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Hypervelocity Impact (HVI)

Volume 5: WLE High Fidelity Specimen Fg(RCC)-1

Michael R. Gorman and Steven M. Ziola
Digital Wave Corporation, Englewood, Colorado

September 2007

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Hypervelocity Impact (HVI)

WLE High Fidelity Specimen Fg(RCC)-1

During 2003 and 2004, the Johnson Space Center's White Sands Testing Facility in Las Cruces, New Mexico conducted hypervelocity impact tests on the space shuttle wing leading edge.

Hypervelocity impact tests were conducted to determine if Micro-Meteoroid/Orbital Debris impacts could be reliably detected and located using simple passive ultrasonic methods.

The objective of Target Fg(RCC)-1 was to study hypervelocity impacts through the reinforced carbon-carbon (RCC) panels of the Wing Leading Edge. Fiberglass was used in place of RCC in the initial tests.

Impact damage was detected using lightweight, low power instrumentation capable of being used in flight.

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Introduction

In the wake of the Columbia accident, NASA personnel decided to test the idea that impacts during space flight could be detected by acoustical sensors at ultrasonic frequencies. The substance of this idea rested on the knowledge that in laboratory experiments lower velocity impacts had created signals with frequencies in the 20 – 200 kHz range. If Shuttle engine and aerodynamic noise were down in the sonic range then locating impacts would be easier in the 20-200 kHz range. The questions were what frequencies would be created during hypervelocity impacts by tiny objects, what would their energies be, and what would be the best way to detect them, keeping in mind the potential need for lightweight, simple installation procedures and low electrical energy consumption.

A further basis for selecting this method was that recent fundamental research had elucidated the basic physics of the ultrasonic signals created by the impacts in a variety of aerospace materials and geometries. This made it more likely that signal and noise could be separated and that subsequent analysis of the signals would yield the desired information about impact severity and location. All of the above reasoning proved to be correct. Hypervelocity impact by tiny aluminum spheres created signals in the 20-200 kHz frequency range easily detectable with small piezoelectric sensors similar to equipment being flown.

Target Fg(RCC)-1 was one of several targets (see below) used for hypervelocity impact testing. There is a section in this Report for each of the other targets. The structure of this Report includes a General Introduction that contains the overall goals, the personnel involved, the test methods, instrumentation, calibration, and overall results and conclusions. Only abbreviated descriptions of the test methods, instrumentation, and calibration are given in each of the Target sections such as this one.
This section describes Target Fg(RCC)-1 and the test equipment, features tables of kinetic energy and damage results, and discusses the linear relationship between kinetic energy, ultrasonic wave signal energy and damage. Also discussed are wave propagation effects, the wave modes and their velocities, and location of impacts by analysis of wave arrival times.

The Appendix has test condition data sheets, impact waveforms, and photos of the damage for each shot. Also included are tables of impact data, gain settings, recorded wave signals, and damage results.

The number of targets tested in the overall HVI study was extensive as shown in the list below:

– A-1 – Fiberglass plate and aluminum plate with standoff rods (with grommets)

- A-2 – Fiberglass plate and aluminum plate with standoff rods (no grommets)
- B-1 –Two fiberglass plates and aluminum plate with standoff rods
- C-1 – Fiberglass flat plate
- C-2 – Fiberglass flat plate
- Fg(RCC)-1 – Fiberglass in the shape of Wing Leading Edge
- Fg(RCC)-2 – Fiberglass in the shape of Wing Leading Edge
- RCC16R – Carbon-Carbon Actual WLE
- A-1 Tile – Tile structure of forward part of wing with no gap filler
- Ag-1 Tile – Tile structure of forward part of wing with gap filler
- B-1 Tile – Tile structure of aft part of wing with no gap filler
- Bg-1 Tile – Tile structure of aft part of wing with gap filler

It is everyday experience that when a solid material is struck, sound is created. This new passive ultrasonic technique has been designated modal acoustic emission (MAE) due to its (physical) similarity to an older, but less robust technique known as acoustic emission. In structures built of plate-like sections (aircraft wings, fuselages, etc.) the sound waves of interest are the extensional mode (in-plane stretching and compressing of the plate) and the flexural mode (bending of the plate). These are called plate waves and they propagate in bounded media where the wavelength of the wave is larger than the thickness of the plate. The frequency spectrum typically ranges from the low kilohertz to about one megahertz. Plate waves can be detected with simple piezoelectric transducers that convert mechanical motion into electrical voltage.

By analyzing mode shapes, and taking into account the material and loading, sources can be identified and located. The direct connection to fundamental physics is a key characteristic of MAE. For simple geometries the wave shapes and velocities have been calculated from wave equations derived from Newton's laws of motion and they compare well with measurements. (See General Introduction to this report for a fuller discussion of modal AE.) By using arrival times at transducers with known positions, the location of the source can be triangulated by various mathematical methods (similar to methods used in SONAR).

Experimental Description

Target Fg(RCC)-1 consisted of a 20-ply fiberglass panel formed to the same dimensions of an actual RCC panel 16R. Figure 1 shows the WLE panel mounted to a green spar with metal joints (the attachments). The spar is fastened to a blue support mount and floated into the target tank on a rail system designed and fabricated by WSTF Engineering (Figure 2 and Figure 3).

Figure 1: Target Fg(RCC)-1 on Mounting Fixture

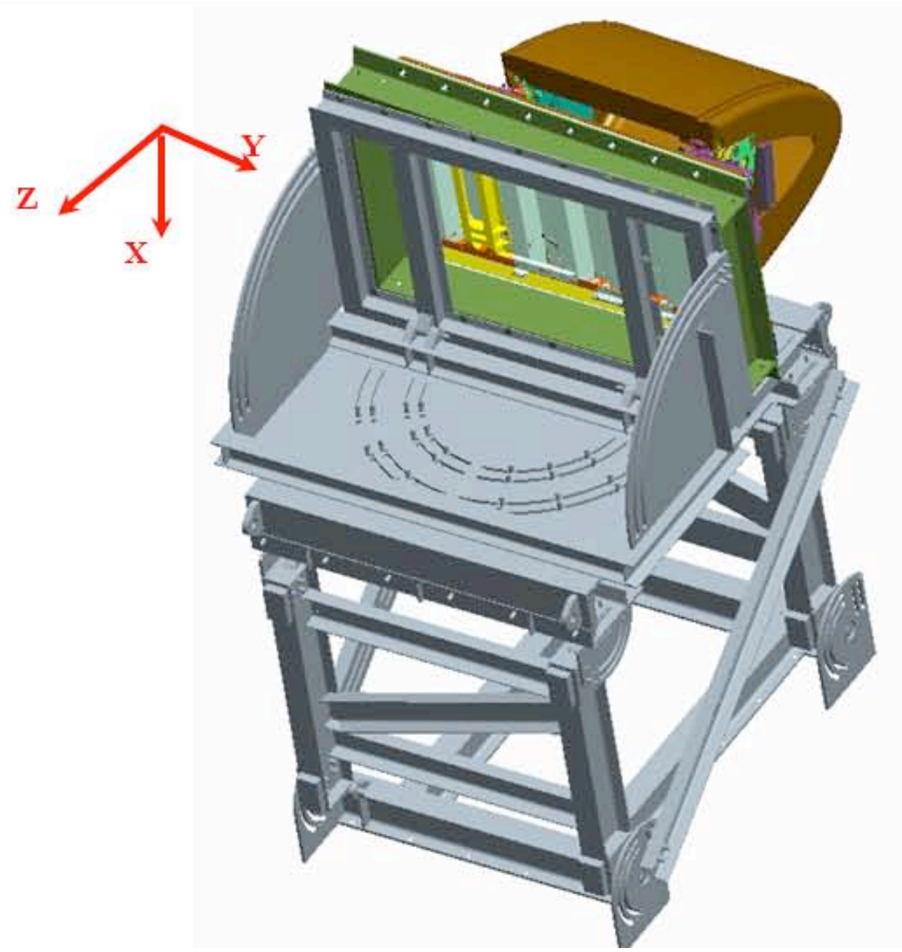


Figure 2: Model of Target Fg(RCC)-1 (brown), Spar (green), and Mount (gray)

Figure 3: Target Fg(RCC)-1 on Rail System. Left: Front View. Right: Back View.

There were 30 impacts. The impact angle of the shots varied from 20 degrees to 90 degrees from the target surface.

The tests were conducted on the 0.50 caliber hypervelocity launcher range at the White Sands Test Facility (WSTF). The flight range for the hypervelocity projectile and target chamber were evacuated to near vacuum pressure (6-8 Torr) prior to each shot. The AE recording equipment was connected by feed-throughs to the sensors on the target inside the vacuum chamber. The connectors were BNC type.

The projectiles were small spheres made of 2017 T-4 aluminum. They ranged in diameter from 0.4 mm to 2.8 mm. Impact velocity was measured with WSTF diagnostic equipment on each shot. The projectile kinetic energy for these shots ranged from 1.82 J to 707.00 J.

Four acoustic (ultrasonic) emission sensors were coupled to the flange, eight sensors were coupled to the inner surface of the target, and an additional four sensors were coupled to the spar with Lord 202 acrylic adhesive (Figure 4). On the shuttle, all sensors would be on the spar to be protected from the extreme heat of the WLE. Diagrams of the sensor layout are shown in Figure 5, Figure 6, Figure 7 and Figure 8. A photo of the post-test impact locations is shown in Figure 9.

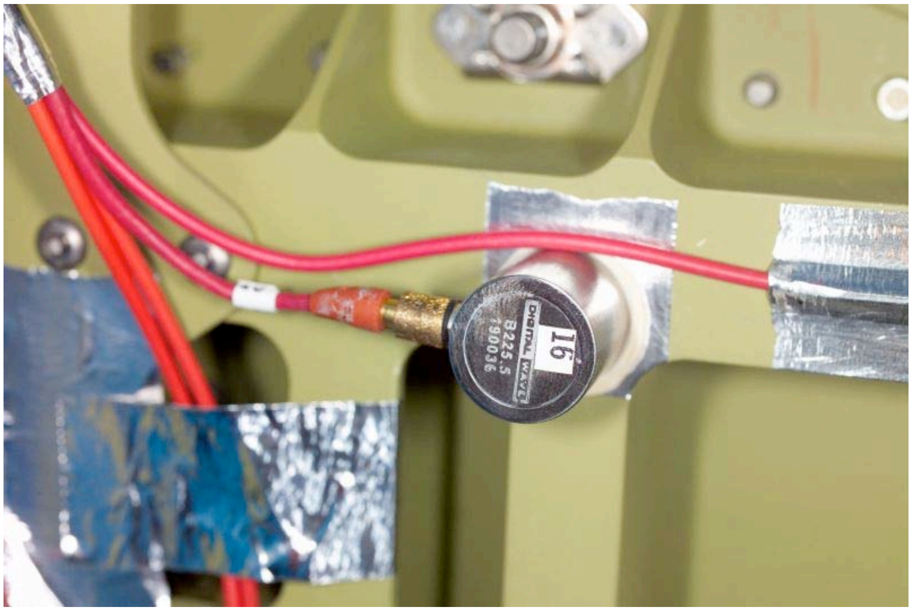
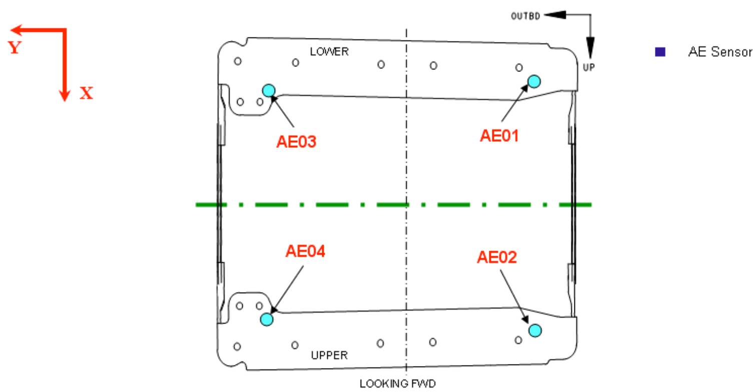


Figure 4: Detail of Sensor 16 on Target Fg(RCC)-1



Notes:
4 AE sensors - one on each corner of Fiberglass panel 16 on lower flange that is connected to fittings on spar.Two AE sensors are located near accelerometers 111 XYZ and 112 XYZ respectively

Figure 5: Fg(RCC)-1 Sensor Locations. Lower Flange.

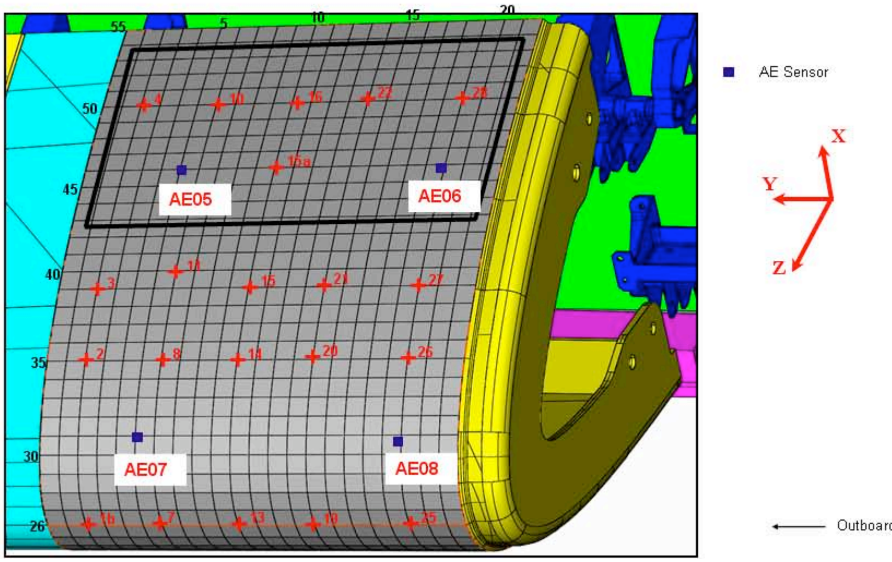


Figure 6: Fg(RCC)-1 Sensor and Impact Locations. Upper Panel.
Acoustic Emission Sensors have the following coordinates:
#5(46, 5), #6(46, 19), #7(31, 5), #8(31, 19) Dimensions are inches.
Impacts have the following coordinates:
#1b(26, 2), #2(35, 2), #3(39, 2), #4(50, 2), #7(26, 6), #8(35, 6), #9(40, 6), #10(50, 6), #13(26, 10), #14(35, 10), #15(39, 10), #15a(46, 10), #16(50, 10), #19(26, 14), #20(35, 14), #21(39, 14), #22(50, 14), #25(26, 19), #26(35, 19), #27(39, 19), #28(50, 19),

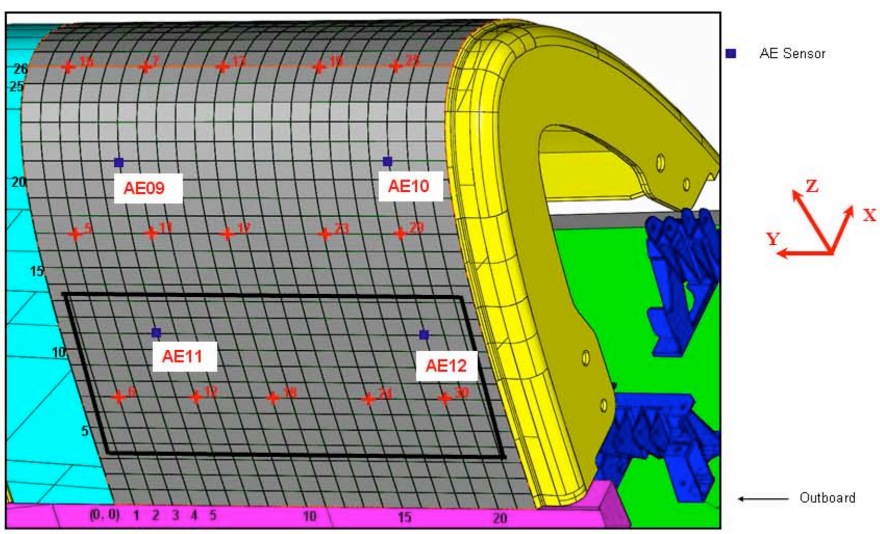


Figure 7: Fg(RCC)-1 Sensor and Impact Locations. Lower Panel.
Acoustic Emission Sensors have the following coordinates:
#9(21, 5), #10(21, 19), #11(11, 5), #12(11, 19) Dimensions are inches.
Impacts have the following coordinates:
#1b(26, 2), #5(17, 2), #6(7, 2), #7(26, 6), #11(17, 6), #12(7, 6), #13(26, 10), #17(17, 10), #18(7, 10), #19(26, 14), #23(17, 14), #24(7, 14), #25(26, 19), #29(17, 19), #30(7, 19)

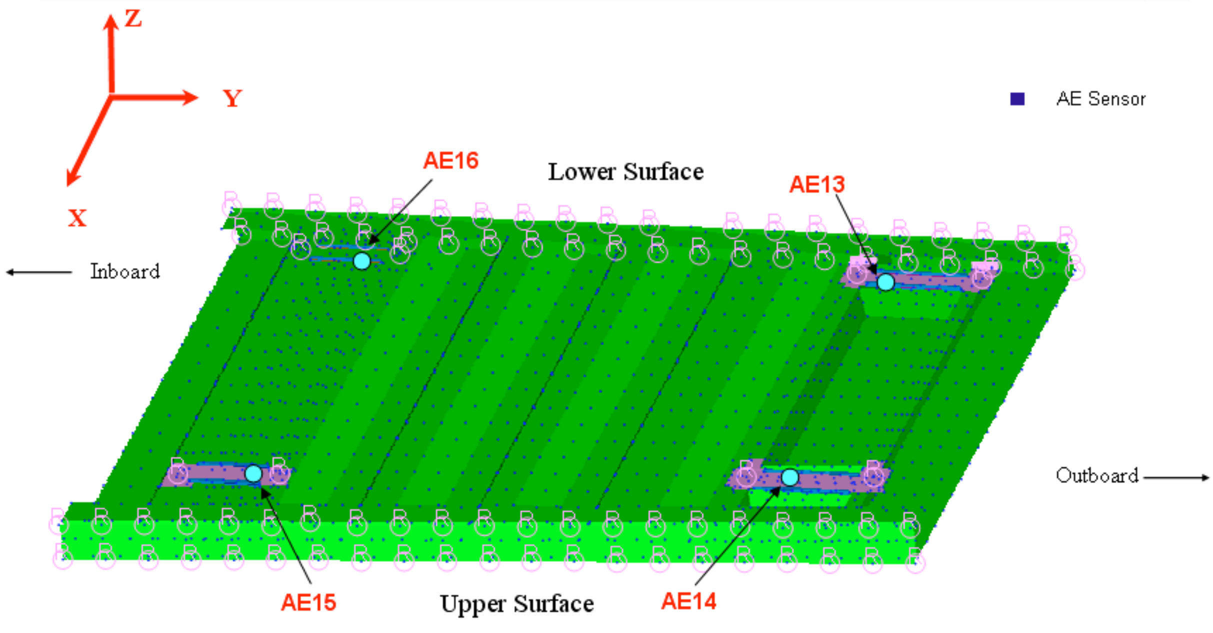


Figure 8: Fg(RCC)-1 Sensor Locations. Spar.

Figure 9: Fg(RCC)-1Post-test Impact Locations. Front View.

The piezoelectric sensors converted the sound wave energy to an electrical voltage. The energy computed from the voltage data collected by each sensor channel is referred to as the wave signal energy. (A complete description of the type of sensor used and calibration is given in the General Introduction to this report.)

The wave signal energy for each channel was analyzed and compared to the impact energy. A full description of the wave recording instrumentation is given in the General Introduction to this report. (Each individual sensor was connected to a separate amplification and filtering channel and the voltage produced by the sensor recorded and stored on a computer.)

The wave signal energy was computed by integrating the squared voltage with respect to time and dividing this number by the impedance at the preamp input. The voltage versus time values of the wave, which were displayed in the waveform window on the computer screen for each channel, were corrected for any applied gain (or attenuation). Attenuation was the norm because hypervelocity impact produced very energetic signals that in most cases would have saturated the A/D converter on the recording card in the computer had the amplitude not been reduced.

Attenuation was the norm because hypervelocity impact produced very energetic signals that in most cases would have saturated the A/D converter on the recording card in the computer had the amplitude not been reduced.

Some recorder channels were found to have a slight DC offset (Figure 10). This added significantly to the wave energy when the integral of squared voltage versus time signal was computed. To eliminate the offset, the average wave signal voltage for the impact event was subtracted from each data point. This resulted in a zeroed raw wave signal (no DC offset. Correcting the offset was more important for small signals than large signals.

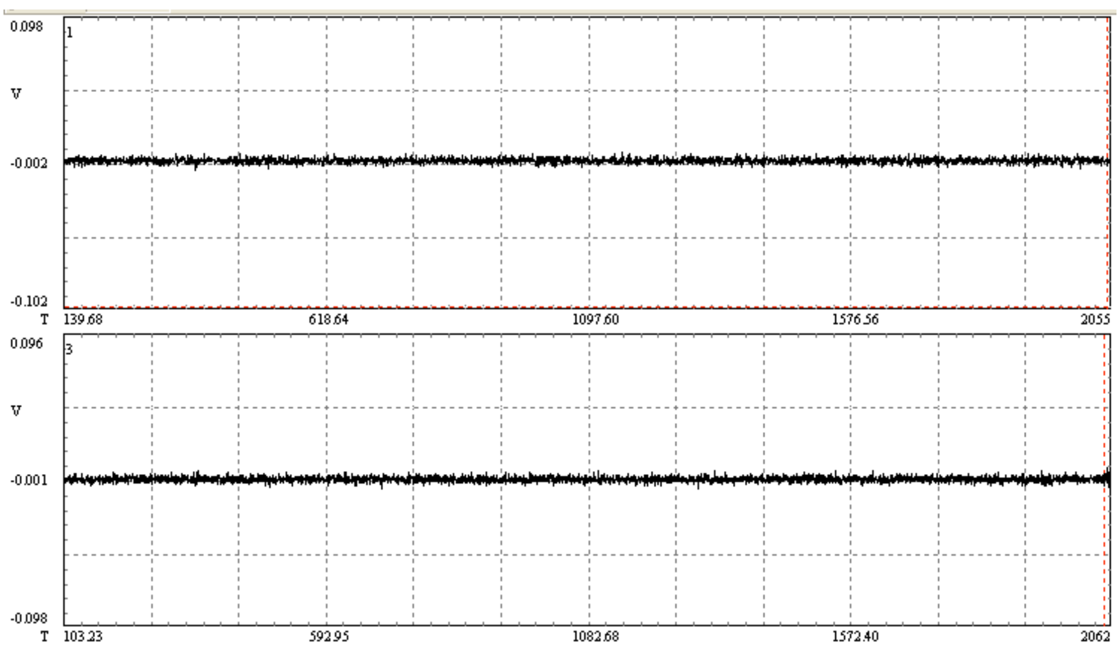


Figure 10: Example of DC Offset

The top signal is centered at -0.002 V whereas the bottom signal is centered at -0.001V.

A typical impact signal is shown in Figure 11. The impact signal has a distinct waveform and varies in both in arrival time and amplitude on each channel. The distinct modal characteristics can be seen in a time expanded view in Figure 12. The E mode is seen to arrive first with its lowest frequency in front followed by progressively higher frequencies. This is followed by the flexural (F) wave. The F wave characteristics are harder to discern because of the filtering of the attenuators and other effects discussed elsewhere in this report.

In some cases, the F wave characteristics are much more visible. The vastly different velocities of the modes were used to confirm the modes' presence.

The sound waves produced by impact are shown complete in the Appendix to this section. There it can be seen that the impact waves have the plate mode characteristics, i.e., the extensional wave arrives first, with its low frequency components out front followed by higher frequency components, and the F wave with just the opposite frequency arrangement. This differs, for example, from noise caused by electromagnetic interference (EMI). In contrast, EMI noise typically looks the same on every channel and arrives simultaneously (Figure 13). EMI exhibits no plate wave propagation characteristics.

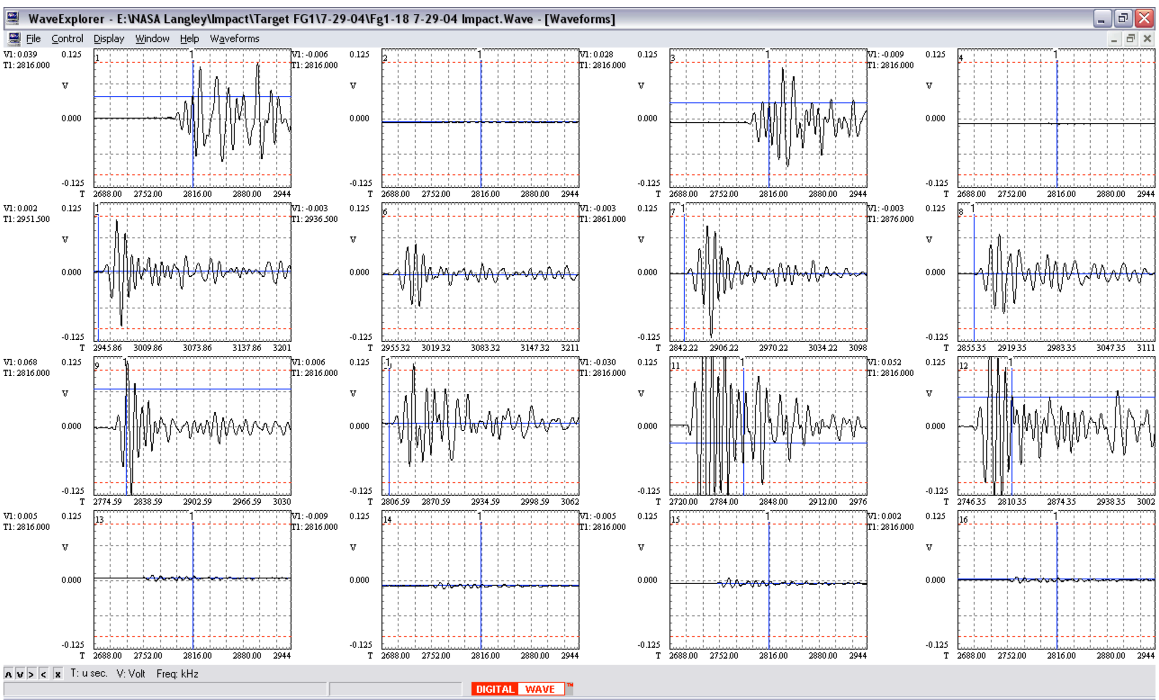


Figure 11: Fg(RCC)-1 Impact Signal for Shot #18

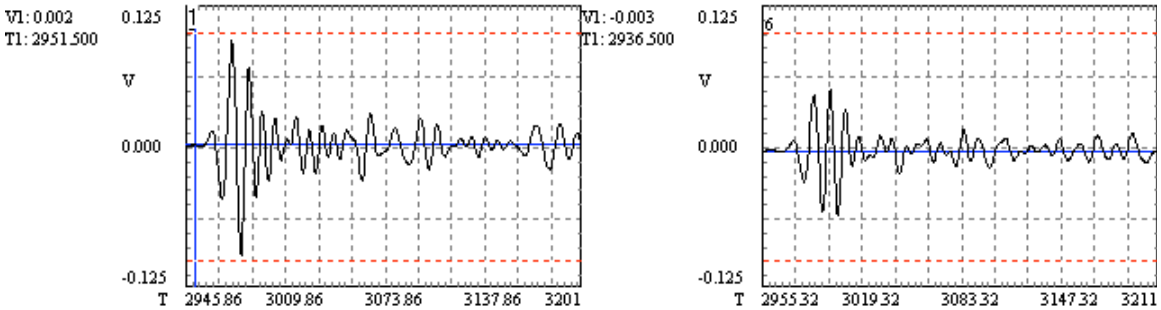


Figure 12: Detail of Fg(RCC)-1 Impact Signal for Shot #18, Channels 5 and 6

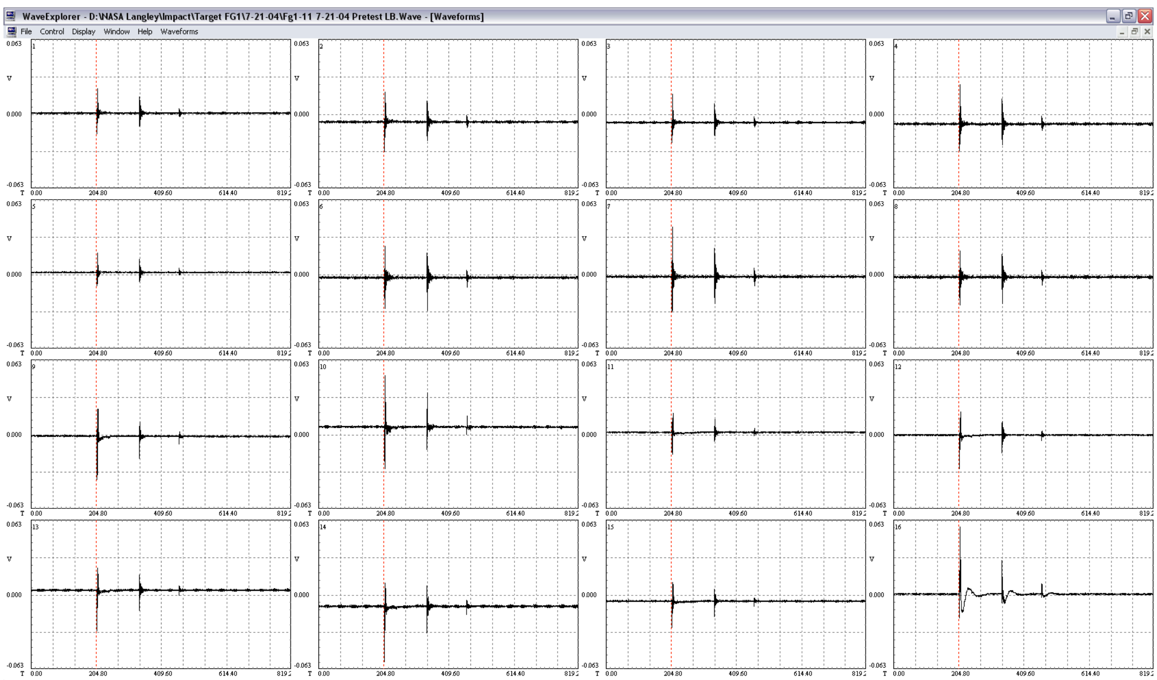


Figure 13: Fg(RCC)-1 Electromagnetic Interference for Shot #18

The MAE software computed the raw wave signal energy in Joules uncorrected for any analog gain or attenuation that may have been applied to the signal path. In order to compare the wave energies from shot to shot, the raw wave signal energy is converted by applying Equation 1 where E_{raw} is the energy computed using the recorded wave (with DC offset eliminated) and G is the system gain.

$$W.S.E. = \frac{E_{raw}}{G^2} \quad \textbf{Equation 1}$$

The gain G is computed by converting the logarithmic gain, M, in decibels with Equation 2 or 3.

$$M\ dB = 20\ Log_{10}\ (G) \quad \textbf{Equation 2}$$

$$G = 10^{\frac{M}{20}} \quad \textbf{Equation 3}$$

The gains, raw wave signals, and wave energies for each shot are listed in the data tables in the Appendix to this section.

High velocity impact produced signals on the order of a few volts directly out of the transducer. These were much larger signals than typically found in most acoustic emission measurements of, say, crack growth in metals. For most shots, attenuators were placed in the signal lines between the sensors and the digital recorders. Greater attenuation was applied for the higher energy shots which made the raw energy appear to be much less. The energy was restored to its full value by compensating in the analysis for the greater attenuation, Equation 3 above.

Results

The most important quantities used in the analysis of the wave signals were the wave signal energy and projectile kinetic energy for each shot. These are given in Table 1 along with the test number, impactor diameter, and angle of impact. Wave signal energy is the sum of the energy, in nano-Joules, detected by all of the sensors. Kinetic energy is calculated based on the velocity and mass of projectile (density of aluminum = 2700 kg/m^3) according to the usual formula K.E. = $mv^2/2$. As will be seen, the kinetic energy correlated fairly well with the damage. Normal KE is just the kinetic energy associated with the projectile velocity component normal to the target surface at the point of impact.

Test No.	Imp Dia mm	Imp Ang Deg	Normal K. E. J (± 5%)	Total K. E. J (± 5%)	W.S.E. nJ
FG1-1b	0.4	90	2.20	2.20	4.609E+02
FG1-2	0.4	45	0.91	1.82	9.726E+02
FG1-3	0.8	45	8.36	16.73	1.468E+04
FG1-4	0.4	30	0.55	2.20	2.263E+02
FG1-5	1.2	60	43.21	57.65	6.021E+05
FG1-6	0.6	45	3.60	7.21	4.508E+03
FG1-7	0.8	90	16.73	16.73	1.967E+04
FG1-8	0.6	60	5.29	7.06	7.470E+03
FG1-9	1.8	30	48.60	194.56	3.050E+06
FG1-10	0.8	45	8.39	16.78	1.459E+04
FG1-11	0.8	45	8.43	16.88	1.264E+04
FG1-12	1.0	30	7.71	30.88	1.260E+05
FG1-13	1.2	90	55.65	55.65	7.715E+05
FG1-14	1.0	30	7.71	30.88	1.831E+04
FG1-15	2.8	60	508.16	677.97	7.377E+06
FG1-15a	0.8	45	8.07	16.15	1.258E+04
FG1-16	1.6	60	104.52	139.45	1.956E+06
FG1-17	1.8	30	49.59	198.55	1.065E+06
FG1-18	2.4	45	213.30	426.94	2.763E+06
FG1-19	2.4	90	426.94	426.94	3.355E+06
FG1-20	2.0	30	61.71	247.07	1.596E+06
FG1-21	0.6	60	5.25	7.00	5.583E+03
FG1-22	2.0	30	64.74	259.18	1.927E+06
FG1-23	1.0	45	16.09	32.21	1.710E+05
FG1-24	2.0	20			2.348E+05
FG1-25	1.8	90	191.18	191.18	3.964E+06
FG1-26	2.4	60	344.67	459.85	3.023E+06
FG1-27	1.8	60	142.04	189.50	2.568E+06
FG1-28	2.8	45	353.21	706.99	1.856E+07
FG1-29	2.8	30	180.27	721.73	1.089E+07
FG1-30	1.6	30	14.74	126.12	6.926E+04

Table 1: Fg(RCC)-1 Normal Kinetic Energy and Wave Signal Energy (All Sensors).
There is no K. E. listed for shot #24 because no velocity was recorded.

The damage for each shot is given in Table 2. The crater volume damage is the product of the recorded length, width, and depth measurements on the front side of the panel for each impact. Damage area is the product of recorded length and width measurements on the front side of the panel. Figure 14 shows the impact damage for shot #18.

Test	Normal K. E.	Total K. E.	Damage Area	Crater Volume
No.	J (± 5%)	J (± 5%)	mm^2	mm^3
FG1-1b	2.20	2.20		0.2
FG1-2	0.91	1.82	24.0	0.2
FG1-3	8.36	16.73	75.0	2.5
FG1-4	0.55	2.20		
FG1-5	43.21	57.65	113.0	9.6
FG1-6	3.60	7.21	45.0	0.7
FG1-7	16.73	16.73	32.0	5.0
FG1-8	5.29	7.06	45.0	0.6
FG1-9	48.60	194.56	196.0	39.9
FG1-10	8.39	16.78	67.0	2.8
FG1-11	8.43	16.88	55.0	2.7
FG1-12	7.71	30.88	61.0	4.7
FG1-13	55.65	55.65	231.0	21.7
FG1-14	7.71	30.88	88.0	9.4
FG1-15	508.16	677.97	1080.0	315.0*
FG1-15a	8.07	16.15	77.0	5.4
FG1-16	104.52	139.45	238.0	38.1
FG1-17	49.59	198.55	189.0	56.3
FG1-18	213.30	426.94	640.0	233.5
FG1-19	426.94	426.94	1700.0	132.0*
FG1-20	61.71	247.07	272.0	158.4
FG1-21	5.25	7.00	50.0	0.4
FG1-22	64.74	259.18	378.0	65.8
FG1-23	16.09	32.21	102.0	6.9
FG1-24			180.0	27.5
FG1-25	191.18	191.18	558.0	146.9
FG1-26	344.67	459.85	1078.0	252.0*
FG1-27	142.04	189.50	812.0	63.0*
FG1-28	353.21	706.99	812.0	198.0*
FG1-29	180.27	721.73	638.0	210.0*
FG1-30	14.74	126.12	112.0	10.2

Table 2: Fg(RCC)-1 Damage.

* = Hole. There is no K. E. listed for shot #24 because no velocity was recorded. There was no Fiber Damage Area recorded for shots #1b and 4. There was no Crater Volume recorded for shot #4. Shots #15, 19, 26-29 created holes. It was assumed that the crater depth for holes was the thickness of the specimen, 6 mm.

Figure 14: Fg(RCC)-1 Impact Damage Area for Shot #18

Discussion

Sound waves containing both sonic and ultrasonic frequencies were created by each impact. The energy in the waves is some fraction of the energy of the impactor. An analysis method was sought that would allow a straightforward and simple technique for comparing the wave energies to the projectile kinetic energy, and thus the damage figures. One way would be to look at the energy sensor by sensor. For example, the wave energy for shot #1 could be computed from just the signal at sensor 1, then the energy from shot #2 could be computed from the signal at sensor 1, and so forth, and then the energies could be graphed.

The problem with this method would be that the impact position changed from shot to shot. The method might work if new identical targets were available each time and the sensor 1 position and shot location were always the same. Given this was not feasible, perhaps correction factors could be developed, but it would be arduous, if not impossible, to compare shot energies by correcting for the all the source to receiver relative positional changes because there are so many effects for which to account. Geometric spreading in 3-D means that the intensity varies as $1/r^2$. In plates the spreading is circular and the intensity only drops as 1/r. Calculating the 1/r attenuation caused by geometric spreading would account for just one effect. There is also attenuation due to material properties which is a function of both frequency and direction. Waves that cut across the main fiber directions were attenuated more than waves that propagated along the fiber directions. This is known as material anisotropy.

In order to reduce the effect of varying impact positions on the acoustical energy values, the energies of the waves at all the transducers on the target were summed together for each shot. This was approach was based on the following reasoning: If a given sensor records the signals for two impacts that have the same kinetic energy, the closer impact would appear to have a larger wave signal energy. Since the sensors surrounded the impacts, variations in the propagation paths would be roughly accounted for by adding the wave signal energy collected by all sensors. This approach also makes use of symmetry: Two symmetric impacts would have symmetric propagation paths and thus the same total wave signal energy if the energies collected by all the sensors were summed. The graphs show that this turned out to be an efficacious approach. Symmetry could not be invoked in every case so there were outliers.

The damage measurements themselves were crude. Although some damage in the interior plies seemed apparent, the "damage area" value that was plotted against KE was related solely to the area the damaged fibers occupied as measured with a ruler on the outside (the impact side) surface.

Overall, the correlations exhibited the correct trend of greater impact energy resulting in larger wave energy.

A separate sum was performed for the set of flange sensors and the set of spar sensors, the reason being that the spar sensors ultimately would be the ones used in an actual flight since they would not be subject to the extreme heat of the RCC. The waves at the RCC, flange and spar sensors died out before the end of the recording time window so the total energy available was captured. The same recording time was used for every shot. Greater attenuation was applied for the higher energy shots which made the raw energy appear to be much less. The energy was restored to its full value by compensating in the analysis for the greater attenuation.

It should be kept in mind that shots were performed at various angles to the normal to the target at the point of impact. In order to compare all shots on the same graph, the kinetic energy for the normal velocity component was computed (sine squared of the angle, ninety degrees is normal). Whether this component alones creates all the damage is debatable, but there is a general trend of increasing normal kinetic energy leading to increasing damage. The question of whether to solely use the normal component rather than the total kinetic energy is a question impact researchers have struggled with for some time. In 1959, J.L. Summers investigated high-speed impact at oblique angles [reference]. He 'assumed that the component of velocity parallel to the target surface does not contribute to the target penetration' and yet conceded that the normal kinetic energy 'does not take into account all of the kinetic energy of the projectile'. Summers found a strong correlation between penetration depth and normal kinetic energy for high-speed impact, but did not speculate on how kinetic energy contributes to damage area or crater size.

Graphs from Targets C-1 and C-2 clearly showed that crater volume was related to total kinetic energy whereas damage area was related to normal kinetic energy. This could agree with Summers' findings if the parallel component of kinetic energy only affected the length and width dimensions of the crater and the normal component affected the depth. Figures 15-18 plotted kinetic energy versus damage for Fg(RCC)-1 but were inconclusive in resolving how impact angle influences damage.

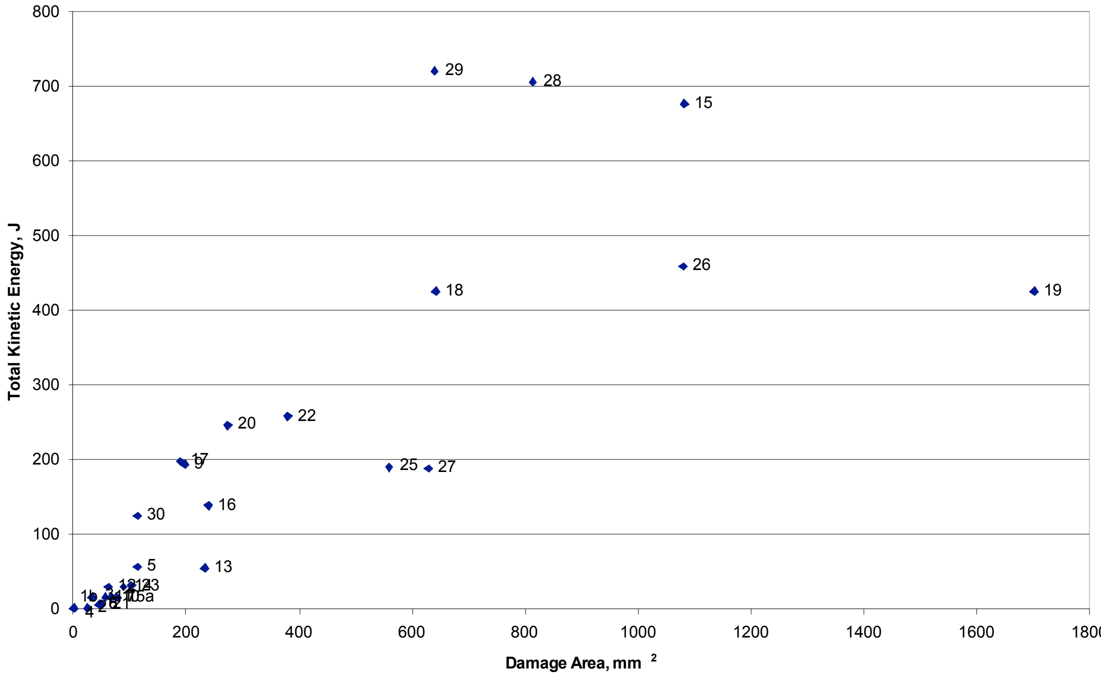


Figure 15: Fg(RCC)-1 Total Kinetic Energy vs. Damage Area

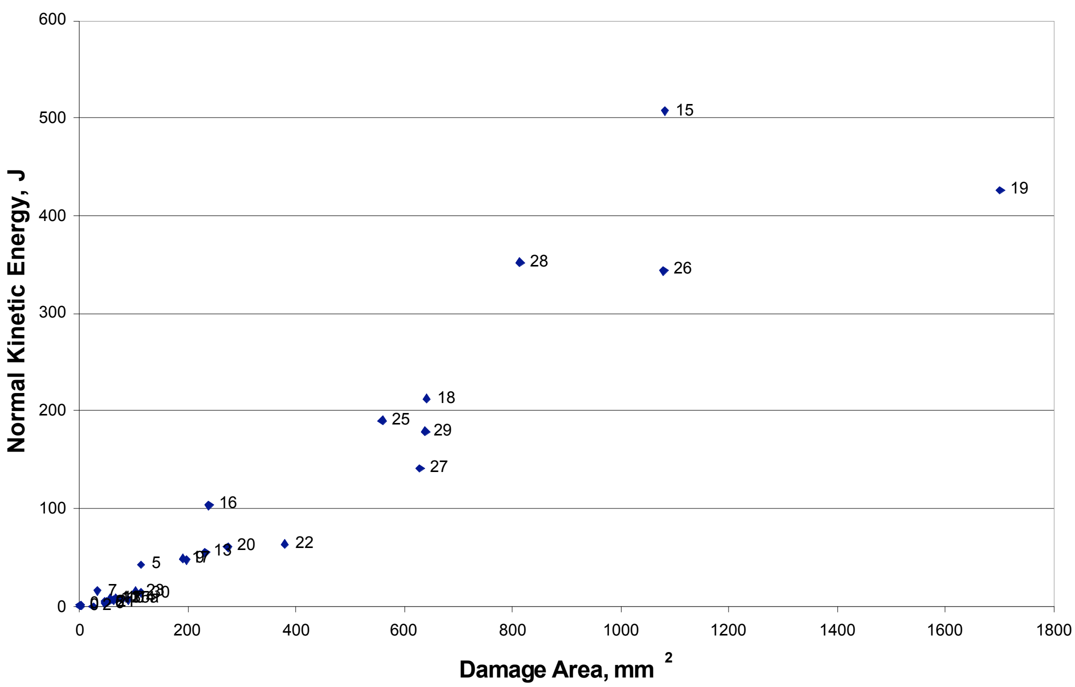


Figure 16: Fg(RCC)-1 Normal Kinetic Energy vs. Damage Area

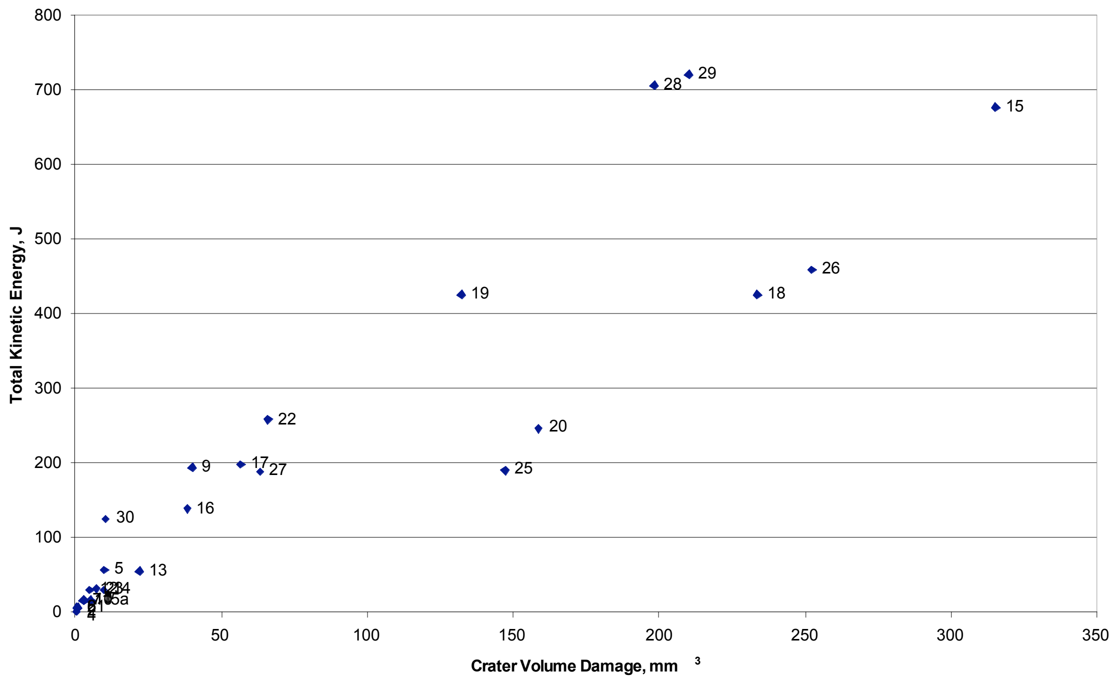


Figure 17: Fg(RCC)-1 Total Kinetic Energy vs. Crater Volume Damage

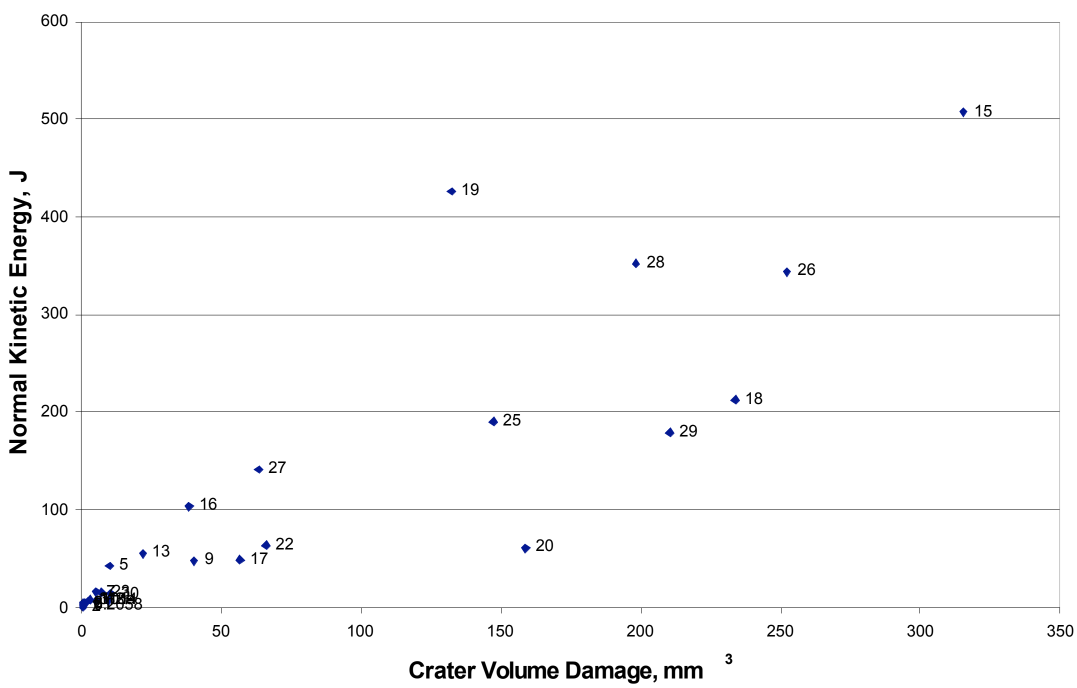


Figure 18: Fg(RCC)-1 Normal Kinetic Energy vs. Crater Volume Damage

The following graphs (Figures 19-43) plot wave signal energy versus kinetic energy and damage for each group of sensors.

All Sensors

"All Sensors" included sensors located on the back surface of the target, the spar, and the flange. The surface sensors were closest to the impacts so they contributed the largest fraction of the total wave signal energy collected by all the sensors.

There was a linear relationship between wave signal energy, total kinetic energy, normal kinetic energy, fiber damage area, crater volume damage, inside delamination are, and outside delamination area. None of these variables stood out as being best correlated with wave signal energy. Since the damage measurements had a large amount of inherent error due to measurement techniques, it is perhaps best to focus on wave signal energy versus kinetic energy.

Obviously, if there was a linear relationship between total kinetic energy and crater volume damage (Figure 17) as well as wave signal energy and total kinetic energy (Figure 19), there should have been a linear relationship between wave signal energy and crater volume damage (Figure 22). Shots #28 and 29 were two of the most troublesome data points that interfered with this outcome. Both produced too much W.S.E. for the amount of kinetic energy they had and the damage they created. There was nothing special about their location on the specimen and both had approximately the same normal and total kinetic energy. The only noticeable trait of shots #28 and 29 was that that the channel gain for sensors 1-12 was set to -55 dB[1]. The only other shot with such a great attenuation was shot #15. Shot #15, however, had a much larger normal kinetic energy than either shots #28 and 29.

[1] The only exception is that the gain for shot #29 on sensor 10 is -61 dB, but this is not significant when considering the total W.S.E. from all sensors.

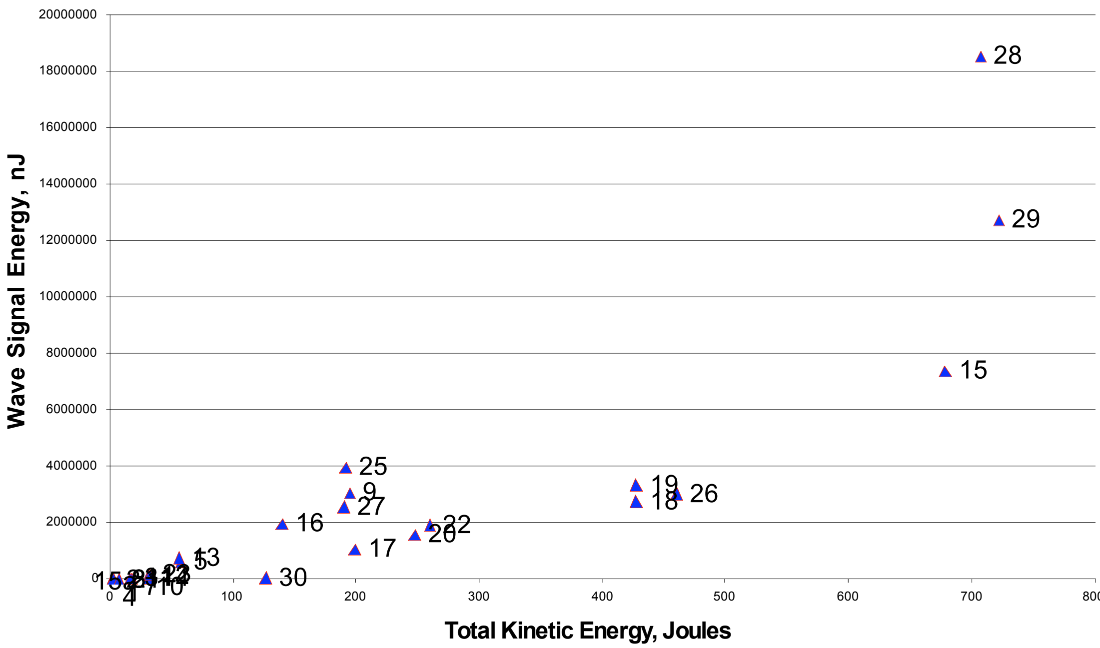


Figure 19: Fg(RCC)-1 Wave Signal Energy vs. Total Kinetic Energy – All Sensors

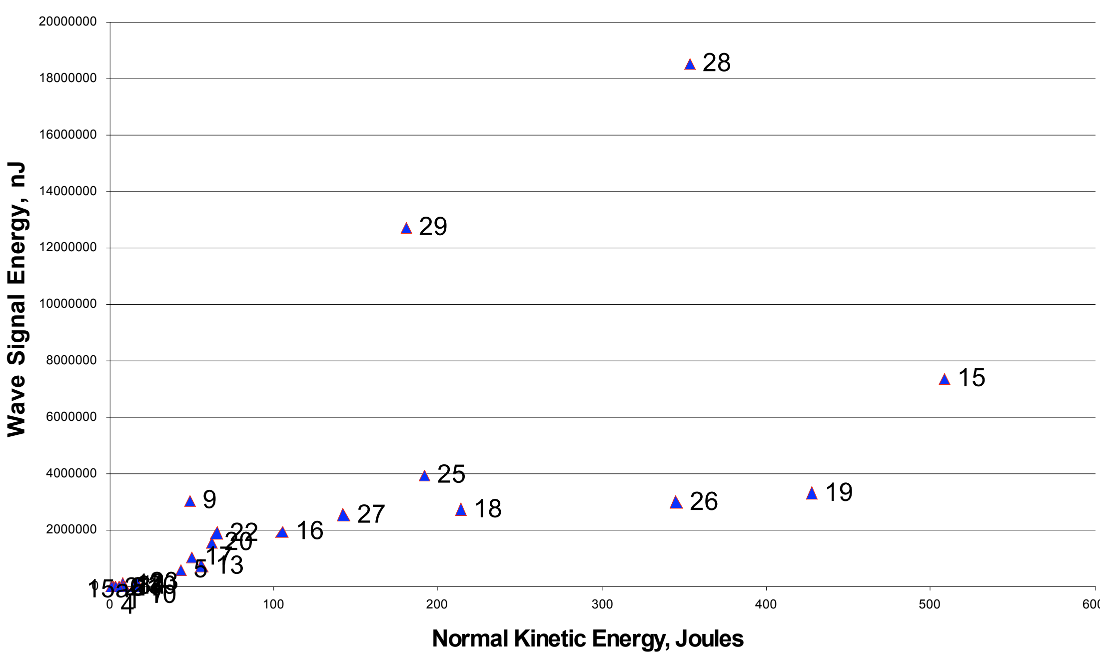


Figure 20: Fg(RCC)-1 Wave Signal Energy vs. Normal Kinetic Energy - All Sensors

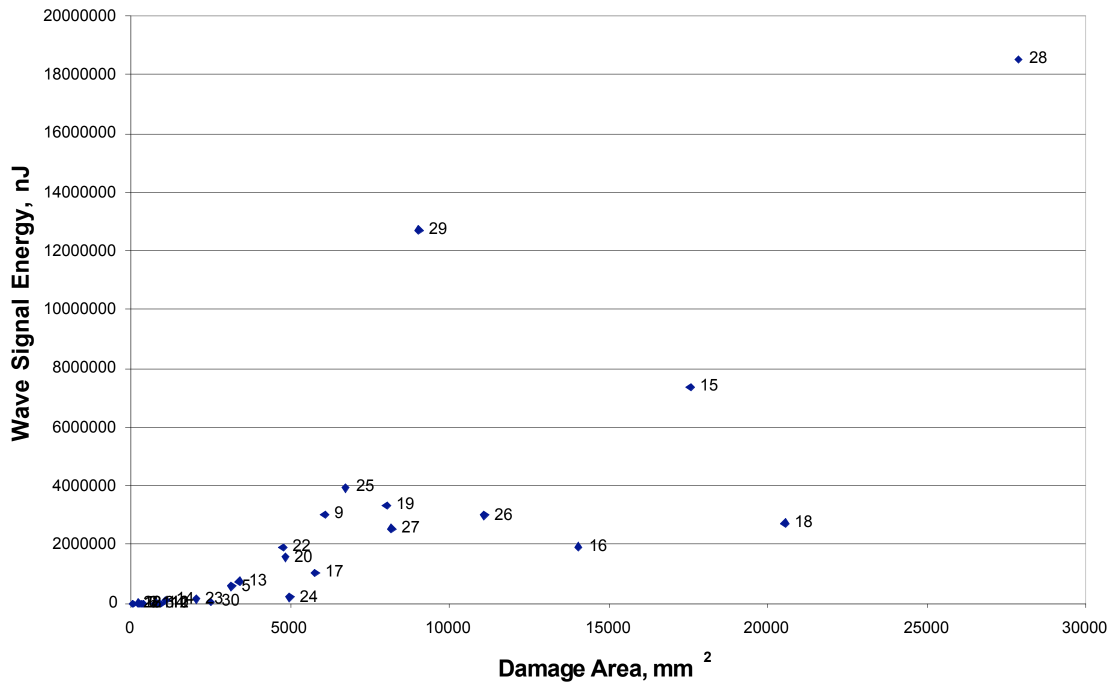


Figure 21: Fg(RCC)-1 Wave Signal Energy vs. Fiber Damage Area – All Sensors

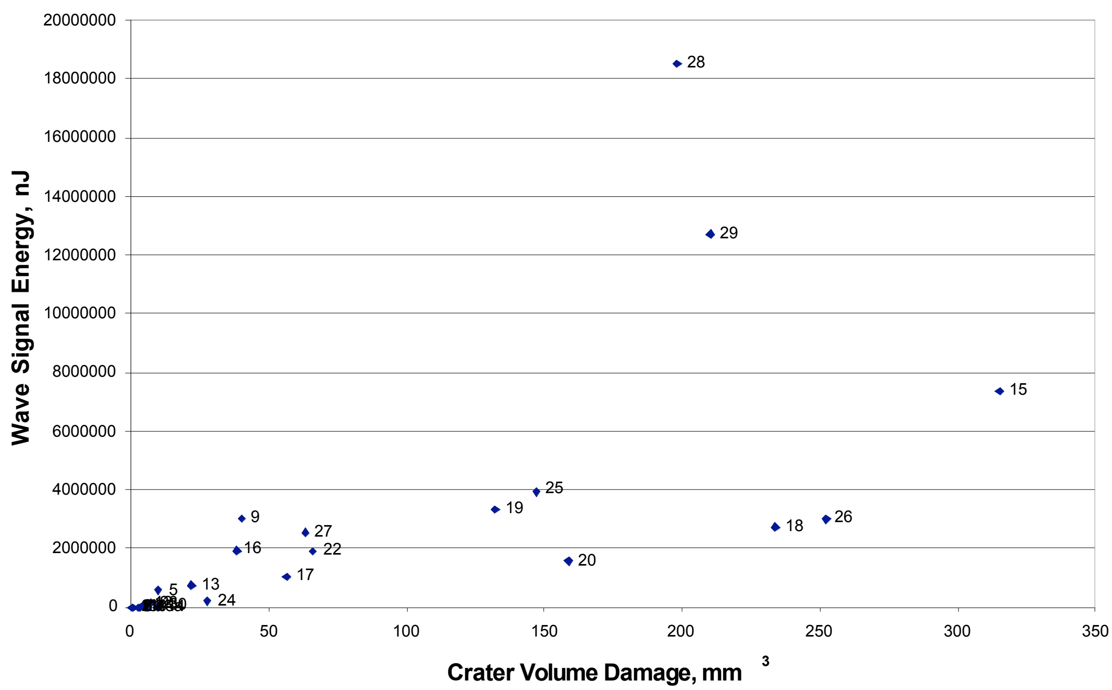


Figure 22: Fg(RCC)-1 Wave Signal Energy vs. Crater Damage Volume – All Sensors

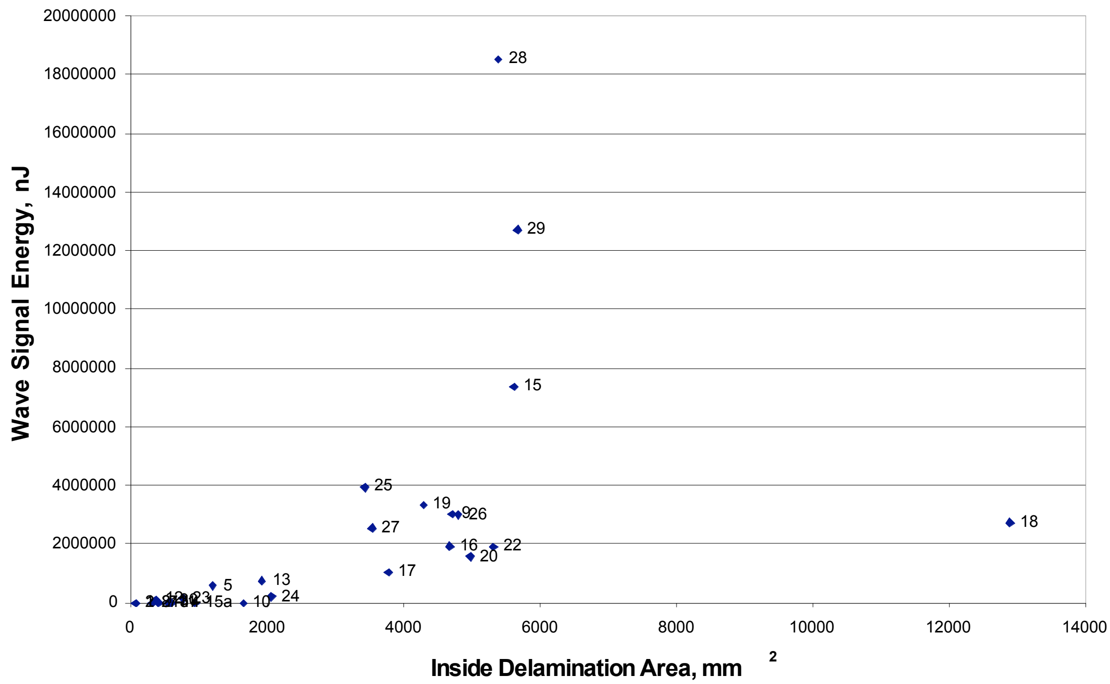


Figure 23: Fg(RCC)-1 Wave Signal Energy vs. Inside Delamination Area – All Sensors

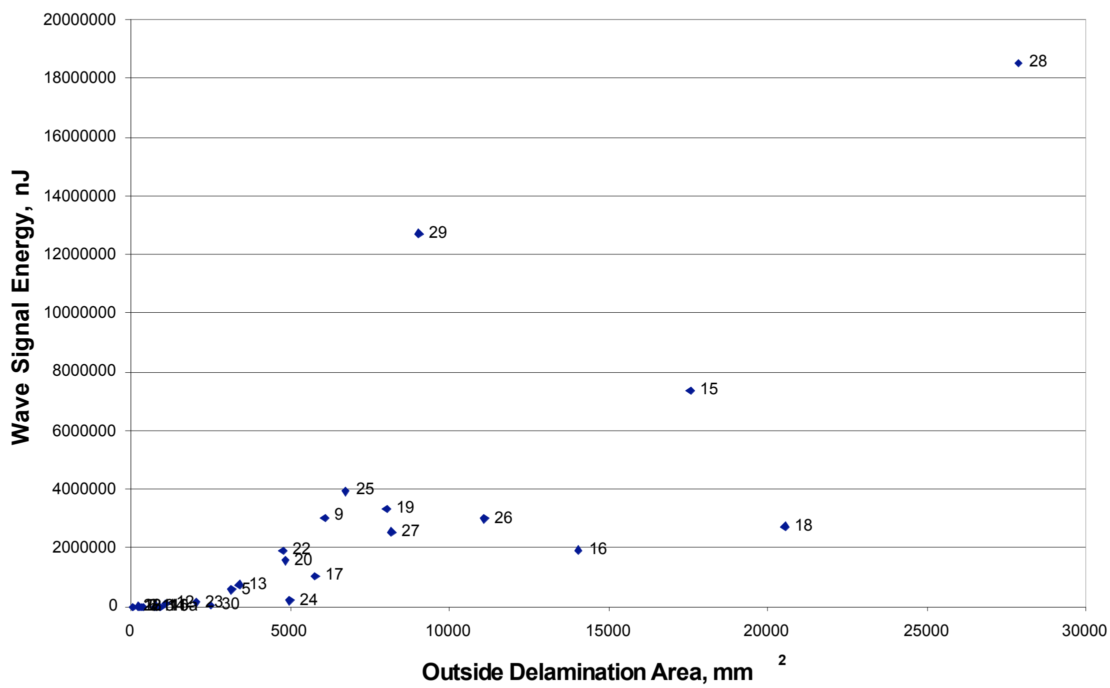


Figure 24: Fg(RCC)-1 Wave Signal Energy vs. Outside Delamination Area – All Sensors

Flange Sensors

The flange sensors collect less impact energy than the surface sensors, but more than the spar sensors. The flange graphs help to describe how the waves propagate through the target from the surface to the spar.

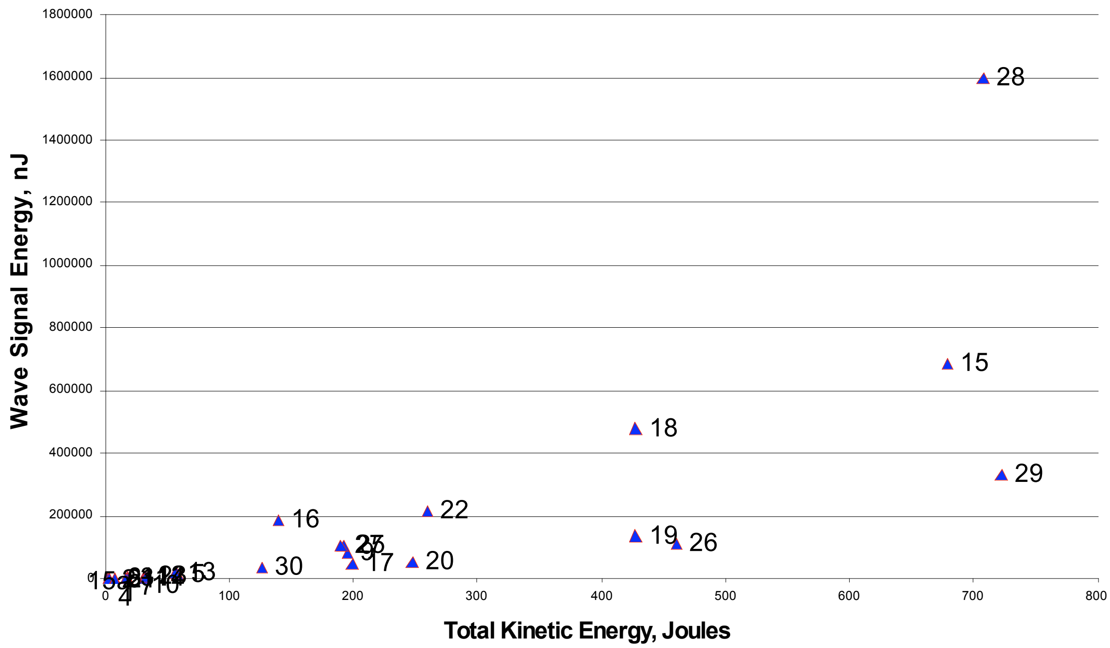


Figure 25: Fg(RCC)-1 Wave Signal Energy vs. Total Kinetic Energy – Flange Sensors Only

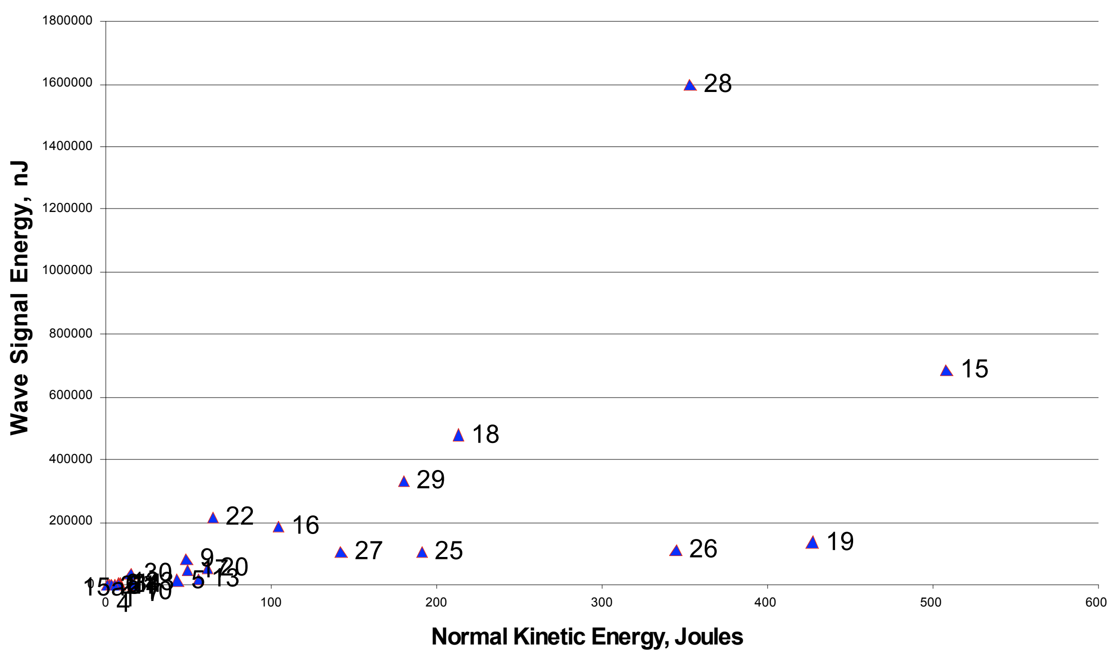


Figure 26: Fg(RCC)-1 Wave Signal Energy vs. Normal Kinetic Energy – Flange Sensors Only

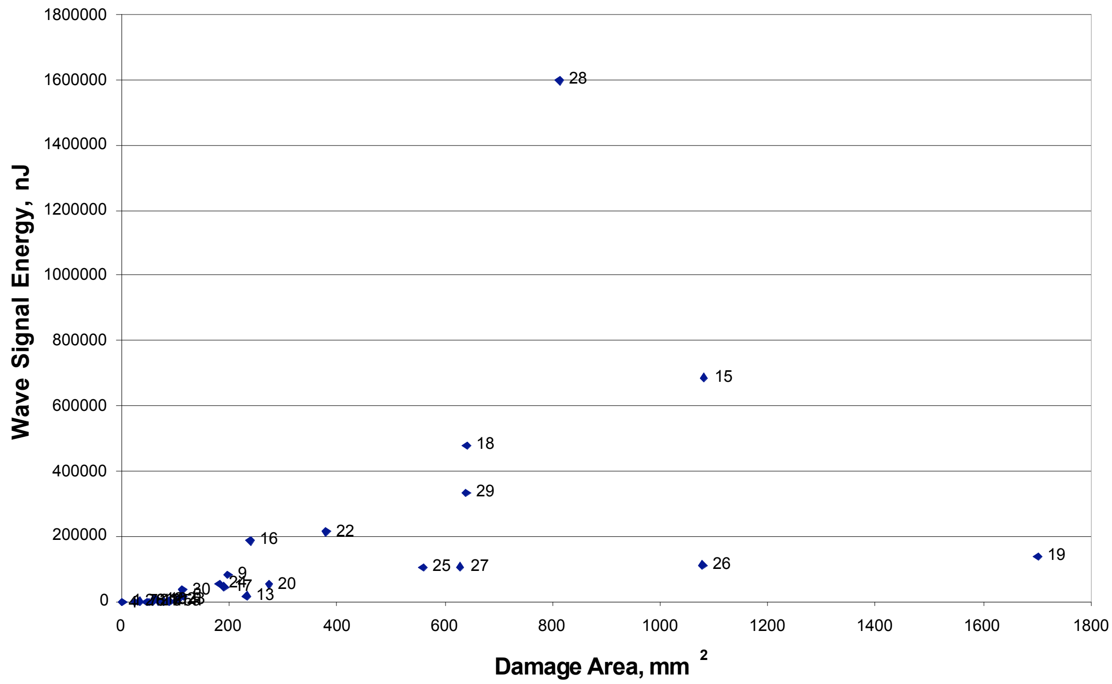


Figure 27: Fg(RCC)-1 Wave Signal Energy vs. Fiber Damage Area - Flange Sensors Only

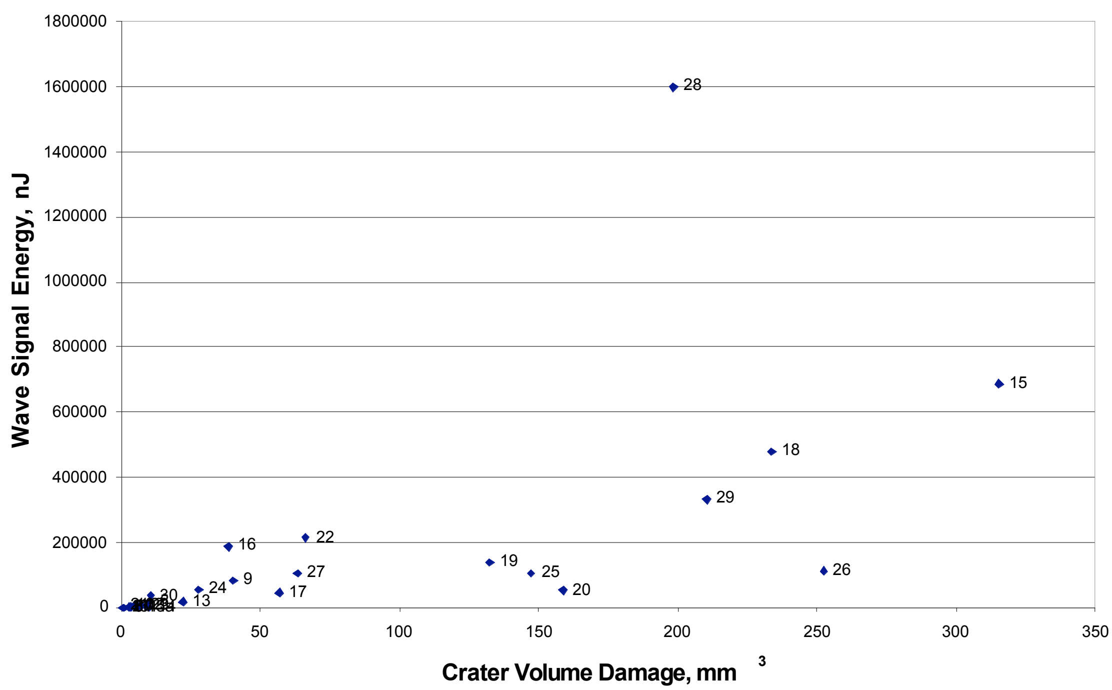


Figure 28: Fg(RCC)-1 Wave Signal Energy vs. Crater Volume Damage - Flange Sensors Only

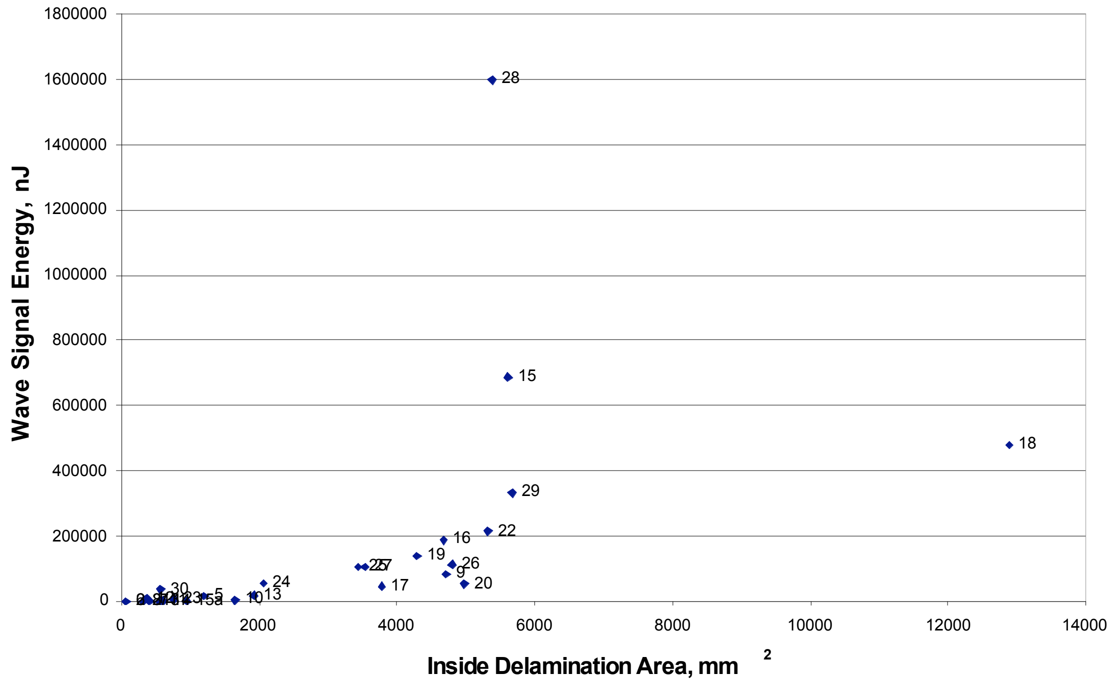


Figure 29: Fg(RCC)-1 Wave Signal Energy vs. Inside Delamination Area - Flange Sensors Only

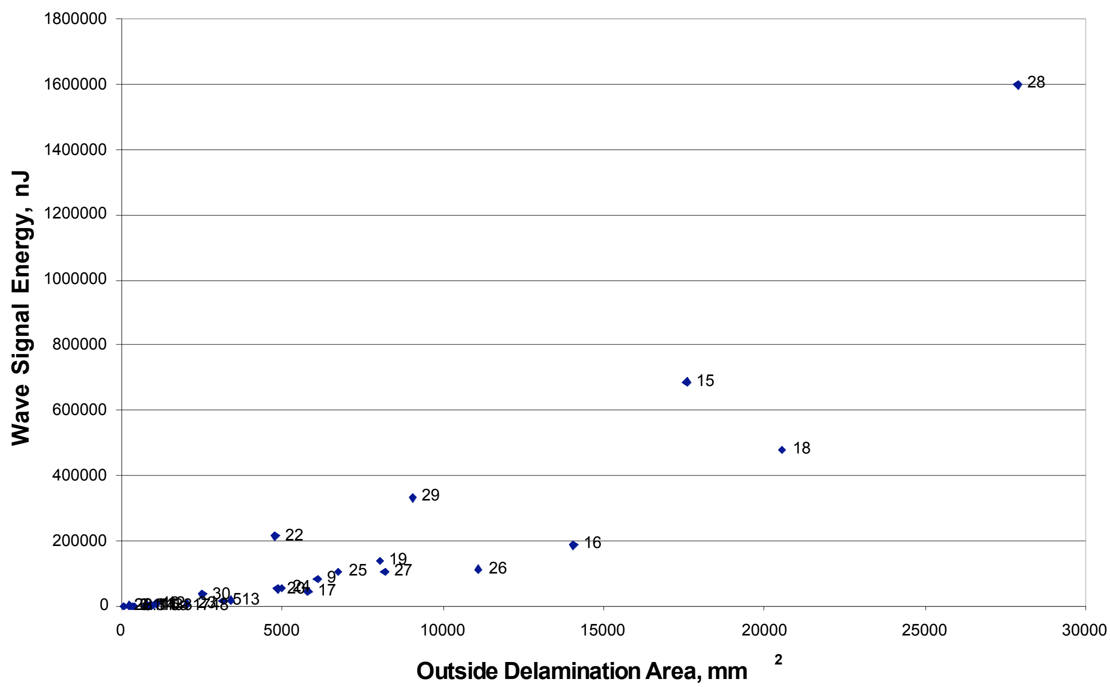


Figure 30: Fg(RCC)-1 Wave Signal Energy vs. Outside Delamination Area - Flange Sensors Only

Spar Sensors

The projectile penetrated the test article for shot #15. Debris struck the spar and saturated the spar sensors. The wave signal for spar sensors 13-16 is shown in Figure 31. Due to saturation, shot #15 was discarded from spar sensor graphs. The data from sensors 1-12 was still valid.

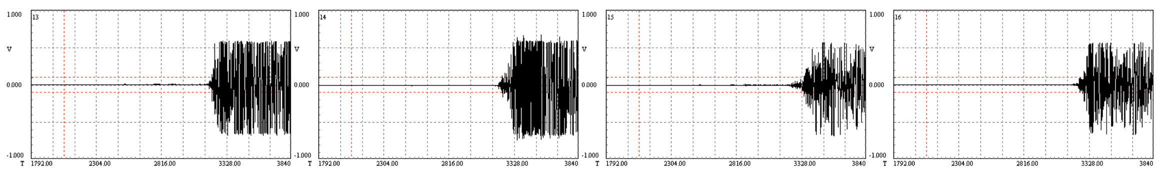


Figure 31: Shot #15 Saturated Spar Sensors

Shots that created holes (# 15, 19, 26-29) appeared as outlying data points on the spar sensor graphs (Figures 26, 28, 30, 32, 34, and 36). When these points were omitted (Figures 32, 34, 36, 38, 40, and 42), the spar wave signal energy appeared to correlate linearly with damage and energy. These shots may have penetrated the test article like shot #15 and caused a small amount of debris to strike the spar. Unlike shot #15, shots #19 and #26-29 did not saturate the sensors.

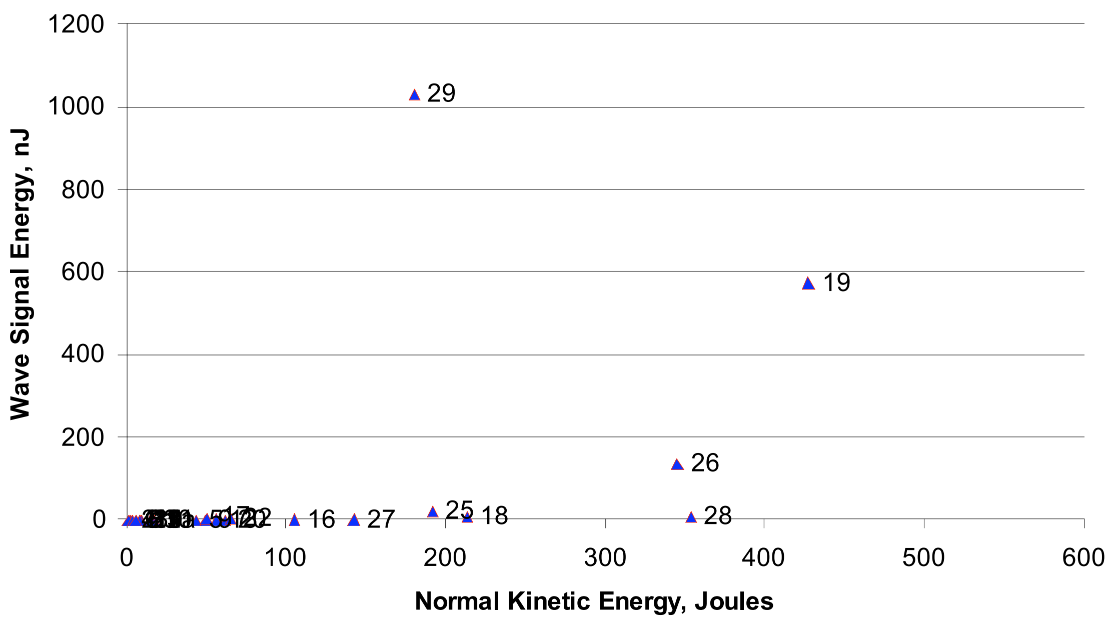


Figure 32: Fg(RCC)-1 Wave Signal Energy vs. Normal Kinetic Energy - Spar Sensors Only. Shot #15 omitted due to saturation.

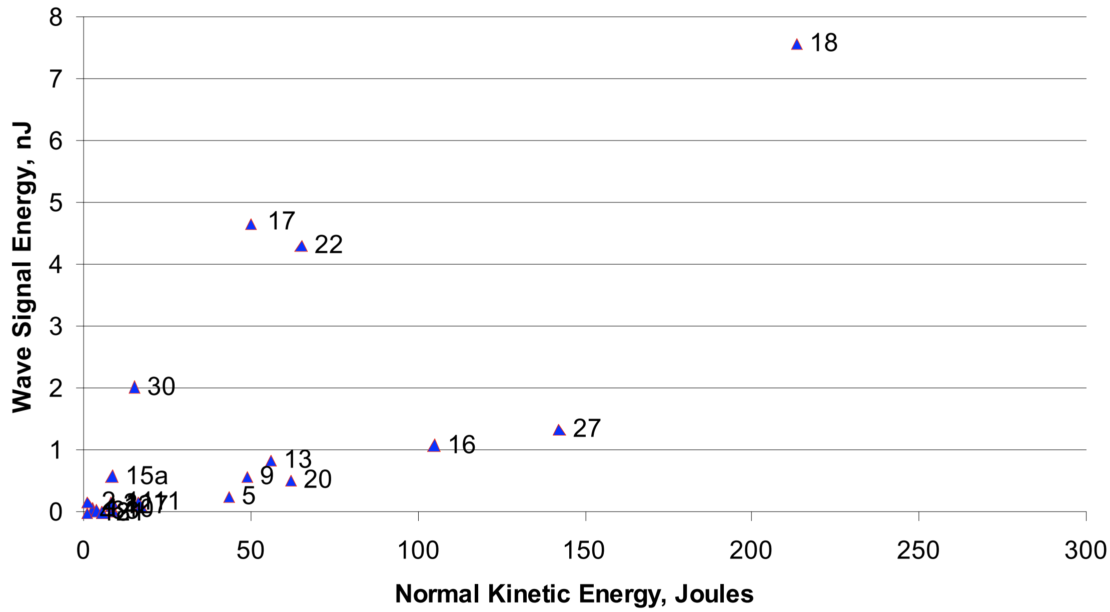


Figure 33: Fg(RCC)-1 Detail of Wave Signal Energy vs. Normal Kinetic Energy - Spar Sensors Only. Shot #15 omitted due to saturation. Shots #19, #25, #26, #28 and #29 shown on rescaled graph above.

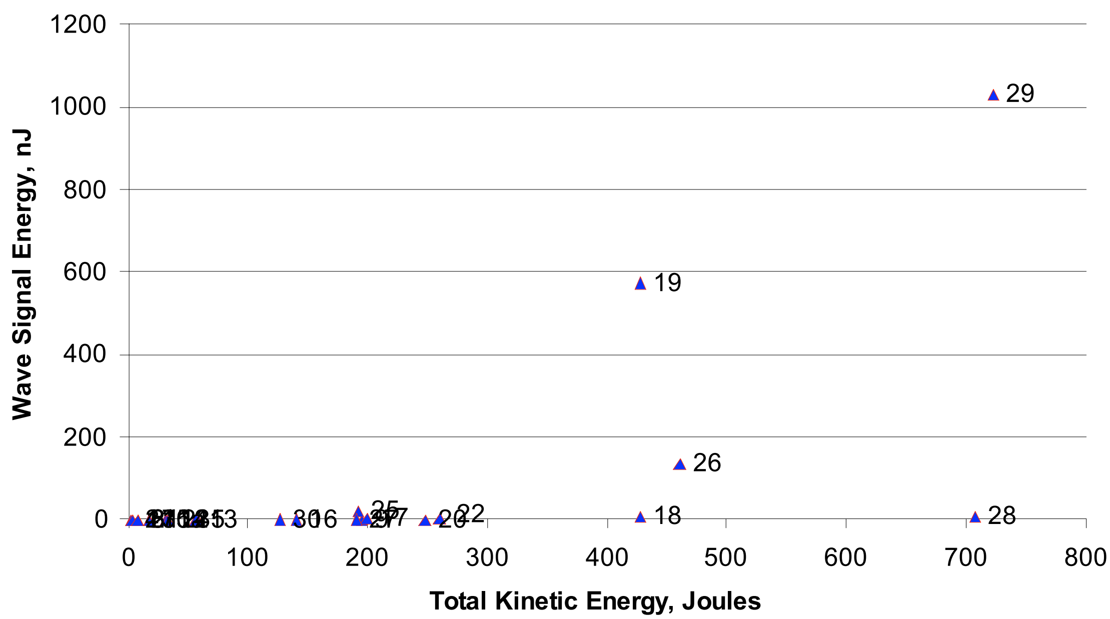


Figure 34: Fg(RCC)-1 Wave Signal Energy vs. Total Kinetic Energy - Spar Sensors Only. Shot #15 omitted due to saturation.

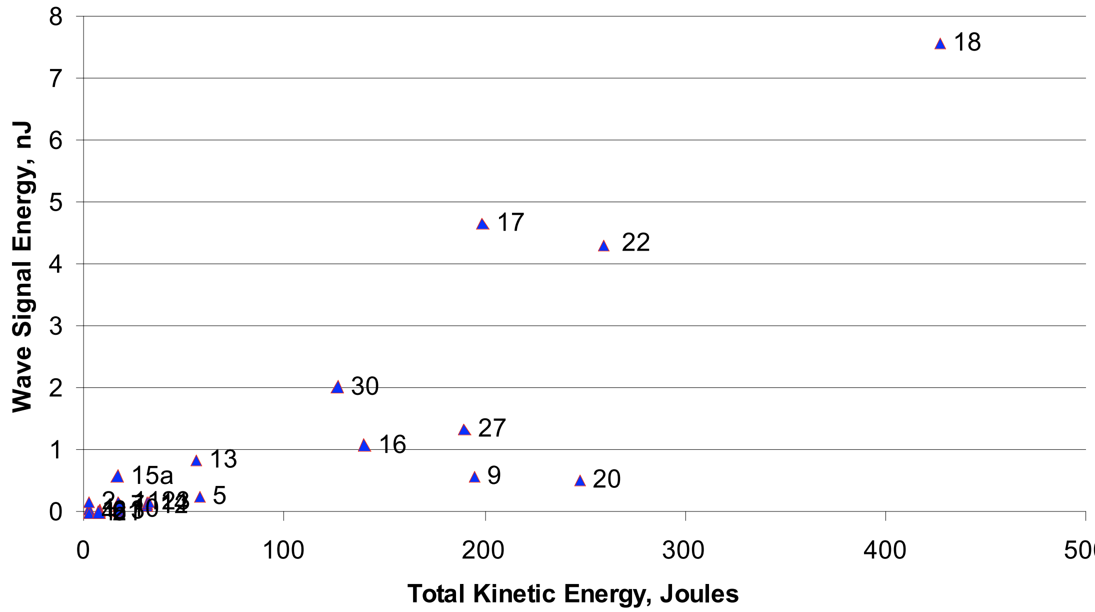


Figure 35: Detail of Fg(RCC)-1 Wave Signal Energy vs. Total Kinetic Energy - Spar Sensors Only. Shot #15 omitted due to saturation. Shots #19, #25, #26, #28 and #29 shown on rescaled graph above.

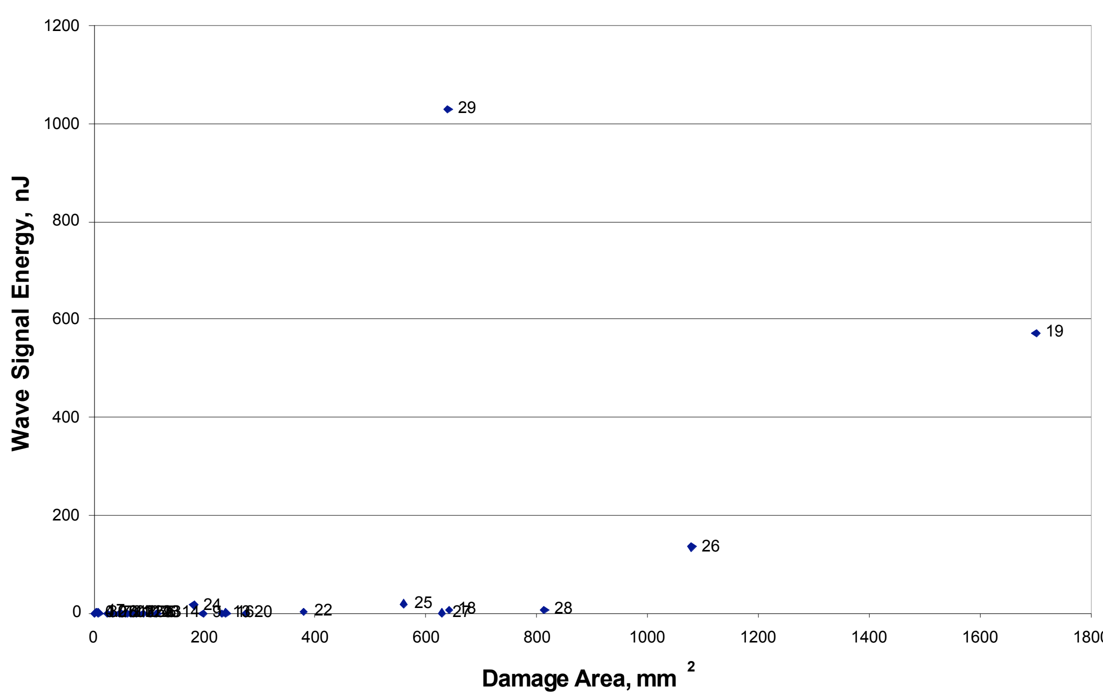


Figure 36: Fg(RCC)-1 Wave Signal Energy vs. Fiber Damage Area - Spar Sensors Only. Shot #15 omitted due to saturation.

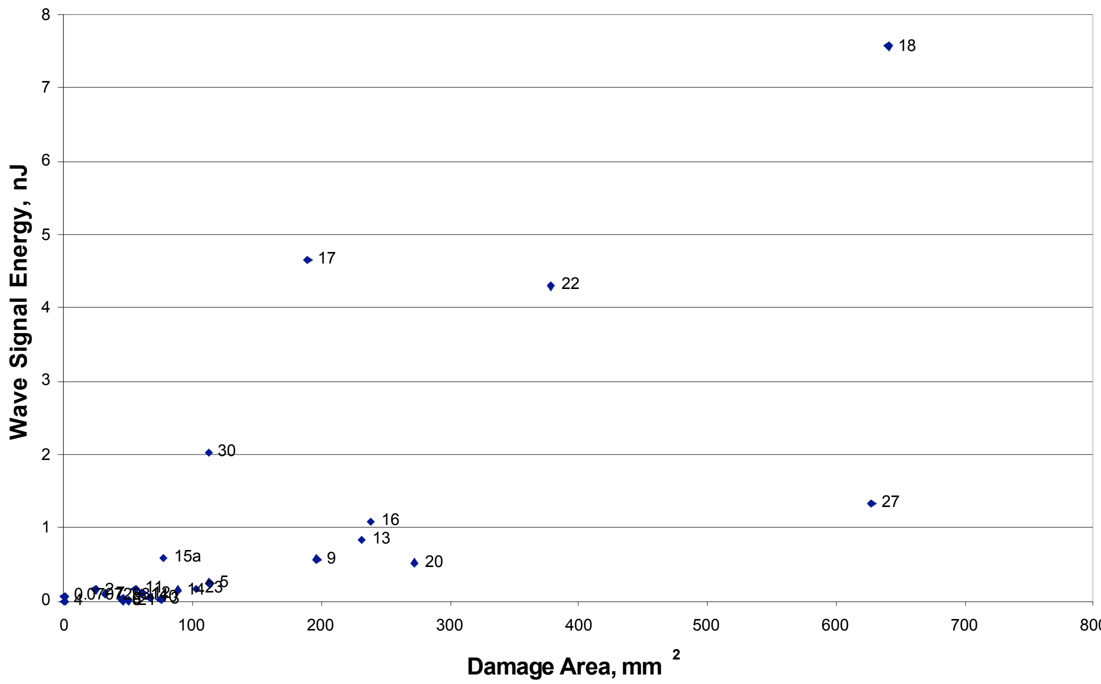


Figure 37: Detail of Fg(RCC)-1 Wave Signal Energy vs. Fiber Damage Area - Spar Sensors Only. Shot #15 omitted due to saturation. Shots #19, #25, #26, #28 and #29 shown on rescaled graph above.

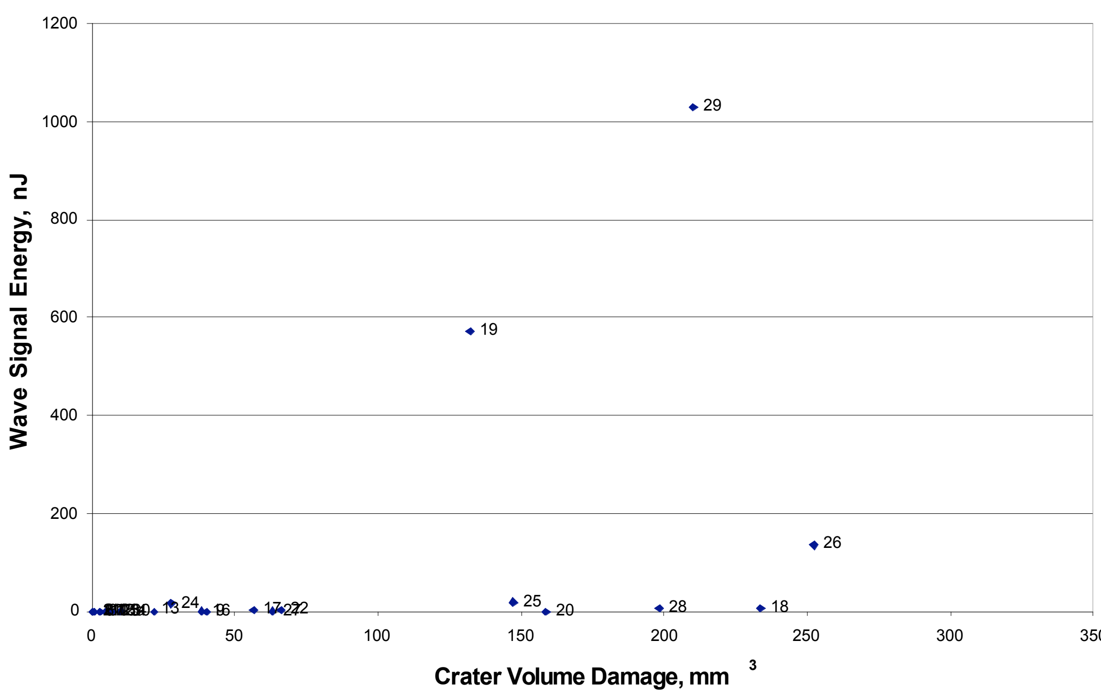


Figure 38: Fg(RCC)-1 Wave Signal Energy vs. Crater Volume Damage - Spar Sensors Only. Shot #15 omitted due to saturation.

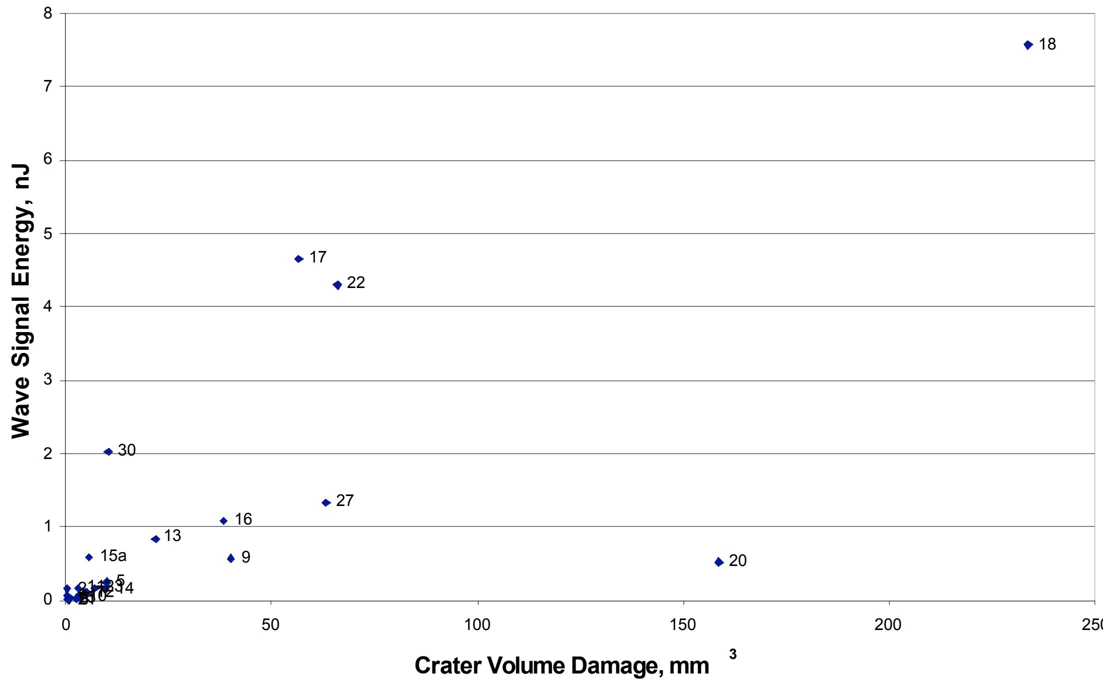


Figure 39: Detail of Fg(RCC)-1 Wave Signal Energy vs. Crater Volume Damage - Spar Sensors Only. Shot #15 omitted due to saturation. Shots #19, #25, #26, #28 and #29 shown on rescaled graph above.

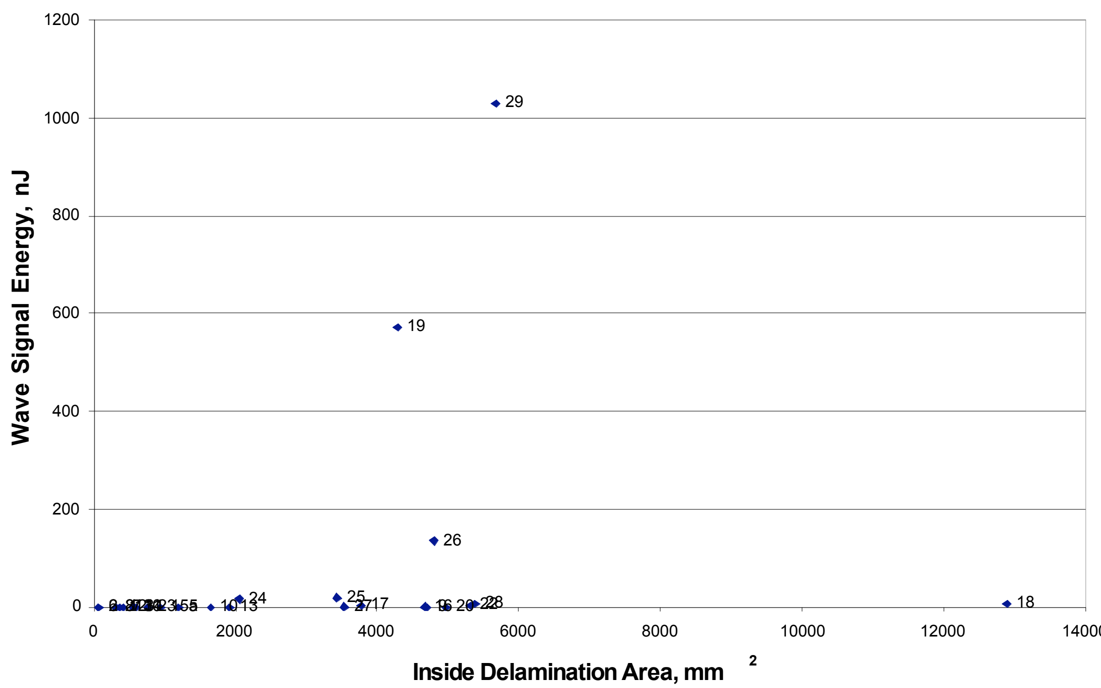


Figure 40: Fg(RCC)-1 Wave Signal Energy vs. Inside Delamination Area - Spar Sensors Only. Shot #15 omitted due to saturation.

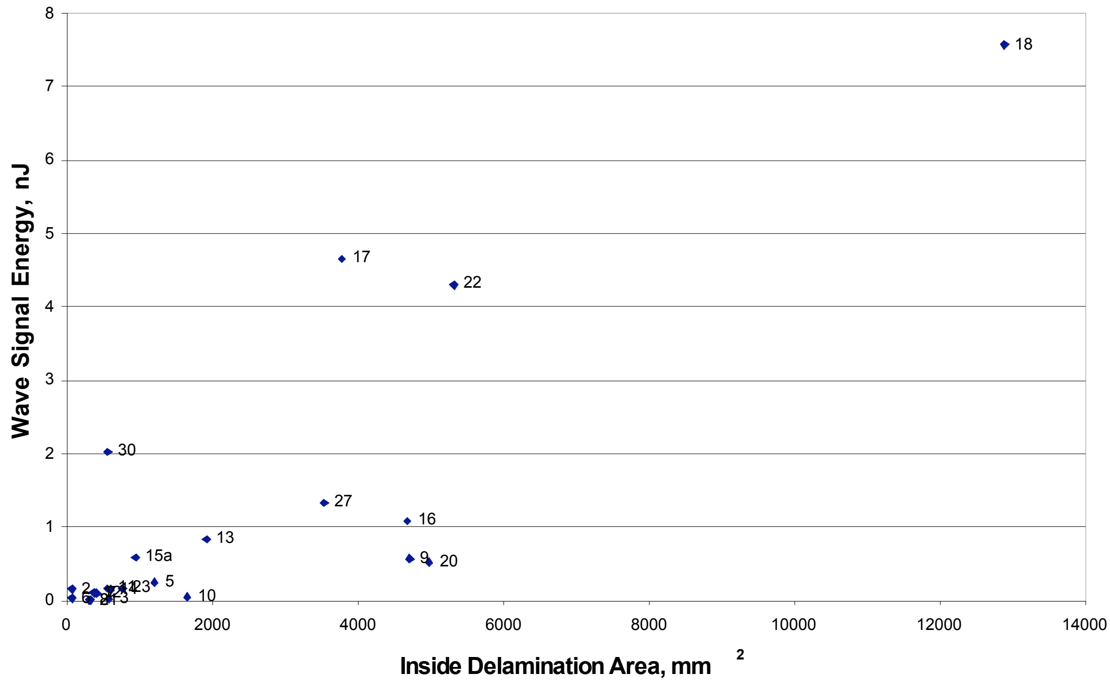


Figure 41: Detail of Fg(RCC)-1 Wave Signal Energy vs. Inside Delamination Area - Spar Sensors Only. Shot #15 omitted due to saturation. Shots #19, #25, #26, #28 and #29 shown on rescaled graph above.

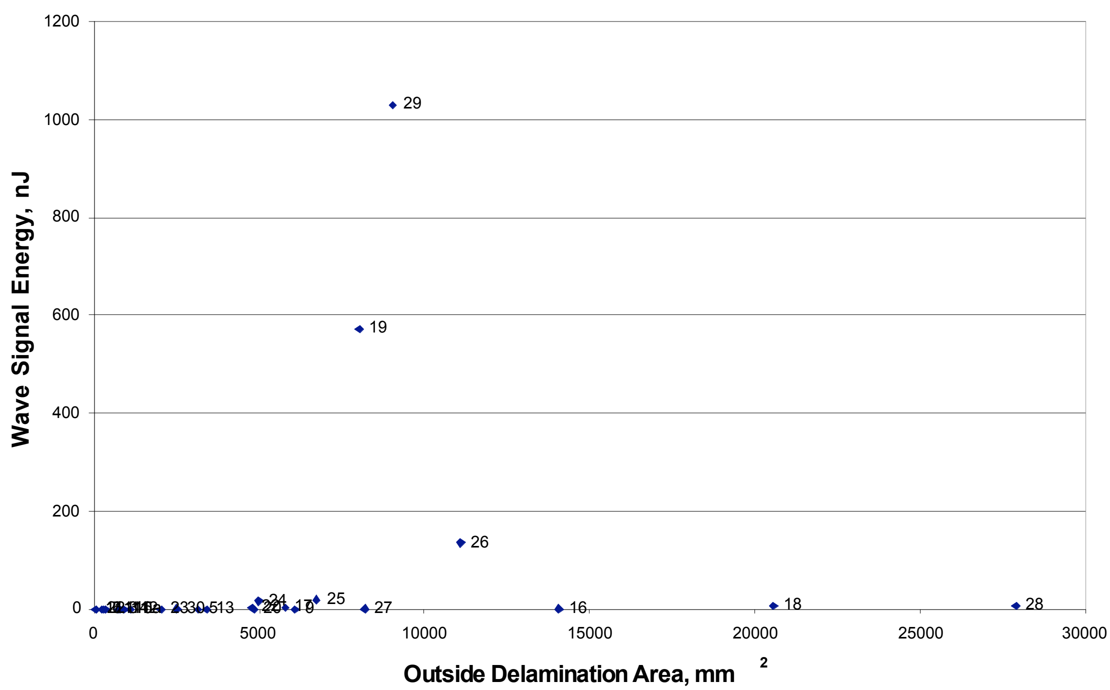


Figure 42: Fg(RCC)-1 Wave Signal Energy vs. Outside Delamination Area – Spar Sensors Only. Shot #15 omitted due to saturation.

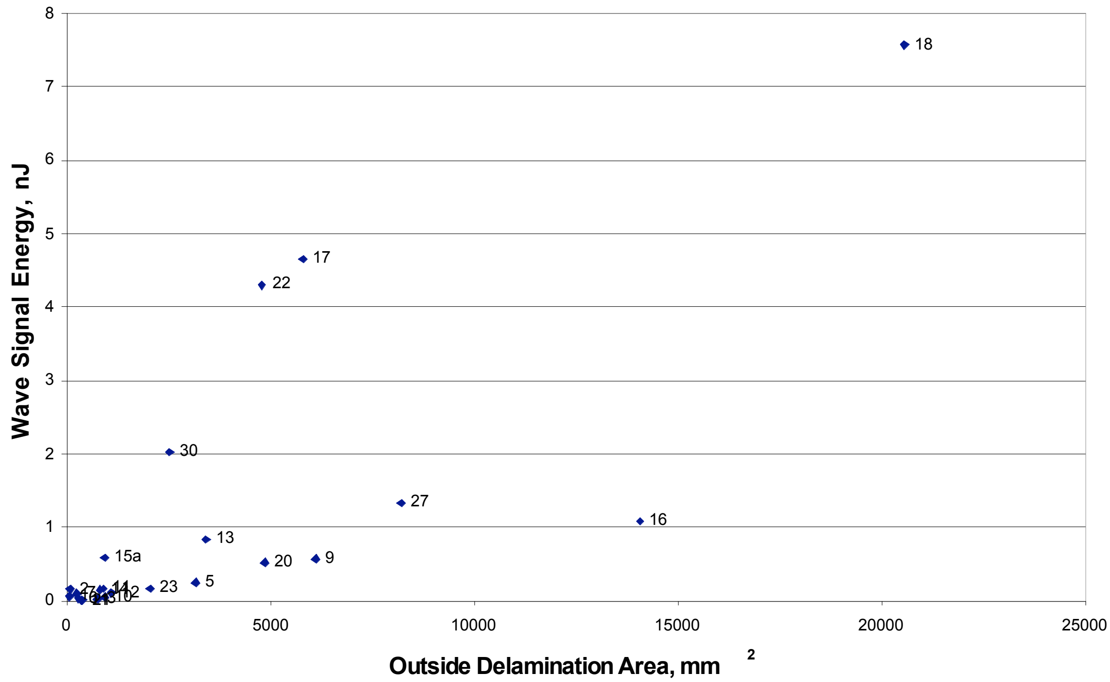


Figure 43: Detail of Fg(RCC)-1 Wave Signal Energy vs. Outside Delamination Area - Spar Sensors Only. Shot #15 omitted due to saturation. Shots #19, #25, #26, #28 and #29 shown on rescaled graph above.

Location Analysis

Location of the source of a wave is part and parcel of the MAE technique. It contributes to understanding of the type and magnitude of the source and is a crucial step in tracking down potentially damaged components and stopping leaks in manned spacecraft.

In these studies the location of the impact was known by visual observation. This enabled a study of the accuracy of locating a source purely by analysis of the wave arrival at different transducers. The source position was triangulated when the source to receiver path was reasonably homogeneous. The velocities of the direct arrivals were measured in advance using pencil lead breaks to create the modes. This is discussed under the section on Wave Propagation below.

In some cases the wave propagation path was interrupted by abrupt changes in the medium and direct triangulation was difficult. For example, the sensors placed on the WLE spar detected sound that had propagated through the attachments that coupled the WLE to the spar. In this case, only the quadrant of the leading edge that was impacted was located.

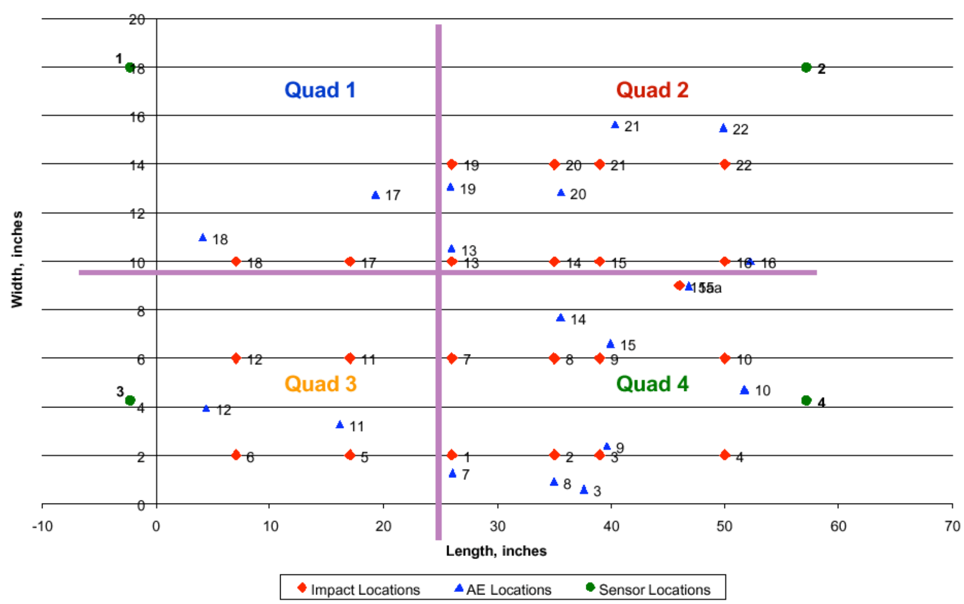


Figure 44: Fg(RCC)-1 WLE specimen unrolled to a "flat plate" in order to show the impact points and their locations computed by triangulation of the waves. Only the sensors attached onto the flange portion were used (sensors 1-4). View is from behind the spar looking out.

In Figure 44 the impact points were located by triangulation of the wave arrivals at the sensors on the flange. There was a ninety degree change of direction that the waves had to negotiate as they propagated from the impact point to the sensors mounted on the flanges. A portion of the upper flange can be seen in Figure 6. Although this caused considerable distortion in the wake of the wave, the front edge of the direct arrival of the extensional mode was still visible but very small. This permitted triangulation of the source locations however the accuracy suffered somewhat due to at times the first cycle in the sinusoid being too small to accurately discern the exact same phase point seen in the wave arrival at another transducer. This figure can be compared to Figure 45 in which the accuracy is much greater.

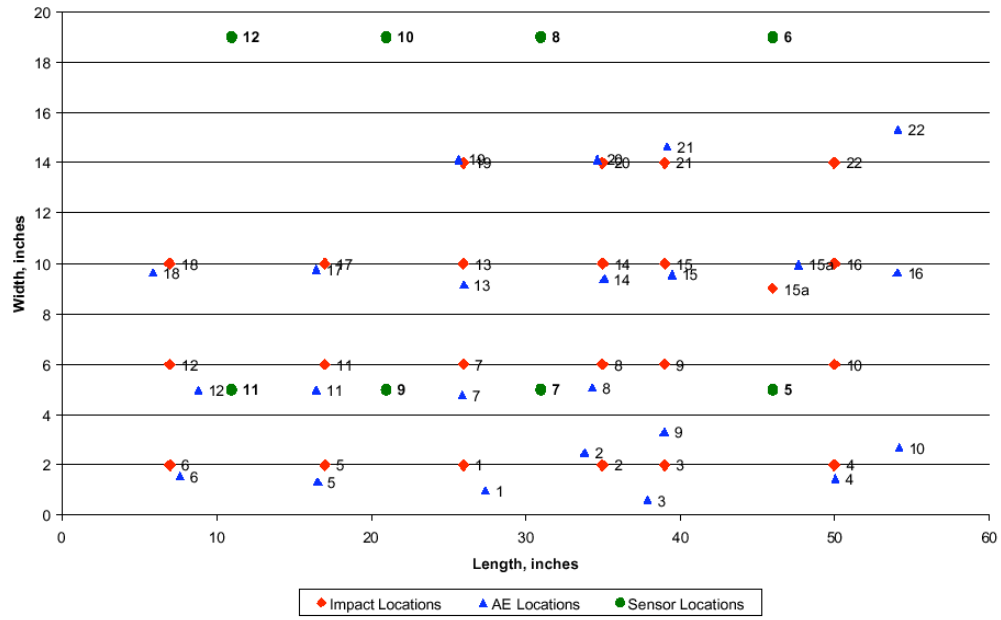


Figure 45: Location results for Fg(RCC)-1. Location was done by triangulation using the sensors on the WLE panel (sensors 5-12).

Figure 45 shows the locations obtained by triangulation. The wave propagation path was smooth and consistent and the results were very accurate.

Wave Propagation

The wave signal energy collected by any given sensor is composed of direct energy and reflected energy. After an impact occurs, a wave propagates radially outward from the impact site. This direct wave is the first signal recorded by a sensor. When this wave reaches the edges of the target, it is reflected back to the sensor. These reflected waves are lower in amplitude than the direct waves and have later arrival times. In general, reflected waves did not contribute not a significant fraction of the signal energy.

The direct wave is composed of two types of waves: extensional and flexural. Extensional waves have two displacements components with the larger displacements perpendicular to the normal to the plate. A sensor on the surface detects the out-of-plane component of the E wave. The largest displacement of the flexural wave motion is perpendicular to the plane of the plate. This motion is caused by bending at the impact location. The E and F modes have very distinct characteristics (see General Introduction and also Figure 47) that can be readily identified. For one thing, the front part of the E wave travels much faster than any frequency component of the F wave.

Wave speed was determined by performing a lead break at one sensor and measuring the time it took for a direct wave to arrive at another sensor at a known distance away. Figure 46 shows a lead break signal at sensor 5. Figure 47 and Figure 48 are diagrams of sensor locations. The extensional wave arrived at sensor 5 at t_1 = 208.1 μs and at sensor 6 at t_2 = 295.6 μs. The sensors were located 14 inches apart, which gave a velocity of 0.16 in/μs in the x-direction. Performing this calculation in the y-direction and the diagonal gave extensional wave velocities of 0.16 in/μs and 0.14 in/μs, respectively. The same calculation for flexural waves yielded velocities of 0.06 in/μs in the x-direction, y-direction, and in the diagonal.

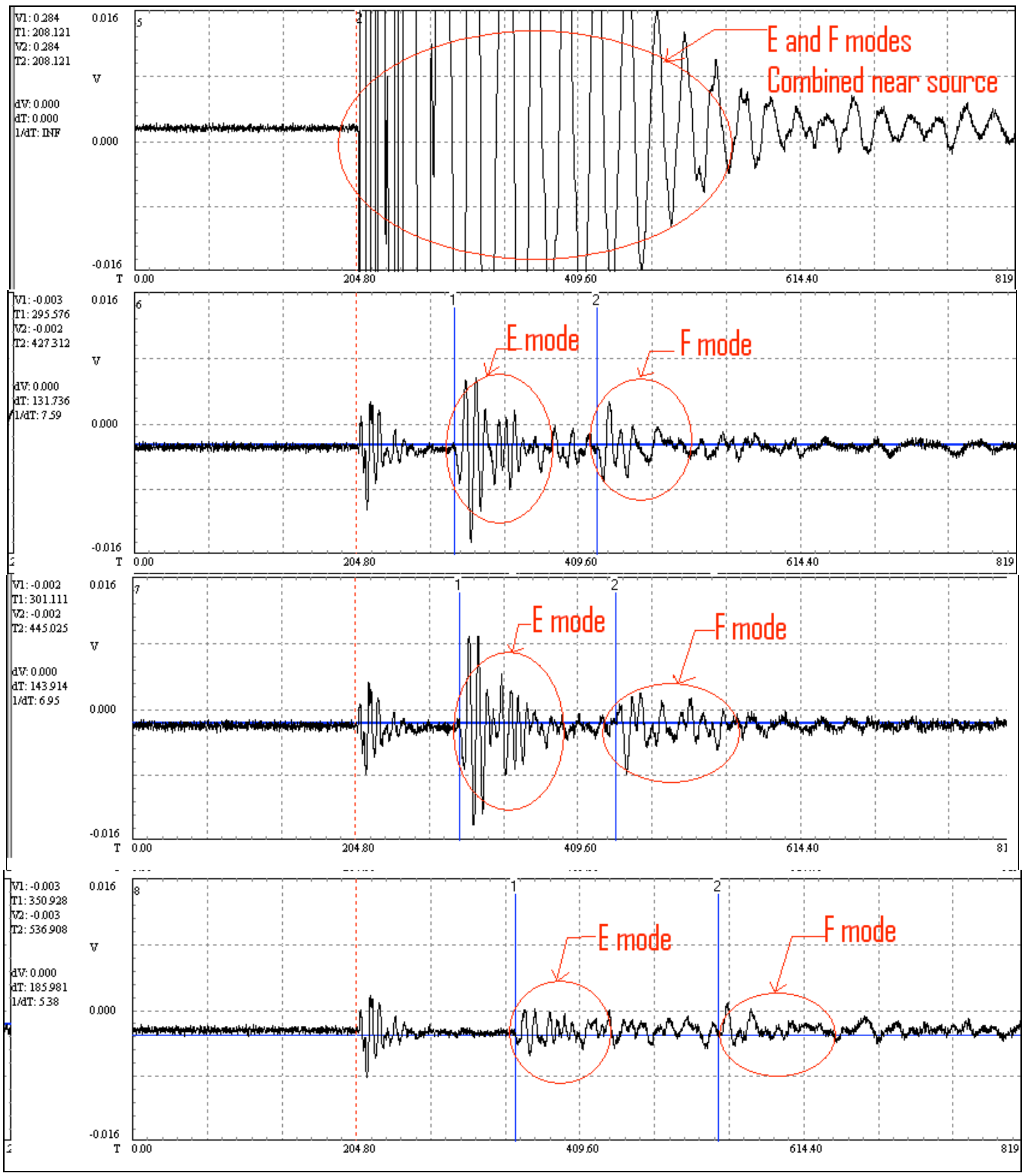


Figure 46: Fg(RCC)-1 Lead Break on Sensors 5, 6, 7, and 8 Shot #1b Pretest

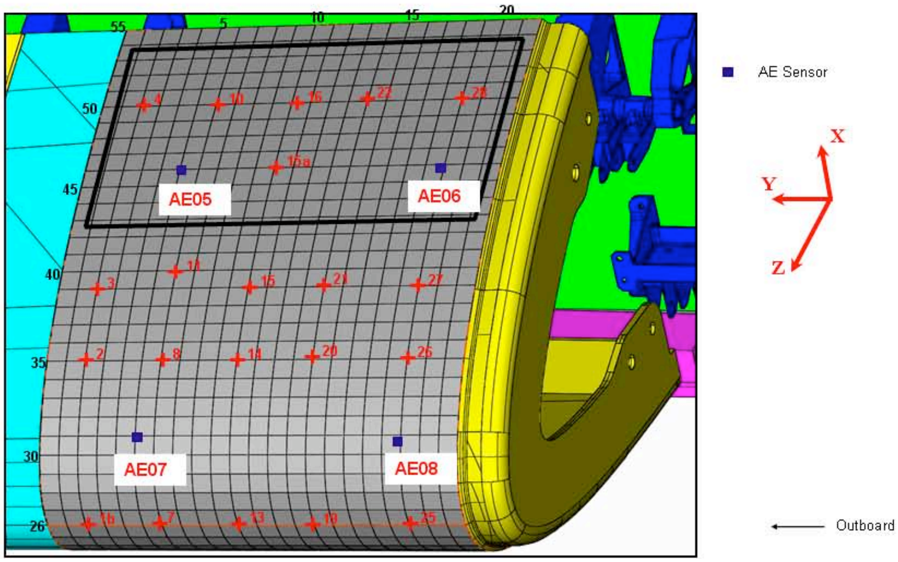


Figure 47: Fg(RCC)-1 Sensor and Impact Locations. Upper Panel. (Repeat of Figure 6)

Sensors have the following coordinates:
#5(46, 5), #6(46, 19), #7(31, 5), #8(31, 19) Dimensions are inches.
Impacts have the following coordinates:
#1b(26, 2), #2(35, 2), #3(39, 2), #4(50, 2), #7(26, 6), #8(35, 6), #9(40, 6), #10(50, 6), #13(26, 10), #14(35, 10), #15(39, 10), #15a(46, 10), #16(50, 10), #19(26, 14), #20(35, 14), #21(39, 14), #22(50, 14), #25(26, 19), #26(35, 19), #27(39, 19), #28(50, 19),

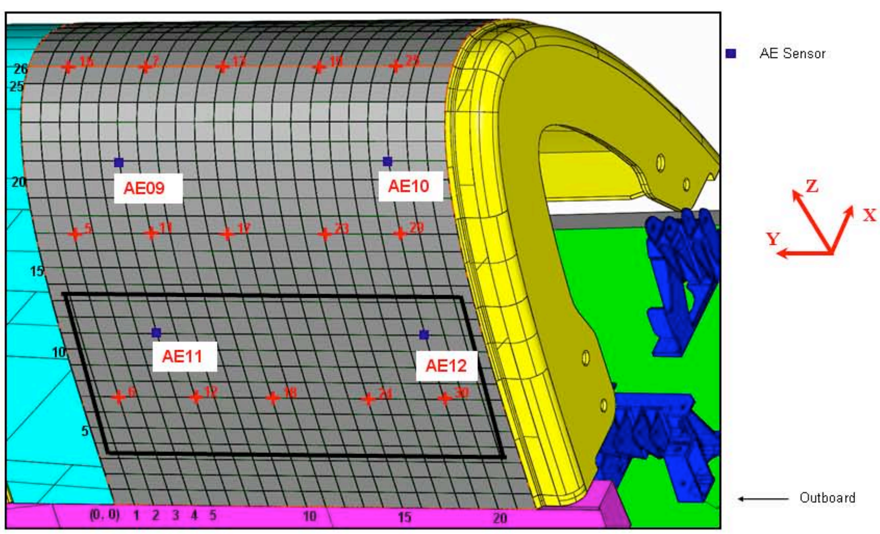


Figure 48: Fg(RCC)-1 Sensor and Impact Locations. Lower Panel. (Repeat of Figure 7)

Sensors have the following coordinates:
#9(21, 5), #10(21, 19), #11(11, 5), #12(11, 19) Dimensions are inches.
Impacts have the following coordinates:
#1b(26, 2), #5(17, 2), #6(7, 2), #7(26, 6), #11(17, 6), #12(7, 6), #13(26, 10), #17(17, 10), #18(7, 10), #19(26, 14), #23(17, 14), #24(7, 14), #25(26, 19), #29(17, 19), #30(7, 19)

The wave velocities were confirmed by considering the impact waveforms. Shot #12, for example, was aligned with sensors 9 and 11 (Figure 49). The impact waves arrived at sensor 11 first and then traveled to sensor 9. This can be seen in Figure 50. The extensional velocity was 0.16 in/µs and the flexural velocity was 0.06 in/µs. These velocities were the same as those calculated with the lead break.

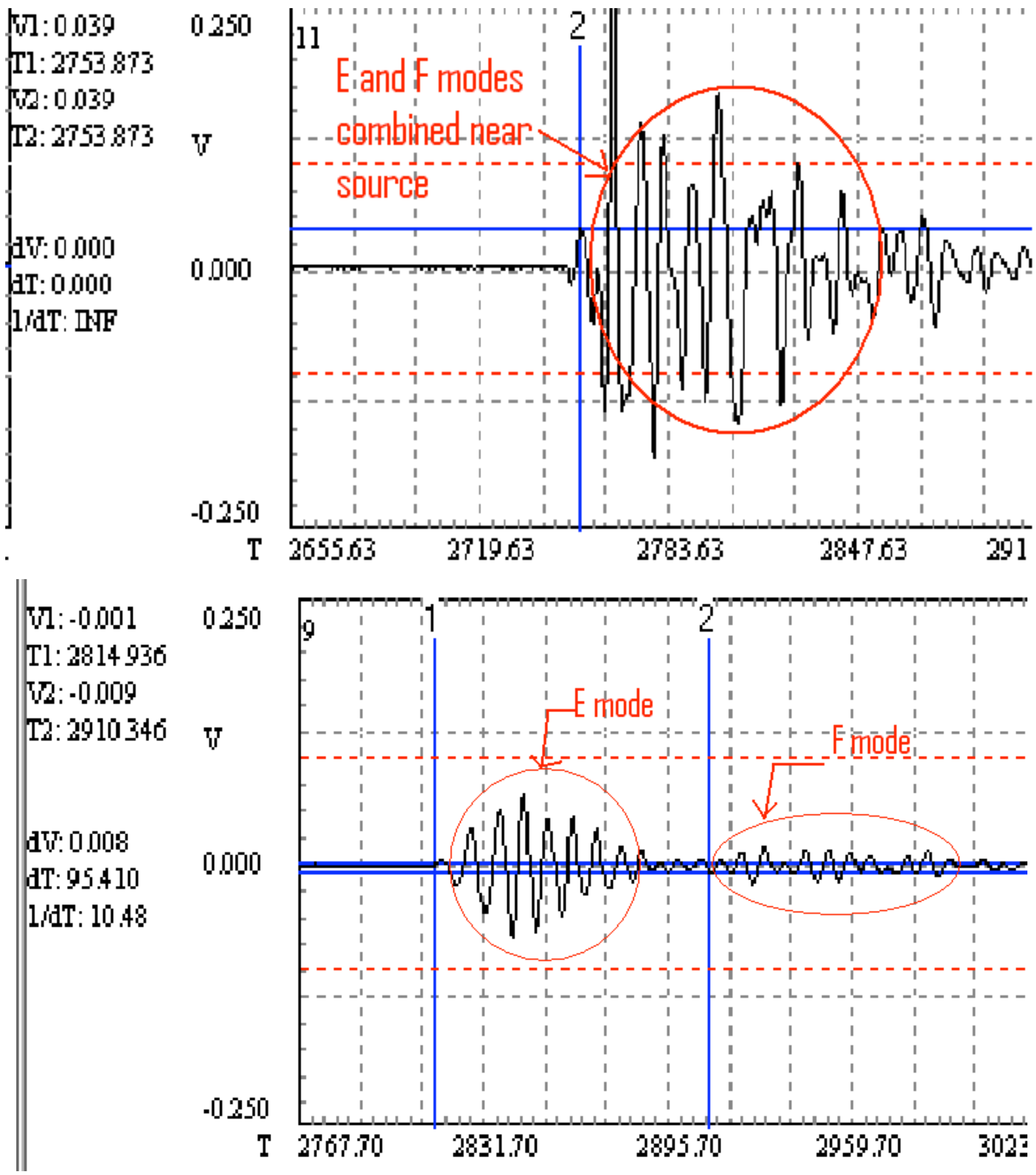


Figure 49: Fg(RCC)-1 Shot #12 Impact Waveform Detail. Top: Sensor 11. Bottom: Sensor 9.

Shot #25, aligned with sensors 6 and 8 (Figure 50), also confirmed the extensional and flexural velocities. The impact waves arrived at sensor 8 first and then traveled to sensor 6.

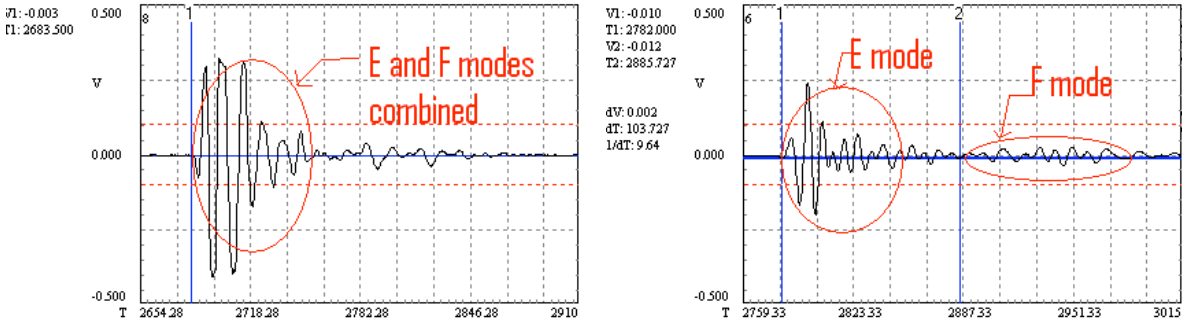


Figure 50: Fg(RCC)-1 Shot #25 Impact Waveform Detail. Left: Sensor 8. Right: Sensor 6.

In the fiberglass panel, fibers are aligned in the x and y directions (see Figure 47 and Figure 48). In addition to having slower speeds, waves that travel diagonally are attenuated more than waves that travel along the fiber direction. This is generally known as material anisotropy and is referred to here as the diagonal attenuation effect. Compensation for this effect is described in detail for Targets C-1 and C-2.

Conclusions

The results of the hypervelocity impact test on fiberglass WLE Target Fg(RCC)-1 are as follows:

- Ultrasonic Sensors were successfully bonded to fiberglass Target Fg(RCC)-1 with a Lord 202 Acrylic Adhesive.
- Ultrasonic Sensors operated well in near-vacuum (6-8 Torr) inside the vacuum chamber at Johnson Space Center's White Sands Testing Facility.[2]
- Impacts created detectable ultrasonic signals at high (>50 kHz) frequencies which should be above flight noise.[3]
- Ultrasonic signals were detected with small, lightweight sensors capable of space flight.[4][5]
- Wave propagation characteristics of the cross-ply fiberglass target were measured and used in the analysis of the wave signal energy.
- Wave signal energy correlated well with kinetic energy and impact damage.
- Ultrasonic energy propagated through WLE attachment joints and was detected by sensors attached on the wing spar. These sensors would not be exposed to the high temperatures of the WLE itself. The spar signals were useable for detecting impacts but the location analysis was limited to determining which quadrant of the WLE was impacted.

This test successfully demonstrated the ability for a wing leading edge impact detection system (WLEIDS) to model the kinetic energy response and material damage below, at and above complete penetration of the projectile through the target.

Appendix

[2] B1025 sensors also functioned well in deep vacuum of ESEM. Michael Horn, NASA LaRC, email 2005.

[3] Based on measurement of noise spectra on F16 bulkhead at full throttle, there will not be significant noise power above 50kHz.

[4] Sensors passed 18,000 g shock test. Henry Whitesel, Naval Surface Warfare Center, verbal communication 1998.

[5] DWC sensors survived intense radiation environment. Dane Spearing, LANL, verbal communication 2003.

The appendices contain the information for each shot and the waveforms. For completeness, and, for usefulness when judging the energy versus damage plots shown in the discussion section above, tables are given at the end that summarize and group together the data for the key test variables.

Test Condition Data Sheets

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/01/04 Specimen ID: FG-1

Test number: FG1-1b Projectile size: .4 mm/90deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (26, 2)

II. Prebonding sensor tests performed: Yes

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X
Test sensors and record file name: FG1-1b 7-01-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 12

Record file name: FG1-1b 7-01-04 Impact
Comments: Good data. Signals small on spar.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X

Record actual impact parameters:

Projectile velocity: 6.97 km/s.

Impact coordinates: ________________

Damage description and comments:

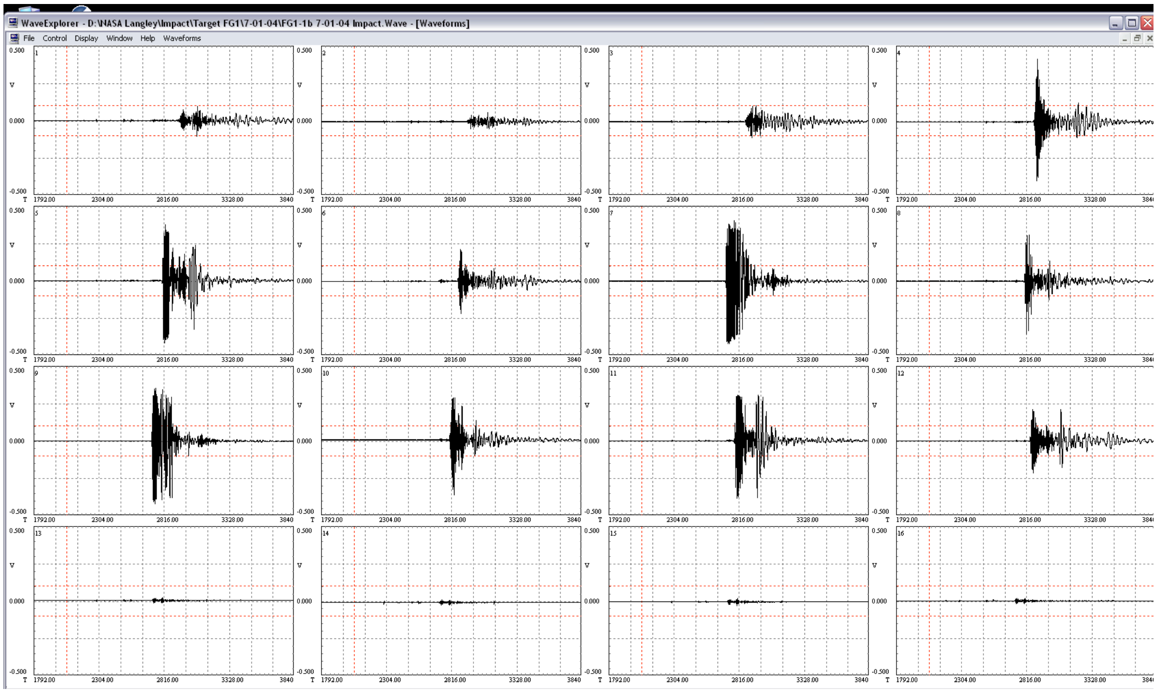


Figure 51: Fg(RCC)-1 Shot #1b Impact Waveform

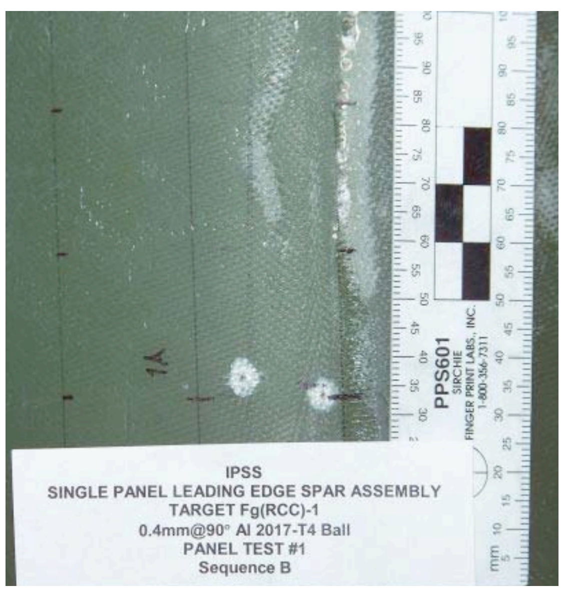
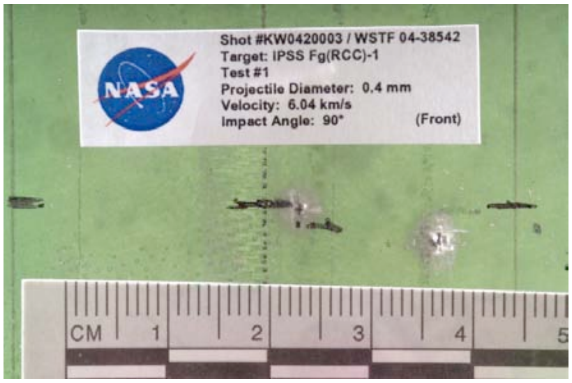


Figure 52: Fg(RCC)-1 Shot #1b Impact Damage



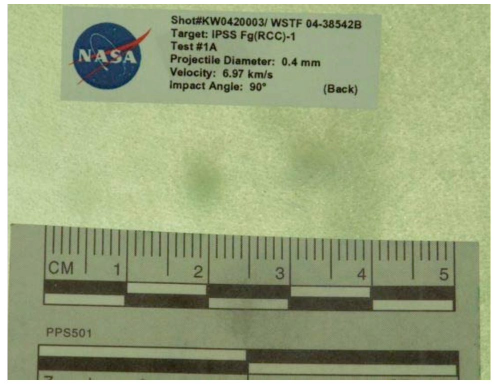


Figure 53: Fg(RCC)-1 Shot #1b Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/07/04 Specimen ID: FG-1

Test number: FG1-2 Projectile size: .4 mm/45deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (35, 2)

II. Prebonding sensor tests performed: Yes

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-2 7-07-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 9
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 9
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 9
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 9

Record file name: FG1-2 7-07-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.35 km/s.
Impact coordinates: ________________
Damage description and comments:

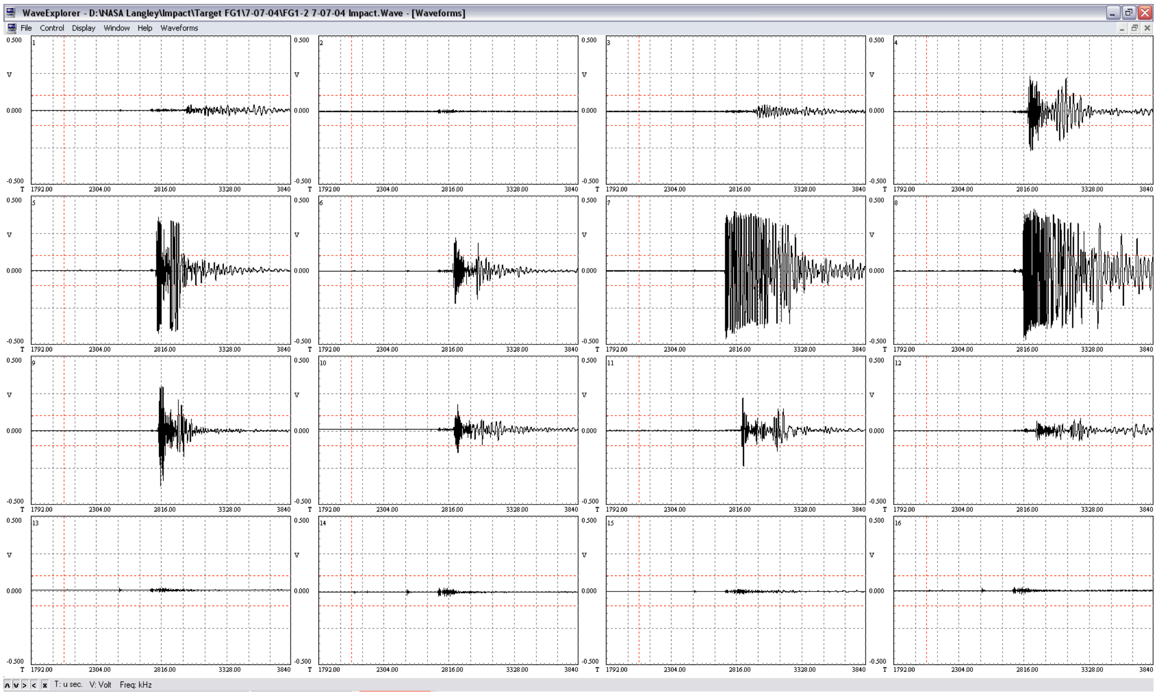


Figure 54: Fg(RCC)-1 Shot #2 Impact Waveform

Figure 55: Fg(RCC)-1 Shot #2 Impact Damage

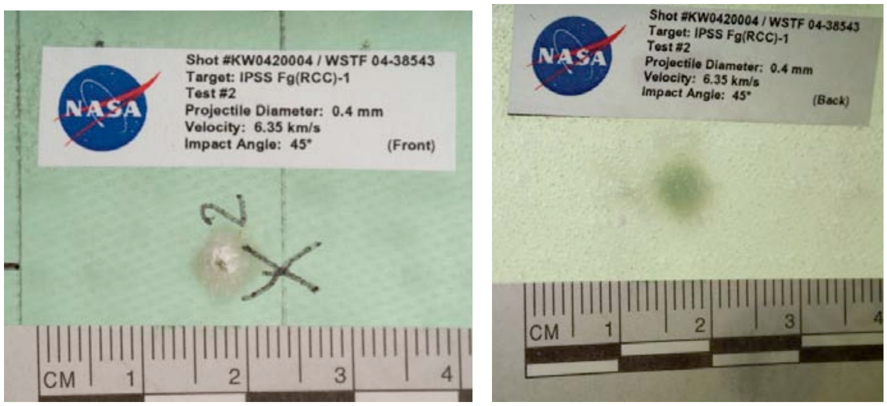


Figure 56: Fg(RCC)-1 Shot #2 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/07/04 Specimen ID: FG-1

Test number: FG1-3 Projectile size: .8 mm/45deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (39, 2)

II. Prebonding sensor tests performed: Yes

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-3 7-07-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-3 7-07-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.80 km/s.
Impact coordinates: ________________
Damage description and comments:

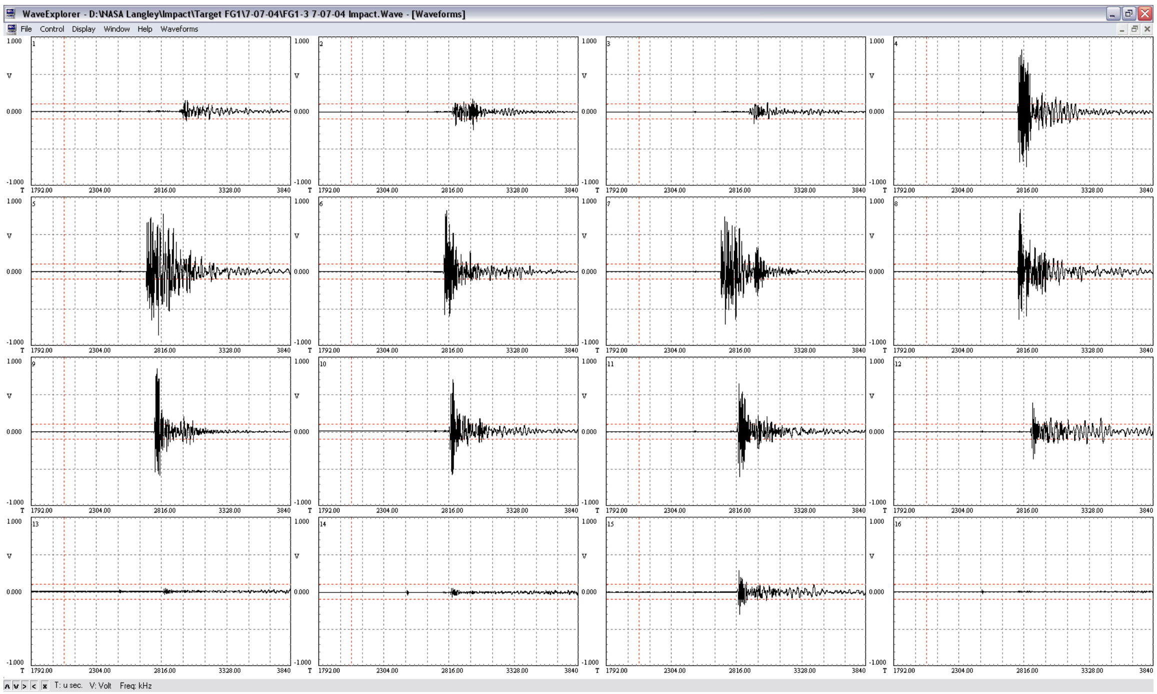


Figure 57: Fg(RCC)-1 Shot #3 Impact Waveform

Figure 58: Fg(RCC)-1 Shot #3 Impact Damage

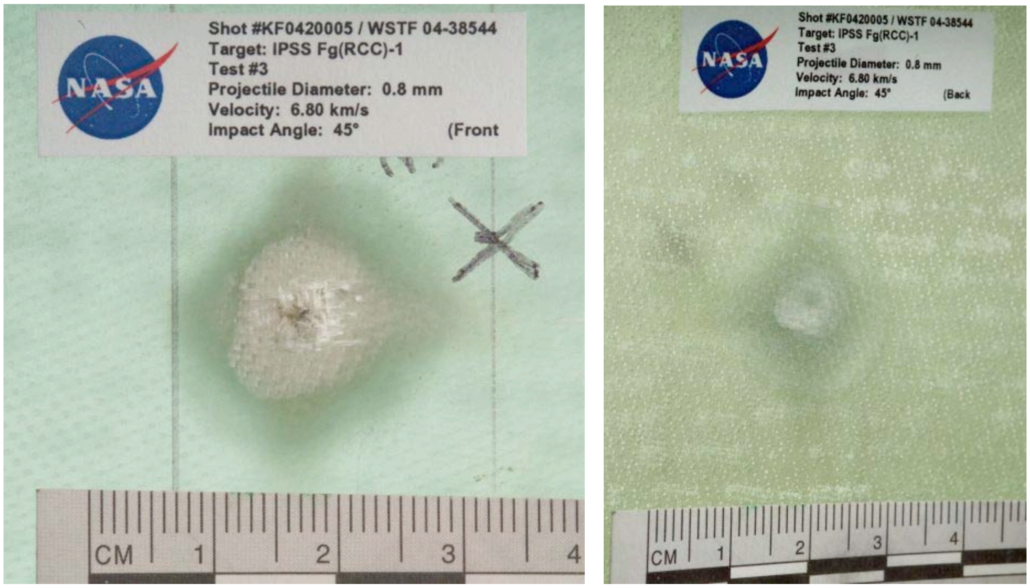


Figure 59: Fg(RCC)-1 Shot #3 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:
Test date: 7/08/04 Specimen ID: FG-1
Test number: FG1-4 Projectile size: .4 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (50, 2)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038
Sensor 2: S/N 0799039
Sensor 3: S/N 0799045
Sensor 4: S/N 101153
Sensor 5: S/N 101146
Sensor 6: S/N 101160
Sensor 7: S/N 101157
Sensor 8: S/N 101148
Sensor 9: S/N 101147
Sensor 10: S/N 101163
Sensor 11: S/N 101150
Sensor 12: S/N 0799050
Sensor 13: S/N 190022
Sensor 14: S/N 190033
Sensor 15: S/N 190034
Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up)
Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down)
Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05)
Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05)
Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05)
Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05)
Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar
Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar
Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:
Verify settings:

SCM trigger source:	X
20 dB PA gain, 3 dB signal gain:	X
20 kHz HP filter, 1500 kHz LP filter:	X
5 MHz SR, 4096 points, 1024 pretrigger:	X

Test sensors and record file name: FG1-4 7-08-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 0	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 5:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 0	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-4 7-08-04 Impact
Comments:

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.97 km/s.
Impact coordinates: ________________
Damage description and comments:

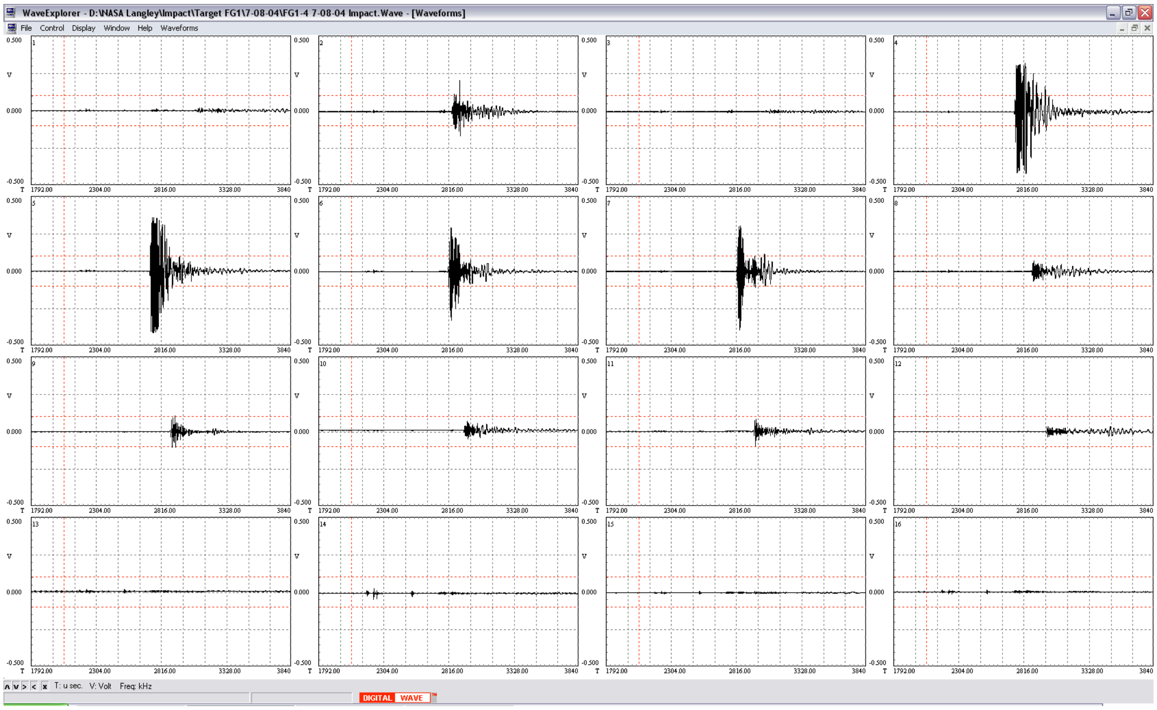


Figure 60: Fg(RCC)-1 Shot #4 Impact Waveform

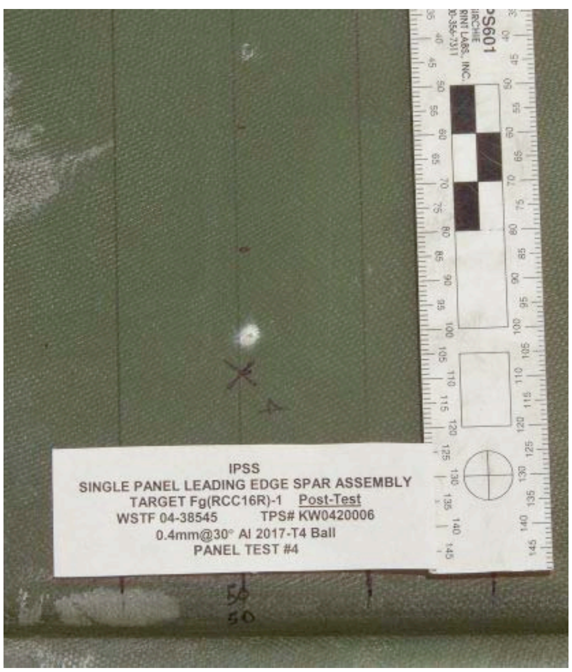


Figure 61: Fg(RCC)-1 Shot #4 Impact Damage

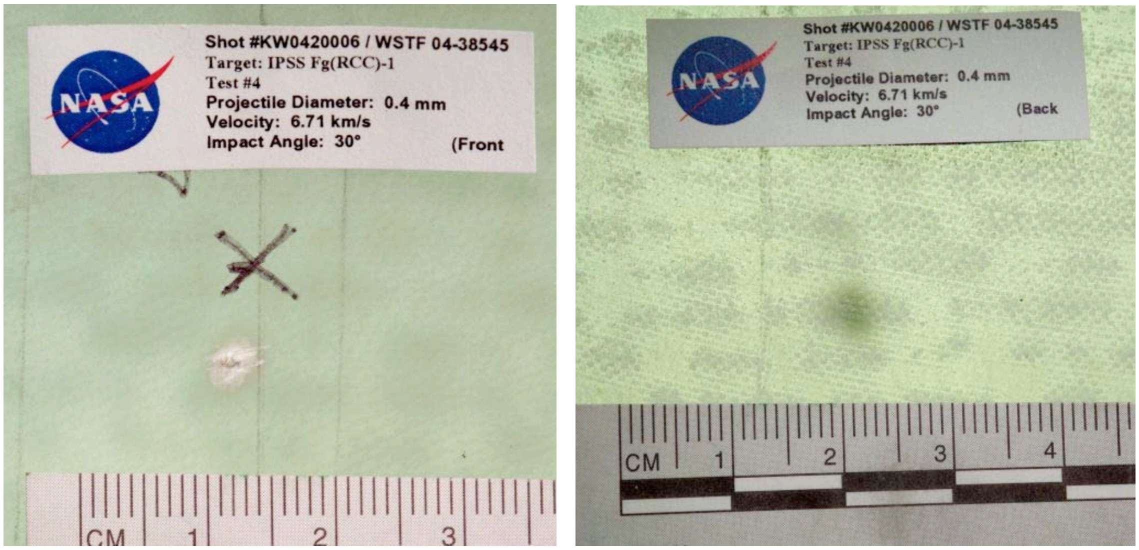


Figure 62: Fg(RCC)-1 Shot #4 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:
Test date: 7/09/04 Specimen ID: FG-1
Test number: FG1-5 Projectile size: 1.2 mm/60deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (17, 2)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:
Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:
Verify settings:
SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-5 7-09-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 3

Record file name: FG1-5 7-09-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.87 km/s.
Impact coordinates: _________________
Damage description and comments:

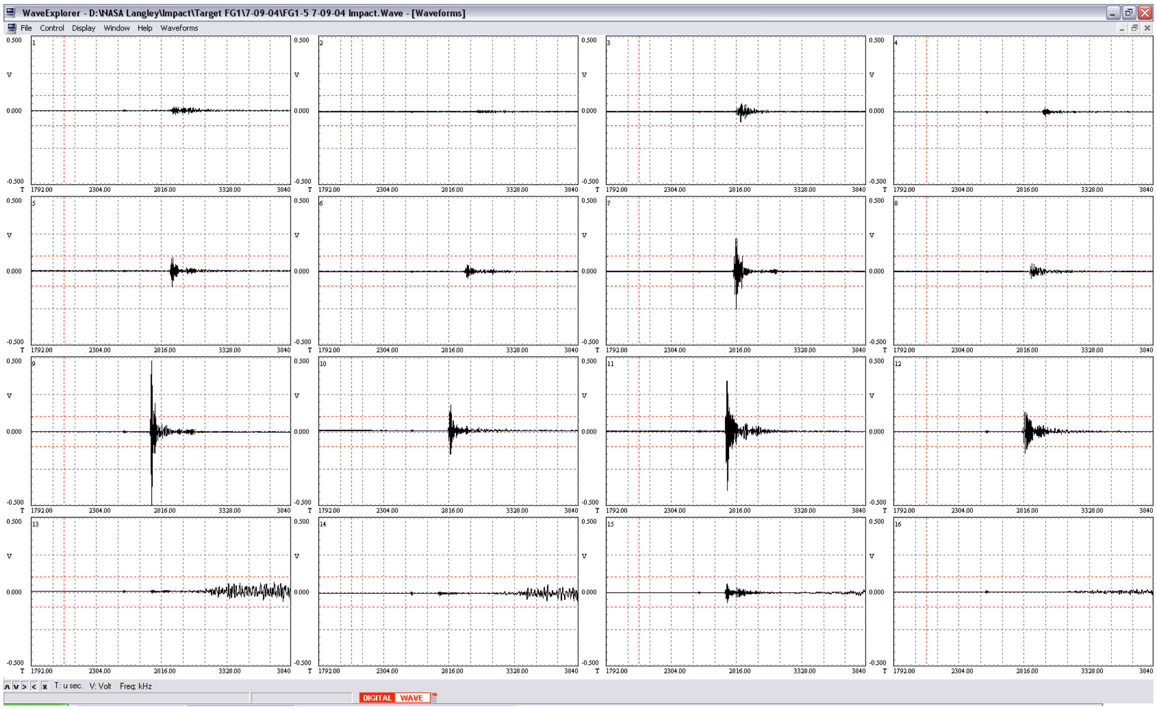


Figure 63: Fg(RCC)-1 Shot #5 Impact Waveform

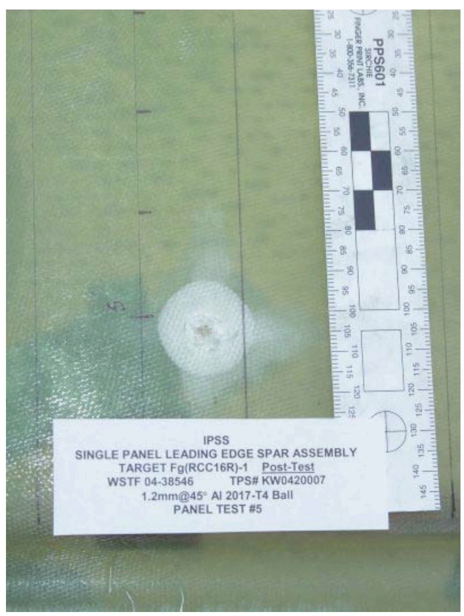


Figure 64: Fg(RCC)-1 Shot #5 Impact Damage

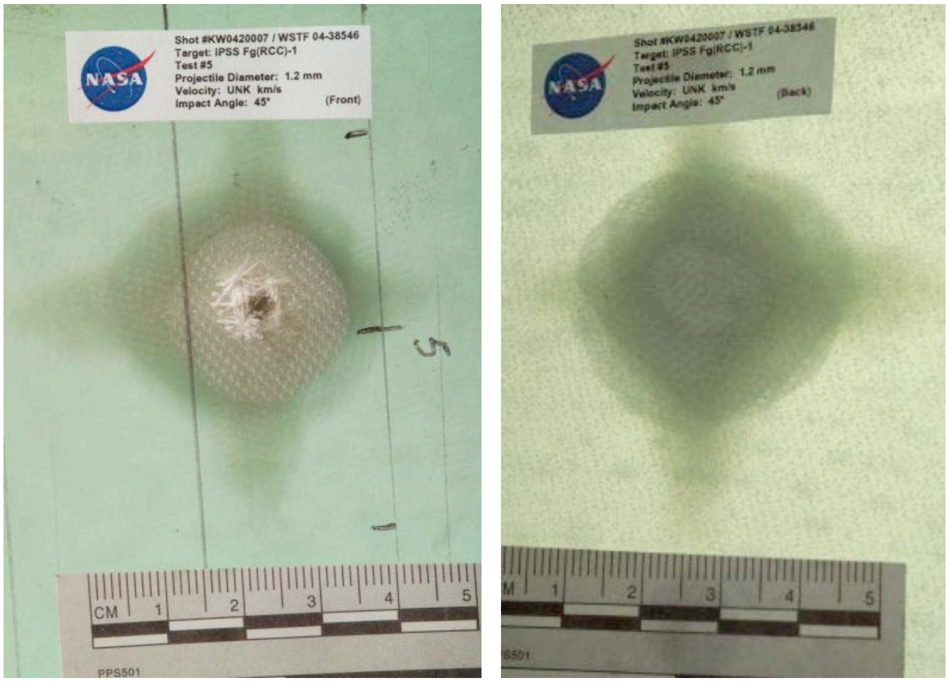


Figure 65: Fg(RCC)-1 Shot #5 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/08/04 Specimen ID: FG-1

Test number: FG1-6 Projectile size: .6 mm/45deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (7, 2)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038
Sensor 2: S/N 0799039
Sensor 3: S/N 0799045
Sensor 4: S/N 101153
Sensor 5: S/N 101146
Sensor 6: S/N 101160
Sensor 7: S/N 101157
Sensor 8: S/N 101148
Sensor 9: S/N 101147
Sensor 10: S/N 101163
Sensor 11: S/N 101150
Sensor 12: S/N 0799050
Sensor 13: S/N 190022
Sensor 14: S/N 190033
Sensor 15: S/N 190034
Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up)
Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down)
Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05)
Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05)
Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05)
Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05)
Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar
Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar
Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-6 7-08-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-6 7-08-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.87 km/s.
Impact coordinates: ________________
Damage description and comments:

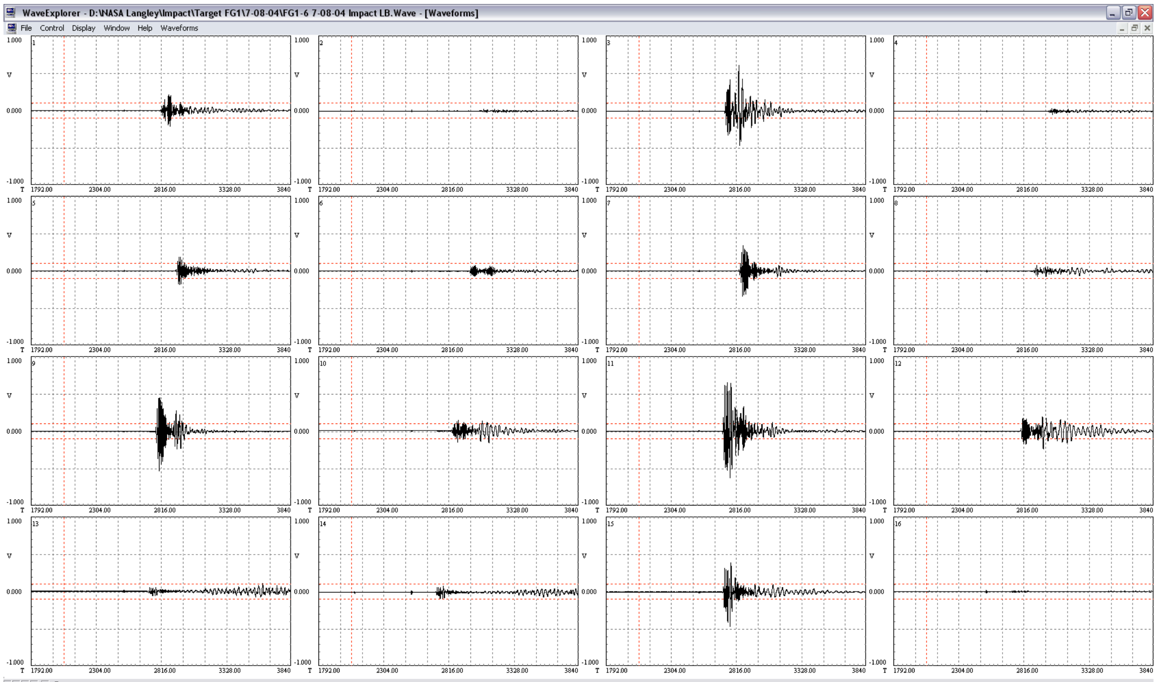


Figure 66: Fg(RCC)-1 Shot #6 Impact Waveform

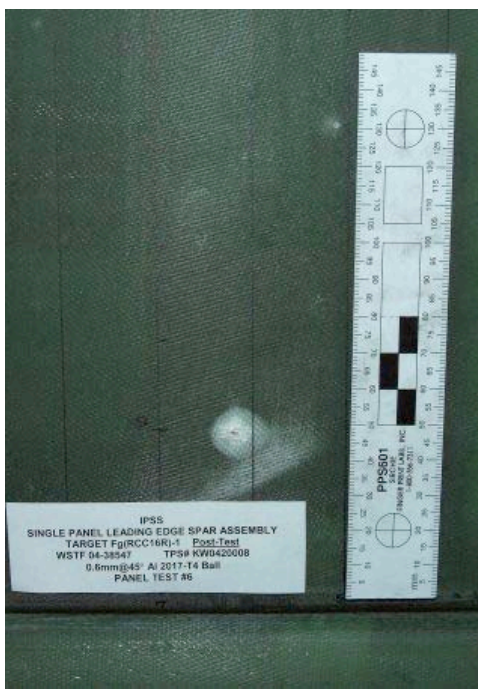


Figure 67: Fg(RCC)-1 Shot #6 Impact Damage

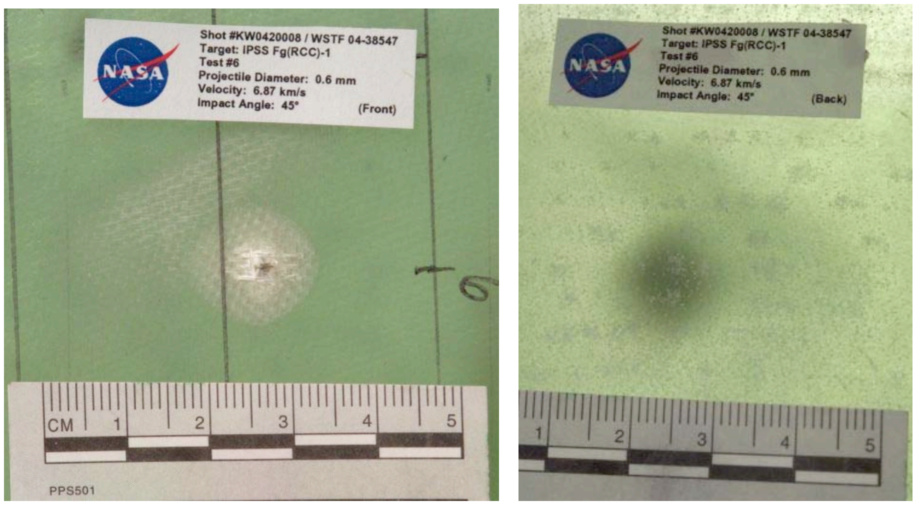


Figure 68: Fg(RCC)-1 Shot #6 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/14/04 Specimen ID: FG-1

Test number: FG1-7 Projectile size: .8 mm/90deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (26, 6)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-7 7-14-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-7 7-14-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.80 km/s.
Impact coordinates: ________________
Damage description and comments:

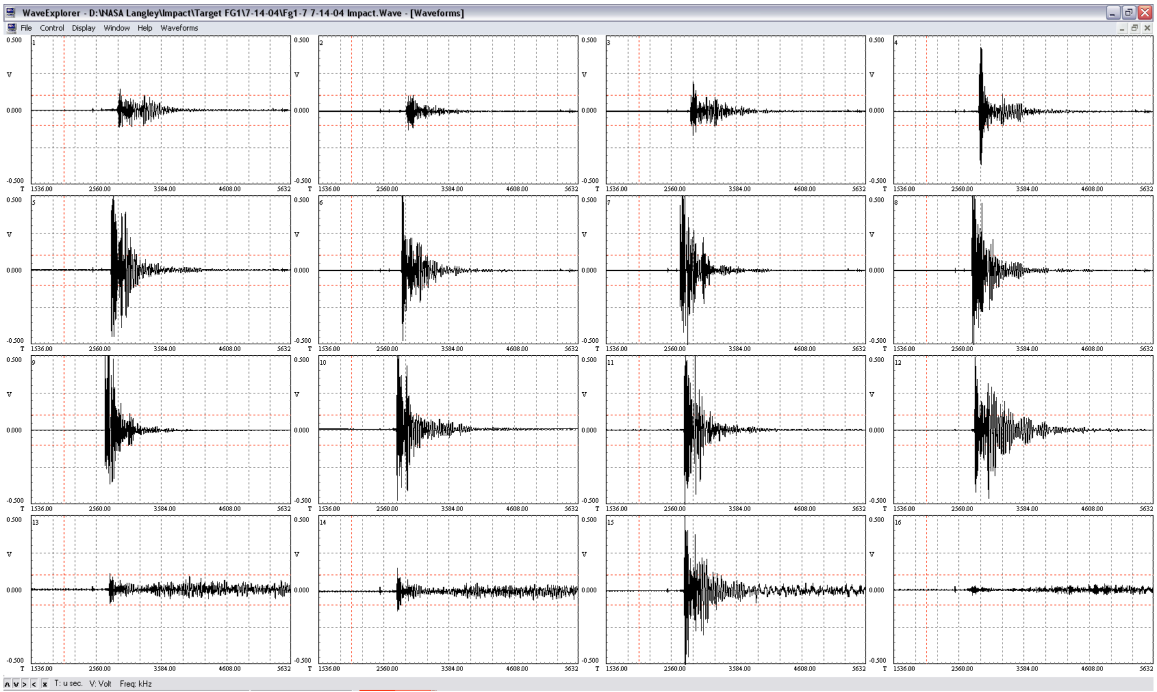


Figure 69: Fg(RCC)-1 Shot #7 Impact Waveform

Figure 70: Fg(RCC)-1 Shot #7 Impact Damage

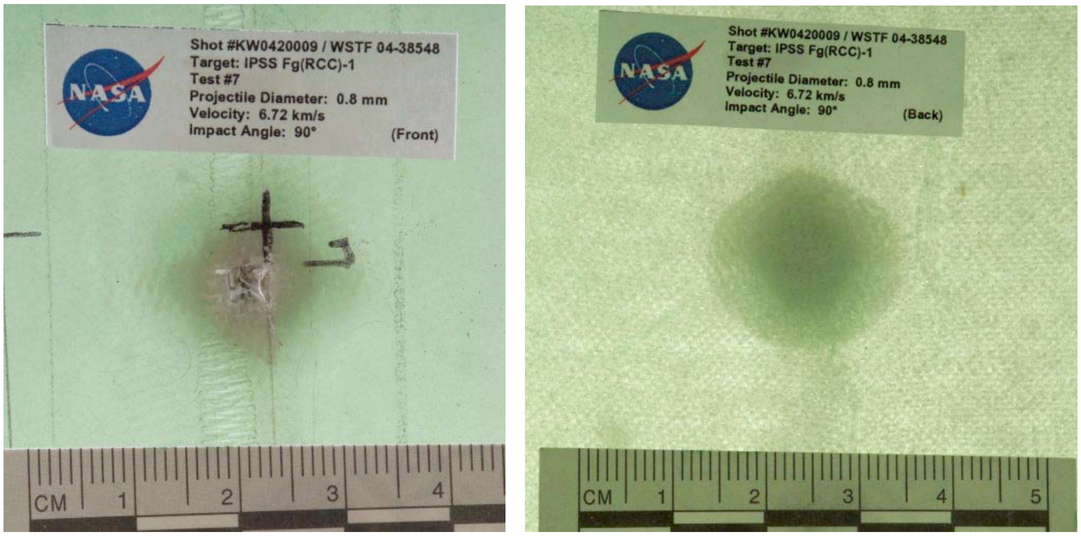


Figure 71: Fg(RCC)-1 Shot #7 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/15/04 Specimen ID: FG-1

Test number: FG1-8 Projectile size: .6 mm/60deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (35, 6)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-8 7-15-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-8 7-15-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.80 km/s.
Impact coordinates: ________________
Damage description and comments:

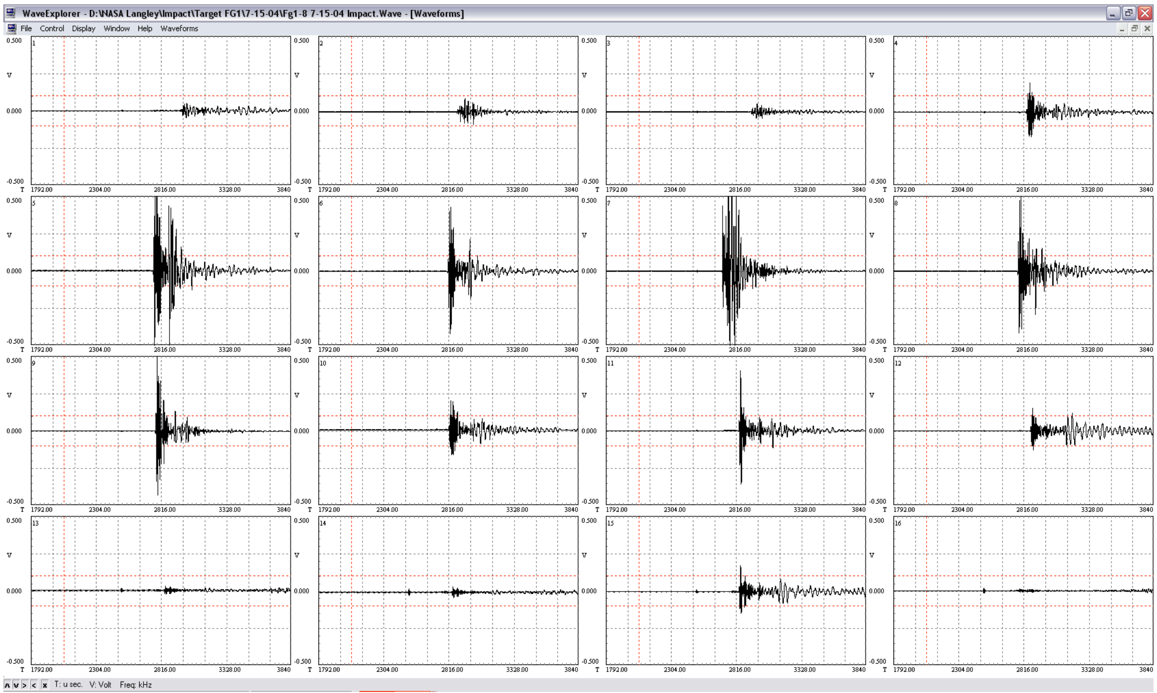


Figure 72: Fg(RCC)-1 Shot #8 Impact Waveform

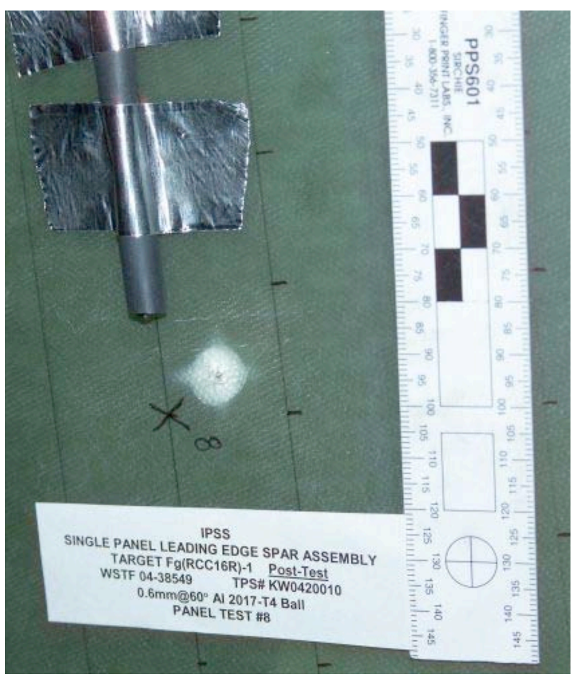


Figure 73: Fg(RCC)-1 Shot #8 Impact Damage

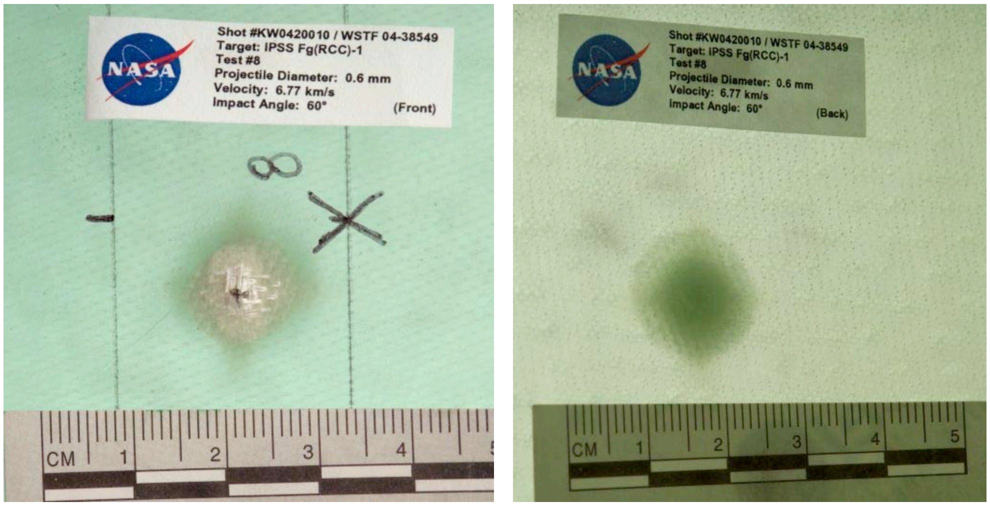


Figure 74: Fg(RCC)-1 Shot #8 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/19/04 Specimen ID: FG-1

Test number: FG1-9 Projectile size: 1.8 mm/30deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (40, 6)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-9 7-19-04 pretest LB
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 15

Record file name: FG1-9 7-19-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.87 km/s.
Impact coordinates: ________________
Damage description and comments:

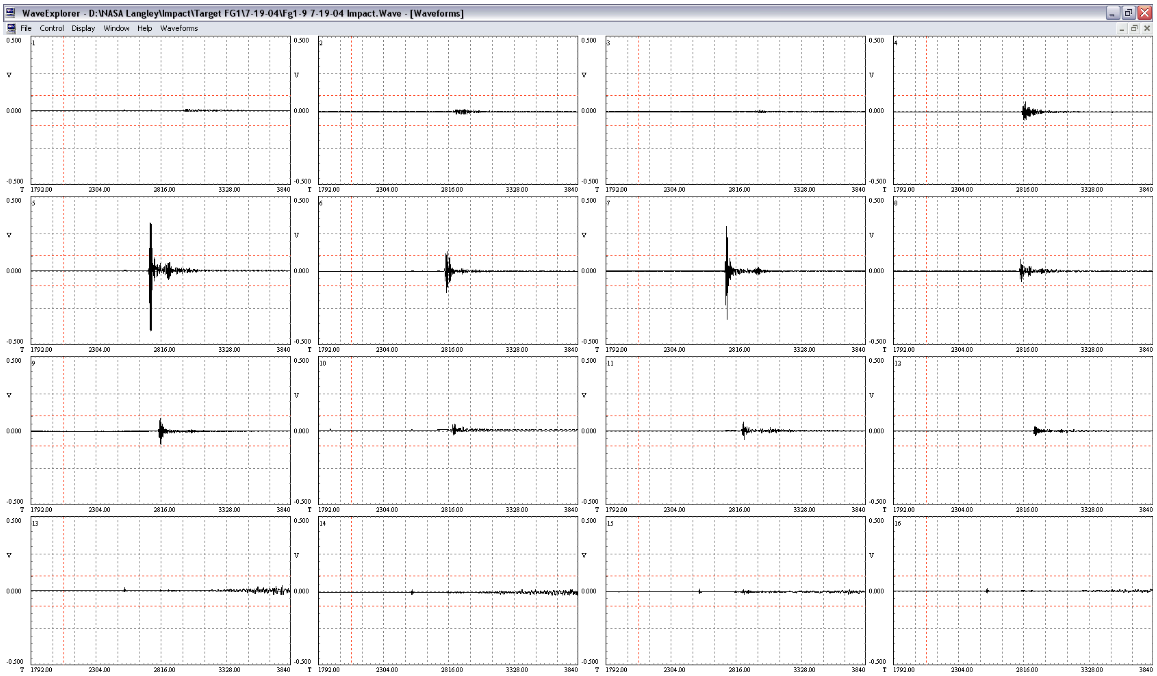


Figure 75: Fg(RCC)-1 Shot #9 Impact Waveform

Figure 76: Fg(RCC)-1 Shot #9 Impact Damage

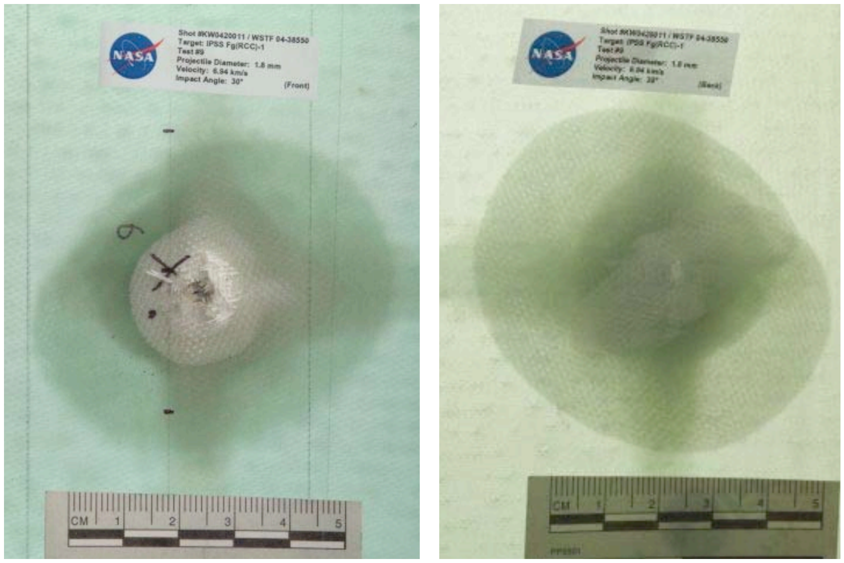


Figure 77: Fg(RCC)-1 Shot #9 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/20/04 Specimen ID: FG-1
Test number: FG1-10 Projectile size: .8 mm/45deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (50, 6)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-10 7-20-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-10 7-20-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.81 km/s.
Impact coordinates: _________________
Damage description and comments:

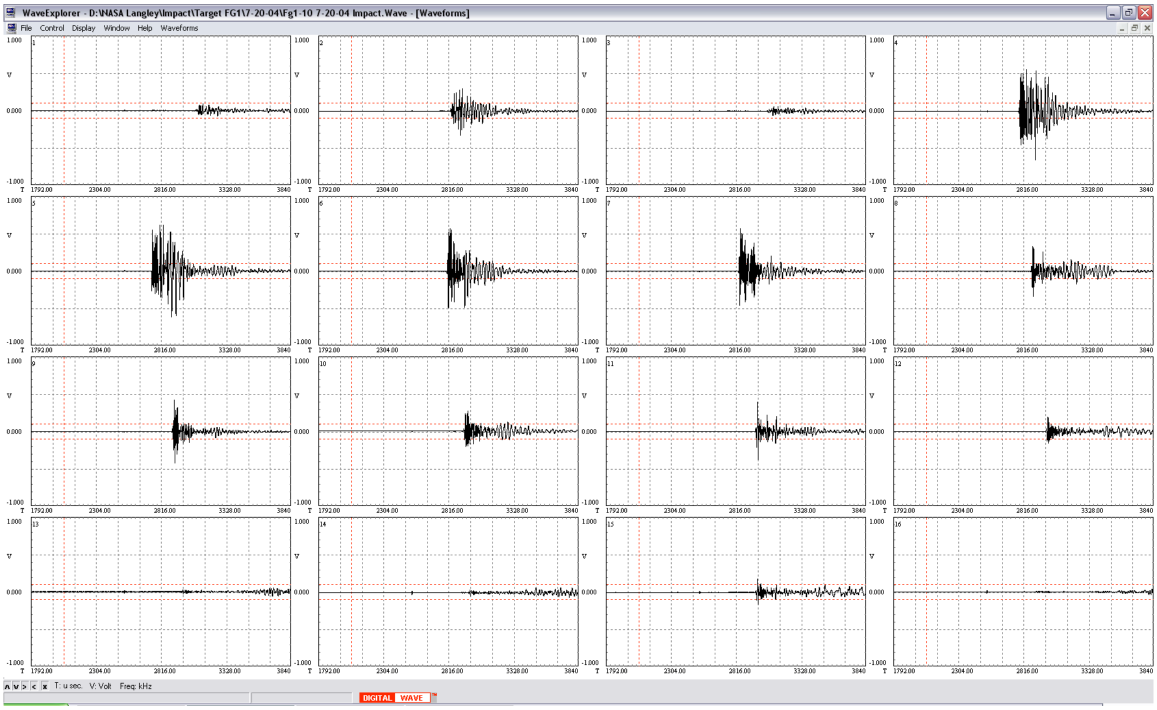


Figure 78: Fg(RCC)-1 Shot #10 Impact Waveform

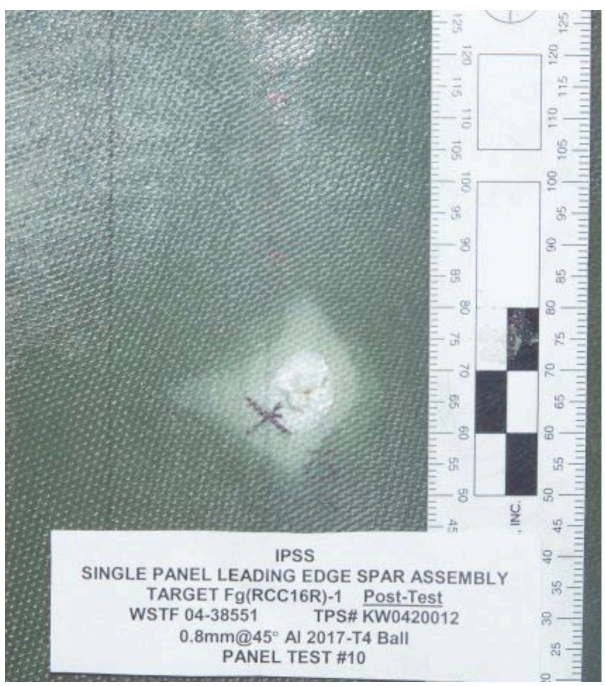


Figure 79: Fg(RCC)-1 Shot #10 Impact Damage

Figure 80: Fg(RCC)-1 Shot #10 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/21/04 Specimen ID: FG-1

Test number: FG1-11 Projectile size: .8 mm/45deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (17, 6)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source:	X
20 dB PA gain, 3 dB signal gain:	X
20 kHz HP filter, 1500 kHz LP filter:	X
5 MHz SR, 4096 points, 1024 pretrigger:	X

Test sensors and record file name: FG1-11 7-21-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-11 7-20-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.83 km/s.
Impact coordinates: ________________
Damage description and comments:

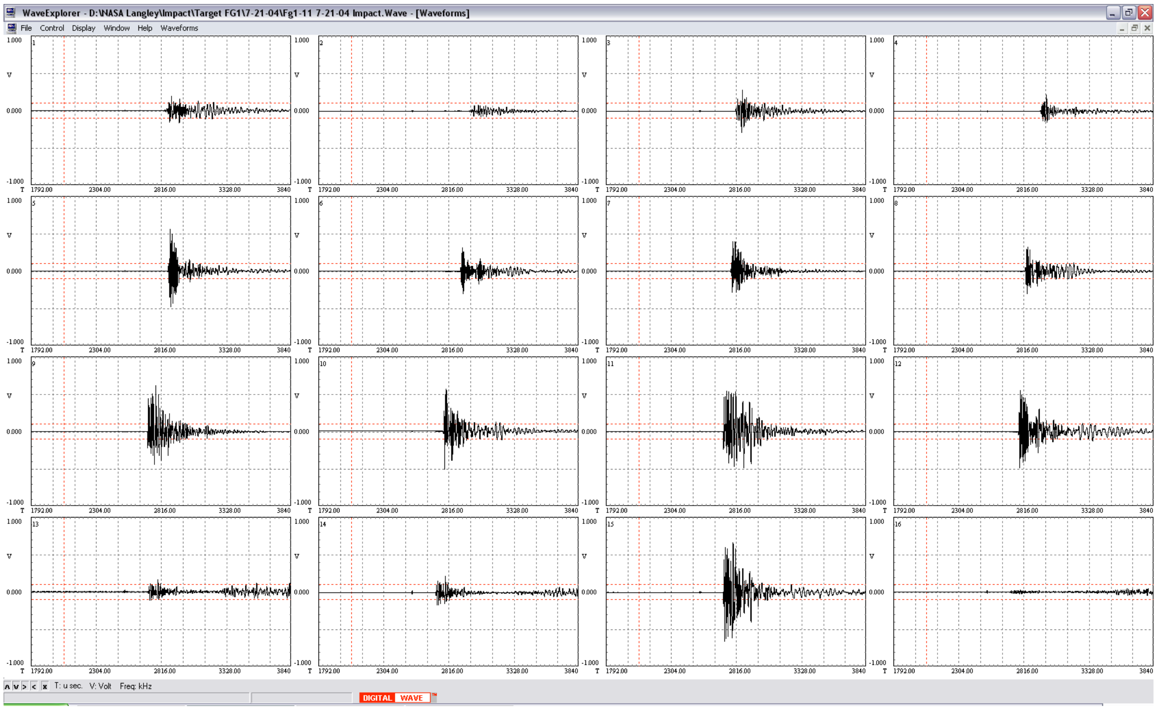


Figure 81: Fg(RCC)-1 Shot #11 Impact Waveform

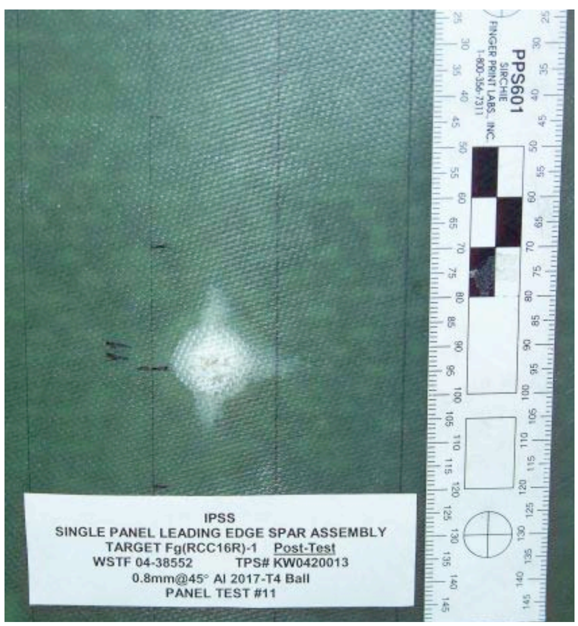


Figure 82: Fg(RCC)-1 Shot #11 Impact Damage

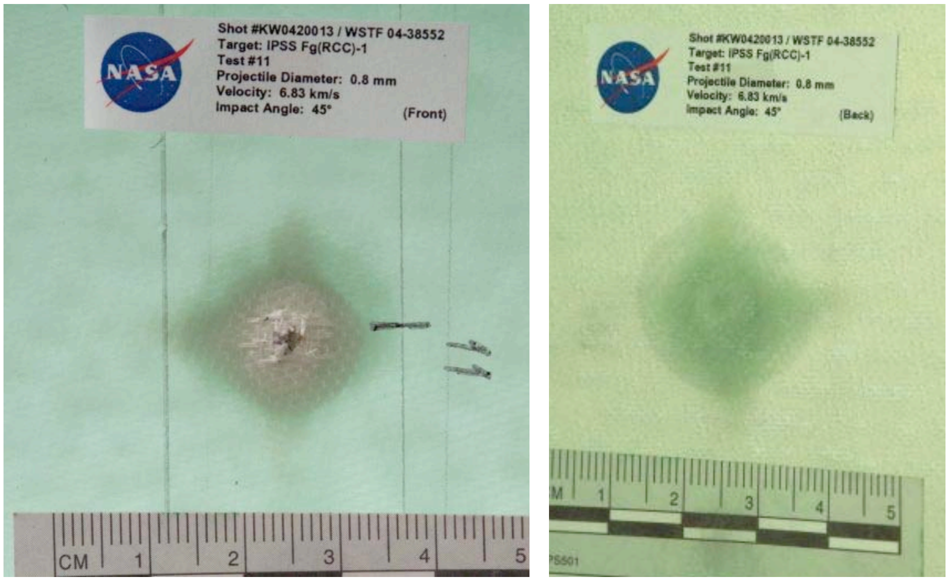


Figure 83: Fg(RCC)-1 Shot #11 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/21/04 Specimen ID: FG-1
Test number: FG1-12 Projectile size: 1.0 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (7, 6)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038
Sensor 2: S/N 0799039
Sensor 3: S/N 0799045
Sensor 4: S/N 101153
Sensor 5: S/N 101146
Sensor 6: S/N 101160
Sensor 7: S/N 101157
Sensor 8: S/N 101148
Sensor 9: S/N 101147
Sensor 10: S/N 101163
Sensor 11: S/N 101150
Sensor 12: S/N 0799050
Sensor 13: S/N 190022
Sensor 14: S/N 190033
Sensor 15: S/N 190034
Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up)
Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down)
Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05)
Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05)
Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05)
Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05)
Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar
Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar
Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-12 7-21-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 9
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 3

Record file name: FG1-12 7-21-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: _________________
Damage description and comments:

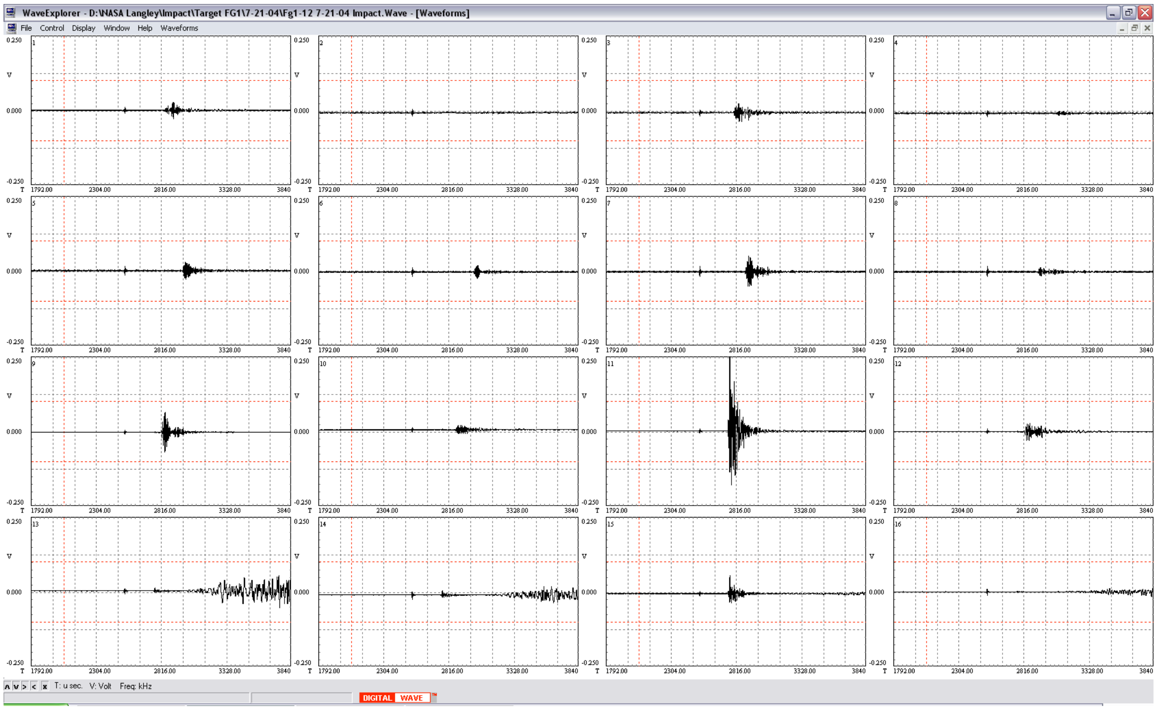


Figure 84: Fg(RCC)-1 Shot #12 Impact Waveform

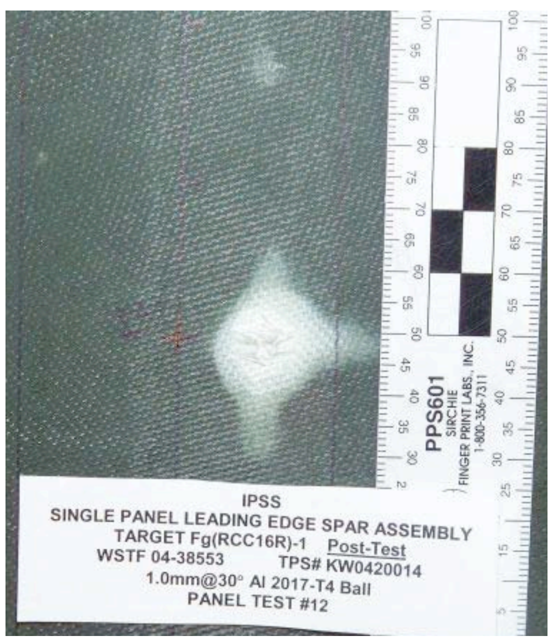


Figure 85: Fg(RCC)-1 Shot #12 Impact Damage

Figure 86: Fg(RCC)-1 Shot #12 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/26/04 Specimen ID: FG-1
Test number: FG1-13 Projectile size: 1.2 mm/90deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (26, 10)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-13 7-26-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 12
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 3

Record file name: FG1-13 7-26-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.75 km/s.
Impact coordinates: ________________
Damage description and comments:

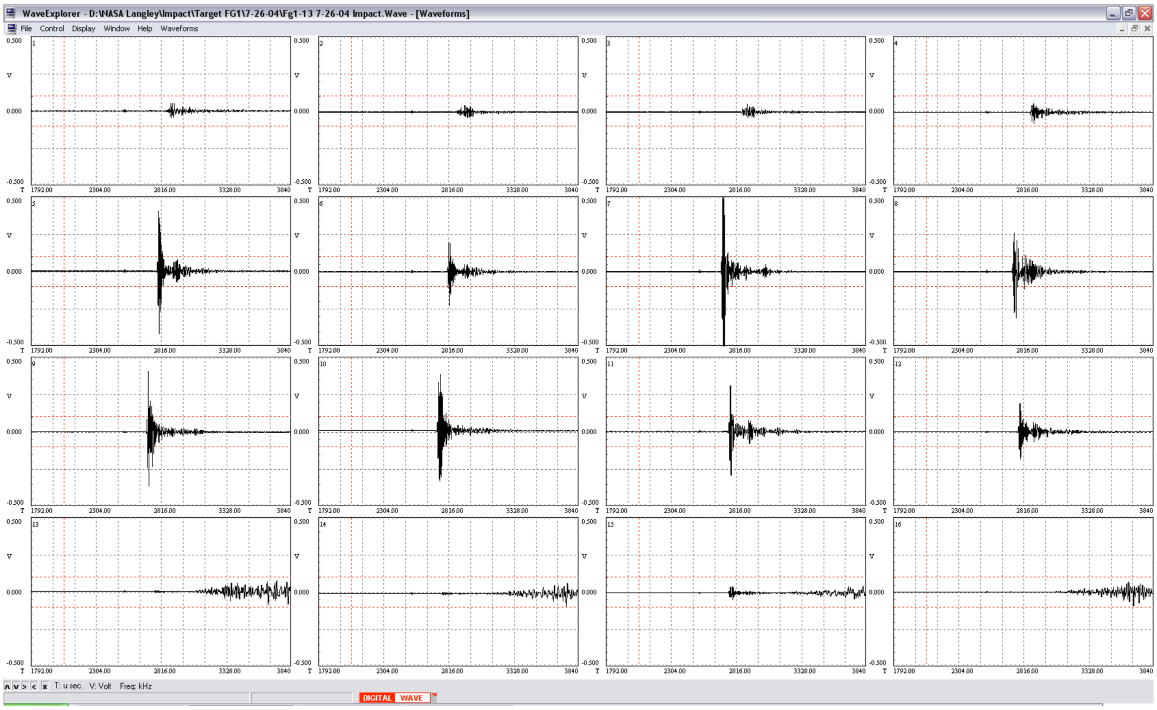


Figure 87: Fg(RCC)-1 Shot #13 Impact Waveform

Figure 88: Fg(RCC)-1 Shot #13 Impact Damage

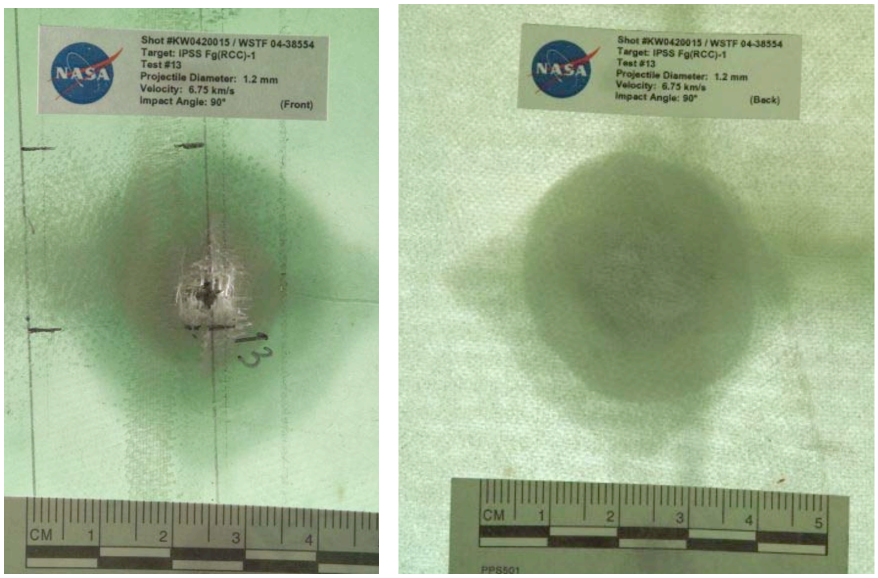


Figure 89: Fg(RCC)-1 Shot #13 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/27/04 Specimen ID: FG-1
Test number: FG1-14 Projectile size: 1.0 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (35, 10)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-14 7-27-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 3

Record file name: FG1-14 7-27-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

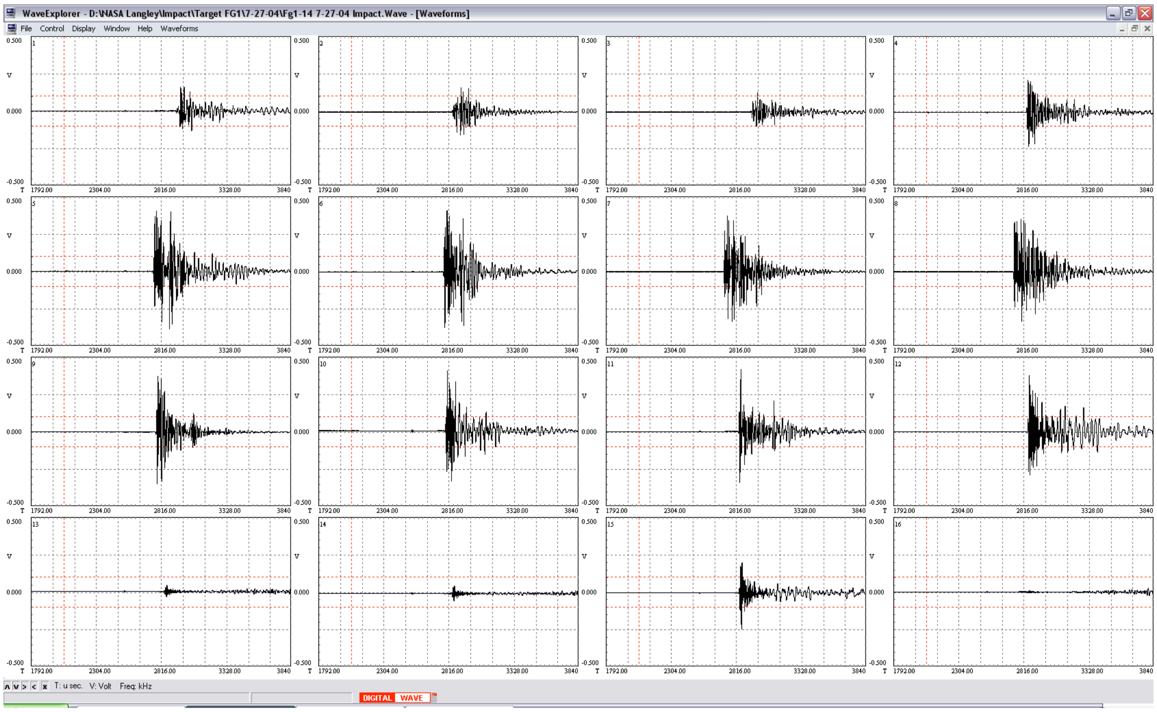


Figure 90: Fg(RCC)-1 Shot #14 Impact Waveform

Figure 91: Fg(RCC)-1 Shot #14 Impact Damage

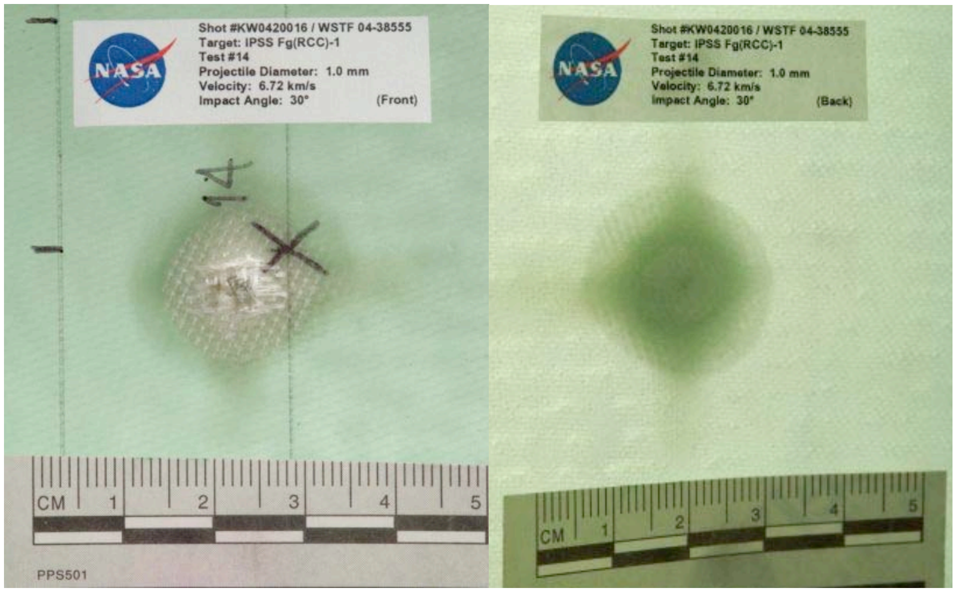


Figure 92: Fg(RCC)-1 Shot #14 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/27/04 Specimen ID: FG-1
Test number: FG1-15 Projectile size: 2.8 mm/60deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (39, 10)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-15 7-27-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 2:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 3:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 4:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 5:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 6:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 7:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 8:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 9:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 10:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 11:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 12:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 6
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 6
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 6
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 6

Record file name: FG1-15 7-27-04 Impact

Comments: The projectile penetrated the test article. Debris struck the spar and saturated the spar sensors. All other sensors O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X

Record actual impact parameters:

Projectile velocity: 6.61 km/s.

Impact coordinates: ________________

Damage description and comments:

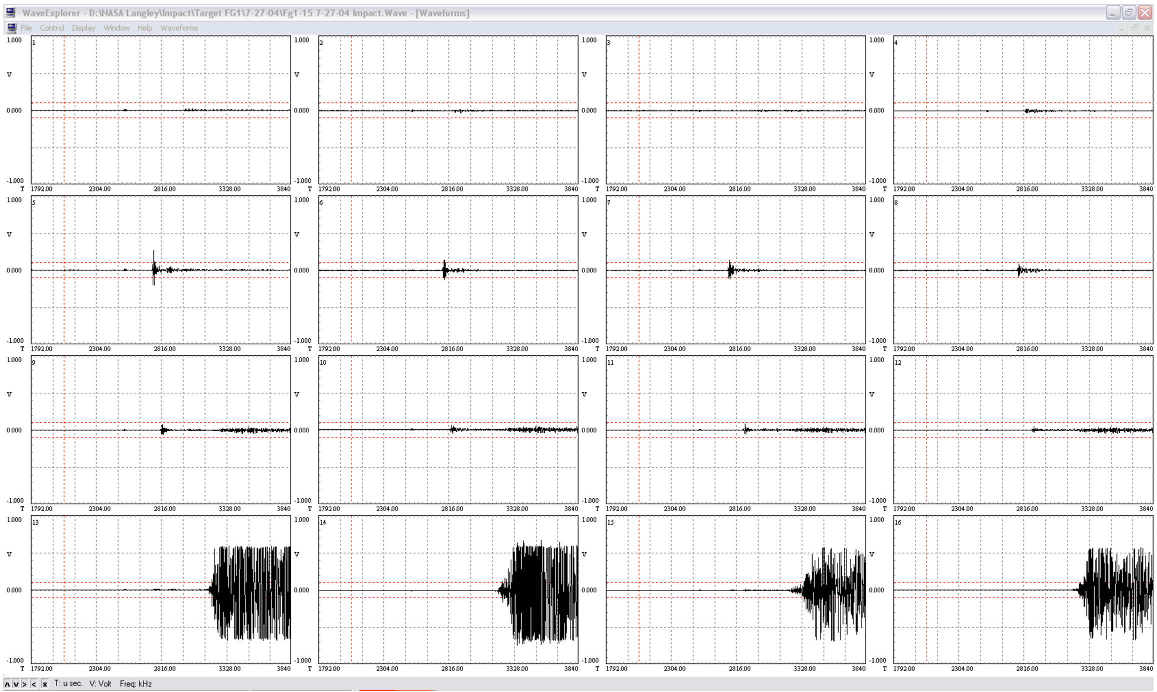
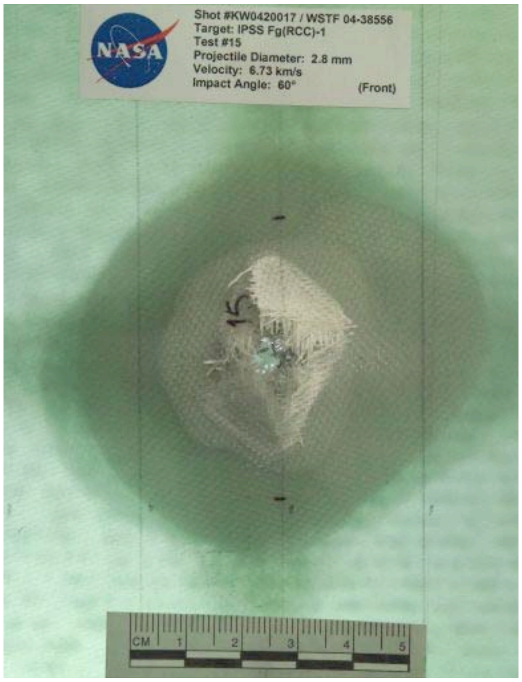


Figure 93: Fg(RCC)-1 Shot #15 Impact Waveform

Figure 94: Fg(RCC)-1 Shot #15 Impact Damage



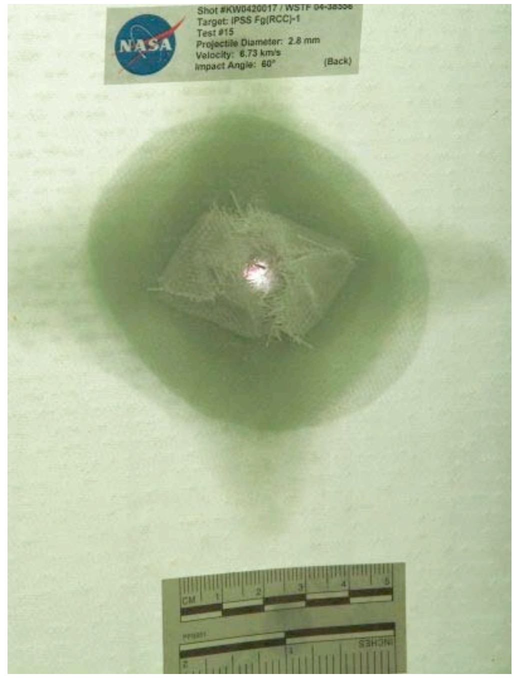


Figure 95: Fg(RCC)-1 Shot #15 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/28/04 Specimen ID: FG-1

Test number: FG1-15a Projectile size: .8 mm/45deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (46, 10)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038
Sensor 2: S/N 0799039
Sensor 3: S/N 0799045
Sensor 4: S/N 101153
Sensor 5: S/N 101146
Sensor 6: S/N 101160
Sensor 7: S/N 101157
Sensor 8: S/N 101148
Sensor 9: S/N 101147
Sensor 10: S/N 101163
Sensor 11: S/N 101150
Sensor 12: S/N 0799050
Sensor 13: S/N 190022
Sensor 14: S/N 190033
Sensor 15: S/N 190034
Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up)
Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down)
Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05)
Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05)
Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05)
Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05)
Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar
Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar
Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source:	X
20 dB PA gain, 3 dB signal gain:	X
20 kHz HP filter, 1500 kHz LP filter:	X
5 MHz SR, 4096 points, 1024 pretrigger:	X

Test sensors and record file name: FG1-15a 7-28-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-15a 7-28-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.68 km/s.
Impact coordinates: ________________
Damage description and comments:

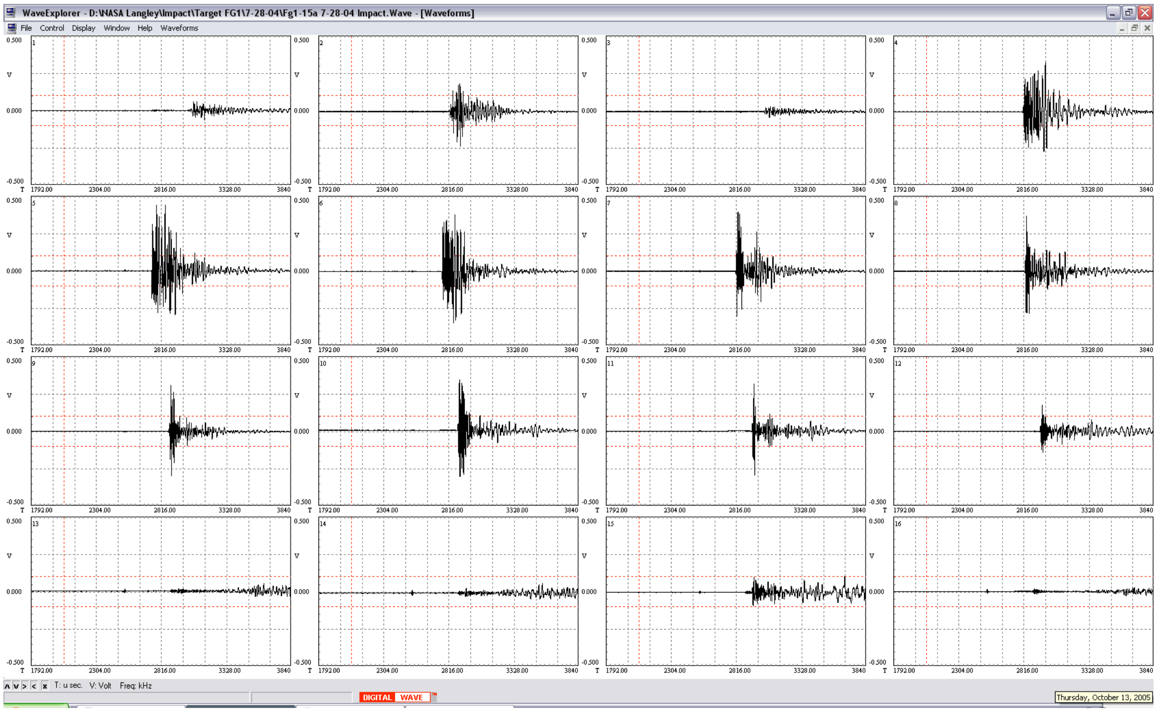


Figure 96: Fg(RCC)-1 Shot #15a Impact Waveform

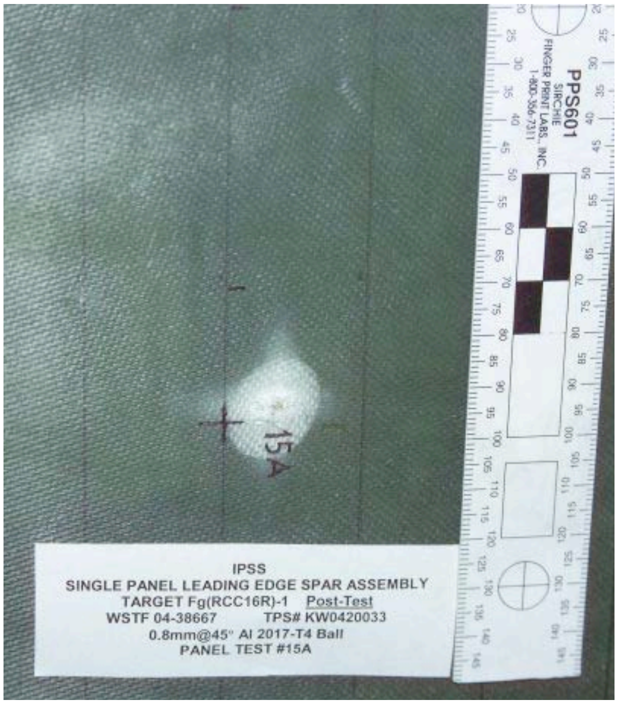


Figure 97: Fg(RCC)-1 Shot #15a Impact Damage

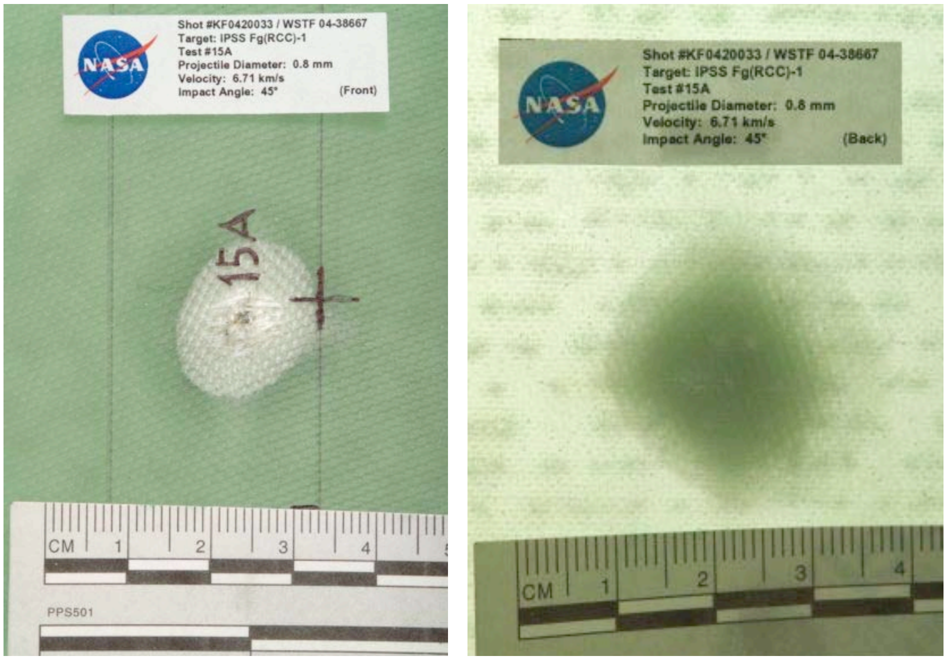


Figure 98: Fg(RCC)-1 Shot #15a Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/28/04 Specimen ID: FG-1

Test number: FG1-16 Projectile size: 1.6 mm/60deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (50, 10)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038
Sensor 2: S/N 0799039
Sensor 3: S/N 0799045
Sensor 4: S/N 101153
Sensor 5: S/N 101146
Sensor 6: S/N 101160
Sensor 7: S/N 101157
Sensor 8: S/N 101148
Sensor 9: S/N 101147
Sensor 10: S/N 101163
Sensor 11: S/N 101150
Sensor 12: S/N 0799050
Sensor 13: S/N 190022
Sensor 14: S/N 190033
Sensor 15: S/N 190034
Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-16 7-28-04 pretest LB
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 6
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 18
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 18
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 18
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 18

Record file name: FG1-16 7-28-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.94 km/s.
Impact coordinates: ________________
Damage description and comments:

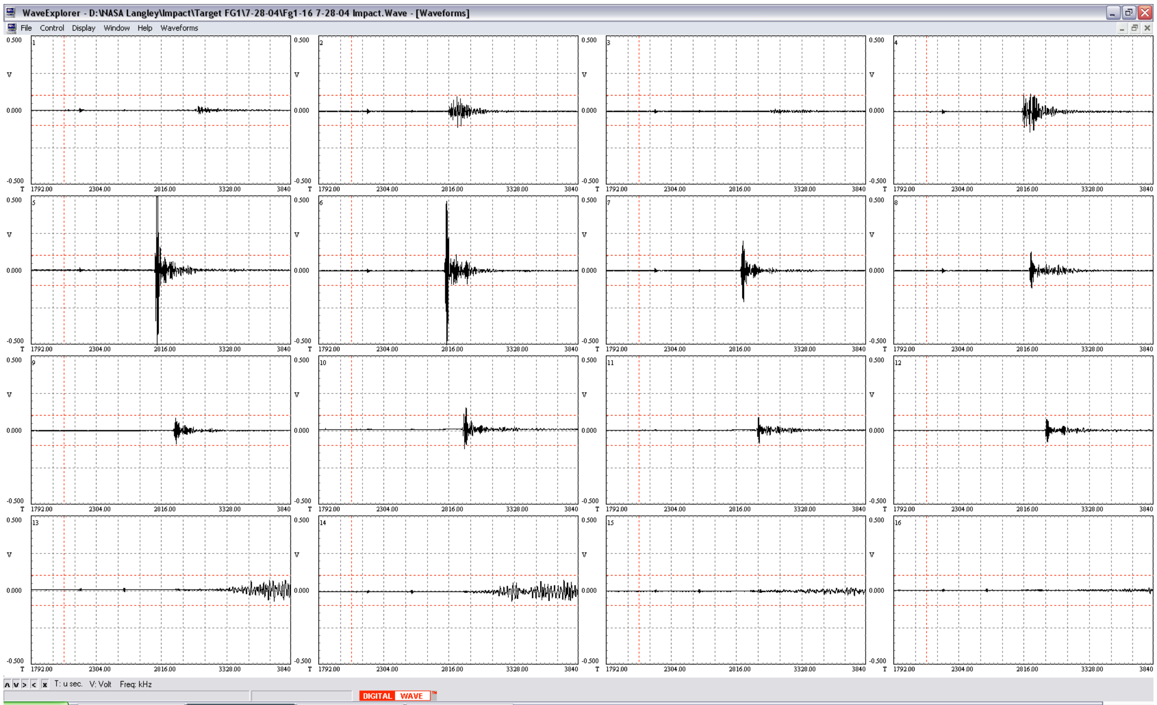


Figure 99: Fg(RCC)-1 Shot #16 Impact Waveform

Figure 100: Fg(RCC)-1 Shot #16 Impact Damage

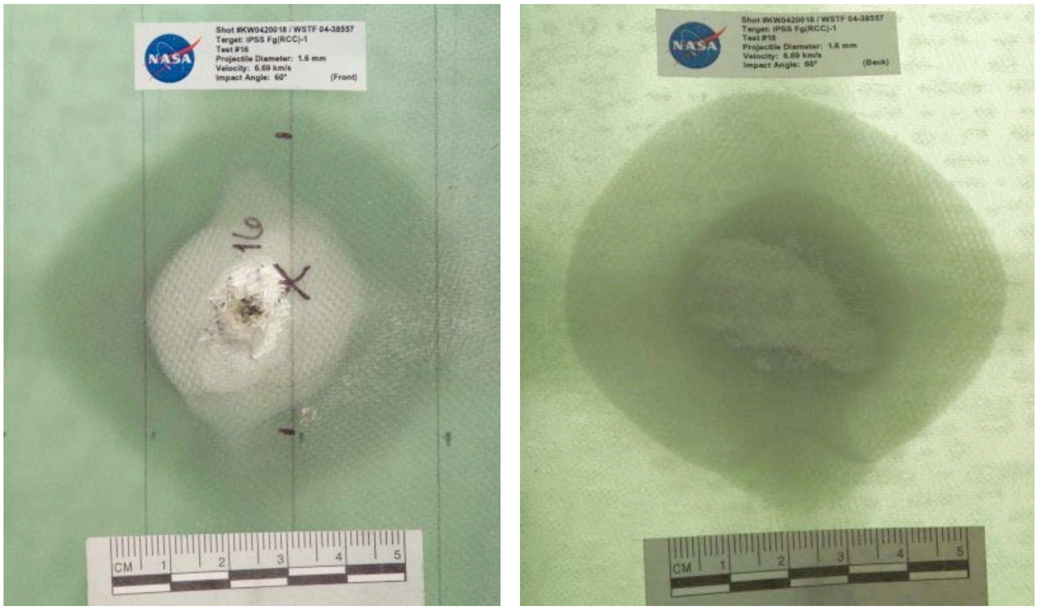


Figure 101: Fg(RCC)-1 Shot #16 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:
Test date: 7/29/04 Specimen ID: FG-1
Test number: FG1-17 Projectile size: 1.8 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (17, 10)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:
Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:
Verify settings:
SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-17 7-29-04 pretest LB
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 18
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 18
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 18
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 18

Record file name: FG1-17 7-29-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.94 km/s.
Impact coordinates: ________________
Damage description and comments:

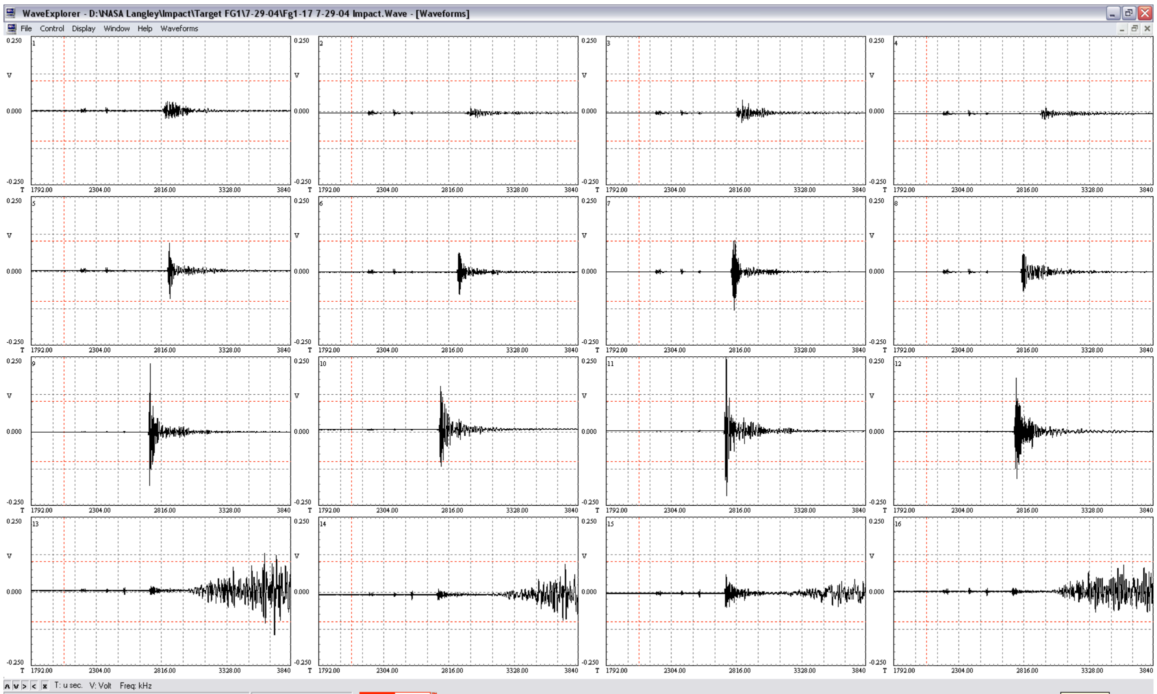


Figure 102: Fg(RCC)-1 Shot #17 Impact Waveform

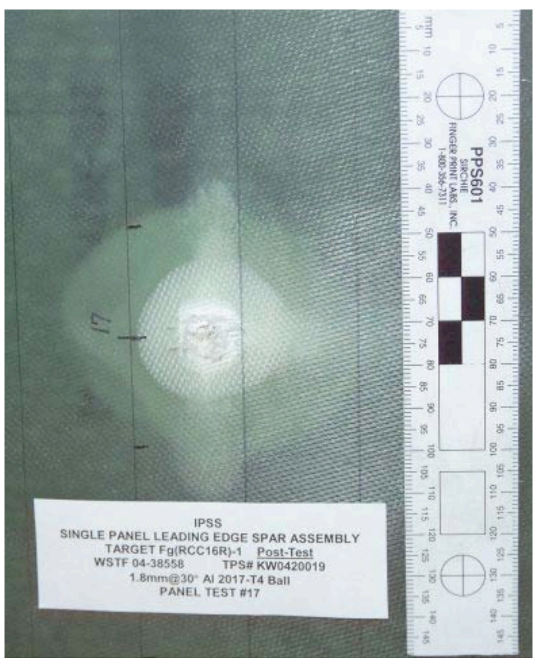


Figure 103: Fg(RCC)-1 Shot #17 Impact Damage

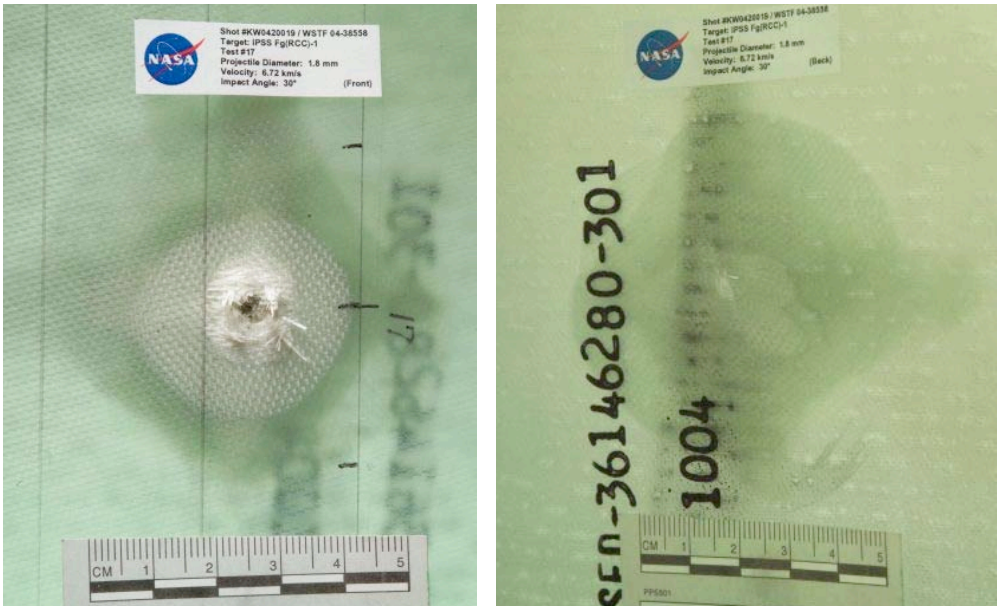


Figure 104: Fg(RCC)-1 Shot #17 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 7/29/04 Specimen ID: FG-1

Test number: FG1-18 Projectile size: 2.4 mm/45deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (7, 10)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard

Flange Corner (down)

Sensor 5: _Upper Surface (46, 05) Sensor 6: _Upper Surface (46, 19)

Sensor 7: _Upper Surface (31, 05) Sensor 8: _Upper Surface (31, 19)

Sensor 9: _Lower Surface (21, 05) Sensor 10: _Lower Surface (21, 19)

Sensor 11: _Lower Surface (11, 05) Sensor 12: _Lower Surface (11, 19)

Sensor 13: _Lower Outboard Underside Spar Sensor 14: _Upper Outboard Underside Spar

Sensor 15: _Upper Inboard Underside Spar Sensor 16: _Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-18 7-29-04 pretestlb

Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X

20 kHz HP filter, 1500 kHz LP filter: X

2 MHz SR, 32 K points, 4096 pretrigger: X

16 channel recording mode: X

Data acquisition in record mode: X

(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 0

Sensor 13: Attenuators: 0 Preamp: -20 SCM: 9
Sensor 14: Attenuators: 0 Preamp: -20 SCM: 9
Sensor 15: Attenuators: 0 Preamp: -20 SCM: 9
Sensor 16: Attenuators: 0 Preamp: -20 SCM: 9

Record file name: FG1-18 7-29-04 Impact
Comments:

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:
Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

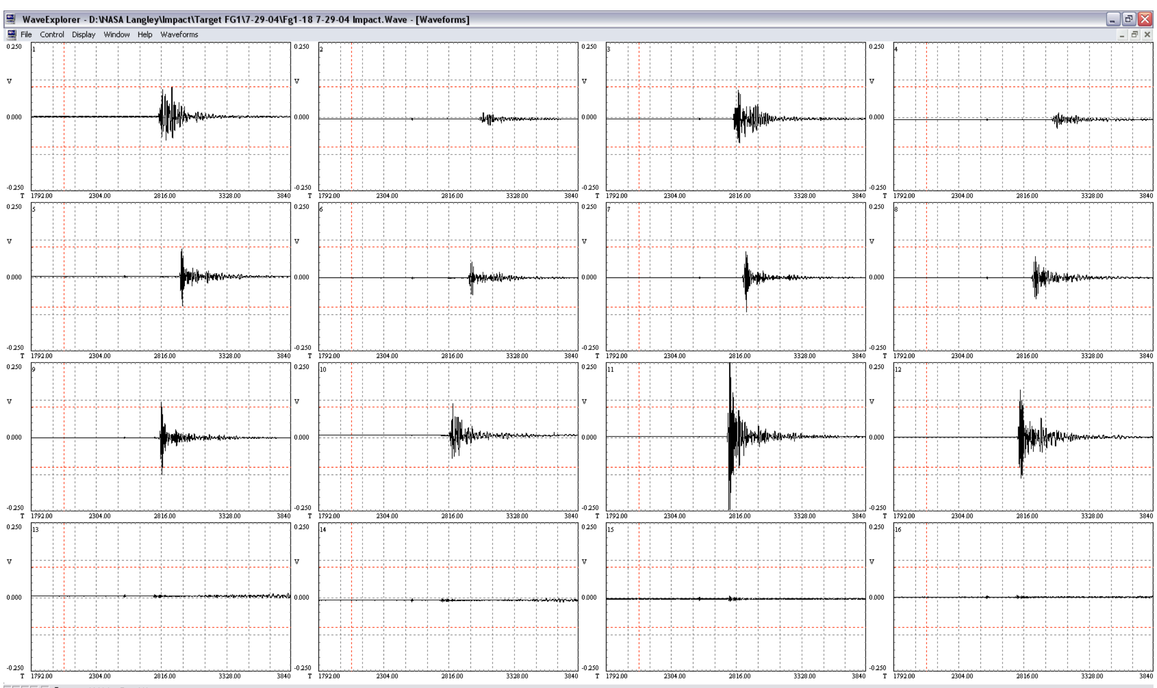


Figure 105: Fg(RCC)-1 Shot #18 Impact Waveform

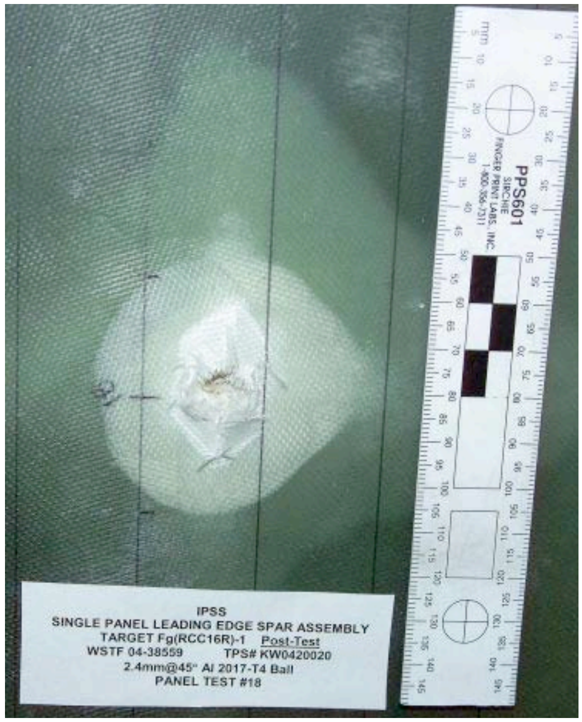


Figure 106: Fg(RCC)-1 Shot #18 Impact Damage

Figure 107: Fg(RCC)-1 Shot #18 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/03/04 Specimen ID: FG-1

Test number: FG1-19 Projectile size: 2.4 mm/90deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (26, 14)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-19 8-03-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: -20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: -20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: -20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: -20	SCM: 12

Record file name: FG1-19 8-03-04 Impact
Comments:

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

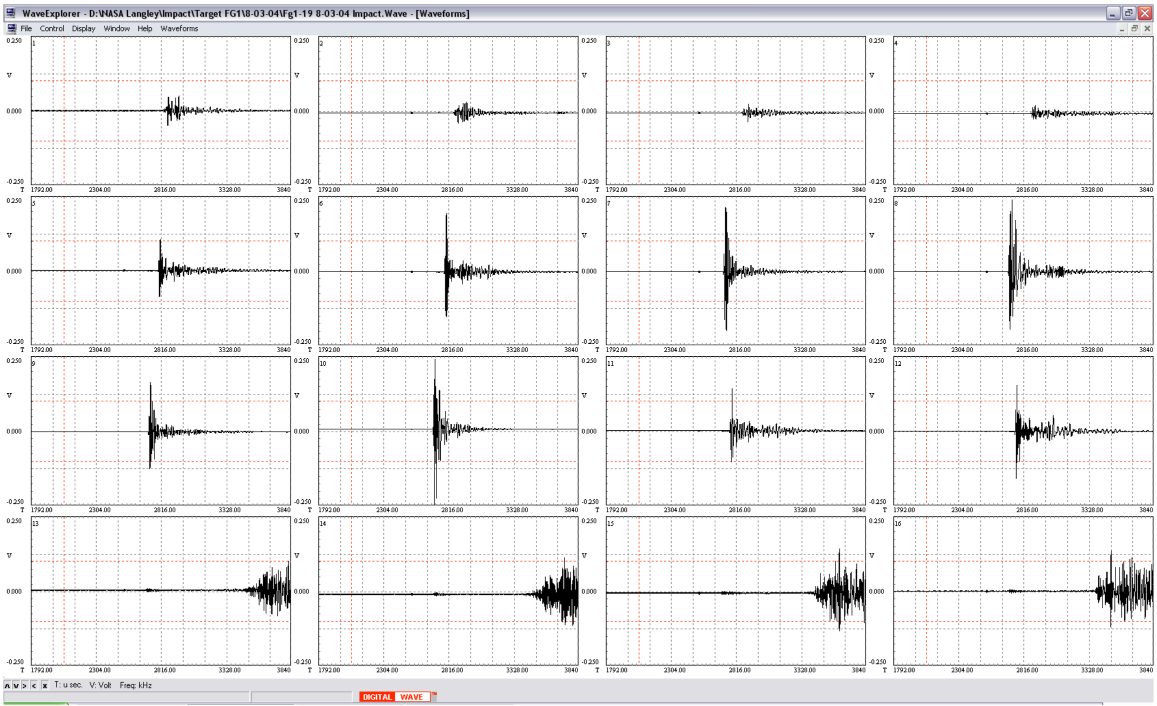


Figure 108: Fg(RCC)-1 Shot #19 Impact Waveform

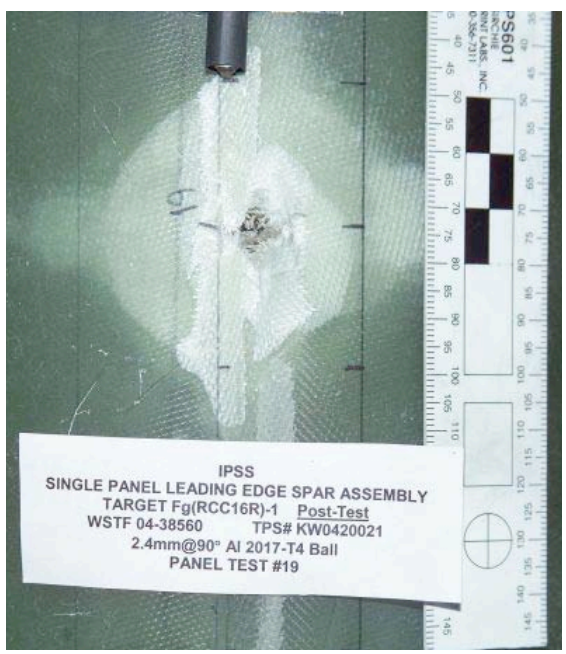


Figure 109: Fg(RCC)-1 Shot #19 Impact Damage

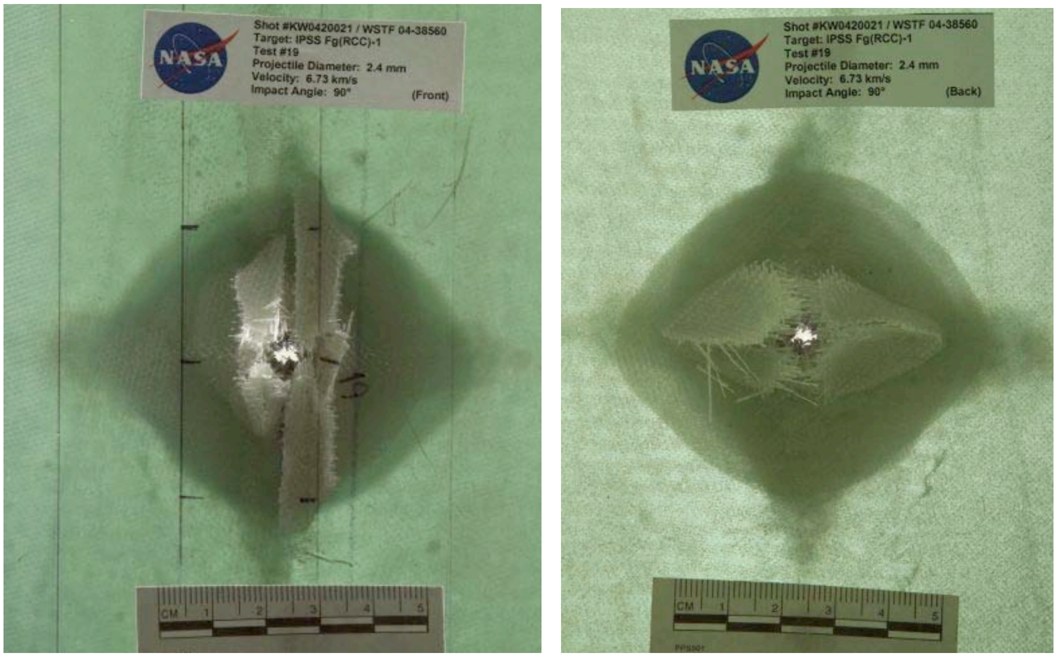


Figure 110: Fg(RCC)-1 Shot #19 Backlit Impact Damage (Left: Front Side, Right: Back Side)

I. Record pretest information:
Test date: 8/03/04   Specimen ID: FG-1
Test number: FG1-20   Projectile size: 2.0 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (35, 14)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038	Sensor 2: S/N 0799039
Sensor 3: S/N 0799045	Sensor 4: S/N 101153
Sensor 5: S/N 101146	Sensor 6: S/N 101160
Sensor 7: S/N 101157	Sensor 8: S/N 101148
Sensor 9: S/N 101147	Sensor 10: S/N 101163
Sensor 11: S/N 101150	Sensor 12: S/N 0799050
Sensor 13: S/N 190022	Sensor 14: S/N 190033
Sensor 15: S/N 190034	Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:
Verify settings:
SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X
Test sensors and record file name: FG1-20 8-03-04 pretestlb

Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X

20 kHz HP filter, 1500 kHz LP filter: X

2 MHz SR, 32 K points, 4096 pretrigger: X

16 channel recording mode: X

Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 15

Record file name: FG1-20 8-03-04 Impact

Comments:

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X

20 kHz HP filter, 1500 kHz LP filter X

5 MHz SR, 4096 points, 1024 pretrigger X

Test sensors and record file name:

Comments:

VIII: Post test

Review data and backup files on CD X

Record actual impact parameters:

Projectile velocity: 6.61 km/s.

Impact coordinates: ________________
Damage description and comments:

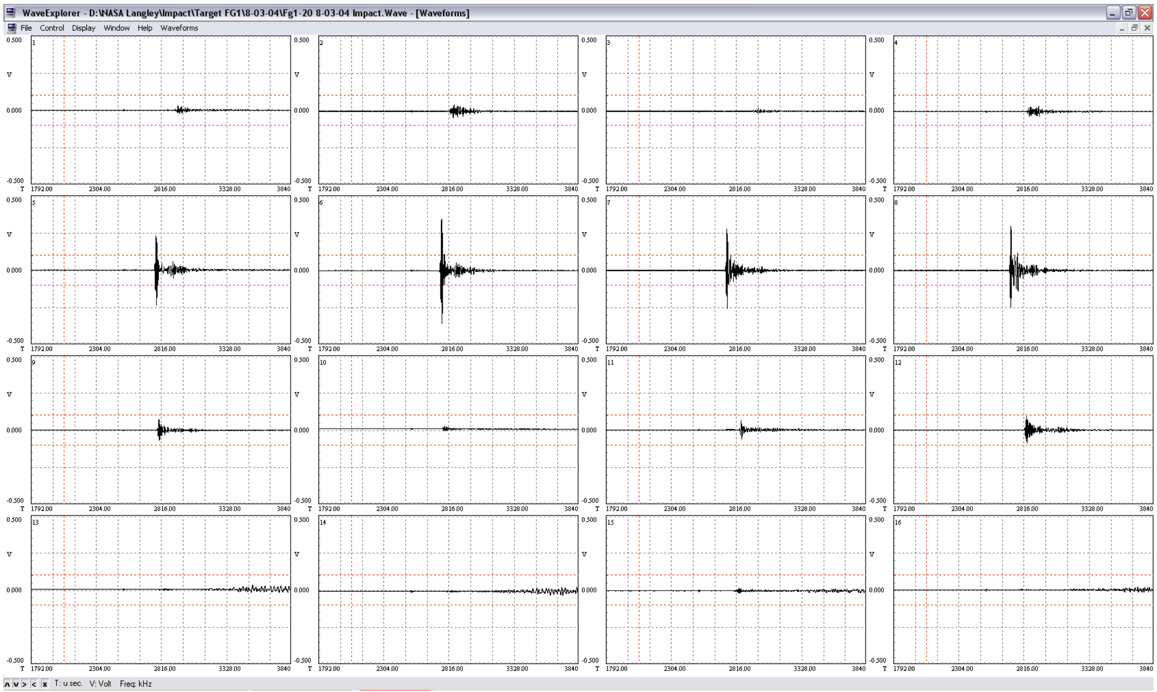


Figure 111: Fg(RCC)-1 Shot #20 Impact Waveform

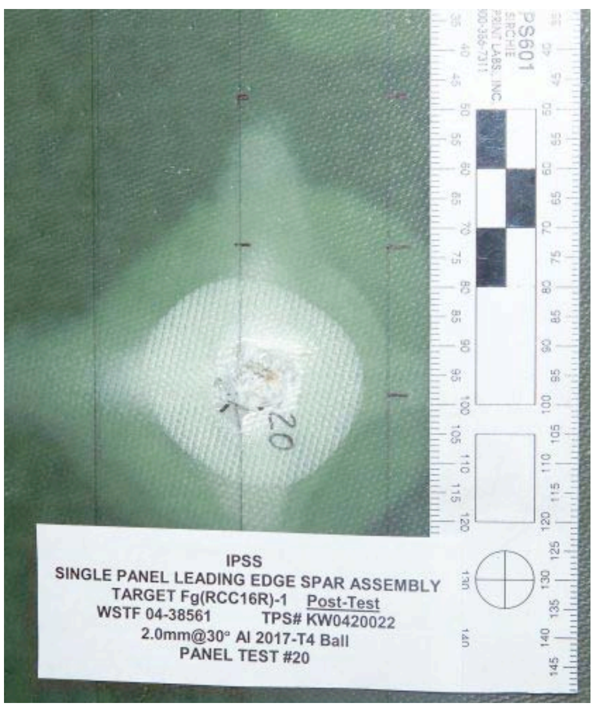


Figure 112: Fg(RCC)-1 Shot #20 Impact Damage

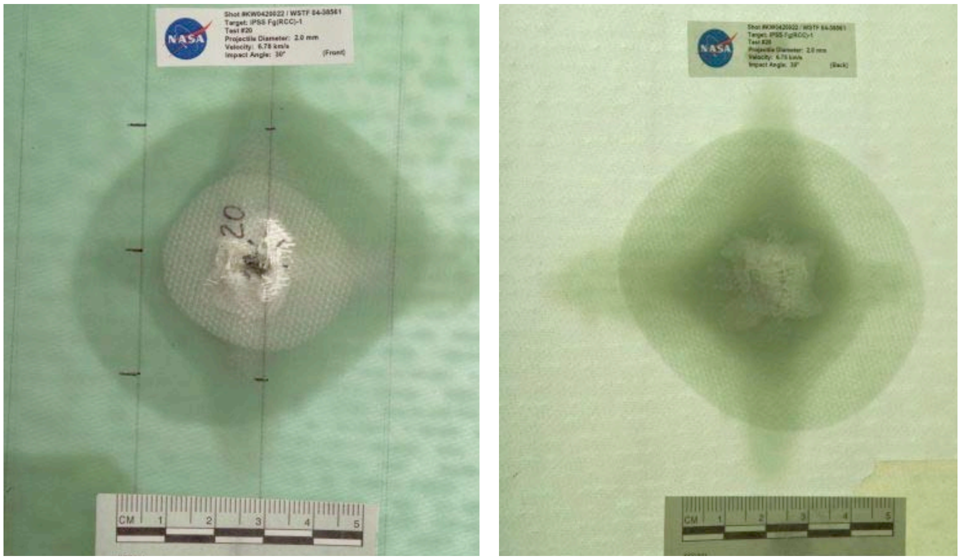


Figure 113: Fg(RCC)-1 Shot #20 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/04/04 Specimen ID: FG-1

Test number: FG1-21 Projectile size: .6 mm/60deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (39, 14)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source:	X
20 dB PA gain, 3 dB signal gain:	X
20 kHz HP filter, 1500 kHz LP filter:	X
5 MHz SR, 4096 points, 1024 pretrigger:	X

Test sensors and record file name: FG1-21 8-04-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 2:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 3:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 4:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 5:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 6:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 7:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 8:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 9:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 10:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 11:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 12:	Attenuators: 0	Preamp: -20	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 12

Record file name: FG1-21 8-04-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.77 km/s.
Impact coordinates: ________________
Damage description and comments

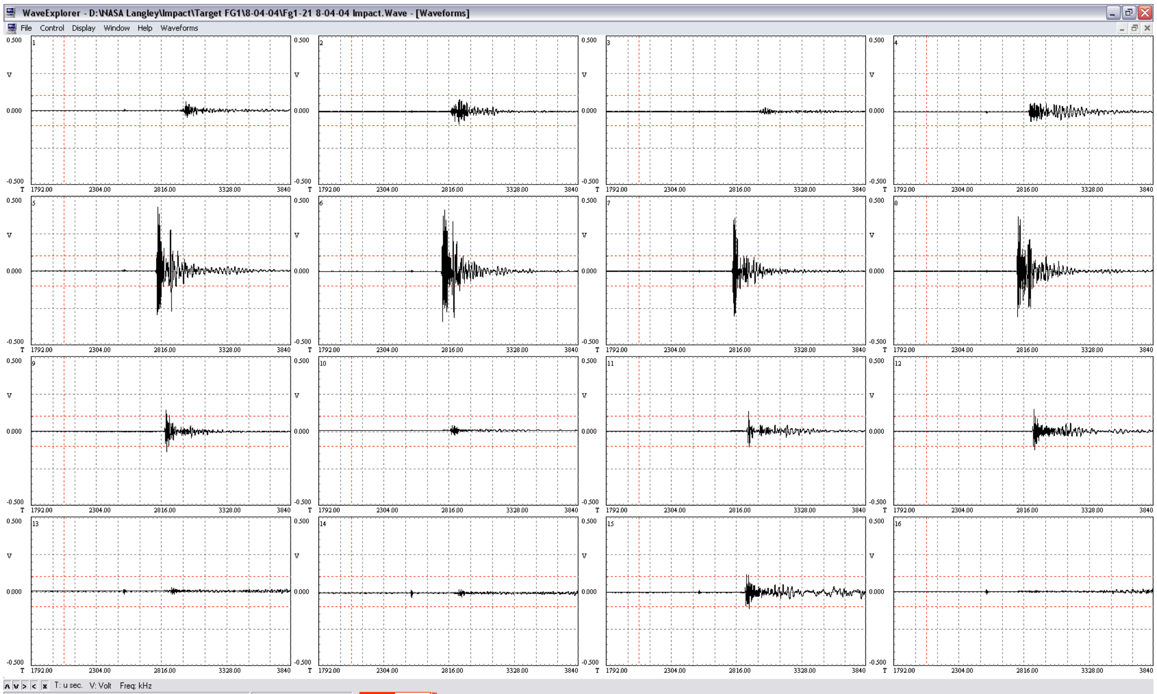


Figure 114: Fg(RCC)-1 Shot #21 Impact Waveform

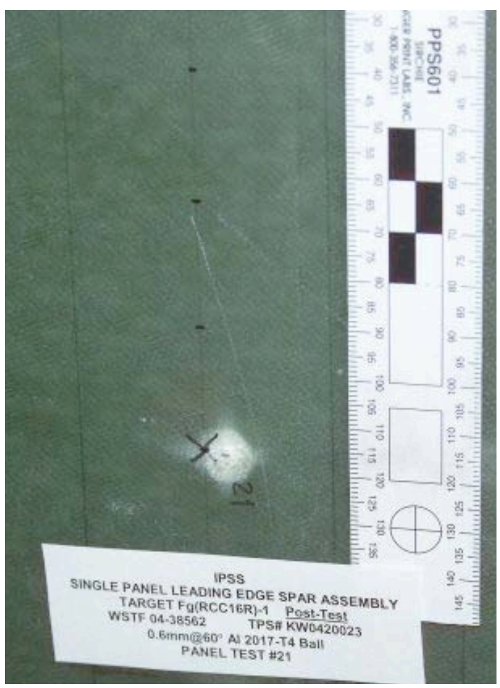


Figure 115: Fg(RCC)-1 Shot #21 Impact Damage

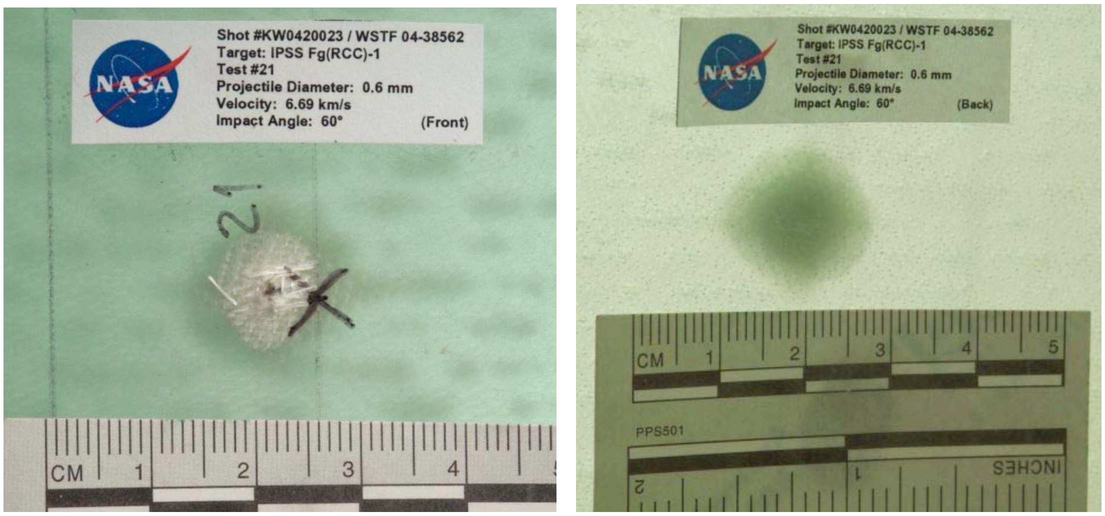


Figure 116: Fg(RCC)-1 Shot #21 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/04/04 Specimen ID: FG-1
Test number: FG1-22 Projectile size: 2.0 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (50, 14)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-22 8-04-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 15

Record file name: FG1-22 8-04-04 Impact
Comments: Attenuators installed inside the target chamber. Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.77 km/s.
Impact coordinates: ________________
Damage description and comments:

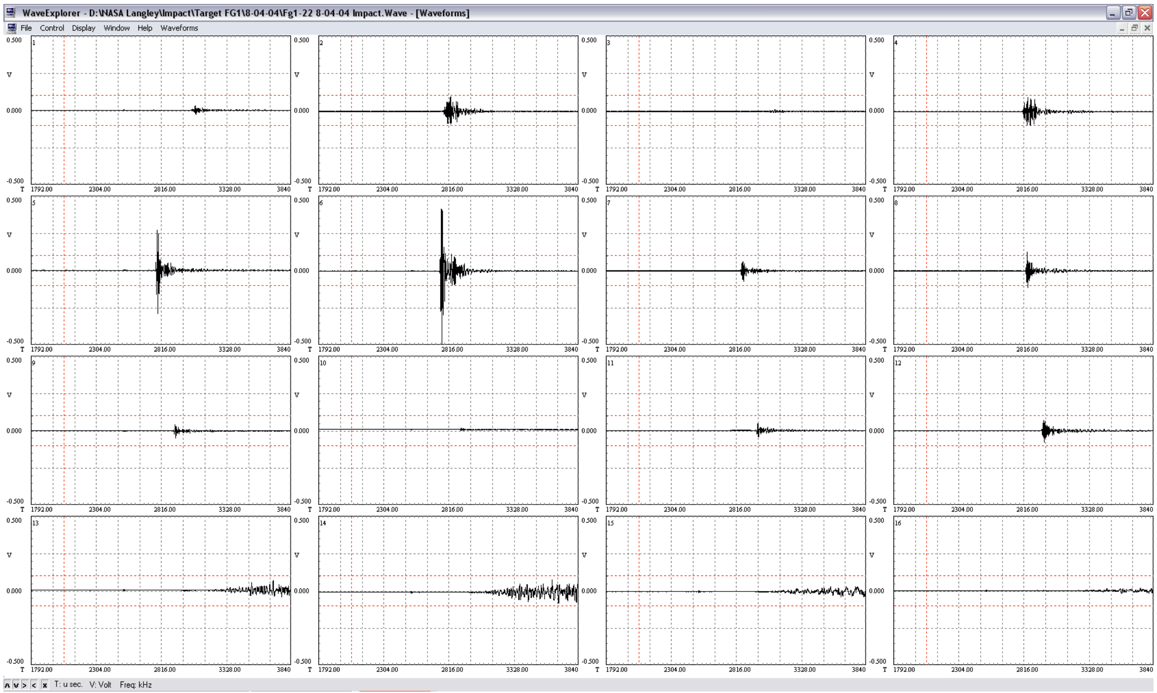


Figure 117: Fg(RCC)-1 Shot #22 Impact Waveform

Figure 118: Fg(RCC)-1 Shot #22 Impact Damage

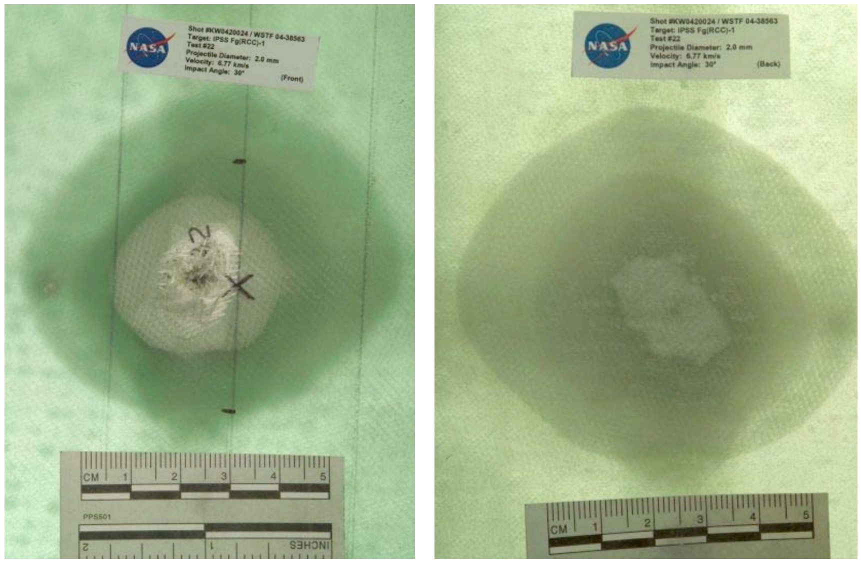


Figure 119: Fg(RCC)-1 Shot #22 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/05/04 Specimen ID: FG-1
Test number: FG1-23 Projectile size: 1.0 mm/45deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (17, 14)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-23 8-05-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 18
Sensor 13:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 14:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 15:	Attenuators: 0	Preamp: 20	SCM: 3
Sensor 16:	Attenuators: 0	Preamp: 20	SCM: 3

Record file name: FG1-23 8-05-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

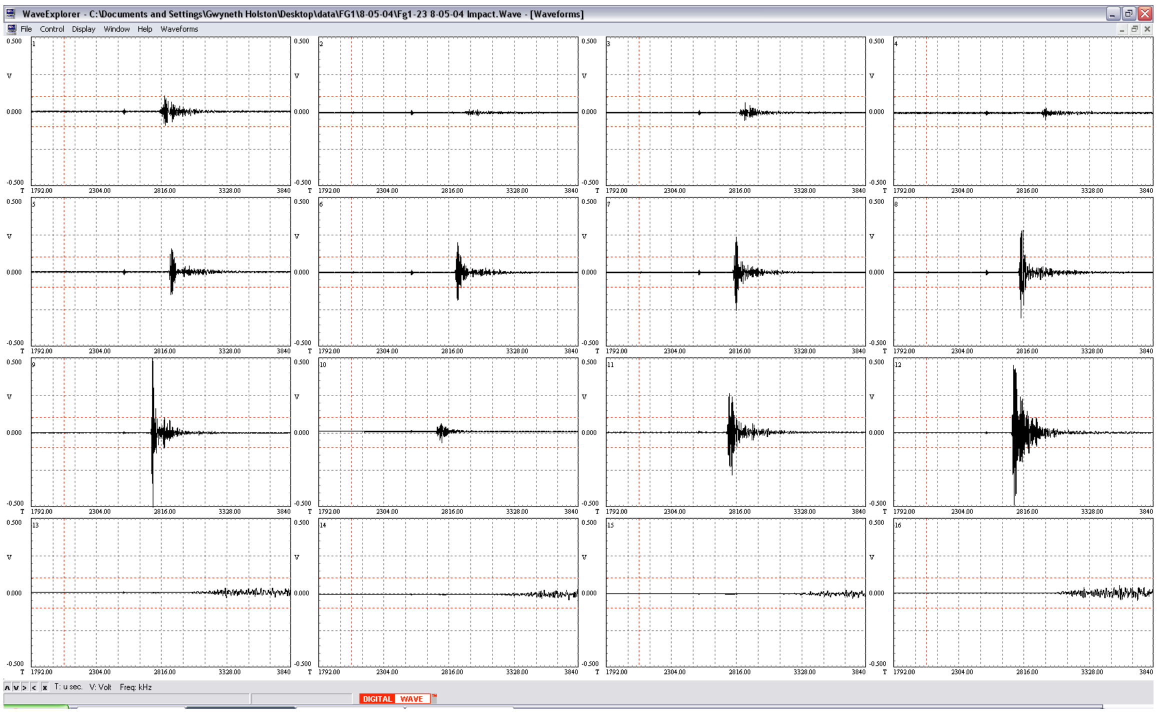


Figure 120: Fg(RCC)-1 Shot #23 Impact Waveform

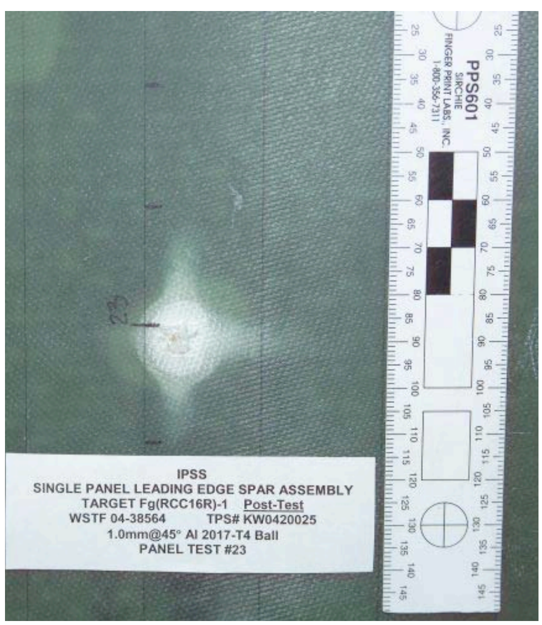


Figure 121: Fg(RCC)-1 Shot #23 Impact Damage

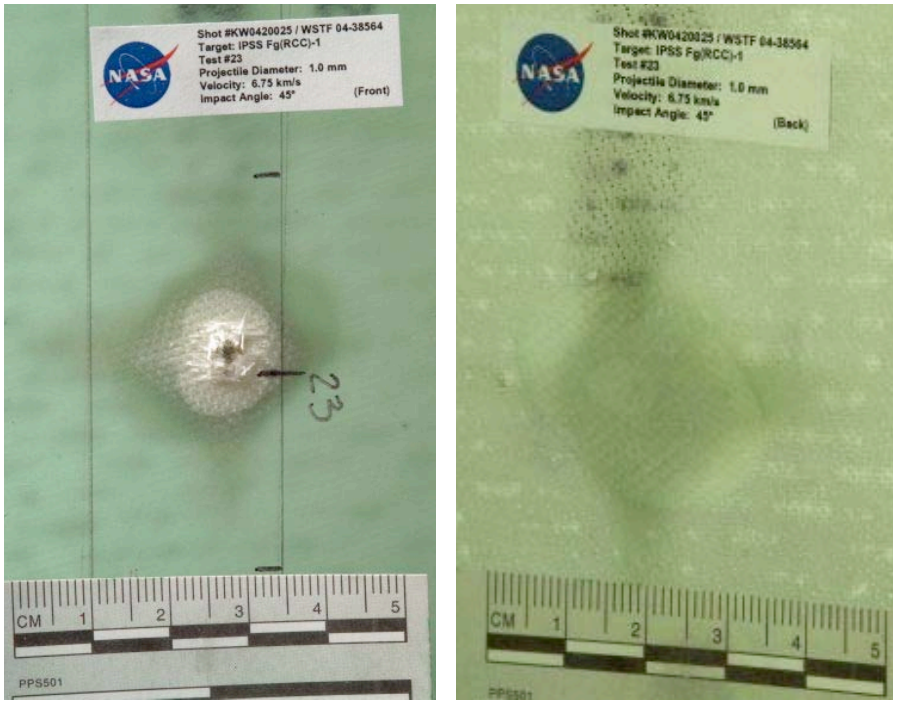


Figure 122: Fg(RCC)-1 Shot #23 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/05/04 Specimen ID: FG-1
Test number: FG1-24 Projectile size: 2.0 mm/60deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (7, 14)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)
Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-24 8-05-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 15

Record file name: FG1-24 8-05-04 Impact
Comments:

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

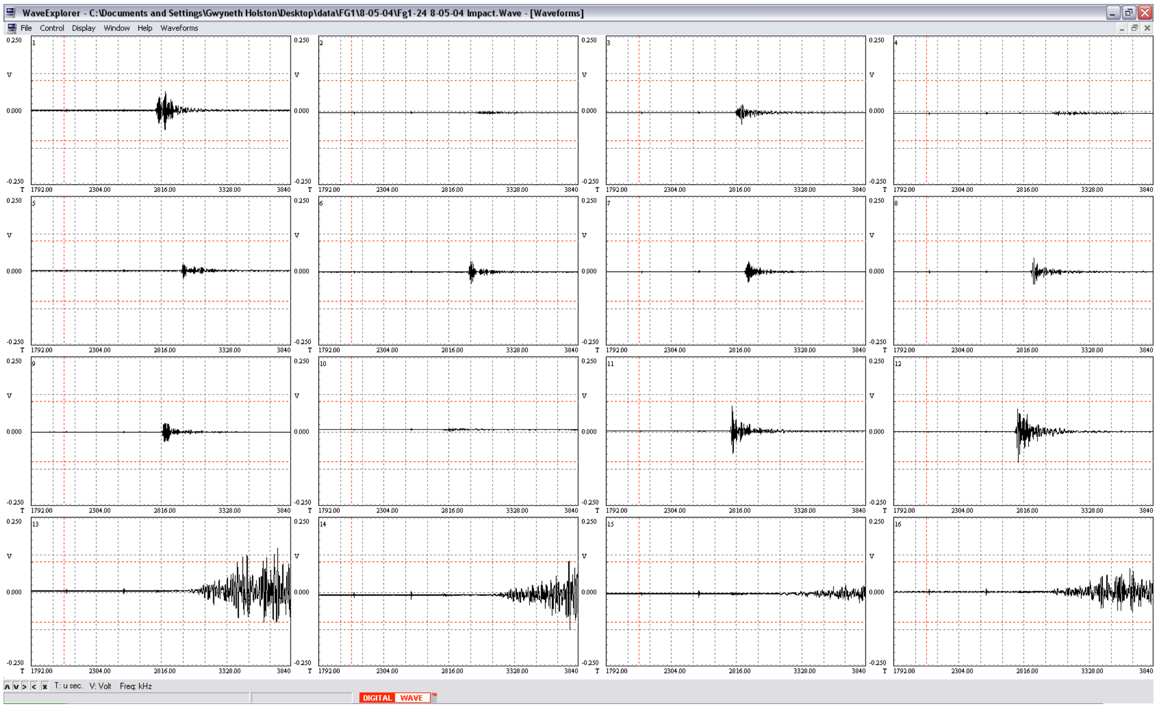


Figure 123: Fg(RCC)-1 Shot #24 Impact Waveform

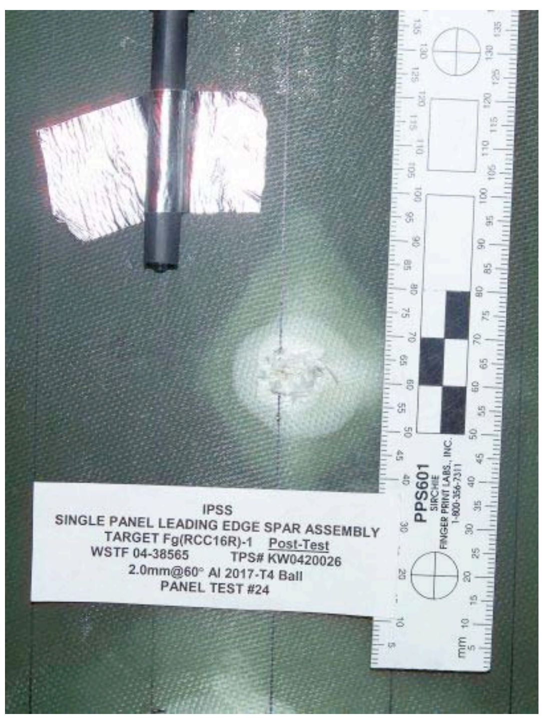


Figure 124: Fg(RCC)-1 Shot #24 Impact Damage

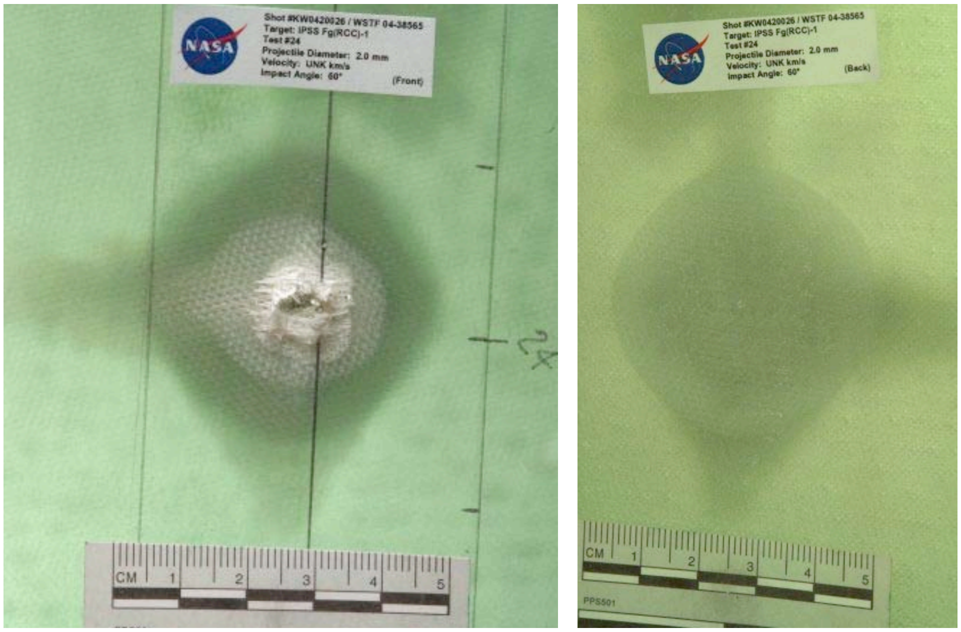


Figure 125: Fg(RCC)-1 Shot #24 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/09/04 Specimen ID: FG-1

Test number: FG1-25 Projectile size: 1.8 mm/90deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (26, 19)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-25 8-09-04 pretest LB
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 12
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 12
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 12
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 12

Record file name: FG1-25 8-09-04 Impact
Comments: Data O.K.

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.94 km/s.
Impact coordinates: ________________
Damage description and comments:

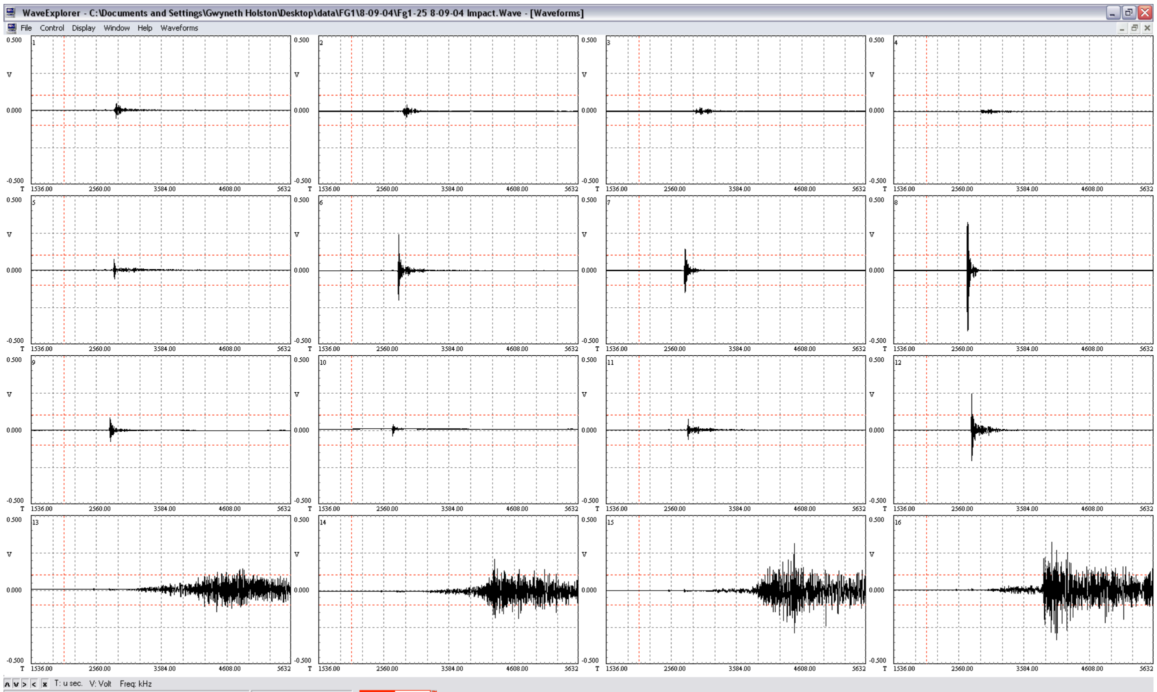


Figure 126: Fg(RCC)-1 Shot #25 Impact Waveform

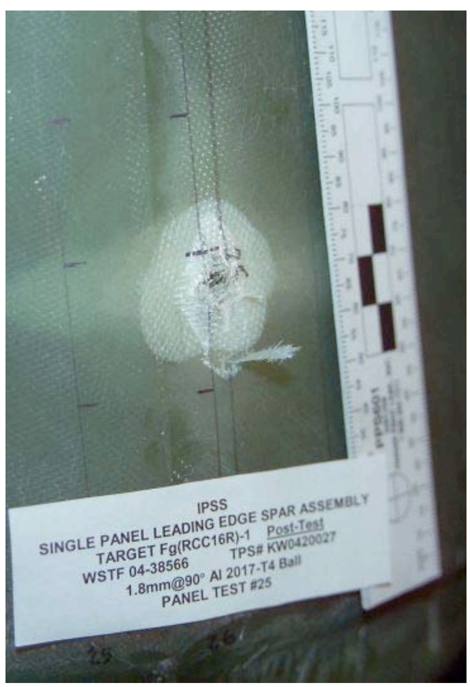


Figure 127: Fg(RCC)-1 Shot #25 Impact Damage

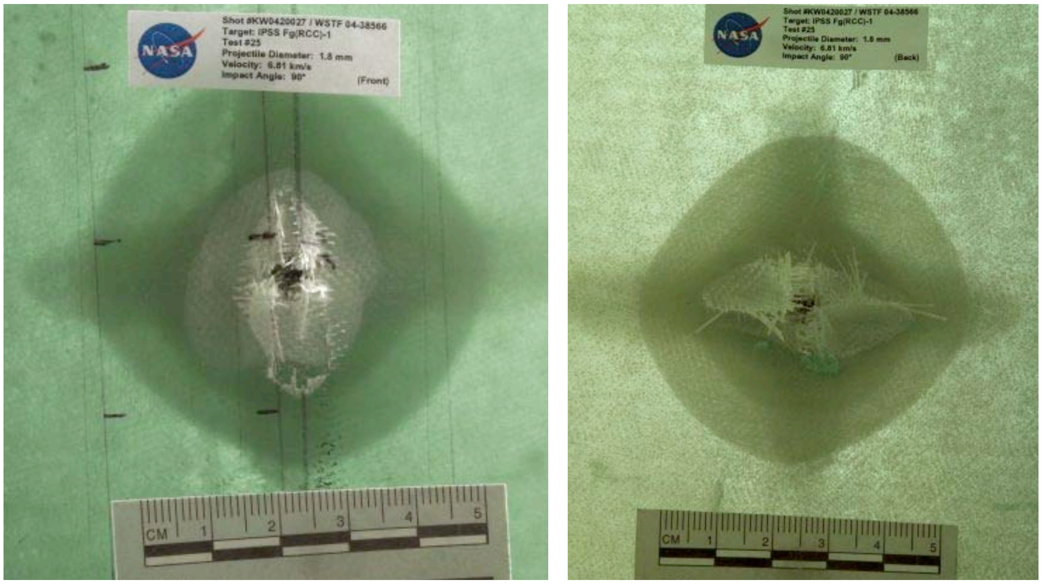


Figure 128: Fg(RCC)-1 Shot #25 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/09/04 Specimen ID: FG-1

Test number: FG1-26 Projectile size: 2.4 mm/60deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (35, 19)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-26 8-09-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 0
Sensor 13:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 14:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 15:	Attenuators: 0	Preamp: -20	SCM: 9
Sensor 16:	Attenuators: 0	Preamp: -20	SCM: 9

Record file name: FG1-26 8-09-04 Impact
Comments:

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

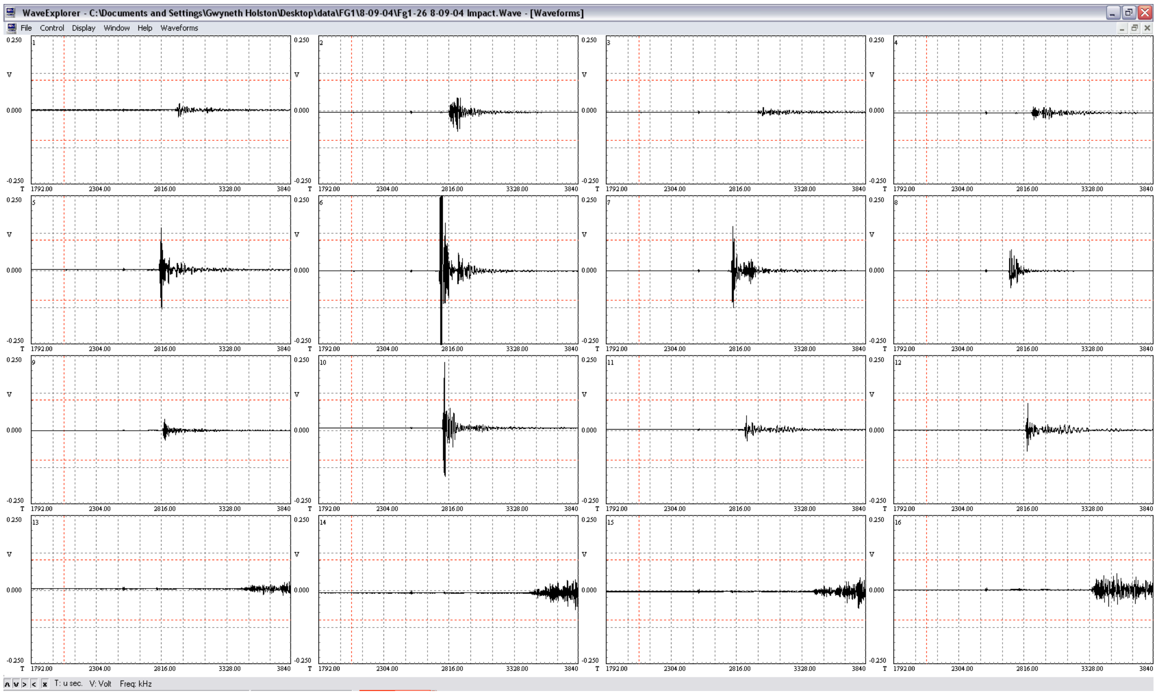


Figure 129: Fg(RCC)-1 Shot #26 Impact Waveform

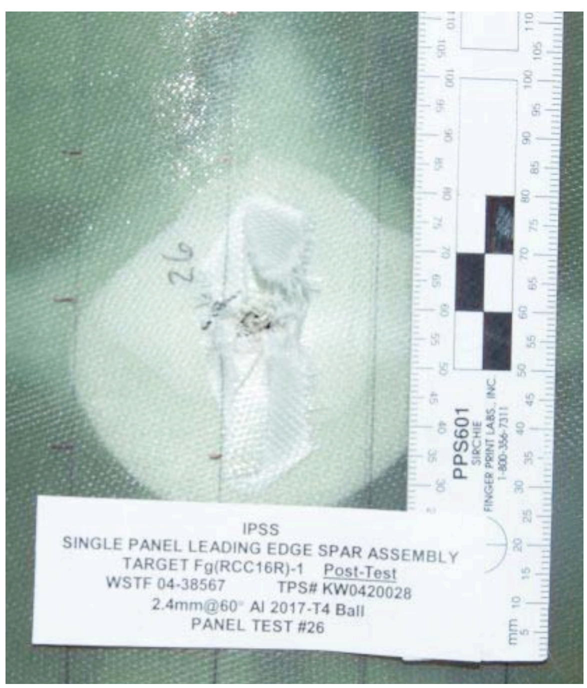


Figure 130: Fg(RCC)-1 Shot #26 Impact Damage

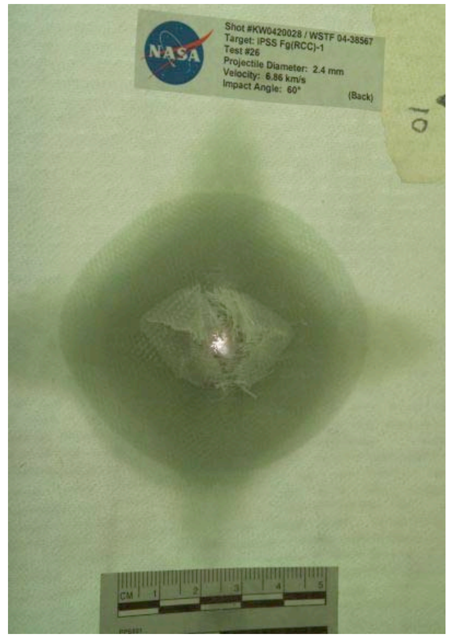


Figure 131: Fg(RCC)-1 Shot #26 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/10/04 Specimen ID: FG-1

Test number: FG1-27 Projectile size: 1.8 mm/60deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (39, 19)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-27 8-10-04 pretest LB
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:

External (gun) trigger source:	X
20 kHz HP filter, 1500 kHz LP filter:	X
2 MHz SR, 32 K points, 4096 pretrigger:	X
16 channel recording mode:	X
Data acquisition in record mode: (DWC logo spinning)	X

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 2:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 3:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 4:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 5:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 6:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 7:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 8:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 9:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 10:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 11:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 12:	Attenuators: 30	Preamp: 0	SCM: 3
Sensor 13:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 14:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 15:	Attenuators: 0	Preamp: 0	SCM: 15
Sensor 16:	Attenuators: 0	Preamp: 0	SCM: 15

Record file name: FG1-27 8-10-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:

20 dB PA gain, 3 dB signal gain	X
20 kHz HP filter, 1500 kHz LP filter	X
5 MHz SR, 4096 points, 1024 pretrigger	X

Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.94 km/s.
Impact coordinates: ________________
Damage description and comments:

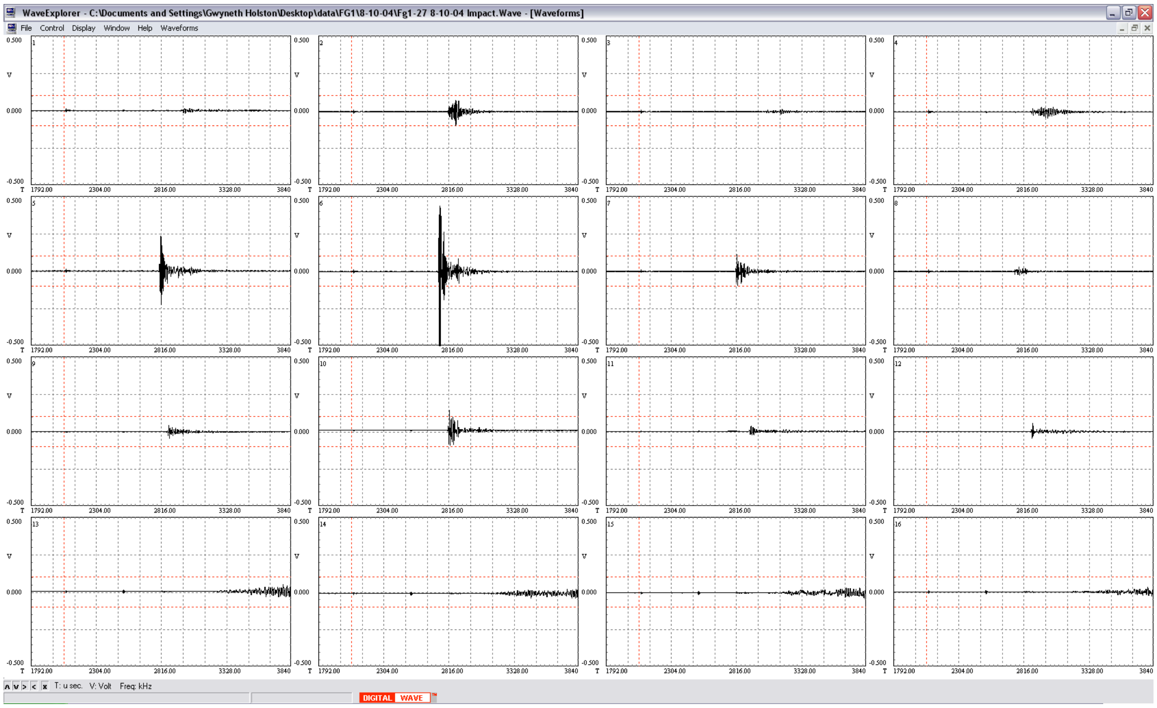


Figure 132: Fg(RCC)-1 Shot #27 Impact Waveform

Figure 133: Fg(RCC)-1 Shot #27 Impact Damage

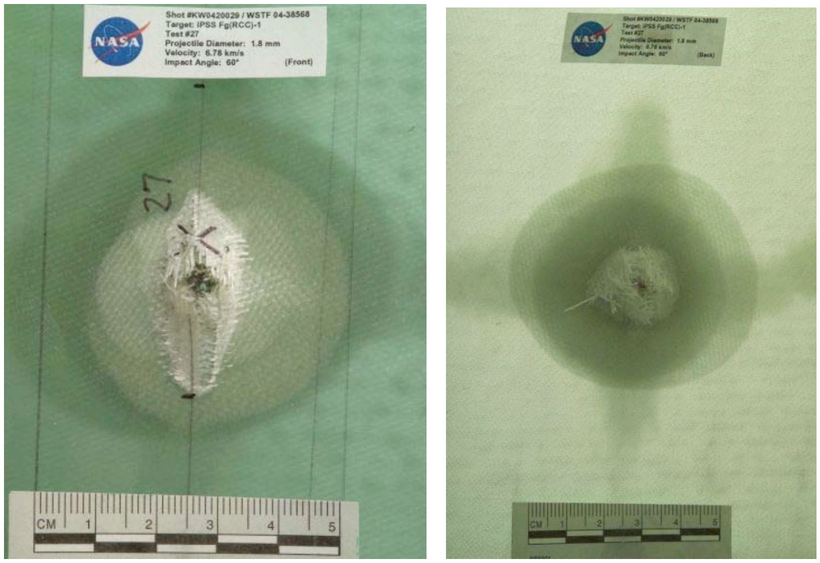


Figure 134: Fg(RCC)-1 Shot #27 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/10/04 Specimen ID: FG-1
Test number: FG1-28 Projectile size: 2.8 mm/45deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (50, 19)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039
Sensor 3: S/N 0799045 Sensor 4: S/N 101153
Sensor 5: S/N 101146 Sensor 6: S/N 101160
Sensor 7: S/N 101157 Sensor 8: S/N 101148
Sensor 9: S/N 101147 Sensor 10: S/N 101163
Sensor 11: S/N 101150 Sensor 12: S/N 0799050
Sensor 13: S/N 190022 Sensor 14: S/N 190033
Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-28 8-10-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:

Verify settings:

External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)

Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 2:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 3:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 4:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 5:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 6:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 7:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 8:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 9:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 10:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 11:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 12:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 13:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 14:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 15:	Attenuators: 0	Preamp: -20	SCM: 6
Sensor 16:	Attenuators: 0	Preamp: -20	SCM: 6

Record file name: FG1-28 8-10-04 Impact
Comments:

VII. Post test sensor check:

Verify settings:

20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test

Review data and backup files on CD X
Record actual impact parameters:

Projectile velocity: 6.61 km/s.
Impact coordinates: ________________
Damage description and comments:

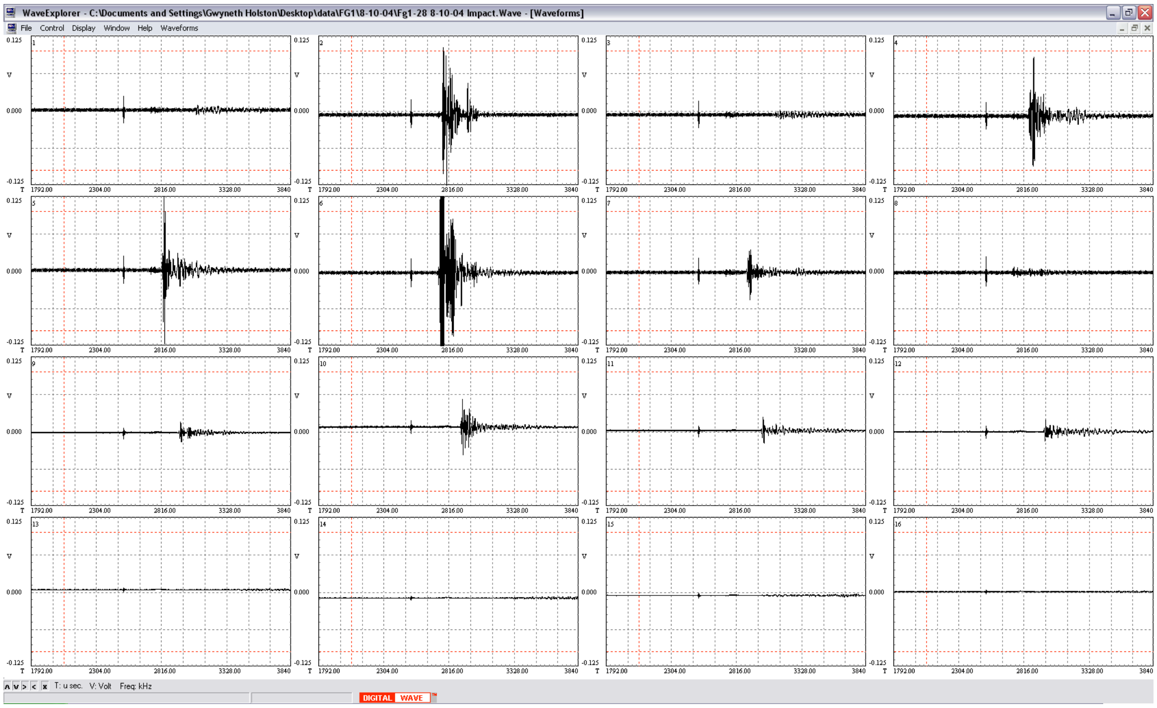


Figure 135: Fg(RCC)-1 Shot #28 Impact Waveform

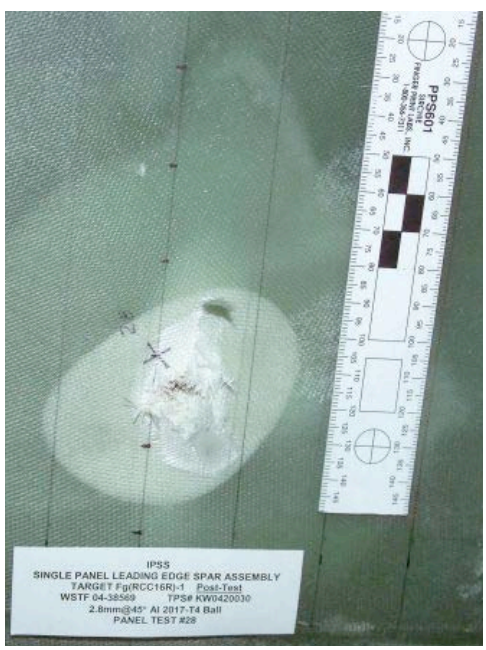


Figure 136: Fg(RCC)-1 Shot #28 Impact Damage

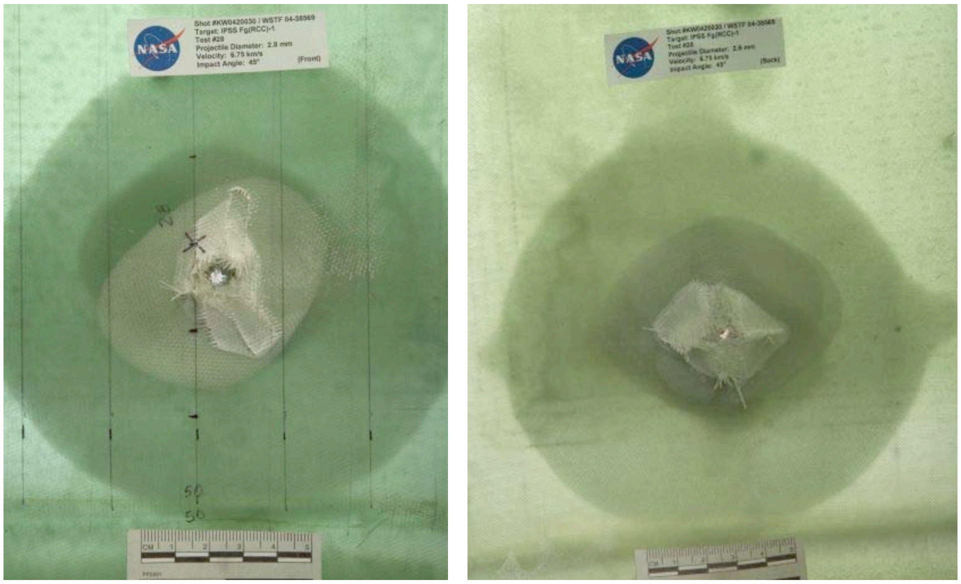


Figure 137: Fg(RCC)-1 Shot #28 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/11/04 Specimen ID: FG-1
Test number: FG1-29 Projectile size: 2.8 mm/30deg.
Planned velocity: 6.8 km/s
Planned impact coordinates: (17, 19)

II. Prebonding sensor tests performed: N/A
(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038
Sensor 2: S/N 0799039
Sensor 3: S/N 0799045
Sensor 4: S/N 101153
Sensor 5: S/N 101146
Sensor 6: S/N 101160
Sensor 7: S/N 101157
Sensor 8: S/N 101148
Sensor 9: S/N 101147
Sensor 10: S/N 101163
Sensor 11: S/N 101150
Sensor 12: S/N 0799050
Sensor 13: S/N 190022
Sensor 14: S/N 190033
Sensor 15: S/N 190034
Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up)
Sensor 2: Upper Outboard Flange Corner (up)
Sensor 3: Lower Inboard Flange Corner (down)
Sensor 4: Upper Inboard Flange Corner (down)
Sensor 5: Upper Surface (46, 05)
Sensor 6: Upper Surface (46, 19)
Sensor 7: Upper Surface (31, 05)
Sensor 8: Upper Surface (31, 19)
Sensor 9: Lower Surface (21, 05)
Sensor 10: Lower Surface (21, 19)
Sensor 11: Lower Surface (11, 05)
Sensor 12: Lower Surface (11, 19)
Sensor 13: Lower Outboard Underside Spar
Sensor 14: Upper Outboard Underside Spar
Sensor 15: Upper Inboard Underside Spar
Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X
20 dB PA gain, 3 dB signal gain: X
20 kHz HP filter, 1500 kHz LP filter: X
5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-28 8-10-04 pretestlb
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor 1:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 2:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 3:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 4:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 5:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 6:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 7:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 8:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 9:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 10:	Attenuators: 30	Preamp: -20	SCM: 9
Sensor 11:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 12:	Attenuators: 30	Preamp: -20	SCM: 15
Sensor 13:	Attenuators: 0	Preamp: -20	SCM: 15
Sensor 14:	Attenuators: 0	Preamp: -20	SCM: 15
Sensor 15:	Attenuators: 0	Preamp: -20	SCM: 15
Sensor 16:	Attenuators: 0	Preamp: -20	SCM: 15

Record file name: FG1-28 8-10-04 Impact
Comments: Impact point is 4-inches from sensor 10. Reduced gain on ch-10 to avoid saturation.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments:

VIII: Post test
Review data and backup files on CD X

Record actual impact parameters:

Projectile velocity: 6.61 km/s.

Impact coordinates: ________________

Damage description and comments:

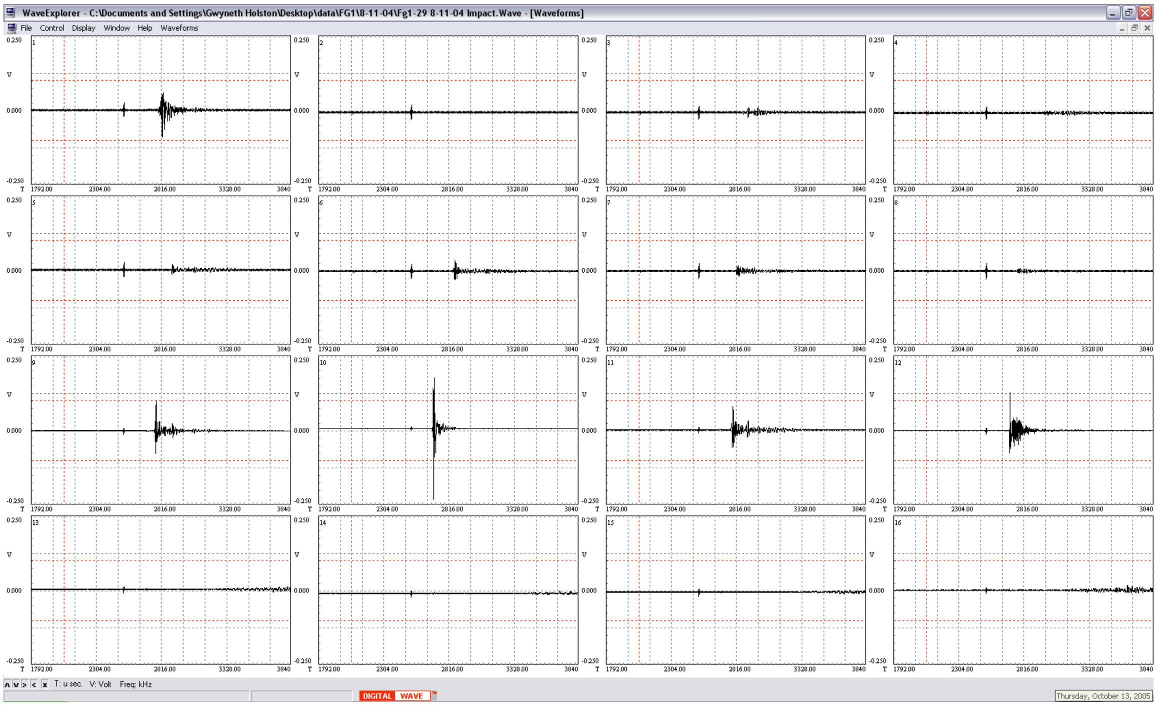


Figure 138: Fg(RCC)-1 Shot #29 Impact Waveform

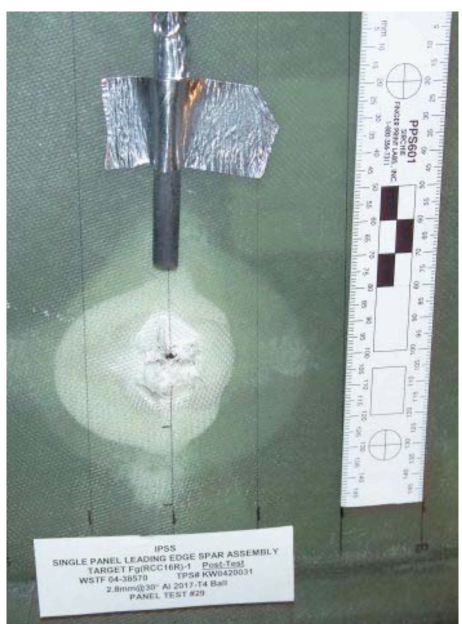


Figure 139: Fg(RCC)-1 Shot #29 Impact Damage

Figure 140: Fg(RCC)-1 Shot #29 Backlit Impact Damage (Left: Front Side, Right: Back Side)

AE Test Data/Checklist

I. Record pretest information:

Test date: 8/11/04 Specimen ID: FG-1

Test number: FG1-30 Projectile size: 1.6 mm/60deg.

Planned velocity: 6.8 km/s

Planned impact coordinates: (7, 19)

II. Prebonding sensor tests performed: N/A

(Only for first test in series or when replacing or rebonding sensors between tests, otherwise indicate N/A)

Comments: Sensors O.K.

III. Record sensor serial number and coordinates:

Sensor 1: S/N 0799038 Sensor 2: S/N 0799039

Sensor 3: S/N 0799045 Sensor 4: S/N 101153

Sensor 5: S/N 101146 Sensor 6: S/N 101160

Sensor 7: S/N 101157 Sensor 8: S/N 101148

Sensor 9: S/N 101147 Sensor 10: S/N 101163

Sensor 11: S/N 101150 Sensor 12: S/N 0799050

Sensor 13: S/N 190022 Sensor 14: S/N 190033

Sensor 15: S/N 190034 Sensor 16: S/N 190036

Sensor 1: Lower Outboard Flange Corner (up) Sensor 2: Upper Outboard Flange Corner (up)

Sensor 3: Lower Inboard Flange Corner (down) Sensor 4: Upper Inboard Flange Corner (down)

Sensor 5: Upper Surface (46, 05) Sensor 6: Upper Surface (46, 19)

Sensor 7: Upper Surface (31, 05) Sensor 8: Upper Surface (31, 19)

Sensor 9: Lower Surface (21, 05) Sensor 10: Lower Surface (21, 19)

Sensor 11: Lower Surface (11, 05) Sensor 12: Lower Surface (11, 19)

Sensor 13: Lower Outboard Underside Spar Sensor 14: Upper Outboard Underside Spar

Sensor 15: Upper Inboard Underside Spar Sensor 16: Lower Inboard Underside Spar

IV. Pretest sensor check:

Verify settings:

SCM trigger source: X

20 dB PA gain, 3 dB signal gain: X

20 kHz HP filter, 1500 kHz LP filter: X

5 MHz SR, 4096 points, 1024 pretrigger: X

Test sensors and record file name: FG1-30 8-11-04 pretest LB
Comments: Sensors O.K.

V. Switch to external (gun) trigger source and complete pretest trigger check: X

VI. Impact test:
Verify settings:
External (gun) trigger source: X
20 kHz HP filter, 1500 kHz LP filter: X
2 MHz SR, 32 K points, 4096 pretrigger: X
16 channel recording mode: X
Data acquisition in record mode: X
(DWC logo spinning)
Record and verify gain settings:

Sensor	Attenuators	Preamp	SCM
Sensor 1:	30	0	9
Sensor 2:	30	0	9
Sensor 3:	30	0	9
Sensor 4:	30	0	9
Sensor 5:	30	0	9
Sensor 6:	30	0	9
Sensor 7:	30	0	9
Sensor 8:	30	0	9
Sensor 9:	30	0	9
Sensor 10:	30	0	9
Sensor 11:	30	0	9
Sensor 12:	30	0	0
Sensor 13:	0	0	18
Sensor 14:	0	0	18
Sensor 15:	0	0	18
Sensor 16:	0	0	18

Record file name: FG1-30 8-11-04 Impact
Comments: Data O.K.

VII. Post test sensor check:
Verify settings:
20 dB PA gain, 3 dB signal gain X
20 kHz HP filter, 1500 kHz LP filter X
5 MHz SR, 4096 points, 1024 pretrigger X
Test sensors and record file name:
Comments: The impact point was 4-inches from sensor 12. Reduced gain on ch-12 to avoid saturation.

VIII: Post test
Review data and backup files on CD X

Record actual impact parameters:

Projectile velocity: 6.94 km/s.

Impact coordinates: _________________

Damage description and comments:

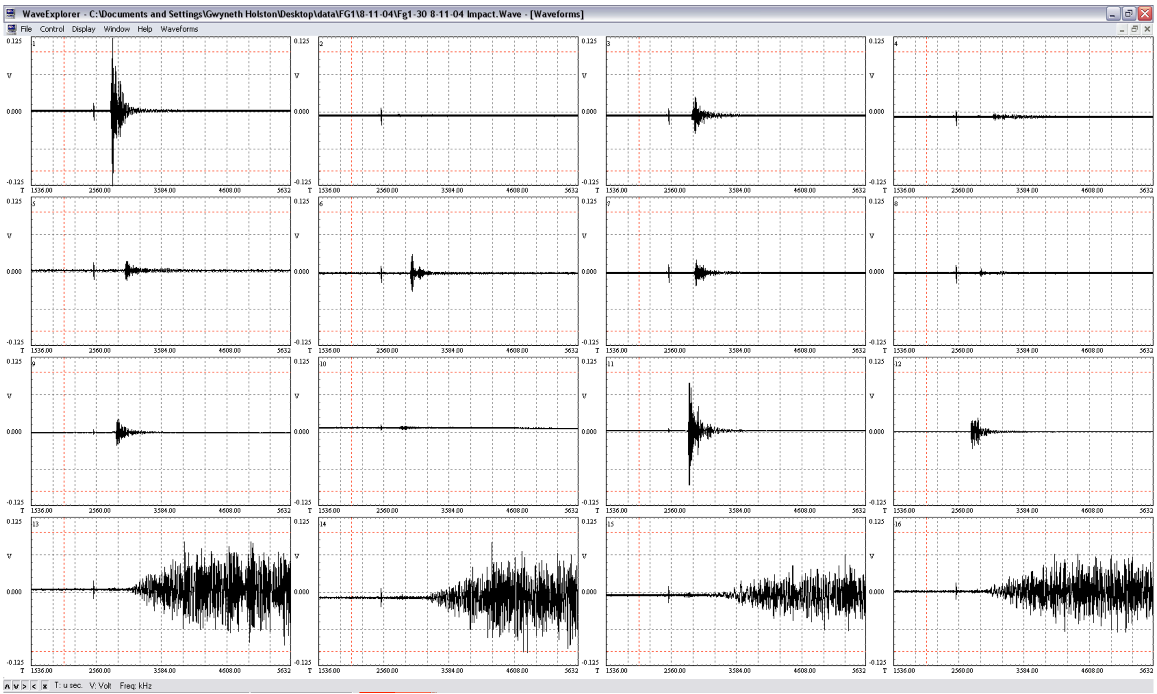


Figure 141: Fg(RCC)-1 Shot #30 Impact Waveform

Figure 142: Fg(RCC)-1 Shot #30 Impact Damage

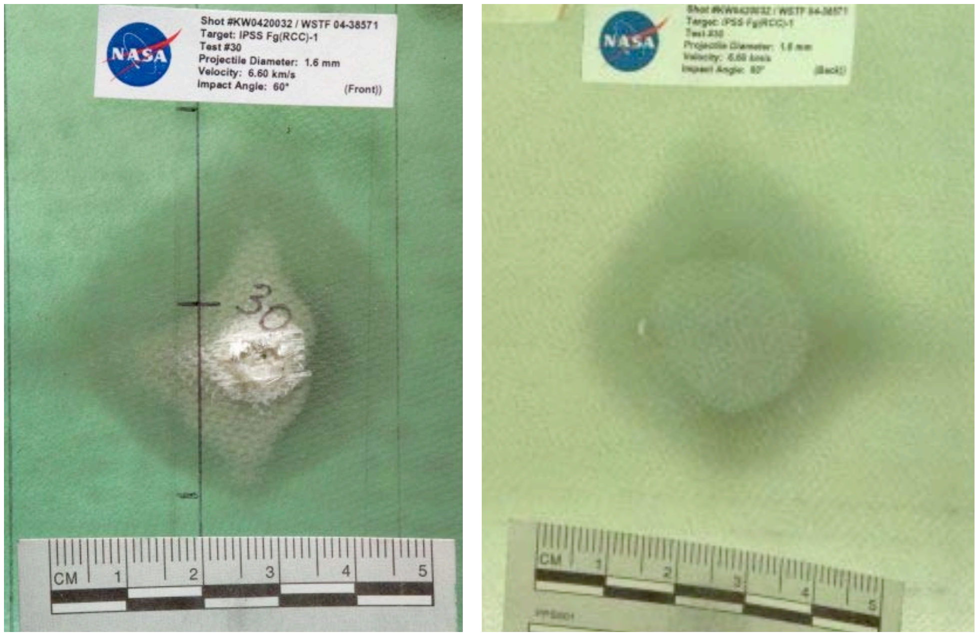


Figure 143: Fg(RCC)-1 Shot #30 Backlit Impact Damage (Left: Front Side, Right: Back Side)

Data Tables

Test No.	Imp Dia mm	Imp Vel km/s	Imp Ang deg	Normal K.E. J	Total K.E. J	Location x	y
FG1-1b1	0.4	6.97	90	2.20	2.20	26	2
FG1-2	0.4	6.35	45	0.91	1.82	35	2
FG1-3	0.8	6.80	45	8.36	16.73	39	2
FG1-4	0.4	6.97	30	0.55	2.20	50	2
FG1-5	1.2	6.87	60	43.21	57.65	17	2
FG1-6	0.6	6.87	45	3.60	7.21	7	2
FG1-7	0.8	6.80	90	16.73	16.73	26	6
FG1-8	0.6	6.80	60	5.29	7.06	35	6
FG1-9	1.8	6.87	30	48.60	194.56	40	6
FG1-10	0.8	6.81	45	8.39	16.78	50	6
FG1-11	0.8	6.83	45	8.43	16.88	17	6
FG1-12	1	6.61	30	7.71	30.88	7	6
FG1-13	1.2	6.75	90	55.65	55.65	26	10
FG1-14	1	6.61	30	7.71	30.88	35	10
FG1-15	2.8	6.61	60	508.16	677.97	39	10
FG1-15a	0.8	6.68	45	8.07	16.15	46	10
FG1-16	1.6	6.94	60	104.52	139.45	50	10
FG1-17	1.8	6.94	30	49.59	198.55	17	10
FG1-18	2.4	6.61	45	213.30	426.94	7	10
FG1-19	2.4	6.61	90	426.94	426.94	26	14
FG1-20	2.0	6.61	30	61.71	247.07	35	14
FG1-21	0.6	6.77	60	5.25	7.00	39	14
FG1-22	2.0	6.77	30	64.74	259.18	50	14
FG1-23	1.0	6.75	45	16.09	32.21	13.9	16.7
FG1-24	2.0	no velocity	20			13.9	6
FG1-25	1.8	6.81	90	191.18	191.18	19.2	26.1
FG1-26	2.4	6.86	60	344.67	459.85	19.1	35.2
FG1-27	1.8	6.78	60	142.04	189.50	18.7	39
FG1-28	2.8	6.75	45	353.21	706.99	19.4	50.3
FG1-29	2.8	6.82	30	180.27	721.73	19.2	17
FG1-30	1.6	6.60	20	14.74	126.12	19.3	7.3

Table 3: Target Fg(RCC)-1 Impactor Diameter, Impactor Velocity, Impactor Angle, Normal Kinetic Energy, Total Kinetic Energy, and Location

Test	Normal K.E.	Total K.E.	Crater Dims			Crater	Damage Area Dims		Damage	Outside Delamination			Inside Delamination		
No.	J	J	x	y	z	Vol	x	y	Area	x	y	Area	x	y	Area
FG1-1b	2.20	2.20	1.0	1.5	0.1	0.2			0.0	5.5	7.0	38.5			
FG1-2	0.91	1.82	1.5	0.8	0.1	0.2	6.0	4.0	24.0	8.0	6.5	52.0	7.0	8.0	56.0
FG1-3	8.36	16.73	2.0	1.8	0.7	2.5	10.0	7.5	75.0	27.0	27.0	729.0	24.0	23.5	564.0
FG1-4	0.55	2.20				No data			No data	4.5	5.0	22.5			No data
FG1-5	43.21	57.65	3.0	2.0	1.6	9.6	12.5	9.0	112.5	56.0	56.0	3136.0	36.0	33.0	1188.0
FG1-6	3.60	7.21	1.3	2.0	0.3	0.7	9.0	5.0	45.0	17.0	15.0	255.0	7.0	8.0	56.0
FG1-7	16.73	16.73	2.0	1.5	1.7	5.0	7.0	4.5	31.5	16.0	14.0	224.0	21.0	19.0	399.0
FG1-8	5.29	7.06	1.5	1.5	0.3	0.6	7.5	6.0	45.0	17.0	19.0	323.0	17.0	18.0	306.0
FG1-9	48.60	194.56	4.5	3.5	2.5	39.9	14.5	13.5	195.8	75.0	81.0	6075.0	77.0	61.0	4697.0
FG1-10	8.39	16.78	2.5	2.0	0.6	2.8	9.5	7.0	66.5	31.0	29.0	899.0	91.0	18.0	1638.0
FG1-11	8.43	16.88	2.5	1.5	0.7	2.7	10.0	5.5	55.0	28.0	31.0	868.0	23.5	23.0	540.5
FG1-12	7.71	30.88	3.0	2.0	0.8	4.7	11.0	5.5	60.5	29.0	37.0	1073.0	18.5	19.0	351.5
FG1-13	55.65	55.65	4.0	2.5	2.2	21.7	11.0	21.0	231.0	72.0	47.0	3384.0	53.0	36.0	1908.0
FG1-14	7.71	30.88	3.0	2.5	1.3	9.4	11.0	8.0	88.0	27.0	29.0	783.0	25.5	23.0	586.5
FG1-15	508.16	677.97	7.5	7.0	6.0	315.0	30.0	36.0	1080.0	135.0	130.0	17550.0	80.0	70.0	5600.0
FG1-15a	8.07	16.15	2.5	2.0	1.1	5.4	11.0	7.0	77.0	29.0	31.0	899.0	30.0	31.0	930.0
FG1-16	104.52	139.45	5.0	4.5	1.7	38.1	14.0	17.0	238.0	115.0	122.0	14030.0	74.0	63.0	4662.0
FG1-17	49.59	198.55	5.5	4.5	2.3	56.3	13.5	14.0	4.0	79.0	73.0	5767.0	66.0	57.0	3762.0
FG1-18	213.30	426.94	6.5	7.0	5.1	233.5	20.0	32.0	640.0	152.0	135.0	20520.0	122.0	105.5	12871.0
FG1-19	426.94	426.94	5.5	4.0	6.0	132.0	25.0	68.0	1700.0	88.0	91.0	8008.0	69.0	62.0	4278.0
FG1-20	61.71	247.07	6.0	5.0	5.3	158.4	16.0	17.0	272.0	72.0	67.0	4824.0	73.0	68.0	4964.0
FG1-21	5.25	7.00	2.0	0.5	0.4	0.4	9.0	5.5	49.5	21.0	17.0	357.0	18.0	16.5	297.0
FG1-22	64.74	259.18	4.5	4.3	3.4	65.8	18.0	21.0	378.0	68.0	70.0	4760.0	78.0	68.0	5304.0
FG1-23	16.09	32.21	2.0	2.5	1.4	6.9	12.0	8.5	102.0	44.0	46.0	2024.0	30.0	25.0	750.0
FG1-24	No data	No data	5.5	3.0	1.7	27.5	15.0	12.0	180.0	69.0	72.0	4968.0	45.0	45.5	2047.5
FG1-25	191.18	191.18	7.0	6.0	3.5	146.9	18.0	31.0	558.0	92.0	73.0	6716.0	59.0	58.0	3422.0
FG1-26	344.67	459.85	7.0	6.0	6.0	252.0	22.0	49.0	1078.0	113.0	98.0	11074.0	76.0	63.0	4788.0
FG1-27	142.04	189.50	3.0	3.5	6.0	63.0	19.0	33.0	627.0	95.0	86.0	8170.0	64.0	55.0	3520.0
FG1-28	353.21	706.99	5.5	6.0	6.0	198.0	28.0	29.0	812.0	161.0	173.0	27853.0	79.0	68.0	5372.0
FG1-29	180.27	721.73	7.0	5.0	6.0	210.0	22.0	29.0	638.0	94.0	96.0	9024.0	76.5	74.0	5661.0
FG1-30	14.74	126.12	3.0	2.0	1.7	10.2	14.0	8.0	8.0	112.0	52.0	2496.0	25.0	22.0	550.0

Table 4: Fg(RCC)-1 Damage Results

Test	**S1 RawEn**	**S2 RawEn**	**S3 RawEn**	**S4 RawEn**	**S5 RawEn**	**S6 RawEn**	**S7 RawEn**	**S8 RawEn**
No.	V^2 -μs	V^2 -μs	V^2 -μs	V^2 -μs	V^2 -μs	V^2 -μs	V^2 -μs	V^2 -μs
FG1-1b	4.363E+01	1.683E+01	6.806E+01	3.326E+02	7.444E+02	1.023E+02	1.260E+03	2.198E+02
FG1-2	1.775E+01	5.010E-01	1.914E+01	3.571E+02	1.108E+03	1.499E+02	3.739E+03	4.005E+03
FG1-3	8.850E+01	1.381E+02	6.986E+01	1.854E+03	2.497E+03	1.025E+03	1.781E+03	1.223E+03
FG1-4	3.221E+00	6.269E+01	1.872E+00	8.216E+02	8.541E+02	2.181E+02	2.503E+02	2.273E+01
FG1-5	2.993E+00	9.362E-01	7.894E+00	1.797E+00	1.195E+01	4.214E+00	6.870E+01	5.258E+00
FG1-6	1.137E+02	3.613E+00	8.037E+02	8.796E+00	8.719E+01	2.638E+01	2.831E+02	3.652E+01
FG1-7	1.235E+02	5.508E+01	1.417E+02	3.828E+02	1.033E+03	6.517E+02	9.654E+02	1.037E+03
FG1-8	1.662E+01	2.013E+01	9.317E+00	7.734E+01	7.564E+02	3.143E+02	7.277E+02	3.878E+02
FG1-9	4.119E-01	1.243E+00	3.772E-01	6.374E+00	1.737E+02	2.221E+01	7.635E+01	7.464E+00
FG1-10	3.243E+01	3.423E+02	2.023E+01	1.541E+03	1.257E+03	8.576E+02	5.914E+02	3.366E+02
FG1-11	1.635E+02	3.334E+01	2.107E+02	7.834E+01	5.190E+02	2.088E+02	2.907E+02	2.852E+02
FG1-12	2.229E+00	1.012E+00	3.161E+00	1.262E+00	3.642E+00	2.479E+00	6.966E+00	2.483E+00
FG1-13	7.152E+00	5.486E+00	6.974E+00	1.110E+01	1.736E+02	5.278E+01	3.616E+02	1.312E+02
FG1-14	8.544E+01	8.398E+01	5.051E+01	1.539E+02	5.081E+02	5.309E+02	4.337E+02	4.951E+02
FG1-15	4.682E+00	5.262E+00	4.489E+00	7.364E+00	4.780E+01	2.059E+01	2.037E+01	1.302E+01
FG1-15a	1.860E+01	1.329E+02	7.478E+00	4.476E+02	4.575E+02	4.318E+02	2.526E+02	2.083E+02
FG1-16	2.119E+00	2.471E+01	1.501E+00	4.690E+01	3.426E+02	2.359E+02	5.050E+01	1.967E+01
FG1-17	3.653E+00	1.072E+00	3.421E+00	1.357E+00	8.520E+00	6.813E+00	1.843E+01	9.349E+00
FG1-18	2.449E+01	1.278E+00	2.036E+01	1.964E+00	1.136E+01	5.477E+00	1.166E+01	1.109E+01
FG1-19	5.876E+00	3.820E+00	2.136E+00	2.186E+00	1.207E+01	3.152E+01	5.580E+01	7.467E+01
FG1-20	1.563E+00	4.851E+00	8.165E-01	3.707E+00	4.822E+01	9.817E+01	6.310E+01	7.319E+01
FG1-21	6.828E+00	1.913E+01	2.513E+00	3.117E+01	2.616E+02	3.159E+02	1.581E+02	2.300E+02
FG1-22	1.431E+00	1.968E+01	5.083E-01	2.151E+01	7.378E+01	2.308E+02	6.226E+00	1.485E+01
FG1-23	2.592E+01	6.630E+00	1.172E+01	9.180E+00	4.140E+01	5.263E+01	7.525E+01	1.168E+02
FG1-24	8.198E+00	3.848E-01	2.276E+00	4.594E-01	1.289E+00	2.370E+00	2.138E+00	3.448E+00
FG1-25	4.317E+00	3.051E+00	2.121E+00	1.091E+00	5.255E+00	4.062E+01	2.821E+01	2.438E+02
FG1-26	1.312E+00	7.393E+00	7.342E-01	1.887E+00	1.802E+01	1.987E+02	1.959E+01	6.193E+00
FG1-27	1.066E+00	1.330E+01	1.113E+00	5.988E+00	5.706E+01	3.849E+02	1.418E+01	1.661E+00
FG1-28	3.883E+00	2.614E+01	3.950E+00	1.666E+01	1.962E+01	4.986E+02	5.765E+00	3.971E+00
FG1-29	4.317E+00	3.051E+00	2.121E+00	1.091E+00	5.255E+00	4.062E+01	2.821E+01	2.438E+02
FG1-30	2.523E+01	7.377E-01	2.852E+00	9.451E-01	1.398E+00	2.269E+00	1.645E+00	7.721E-01

Table 5: Fg(RCC)-1 Raw Wave Signal, Sensors 1-8

	Channel Gain (dB)															
Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
FG1-1b1	3	3	3	3	0	0	0	0	0	0	0	0	12	12	12	12
FG1-2	3	3	3	3	0	0	0	0	0	0	0	0	9	9	9	9
FG1-3	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	32	32	32	32
FG1-4	3	3	3	0	0	0	0	0	0	0	0	0	32	32	32	32
FG1-5	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	23	23	23	23
FG1-6	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	32	32	32	32
FG1-7	-14	-14	-14	-14	-14	-14	-14	-14	-11	-14	-14	-14	32	32	32	32
FG1-8	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	32	32	32	32
FG1-9	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	15	15	15	15
FG1-10	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	32	32	32	32
FG1-11	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	32	32	32	32
FG1-12	-41	-41	-41	-41	-38	-38	-38	-38	-41	-41	-41	-41	23	23	23	23
FG1-13	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	23	23	23	23
FG1-14	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	23	23	23	23
FG1-15	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	6	6	6	6
FG1-15a	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	22	22	22	22
FG1-16	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	18	18	18	18
FG1-17	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	18	18	18	18
FG1-18	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-11	-11	-11	-11
FG1-19	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-8	-8	-8	-8
FG1-20	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	15	15	15	15
FG1-21	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	32	32	32	32
FG1-22	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	15	15	15	15
FG1-23	-32	-32	-32	-32	-32	-32	-32	-32	-32	-32	-32	-32	23	23	23	23
FG1-24	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	15	15	15	15
FG1-25	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	12	12	12	12
FG1-26	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-11	-11	-11	-11
FG1-27	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	-47	15	15	15	15
FG1-28	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-14	-14	-14	-14
FG1-29	-55	-55	-55	-55	-55	-55	-55	-55	-55	-61	-55	-55	-5	-5	-5	-5
FG1-30	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	18	18	18	18

Table 6: Fg(RCC)-1 Gain Settings

Test No.	S9 RawEn V^2 -μs	S10 RawEn V^2 -μs	S11 RawEn V^2 -μs	S12 RawEn V^2 -μs	S13 RawEn V^2 -μs	S14 RawEn V^2 -μs	S15 RawEn V^2 -μs	S16 RawEn V^2 -μs
FG1-1b	8.870E+02	2.624E+02	7.060E+02	1.958E+02	2.504E+00	3.591E+00	2.490E+00	2.625E+00
FG1-2	2.832E+02	6.916E+01	1.230E+02	4.915E+01	2.589E+00	3.475E+00	4.819E+00	2.346E+00
FG1-3	8.973E+02	7.236E+02	8.176E+02	5.482E+02	1.114E+02	1.185E+02	2.788E+02	3.263E+01
FG1-4	2.165E+01	1.400E+01	1.517E+01	1.155E+01	3.853E+00	5.251E+00	3.205E+00	1.450E+00
FG1-5	1.626E+02	3.072E+01	1.412E+02	4.002E+01	2.264E+02	1.802E+02	6.130E+01	4.238E+01
FG1-6	6.382E+02	1.528E+02	1.096E+03	3.310E+02	1.701E+02	1.541E+02	3.743E+02	6.727E+00
FG1-7	6.916E+02	8.215E+02	1.029E+03	1.244E+03	2.123E+02	2.063E+02	1.265E+03	5.873E+01
FG1-8	3.009E+02	9.874E+01	1.616E+02	1.030E+02	4.661E+01	4.492E+01	1.564E+02	2.769E+01
FG1-9	7.393E+00	3.223E+00	4.372E+00	1.844E+00	7.381E+01	5.952E+01	3.373E+01	1.642E+01
FG1-10	2.659E+02	2.169E+02	2.343E+02	1.103E+02	2.273E+02	2.993E+02	3.854E+02	9.717E+01
FG1-11	7.507E+02	5.170E+02	1.162E+03	8.133E+02	3.317E+02	3.832E+02	1.876E+03	1.660E+02
FG1-12	7.076E+00	1.651E+00	7.341E+01	2.465E+00	1.091E+02	9.229E+01	1.831E+01	1.721E+01
FG1-13	1.454E+02	1.869E+02	9.418E+01	4.645E+01	3.492E+02	4.207E+02	5.815E+02	3.442E+02
FG1-14	2.793E+02	3.589E+02	2.303E+02	4.426E+02	2.590E+01	2.553E+01	2.239E+02	4.863E+01
FG1-15	2.708E+01	3.344E+01	2.463E+01	2.448E+01	2.947E+04	2.948E+04	1.430E+04	1.488E+04
FG1-15a	1.284E+02	2.307E+02	1.186E+02	7.500E+01	1.962E+02	2.088E+02	4.063E+02	1.309E+02
FG1-16	1.040E+01	2.577E+01	9.983E+00	8.702E+00	2.684E+02	3.055E+02	8.123E+01	3.751E+01
FG1-17	3.387E+01	2.900E+01	5.652E+01	4.044E+01	8.649E+02	8.398E+02	5.921E+02	6.489E+02
FG1-18	1.593E+01	1.879E+01	1.104E+02	4.351E+01	2.615E+00	2.049E+00	7.466E-01	6.107E-01
FG1-19	2.481E+01	7.098E+01	2.095E+01	3.063E+01	1.699E+02	1.993E+02	2.424E+02	2.979E+02
FG1-20	6.105E+00	1.281E+00	4.795E+00	1.259E+01	5.839E+01	6.399E+01	2.516E+01	2.107E+01
FG1-21	2.760E+01	3.148E+00	2.187E+01	3.619E+01	2.344E+01	3.247E+01	1.538E+02	4.974E+01
FG1-22	2.797E+00	1.039E+00	2.957E+00	8.817E+00	4.803E+02	6.347E+02	1.558E+02	9.266E+01
FG1-23	2.005E+02	7.417E+00	1.151E+02	4.163E+02	5.026E+01	6.085E+01	9.854E+01	1.407E+02
FG1-24	2.617E+00	1.073E+00	7.185E+00	1.541E+01	2.301E+03	2.175E+03	4.794E+02	4.896E+02
FG1-25	7.573E+00	2.069E+00	6.286E+00	5.201E+01	4.535E+02	5.318E+02	1.013E+03	1.263E+03
FG1-26	1.940E+00	3.623E+01	2.974E+00	7.319E+00	1.894E+01	3.253E+01	2.223E+01	3.465E+01
FG1-27	3.167E+00	2.484E+01	2.090E+00	3.018E+00	1.206E+02	1.317E+02	9.519E+01	7.721E+01
FG1-28	9.026E-01	5.196E+00	1.018E+00	1.099E+00	8.354E-01	1.447E+00	5.973E-01	4.369E-01
FG1-29	7.573E+00	2.069E+00	6.286E+00	5.201E+01	4.535E+02	5.318E+02	1.013E+03	1.263E+03
FG1-30	1.409E+00	9.111E-01	1.513E+01	1.726E+00	4.342E+02	4.276E+02	1.945E+02	2.278E+02

Table 7: Fg(RCC)-1 Raw Wave Signal, Sensors 9-16

Test No.	**S1 En** J x 10^{-10}	**S2 En** J x 10^{-10}	**S3 En** J x 10^{-10}	**S4 En** J x 10^{-10}	**S5 En** J x 10^{-10}	**S6 En** J x 10^{-10}	**S7 En** J x 10^{-10}	**S8 En** J x 10^{-10}
FG1-1b	2.187E+01	8.435E+00	3.411E+01	1.667E+02	7.444E+02	1.023E+02	1.260E+03	2.198E+02
FG1-2	8.896E+00	2.511E-01	9.593E+00	1.790E+02	1.108E+03	1.499E+02	3.739E+03	4.005E+03
FG1-3	1.114E+03	1.739E+03	8.794E+02	2.334E+04	3.143E+04	1.291E+04	2.243E+04	1.540E+04
FG1-4	1.615E+00	3.142E+01	9.381E-01	8.216E+02	8.541E+02	2.181E+02	2.503E+02	2.273E+01
FG1-5	3.768E+04	1.179E+04	9.938E+04	2.263E+04	1.504E+05	5.305E+04	8.648E+05	6.619E+04
FG1-6	1.431E+03	4.548E+01	1.012E+04	1.107E+02	1.098E+03	3.321E+02	3.564E+03	4.598E+02
FG1-7	3.101E+03	1.384E+03	3.559E+03	9.616E+03	2.595E+04	1.637E+04	2.425E+04	2.604E+04
FG1-8	4.175E+02	5.056E+02	2.340E+02	1.943E+03	1.900E+04	7.895E+03	1.828E+04	9.741E+03
FG1-9	4.119E+04	1.243E+05	3.772E+04	6.374E+05	1.737E+07	2.221E+06	7.635E+06	7.464E+05
FG1-10	8.146E+02	8.599E+03	5.082E+02	3.872E+04	3.158E+04	2.154E+04	1.485E+04	8.456E+03
FG1-11	4.107E+03	8.375E+02	5.293E+03	1.968E+03	1.304E+04	5.244E+03	7.302E+03	7.163E+03
FG1-12	2.806E+04	1.275E+04	3.980E+04	1.589E+04	2.298E+04	1.564E+04	4.396E+04	1.567E+04
FG1-13	4.513E+04	3.462E+04	4.400E+04	7.005E+04	1.096E+06	3.330E+05	2.282E+06	8.276E+05
FG1-14	4.282E+03	4.209E+03	2.531E+03	7.715E+03	2.546E+04	2.661E+04	2.174E+04	2.482E+04
FG1-15	1.481E+06	1.664E+06	1.420E+06	2.329E+06	1.511E+07	6.512E+06	6.441E+06	4.116E+06
FG1-15a	9.321E+02	6.658E+03	3.748E+02	2.243E+04	2.293E+04	2.164E+04	1.266E+04	1.044E+04
FG1-16	5.321E+04	6.208E+05	3.771E+04	1.178E+06	8.605E+06	5.927E+06	1.268E+06	4.940E+05
FG1-17	1.831E+05	5.372E+04	1.714E+05	6.801E+04	4.270E+05	3.415E+05	9.236E+05	4.685E+05
FG1-18	2.449E+06	1.278E+05	2.036E+06	1.964E+05	1.136E+06	5.477E+05	1.166E+06	1.109E+06
FG1-19	5.876E+05	3.820E+05	2.136E+05	2.186E+05	1.207E+06	3.152E+06	5.580E+06	7.467E+06
FG1-20	7.832E+04	2.431E+05	4.092E+04	1.858E+05	2.417E+06	4.920E+06	3.163E+06	3.668E+06
FG1-21	3.422E+02	9.587E+02	1.260E+02	1.562E+03	1.311E+04	1.583E+04	7.921E+03	1.153E+04
FG1-22	7.170E+04	9.864E+05	2.548E+04	1.078E+06	3.698E+06	1.157E+07	3.120E+05	7.444E+05
FG1-23	4.108E+04	1.051E+04	1.857E+04	1.455E+04	6.562E+04	8.342E+04	1.193E+05	1.851E+05
FG1-24	4.109E+05	1.929E+04	1.141E+05	2.303E+04	6.460E+04	1.188E+05	1.071E+05	1.728E+05
FG1-25	4.317E+05	3.051E+05	2.121E+05	1.091E+05	5.255E+05	4.062E+06	2.821E+06	2.438E+07
FG1-26	1.312E+05	7.393E+05	7.342E+04	1.887E+05	1.802E+06	1.987E+07	1.959E+06	6.193E+05
FG1-27	5.341E+04	6.668E+05	5.580E+04	3.001E+05	2.860E+06	1.929E+07	7.105E+05	8.323E+04
FG1-28	1.228E+06	8.267E+06	1.249E+06	5.269E+06	6.204E+06	1.577E+08	1.823E+06	1.256E+06
FG1-29	1.365E+06	9.647E+05	6.708E+05	3.451E+05	1.662E+06	1.285E+07	8.921E+06	7.709E+07
FG1-30	3.176E+05	9.287E+03	3.590E+04	1.190E+04	1.761E+04	2.856E+04	2.071E+04	9.720E+03

Table 8: Fg(RCC)-1 Wave Signal Energy, Sensors 1-8

Test	S9 En	S10 En	S11 En	S12 En	S13 En	S14 En	S15 En	S16 En	Total W.S.E.
No.	J x 10^{-10}	J x 10^{-10}	J x 10^{-10}	J x 10^{-10}	J x 10^{-10}	J x 10^{-10}	J x 10^{-10}	J x 10^{-10}	nJ
FG1-1b	8.870E+02	2.624E+02	7.060E+02	1.958E+02	1.580E-01	2.266E-01	1.571E-01	1.656E-01	4.609E+02
FG1-2	2.832E+02	6.916E+01	1.230E+02	4.915E+01	3.259E-01	4.375E-01	6.066E-01	2.954E-01	9.726E+02
FG1-3	1.130E+04	9.110E+03	1.029E+04	6.901E+03	7.026E-02	7.474E-02	1.759E-01	2.059E-02	1.468E+04
FG1-4	2.165E+01	1.400E+01	1.517E+01	1.155E+01	2.431E-03	3.313E-03	2.022E-03	9.149E-04	2.263E+02
FG1-5	2.047E+06	3.868E+05	1.777E+06	5.038E+05	1.134E+00	9.034E-01	3.072E-01	2.124E-01	6.021E+05
FG1-6	8.034E+03	1.924E+03	1.379E+04	4.167E+03	1.073E-01	9.720E-02	2.362E-01	4.244E-03	4.508E+03
FG1-7	8.707E+03	2.064E+04	2.584E+04	3.125E+04	1.340E-01	1.302E-01	7.983E-01	3.705E-02	1.967E+04
FG1-8	7.558E+03	2.480E+03	4.060E+03	2.586E+03	2.941E-02	2.834E-02	9.870E-02	1.747E-02	7.470E+03
FG1-9	7.393E+05	3.223E+05	4.372E+05	1.844E+05	2.334E+00	1.882E+00	1.067E+00	5.193E-01	3.050E+06
FG1-10	6.679E+03	5.449E+03	5.884E+03	2.771E+03	1.434E-01	1.888E-01	2.432E-01	6.131E-02	1.459E+04
FG1-11	1.886E+04	1.299E+04	2.920E+04	2.043E+04	2.093E-01	2.418E-01	1.184E+00	1.047E-01	1.264E+04
FG1-12	8.909E+04	2.078E+04	9.242E+05	3.103E+04	5.470E-01	4.626E-01	9.178E-02	8.624E-02	1.260E+05
FG1-13	9.172E+05	1.179E+06	5.942E+05	2.931E+05	1.750E+00	2.109E+00	2.914E+00	1.725E+00	7.715E+05
FG1-14	1.400E+04	1.799E+04	1.154E+04	2.218E+04	1.298E-01	1.280E-01	1.122E+00	2.437E-01	1.831E+04
FG1-15	8.563E+06	1.058E+07	7.788E+06	7.742E+06	7.402E+03	7.405E+03	3.592E+03	3.738E+03	7.377E+06
FG1-15a	6.436E+03	1.156E+04	5.946E+03	3.759E+03	1.238E+00	1.317E+00	2.563E+00	8.258E-01	1.258E+04
FG1-16	2.613E+05	6.472E+05	2.508E+05	2.186E+05	4.255E+00	4.841E+00	1.287E+00	5.945E-01	1.956E+06
FG1-17	1.698E+06	1.454E+06	2.833E+06	2.027E+06	1.371E+01	1.331E+01	9.384E+00	1.028E+01	1.065E+06
FG1-18	1.593E+06	1.879E+06	1.104E+07	4.351E+06	3.291E+01	2.580E+01	9.399E+00	7.688E+00	2.763E+06
FG1-19	2.481E+06	7.098E+06	2.095E+06	3.063E+06	1.072E+03	1.258E+03	1.529E+03	1.880E+03	3.355E+06
FG1-20	3.060E+05	6.422E+04	2.403E+05	6.311E+05	1.846E+00	2.024E+00	7.957E-01	6.663E-01	1.596E+06
FG1-21	1.383E+03	1.578E+02	1.096E+03	1.814E+03	1.479E-02	2.048E-02	9.704E-02	3.139E-02	5.583E+03
FG1-22	1.402E+05	5.208E+04	1.482E+05	4.419E+05	1.519E+01	2.007E+01	4.925E+00	2.930E+00	1.927E+06
FG1-23	3.178E+05	1.176E+04	1.825E+05	6.598E+05	2.519E-01	3.050E-01	4.939E-01	7.053E-01	1.710E+05
FG1-24	1.311E+05	5.378E+04	3.601E+05	7.723E+05	7.275E+01	6.878E+01	1.516E+01	1.548E+01	2.348E+05
FG1-25	7.573E+05	2.069E+05	6.286E+05	5.201E+06	2.861E+01	3.355E+01	6.394E+01	7.968E+01	3.964E+06
FG1-26	1.940E+05	3.623E+06	2.974E+05	7.319E+05	2.385E+02	4.096E+02	2.799E+02	4.363E+02	3.023E+06
FG1-27	1.587E+05	1.245E+06	1.048E+05	1.512E+05	3.814E+00	4.166E+00	3.010E+00	2.441E+00	2.568E+06
FG1-28	2.854E+05	1.643E+06	3.219E+05	3.476E+05	2.098E+01	3.633E+01	1.500E+01	1.097E+01	1.856E+07
FG1-29	2.395E+06	2.605E+06	1.988E+01	1.645E+02	1.434E+03	1.682E+03	1.988E+06	1.645E+07	1.273E+07
FG1-30	1.773E+04	1.147E+04	1.904E+05	2.173E+04	6.882E+00	6.777E+00	3.083E+00	3.610E+00	6.926E+04

Table 9: Fg(RCC)-1 Wave Signal Energy, Sensors 9-16 and Total Wave Signal Energy

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14. ABSTRACT
During 2003 and 2004, the Johnson Space Center's White Sands Testing Facility in Las Cruces, New Mexico conducted hypervelocity impact tests on the space shuttle wing leading edge. Hypervelocity impact tests were conducted to determine if Micro-Meteoroid/Orbital Debris impacts could be reliably detected and located using simple passive ultrasonic methods. The objective of Target Fg(RCC)-1 was to study hypervelocity impacts through the reinforced carbon-carbon (RCC) panels of the Wing Leading Edge. Fiberglass was used in place of RCC in the initial tests. Impact damage was detected using lightweight, low power instrumentation capable of being used in flight.

15. SUBJECT TERMS
Hypervelocity impact tests; Space shuttle; Wing leading edge; Debris; Impact damage

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