



ARA-TR-04-16496-1

Explosive Test for the Evaluation of CPFilms, Inc. Window Systems

(Quick-Look Report)

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Prepared for:

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PREFACE

Applied Research Associates, Inc. (ARA) conducted four high-explosive tests from September 20 - 21, 2004 to evaluate the glass fragment hazard mitigation characteristics of window systems developed by CPFilms, Inc. Four high-explosive tests were conducted with four windows evaluated in each test.

The tests were performed at the Energetic Materials Research and Testing Center (EMRTC) located in Socorro, New Mexico. The test site is jointly operated by the New Mexico Institute of Mining and Technology and Applied Research Associates, Inc.

The Security Engineering Group of ARA provided test structures, test design, test planning, and documentation of the results. Mr. James T. Brokaw was the principal investigator and the field test engineer for this effort. The ARA team assigned to this project included Mr. Kenneth W. Herrle and Mr. Ryan D. Wade. The Shock Physics Division and Rocky Mountain Division of ARA, under the direction of Mr. Donald Cole and Mr. Larry Brown, respectively, were responsible for test bed preparation, construction, test instrumentation, data collection, and test execution.

This work was sponsored by CPFilms, Inc. The support and effort provided by Mr. Andres A. Vasquez, CPFilms' point of contact, are greatly appreciated.

EXECUTIVE SUMMARY

In response to the heightened concern about terrorism, the US Government and private industry are developing and testing new technologies to mitigate hazards to people in the vicinity of a terrorist bombing. Propelled by the forces of a terrorist bomb, glass fragments cause serious injuries to large numbers.

The US General Services Administration (GSA) developed a comprehensive security criteria (GSA Security Criteria, October 8, 1997) that includes physical security, electronic security, and many other criteria for blast considerations. These criteria formed the basis for the Interagency Security Committee (ISC) Security Criteria (October 31, 2003). The GSA has indicated that manufacturers must test their window products against the criteria to evaluate the performance of these products in blast if they want to be considered for use in GSA buildings. Actual window designs are then performed with the GSA computer program **WINGARD** (Window Glazing Analysis Response and Design).

CPFilms commissioned ARA to perform open-air high-explosive tests from September 20 - 21, 2004. Four high-explosive tests were conducted with four windows evaluated in each test. The test used the GSA standard test protocol (GSA-TS01-2003) which will be included in the final report. The window systems were mounted in enclosed concrete reaction structures. The response of the window systems was captured with high-speed film and still photography. An exterior, high-speed camera and an exterior, normal-speed video camera were used to capture the view of the structures and the explosive detonation for the test. The reaction structures were instrumented with pressure gauges to measure the exterior reflected pressure on the specimens and the internal pressure in the structures.

The test charge was 600 lb of Ammonium Nitrate and Fuel Oil (ANFO), which is equivalent to 500 lb of TNT. The standoff distance to the test structures was 165 ft. The ANFO charge was hemispherical and was detonated at ground level.

The nominal total window size for the test was 48 inches wide by 66 inches high. The glass types used for the tests were both monolithic annealed glass (AG) and thermally tempered glass (TTG). The vision opening of the windows was measured to be 44 1/2 inches wide by 63 inches high. The windows were tested in typical commercial aluminum frames. The windows

were anchored to the test structure using 1/2-inch diameter Grade 5 steel bolts spaced at 6 inches on center around the window perimeter.

The ISC performance conditions for windows are presented graphically in the figure and described in the table below. The ISC approach compares potential hazards based on the type and location of glass fragments interior and exterior to the test cubicle. These criteria indirectly reflect the velocity (hence hazard level) of fragments based on their distance from the original window position.

The results of the test are documented in Tables 2 - 5 and Figures 2 - 17. As tested, all windows can be developed to provide a high level of protection or greater against the GSA Level C (ISC Medium) loading of 4 psi and 28 psi-msec. Quality control during installation is very important and could drastically affect window response. The CPFilms' window number designation for each window tested is provided in Table 6. A sketch of the Frame/lok[®] mechanical attachment system used in Test 1 and 2 is shown in Figure 35. A sketch of the Tremco Proglaze[®] SSG wet-glazed attachment system used in Test 3 and 4 is shown in Figure 36.

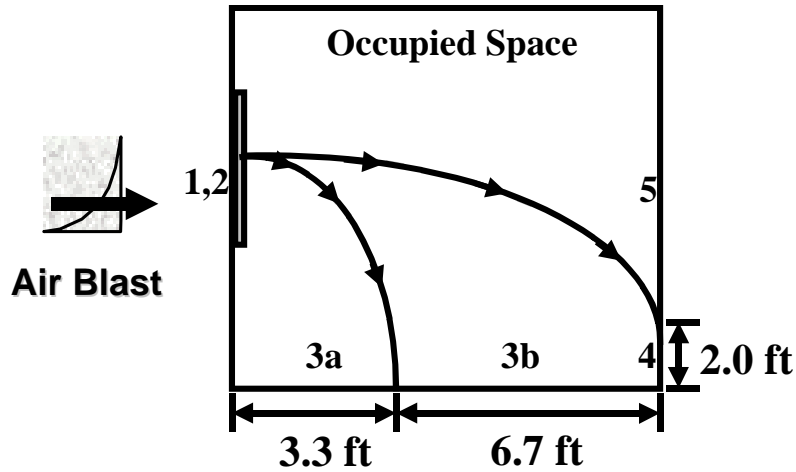


Figure 1. Glazing protection levels based on fragment impact locations.

Table 1. Glazing protection levels based on fragment impact locations.

Performance Condition	Protection Level	Hazard Level	Description of Window Glazing Response
1	Safe	None	Glazing does not break. No visible damage to glazing or frame.
2	Very High	None	Glazing cracks but is retained by the frame. Dusting or very small fragments near sill or on floor acceptable.
3a	High	Very Low	Glazing cracks. Fragments enter space and land on floor no further than 3.3 ft. from the window.
3b	High	Low	Glazing cracks. Fragments enter space and land on floor no further than 10 ft. from the window.
4	Medium	Medium	Glazing cracks. Fragments enter space and land on floor and impact a vertical witness panel at a distance of no more than 10 ft. from the window at a height no greater than 2 ft. above the floor.
5	Low	High	Glazing cracks and window system fails catastrophically. Fragments enter space impacting a vertical witness panel at a distance of no more than 10 ft. from the window at a height greater than 2 ft. above the floor.

TEST 1 SUMMARY

Date: 20 September 2004
 Nominal Charge Weight, lb ANFO: 600
 Standoff to structure, ft: 165
 Avg. Measured Peak Pressure, psi: 4.69
 Avg. Measured Positive Impulse, psi-msec: 30.58
 Time of Detonation: 12:31 pm
 Ambient Temperature, deg F: 75

Table 2. Test 1 window summary.

Test Article	Window 1	Window 2	Window 3	Window 4
Specimen Description	1/4-inch monolithic TTG, mechanically attached 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch monolithic AG, mechanically attached 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch monolithic AG, mechanically attached 8-mil security film ⁽⁷⁾ with mirror-tinted finish (R20-SR-PS8)	1/4-inch monolithic TTG, mechanically attached 8-mil security film ⁽⁷⁾ (R20-SR-PS8)
Damage Description	Glazing cracked but remained in frame. No failure of film or mechanical attachment. No visible frame deformation.	Glazing cracked. Film remained attached to the frame. Tear in center of film and small tear in lower left corner of film. No visible frame deformation.	Glazing cracked. Film remained attached to the frame. Slight separation between mechanical attachment system and window film in the upper left corner. No visible frame deformation.	Glazing cracked. Film remained attached to the frame. Large separation between the mechanical attachment system and the left side of the frame. No visible frame deformation.
Window Glazing Response	A small amount of glass was stripped from the center of the film and landed exterior to the test structure. No fragments visible inside of test structure.	Most of the glass was stripped from the film and landed exterior to the test structure. Small fragments entered the 3a-3b performance condition region. No impacts visible on witness panel.	Most of the glass was stripped from the film and landed exterior to the test structure. Light dusting of glass on sill. No impacts visible on witness panel.	Some of the glass was stripped from the film and landed exterior to the test structure. Small fragments entered the 3a-3b performance condition region. No impacts visible on witness panel.
Hazard Level	None	Low	None	Low
Protection Level	Very High	High	Very High	High
Performance Condition	2	3b	2	3b

Test Notes:

- 1) The window system was mounted in a standard commercial fixed aluminum frame.
- 2) The window system was anchored to the test structure with 1/2-inch Grade 5 steel bolts at 6 inches on center.
- 3) Witness panels were located approximately 120 inches behind window.
- 4) The tests site is at an altitude of 6200 ft above sea level.
- 5) AG = annealed glass, TTG = tempered glass
- 6) Window edges (left and right) are based on a person standing interior to the window looking outside.
- 7) Frame/lok[®] mechanical attachment system used on all four sides of the window frame.

TEST 2 SUMMARY

Date:	20 September 2004
Nominal Charge Weight, lb ANFO:	600
Standoff to structure, ft:	165
Avg. Measured Peak Pressure, psi:	4.36
Avg. Measured Positive Impulse, psi-msec:	30.49
Time of Detonation:	4:31 pm
Ambient Temperature, deg F:	82

Table 3. Test 2 window summary.

Test Article	Window 1	Window 2	Window 3	Window 4
Specimen Description	1/4-inch AG (outer), 1/2-inch air gap, 1/4-inch AG (inner), mechanically attached 8-mil security film ⁽⁷⁾ with mirror-tinted finish (R20-SR-PS8)	1/4-inch TTG (outer), 1/2-inch air gap, 1/4-inch TTG (inner), mechanically attached 8-mil security film ⁽⁷⁾ (R20-SR-PS8)	1/4-inch TTG (outer), 1/2-inch air gap, 1/4-inch TTG (inner), mechanically attached 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch AG (outer), 1/2-inch air gap, 1/4-inch AG (inner), mechanically attached 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)
Damage Description	Outer glazing failed with fragments landing outside of test structure. Inner glazing cracked but remained in frame. No failure of film or mechanical attachment. No visible frame deformation.	No damage to outer and inner glazing. Slight film bubbling along the top center of the interior glazing. No failure of film or mechanical attachment. No visible frame deformation.	No damage to outer and inner glazing. Slight film bubbling along the top and right side of the interior glazing. No failure of film or mechanical attachment. No visible frame deformation.	Outer glazing failed with fragments landing outside of test structure. Inner glazing cracked but remained in frame. No failure of film or mechanical attachment. No visible frame deformation.
Window Glazing Response	No fragments visible inside of test structure.	No visible damage.	No visible damage.	No fragments visible inside of test structure.
Hazard Level	None	None	None	None
Protection Level	Very High	Safe	Safe	Very High
Performance Condition	2	1	1	2

Test Notes:

- 1) The window system was mounted in a standard commercial fixed aluminum frame.
- 2) The window system was anchored to the test structure with 1/2-inch Grade 5 steel bolts at 6 inches on center.
- 3) Witness panels were located approximately 120 inches behind window.
- 4) The tests site is at an altitude of 6200 ft above sea level.
- 5) AG = annealed glass, TTG = tempered glass
- 6) Window edges (left and right) are based on a person standing interior to the window looking outside.
- 7) Frame/lok[®] mechanical attachment system used on all four sides of the window frame.

TEST 3 SUMMARY

Date:	21 September 2004
Nominal Charge Weight, lb ANFO:	600
Standoff to structure, ft:	165
Avg. Measured Peak Pressure, psi:	4.48
Avg. Measured Positive Impulse, psi-msec:	30.49
Time of Detonation:	12:41 pm
Ambient Temperature, deg F:	82

Table 4. Test 3 window summary.

Test Article	Window 1	Window 2	Window 3	Window 4
Specimen Description	1/4-inch outer AG, 1/2-inch air gap, 1/4-inch inner AG, wet-glazed 8-mil security film ⁽⁷⁾ (R20-SR-PS8)	1/4-inch outer AG, 1/2-inch air gap, 1/4-inch inner AG, wet-glazed 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch outer TTG, 1/2-inch air gap, 1/4-inch inner TTG, wet-glazed 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch outer TTG, 1/2-inch air gap, 1/4-inch inner TTG, wet-glazed 8-mil security film ⁽⁷⁾ with mirror-tinted finish (R20-SR-PS8)
Damage Description	Outer glazing failed with fragments landing outside of test structure. Inner glazing cracked but remained in frame. No failure of film or wet-glazed attachment. No visible frame deformation.	Outer glazing failed with fragments landing outside of test structure. Inner glazing cracked. Film remained attached to the frame. No failure of film or wet-glazed attachment. No visible frame deformation.	No visible damage to glazing. No failure of film or wet-glazed attachment. No visible frame deformation.	Outer glazing cracked but remained in frame. No visible damage to inner glazing. No visible frame deformation.
Window Glazing Response	Inner glazing cracked but remained in frame. No fragments visible inside the test structure.	Some of the interior glass was stripped from the film and landed exterior of the test structure. No fragments visible inside the test structure.	No visible damage to glazing. No fragments visible inside the test structure.	No visible damage to inner glazing. No fragments visible inside the test structure.
Hazard Level	None	None	None	None
Protection Level	Very High	Very High	Safe	Very High
Performance Condition	2	2	1	2

Test Notes:

- 1) The window system was mounted in a standard commercial fixed aluminum frame.
- 2) The window system was anchored to the test structure with 1/2-inch Grade 5 steel bolts at 6 inches on center.
- 3) Witness panels were located approximately 120 inches behind window.
- 4) The tests site is at an altitude of 6200 ft above sea level.
- 5) AG = annealed glass, TTG = tempered glass
- 6) Window edges (left and right) are based on a person standing interior to the window looking outside.
- 7) Tremco Proglaze[®] SSG wet-glazed attachment system (3/4-inch by 3/4-inch silicone contact lengths) used on all four sides.

TEST 4 SUMMARY

Date:	21 September 2004
Nominal Charge Weight, lb ANFO:	600
Standoff to structure, ft:	165
Avg. Measured Peak Pressure, psi:	4.43
Avg. Measured Positive Impulse, psi-msec:	30.34
Time of Detonation:	3:48 pm
Ambient Temperature, deg F:	84.9

Table 5. Test 4 window summary.

Test Article	Window 1	Window 2	Window 3	Window 4
Specimen Description	1/4-inch monolithic TTG, wet-glazed 8-mil security film ⁽⁷⁾ (R20-SR-PS8)	1/4-inch monolithic AG, wet-glazed 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch monolithic TTG, wet-glazed 8-mil security film ⁽⁷⁾ (SCL-SR-PS8)	1/4-inch monolithic AG, wet-glazed 8-mil security film ⁽⁷⁾ (R20-SR-PS8)
Damage Description	No visible damage to glazing. No failure of film or wet-glazed attachment. Slight film bubbling at top center of glazing. No visible frame deformation.	Glazing cracked but remained partially in frame due to wet-glazed attachment of film. The film tore from the attachment completely along the right side and a significant length along the top and bottom of the frame. Large tear located in the center of the window film. No visible frame deformation.	Glazing cracked but remained partially in frame due to wet-glazed attachment of film. The film tore from the attachment completely along the right side and a significant length along the bottom of the frame. No visible frame deformation.	Glazing cracked. Film remained attached to the frame. Slight tear in bottom right corner of film. No visible frame deformation.
Window Glazing Response	No visible damage to glazing. No fragments visible inside the test structure.	Much of the glass was stripped from the film and landed exterior of the test structure. Several fragments entered the 3a-3b performance condition region. No impacts evident on witness panel.	Some of the glass was stripped from the film and landed exterior of the test structure. Several fragments entered the 3a-3b performance condition region. No impacts evident on witness panel.	Some of the glass was stripped from the film and landed exterior of the test structure. One small fragment entered the 3b performance condition region. No impacts evident on witness panel.
Hazard Level	None	Low	Low	Low
Protection Level	Very High	High	High	High
Performance Condition	1	3b	3b	3b

Test Notes:

- 1) The window system was mounted in a standard commercial fixed aluminum frame.
- 2) The window system was anchored to the test structure with 1/2-inch Grade 5 steel bolts at 6 inches on center.
- 3) Witness panels were located approximately 120 inches behind window.
- 4) The tests site is at an altitude of 6200 ft above sea level.
- 5) AG = annealed glass, TTG = tempered glass
- 6) Window edges (left and right) are based on a person standing interior to the window looking outside.
- 7) Tremco Proglaze[®] SSG wet-glazed attachment system (3/4-inch by 3/4-inch silicone contact lengths) used on all four sides.

Table 6. CPFilms window number summary.

Test	Test Structure	CPFilms Window Number
1	1	3
	2	11
	3	15
	4	7
2	1	31
	2	23
	3	19
	4	27
3	1	29
	2	25
	3	17
	4	21
4	1	5
	2	9
	3	1
	4	13

Pressure gauges were installed in each reaction structure to measure the pressure levels that the window systems experienced in the explosive test. There were a total of 12 gauges used during this series. Figure 18 shows the location of each gauge.

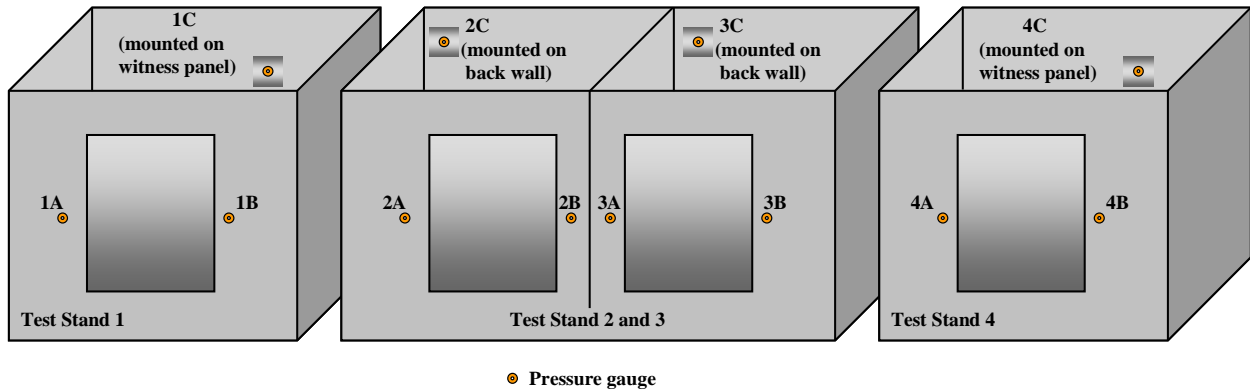


Figure 18. Illustration of pressure gauge locations.

Waveforms for each of the gauges are shown in Figure 19 - 34. It should be noted that when attempting to determine the peak pressure and impulses, obvious noise (spikes) in the waveforms were ignored.

CPFilms Window Tests

10/22/2004

Test 1 - September 20, 2004

Exterior Gauges - Pressure

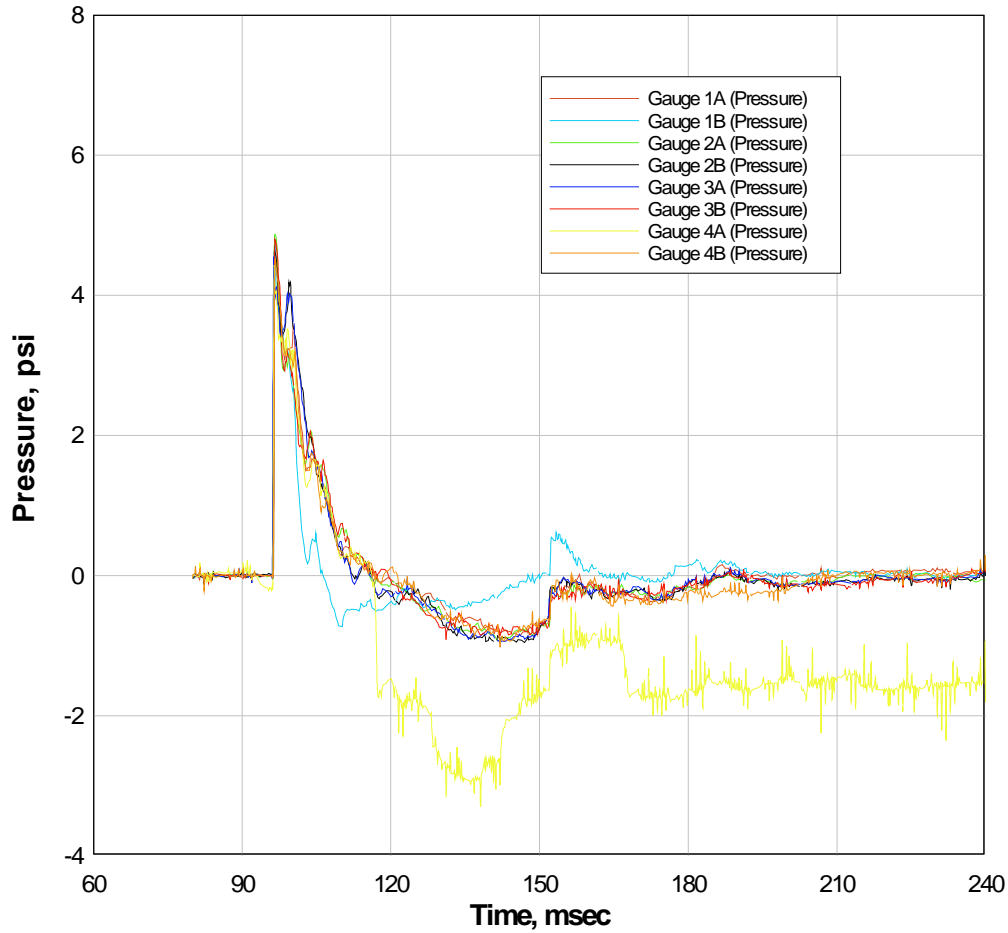


Figure 19. Test 1 exterior pressure gauges.

CPFilms Window Tests

10/25/2004

Test 1 - September 20, 2004

Exterior Gauges - Impulse

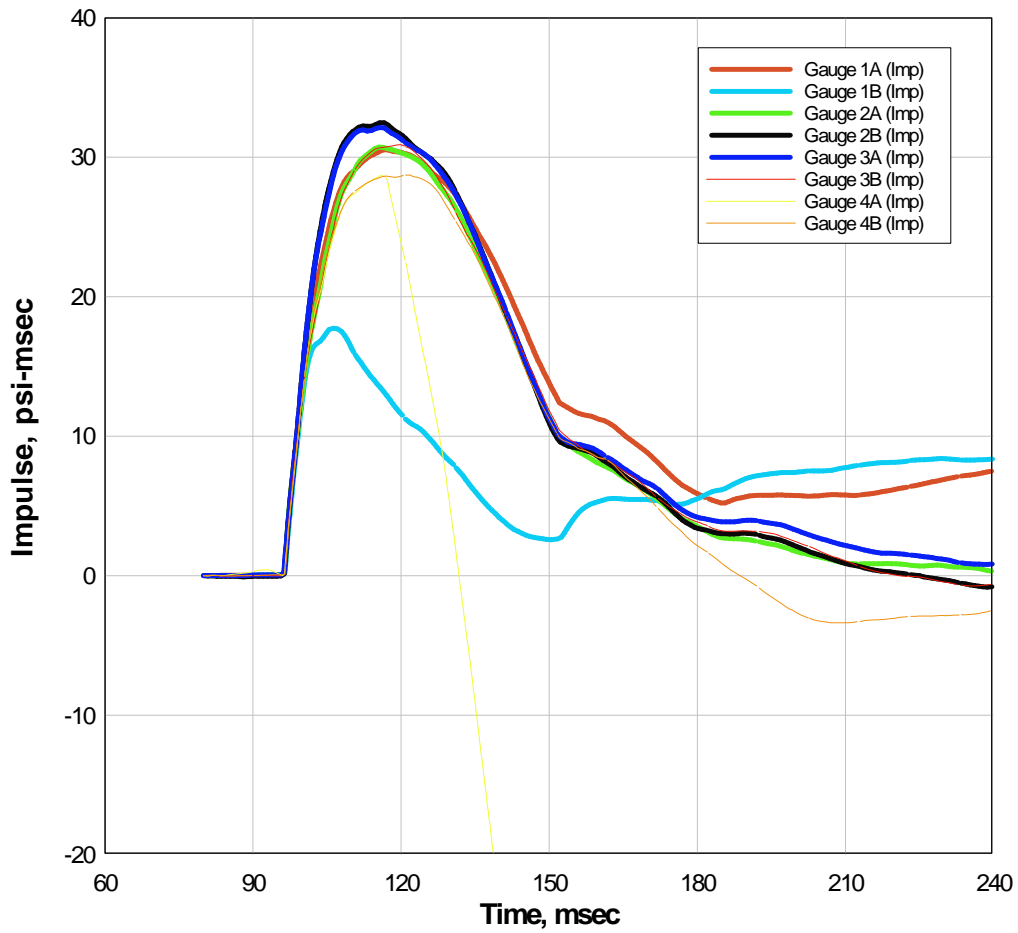


Figure 20. Test 1 exterior impulse gauges.

CPFilms Window Tests

10/22/2004

Test 1 - September 20, 2004

Interior Gauges - Pressure

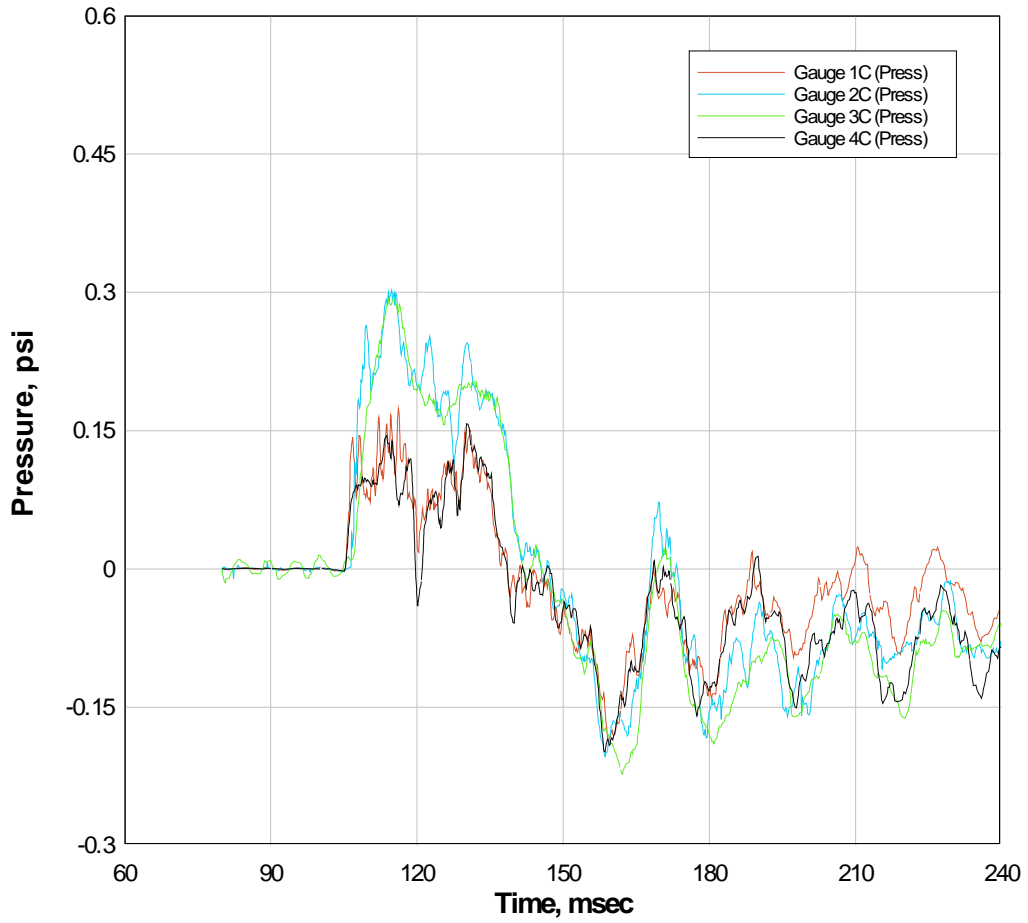


Figure 21. Test 1 interior pressure gauges.

CPFilms Window Tests

10/25/2004

Test 1 - September 20, 2004

Interior Gauges - Impulse

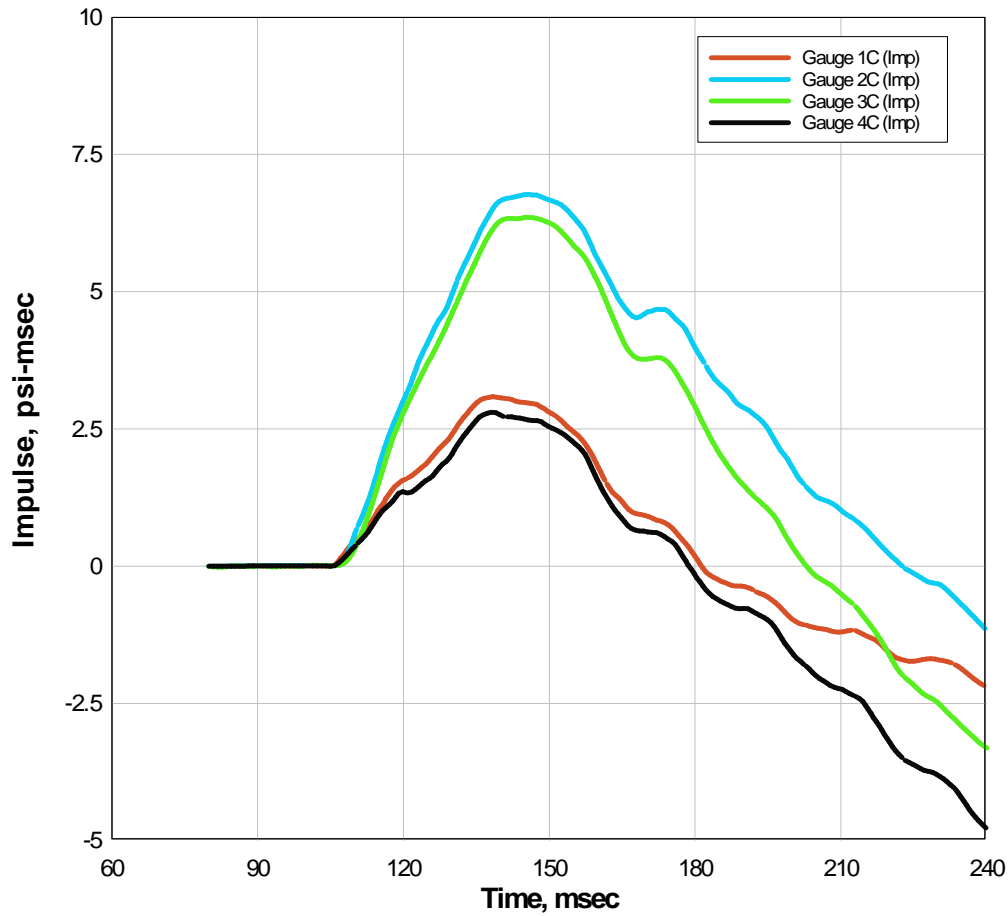


Figure 22. Test 1 interior impulse gauges.

CPFilms Window Tests

10/22/2004

Test 2 - September 20, 2004

Exterior Gauges - Pressure

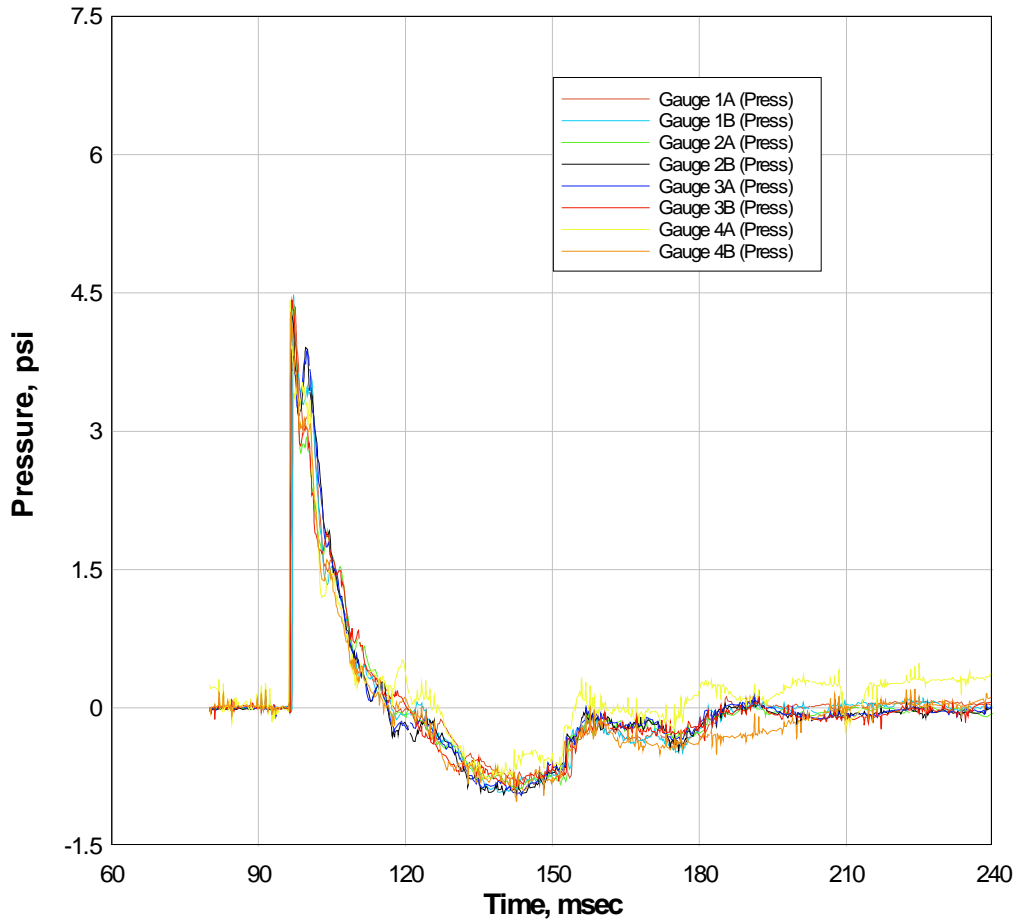


Figure 23. Test 2 exterior pressure gauges.

CPFilms Window Tests

10/25/2004

Test 2 - September 20, 2004

Exterior Gauges - Impulse

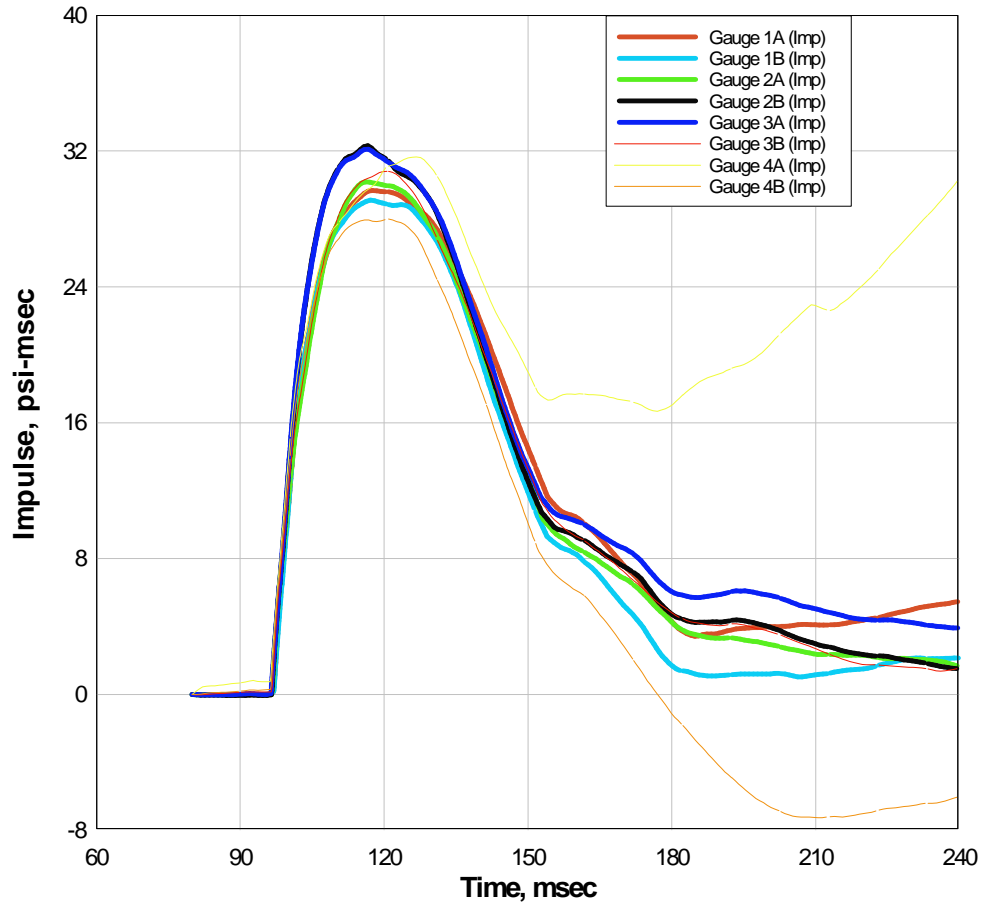


Figure 24. Test 2 exterior impulse gauges.

CPFilms Window Tests

Test 2 - September 20, 2004

Interior Gauges - Pressure

10/22/2004

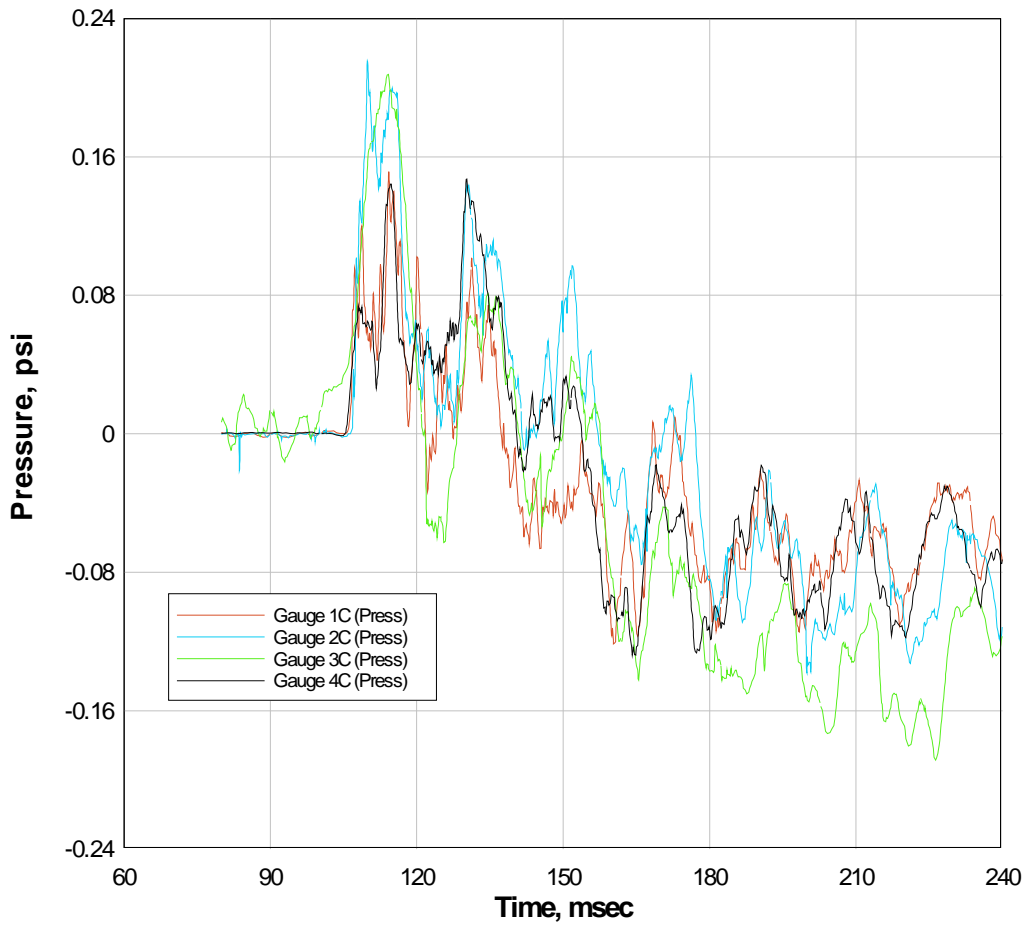


Figure 25. Test 2 interior pressure gauges.

CPFilms Window Tests

10/25/2004

Test 2 - September 20, 2004

Interior Gauges - Impulse

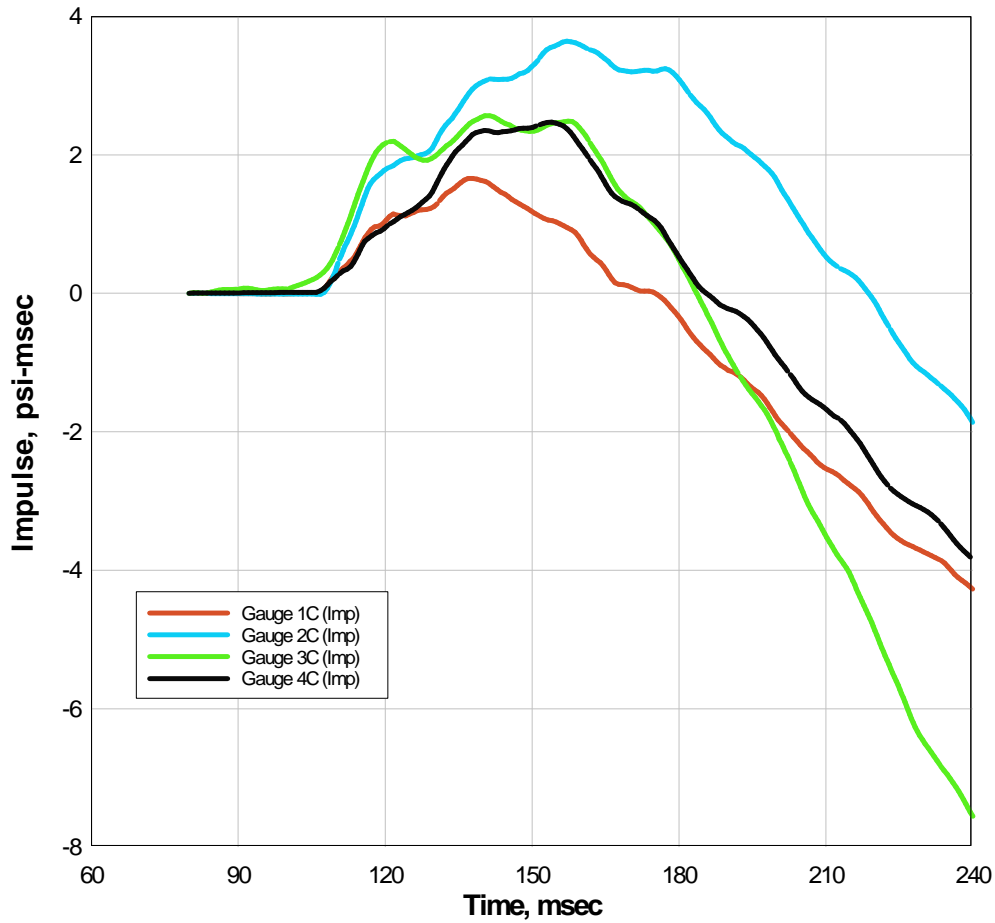


Figure 26. Test 2 interior impulse gauges.

CPFilms Window Tests

10/22/2004

Test 3 - September 21, 2004

Exterior Gauges - Pressure

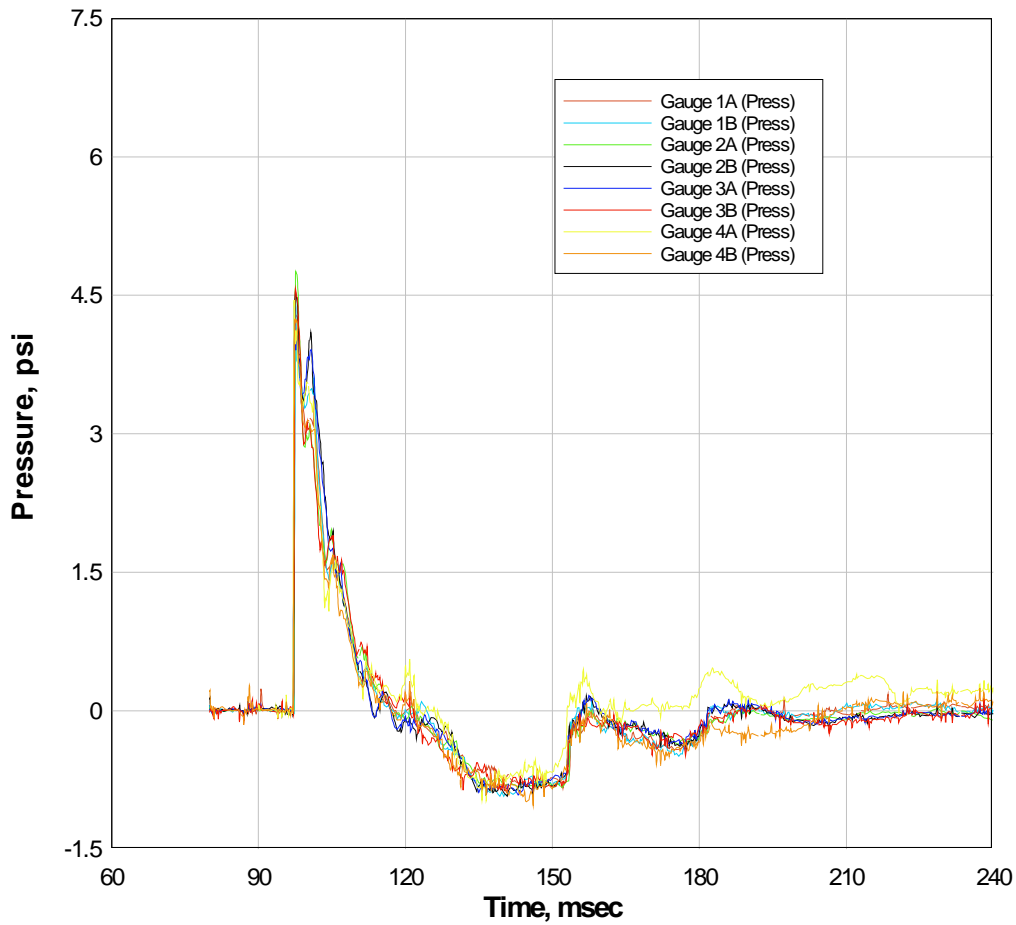


Figure 27. Test 3 exterior pressure gauges.

CPFilms Window Tests

Test 3 - September 21, 2004

Exterior Gauges - Impulse

10/25/2004

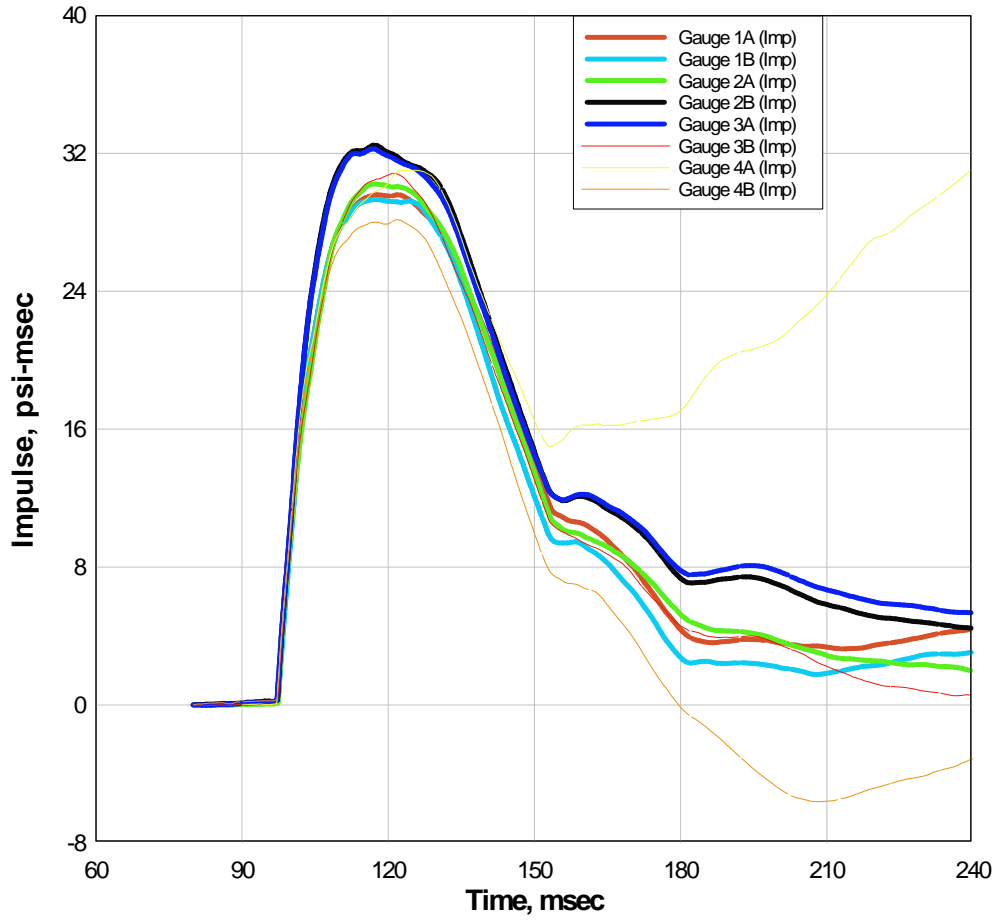


Figure 28. Test 3 exterior impulse gauges.

CPFilms Window Tests
Test 3 - September 21, 2004
Interior Gauges - Pressure

10/22/2004

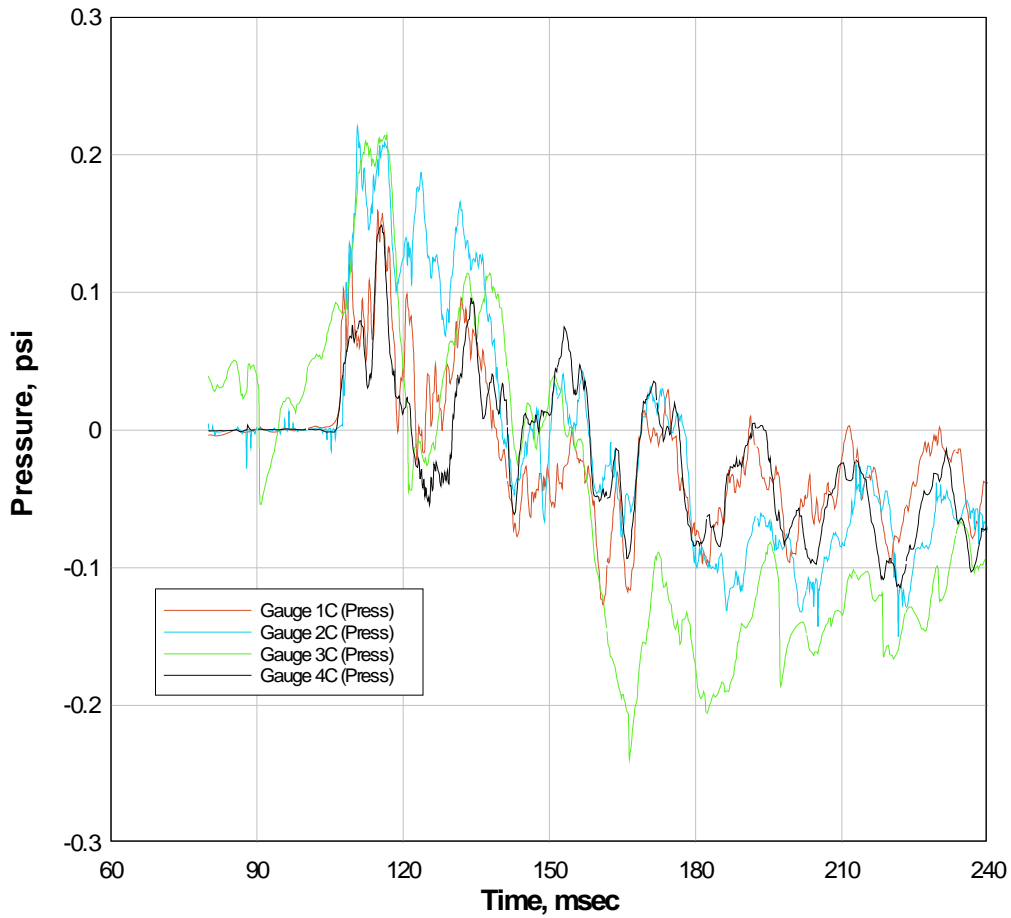


Figure 29. Test 3 interior pressure gauges.

CPFilms Window Tests
Test 3 - September 21, 2004
Interior Gauges - Impulse

10/25/2004

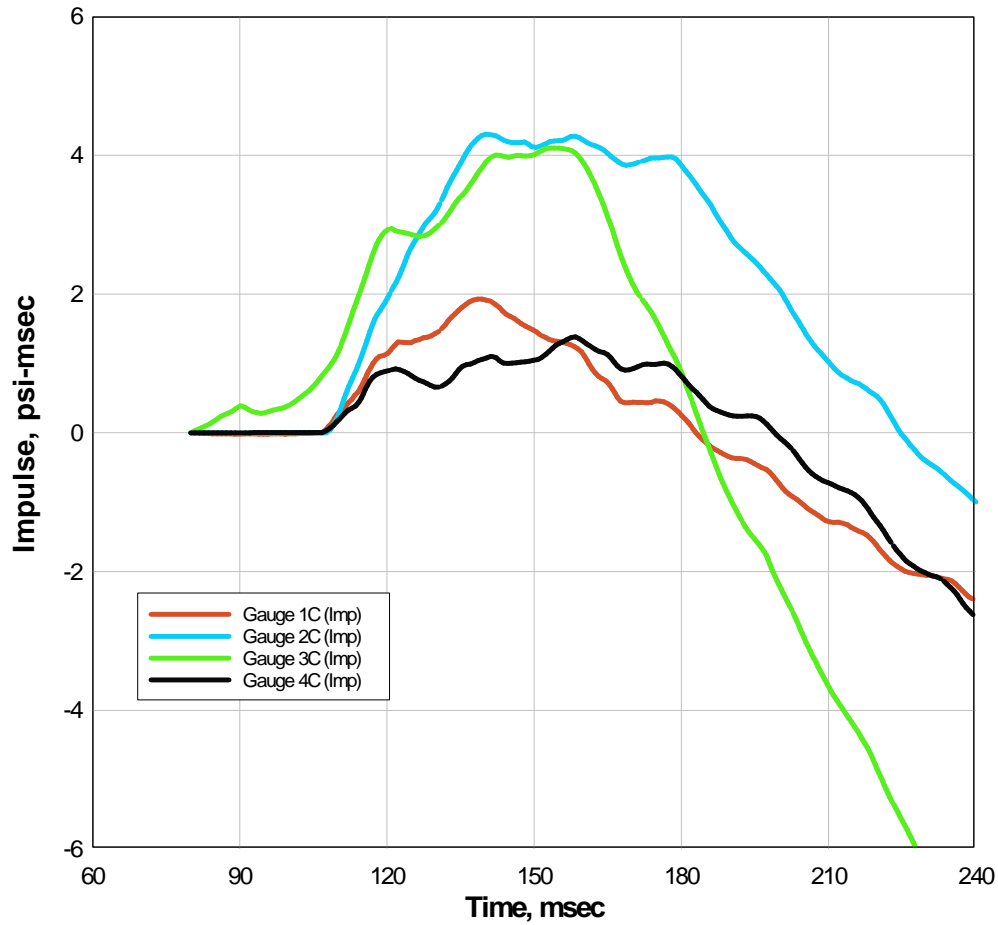


Figure 30. Test 3 interior impulse gauges.

CPFilms Window Tests

10/22/2004

Test 4 - September 21, 2004 Exterior Gauges - Pressure

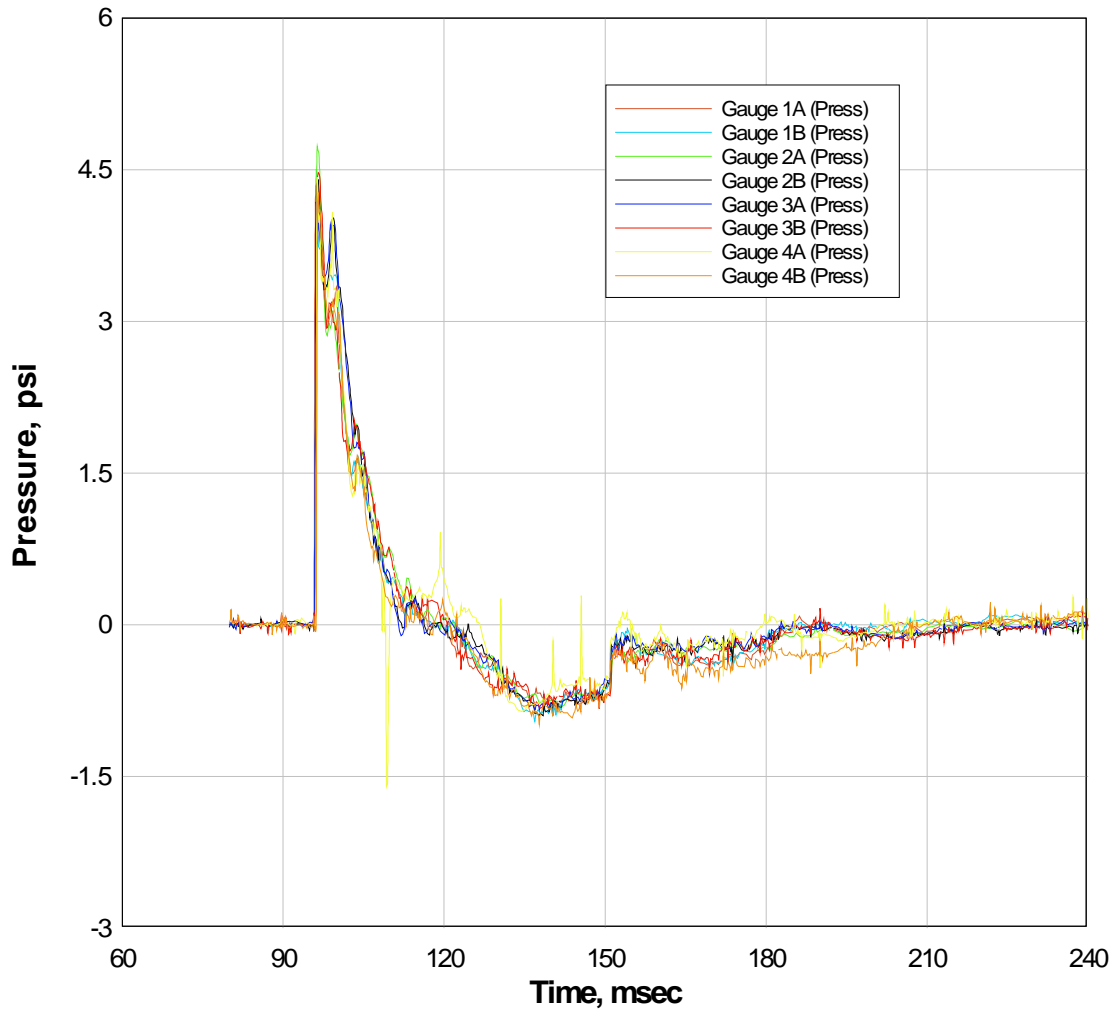


Figure 31. Test 4 exterior pressure gauges.

CPFilms Window Tests

Test 4 - September 21, 2004

Exterior Gauges - Impulse

10/25/2004

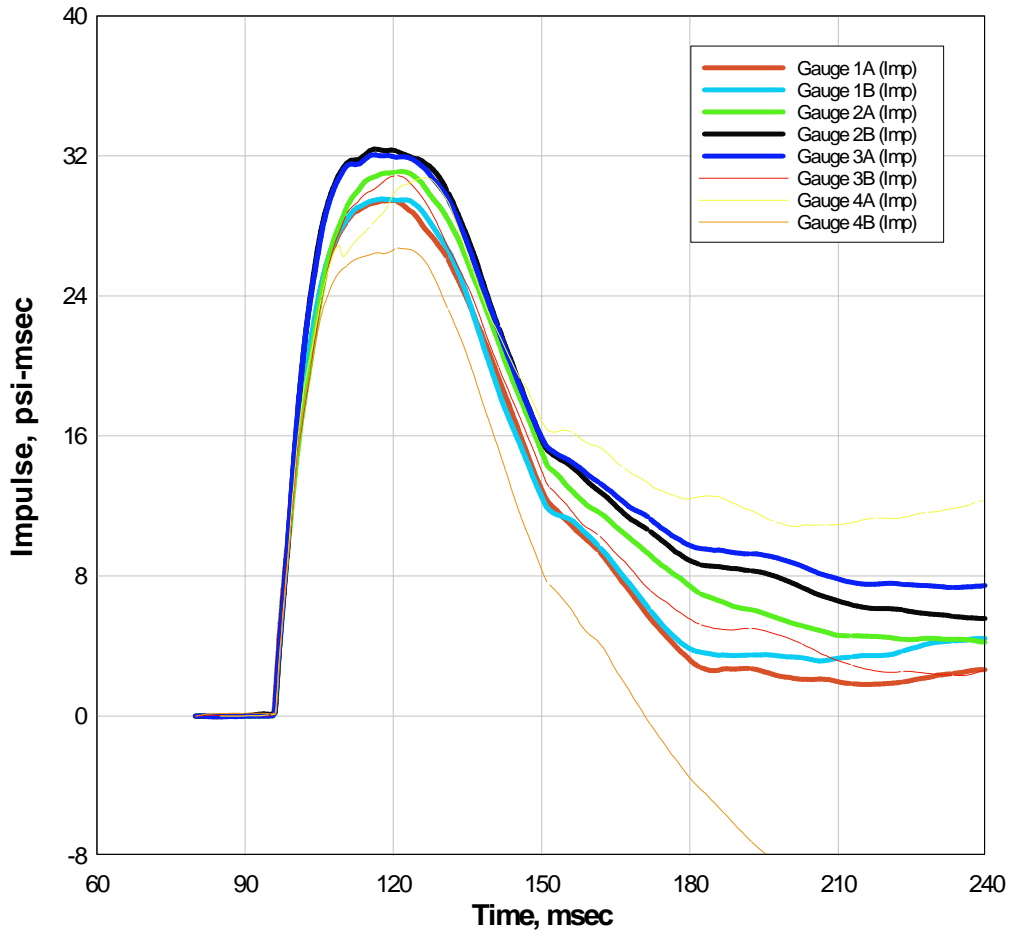


Figure 32. Test 4 exterior impulse gauges.

CPFilms Window Tests

Test 4 - September 21, 2004

Interior Gauges - Pressure

10/22/2004

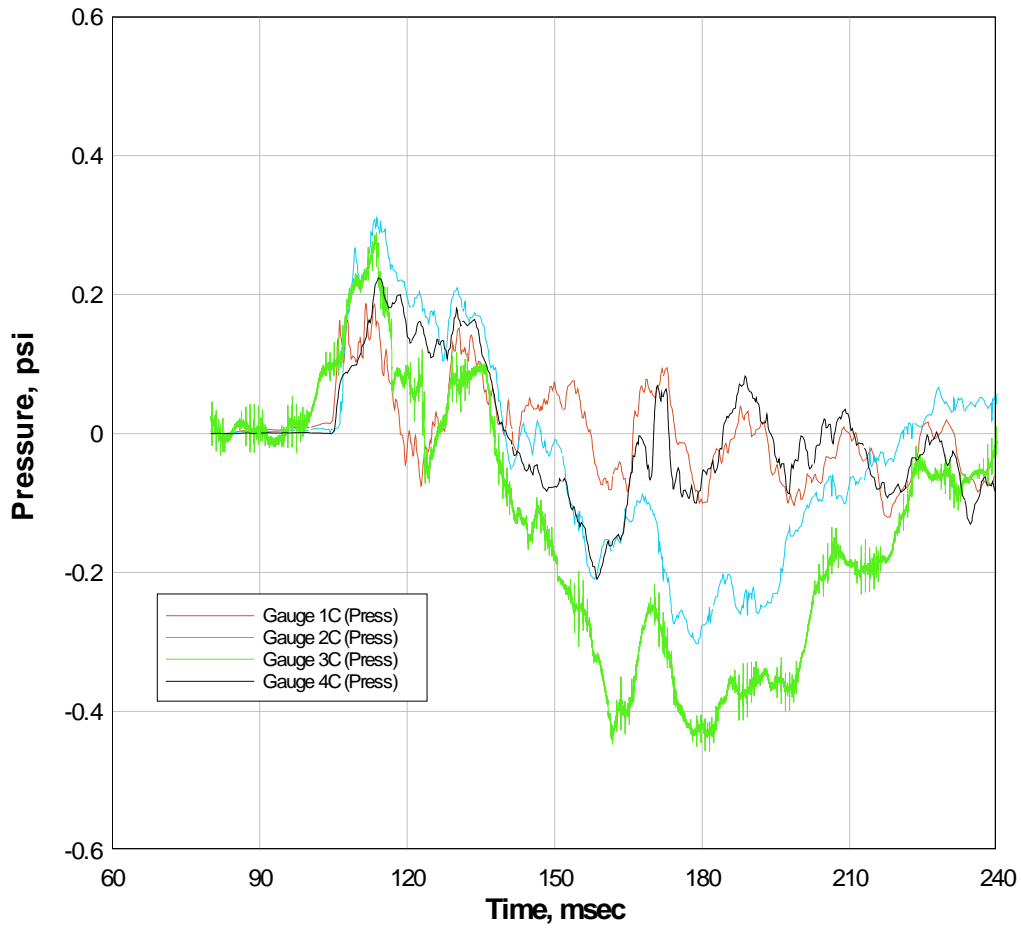


Figure 33. Test 4 interior pressure gauges.

CPFilms Window Tests
Test 4 - September 21, 2004
Interior Gauges - Impulse

10/25/2004

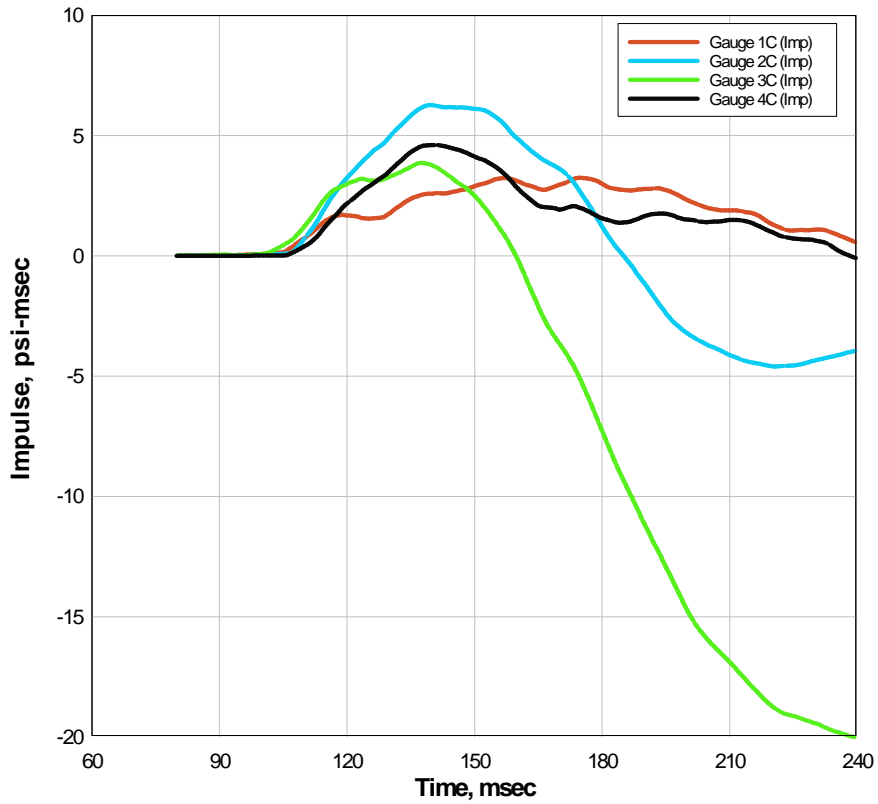


Figure 34. Test 4 interior impulse gauges.

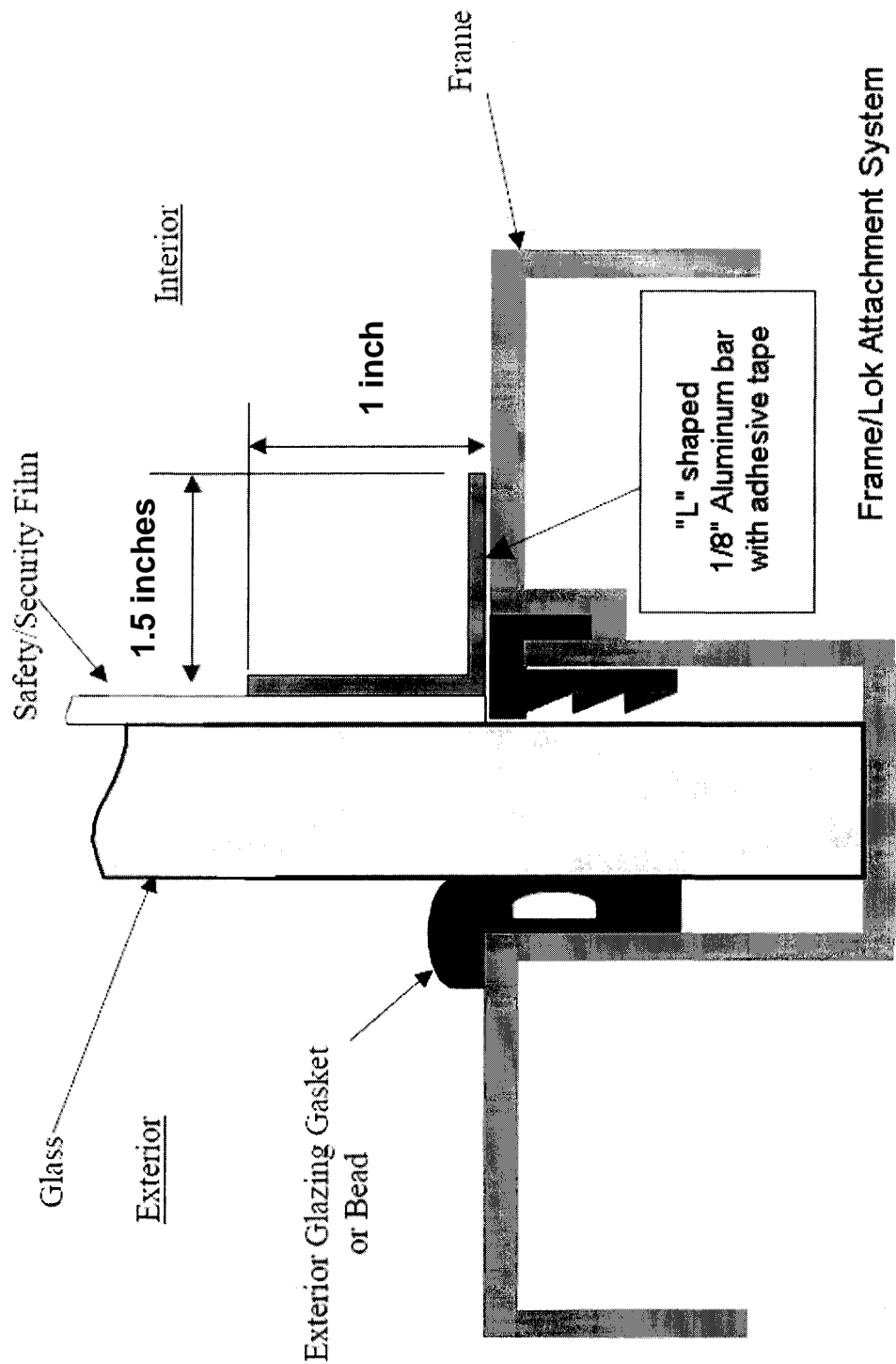


Figure 35. Frame/Lok attachment system.

Frame/Lok

Specification Data Chart

Tensile loading transfer strip is preferably a metal strip advantageously according to the following specifications:

Galvanized	Carbon Manganese
CQ	Commercial Quality
ASTM	A526 R-A653 (m)
SAE	1066-1012
Chemical Composition % Max	C.O.15 Mn 0.60
Yield Strength PSI MPA	35,000-45,000 240-310
Melt (HEAT)	800 degree Farenheit
Paint Coating (MELT)	350-400 degree Farenheit
Thickness mm 0.38	(IN) mm IN 0.015 4.27 0.166
Elongation In 50 mm (2inches) %	32-42mm

Technical specification and Attributes on adhesion

Tensile Strength PSI (KPa)	140 (965)	ASTM D-412 Die C
Dynamic Shear PSI (KPa) 72 hours dwell stainless steel to paint	120 (827)	NIP-5
Recommended Service Temperature:	40°F to 200° F (-40°C TO 93°C)	
Recommended Application Temperature	60°F to 125°F (16°C to 52°C)	
Elongation %	260	ASTM D-412 Die C

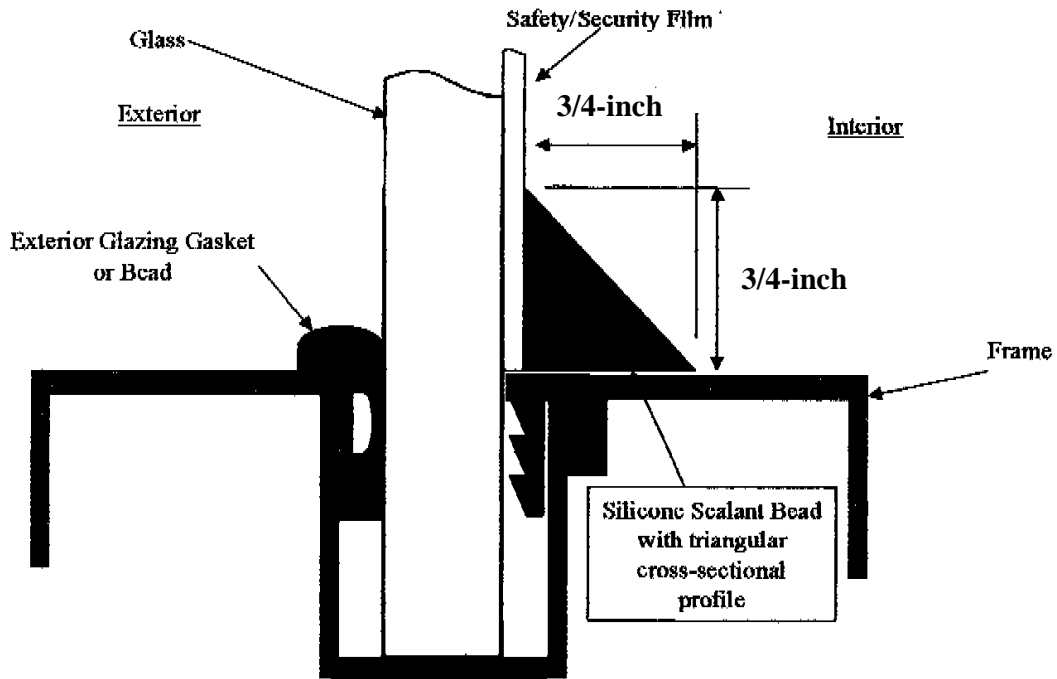


Figure 36. Wet-glazed attachment system.

Proglaze[®] SSG

Structural Glazing Silicone Sealant

Product Description:

Proglaze SSG is a one-part, high modulus, neutral cure silicone sealant ideal for a wide variety of glazing applications. Proglaze SSG provides high performance capabilities as well as exceptional cure stability and shelf life properties.

Basic Uses:

Proglaze SSG is designed to meet the stringent needs for performance glazing. Whether it is a two or four-sided conventional structural glazing, Miami/Dade Hurricane protocol or bomb blast mitigation, Proglaze SSG will perform in the most demanding structural silicone applications. Proglaze SSG can also be used for sealing joints within window or wall systems as well as a cap, heel or toe bead. **All structural glazing applications must be reviewed and approved by Tremco Technical Service.**

Limitations:

- Do not apply over damp or contaminated surfaces.
- Use with adequate ventilation.

Packaging:

1/12 Gallon (300 ml) cartridges, 20 oz. (600 ml) sausages, 4.5 (17.1 L) gallon pails and 50 gallon (189.3 L) drums.

Color:

Black

Applicable Standards:

Conforms to ASTM C920 Type S, Grade NS. Use NT, G, A and O and CAN/CGSB-19.13-M87 and U.S. Federal Specification TT-S-00230C (COM-NBS) Class A, Type II, and U.S. Federal Specification TT-S-001543A (COM-NBS) Class A.

INSTALLATION**Joint Design:**

May be used in any vertical design in accordance with accepted architectural/engineering practices. Joint width should be 4 times anticipated movement, but not less than 1/4 inch (6.4 mm) wide.

Dimensions:

For joints 1/4 inch (6.4 mm) to 1/2 inch (12.7 mm) wide, the width to depth ratio should be equal. Joints 1/2 inch (12.7 mm) wide or greater should have a maximum sealant depth of 1/2 inch (12.7 mm). Minimum joint size is 1/4 inch by 1/4 inch (6.4 mm by 6.4 mm).

Surface Preparation:

Substrates for every structural silicone glazed project should be submitted for adhesion and compatibility testing by Tremco Technical Services prior to commencement of glazing. The surface preparation (cleaning method and primer if required) for each structural glazing project will be recommended based on production run sample substrates supplied by the customer and based on laboratory testing performed by Tremco.

Joint interfaces must be clean, dry, and free from any foreign matter prior to sealant application. Metal, glass and other non-porous surfaces should be wiped clean with a solvent dampened clean towel, followed immediately by a dry wipe with a clean, lint free towel before the solvent evaporates (i.e. 2 rag method). Preferred solvent is Isopropyl Alcohol (IPA) or Methyl Ethyl Ketone (MEK). Follow all precautions on label during handling of solvent. A trial application of the solvent is recommended to ensure there is not adverse reaction with the substrates.

Tooling & Cleaning:

Tooling is recommended immediately after application to insure firm, intimate contact with the joint interface. Dry tooling is preferred. Cleaning can be accomplished with solvents such as IPA or MEK while sealant is in uncured state.

Joint Backing**Bond Breaking Tape:**

Closed cell polyethylene backer rods are preferred as joint backing to control depth of sealant bead. Where depth of joint will prevent use of joint backing, an adhesive backed polyethylene tape should be installed to prevent three-sided adhesion.

Joint backing must be dry at time of sealant application

Application:

Proglaze SSG is easy to apply with conventional caulking equipment. Fill joint completely and tool. At 75°F (23.9°C), 50% R.H. recorded tooling time is 7 minutes.

Maintenance:

Damaged sealant can be repaired. Consult your Tremco Field Representative or Distributor for repair procedures.

TYPICAL PHYSICAL PROPERTIES

Extrusion rate	33 seconds
Sag (ASTM C-619)	None
Tooling time	5-10 minutes
Tack free time (ASTM C-679)	10-15 minutes
Shore A hardness (ASTM C-661)	40
Tensile (ASTM D-412)	350 psi
Tear strength (ASTM D-624)	67 lbs/in
Peel adhesion: (ASTM C-794)	
Aluminum and Glass	60 lbs/in
Elongation (ASTM D-412)	380%



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