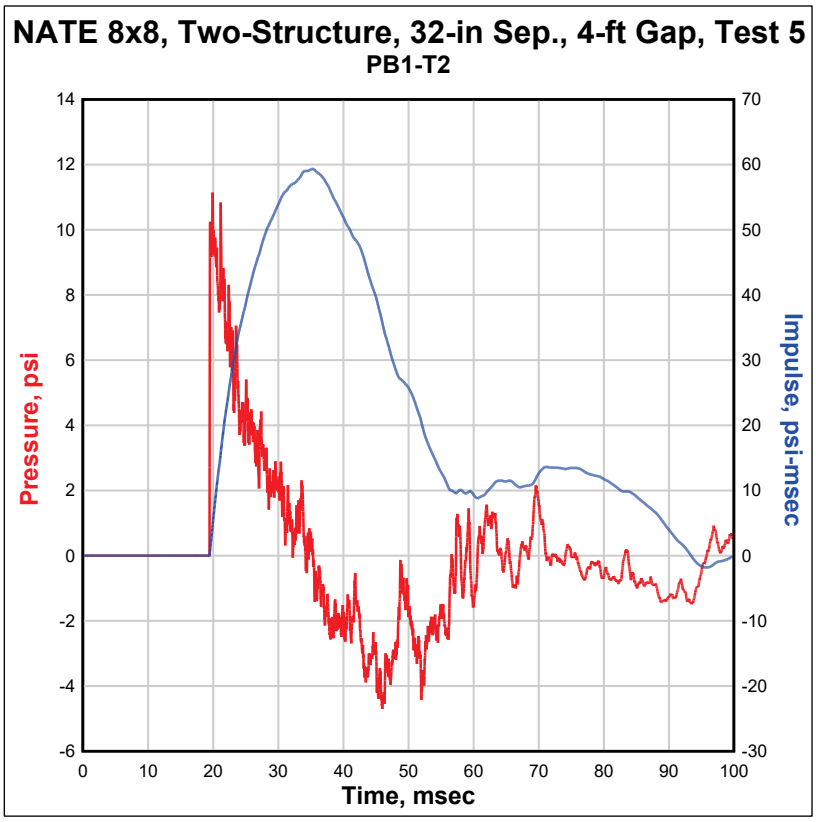
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-T1
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-T2
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
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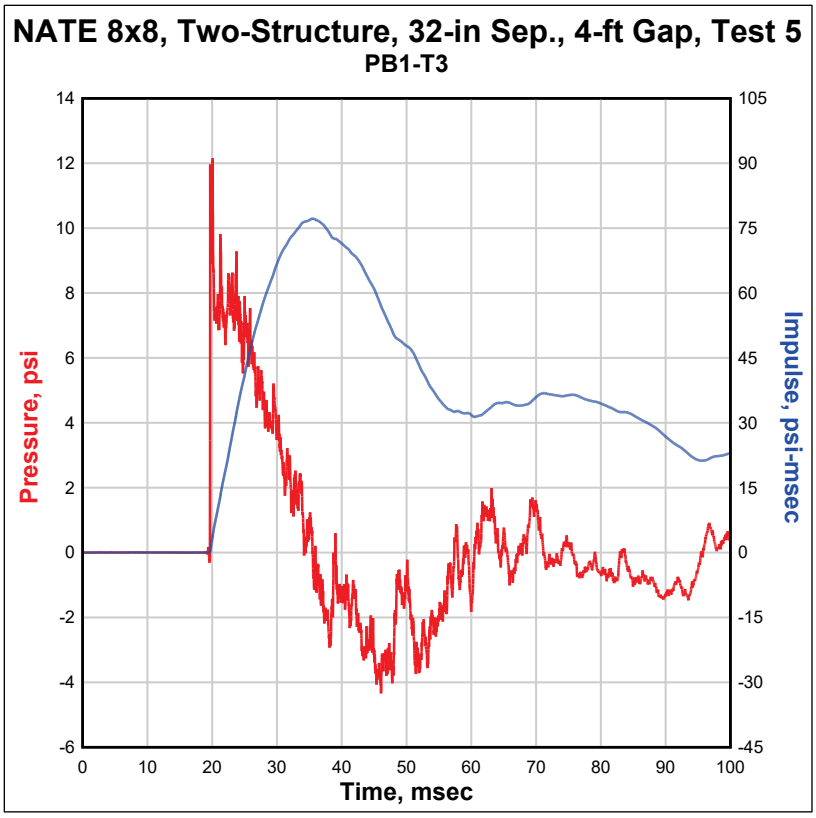
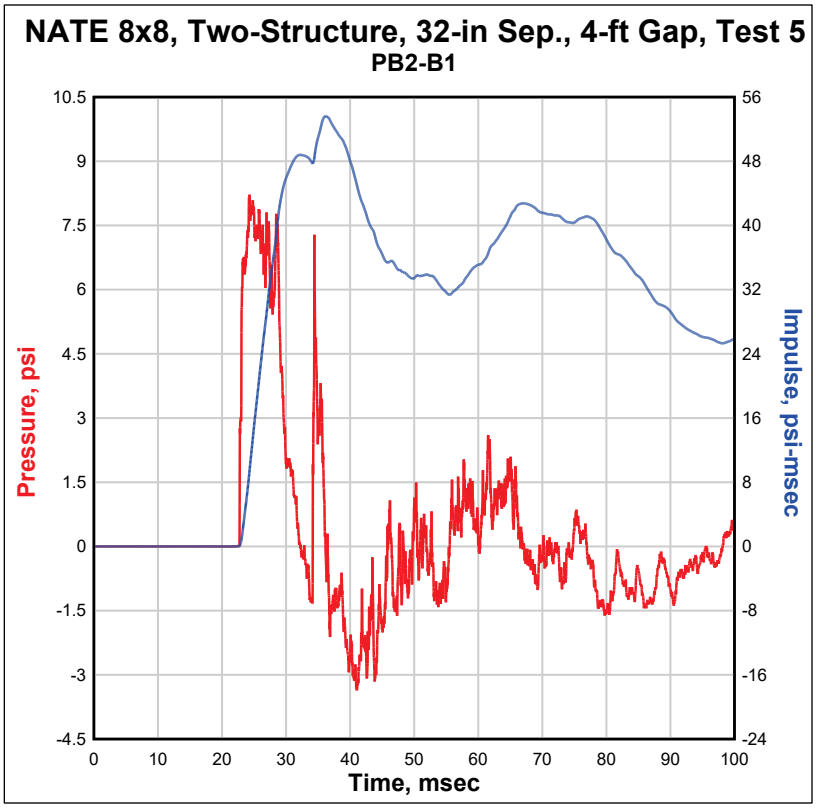
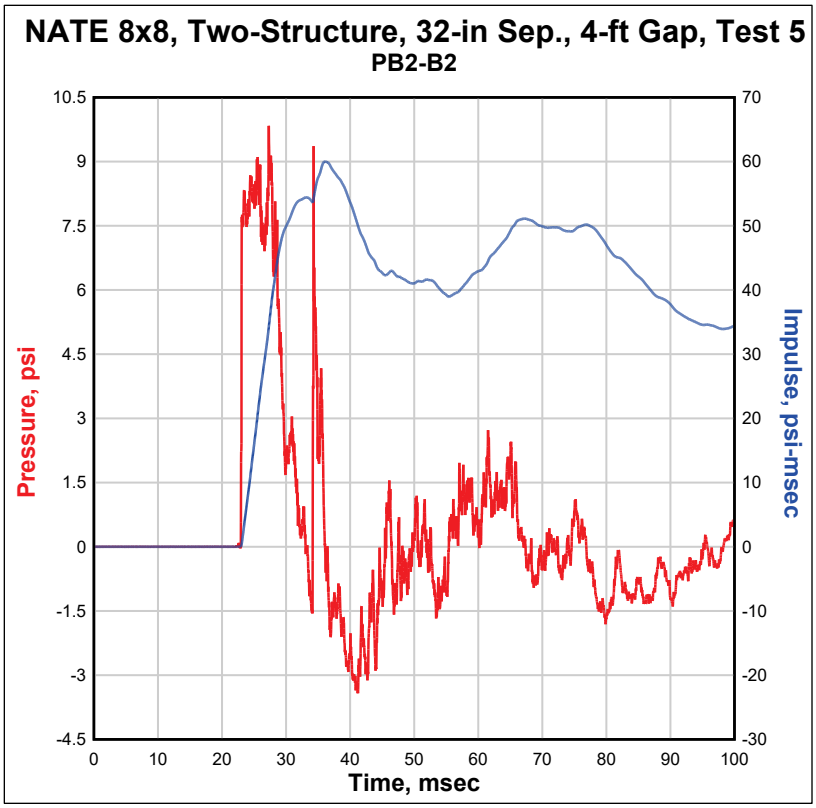
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB1-T3
Pressure, psi
Impulse, psi-msec
Time, msec
14
12
10
8
6
4
2
0
-2
-4
-6
105
90
75
60
45
30
15
0
-15
-30
-45
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB2-B1
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
56
48
40
32
24
16
8
0
-8
-16
-24
0
10
20
30
40
50
60
70
80
90
100


NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB2-B2
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
0
-1.5
-3
-4.5
70
60
50
40
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
80
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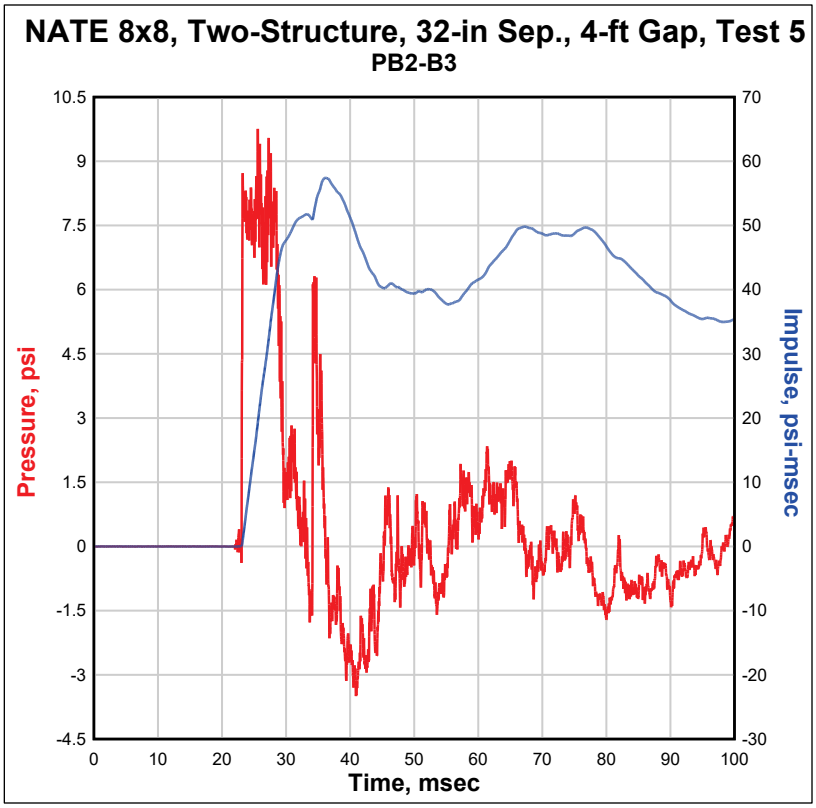
NATE 8x8, Two-Structure, 32-in Sep., 4-ft Gap, Test 5
PB2-B3
Pressure, psi
Impulse, psi-msec
Time, msec
10.5
9
7.5
6
4.5
3
1.5
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-3
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70
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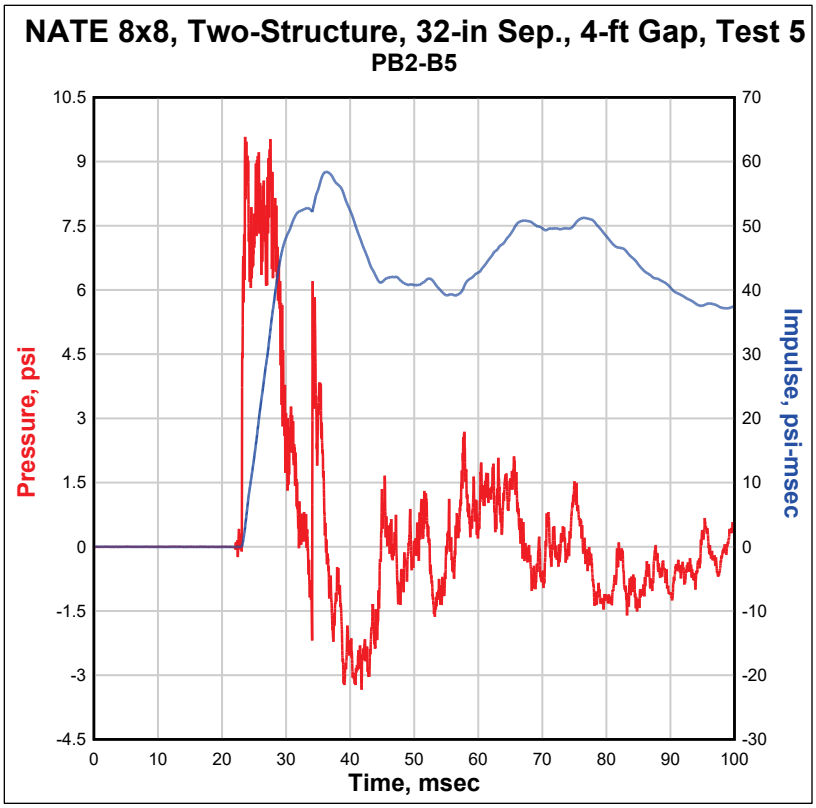
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Impulse, psi-msec
Time, msec
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6
4.5
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1.5
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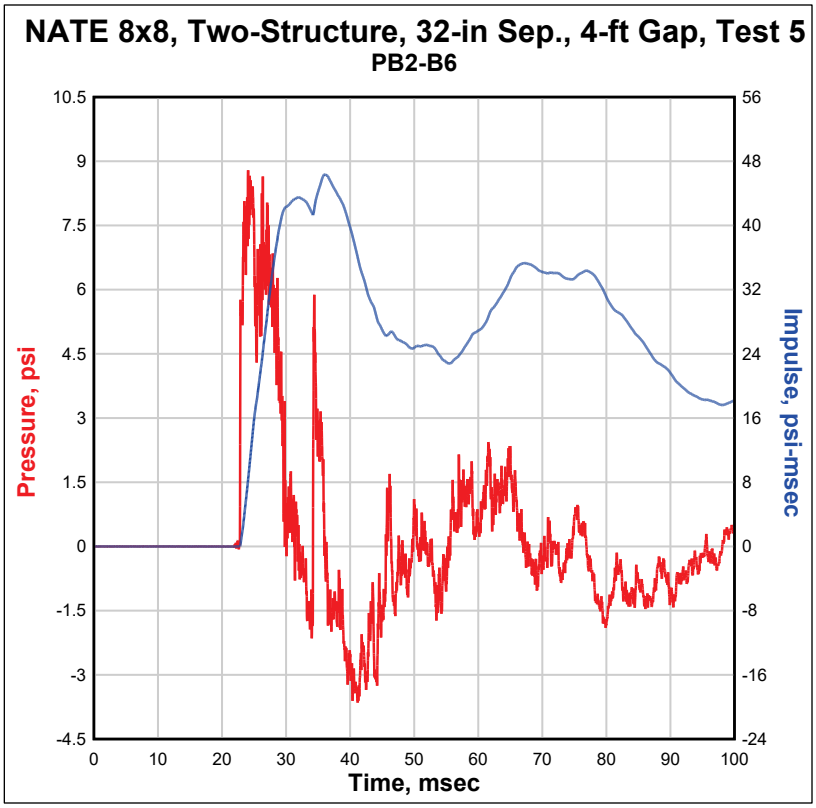
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Impulse, psi-msec
Time, msec
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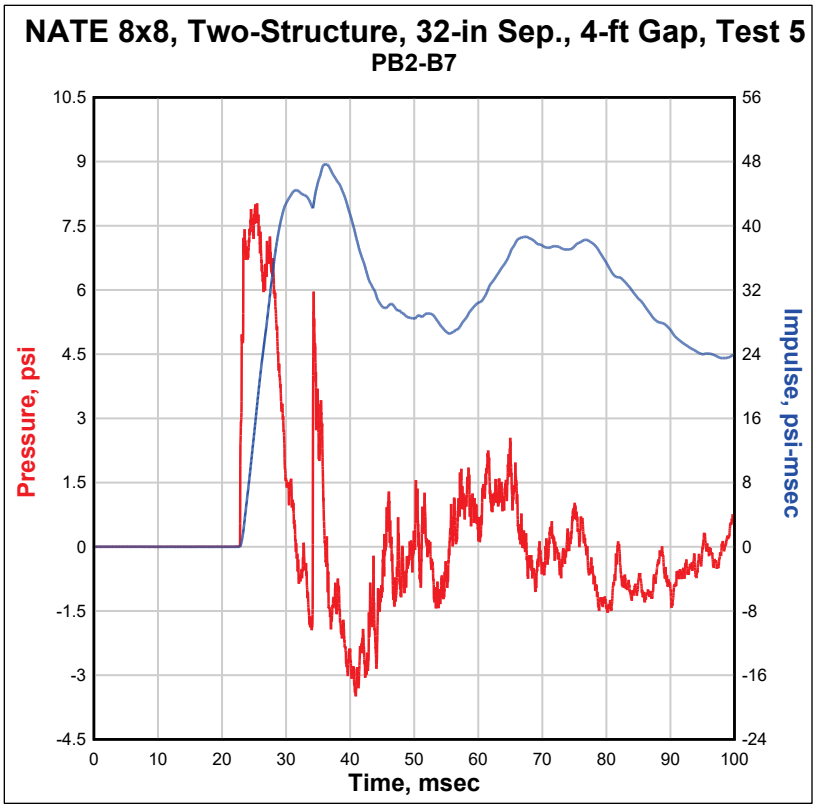
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Impulse, psi-msec
Time, msec
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48
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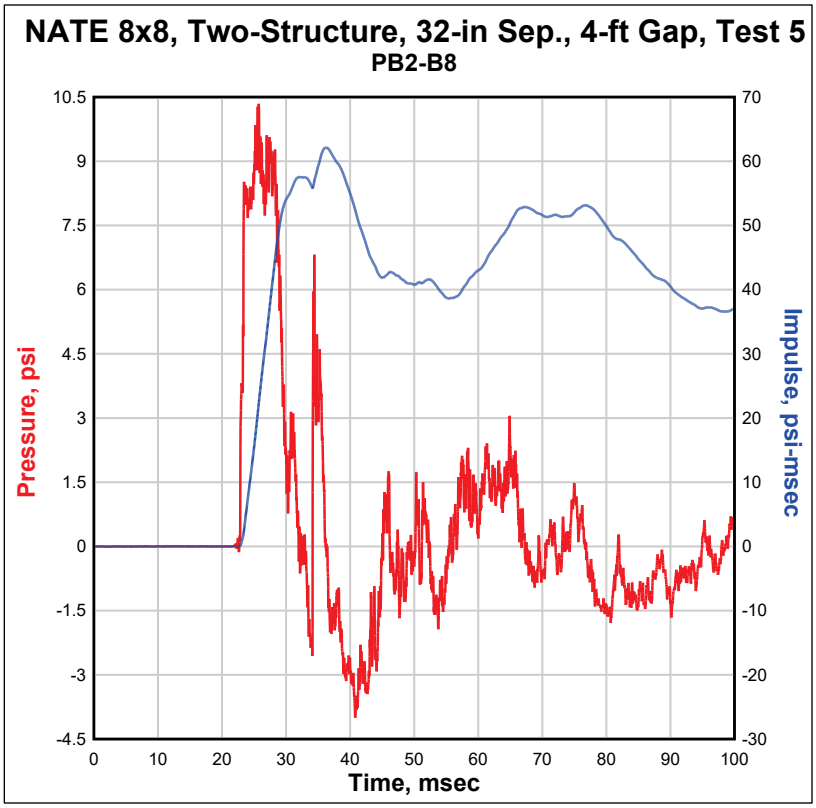
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Impulse, psi-msec
Time, msec
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4.5
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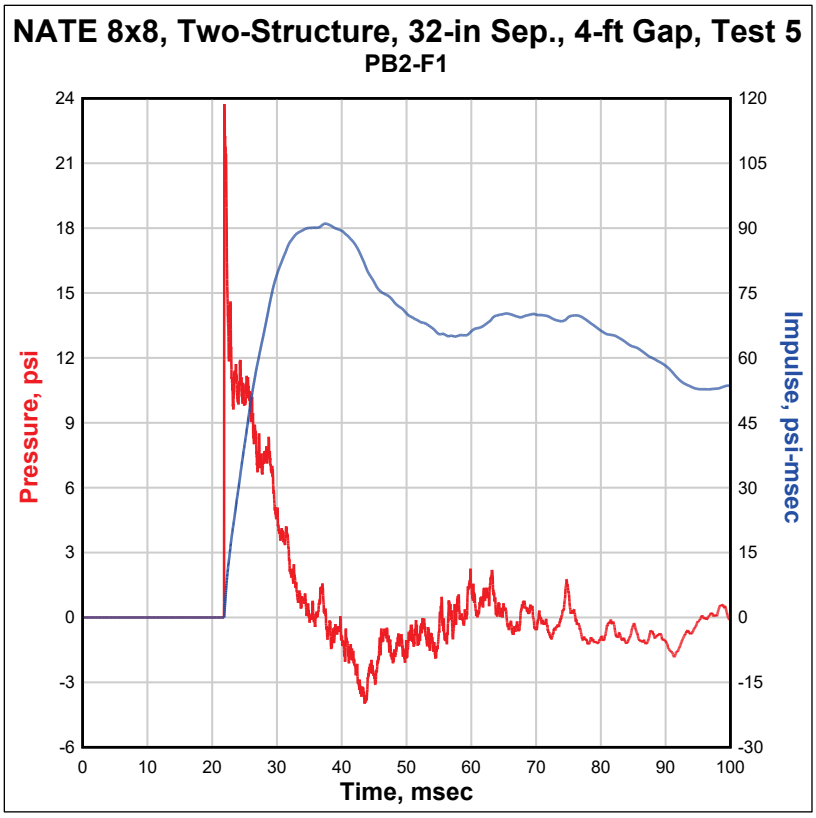
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PB2-F1
Pressure, psi
Impulse, psi-msec
Time, msec
24
21
18
15
12
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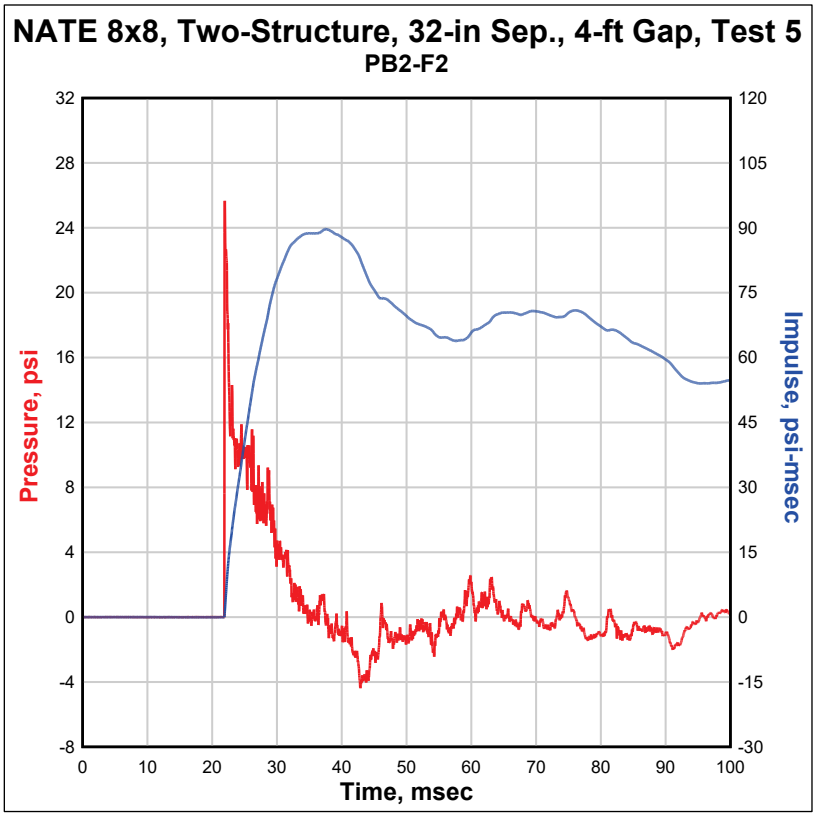
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Pressure, psi
Impulse, psi-msec
Time, msec
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28
24
20
16
12
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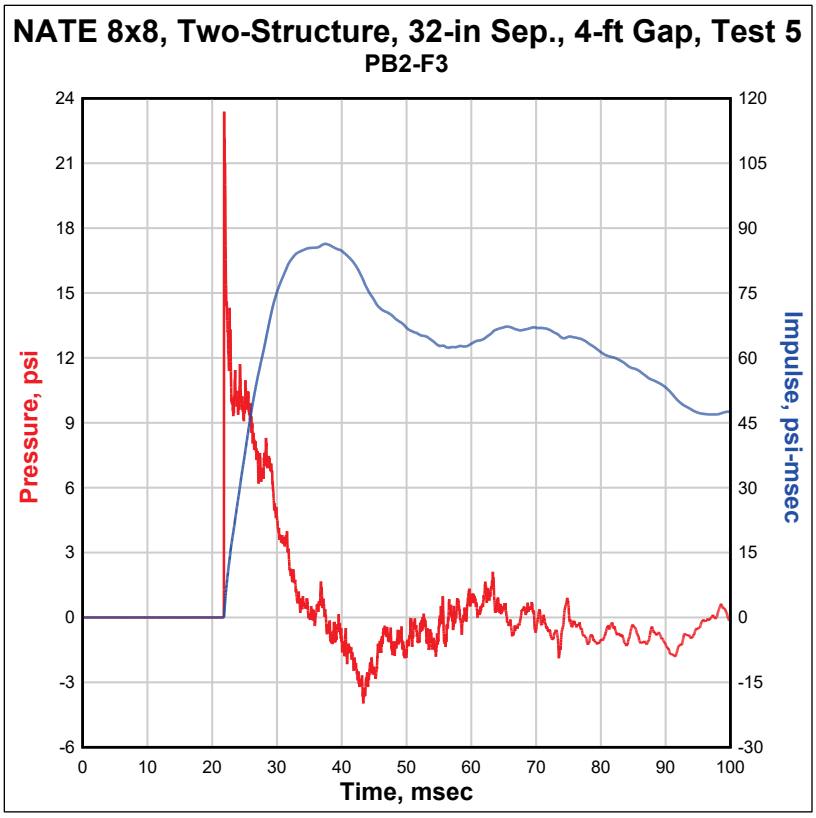
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Pressure, psi
Impulse, psi-msec
Time, msec
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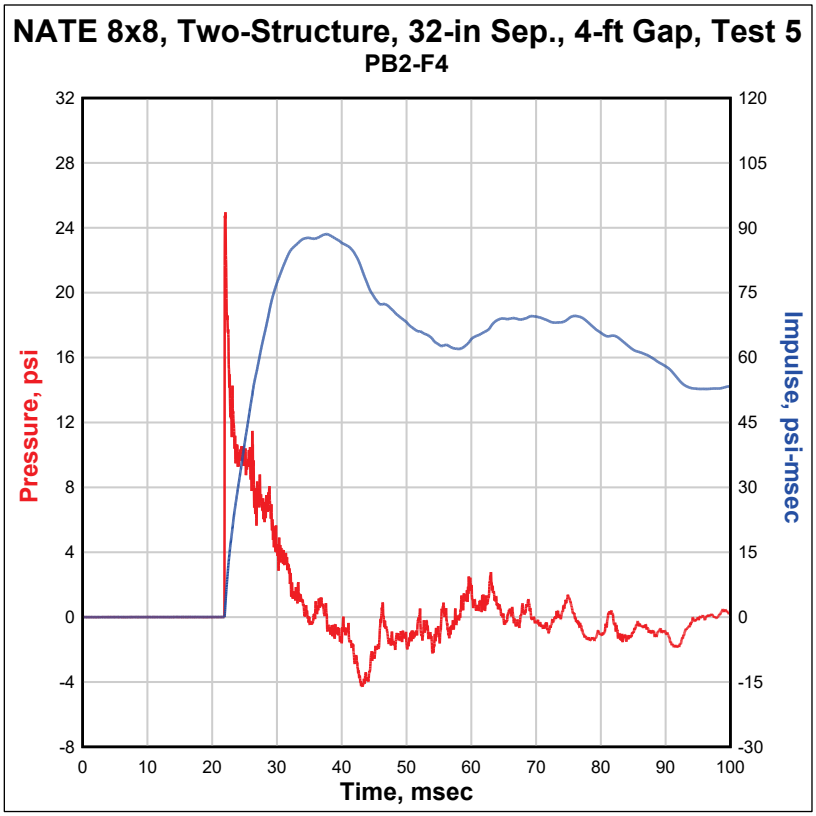
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Impulse, psi-msec
Time, msec
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-4
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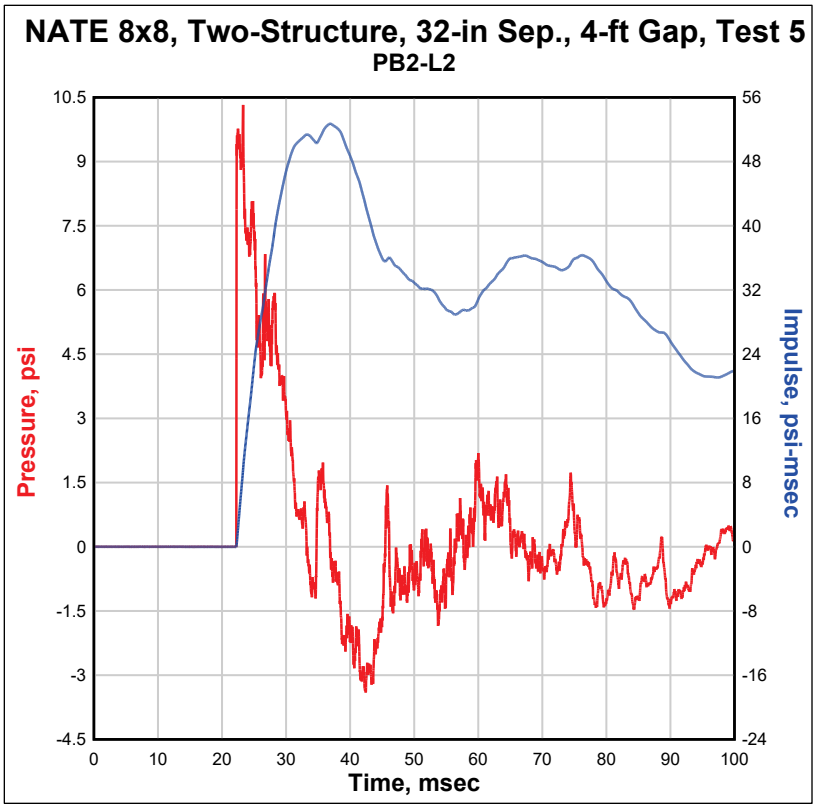
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Impulse, psi-msec
Time, msec
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6
4.5
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-1.5
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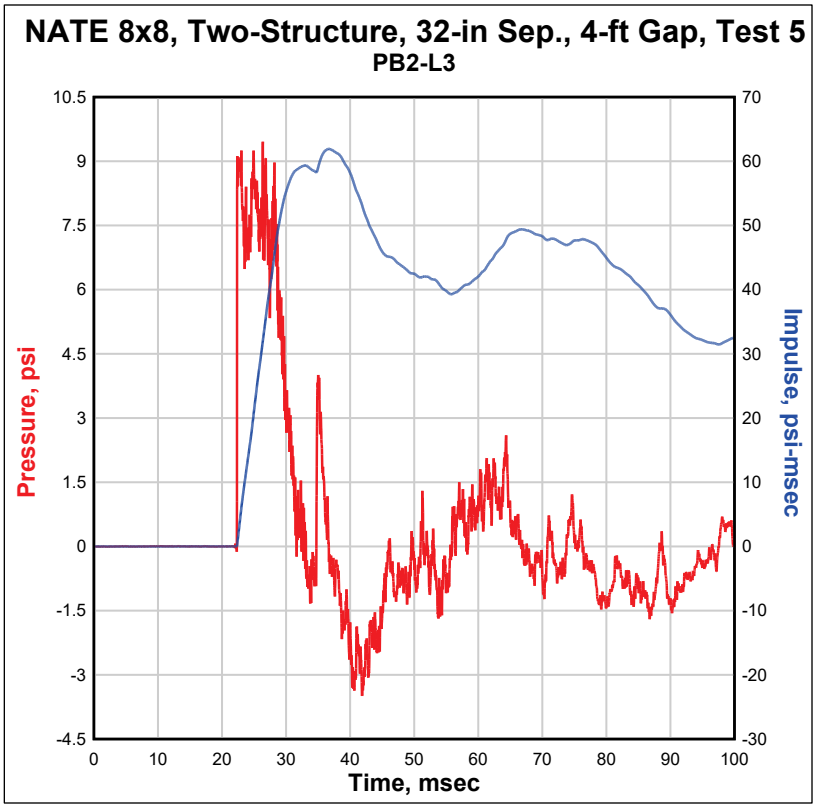
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Impulse, psi-msec
Time, msec
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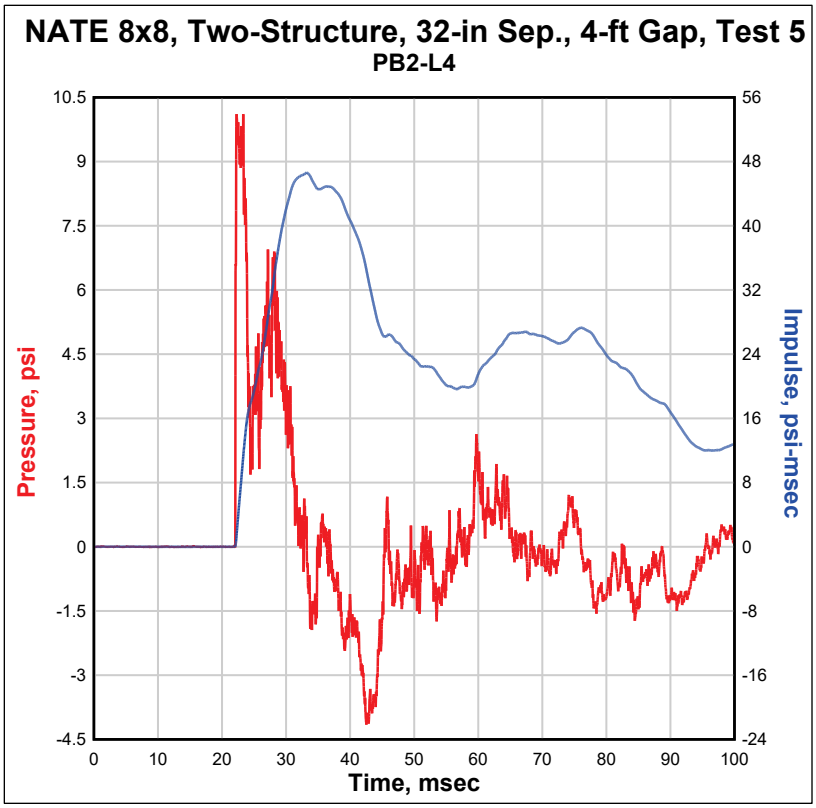
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Impulse, psi-msec
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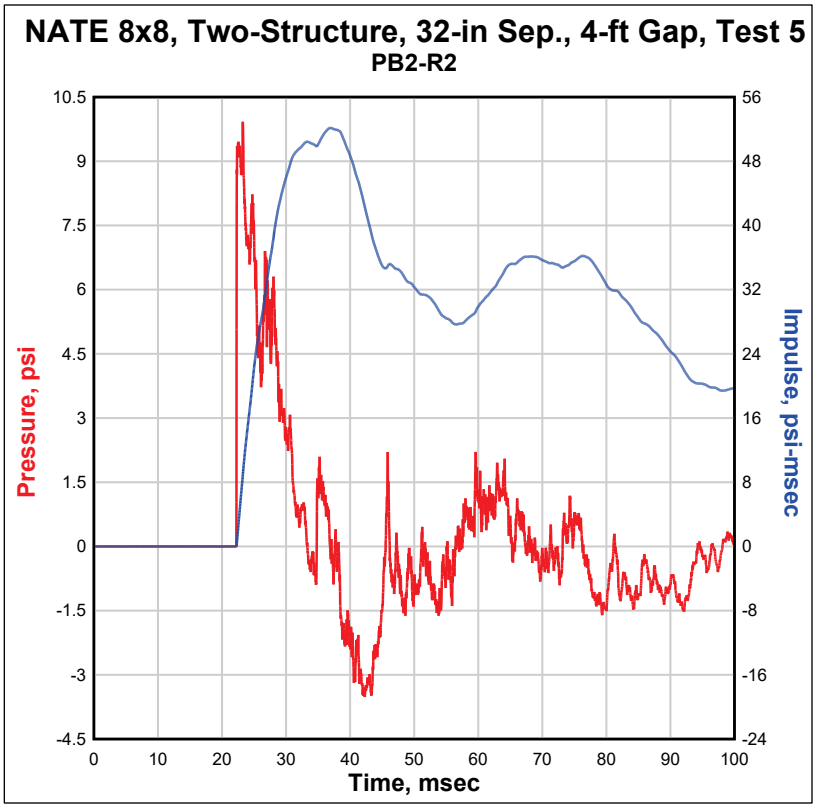
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Impulse, psi-msec
Time, msec
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7.5
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4.5
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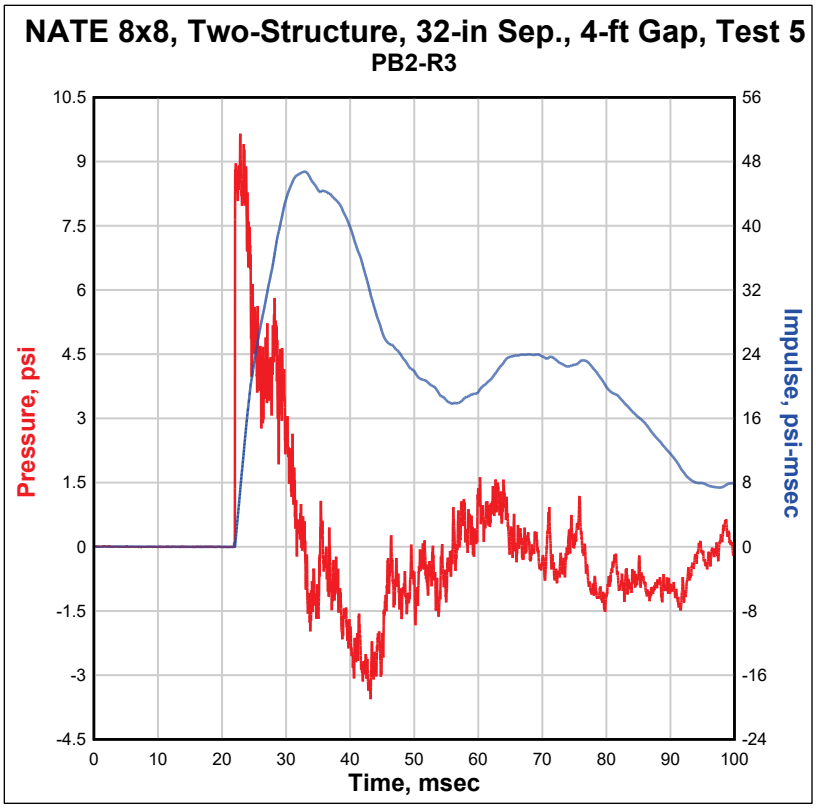
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Impulse, psi-msec
Time, msec
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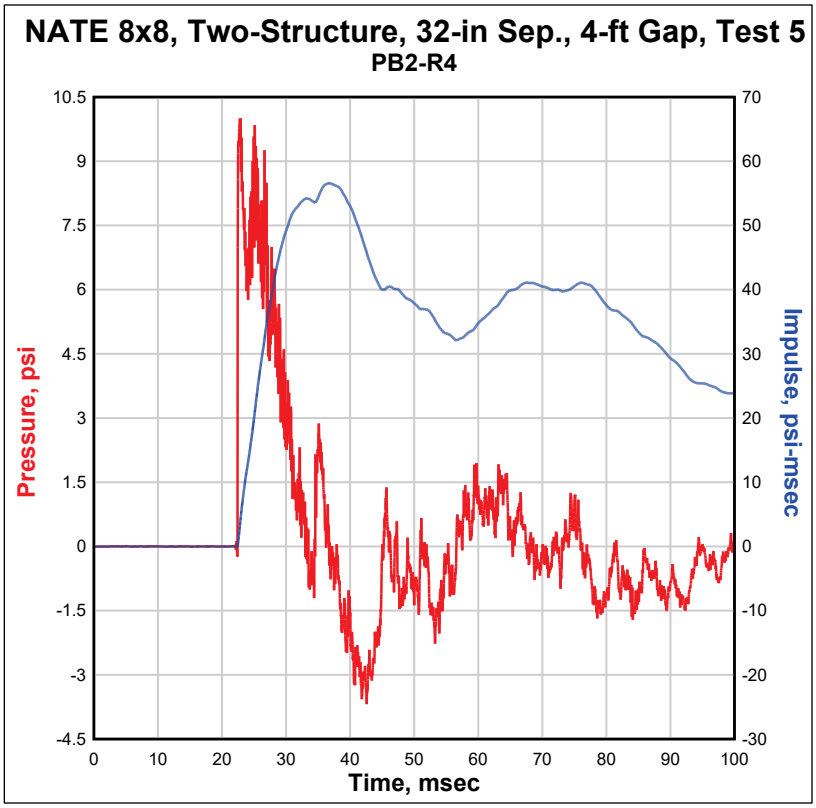
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Impulse, psi-msec
Time, msec
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4.5
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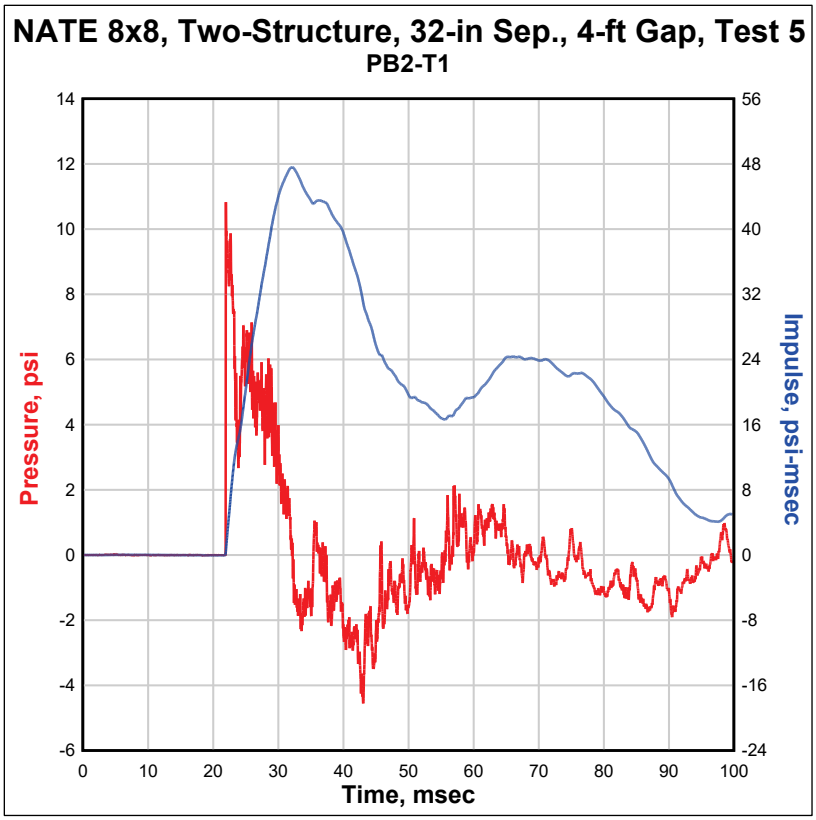
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Pressure, psi
Impulse, psi-msec
Time, msec
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10
8
6
4
2
0
-2
-4
-6
56
48
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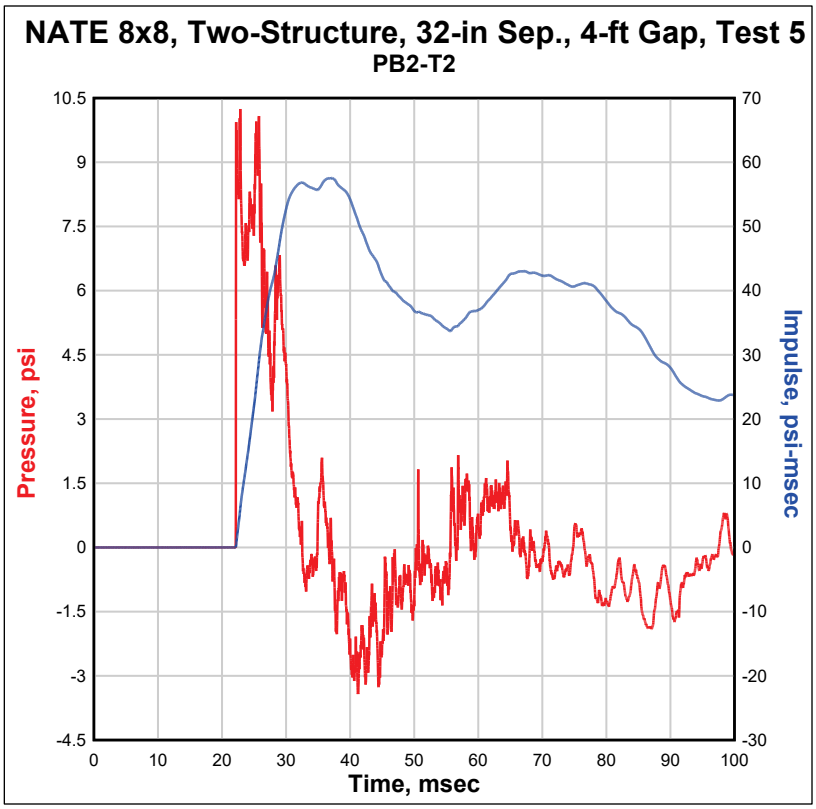
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Impulse, psi-msec
Time, msec
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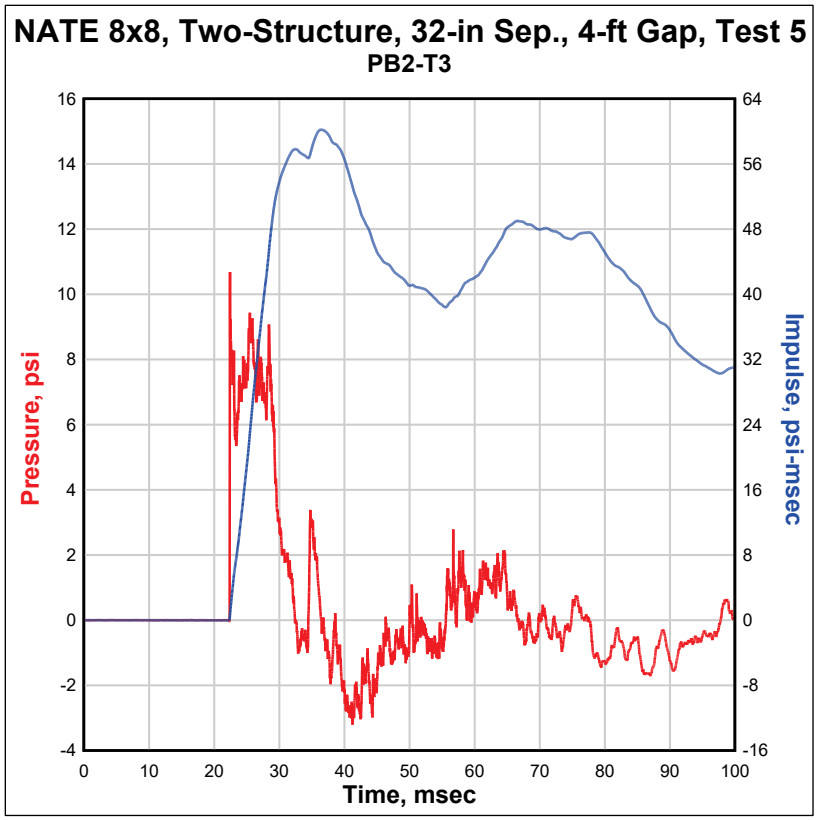
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Impulse, psi-msec
Time, msec
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Blast Load Simulator Experiments for Computational Model Validation: Report 5

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**14. ABSTRACT**

The Department of Defense (DoD) needs the capability to accurately predict airblast environments produced by explosive detonations and their interaction with geometrically complex objects that create complex flow fields, such as buildings, bridges, dams, etc. First-principles computer codes are typically used to generate high-fidelity simulations of these explosive events and their effects. These codes are continuously improving, yet still require validation against experimental data to establish confidence in the results produced by simulations. This report describes two sets of replicate experiments in which two steel box-type structures were installed in a Blast Load Simulator (BLS) with varying spacing between them and subjected to a simulated blast loading to provide pressure-time data at multiple locations on the surfaces of the structures. The BLS is a highly tunable, compressed-gas-driven, closed-end shock tube designed to simulate blast waveforms for explosive yields up to 20,000 lb of TNT equivalent at a peak reflected pressure up to 80 psi and a peak reflected impulse up to 1,100 psi-msec. Pressure and impulse waveforms are presented, and comparisons are made among the replicated experiments to evaluate repeatability. The uncertainty in the experimental pressures and impulses was evaluated by computing 95% confidence intervals on the results.

**15. SUBJECT TERMS**

Blast effect – Testing
Detonation waves
Pressure gages
Airblast
Blast Load Simulator
Verification and Validation
Shock (Mechanics)
Shock tubes
Scientific apparatus and instruments

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