DOT/FAA/AR-11/4

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

Adhesively Bonded Repairs to Metallic Fuselage Structure: Test 1, Fatigue and Residual Strength Performance

April 2013

Final Report

This document is available to the U.S. public through the National Technical Information Services (NTIS), Springfield, Virginia 22161.

This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof. The U.S. Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report. The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the funding agency. This document does not constitute FAA policy. Consult the FAA sponsoring organization listed on the Technical Documentation page as to its use.

This report is available at the Federal Aviation Administration William J. Hughes Technical Center's Full-Text Technical Reports page: actlibrary.tc.faa.gov in Adobe Acrobat portable document format (PDF).

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AR-11/4		

4. Title and Subtitle	5. Report Date
ADHESIVELY BONDED REPAIRS TO METALLIC FUSELAGE STRUCTURE: TEST 1, FATIGUE AND RESIDUAL STRENGTH PERFORMANCE	April 2013
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Reewanshu Chadha* and John G. Bakuckas, Jr. *FAA-Drexel Fellow	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Federal Aviation Administration William J. Hughes Technical Center Aviation Research Division Aircraft Systems & Structures Branch Structures and Materials Section Atlantic City International Airport, NJ 08405	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Aviation Administration Northwest Mountain Region—Transport Airplane Directorate 1601 Lind Avenue, SW Renton, WA 98057	Final Report
	14. Sponsoring Agency Code ANM-115

15. Supplementary Notes

The Federal Aviation Administration William J. Hughes Technical Center Aviation Research Division COR was John G. Bakuckas, Jr.

16. Abstract

In a joint effort, the Federal Aviation Administration (FAA) and The Boeing Company are investigating the reliability and performance aspects of adhesively bonded repair technology through test and analysis of bonded repairs to metallic fuselage panels using the FAA Full-Scale Aircraft Structural Test Evaluation and Research facility. The program objectives were to characterize the fatigue behavior of bonded repairs under simulated service load conditions and to determine if the repair patches meet strength, deformation, and damage tolerance requirements in residual strength tests.

A phased approach was undertaken where a number of fuselage panels with bonded repairs were tested under various configurations. This report summarizes the results of the first panel tested. The panel was removed from a retired Boeing 727 airplane near its design service goal. A phased approach was used to study the fatigue and residual strength characteristics of adhesively bonded repairs to metallic fuselage under a variety of loading conditions and initial damage scenarios. Both boron/epoxy and aluminum bonded patches were used to repair lap joint scribes and through-the-thickness cracks. Various loading conditions were applied, including fatigue under simulated in-service and elevated loads and thermal-mechanical static loading to measure residual strength. During all test phases, damage formation and crack and disbond growth were monitored and recorded using nondestructive inspection methods, including visual inspections, eddy current, flash thermography, and acoustic emission. Full-field strain and displacement measurements using photogrammetry were used to measure load transfer in the vicinity of the repair patches. In general, there were limited indications of damage development in the form of crack growth or disbonding. Results from this study revealed that properly designed and installed bonded repairs are durable under fatigue and can effectively contain large damage under severe static loads in excess of ultimate load requirements. Data from this effort will be used to further calibrate and verify predictive models.

17. Key Words	18. Distribution Statement
Boron/epoxy, Disbond, Crack, Inspection, Test, Analysis	This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	235	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGEMENTS

This report summarizes a team effort consisting of representatives from several organizations including the Federal Aviation Administration (FAA), The Boeing Company, and Drexel University. From the FAA, the authors wish to acknowledge Yongzhe Tian and Jeff Panco for their diligent efforts running the tests using the Full-Scale Aircraft Structural Test Evaluation and Research facility at the FAA William J. Hughes Technical Center, to Dave Galella and Paul Swindell for providing nondestructive inspection (NDI) support, to Curtis Davis for providing photogrammetry support, and to Ian Won for his cosponsorship.

From Boeing, thanks go to Ron Turner, Bud Westerman for their cosponsorship; to Russell Keller, Keith McIver, Carly Schlottman, and Kelly Greene for managing the activities; to Ching Hsu, Cong Duong, and Trica Carr for their technical contributions in the design and analysis of the repairs; to Mike Evans and Joel Baldwin for installing the repairs; and to Bill Tapia, Morteza Safai, and Kimberly Meredith for the it efforts in providing NDI support.

Finally, the authors would like to recognize Professors Jonathan Awerbuch and T.M. Tan from the Department of Mechanical Engineering and Mechanics of Drexel University for their input and guidance in all aspects of the work reported herein.

TABLE OF CONTENTS

		Page
EXECUTIVE SUMMARY		xiii
1.	INTRODUCTION	1
2.	EXPERIMENTAL PROCEDURE	2
2.1	Full-Scale Aircraft Structural Test Evaluation and Research Facility	2
2.2	Panel Description	3
2.3	Test Phases	5
2.3.1	Phase 1—Durability Study	6
2.3.2	Phase 2—No-Damage Growth Repair Design	9
2.3.3	Phase 3—Large-Damage Repair Design	10
2.3.4	Phase 4—Large-Damage Repair Design Performance Under Thermal-Mechanical Load	11
2.4	Inspection and Monitoring Methods	12
2.4.1	Strain Gages	13
2.4.2	Deformation and Strain Photogrammetry	13
2.4.3	Visual Inspection	14
2.4.4	Eddy Current	15
2.4.5	Thermography	16
2.4.6	Computer-Aided Tap Test	17
2.4.7	Acoustic Emission	18
3.	ANALYTICAL PROCEDURE	19
4.	RESULTS AND DISCUSSION	21
4.1	Phase 1—Durable Patch Design and Installation	21
4.1.1	Fatigue Precracking	21
4.1.2	Baseline Strain Survey	22
4.1.3	Fatigue Test	27
4.1.4	Residual Strength Tests	32
4.2	Phase 2—No-Growth Repair Design	33

4.3 Large Repair Design 36

4.3.1 Strain Survey 36
4.3.2 Fatigue Test 37
4.3.3 Residual Strength Tests 40

4.4 Phase 4—Elevated Temperature 40

5. SUMMARY 43

6. REFERENCES 44

APPENDICES

A—PANEL ENGINEERING DRAWINGS
B—INITIAL DAMAGE SCENARIOS, PATCH CONFIGURATIONS, AND STRAIN GAGE LOCATION
C—PATCH INSTALLATION AND STRAINS MONITORED DURING CURING PROCESS
D—RAW STRAIN GAGE DATA SUMMARY
E—STRAIN GAGE DATA REDUCTION PROCEDURE
F—ARAMIS™ STRAIN SURVEY RESULTS
G—CRACK GROWTH DATA
H—RESIDUAL STRENGTH TEST
I—INSPECTION RESULTS

LIST OF FIGURES

Figure		Page
1	The FASTER Test Fixture	3
2	Retired B-727 Airplane and Location of Panel	4
3	Panel Configuration	4
4	Phase 1 Initial Damage Scenarios and Repair Designations	7
5	Midbay Repair Configurations B/Ep and Aluminum	7
6	Lap Joint Scribe Repairs Configuration, Aluminum Fillers, B/Ep PatchWith Low Stiffness, B/Ep Patch With High Stiffness, and Aluminum Patch	8
7	Phase 2 Initial Damage Scenarios and Repair Designations	9
8	Midbay Crack Repair Configuration, C1A	9
9	Phase 3 Initial Damage Scenarios and Repair Designations	10
10	Large Repair to Through-the-Thickness Notch Along Lap Joint, LJC3A	11
11	Phase 4 Test Setup for Thermal-Mechanical Loading	12
12	Two 4-Megapixel Cameras, Stochastic Speckled Pattern, Baseline Image at Zero Load, Deformed Image at Applied Load, and Example of Resulting Full-Field Strain	14
13	Visual Inspection Systems External and Internal	15
14	Eddy-Current System Used to Inspect for Skin Cracks	16
15	Flashed Thermography System Used to Inspect for Disbonds and Delaminations	17
16	Computer-Aided Tap Tester Used to Inspect for Disbonds and Delaminations	18
17	Acoustic Emission System and Example Sensor Layout Used to Monitor a Repair Patch	19
18	Finite Element Model Showing Full Assembly, Substructure, and Boundary Conditions	20
19	Four SIFs for Thin Cracked Shells and Crack Tip Element and Nodes for Computing the Rate of Work Done to Close a Crack Using the MCCI Method	20

20	Photographs of Crack Growth From Notch 1 During Fatigue Precracking	22
21	Crack Growth From Notches 1 and 2 During Fatigue Precracking	22
22	Test and Analysis Results From Strain Survey at a Skin Midbay Gage	23
23	Measured and Predicted Strain Distribution	24
24	Full-Field Hoop Strains Near the Repair Patches	24
25	Hoop Strain Variation Measured Along Several Horizontal Sections Near Patch C1BE	25
26	Hoop Strain Variation Measured Along Several Vertical Sections Near Patch C1BE	26
27	The FEA Results Showing Effect of Eccentric Loading From Patch Installations at Midbay Regions Deformed Mesh of Skin Displayed Without the Patch and Strains in the Patch	26
28	Strain Measurements Showing Bending Effect at Midbay Patch C1BE	27
29	Strains at Skin Midbay Locations During Fatigue Test	28
30	Graph Showing the Strains Remained Relatively Constant Throughout Fatigue, Patch C1BE	28
31	Strains at Scribe Locations During the Fatigue Test	29
32	Flash Thermography Inspections of Patch C1BE During the Fatigue Test	29
33	Results From Phase 1 Location of Patches and Skin Thickness, Crack Growth Under Patch C1BE, and Crack Growth Under Patch C2A	30
34	Crack Length Measurements From Visual, Internal Eddy-Current, and External Eddy-Current Inspections of Patch C1BE	31
35	Phase 1 Results Applied Loads, Effect of Patches on Crack Growth Rates, and Correlation of Test and Analysis	32
36	Phase 1 Results Location of Strain Gage, Strains Measured Along Patch Boundary and Centerline, and Strains Measured During Fatigue	33

37 Phase 2 Results External Surface of Repair C1A, Interior Surface of Repair C1A, Measured Hoop Strain Field After 5,000 Cycles Under 115% of SL, Measured Hoop Strain Field After 10,000 Cycles Using 115%, of SL Measured Hoop Strain Field After 5,000 Cycles Using 133% of SL, and Measured Hoop Strain Field After 10,000 Cycles Using 133% of SL 34

38 Phase 2 Results Gage Locations, C1A, Strains Measured on the Outer Surface After Fatigue Intervals Under 115% and 133% of SL, Strains Measured on the Inner Surface After Fatigue Intervals Under 115% and 133% of SL 35

39 Phase 2 Results Measured Hoop Strain Field After 5,000 Cycles Under 115% of SL, Measured Hoop Strain Field After 10,000 Cycles Using 115% of SL, Measured Hoop Strain Field After 5,000 Cycles Using 133% of SL, and Measured Hoop Strain Field After 10,000 Cycles Using 133% of SL 36

40 Full-Field Hoop Strains Near the Repair Patches During a Strain Survey 37

41 Hoop Strains Measured From Strain Gages Near Patch LJC3A During Fatigue Test for 20,000 Cycles 38

42 Hoop Strains Measured From Strain Gages Near the Notch Tip Region in Patch LJC3A During Fatigue Test for 20,000 Cycles 38

43 Fatigue Cycle Count Summary for Each Repair After Phase 3 Fatigue Test 39

44 Crack Extension Measured in the Skin Under Patch C2A for All Test Phases 39

45 Severed Tear Strap and Frame Under LJC3A Before Residual Strength Test and After the Residual Strength Test 40

46 Effect of Temperature on Measured Strains Location of Gages, Notch Tip Strain in the Thin Gage Section, and Notch Tip Strain in the Thick Gage Section 41

47 Strains During Residual Strength Test at 250°F Illustrating Load Transfer due to Bond Failure 42

48 Phase 4 Results Panel Failure After Residual Strength Test, Failure Path, and Disbond Surfaces Indicating a Combination of Cohesion and Adhesion Failure of the Bond 43

LIST OF TABLES

Table		Page
1	Summary of Test Phases and Loading History	5
2	Inspection Methods	12

LIST OF ACRONYMS

AD	Airworthiness Directive
AE	Acoustic emission
aft	After
B/Ep	Boron/epoxy
CATT	Computer-Aided Tap Tester
CFR	Code of Federal Regulations
CRAS	Composite Repair of Aircraft Structure
DSG	Design service goal
FAA	Federal Aviation Administration
FASTER	Full-Scale Aircraft Structural Test Evaluation and Research
FEA	Finite element analysis
fwd	Forward
FS	Frame station
ISU	Iowa State University
MCCI	Modified crack closure integral
NDI	Nondestructive inspection
PAC	Physical Acoustics Corporation
S	Stringer
SIF	Stress-intensity factor
SL	Service load

EXECUTIVE SUMMARY

In a joint effort, the Federal Aviation Administration (FAA) and The Boeing Company investigated the reliability and performance aspects of adhesively bonded repair technology through test and analysis of bonded repairs to metallic fuselage panels using the FAA Full-Scale Aircraft Structural Test Evaluation and Research facility. The program objectives were to characterize the fatigue behavior of bonded repairs under simulated service load conditions and to determine if the repair patches meet strength, deformation, and damage tolerance requirements in residual strength tests.

A phased approach was undertaken where a number of fuselage panels with bonded repairs were tested under various configurations. This report summarizes the results of the first panel tested. The panel was removed from a retired Boeing 727 airplane near its design service goal. A phased approach was used to study the fatigue and residual strength characteristics of adhesively bonded repairs to metallic fuselage under a variety of loading conditions and initial damage scenarios. Both boron/epoxy and aluminum bonded patches were used to repair lap joint scribes and through-the-thickness cracks. Various loading conditions were applied, including fatigue under simulated in-service and elevated loads and thermal-mechanical static loading to measure residual strength. During all test phases, damage (both crack and disbonds) formation and growth were monitored and recorded using nondestructive inspection methods, including visual inspections, eddy current, flash thermography, and acoustic emission. Full-field strain and displacement measurements using photogrammetry were used to measure load transfer in the vicinity of the repair patches. In general, there were limited indications of damage development in the form of crack growth or disbonding. Results from this study revealed that properly designed and installed bonded repairs are durable under fatigue and can effectively contain large damage under severe static loads in excess of ultimate load requirements. Data from this effort will be used to further calibrate and verify predictive models.

1. INTRODUCTION.

The application of bonded repairs to metallic aircraft structure has been studied extensively over the past 3 decades, during which durability and damage tolerance aspects have been demonstrated [1-4]. Adhesively bonded repairs have long been used in military applications, especially by the Australian Air Force, who pioneered and instituted this technology to maintain their aging fleet. Bonded repair technology has matured considerably and has been demonstrated to be a viable alternative to metallic fastened or bolted repairs. Obvious advantages are the aerodynamic and structural efficiency of bonded repairs and the ability to significantly reduce stress concentrations.

However, several technical challenges need to be addressed before bonded repair technology may be generally accepted and implemented in primary structural applications. Currently, credit is typically not provided in certification programs of bonded repairs for slowing crack growth or restoring ultimate strength. Of primary concern is the ability to predict the fatigue behavior and ensuring the integrity and durability of bonded repairs over the remaining life of the airplane.

In an effort to gain a better understanding of and the durability and damage tolerance aspects of bonded repair technology, the Federal Aviation Administration (FAA) and The Boeing Company partnered in a 5-year Cooperative Research and Development Agreement in October 2007. A phased approach was undertaken wherein the program objectives were to characterize the long-term durability of bonded repairs under simulated service load (SL) conditions up to one typical design service goal and then determine if the repair patches meet strength, deformation, and damage tolerance requirements in residual strength tests. The tests were conducted at the FAA Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility.

A phased approach was undertaken where a number of fuselage panels with bonded repairs were tested under various configurations. This report summarizes the results of the first panel test. The panel was removed from a retired Boeing-727 airplane near its design service goal. The objectives were to characterize the fatigue and residual strength performance of adhesive bonded repairs. This initial test program followed four test phases to study different damage scenarios (midbay through-the-thickness cracks, lap joint scribes, and lap joint through-the-thickness cracks) and corresponding repair configurations using both boron/epoxy (B/Ep) and aluminum patches:

- Phase 1—Demonstrate long-term durability. Bonded repairs to midbay through-the-thickness cracks and lap joint scribes were fatigued to one design service goal (DSG) (60,000 cycles) using simulated SL conditions. Slow, stable crack growth was measured for the midbay crack with a B/Ep patch.

- Phase 2—Demonstrate no-damage growth repair design. The midbay B/Ep patch was removed and replaced with a no-damage growth repair. The through-the-thickness crack tips were stop-drilled and repaired using an aluminum patch. The panel was subjected to elevated loads for 20,000 cycles with no-damage growth under the new repair design.

- Phase 3—Demonstrate large-damage repair capability. A 26-inch, two-bay lap joint through-the-thickness crack was repaired using an aluminum patch. An additional 20,000 cycles were applied with no evidence of damage growth. Residual strength tests were then conducted up to 24.73-psi pressure (exceeding two times the limit load) with the central tear strap and frame severed. All patches were effective in containing damage.

- Phase 4—Demonstrate large-damage repair capability at elevated temperature. The large, two-bay repair patch was subjected to elevated temperatures of 220° and 250°F (the cure temperature used to install the original patch) and loaded to failure. The panel failed at approximately 20.5-psi pressure, well above the ultimate load.

For all test phases, a photogrammetry method was used to obtain full-field displacement and strain measurements in the patch and surrounding regions. Several nondestructive inspection (NDI) methods were used, including flash thermography and computer-aided tap techniques to scan for patch disbonds and eddy current to monitor crack growth.

Initial results from Phase 1 were reported in references 5 through 7. Both B/Ep and aluminum bonded repairs were subjected to simulated SL conditions up to 60,000 cycles (one DSG). In general, there were no indications of damage development in the form of crack growth or disbonding for the lap joint scribe line repair patches. For the midbay repair patches, no disbonding occurred; however, slow crack growth was measured. Test and analysis revealed that the installation of the midbay repairs resulted in eccentric loading and inward deformation of the midbay region, which also resulted in higher tensile strains on the inner skin surface and compressive strain on the outer patch surface. All repairs were effective in containing damage during the post-fatigue residual strength test to loads representing the damage tolerance requirements in Title 14 Code of Federal Regulations (CFR) 25.571.

In this report, an overview of the results obtained from all four test phases is provided in terms of data to validate analytical predictions of bonded repair patch durability and damage tolerance, and an assessment of several NDI techniques in detecting disbonds and fatigue cracking is also provided. Test results revealed that a properly designed and installed bonded repair can effectively contain large damage under severe loads in excess of ultimate load requirements.

2. EXPERIMENTAL PROCEDURE.

2.1 FULL-SCALE AIRCRAFT STRUCTURAL TEST EVALUATION AND RESEARCH FACILITY.

As part of The Aging Aircraft Research/Continued Airworthiness Program, the FASTER facility was established at the FAA William J. Hughes Technical Center for testing large, curved panels representative of aircraft fuselage structures under realistic flight load conditions. The FASTER facility provides experimental data to validate and support analytical methods under development, including widespread fatigue damage assessment approaches, analysis and design of repairs, and new aircraft design methodologies. The FASTER test fixture, shown in figure 1, features a unique adaptation of mechanical, fluid, and electronic components and is capable of

applying internal pressurization, longitudinal, hoop, frame, and shear loads to a curved panel. The fixture consists of a base structure, hoop load assembly, longitudinal load assembly, fuselage pressure box, frame load assembly, and shear fixture assembly. The FASTER facility also includes a computerized instrument control and data acquisition system and a remote-controlled video system that are not shown in figure 1.

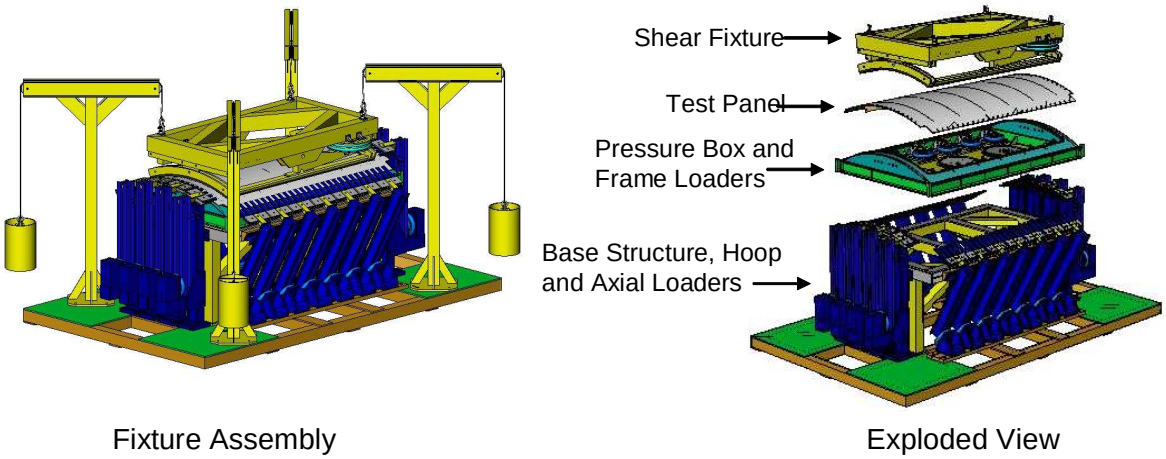


Figure 1. The FASTER Test Fixture

In general, the test fixture is capable of dynamically cycling the internal pressure as well as performing a static pressurization. The hoop and longitudinal stresses are simulated by the controlled application of distributed loads around the perimeter of the test panel. Hoop forces are distributed by individual loading linkage using a two-tier coaxial whiffle tree assembly, which generates four equal forces from each controlled load point. A total of seven load points are used on each side of the specimen, creating a total of 28 attachment points. Longitudinal forces are applied using similar loading devices on each end of the panel, consisting of 4 load control points and 16 attachment points. Similar devices are available to apply hoop tension loads at each end of a frame.

All forces are generated using water and air as the fluid medium. The external loads are generated by applying water pressure to bladder-type actuators controlled by pressure-activated dome valves. Additional details of the FASTER test fixture are given in reference 8.

2.2 PANEL DESCRIPTION.

The fuselage panel used in this study was removed from the retired passenger service airplane shown in figure 2, a B-727-232, serial number 20751, line number 1000, and registration number N474DA. The airplane was placed into service in 1974 and retired in 1998. While in service, the airplane accumulated 59,497 flight cycles and 66,412 flight hours and was near its DSG of 60,000 flight cycles. The airplane was retired prior to the issuance of Airworthiness Directive (AD) 99-04-22, mandating inspections and repairs for inner layer cracking of the lap joints of the B-727; thus, the AD inspections and repairs were not made on this airplane. The airplane was owned and operated exclusively by Delta Air Lines, was well maintained and stored, and had a

well-documented and accessible service history. Its use is representative of typical 14 CFR Part 121 revenue service passenger aircraft currently in the domestic fleet. Further information regarding the airplane can be found in reference 9.

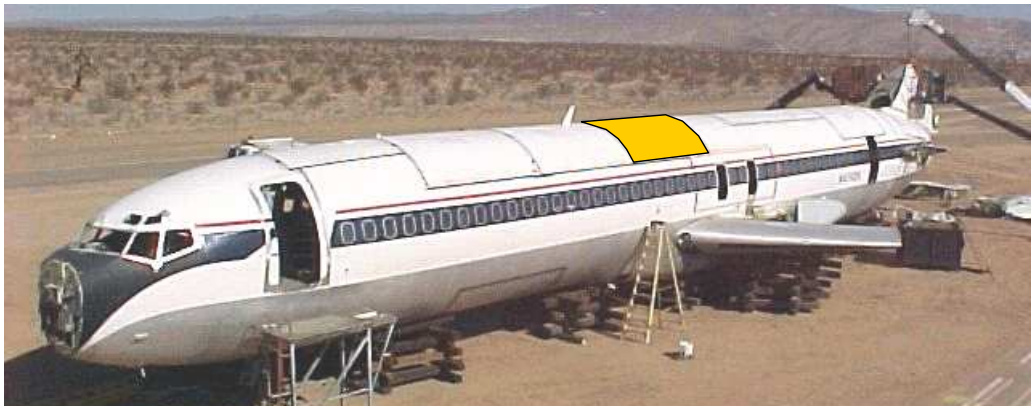


Figure 2. Retired B-727 Airplane and Location of Panel

The panel was removed from the crown of the airplane, having dimensions of 125 by 73 inches and a radius of 74 inches, as shown in figure 3. The substructure included six stringers (S), S-2L through S-7L, in the longitudinal direction with 9.5-inch spacing and six frame stations (FS), FS-720D through FS-740, in the hoop direction with 20-inch spacing. The Z-shaped frames, stringer clips, and hat-shaped stringers are made from 7075-T6 aluminum.

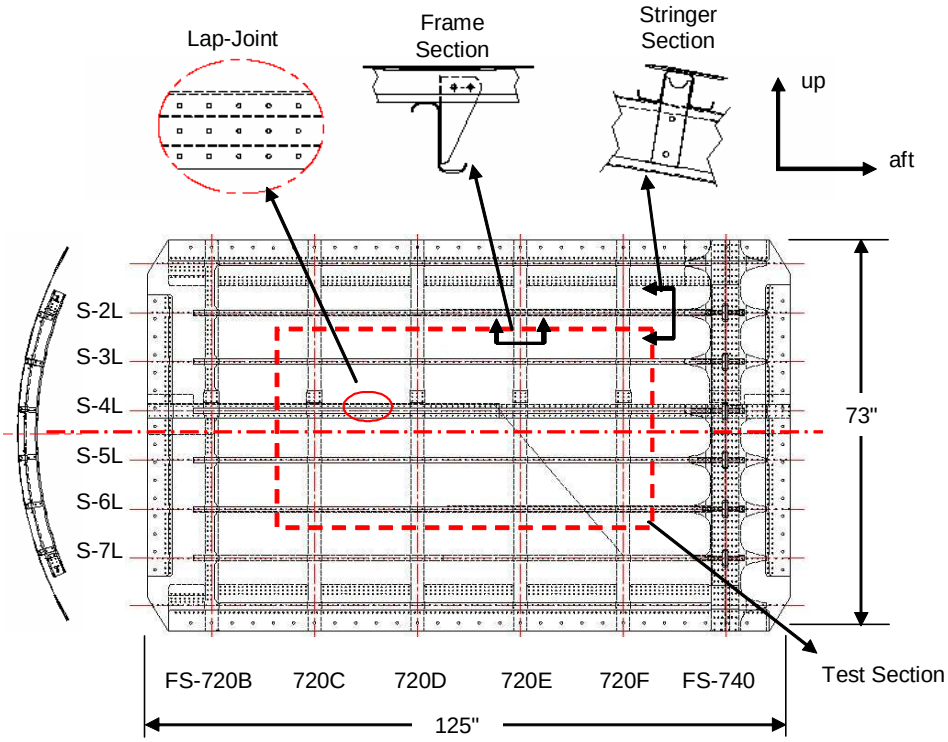


Figure 3. Panel Configuration

The panel skin was 2024-T3 aluminum with the thickness varying from 0.040 inch between FS-720C and FS-720D to 0.080 inch between FS-720F and FS-740. A longitudinal lap joint was located along S-4L and a circumferential butt joint was located along FS-740. The longitudinal lap joint consisted of two skin layers and a 0.02-inch-thick 2024-T3 aluminum doubler layer sandwiched between the two skin layers, which were connected by three rows of rivets. The doubler was bonded to the outer skin, and there was a sealant between the doubler and the inner skin of the lap joint.

The panel was reinforced along the four edges with aluminum doublers. In both longitudinal doublers, 28 half-inch-diameter holes were inserted, spaced 4 inches apart. In both hoop doublers, 16 half-inch-diameter holes were inserted, spaced 3.5 inches apart. These holes were used to attach the panel edges to the loading mechanisms of the FASTER fixture, which had seven hoop loaders on each side, and four longitudinal loaders on both ends. Each actuator was attached to the panel at four holes using a whiffle tree assembly. The two ends of each frame, where the frame load is applied, were also reinforced with aluminum doublers. An elastomeric seal was bonded along the perimeter of the inner surface of the curved panel to attach it to the pressure box of the FASTER fixture. Further details of the test panel are provided in appendix A.

2.3 TEST PHASES.

Table 1 summarizes the initial damage scenarios, repair configurations, and applied load history for each of the four test phases. Details of the damage scenarios and repair configurations are provided in appendix B. A description of the test phases is provided in the subsequent sections.

Table 1. Summary of Test Phases and Loading History

Phase	Description (Test type, applied load, damage scenario, repair type, number of cycles)	Load Type	Maximum Load			
			Pressure (psi)	Hoop (lb)	Axial (lb)	Frame (lb)
1 – Durability Study	Strain survey, 75% of SL	Quasi-static	6.7	7,140	6675	1133
	Fatigue Precracking, 75% of SL, two midbay notches and three lap joint scribes	Cyclic, R = 0.1	6.7	7,140	6675	1133
	Fatigue, SL, two midbay notches and three lap joint scribes, soft B/EP midbay patch, 5000 cycles	Cyclic, R = 0.1	8.9	9,520	8900	1510
	Fatigue, SL, two midbay notches and three lap joint scribes, optimized patches, 60,000 cycles	Cyclic, R = 0.1	8.9	9,520	8900	1510
	Residual strength, 1.15 SL, two midbay notches and 3 lap joint scribes, optimized patches	Quasi-static	10.24	10,948	8900	1737
2 – No Growth Design Study	Fatigue, 1.15 SL, one midbay notch and three lap joint scribes, no-growth midbay aluminum patch with stop-drilled holes, 10,000 cycles	Cyclic, R = 0.1	10.24	10,948	8900	1737
	Fatigue, 1.33 SL, one midbay notch and three lap joint scribes, no-growth midbay aluminum patch with stop-drilled holes, 10,000 cycles	Cyclic, R = 0.1	11.84	12,662	8900	2008

Table 1. Summary of Test Phases and Loading History (Continued)

Phase	Description (Test type, applied load, damage scenario, repair type, number of cycles)	Load Type	Maximum Load			
			Pressure (psi)	Hoop (lb)	Axial (lb)	Frame (lb)
3 – Large-Damage Repair Study	Fatigue, SL, midbay notch and 26″ lap joint scribe without repair, no-growth midbay patch, 5000 cycles	Cyclic, R = 0.1	8.9	9,520	8900	1510
	Fatigue, SL, midbay notch, and 26″ lap joint notch, optimized patches, 20,000 cycles	Cyclic, R = 0.1	8.9	9,520	8900	1510
	Residual strength, 1.15 SL, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	10.24	10,948	8900	1737
	Residual strength, 1.33 SL, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	11.84	12,662	8900	2008
	Residual strength, 1.5 limit load, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	15.35	16,416	8900	2602
	Residual strength, 2.8 SL, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	24.73	26,446	8900	4193
4 – Elevated Temperature Study	Residual strength, elevated temperature 220° and 250°F, 1.15 SL, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	10.24	10,948	8900	1737
	Residual strength, elevated temperature 220° and 250°F, 1.33SL, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	11.84	12,662	8900	2008
	Residual strength, elevated temperature 220° and 250°F, 1 1.5 limit load, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	15.35	16,416	8900	2602
	Residual strength, elevated temperature 250°F, load to failure, midbay notch, 26″ lap joint notch, and central stiffeners severed	Quasi-static	20.5	21,923	8900	3477

2.3.1 Phase 1—Durability Study.

The purpose of the Phase 1 tests was to demonstrate and evaluate the reliability and performance capability of bonded repairs and to correlate with analytical models. Two damage scenarios were considered, namely, a midbay through-the-thickness crack (fatigue presharpened) and a lap joint scribe, as shown in figure 4. Both B/Ep and aluminum patches were used to repair this damage. For the composite repairs, the patch material used was B/Ep 5521 prepreg tape. The precured B/Ep patches had a taper ratio of 20:1 for all eight sides. For the aluminum patches and fillers, 2024-T3 bare aluminum sheets were used. All patches had a 45° corner truncation angle. Henkel EA-9696 OST (one side tacky) mat carrier, grade 10 film adhesive was used as the bonding adhesive. The aluminum skin panel surface preparation included paint removal, solvent cleaning, leak testing, sol-gel application, and primer application. The patches were precured using the calibration fuselage section as the tool surface to match the curvature of the test part. The patches were then bonded to the test panel by portable composite repair equipment, vacuum bag, and heat blankets at a cure temperture of 250ºF for 60 minutes. Details of the patch installation procedure and strains measured during the cure process at selected repairs are described in appendix C.

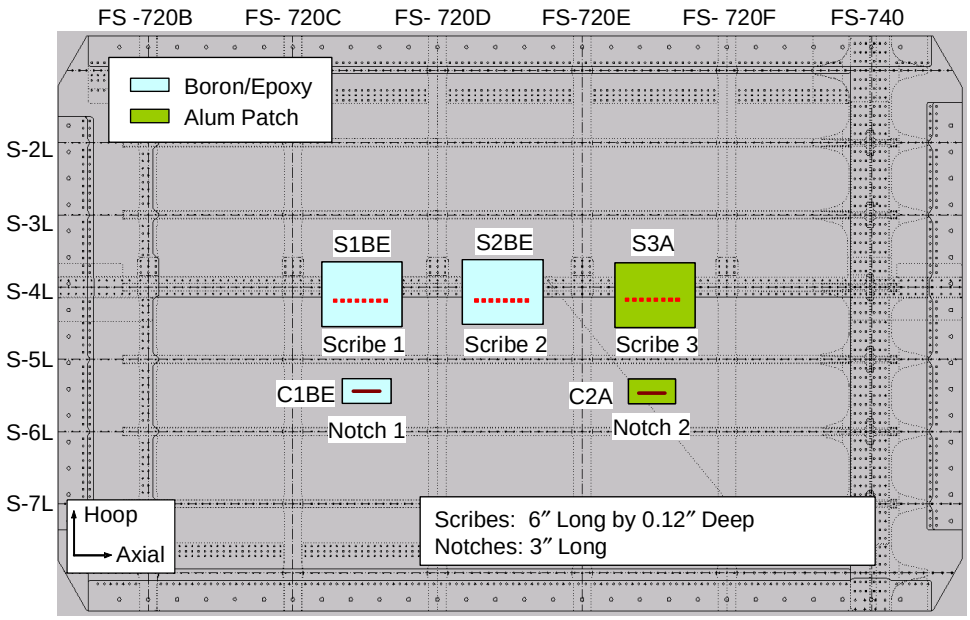


Figure 4. Phase 1 Initial Damage Scenarios and Repair Designations

The repair patch configurations are shown in figures 5 and 6 for the midbay cracks and the lap joint scribes, respectively. For the midbay patch, Crack 1 B/Ep patch (C1BE), the fibers were oriented in the hoop direction to provide a stiff repair, figure 5(a). Midbay Crack 2 aluminum patch (C2A) was used to match the properties to the skin material, figure 5(b).

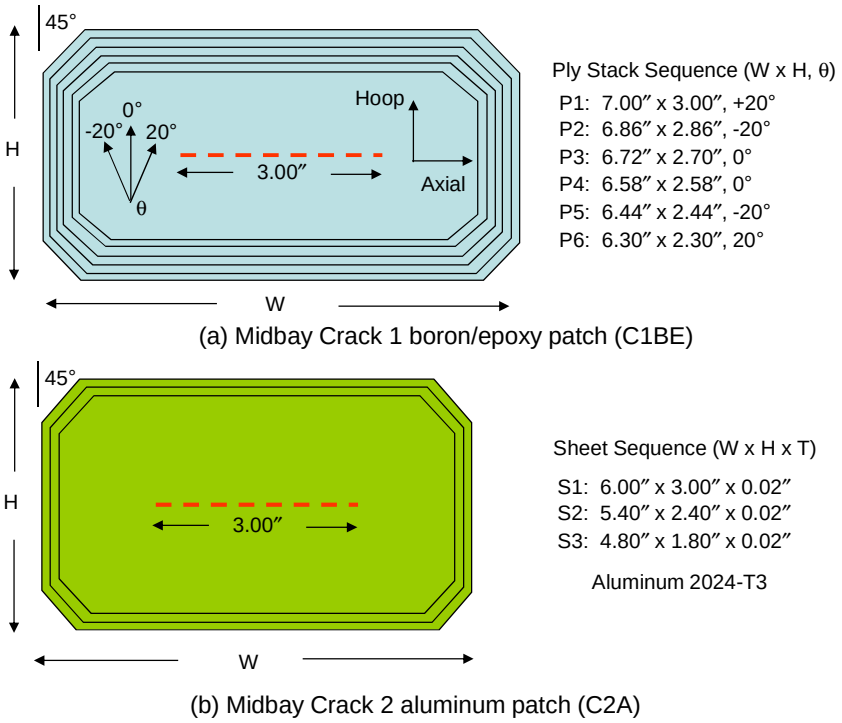


Figure 5. Midbay Repair Configurations (a) B/Ep (C1BE) and (b) Aluminum (C2A)

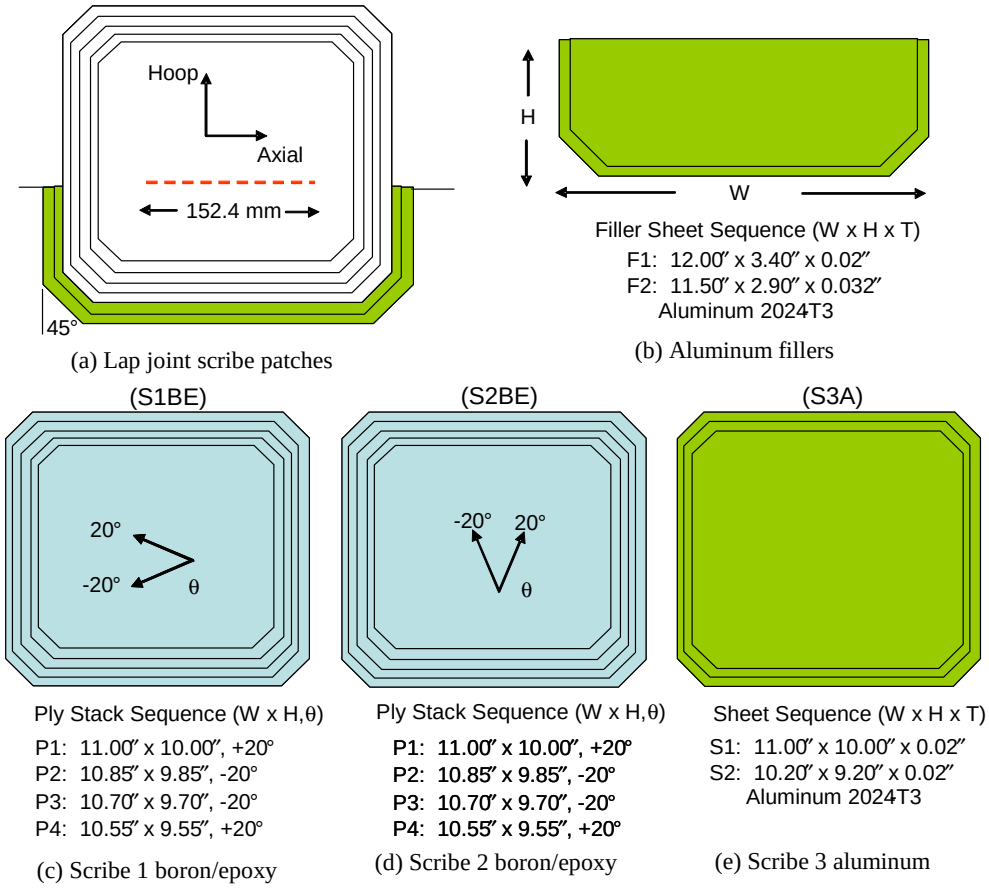


Figure 6. Lap Joint Scribe Repairs (a) Configuration, (b) Aluminum Fillers, (c) B/Ep Patch With Low Stiffness (S1BE), (d) B/Ep Patch With High Stiffness (S2BE), and (e) Aluminum Patch (S3A)

The effect of stiffness was studied using the lap joint scribe repairs. As shown in figure 6, fibers were oriented in the axial direction for repair scribe 1 B/Ep (S1BE) to yield a low-stiffness, compliant patch in the hoop direction (figure 6(c)). For repair scribe 2 B/Ep (S2BE), the fibers were directed in the hoop direction to provide a high-stiffness patch (figure 6(d)). For repair scribe 3 aluminum (S3A), aluminum was used to match the properties of the skin material (figure 6(e)). Further details of the Phase 1 patches are provided in appendix B.

The test sequence for Phase 1, summarized in table 1, consisted of baseline strain survey, fatigue precracking, fatigue, and residual strength tests. The loads used for the fatigue test simulated the in-service load conditions, including cabin pressurization (8.9 psi) and fuselage vertical bending, and were represented by an equivalent constant-amplitude spectrum. Fatigue loading was applied for 60,000 cycles. For the residual strength test, the load applied corresponded to the damage tolerance requirements of 14 CFR 25.571, “Maximum value of the normal operating pressure including the expected external aerodynamic pressure during 1 g level flight multiplied by 1.15” (10.24-psi pressure). The magnitude of the applied loads used in the strain survey and precracking was 75% of the SL conditions used for the fatigue test. For the baseline strain survey tests, quasi-static loadings were applied in ten increments up to the maximum loads listed

in table 1. For the precracking and fatigue tests, constant-amplitude loading was applied at a frequency of 0.033 Hz with an R ratio (minimum to maximum load) of 0.1.

2.3.2 Phase 2—No-Damage Growth Repair Design.

The purpose of the Phase 2 tests was to demonstrate a no-damage growth repair design and installation. For this, the original midbay B/Ep repair (C1BE) was removed and replaced with an aluminum patch repair (C1A) that would prevent crack formation and growth in the skin. All other repair patches remained intact. Figure 7 shows the damage scenarios and the corresponding repairs for the Phase 2 tests. Figure 8 shows repair patch C1A consisting of three layers of aluminum. The crack tips developed during the Phase 1 tests were removed using a 0.75-inch stop-drill hole. Additional details of the initial damage scenario and the repair patch configuration are provided in appendix B. The procedure used to apply the patch and the strains measured during the cure process are shown in appendix C.

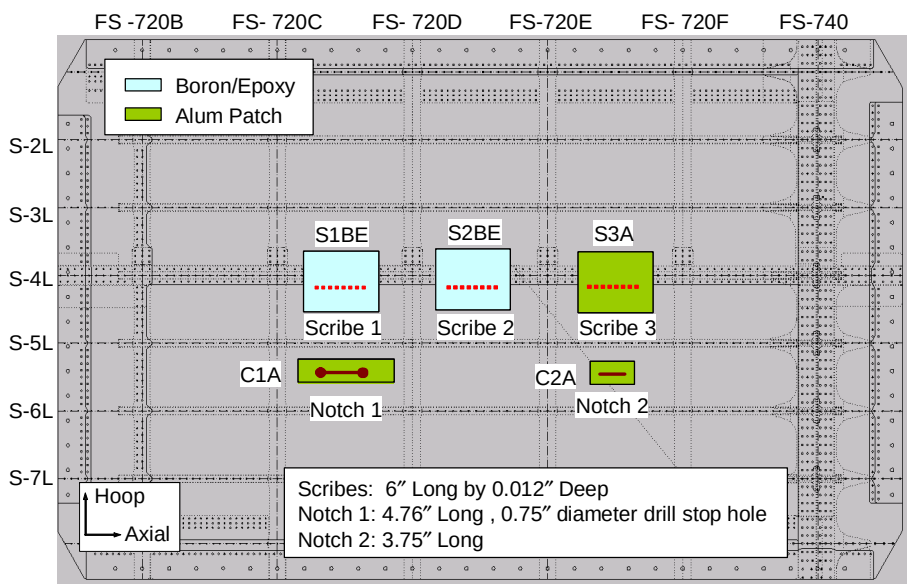


Figure 7. Phase 2 Initial Damage Scenarios and Repair Designations

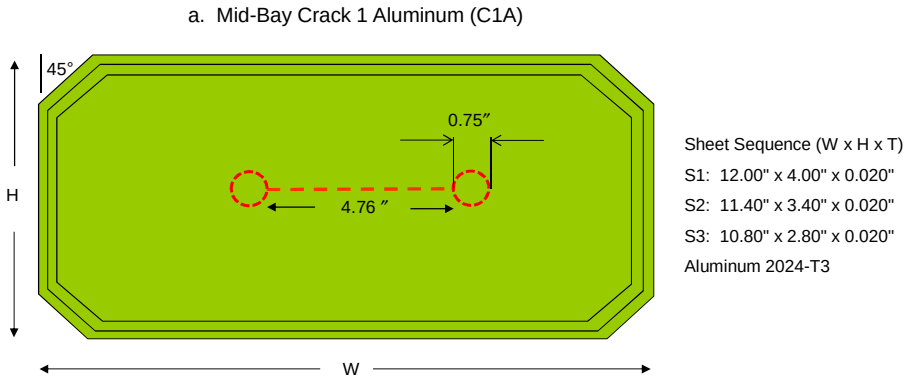


Figure 8. Midbay Crack Repair Configuration, C1A (No-Damage Growth Design)

The test sequence for Phase 2 is summarized in table 1 and consisted of fatigue tests at two elevated load levels that corresponded to (1) the damage tolerance requirements of 14 CFR 25.571 (10.24-psi pressure) and (2) the pressurized compartment load requirements of 14 CFR 25.365 (11.84-psi pressure), "The airplane structure must be designed to be able to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33 ..." For each loading condition, 10,000 fatigue cycles were applied.

2.3.3 Phase 3—Large-Damage Repair Design.

The purpose of the Phase 3 tests was to demonstrate the fatigue and residual strength performance of a large-damage repair design and installation. For this, the original B/Ep lap joint scribe repairs (S1BE and S2BE) were removed. A 26-inch-long through-the-thickness notch was inserted along the lap joint where the original scribes were located. The two-bay notch was centered over FS-720D. An aluminum repair patch, LJC3A, was applied in the lap joint region. All other repairs from Phase 2 remained (C1A, C2A, and S3A) intact. Figure 9 shows the damage scenarios and the corresponding repairs for the Phase 3 tests. Figure 10 shows the large repair patch LJC3A consisting of two fillers and four layers of aluminum sheets. Additional details of the initial damage scenario and the repair patch configuration are provided in appendix B. The procedure used to apply the patch and the strains measured during the cure process are shown in appendix C.

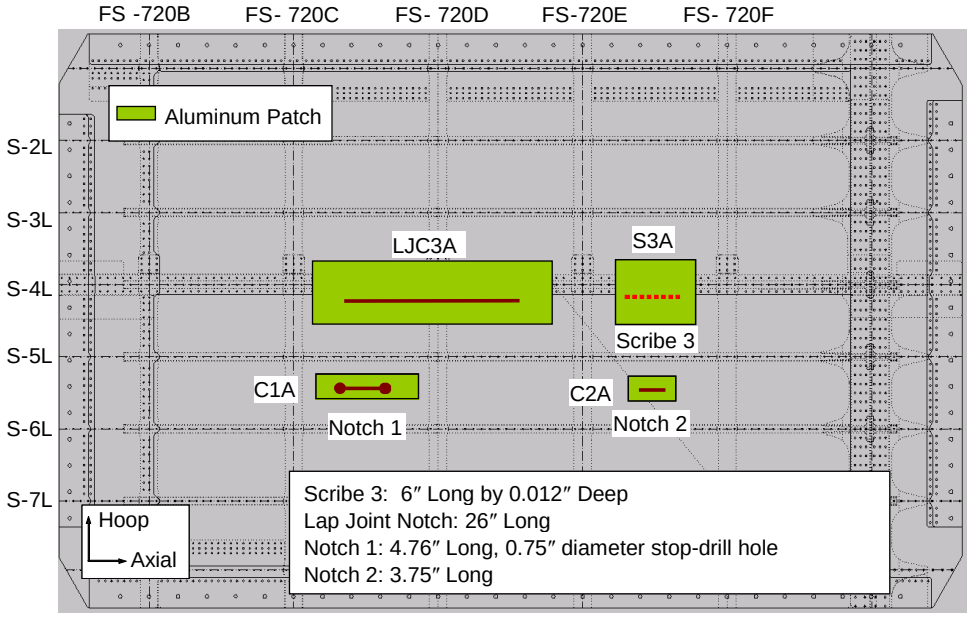


Figure 9. Phase 3 Initial Damage Scenarios and Repair Designations

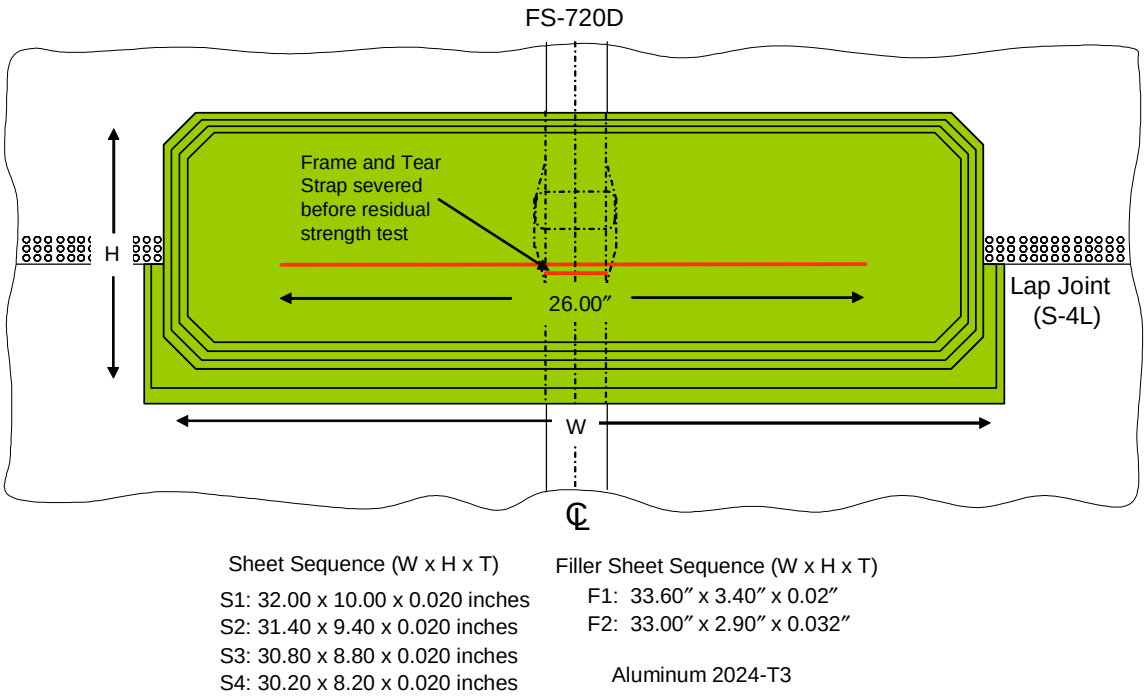
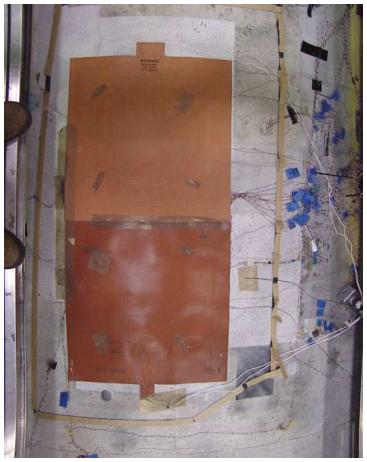


Figure 10. Large Repair to Through-the-Thickness Notch Along Lap Joint, LJC3A (Initial damage consisted of a 26 inch-long crack. After fatigue tests, central stiffeners were severed.)

The test sequence for Phase 3, summarized in table 1, consisted of a fatigue test using the simulated SL conditions for 20,000 cycles. Then the center frame and tearstrap were severed along the plane of the notch. Three quasi-static residual strength tests were then conducted to load levels that corresponded to (1) the damage tolerance requirements of 14 CFR 25.571 (10.24-psi pressure); (2) the pressurized compartment load requirements of 14 CFR 25.365 (11.84-psi pressure); and (3) the strength and deformation requirements of 14 CFR 25.305 (15.35-psi pressure), "The structure must be able to support ultimate loads without failure for at least 3 seconds…," where ultimate load is equal to 1.5 times the limit load. A fourth residual strength test was conducted to the maximum capacity (24.73-psi pressure) of the FASTER fixture.

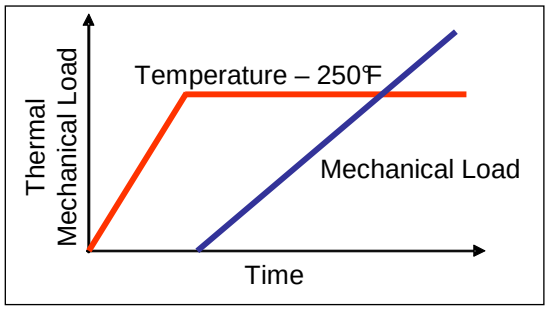
2.3.4 Phase 4—Large-Damage Repair Design Performance Under Thermal-Mechanical Load.

The purpose of the Phase 4 tests was to demonstrate the load-carrying capacity of a large-damage repair design and installation under thermal-mechanical loading. For this, all repairs and initial damage were the same as in Phase 3. In Phase 4, elevated temperatures of 220° and 250°F were applied to degrade the bond properties and strength in repair LJC3A and determine if there was a reduction in load-carrying capacity compared to the four residual strength tests in Phase 3. Heat blankets (figure 11(a)), in combination with vacuum bags (figure 11(b)), were used to apply the temperature profile (figure 11(c)), which consisted of linear ramp-up to, and then held at, 220° or 250°F. Mechanical loads were then applied once steady-state temperature was reached in the immediate vicinity of repair LJC3A, as summarized in table 1.



(a) Heat blankets

(b) Vacuum bag



(c) Thermal-mechanical load profile

Figure 11. Phase 4 Test Setup for Thermal-Mechanical Loading

2.4 INSPECTION AND MONITORING METHODS.

Several NDI methods were used to monitor and record damage formation and growth of cracks and disbonds, as indicated in table 2 and summarized in the following sections.

Table 2. Inspection Methods

Method	Inspection	Interval
High-magnification visual from interior surface	Crack growth under patches	Continuous
Eddy current from internal surface	Crack growth under patches	5000 cycles
Eddy current from external surface	Crack growth under B/Ep patches	5000 cycles
Flash thermography from exterior surface	Disbonding of all patches	5000 cycles
Tap tester from exterior surface	Disbonding of all patches	5000 cycles
Acoustic emission from external surface	Monitor damage from acoustic emission activity in selected patches	Continuous

2.4.1 Strain Gages.

The test panel was fully instrumented with strain gages within the test section to measure residual strains during the curing process of several repair installations, to ensure proper load introduction from the load applications points, and to provide for real-time monitoring of the panel strain distributions. Strain gages were installed on the skin, frames, stringers, and repair patches for each test phase, as described in appendix B. The panel skins were instrumented with uniaxial, biaxial, and rosette strain gages to provide a measure of the strain in the hoop and axial directions as well as the shear strain. On the frames, uniaxial gages were installed on the outer flange close to the skin and on the inner flange. Some stringers were instrumented with uniaxial strain gages at the center of the stringer and on the flange and hat section. In several locations in the vicinity of the repair patches, back-to-back gages were installed to measure the amount of bending.

Strain readings were recorded during holds occurring at equal load intervals up to the maximum applied loads during strain surveys. In addition, data were also continuously recorded to a buffer file at a frequency of 150 Hz to monitor the strains during the curing process of several repair installations.

2.4.2 Deformation and Strain Photogrammetry.

Full-field deformation and strain data were recorded during the loading of the test panels using the ARAMIS™ three-dimensional deformation and strain photogrammetry system. The system, which uses two 4-megapixel cameras, is capable of accurately measuring full-field strain within 50 $\mu\varepsilon$, as shown in figure 12(a).

Prior to testing, the areas to be monitored by the photogrammetry system were coated with a high-contrast stochastic speckle pattern, as shown in figure 12(b). Flat black spray paint was used to create a random pattern over top a flat white layer. The coarseness of the pattern directly affects the resolution of the measured strain field. Baseline images were taken using both cameras at zero loads, as shown in figure 12(c). Deformed images were recorded using both cameras while under an applied load, as shown in figure 12(d).

The baseline and deformed images are then used to determine the full-field deformation and strain field, as shown in figure 12(e). In the approach used, a grid of user-definable resolution is superimposed over one of the captured baseline images to define the set of points to be used in the deformation and strain calculations. The grayscale distribution within each grid element is used to first recognize and locate the same element in the corresponding baseline image, and then in the subsequent deformed loaded image pairs. A deformation gradient tensor is calculated between each of the image pairs. The deformation gradient tensor transforms one set of spatial coordinates to another and can be decomposed into the rigid-body rotation tensor and the right stretch tensor. The stretch tensor is approximately equal to the strain tensor summed with an identity matrix.

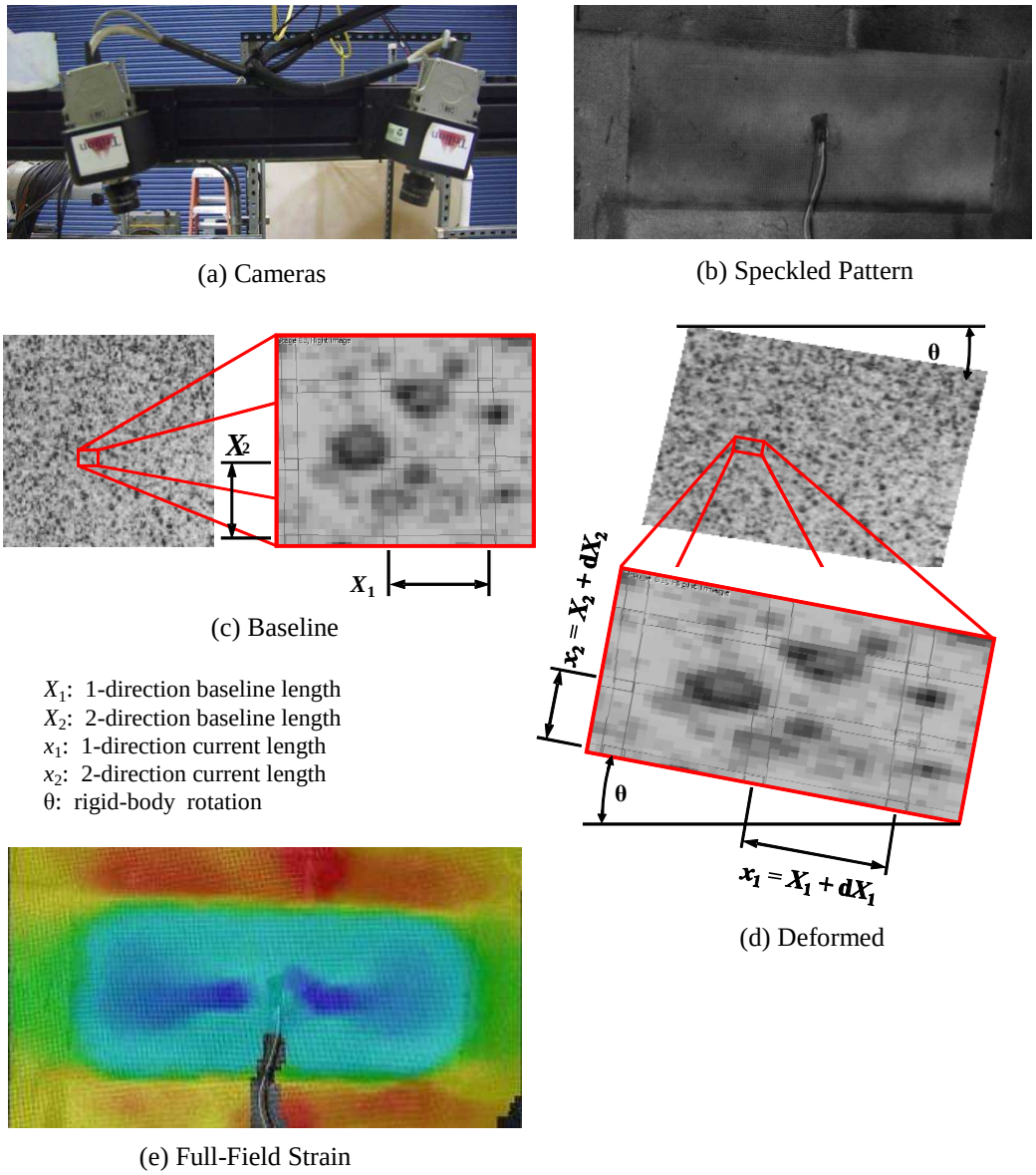
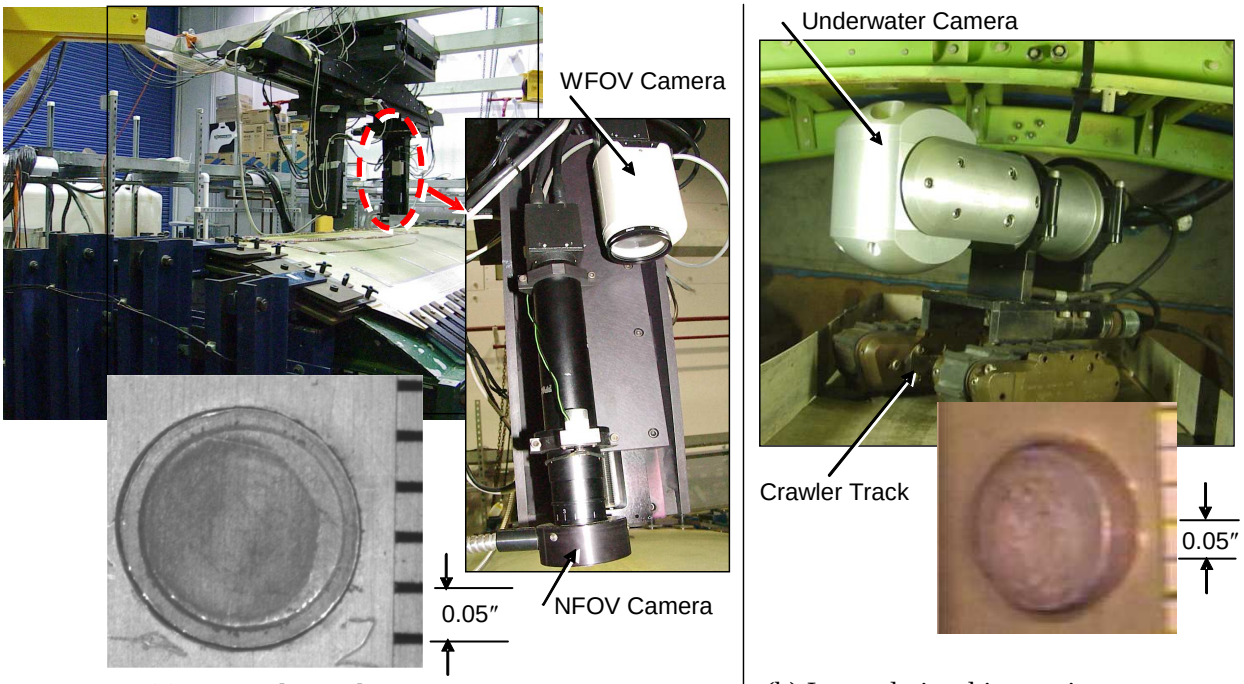


Figure 12. (a) Two 4-Megapixel Cameras, (b) Stochastic Speckled Pattern, (c) Baseline Image at Zero Load, (d) Deformed Image at Applied Load, and (e) Example of Resulting Full-Field Strain

2.4.3 Visual Inspection.

Two methods of high-magnification visual inspections were used in this study, an external and internal system, as shown in figure 13. The external system was used to measure and record crack growth during fatigue precracking. It is a stand-alone, computer-based video data acquisition system capable of monitoring the entire fuselage panel test surface at several levels of magnification, with a field of view ranging from 0.05 inch up to 14 inches and motion resolution of 1 micron.

The remotely controlled internal system is capable of detailed visual inspections on the interior surface of the test section from within the pressure box while submersed in water. The system consists of an articulated and watertight camera head mounted on two underwater crawler tracks. The camera is capable of 340º mechanical pan range and 270º tilt range. The camera provides a 72:1 zoom (18X optical and 4X digital) and has a resolution of 460TV lines. A custom aluminum chassis supports the camera housing and is mounted on a pair of motor-controlled crawler track systems. The entire system is rated for 43 psi.



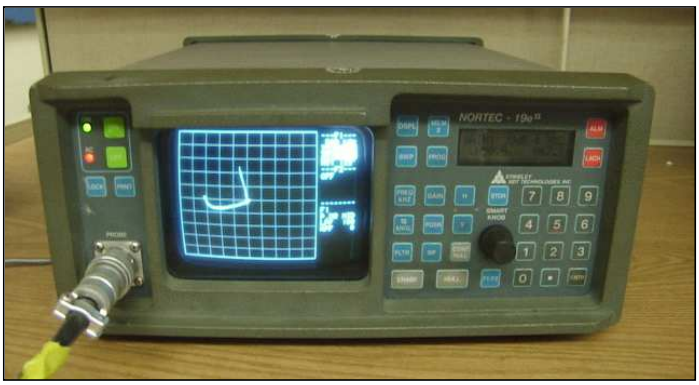
(a) External visual inspection system (b) Internal visual inspection system

WFOV = Wide field of view
NFOV = Narrow field of view

Figure 13. Visual Inspection Systems (a) External and (b) Internal

2.4.4 Eddy Current.

A Staveley Nortec 19eII, an impedance plane, multifrequency eddy-current system, was used to inspect for skin cracking, as shown in figure 14(a). Using a low-frequency probe (Nortec SR/500Hz~60kHz/.44) and settings, external inspections were made for second-layer cracking in the skin underneath the B/Ep repair patches, as shown in figure 14(b); and using a high-frequency probe (Nortec ML/100kHz~500kHz/A/90.215/6) and settings, internal inspections were made for surface cracks, as shown in figure 14(c).



(a) Nortec 19eII Eddy-Current System

(b) External inspections using low-frequency probe

(c) Internal inspections using high-frequency probe

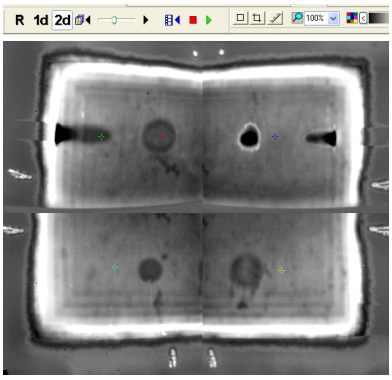
Figure 14. Eddy-Current System Used to Inspect for Skin Cracks

2.4.5 Thermography.

The EchoTherm® flash thermography system, developed by Thermal Wave Imaging, Inc., was used to inspect the panel repairs for nonvisual disbonds and delaminations, as shown in figure 15. The system consists of a computer, which contains data acquisition and processing software, and a flash lamp heat source and infrared camera unit. A brief pulse of light energy from a flash lamp is used to heat the surface of a sample, while an infrared camera records changes in the surface temperature as the sample cools. The surface temperature falls predictably as heat from the surface diffuses into the sample. The surface cooling is affected by internal flaws such as disbonds, voids, or inclusions, which obstruct the flow of heat into the sample [10]. The system provides an image of approximately 6″ by 5″ and is capable of taking a single image or multiple images established in a grid pattern.

(a) Control and data acquisition

(b) Heat sources and infrared camera



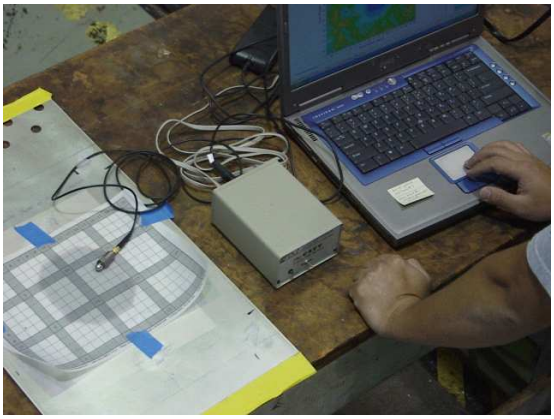
(c) Image from calibration standard

Figure 15. Flashed Thermography System Used to Inspect for Disbonds and Delaminations

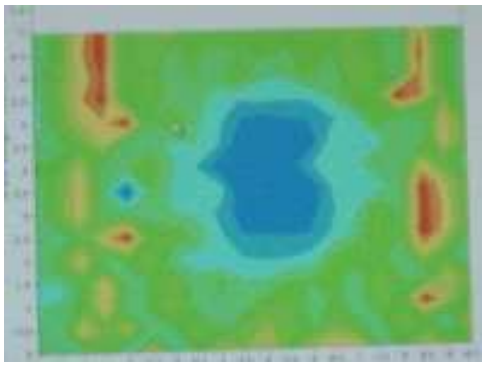
2.4.6 Computer-Aided Tap Test.

Tap tests were performed using the Computer-Aided Tap Tester (CATT) (developed by Iowa State University (ISU)) as another method to detect nonvisual disbonds and delaminations at repair locations. The CATT is a portable inspection device based on the "coin tap" method, but with capabilities that allow it to produce quantitative images from what has traditionally been only an audible test. The CATT, shown in figure 16, consists of a brass-tipped accelerometer (impactor), electronic circuitry for conditioning the signal and measuring the impact duration, and a laptop personal computer that contains data acquisition and processing software.

Based on previous ISU research, a simple spring model may be used to describe the response to a tap [11]. From the spring model, the local stiffness may be deduced from the measured impact duration and the mass of the impactor. The impact duration, as well as the deduced local stiffness, can then both be used to produce an image of the tested area. The impact duration image reveals damage as regions of abnormally large impact duration, whereas the image based on the computed local stiffness shows the quantitative stiffness value of the structure as a function of position. This stiffness has been shown to agree with that obtained from mechanical load tests and is independent of the mass of the tapper used. Data points were collected in a 0.25″ resolution grid.



(a) Control and Data Acquisition System and Impactor



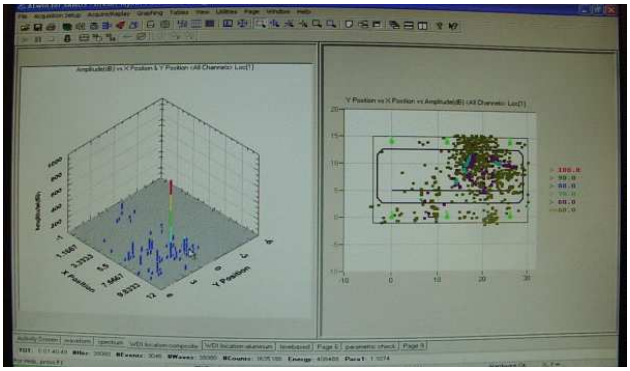
(b) Image From Calibration Standard

Figure 16. Computer-Aided Tap Tester Used to Inspect for Disbonds and Delaminations

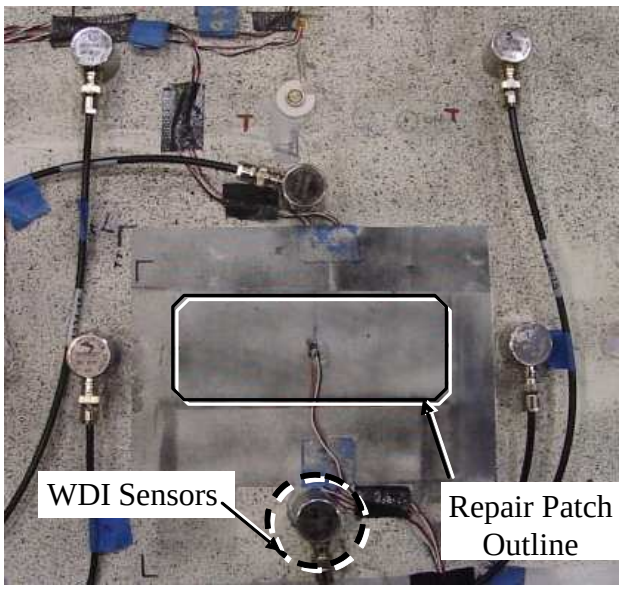
2.4.7 Acoustic Emission.

The acoustic emission (AE) method uses a system of sensors to monitor for internal stress waves resultant of damage formation and propagation within a material. As such, AE is a passive nondestructive evaluation method, meaning it is not necessary to artificially excite the material to characterize the state of damage. Because of the structure's complexities, the waveforms recorded by the sensors are significantly altered during its propagation through the material. Rather than attempting to transform the recorded waveform back to its original shape, certain characteristics of the waveform are extracted and analyzed. These characteristics include amplitude, rise time, duration, counts, and energy.

The AE test instrumentation, of Physical Acoustics Corporation (PAC), used in this study consisted of a data acquisition board, software, and sensors, as shown in figure 17. The PAC 16-bit PCI-8, an 8-channel Digital Signal Processing AE data acquisition system, was used with a 16-bit A/D conversion capability and a 132-MByte/sec transfer rate. The WDI wideband sensors were used with a low-noise input, 40-dB preamplifier and a filter all inside the sensor housing. The AE was used in an exploratory study using several sensor configurations to monitor repair patches for different test phases. Data were collected for later posttest analysis to help assess the occurrence and location of possible damage.



(a)



(b)

Figure 17. (a) Acoustic Emission System and (b) Example Sensor Layout Used to Monitor a Repair Patch

3. ANALYTICAL PROCEDURE.

Geometric nonlinear finite element analyses were conducted to predict the strain distributions for the initial strain survey and to compute the stress-intensity factor (SIF) solutions used to predict crack growth during fatigue precracking. The commercial finite element code ABAQUS™ was used. The panel was modeled using shell elements with each node having six degrees of freedom. Figure 18 shows the global view of a typical finite element model of the panel. Four-noded shell elements were used throughout to model the skin, frames, stringers, and clips. In the immediate vicinity of the crack tips, a highly refined mesh was used where the element dimension was approximately 0.04 inch. Beam elements were used to model the rivets. The repair patches were modeled using four-noded shell elements (not shown). Three-dimensional solid elements were used to connect the shell elements using the average thickness of the bonded parts.

The model contained the major geometric details and dimensions of the panels, including the cross-section properties of the substructure (frames, stringers, and clips) and the load attachment doublers. Typically, the panel model had 250,000 degrees of freedom. The load conditions specified in table 1 were simulated in the analysis. For the hoop, frame, and longitudinal loads, nodal point forces were applied at the load application points, as shown by the arrows in figure 18. Internal pressure was applied to the inner surface of the skin.

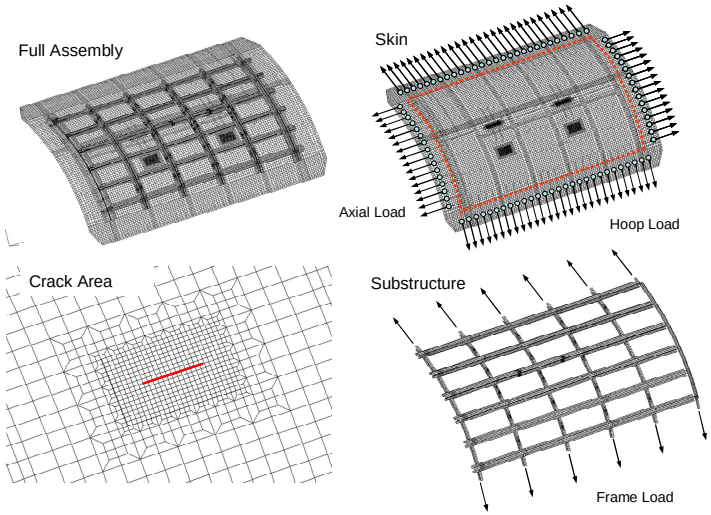


Figure 18. Finite Element Model Showing Full Assembly, Substructure, and Boundary Conditions

The modified crack closure integral (MCCI) approach [12] was used to obtain the four components of SIF. The four components of SIF are the mode I SIF caused by tensile load, K_1; the mode II SIF caused by in-plane shear load, K_2; the SIF due to symmetric bending loads, k_1; and the SIF due to out-of-plane shear and twist loads, k_2, as shown in figure 19.

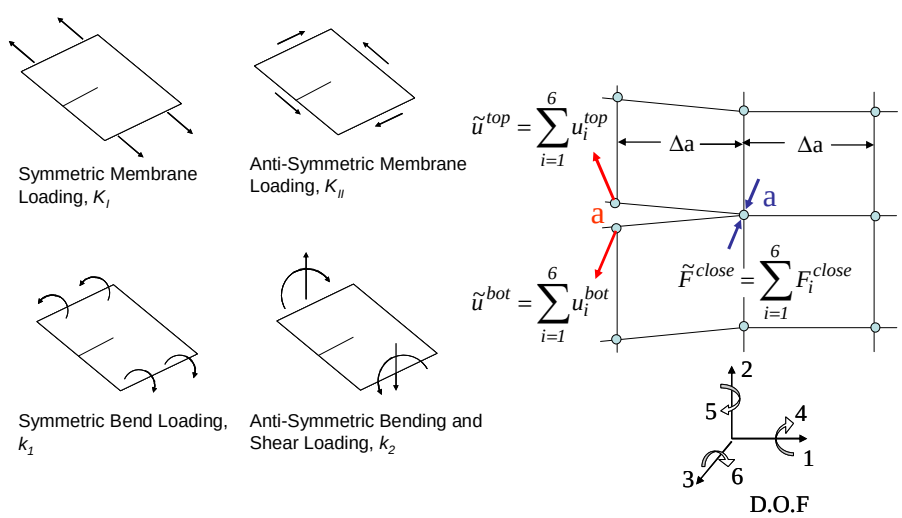


Figure 19. Four SIFs for Thin Cracked Shells and Crack Tip Element and Nodes for Computing the Rate of Work Done to Close a Crack Using the MCCI Method

A review of the analysis procedure used is provided in references 5 through 7. The initial design and size of the repair patches was done using the U.S. Air Force/Boeing-developed tool, Composite Repair of Aircraft Structure (CRAS). The basic analysis methodology in CRAS was developed by Hart-Smith, Duong, Wang, and Yu [1 and 13]. Their approach was based on the pioneering work of Rose [1 and 14] incorporating several enhanced capabilities including nonelliptical patch geometries (octagonal), accounting for thermal residual stresses, use of nonlinear adhesive properties, and accounting for stiffener substructure such as frames and stringers. The CRAS program was verified at the coupon and limited subcomponent levels using a building-block approach for flat panel applications. In this study, the enhancement and calibration of the CRAS program to more complex repairs to curved fuselage structure applications was initiated.

4. RESULTS AND DISCUSSION.

Tests and analyses were performed to study the fatigue and residual strength performance of B/Ep and aluminium bonded repairs to metallic fuselage structure in four test phases. Representative results are outlined in the subsequent sections.

4.1 PHASE 1—DURABLE PATCH DESIGN AND INSTALLATION.

The objective of Phase 1 was to demonstrate the fatigue and residual strength performance of adhesively bonded repairs.

4.1.1 Fatigue Precracking.

Defects were first introduced in the panel, which consisted of midbay through-the-thickness notches at two locations and lap joint scribes at three locations, figure 4. The midbay through-the-thickness notch lengths were approximately 3 inches, designated notches 1 and 2. The notches were fatigue-presharpened using cyclic loads that were 75% of applied fatigue loads, as shown in figure 20 for notch 1. Note the symmetric and colinear crack extension from the notch tips. Fatigue precracking was applied until a natural crack extended from the notches to a length of 0.04 to 0.157 inch.

The measured and predicted crack extension for both midbay notches is shown in figure 21. The mode I SIF was used in the analysis since it was the dominant SIF. After fatigue precracking the midbay notches, the B/Ep patch, C1BE, was installed over notch 1, and the aluminium patch, C2A, was installed over notch 2. In addition, the B/Ep patches, S1BE and S2BE, were installed over scribe 1 and 2, respectively, and the aluminium patch, S3A, over scribe 3. Details of the patch configurations are provided in appendix B.

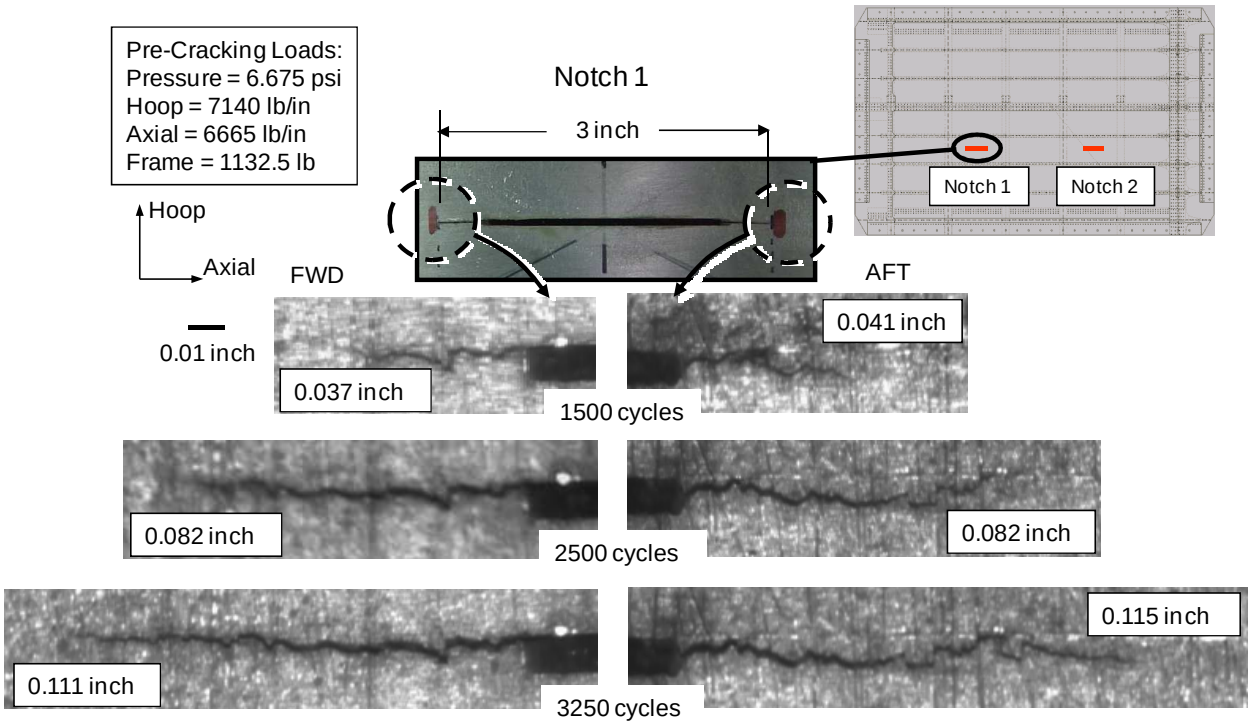


Figure 20. Photographs of Crack Growth From Notch 1 During Fatigue Precracking

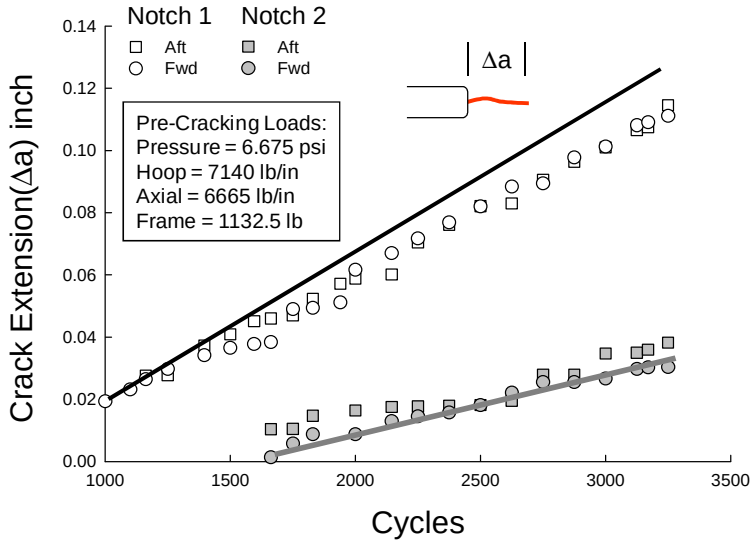


Figure 21. Crack Growth From Notches 1 and 2 During Fatigue Precracking

4.1.2 Baseline Strain Survey.

Strain surveys were performed and several NDI methods were used to baseline the patches. The strain distribution was measured and predicted under quasi-static load conditions. Detailed strain gage data are presented in appendix D. In general, three tests were conducted where the load was applied in ten increments up to the maximum values listed in table 1. The results indicate the

strain distributions measured from all three tests were nearly identical. Figure 22 shows representative results for three quasi-static tests of the strain in the hoop direction, which was measured using a rosette strain gage (S2-H) located in a skin midbay between FS-720C and FS-720D. As shown in figure, the strains were highly repeatable for all three tests. In addition, good agreement was obtained between the test results and predictions using finite element analysis (FEA), which is indicated by the solid line.

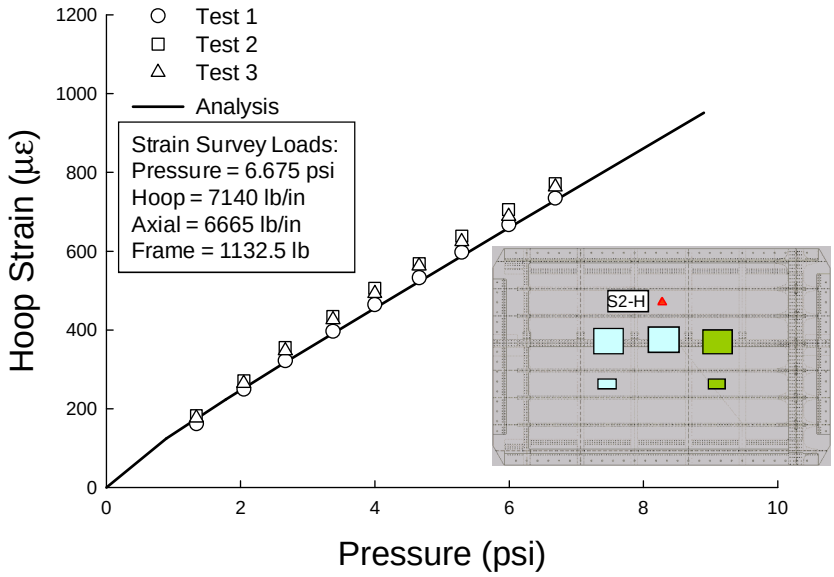


Figure 22. Test and Analysis Results From Strain Survey at a Skin Midbay Gage

The distribution of hoop strains in the midbay regions of the panel is shown in figure 23. Note that the strains are not constant because the skin thickness varied from 0.040 to 0.080 inch. Good agreement was obtained between the test results and predictions using FEA.

The full-field surface hoop strains in the vicinity of all five patches, which was measured using the ARAMIS system, is shown in figure 24. In the figure, the patch boundary and initial defect are indicated. The white regions are areas where data could not be processed because of interference from strain gage wires. In general, the strain increased in the panel skin along the edges of the repair patches (indicted by the red and yellow fringe patterns) and decreased in the repair patch region. Comparing the lap joint scribe repairs, the low-stiffness repair, S1BE, carried less strain and attracted fewer loads in the skin region along the repair boundary in the hoop direction. For the high-stiffness repair, S2BE, the strains were lowest in the patch and highest in the skin along the boundary. The aluminum patch, S3A, had stiffness comparable to the skin.

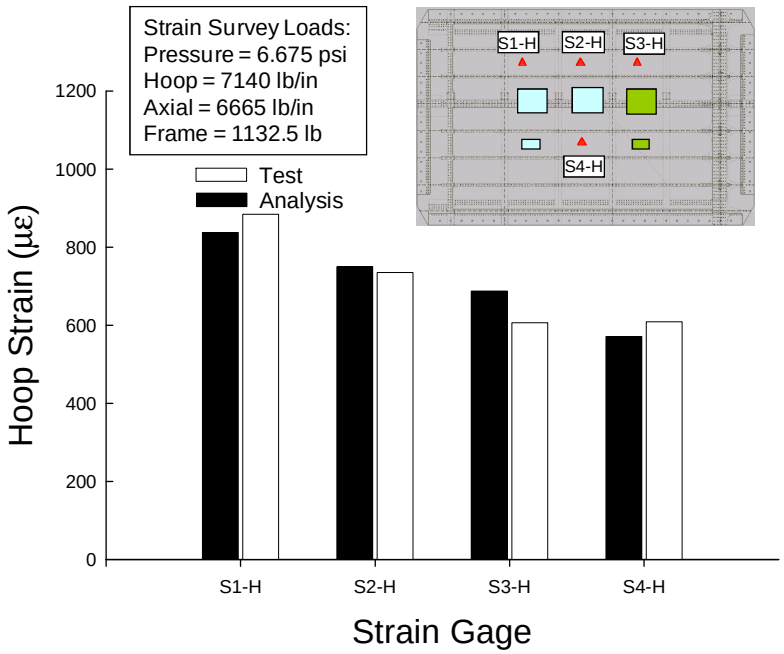


Figure 23. Measured and Predicted Strain Distribution

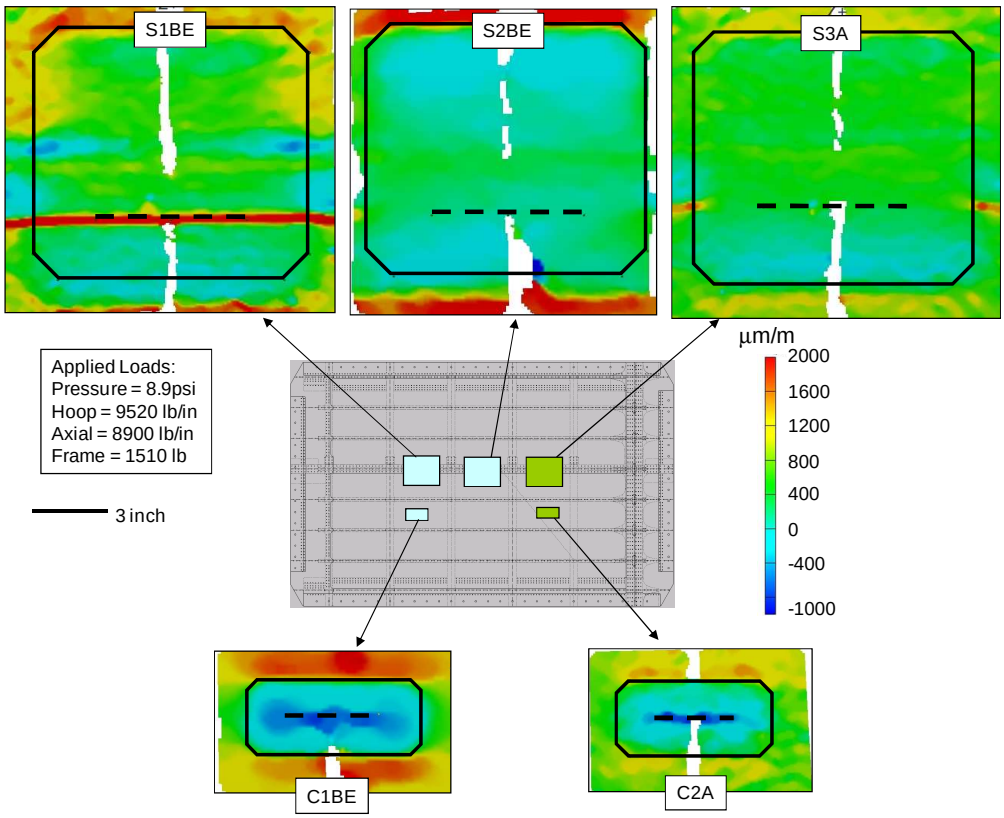


Figure 24. Full-Field Hoop Strains Near the Repair Patches

For the midbay patches, the C1BE attracted more load to the skin (indicated by the red fringe patterns) along the patch boundary compared to C2A (figure 24). Note that both midbay patches were both under compressive loading in the center along the notch region, as indicated by the blue fringe patterns.

Details of the hoop strain variation in the vicinity of midbay patch C1BE is shown in figures 25 and 26 along horizontal and vertical sections, respectively. In these figures, the distance between sections is 0.75 inch. The breaks in the line plots are regions in which data could not be obtained due to interference from strain gage wires. Along the horizontal sections (figure 25), hoop strains varied most along the patch centerline (section 1), ranging in values from approximately 500 με in the skin outside the patch to approximately -1000 με in the center of the patch. The variation reduced from the patch centerline (section 1) to the edge of the patch (section 3), where the hoop strain remained relatively constant at approximately 850 με. Just outside the patch (section 4), the strains varied in the skin from approximately 850 to 1200 με. Data measured from two strain gages designated S8 and S9 are also indicted in the figure. As shown, the strains measured using the ARAMIS system along sections 1 and 4 near strain gages S8 and S9, respectively, agreed with the strain gage data.

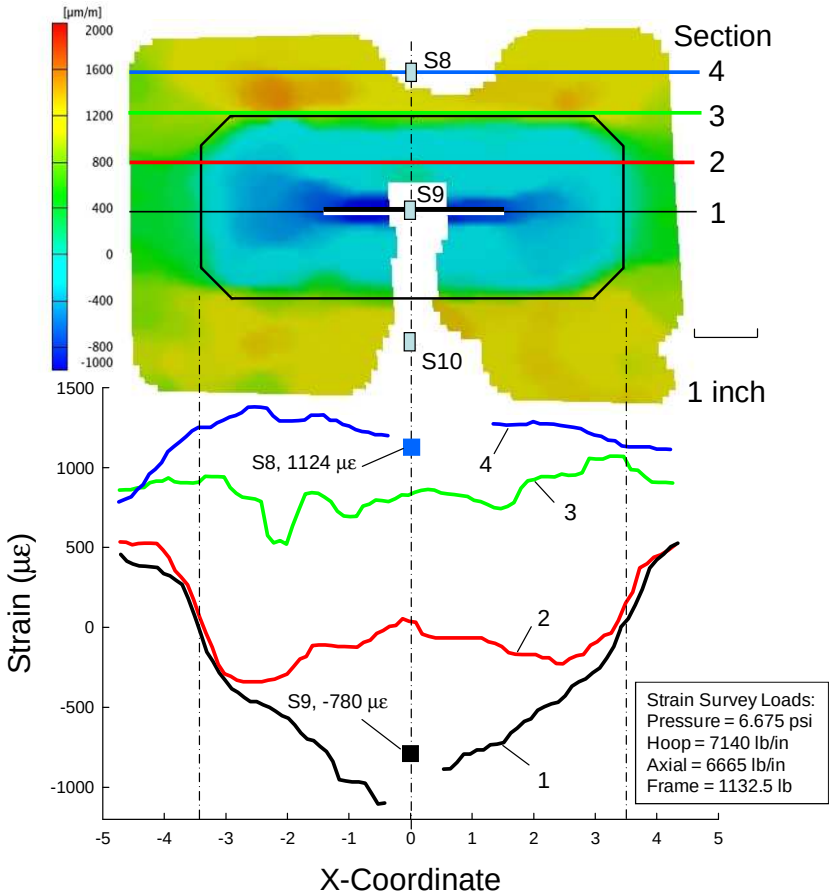


Figure 25. Hoop Strain Variation Measured Along Several Horizontal Sections Near Patch C1BE

Along the vertical sections (figure 26), hoop strains varied the most toward the middle of the patch (section 1 located 0.75 inch from the patch vertical centerline), where the values ranged from approximately 1200 με in the skin outside the patch to approximately -1000 με in the center of the patch. The strain gradient was quite high in a narrow band of approximately ±0.5 inch about the crack (section 1); over this short distance the strain ranges from 0 to -1000 με. Strains also changed rapidly at the patch boundary crossing from the skin into the patch (sections 1-4) at ±1.5 inches about the centerline. The severity of the strain gradient reduced substantially in patch sections ahead of the crack (sections 3-4) and more so outside the patch in the skin (sections 5-6). Detailed ARAMIS results of all the patches are provided in appendix F.

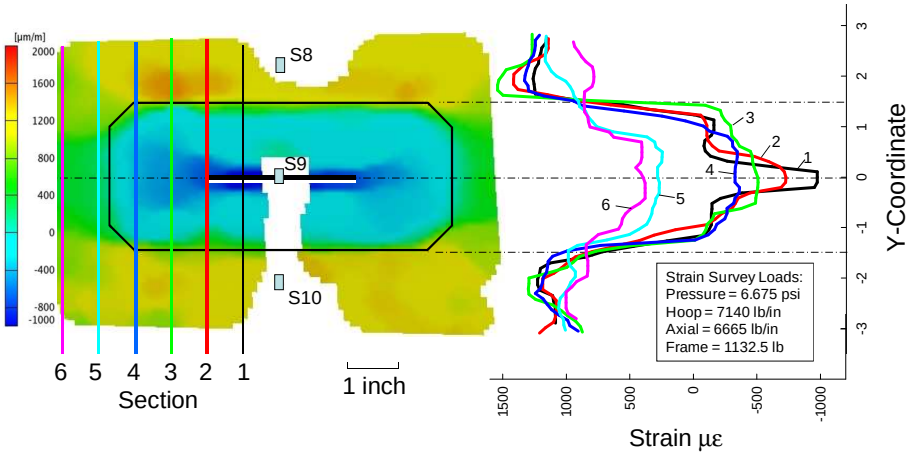
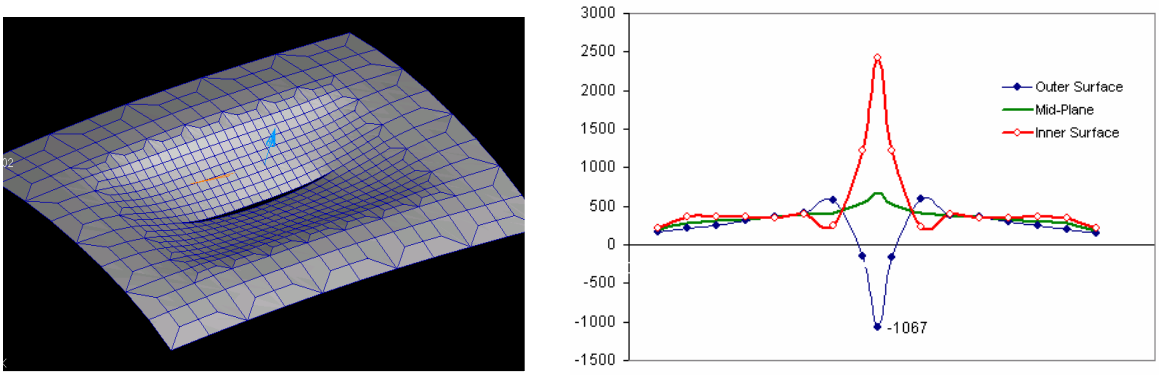


Figure 26. Hoop Strain Variation Measured Along Several Vertical Sections Near Patch C1BE

The FEA results revealed that the installation of the midbay repairs resulted in eccentric loading and inward deformation of the midbay region (figure 27(a)). As a result, there are higher tensile stresses on the inner patch surface and compressive stresses on the outer patch surface (figure 27(b)).



(a) (b)

Figure 27. The FEA Results Showing Effect of Eccentric Loading From Patch Installations at Midbay Regions (a) Deformed Mesh of Skin Displayed Without the Patch and (b) Strains in the Patch

The measured and predicted hoop strains from several strain gages used to monitor the amount of bending in patch C1BE are shown in figure 28. As shown, gage S9 was located in the center of the patch on the outer surface and was under compression. Gages S8 and S10 were located on the outer surface of the skin 0.75-inch from the patch boundary. Gages IS26 and IS27 were at the same location on the inner skin surface. Comparing the back-to-back gages, there was a large amount of bending along the patch boundary with the outer surface in tension and the inner surface in compression. In general, good agreement was obtained between the FEA and measured strains.

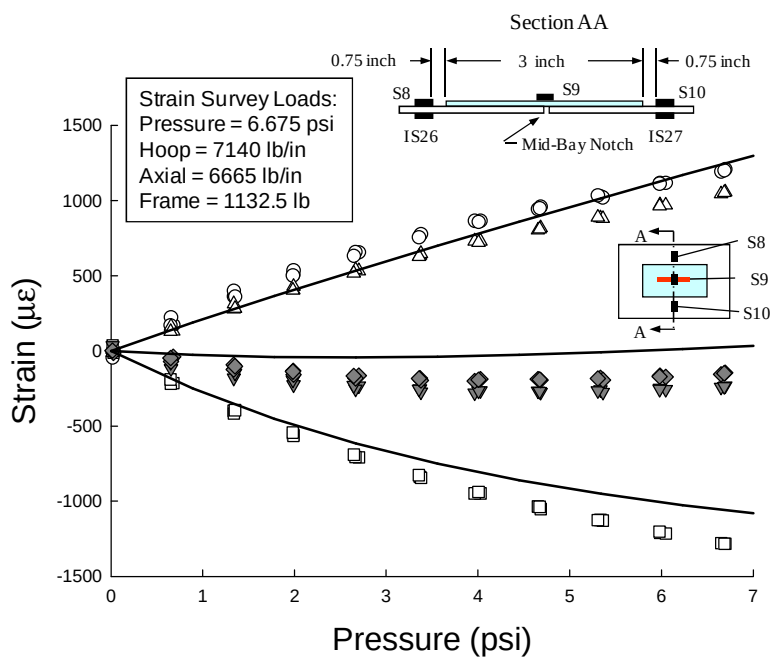


Figure 28. Strain Measurements Showing Bending Effect at Midbay Patch C1BE

4.1.3 Fatigue Test.

After the baseline strain survey test, the panel was subjected to fatigue loads that simulated in-service loading conditions, including cabin pressurization (8.9-psi pressure) and fuselage vertical bending at the levels shown in table 1. Strains and damage growth were monitored and recorded during the fatigue test, which lasted 60,000 cycles (one DSG). In general, the global strains remained relatively constant throughout the fatigue test. The results are summarized in figures 29 and 30 for skin midbay regions and repair patch C1BE, respectively.

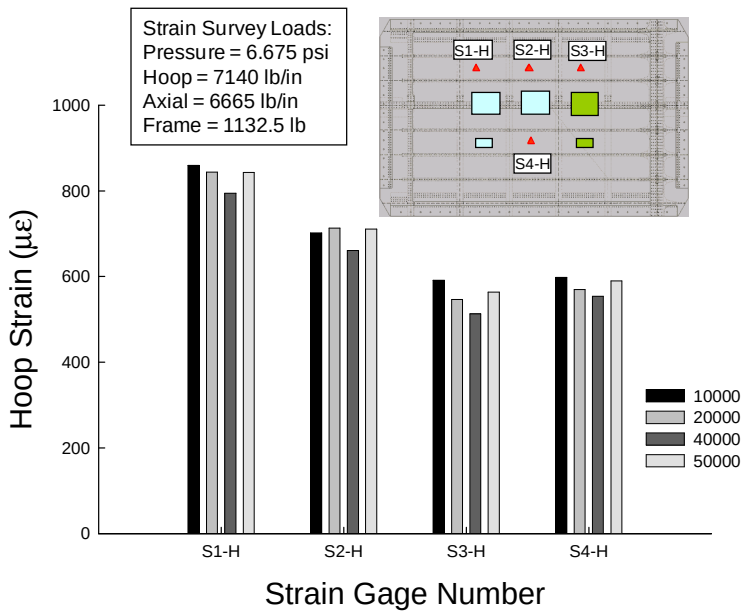


Figure 29. Strains at Skin Midbay Locations During Fatigue Test

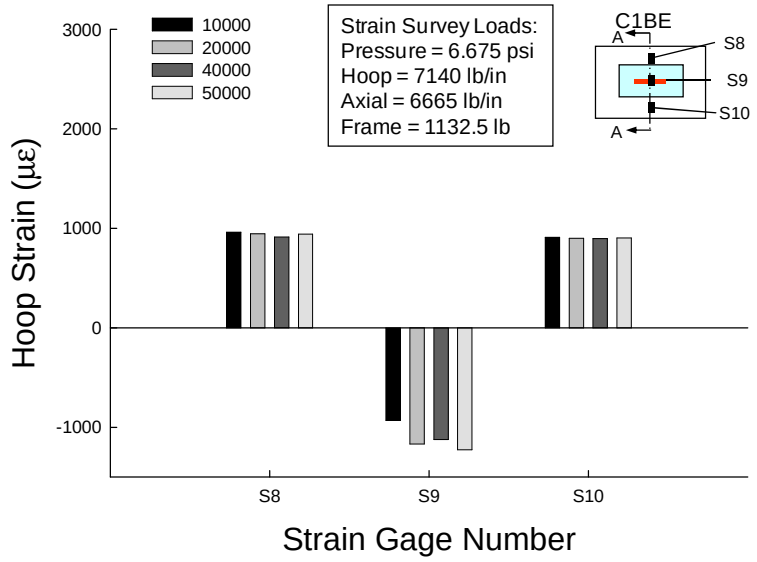


Figure 30. Graph Showing the Strains Remained Relatively Constant Throughout Fatigue, Patch C1BE

There were no indications of damage development in the form of crack growth or disbonding for the lap joint scribe line repair patches. Strain gages mounted on the inner surface of the skin to monitor crack growth from the scribe lines remained relatively constant throughout the fatigue test, as indicated in figure 31.

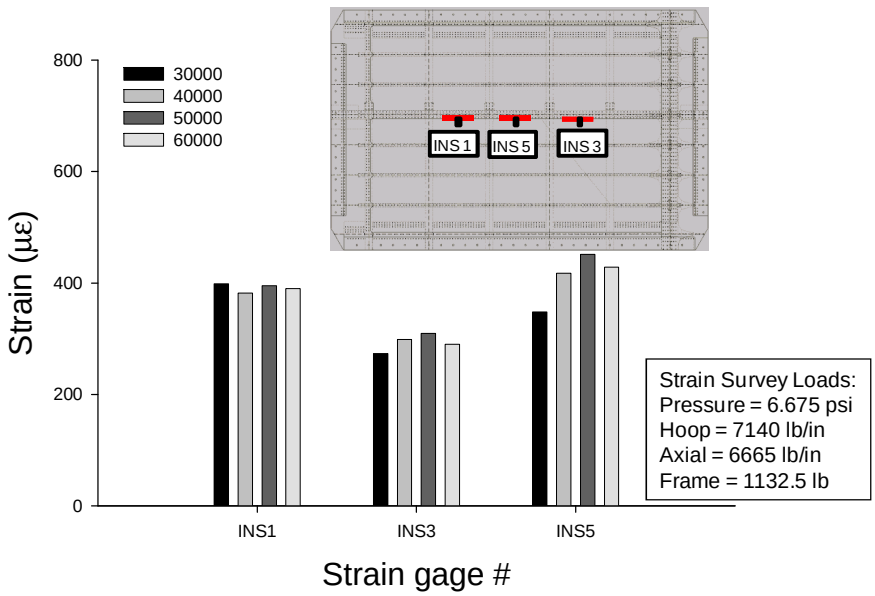


Figure 31. Strains at Scribe Locations During the Fatigue Test

For the midbay patches, there was no gross or measurable disbonding; however, a slow, stable crack growth was observed, particularly the crack under patch C1BE, as shown in figure 32. The images in this figure were taken using a flash thermography system. Appendix I provides the inspection results.

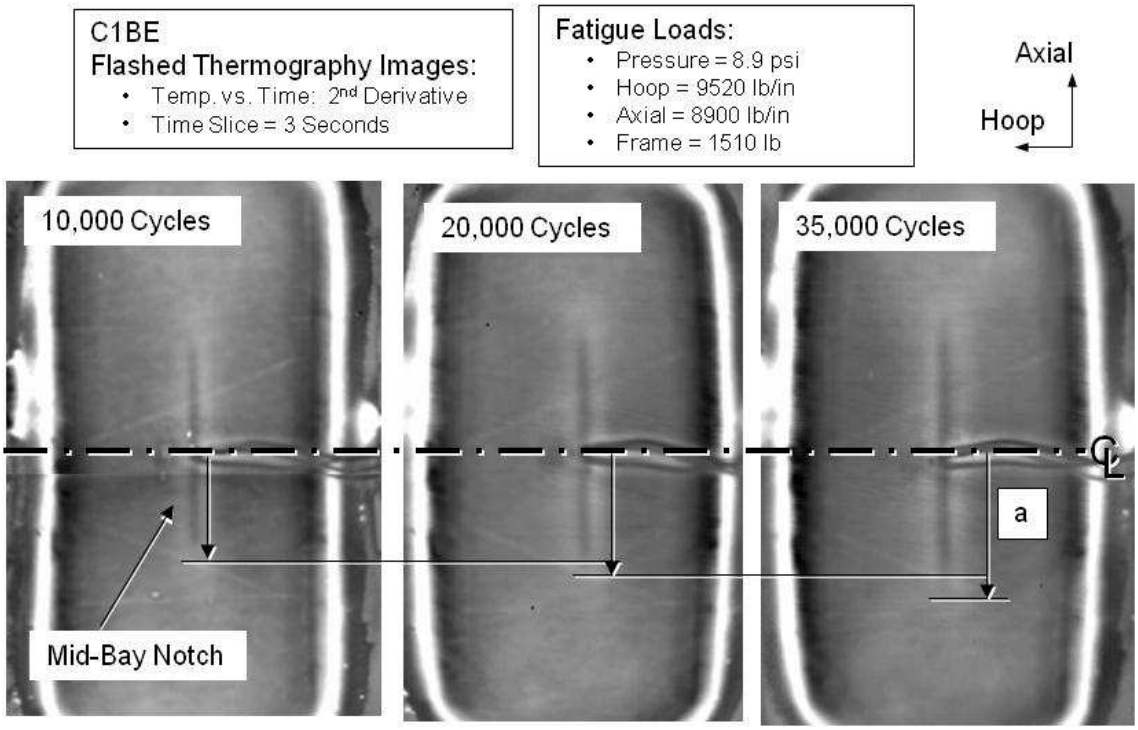
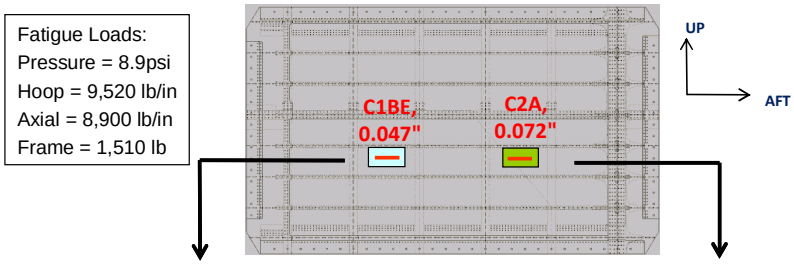
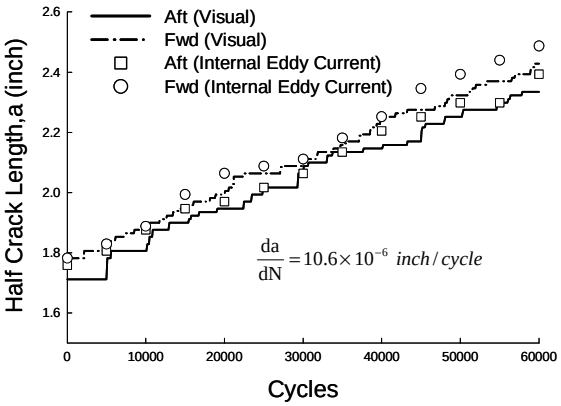


Figure 32. Flash Thermography Inspections of Patch C1BE During the Fatigue Test

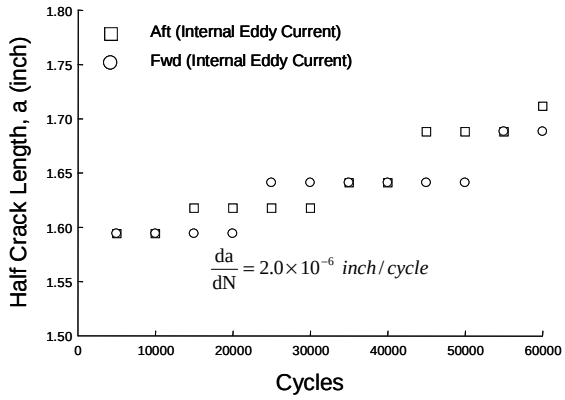
The observed crack growth was measured during the fatigue test using visual and internal eddy-current inspections for patches C1BE and C2A, as shown figure 33. For the B/Ep repair, C1BE, the crack lengths measured visually and using eddy-current inspections were in good agreement (figure 33(b)). The crack lengths measured using internal eddy current were slightly longer than those measured visually, indicating that crack tunneling occurred. The visual measurements were made during the fatigue test with the high-magnification camera shown in figure 13(b). The crack tip could be located only when the crack opening was maximized at the upper load levels of the fatigue cycle. At the lower levels of the fatigue cycle, it was difficult to distinguish the crack tip. The internal eddy-current inspections were made under no-load conditions.



(a) Designation of Midbay Patches and Skin Thickness



(b) Crack length under patch C1BE



(c) Crack length under patch C2A

Figure 33. Results From Phase 1 (a) Location of Patches and Skin Thickness, (b) Crack Growth Under Patch C1BE, and (c) Crack Growth Under Patch C2A

For the crack under the aluminum patch C2A, the extension was much less than under B/Ep patch C1BE. Crack extension was measured using the internal eddy current only because the crack tip could not be reliably located for visual measurements (figure 33(c)). Alternative patch C2A was very effective in constraining the crack and keeping the two surfaces in contact. For both repair patches, the observed crack growth was symmetric, colinear, and the measured rate was nearly constant. Note that the crack growth rate measured in the thinner skin gage region under C1BE was approximately 5 times higher than that measured in the thicker skin gage region under C2A.

Figure 34 shows a comparison of three methods of measuring the average crack growth under B/Ep patch C1BE: visual, internal eddy current, and external eddy current. As shown, the measurements made by the three methods were in good agreement.

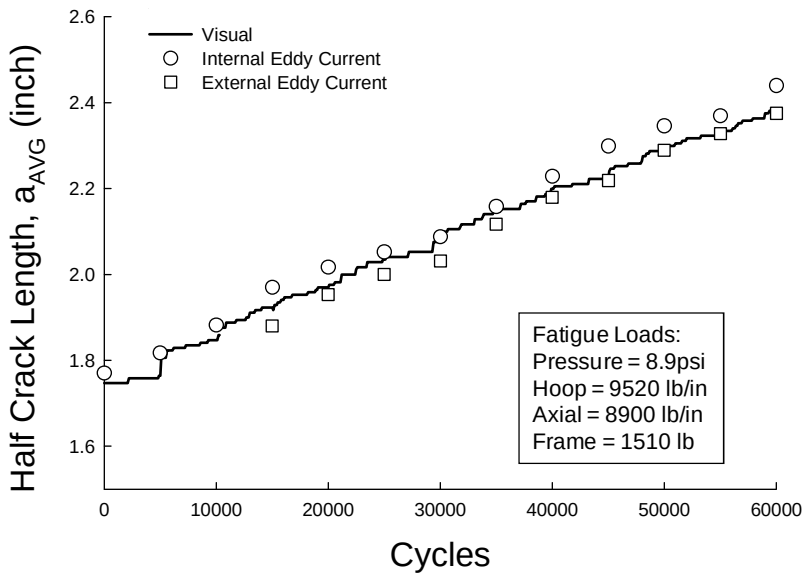
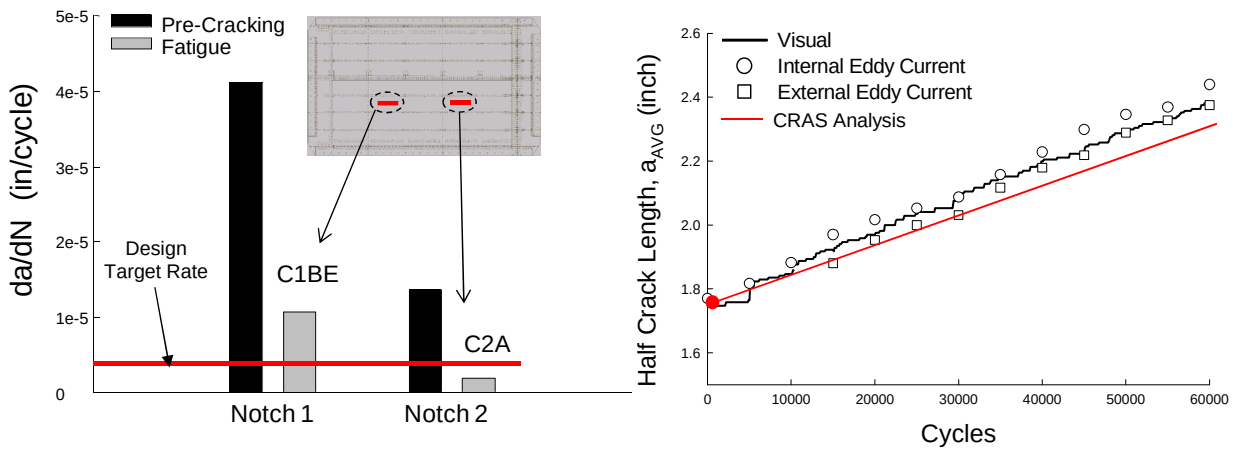


Figure 34. Crack Length Measurements From Visual, Internal Eddy-Current, and External Eddy-Current Inspections of Patch C1BE

The midbay repair patches were quite effective in reducing the crack growth rate, as shown in figure 35. Figure 35(b) shows a comparison of the measurements made during fatigue precracking before the patches were installed and during fatigue at SL conditions after the patches were installed. In both repairs, the crack growth rates were reduced substantially. It should be noted that the precracking loads were 75% of the SL used during fatigue (figure 35(a)). In addition, the measured rates in the B/Ep patch, C1BE, were higher than the target rate provided by the original CRAS analysis. After further evaluations, enhancements were made to the CRAS program to obtain better correlation with the experiments by accounting for curvature and applied pressure, and by using measured thermal strains during the cure process. Results of the test and analysis correlation are shown in figure 35(c).

Load Component	Pre-Cracking (before Patch Installation)	Fatigue (after Patch Installation)
Pressure	6.7 psi	8.9 psi
Hoop	7,140 lb	9,520 lb
Axial	6,675 lb	8,900 lb
Frame	1,133 lb	1,510 lb

(a) Applied loads



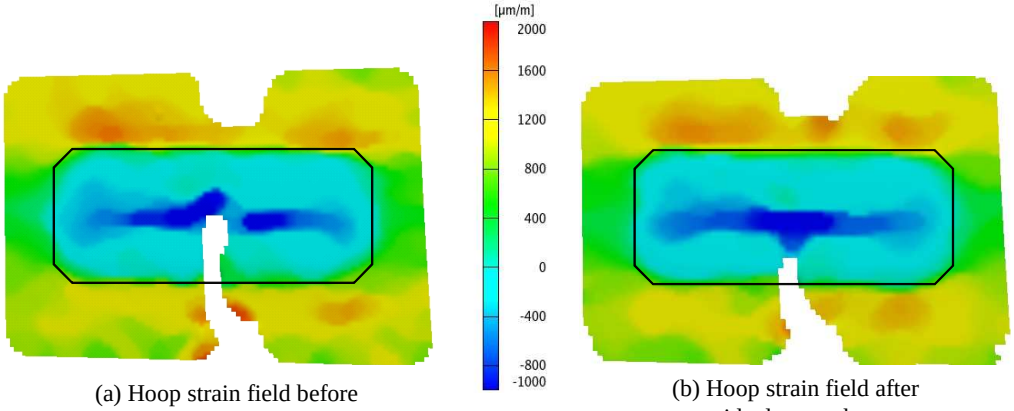
(b) Measured rates before and after patch installation

(c) Crack length test and analysis correlation

Figure 35. Phase 1 Results (a) Applied Loads, (b) Effect of Patches on Crack Growth Rates, and (c) Correlation of Test and Analysis

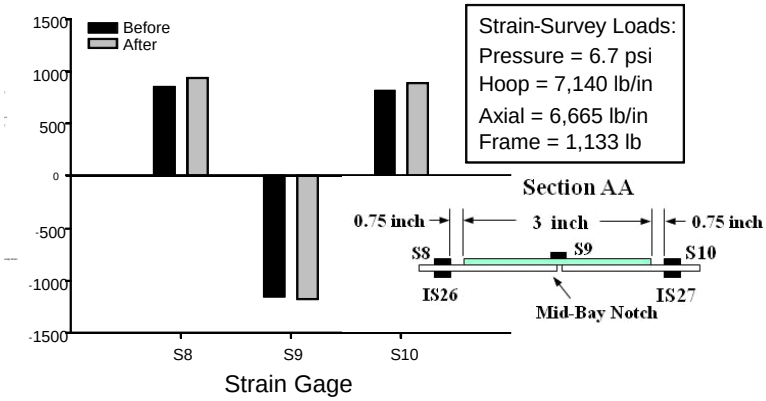
4.1.4 Residual Strength Tests.

After the fatigue test, the panel was subjected to quasi-static loading to 10.24-psi pressure, a level that simulates the damage tolerance requirements defined in 14 CFR 25.571. The load levels are listed in table 1 for the residual strength test. All five repair patches were effective in preventing failure of the damaged panel. No disbond or crack growth was observed during inspections made after the residual strength test. In addition, there was no evidence of load redistribution: strain survey results after the residual strength test were similar to the baseline strain survey results for midbay patch C1BE, as indicated in figure 36. The strain gage readings for all the patches during the residual strength tests are provided in appendix H.



(a) Hoop strain field before residual strength test

(b) Hoop strain field after residual strength test



(c) Hoop strain before and after residual strength test

Figure 36. Phase 1 Results (a) Location of Strain Gage, (b) Strains Measured Along Patch Boundary and Centerline, and (c) Strains Measured During Fatigue

4.2 PHASE 2—NO-DAMAGE GROWTH REPAIR DESIGN.

The purpose of Phase 2 was to demonstrate a no-damage growth repair design. The midbay B/Ep patch, C1BE, was removed and replaced with a no-damage growth repair, C1A. The tips of the through-the-thickness crack were stop-drilled and repaired using an aluminum patch, as shown in figure 37(a) and (b). A strain survey was first conducted to baseline the new repair results and is presented in appendix D. The panel was then subjected to an elevated load of 115% of SL (10.24-psi pressure) for 10,000 cycles and then to an elevated load of 133% of SL (11.84-psi pressure) for an additional 10,000 cycles. During both fatigue tests, there were no indications of damage growth under the new repair design, C1A, using all methods of inspections. As shown in figure 37, there were no global changes in the hoop strain field measured using the ARAMIS system, which would indicate load redistribution due to disbonding or crack growth. The patch boundary and initial defect are indicated in the figure. The white regions are areas where data could not be processed because of interference from strain gage wires. In general, the strain increased in the panel skin along the edges of the repair patches (indicted by the red and yellow fringe patterns) and decreased in the repair patch region. In the center of the patch, along the notch centerline, the patch region was in compression (indicated by the blue fringe patterns).

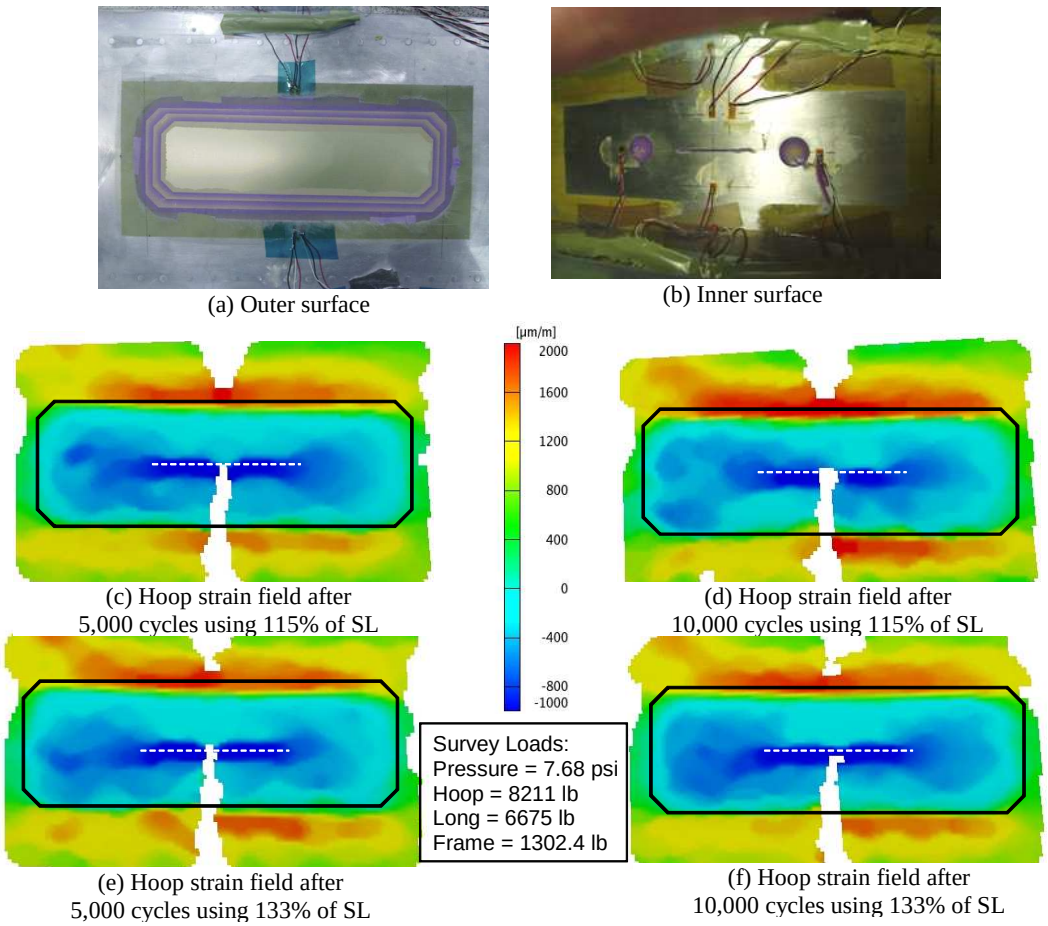
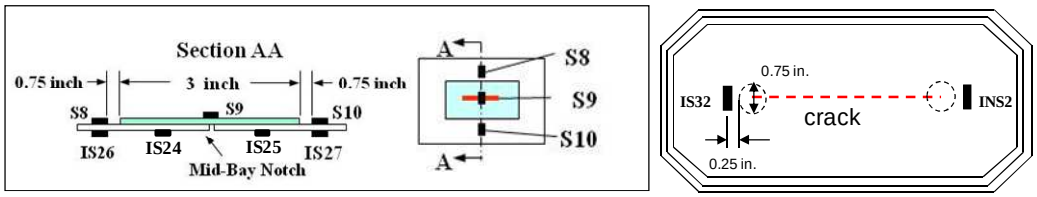
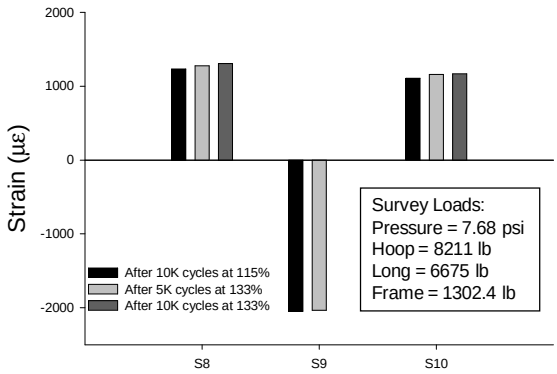


Figure 37. Phase 2 Results (a) External Surface of Repair C1A, (b) Interior Surface of Repair C1A, (c) Measured Hoop Strain Field After 5,000 Cycles Under 115% of SL, (d) Measured Hoop Strain Field After 10,000 Cycles Using 115% of SL, (e) Measured Hoop Strain Field After 5,000 Cycles Using 133% of SL, and (f) Measured Hoop Strain Field After 10,000 Cycles Using 133% of SL

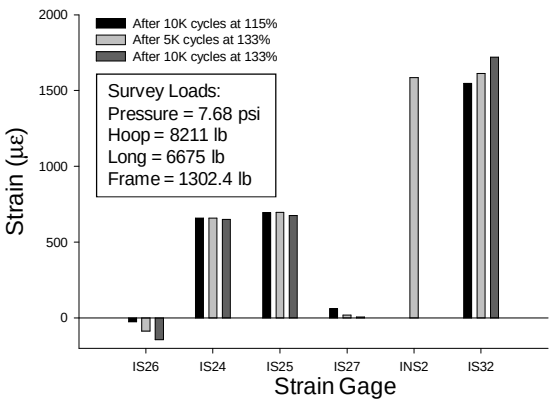
The strains measured at the gages also remained unchanged during Phase 2 fatigue loading for all repair patches. Representative results are shown in figure 38 for midbay patch C1A. The gage locations are shown in figure 38(a). Strains measured in gages on the outer surface and inner skin surface are provided in figure 38(b) and (c), respectively. As indicated, the strain values remained relatively constant and the strains field was symmetric about the repair. The highest tensile strains were measured in the inner skin surface at gages located approximately 0.25 inch from the notch, IS32 and INS2. The magnitude of these notch region strains was slightly higher than strains measured in the outer skin surface at gages along the patch boundary, S8 and S10. Strain levels were low enough not to cause crack initiation in the notch region and patch boundaries. High-frequency, eddy-current inspections confirmed that no cracks developed in the notch region during Phase 2.



(a) Strain gage locations, C1A



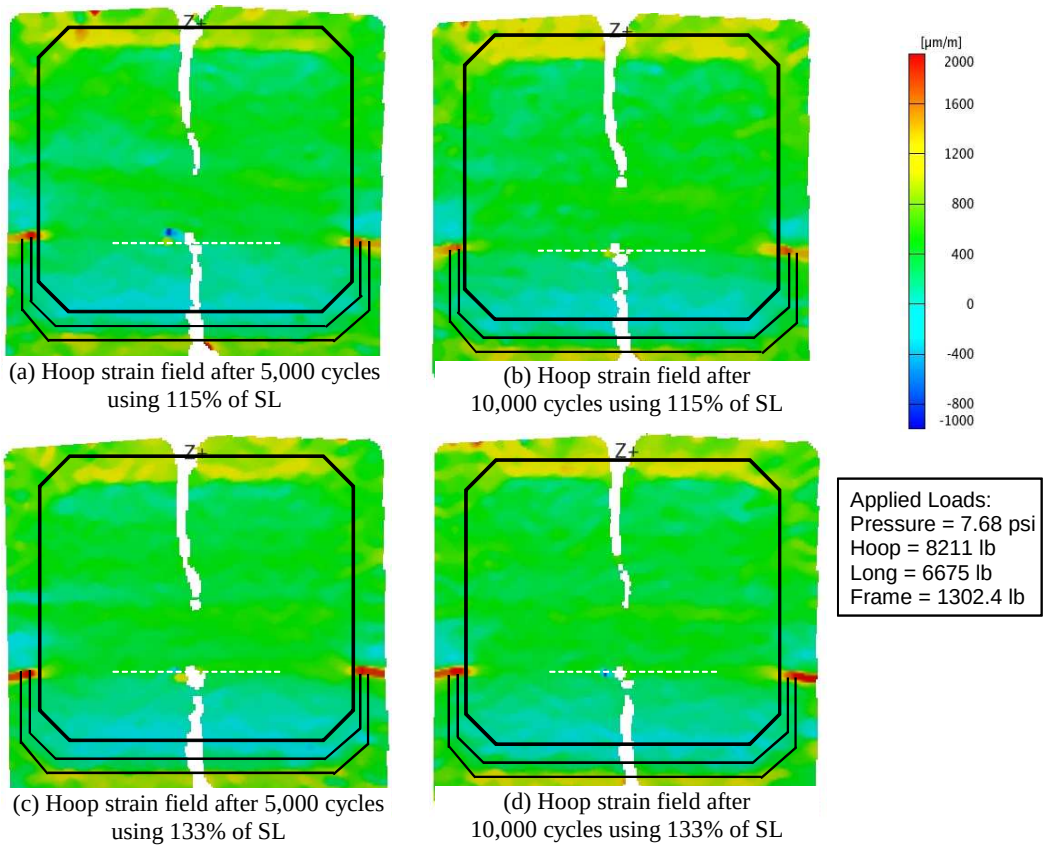
(b) Strains on outer surface



(c) Strains on inner surface

Figure 38. Phase 2 Results (a) Gage Locations, C1A, (b) Strains Measured on the Outer Surface After Fatigue Intervals Under 115% and 133% of SL, (c) Strains Measured on the Inner Surface After Fatigue Intervals Under 115% and 133% of SL

In addition, there were no indications of disbonding and crack growth from the scribe lines in the lap joint repairs, S1BE, S2BE, and S3A. As shown in figure 39, there were no global changes in the hoop strain field measured using the ARAMIS system, which would indicate load redistribution due to the occurrence of damage initiation and progression.



(a) Hoop strain field after 5,000 cycles using 115% of SL

(b) Hoop strain field after 10,000 cycles using 115% of SL

(c) Hoop strain field after 5,000 cycles using 133% of SL

(d) Hoop strain field after 10,000 cycles using 133% of SL

Figure 39. Phase 2 Results (a) Measured Hoop Strain Field After 5,000 Cycles Under 115% of SL, (b) Measured Hoop Strain Field After 10,000 Cycles Using 115% of SL, (c) Measured Hoop Strain Field After 5,000 Cycles Using 133% of SL, and (d) Measured Hoop Strain Field After 10,000 Cycles Using 133% of SL

4.3 LARGE REPAIR DESIGN.

The purpose of Phase 3 was to demonstrate large-damage repair capability. Lap joint repair patches S1BE and S2BE were removed. A 26-inch, two-bay lap joint through-the-thickness crack was inserted and repaired using an aluminum patch, LJC3A.

4.3.1 Strain Survey.

The full-field surface hoop strain near all four patches was first measured during a strain survey. Representative results are shown in figure 40. In the figure, the patch boundary and initial defect are indicated. In general, the strain increased in the panel skin along the edges of the repair patches (indicted by the red and yellow fringe patterns) and decreased in the repair patch region. For the lap joint repair LJC3A, in the thinner skin gage region between FS-720C and FS-720D, more load was attracted along the patch boundary compare to the thicker skin gage region between FS-720D and FS-720E (indicated by the red fringe patterns).

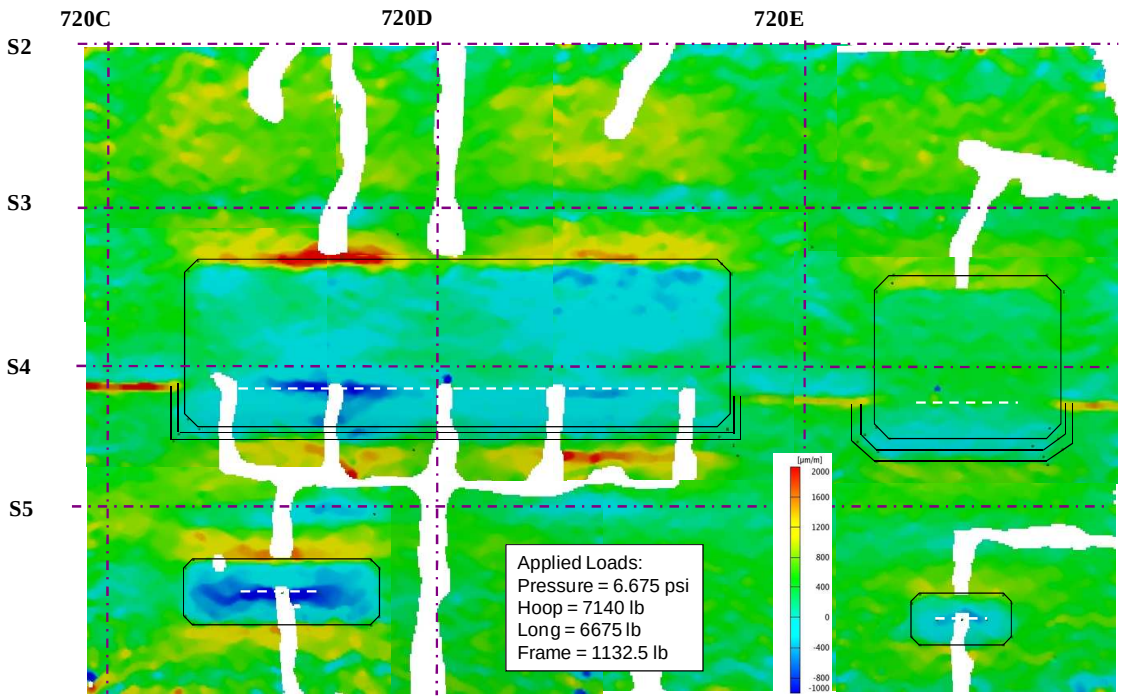


Figure 40. Full-Field Hoop Strains Near the Repair Patches During a Strain Survey

4.3.2 Fatigue Test.

An additional 20,000 cycles were then applied using the simulating SL conditions (8.9-psi pressure). During fatigue, crack growth and disbonding were monitored at all four patches. No indications of damage growth occurred from measured strains. Representative results are summarized in figure 41, showing hoop strains measured on the outer surface using strain gages during the fatigue test in repair LJC3A. As shown, all strains remained relatively constant during the fatigue, indicating no load redistribution, which would also signify damage formation.

Figure 42 shows measured hoop strains on the inner skin surface near the notch tip during the fatigue test in repair LJC3A. As shown, there is a strain variation near the notch tip with strains highest near the notch. Gages P6-1 through P6-3 were located in the thin gage section (t = 0.046 inch) and gages P6-10 through P6-12 were located in the thicker gage section (t = 0.06 inch). Thus, the strains were not symmetric about the notch centerline. Measured strains remained relatively constant during fatigue. The patch was very effective in reducing the notch tip strain field to nondamaging levels. High-frequency, eddy-current inspections confirmed that no crack growth occurred in the notch tip region. The magnitude of strain in the notch regions (e.g., P6-2 in figure 42) was much lower than the strains in the skin along the patch boundary (e.g., S29 in figure 41).

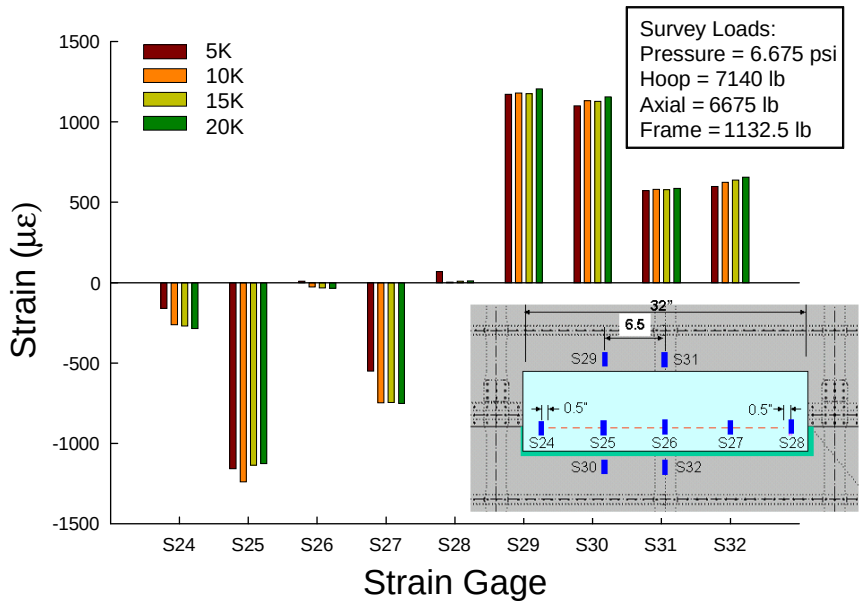


Figure 41. Hoop Strains Measured From Strain Gages Near Patch LJC3A During Fatigue Test for 20,000 Cycles

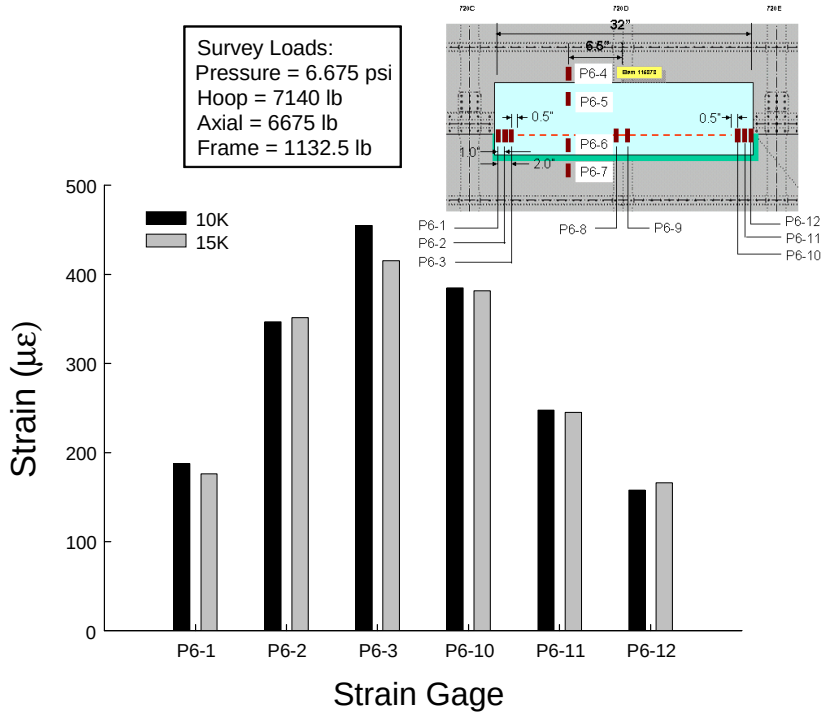


Figure 42. Hoop Strains Measured From Strain Gages Near the Notch Tip Region in Patch LJC3A During Fatigue Test for 20,000 Cycles

Figure 43 summarizes the number of cycles each repair patch was subjected to after the Phase 3 fatigue test and demonstrates the durability of the patches installed. The large repair, LJC3A,

was installed in Phase 3 and was subjected to 20,000 cycles. There were no indications of crack growth from the notch tips or disbonds from NDI and strain measurements. The no-damage growth repair, C1A, was installed in Phase 2 and was subjected to 45,000 cycles with no indications of disbonds or crack formation from the stop-drilled holes.

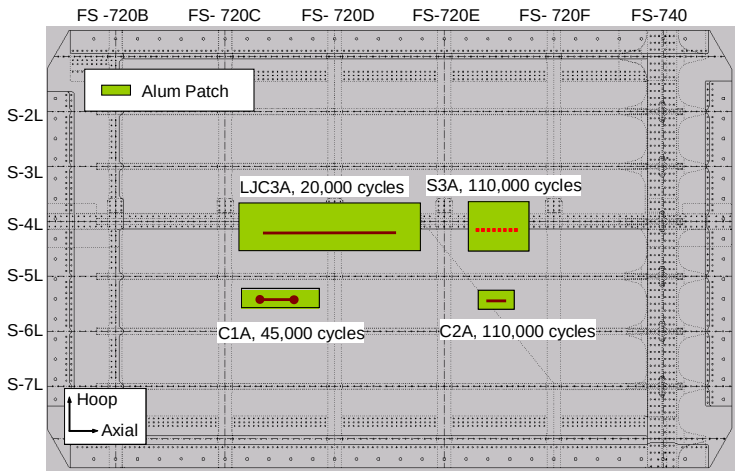


Figure 43. Fatigue Cycle Count Summary for Each Repair After Phase 3 Fatigue Test

The fatigue performance of the original scribe line and midbay repairs, S3A and C2A, which were subjected to 110,000 cycles, were more significant. For the scribe line repair, there were no indications of damage formation. For the other midbay repair, C2A, there was no measurable disbonding; however, limited crack extension occurred. Figure 44 shows the crack growth measured in the midbay crack under C2A for all test phases. As shown, the crack growth rate increased during Phase 2 due to the elevated applied load levels compared to the Phase 1 results. The rate then reduced substantially during Phase 3 when subjected to SL conditions. The total amount of crack extension from the notches was under 0.3 inch with an average rate of less than 2.5 x 10^{-6} inch/cycle. The fatigue crack growth results are provided in appendix G.

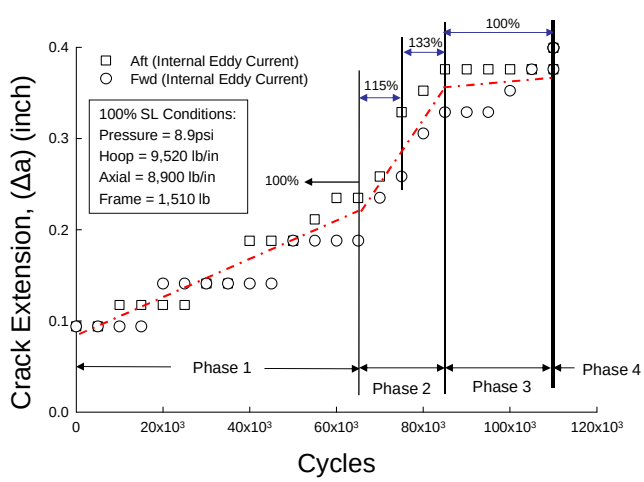
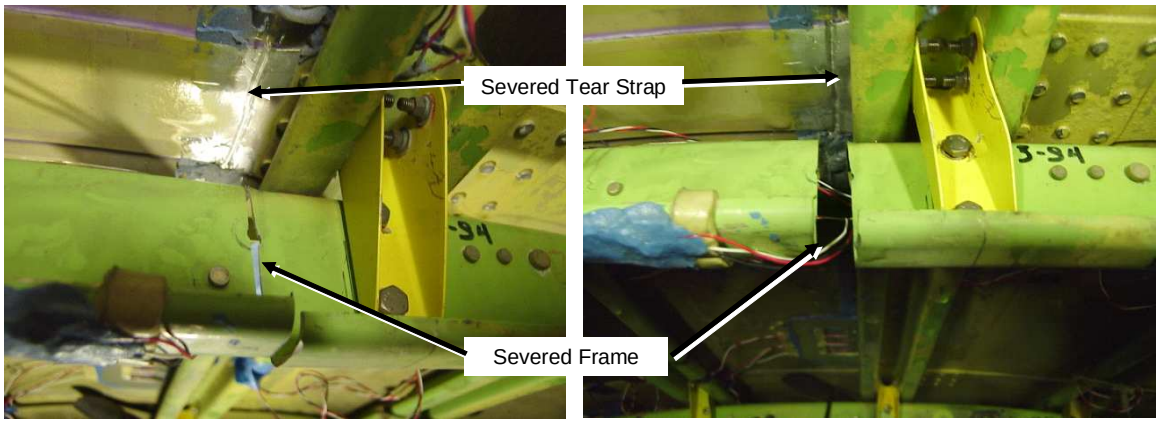


Figure 44. Crack Extension Measured in the Skin Under Patch C2A for All Test Phases

4.3.3 Residual Strength Tests.

After the fatigue test, the central tear strap and frame were severed at FS-720C along the plane of the 26-inch center notch. A quasi-static residual strength test was then conducted to load levels corresponding to (1) damage tolerance requirements of 14 CFR 25.571 (10.24-psi pressure), (2) the pressurized compartment load requirements of 14 CFR 25.365 (11.84-psi pressure), and (3) the strength and deformation requirements of 14 CFR 25.305 (15.35-psi pressure). A fourth residual strength test was conducted to the maximum capacity of the fixture (24.74-psi pressure). The load levels applied during the residual strength test are summarized in table 1. In general, there was no measurable disbonding or notch tip crack extension in patch LJC3A nor in the other three patches (C1A, C2A, and S3A). However, there was permanent deformation in the stringer tie and frame bending, as shown in figure 45. The residual strength test results are provided in appendix H.



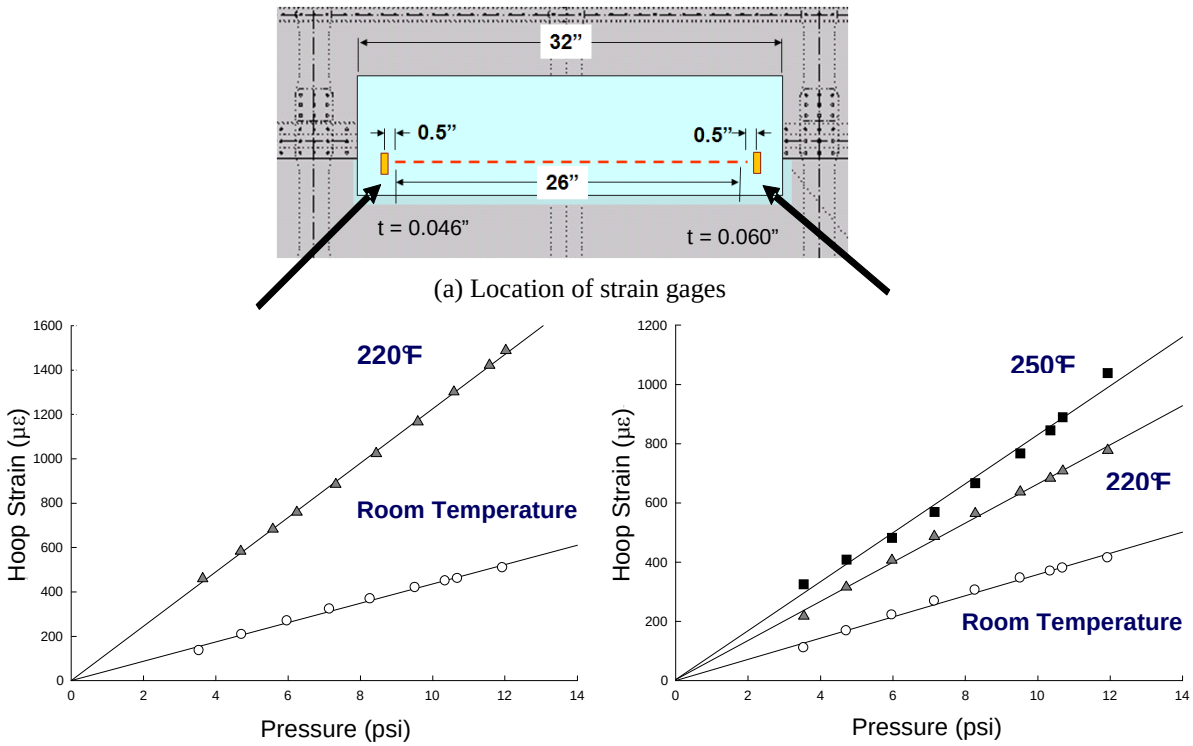
(a) Before (b) After

Figure 45. Severed Tear Strap and Frame Under LJC3A (a) Before Residual Strength Test and (b) After the Residual Strength Test

4.4 PHASE 4—ELEVATED TEMPERATURE.

The purpose of Phase 4 was to demonstrate the load-carrying capacity of a large-damage repair design and installation under thermal-mechanical loading. For this, all repairs and initial damage were the same as in Phase 3. In Phase 4, elevated temperatures of 220° and 250°F were applied to reduce the adhesive bond properties and strength in repair LJC3A and to determine if there was a reduction in load-carrying capacity compared to the residual strength tests in Phase 3.

The effect of temperature on the local notch tip strain in the skin under LJC3A is shown in figure 46. The measured strain at gage P6-3 located in the thin gage section (t = 0.046 inch) and gage P6-10 located in the thicker gage section (t = 0.06 inch) are shown in figure 46(b) and (c), respectively. As shown, the value of strain at the notch tip increased with increase in temperature, indicating less load transfer into the patch.



(a) Location of strain gages

(b) Measured strain, gage P6-3, t = 0.046″

(c) Measured strain, gage P6-10, t = 0.060″

Figure 46. Effect of Temperature on Measured Strains (a) Location of Gages, (b) Notch Tip Strain in the Thin Gage Section, and (c) Notch Tip Strain in the Thick Gage Section

The results from the residual strength test at an elevated temperature of 250°F are shown in figure 47. As shown, gages P6-1 and P6-2 are near the notch tip of the thin gage section (t = 0.046 inch), gages P6-10 through P6-12 are near the notch tip of the thicker gage section (t = 0.06 inch), and gages S31 and S32 on the inner skin in the center of LJC3A along the boundary. The strains measured from these gages indicated a load transfer, most likely due to bond failure, as shown in the figure. As the strains measured in the skin at the center of the patch reduced (S31 and S32), strain at the notch tip gages increased substantially. The details of the measured strains during the residual strength test are provided in appendix H.

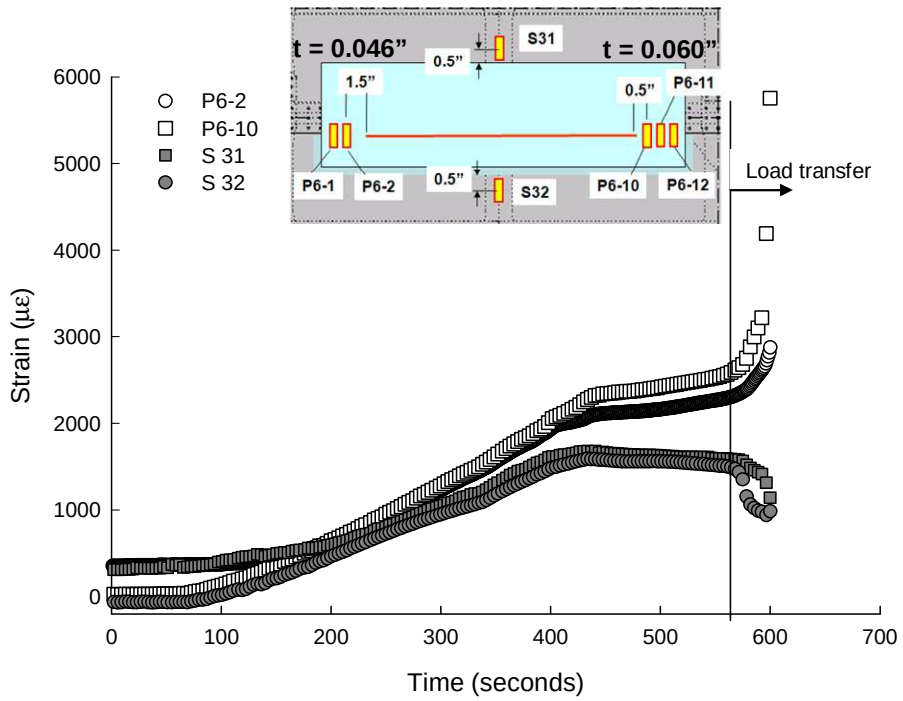


Figure 47. Strains During Residual Strength Test at 250°F Illustrating Load Transfer due to Bond Failure

The panel failed catastrophically at an applied pressure of 20.5 psi, well above ultimate strength requirements, as shown in figure 48(a). Bond failure occurred in the patch overlap region between the first doubler layer, S1, and the second filler layer, F2, as shown in figure 48(b). In addition, crack turning occurred from the notch tip, which resulted in final skin failure path along the outer rivet row of the lap joint in S4L. The majority of the disbonded surfaces of S1 and F2 layers were coated with residual adhesive, indicating cohesion failure, as shown in figure 48(c). There were also some small regions where the surfaces were clean of the adhesive, indicating interfacial or adhesion failure of the bond.

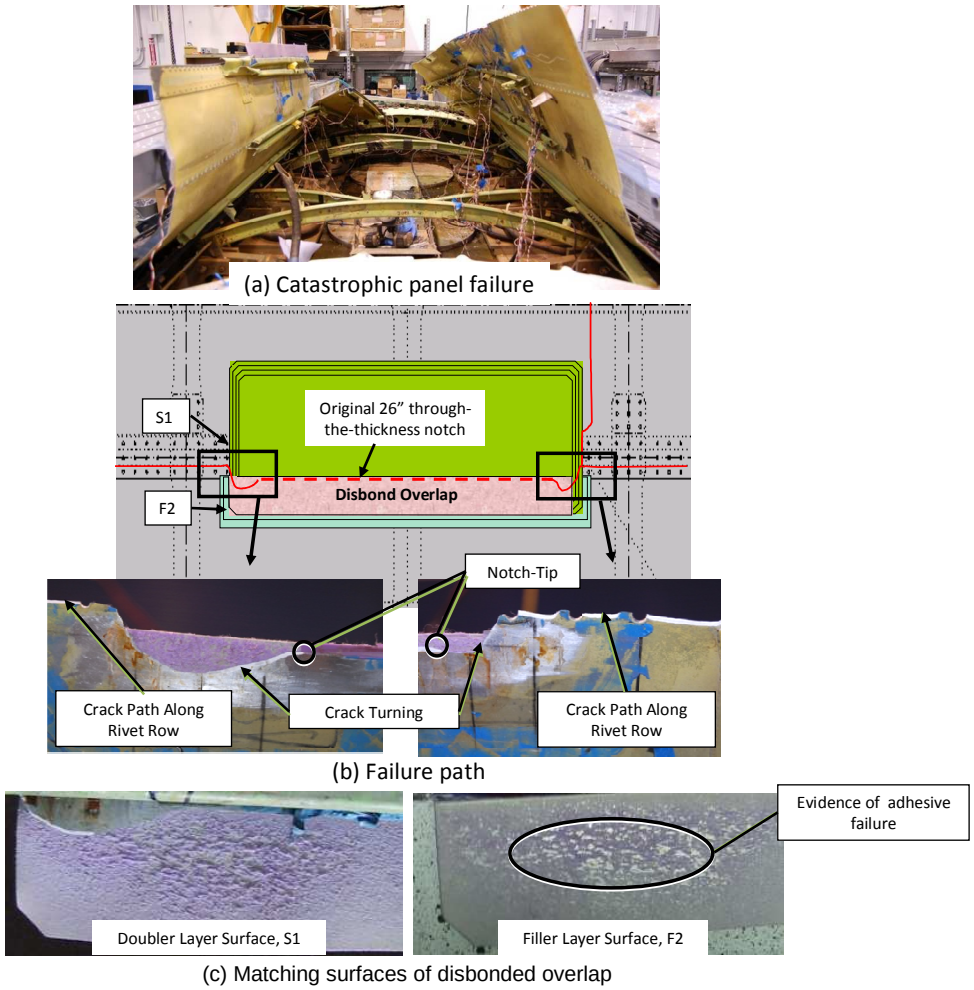


Figure 48. Phase 4 Results (a) Panel Failure After Residual Strength Test, (b) Failure Path, and (c) Disbond Surfaces Indicating a Combination of Cohesion and Adhesion Failures of the Bond

5. SUMMARY.

Tests and analyses were performed in a phased approach to study the fatigue and residual strength performance of B/Ep and aluminum bonded repairs to metallic fuselage under a variety of loading conditions and initial damage scenarios. Several nondestructive inspection methods were used to monitor and record damage formation, including crack growth and disbonding. Full-field strain and displacements were measured using photogrammetry to ascertain the load transfer in the vicinity of the repair patches.

In Phase 1, a fatigue test demonstrated the durability of B/Ep and aluminum bonded patches using simulated SL conditions (8.9 psi) up to 60,000 cycles. There were no indications of damage development in the form of crack growth or disbonding for the lap joint scribe repairs. For the midbay repairs, no disbonding occurred; however, slow crack growth was measured and correlated with analysis. Subsequent residual strength loads representative of damage tolerance

requirements in 14 CFR 25.571 (10.24-psi pressure) revealed that all repairs were effective in containing the damage.

A no-damage growth repair design was verified in Phase 2 using an aluminum patch concept in conjunction with stop-drilled holes to remove fatigue crack tips. The panel was subjected to an elevated load of 115% the of SL (10.24-psi pressure) for 10,000 cycles and then an elevated load of 133% of SL (11.84-psi pressure) for an additional 10,000 cycles. During both fatigue tests, there were no indications of damage growth under the new repair design using all methods of inspections.

For Phase 3, a large-damage repair design and installation capability was demonstrated. A 26-inch, two-bay lap joint through-the-thickness crack was inserted and repaired using an aluminum patch. An additional 20,000 cycles were then applied using the simulating SL conditions with no indications of damage growth. After the fatigue test, the central tear strap and frame were severed. The panel was subjected to residual strength tests to applied pressures of 10.24 psi (115% of SL), 11.84 psi (133% of SL), 15.35 psi (1.5 limit load), and 24.73 psi (280% of SL, maximum capacity of fixture). Inspections verified that the repairs were intact with no measurable damage growth.

The load-carrying capacity of a large-damage repair design under thermal-mechanical loading was evaluated in Phase 4. For this, all repairs and initial damage were the same as in Phase 3. Elevated temperatures of 220° and 250°F were applied to reduce the adhesive bond properties and strength in the large repair and to determine if there was a reduction in load-carrying capacity compared to the residual strength tests in Phase 3. The applied temperature degraded the adhesive properties causing a reduction in load transfer capabilities of the large repair patch. Catastrophic failure occurred at 20.5 psi at an applied temperature of 250°F, which was 17% lower than the maximum applied pressure of 24.74 psi obtained during the room temperature residual strength test conducted in Phase 3.

The results from this study revealed that properly designed and installed bonded repairs are durable under fatigue and can effectively contain large damage under severe static loads in excess of ultimate load requirements. Data from this effort will be used to further calibrate and verify predictive models.

6. REFERENCES.

1. *Advances in the Bonded Composite Repair of Metallic Aircraft Structure*, Volumes 1 and 2, Baker, A.A., Rose, L.R.F., and Jones, R., eds., Elsevier, 2002.

2. Roach, D. and Rackow, K., "Development and Validation of Bonded Composite Double Repairs for Commercial Aircraft," Sandia Report SAND2007-4088, July 2007.

3. Kressel, I., Botsev, Y., Green, A.K., Ben-Simon, U., Ghiai, G., Tur, M., Banks-Sills, L., and Gali, S., "Damage Tolerance of Bonded Composite Repairs: Analysis and Testing," *Proceedings of the 23rd ICAF Symposium*, Vol. II, Dalle Donne, C., ed., DGLR-Bericht 2005-03, ISBN 3-932182-42-1, Hamburg, 2005, pp. 585-588.

4. Baker, A., "Issues in the Certification of Bonded Composite Patch Repairs for Cracked Metallic Aircraft Structures," *Proceedings of the 20th ICAF Symposium*, Vol. I, Rudd, J.L. and Bader, R.M., eds., Electric Print Imaging Corporation, Bellevue, Washington, July 14-16, 1999, pp. 299-320.

5. Bakuckas, J.G., McIver, K., and Hsu, C., "Durability and Damage Tolerance of Bonded Repairs to Metallic Fuselage Structure," *Proceedings of the 25th ICAF Symposium*, May 27-29, 2009, Rotterdam, The Netherlands.

6. Chadha, R., Bakuckas, J.G., McIver, K., Hsu, C., Awerbuch, J., and Tan, T., "Test and Analysis of Adhesive Bonded Repairs to Fuselage Structure," *Proceedings of the 12th Joint NASA/FAA/DoD Conference on Aging Aircraft*, May 4-7, 2009, Kansas City, Missouri.

7. Duong, C., "Bonded Repair of a Commercial Airframe Curved Fuselage Panel: Design/Analysis, Installation and Validation Test," *Proceedings of the 12th Joint NASA/FAA/DoD Conference on Aging Aircraft*, May 4-7, 2009, Kansas City, Missouri.

8. Bakuckas, J.G., Jr., "Full-Scale Testing and Analysis of Fuselage Structure Containing Multiple Cracks," FAA report DOT/FAA/AR-01/46, July 2002.

9. Steadman, D. and Bakuckas, J.G., "Destructive Evaluation and Extended Fatigue Testing of Retired Transport Aircraft, Volume 1: Program Overview," FAA report DOT/FAA/AR-07/22,V1, October 2007.

10. ASTM WK12796 Draft Specification, "Standard Practice for Infrared Flash Thermography of Composite Panels and Repair Patches Used in Aerospace Applications."

11. D.K., Hsu, Barnard, D.J., Peters, J.J., and Dayal, V., "Physical Basis of Tap Test as a Quantitative Imaging Tool for Composite Structures on Aircraft," *Review of Progress in Quantitative NDE*, Vol. 19B, Thompson, D.O. and Chimenti, D.E., eds., *American Institute of Physics*, New York, New York, 2000, pp. 1857-1864.

12. Viz, M.J., Potyondy, D.O., and Zehnder, A.T., Computation of Membrane and Bending Stress-Intensity Factors for Thin, Cracked Plates," *International Journal of Fracture*, Vol. 72, 1995, pp. 21-38.

13. Duong, C., Wang, J.J., and Yu, J., "An Approximate Algorithm Solution for the Elastic Fields in Bonded Patched Sheets," *International Journal of Solids and Structures*, Vol. 38, 2001, pp. 4685-4699.

14. Rose, L.R.F., "An Application of the Inclusion Analogy for Bonded Reinforcements," *International Journal of Solids and Structures*, Vol. 17, 1981, pp. 827-838.

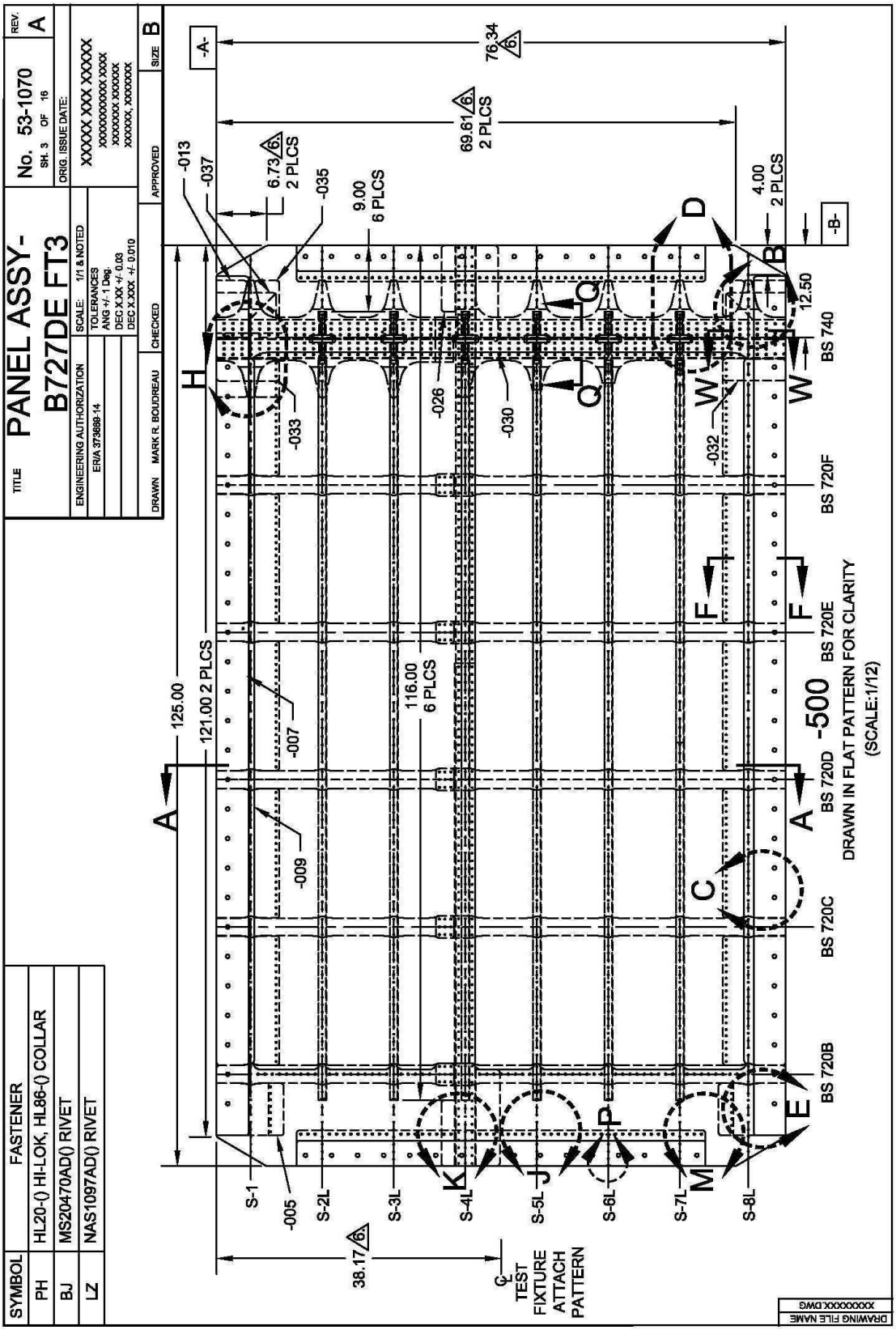
APPENDIX A—PANEL ENGINEERING DRAWINGS

Detailed engineering drawings for the tested panel are presented in this appendix. The panel is cross-referenced in the accompanied engineering drawings numbered 53-1070. The selected panel configurations represent generic fuselage structure from a retired passenger service airplane, a Boeing 727-232 with serial number 20751, line number 1000, and registration number N474DA. The airplane was placed into service in 1974 and retired in 1998. While in service, the airplane accumulated 59,497 flight cycles and 66,412 flight hours and was near its design service goal of 60,000 flight cycles. The airplane was owned and operated exclusively by Delta Air Lines, was well maintained and stored, and had a well-documented and accessible service history. Its use is representative of typical Title 14 Code of Federal Regulations Part 121 revenue service passenger aircraft currently in the domestic fleet.

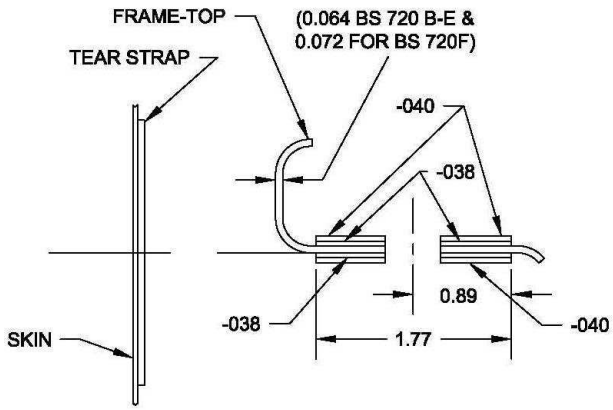
The panel was removed from the crown of the airplane and was 125 inches long by 73 inches wide with a radius of 74 inches. The substructure included six stringers (S), S-2L through S-7L, in the longitudinal direction with 9.5-inch spacing and six frame stations (FS), FS-720D through FS-740 in the hoop direction with 20-inch spacing. The Z-shaped frames, stringer clips, and hat-shaped stringers were 7075-T6 aluminum.

The panel skin was 2024-T3 aluminum varying in thickness from 0.040 inch between FS-720C and FS-720D to 0.080 inch between FS-720F and FS-740. A longitudinal lap joint was located along stringer S-4L and a circumferential butt joint was located along FS-740. The longitudinal lap joint consisted of two skin layers and a 0.02-inch-thick 2024-T3 aluminum doubler layer sandwiched between the two skin layers, which were connected together by three rows of rivets. The doubler was bonded to the outer skin and there was a sealant between the doubler and the inner skin of the lap joint.

The panel was reinforced along the four edges with aluminum doublers. In both longitudinal doublers, 28 half-inch-diameter holes were inserted 4 inches apart. In both hoop doublers, 16 half-inch-diameter holes were inserted 3.5 inches apart. These holes were used to attach the edges of panel to the loading mechanisms of the Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) fixture, which has seven hoop loaders on each side, and four longitudinal loaders on both ends. Each actuator was attached to the panel at four holes using a whiffle tree assembly. The two ends of each frame, where the frame load is applied, were also reinforced with aluminum doublers. An elastomeric seal was bonded along the perimeter of the inner surface of the curved panel to attach to the pressure box of the FASTER fixture.

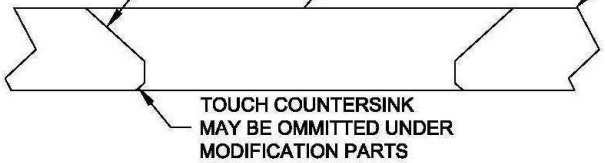

TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 3 OF 16
REV. A
ORIG. ISSUE DATE:
XXXXX XXX XXXXX
XXXXXXXXXX.XXXX
XXXXXXX.XXXXXX
XXXXXX, XXXXXXX
ENGINEERING AUTHORIZATION
ERA 373669-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
SYMBOL
FASTENER
PH HL20-() HI-LOK, HL86-() COLLAR
BJ MS20470AD() RIVET
LZ NAS1097AD() RIVET
-A-
-B-
76.34 6
69.61 6 2 PLCS
6.73 6 2 PLCS
9.00 6 PLCS
4.00 2 PLCS
12.50
125.00
121.00 2 PLCS
116.00 6 PLCS
38.17 6
-013
-037
-035
-033
-026
-030
-032
-007
-009
-005
S-1
S-2L
S-3L
S-4L
S-5L
S-6L
S-7L
S-8L
BS 740
BS 720F
BS 720E
BS 720D
BS 720C
BS 720B
-500
DRAWN IN FLAT PATTERN FOR CLARITY
(SCALE:1/12)
℄ TEST FIXTURE ATTACH PATTERN
DRAWING FILE NAME
XXXXXXXX.DWG

TITLE	PANEL ASSY- B727DE FT3	No. 53-1070 SH. 16 OF 16	REV. A
ENGINEERING AUTHORIZATION	SCALE: 1/1 & NOTED	ORIG. ISSUE DATE:	
ER/A 373869-14	TOLERANCES ANG +/- 1 Deg. DEC X.XX +/- 0.03 DEC X.XXX +/- 0.010	XXXXX XXX XXXXX XXXXXXXXXXX XXXX XXXXXXX XXXXXX XXXXXX, XXXXXXX	
DRAWN MARK R. BOUDREAU	CHECKED	APPROVED	SIZE B



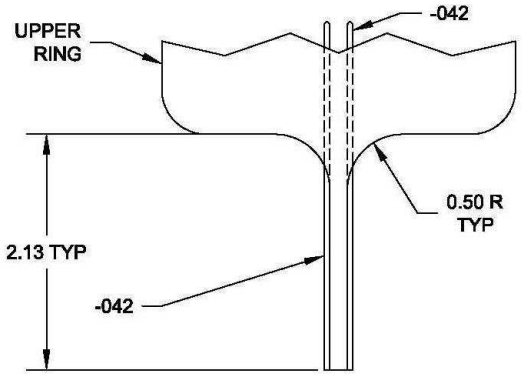
SECTION S-S

TYPICAL SECTION FOR FRAMES AT BS 720B - BS 720E
LEFT HAND SHOWN, RIGHT HAND OPPOSITE



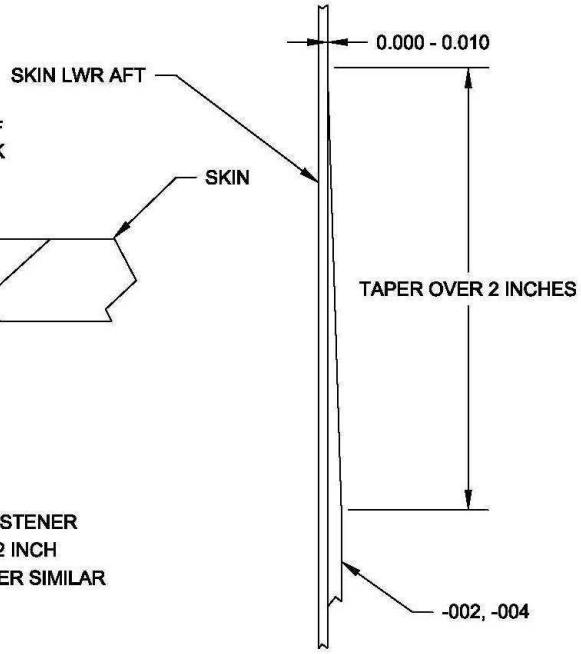
SECTION V-V

TYPICAL SECTION FOR ALL PLUGGED FASTENER
LOCATIONS AT EXISTING SPLICES, 8/32 INCH
DIAMETER SHOWN 6/32 & 5/32 INCH DIAMETER SIMILAR
(SCALE: 10/1)



SECTION Y-Y (A)

TYPICAL BS 740 FRAME RIENFORCEMENT AND MODIFICATION
LEFT HAND SHOWN RIGHT HAND OPPOSITE



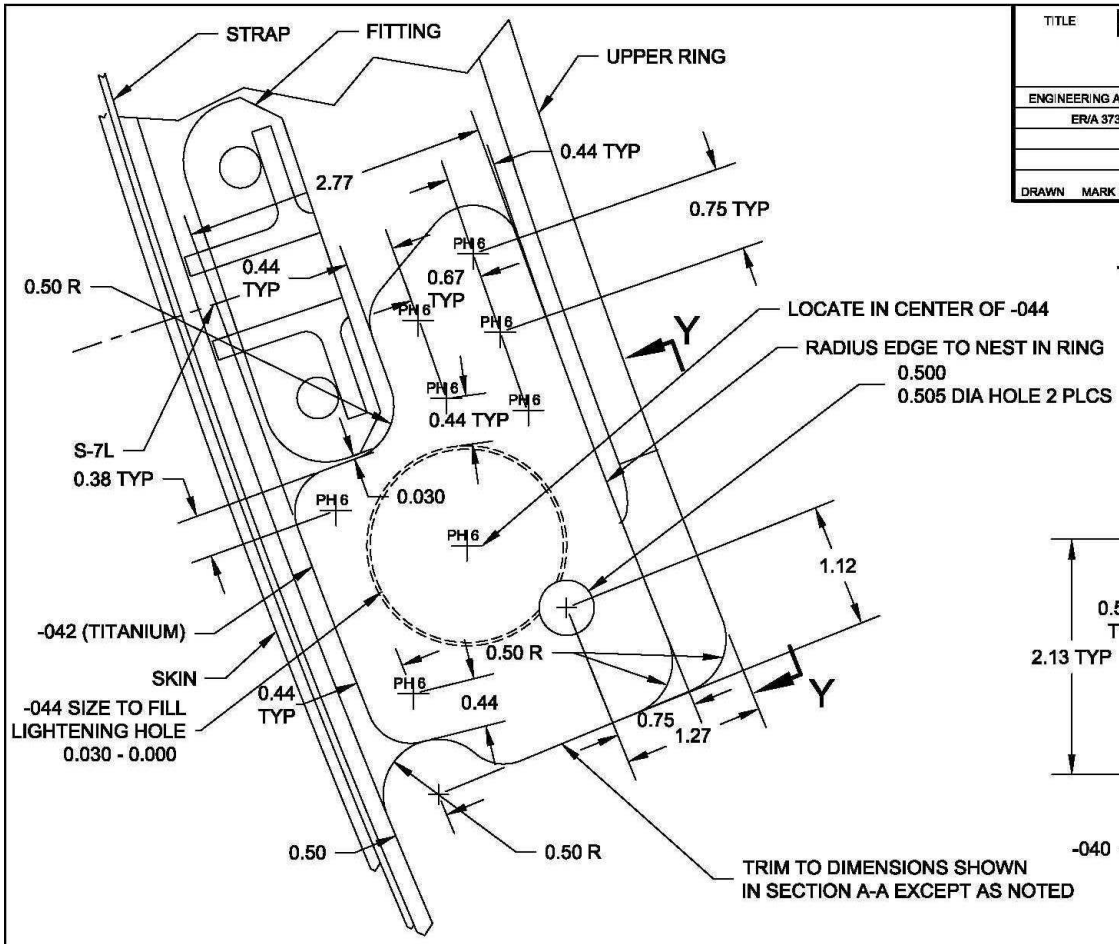
SECTION U-U

TYPICAL SECTION FOR -004 & -005
(SCALE: 2/1)

DRAWING FILE NAME	XXXXXXX.DWG

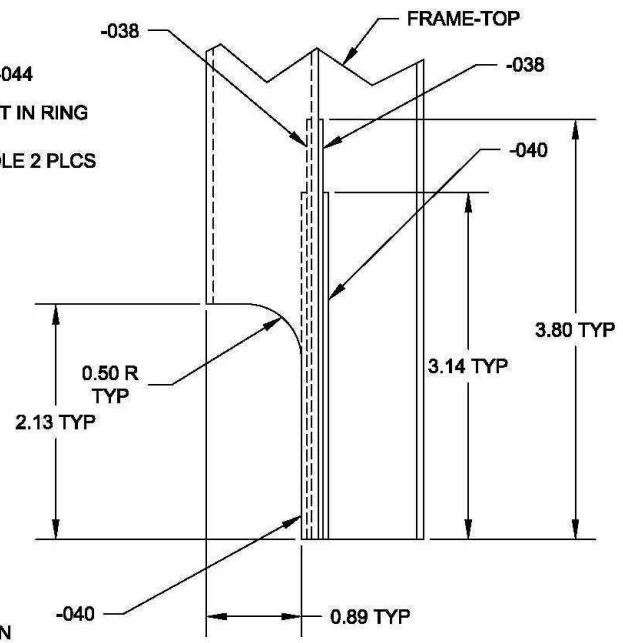
REV. & DATE	CHANGE DESCRIPTION	EA AFFECTED	DWN.	CK'D	APPR.

TITLE	PANEL ASSY- B727DE FT3	No. 53-1070 SH. 15 OF 16	REV. A
ENGINEERING AUTHORIZATION	SCALE: 1/1 & NOTED	ORIG. ISSUE DATE:	
ER/A 373669-14	TOLERANCES ANG +/- 1 Deg. DEC X.XX +/- 0.03 DEC X.XXX +/- 0.010	XXXXX XXX XXXXX XXXXXXXXXXX XXXX XXXXXXX XXXXXX XXXXXX, XXXXXXX	
DRAWN MARK R. BOUDREAU	CHECKED	APPROVED	SIZE B



SECTION W-W (A)

TYPICAL BS 740 FRAME RIENFORCEMENT AND FIXTURE ATTACHMENT
LEFT HAND SHOWN RIGHT HAND OPPOSITE



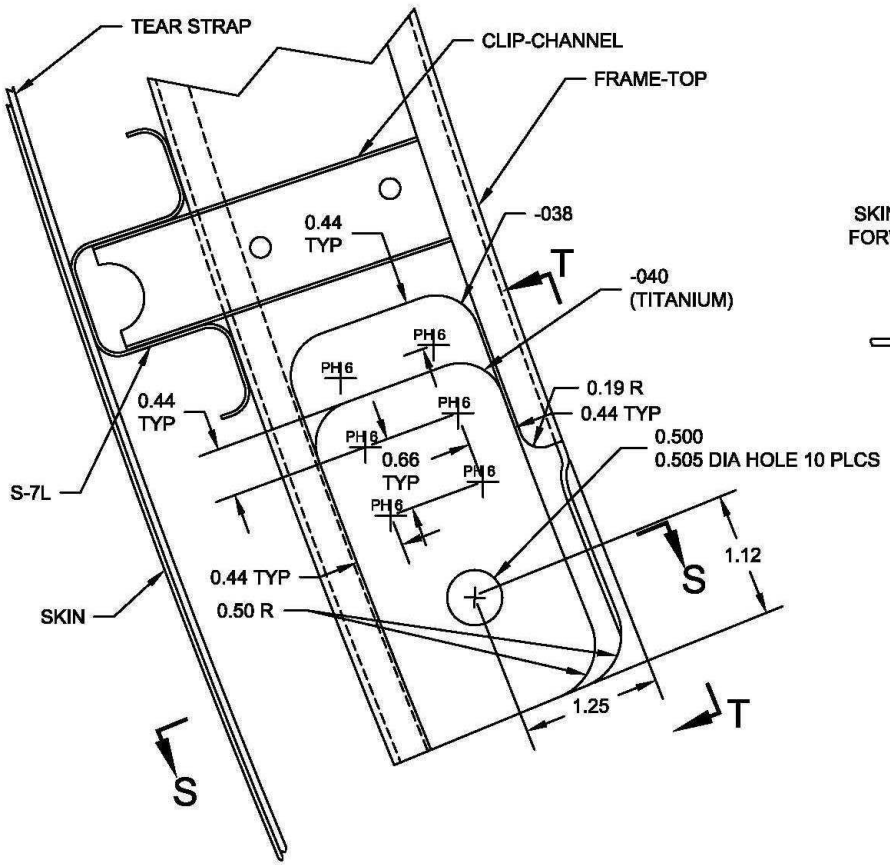
SECTION T-T (A)

TYPICAL SECTION FOR FRAMES AT BS 720B - BS 720E
LEFT HAND SHOWN, RIGHT HAND OPPOSITE

DRAWING FILE NAME XXXXXXXX.DWG

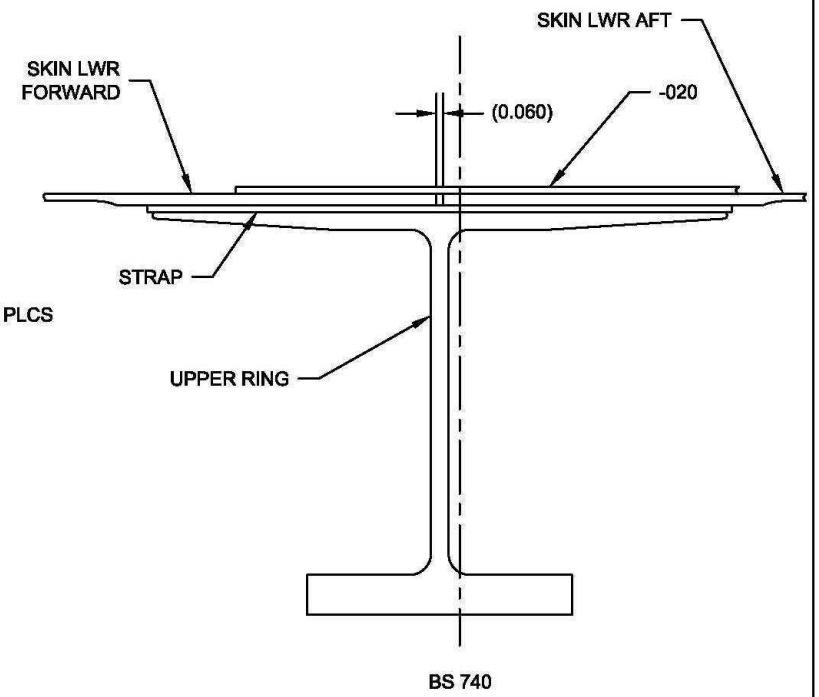
REV. & DATE	CHANGE DESCRIPTION	EA AFFECTED	DWN.	CK'D	APPR.

TITLE	PANEL ASSY- B727DE FT3	No. 53-1070 SH. 14 OF 16	REV. A
ENGINEERING AUTHORIZATION	SCALE: 1/1 & NOTED	ORIG. ISSUE DATE:	
ER/A 373669-14	TOLERANCES ANG +/- 1 Deg. DEC X.XX +/- 0.03 DEC X.XXX +/- 0.010	XXXXX XXX XXXXX XXXXXXXXXXX XXXX XXXXXXX XXXXXX XXXXXX, XXXXXXX	
DRAWN MARK R. BOUDREAU	CHECKED	APPROVED	SIZE B



VIEW R Ⓐ

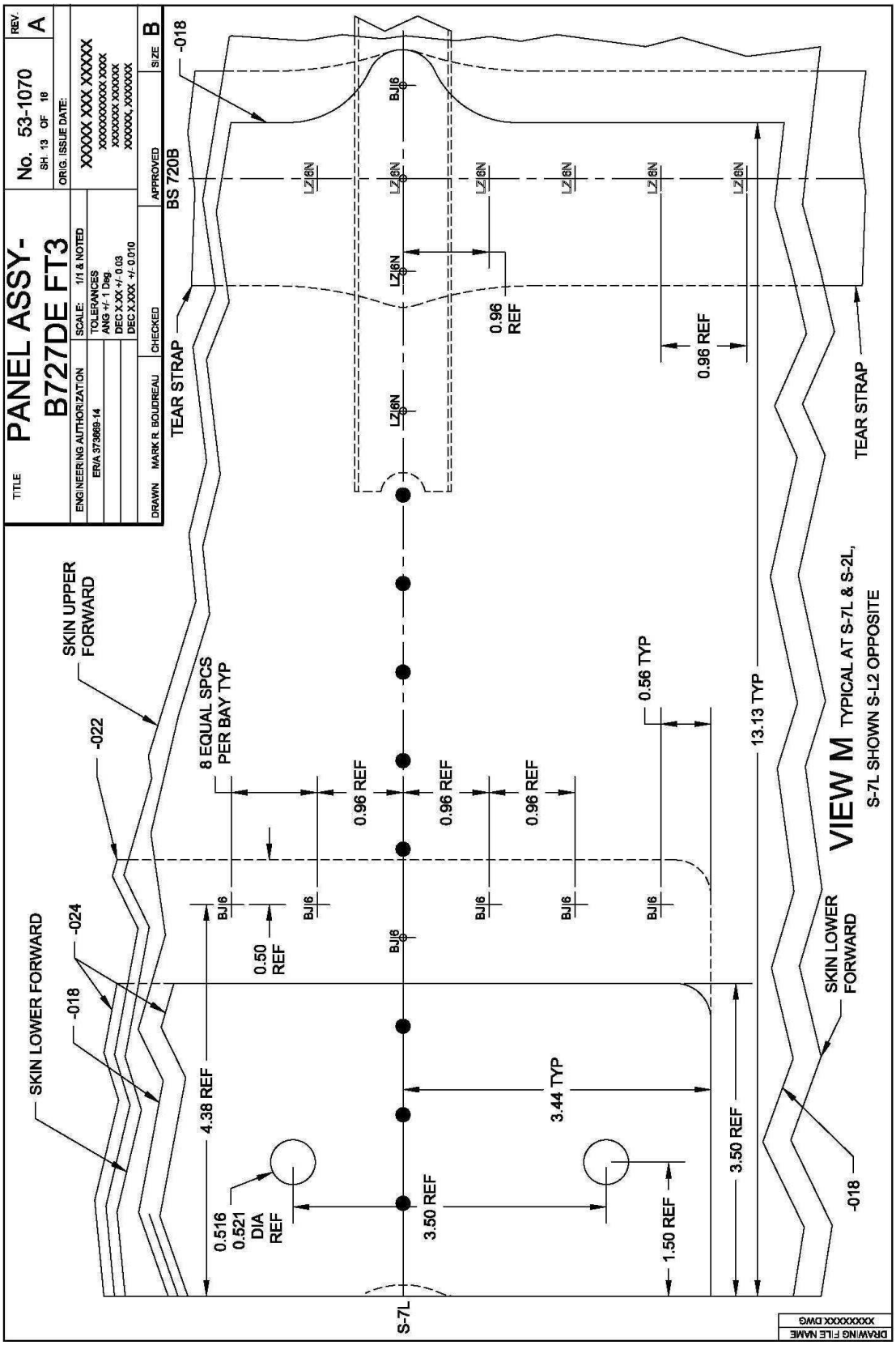
TYPICAL BS 720B - 720E FRAME RIENFORCEMENT AND FIXTURE ATTACHMENT
LEFT HAND SHOWN RIGHT HAND OPPOSITE

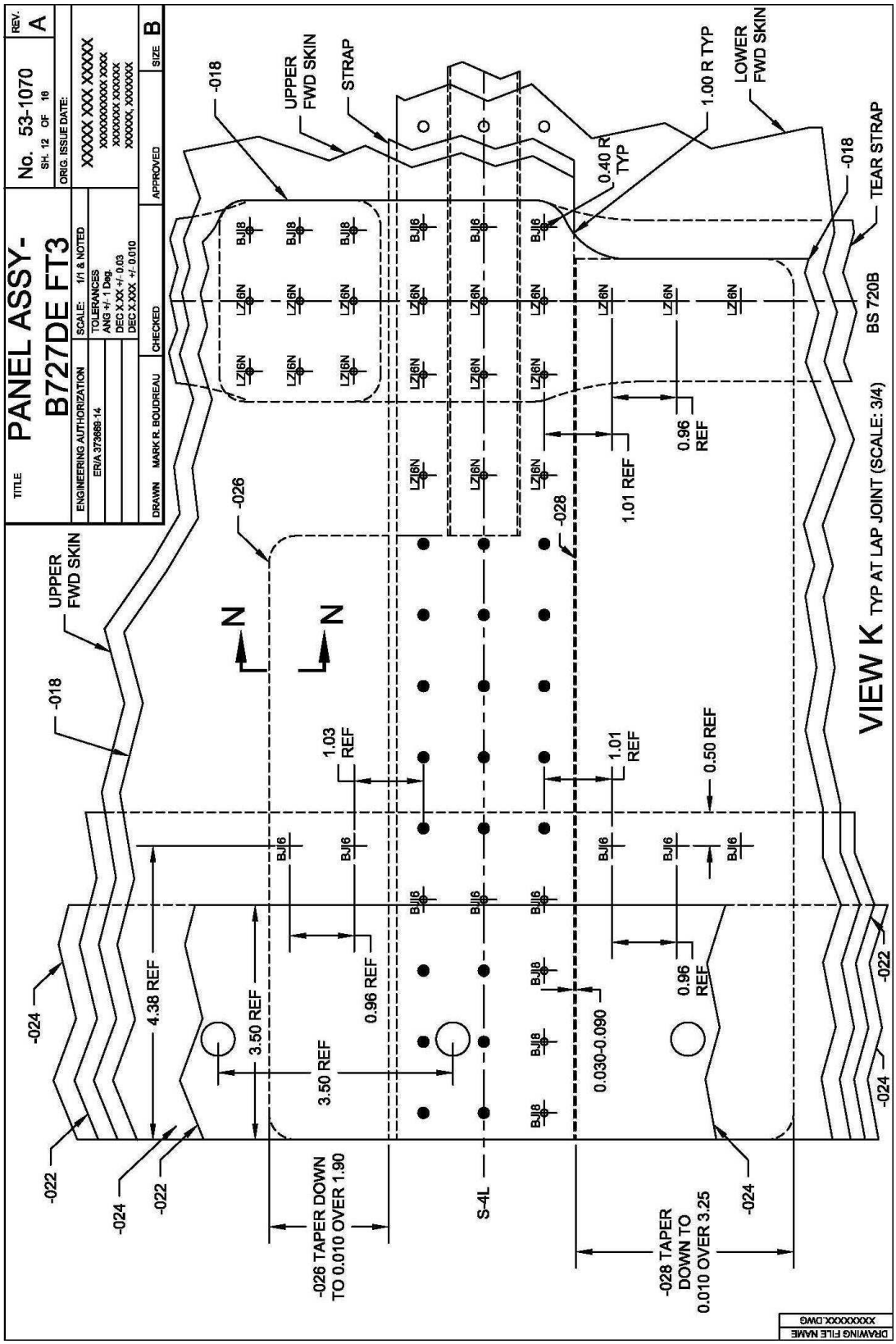


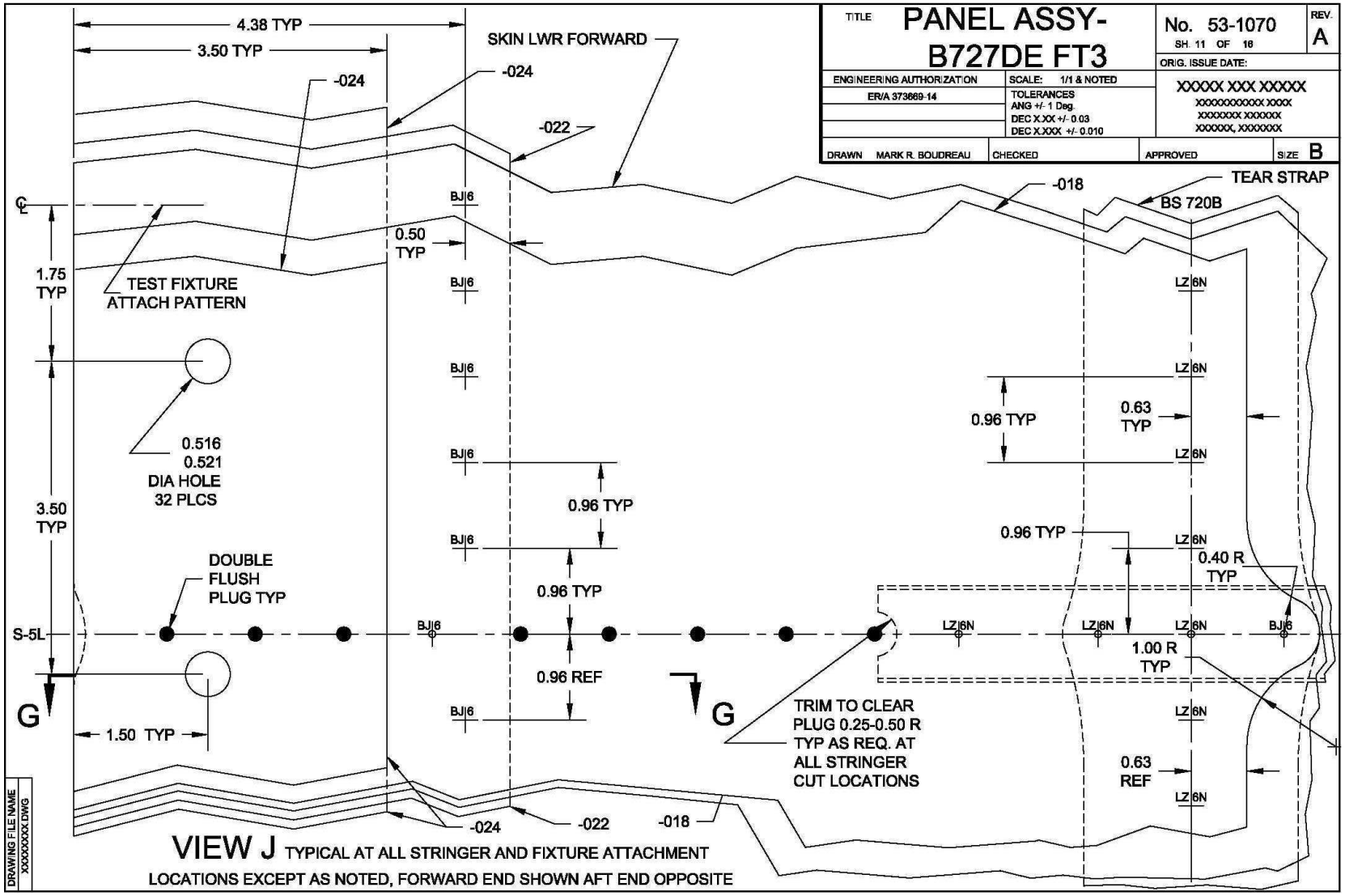
SECTION Q-Q

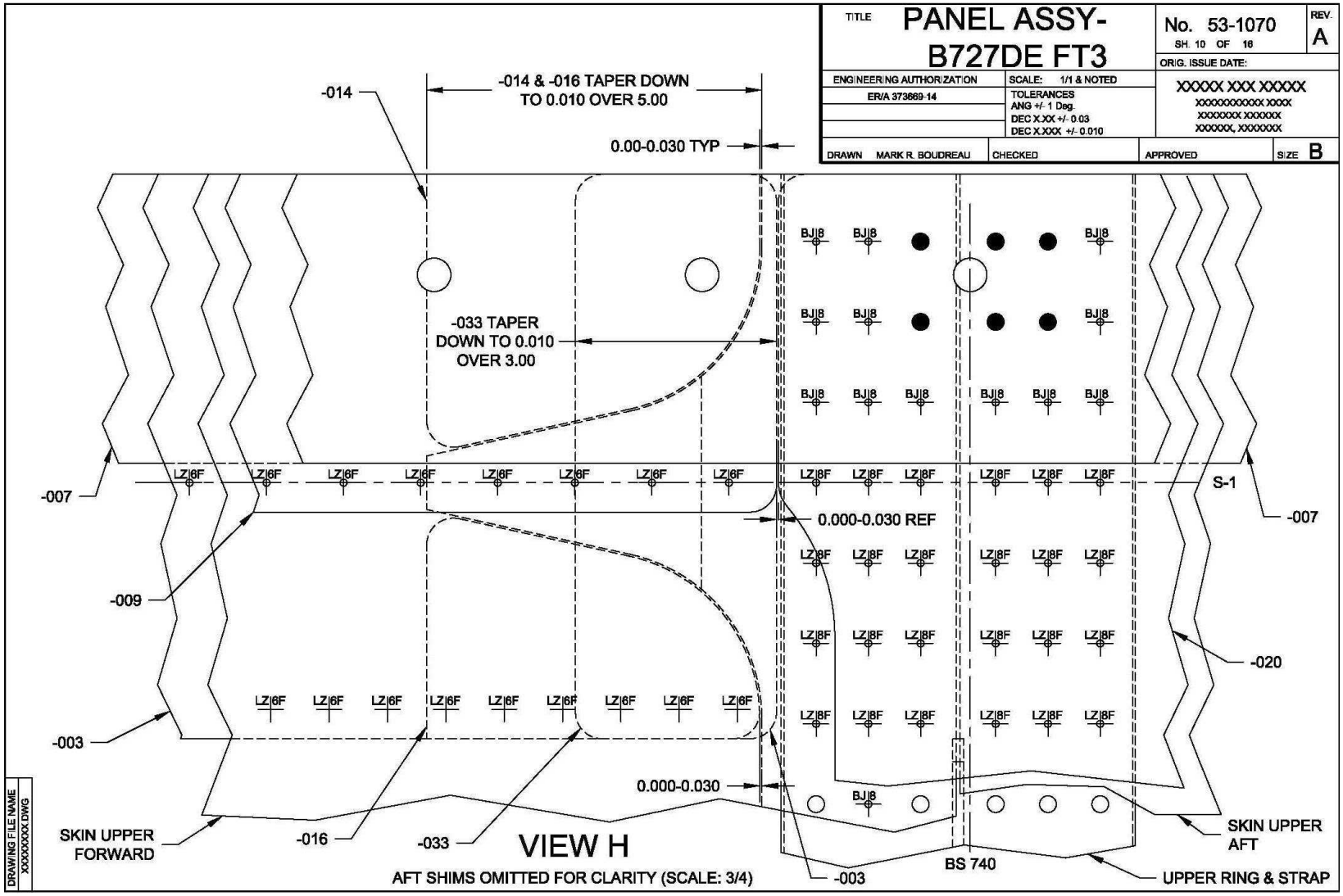
TYPICAL SECTION FOR BS 740 BUTT SPLICE

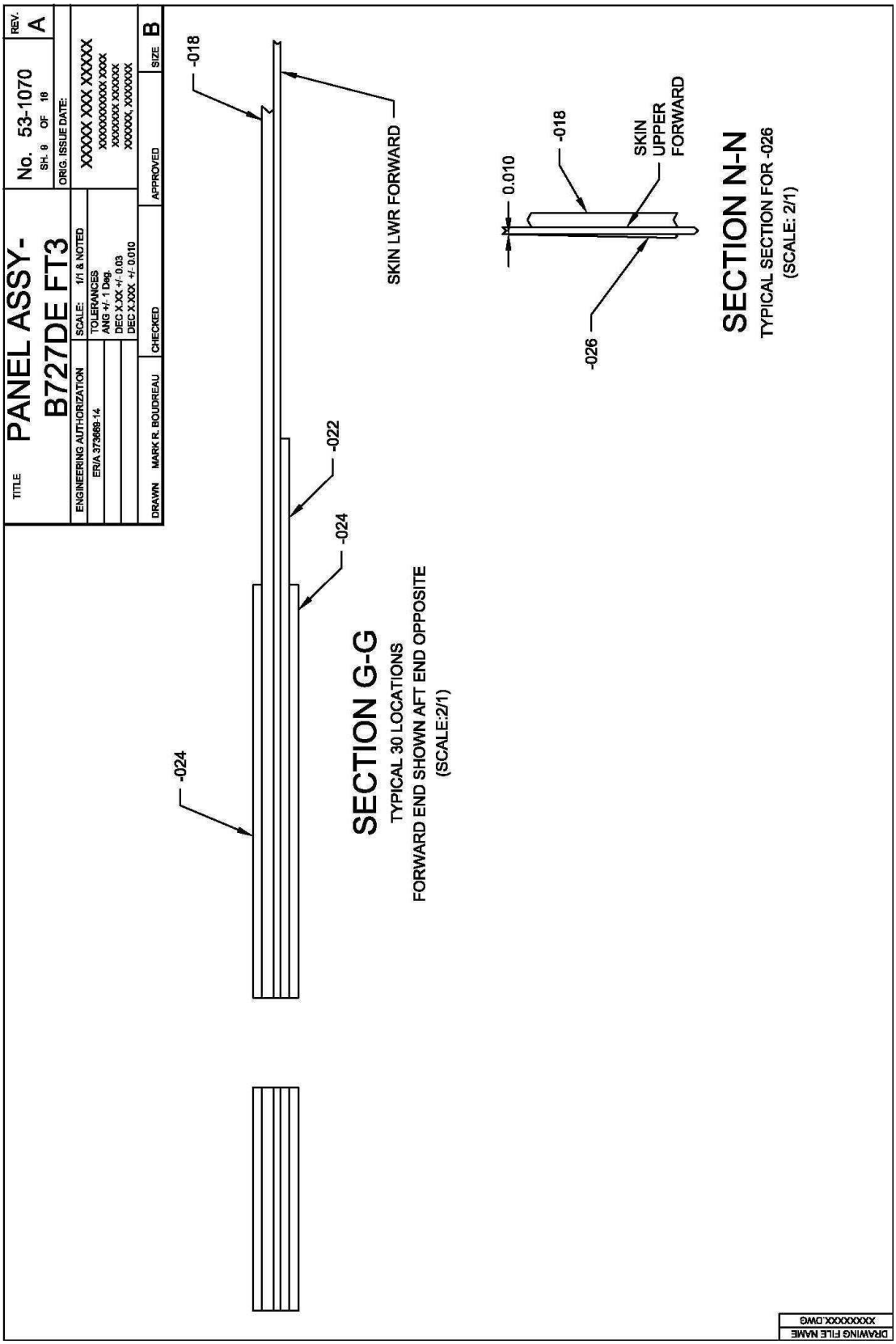
DRAWING FILE NAME XXXXXXXX.DWG


TITLE PANEL ASSY-
B727DE FT3
No. 53-1070
SH 13 OF 18
REV. A
ORIG. ISSUE DATE:
XXXXX XXX XXXXX
XXXXXXXXXXX XXXXX
XXXXXXX XXXXXXX
XXXXXX, XXXXXXX
ENGINEERING AUTHORIZATION
ER/A 373869-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
-018
BS 720B
TEAR STRAP
LZ6N
BJ6
0.96 REF
0.96 REF
TEAR STRAP
SKIN UPPER FORWARD
-022
8 EQUAL SPCS PER BAY TYP
0.96 REF
0.96 REF
0.96 REF
0.56 TYP
13.13 TYP
VIEW M TYPICAL AT S-7L & S-2L,
S-7L SHOWN S-L2 OPPOSITE
SKIN LOWER FORWARD
-024
-018
0.50 REF
SKIN LOWER FORWARD
4.38 REF
3.44 TYP
3.50 REF
0.516
0.521
DIA
REF
3.50 REF
1.50 REF
-018
S-7L
DRAWING FILE NAME
XXXXXXXX DWG

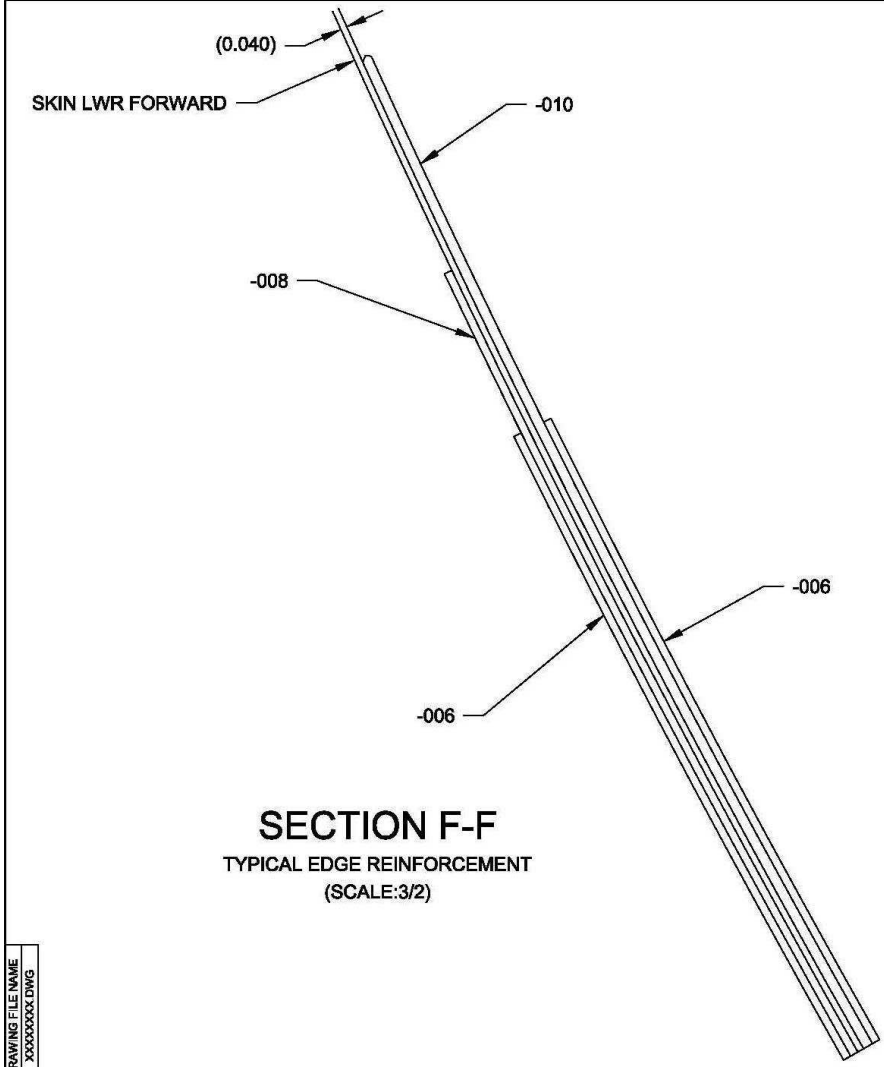

TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH: 12 OF 18
REV. A
ORIG. ISSUE DATE:
XXXXX XXX XXXXX
ENGINEERING AUTHORIZATION
ER/A 373669-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
DRAWING FILE NAME
XXXXXXXX.DWG
VIEW K TYP AT LAP JOINT (SCALE: 3/4)
UPPER FWD SKIN
STRAP
LOWER FWD SKIN
TEAR STRAP
BS 720B
1.00 R TYP
0.40 R TYP
-018
-022
-024
-026
-028
N
N
1.03 REF
1.01 REF
0.96 REF
0.50 REF
4.38 REF
3.50 REF
0.030-0.090
S-4L
-026 TAPER DOWN TO 0.010 OVER 1.90
-028 TAPER DOWN TO 0.010 OVER 3.25


TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 11 OF 16
REV.
A
ORIG. ISSUE DATE:
ENGINEERING AUTHORIZATION
ER/A 373669-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
XXXXX XXX XXXXX
XXXXXXXXXXX XXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
4.38 TYP
3.50 TYP
SKIN LWR FORWARD
-024
-024
-022
-018
TEAR STRAP
BS 720B
BJ6
LZ6N
0.50
TYP
1.75
TYP
TEST FIXTURE
ATTACH PATTERN
0.516
0.521
DIA HOLE
32 PLCS
3.50
TYP
0.96 TYP
0.63
TYP
0.96 TYP
0.96 TYP
0.40 R
TYP
DOUBLE
FLUSH
PLUG TYP
S-5L
0.96 REF
1.00 R
TYP
G
G
1.50 TYP
TRIM TO CLEAR
PLUG 0.25-0.50 R
TYP AS REQ. AT
ALL STRINGER
CUT LOCATIONS
0.63
REF
DRAWING FILE NAME
XXXXXXX.DWG
VIEW J TYPICAL AT ALL STRINGER AND FIXTURE ATTACHMENT
LOCATIONS EXCEPT AS NOTED, FORWARD END SHOWN AFT END OPPOSITE


TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 10 OF 16
REV.
A
ORIG. ISSUE DATE:
ENGINEERING AUTHORIZATION
ER/A 373669-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
XXXXX XXX XXXXX
XXXXXXXXXX XXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
-014
-014 & -016 TAPER DOWN
TO 0.010 OVER 5.00
0.00-0.030 TYP
-033 TAPER
DOWN TO 0.010
OVER 3.00
BJ|8
LZ|6F
LZ|8F
-007
-009
-003
S-1
-007
0.000-0.030 REF
-020
0.000-0.030
SKIN UPPER
FORWARD
-016
-033
VIEW H
AFT SHIMS OMITTED FOR CLARITY (SCALE: 3/4)
-003
BS 740
SKIN UPPER
AFT
UPPER RING & STRAP
DRAWING FILE NAME
XXXXXXX.DWG


TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 9 OF 18
REV. A
ORIG. ISSUE DATE:
XXXXX XXX XXXXX
XXXXXXXXXXX XXXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX
ENGINEERING AUTHORIZATION
ERA 373688-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
-018
SKIN LWR FORWARD
-022
-024
-024
SECTION G-G
TYPICAL 30 LOCATIONS
FORWARD END SHOWN AFT END OPPOSITE
(SCALE:2/1)
0.010
-018
SKIN
UPPER
FORWARD
-026
SECTION N-N
TYPICAL SECTION FOR -026
(SCALE: 2/1)
DRAWING FILE NAME
XXXXXXXX.DWG

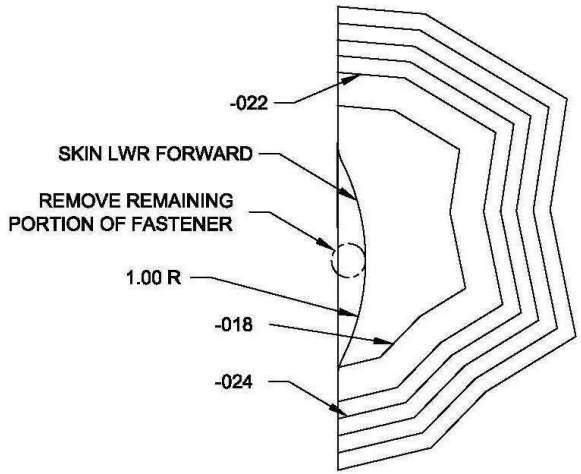
TITLE PANEL ASSY-B727DE FT3		No. 53-1070 SH. 8 OF 16	REV. A
ENGINEERING AUTHORIZATION	SCALE: 1/1 & NOTED	ORIG. ISSUE DATE:	
ER/A 373669-14	TOLERANCES ANG +/- 1 Deg. DEC X.XX +/- 0.03 DEC X.XXX +/- 0.010	XXXXX XXX XXXXX XXXXXXXXXXX XXXX XXXXXXX XXXXXX XXXXXX, XXXXXXX	
DRAWN MARK R. BOUDREAU	CHECKED	APPROVED	SIZE B



SECTION F-F

TYPICAL EDGE REINFORCEMENT

(SCALE:3/2)

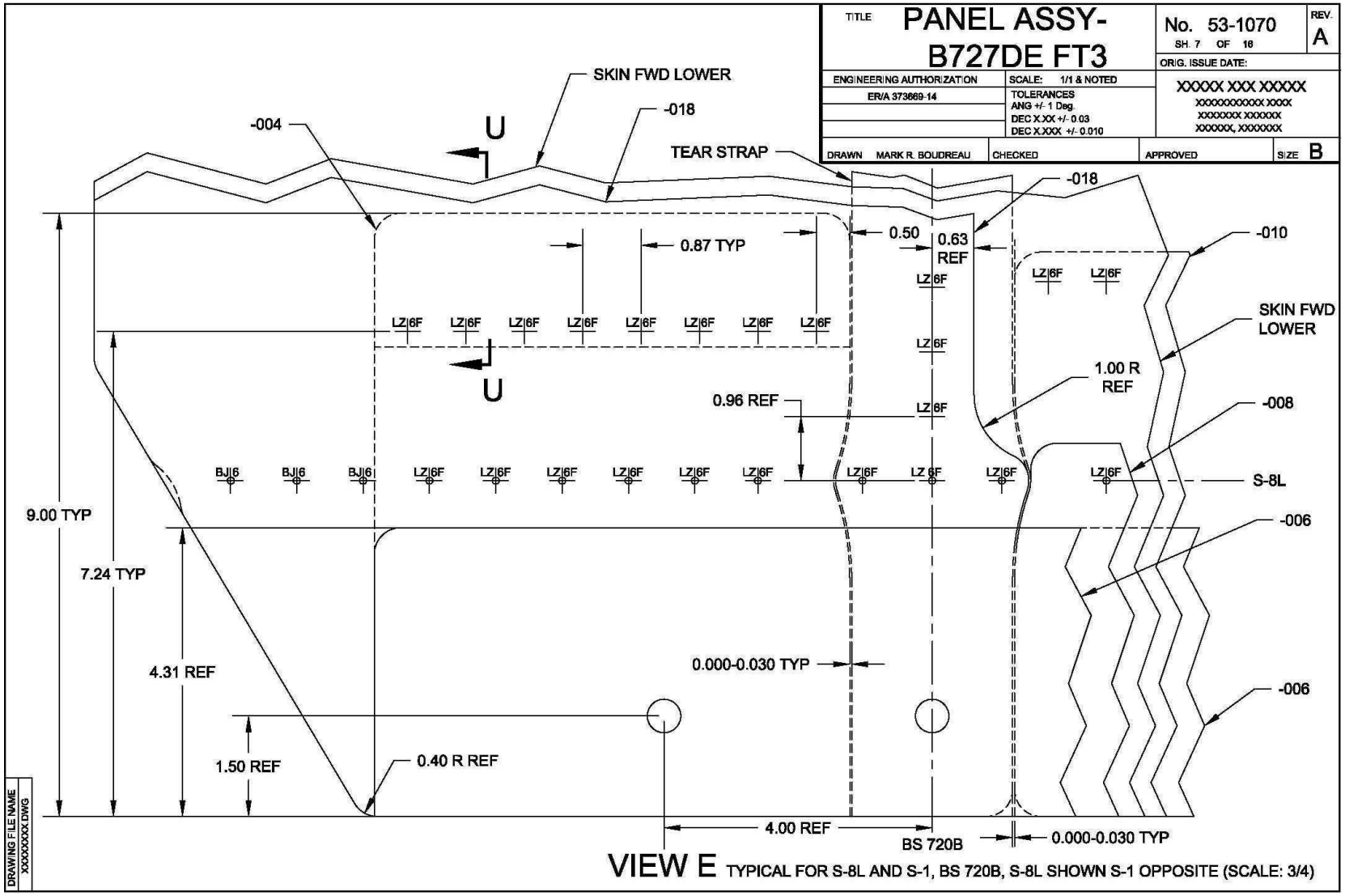


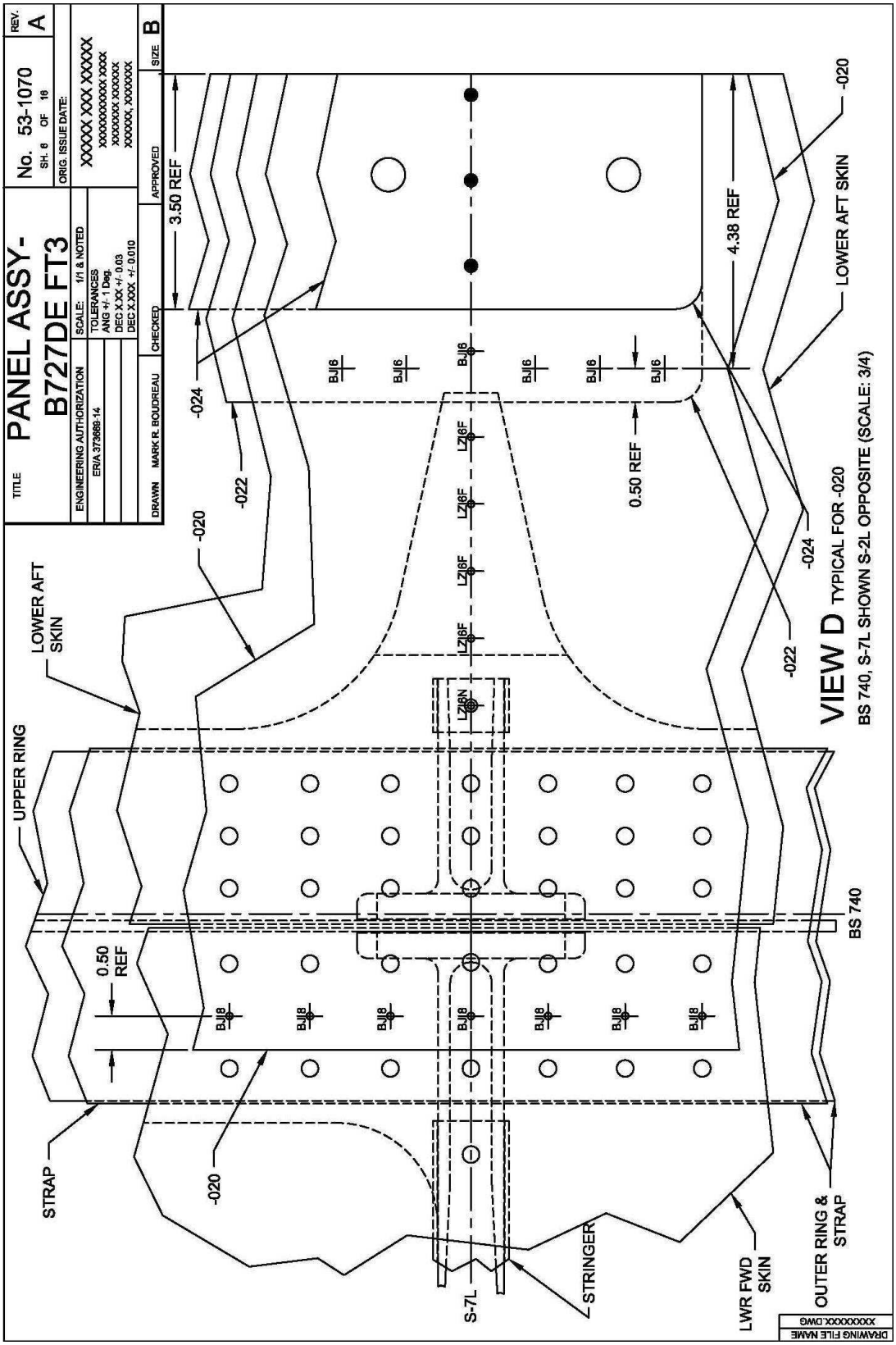
VIEW P

TYPICAL EXISTING FASTENER LOCATIONS THAT FALL ON THE EDGE OF THE PANEL CUT

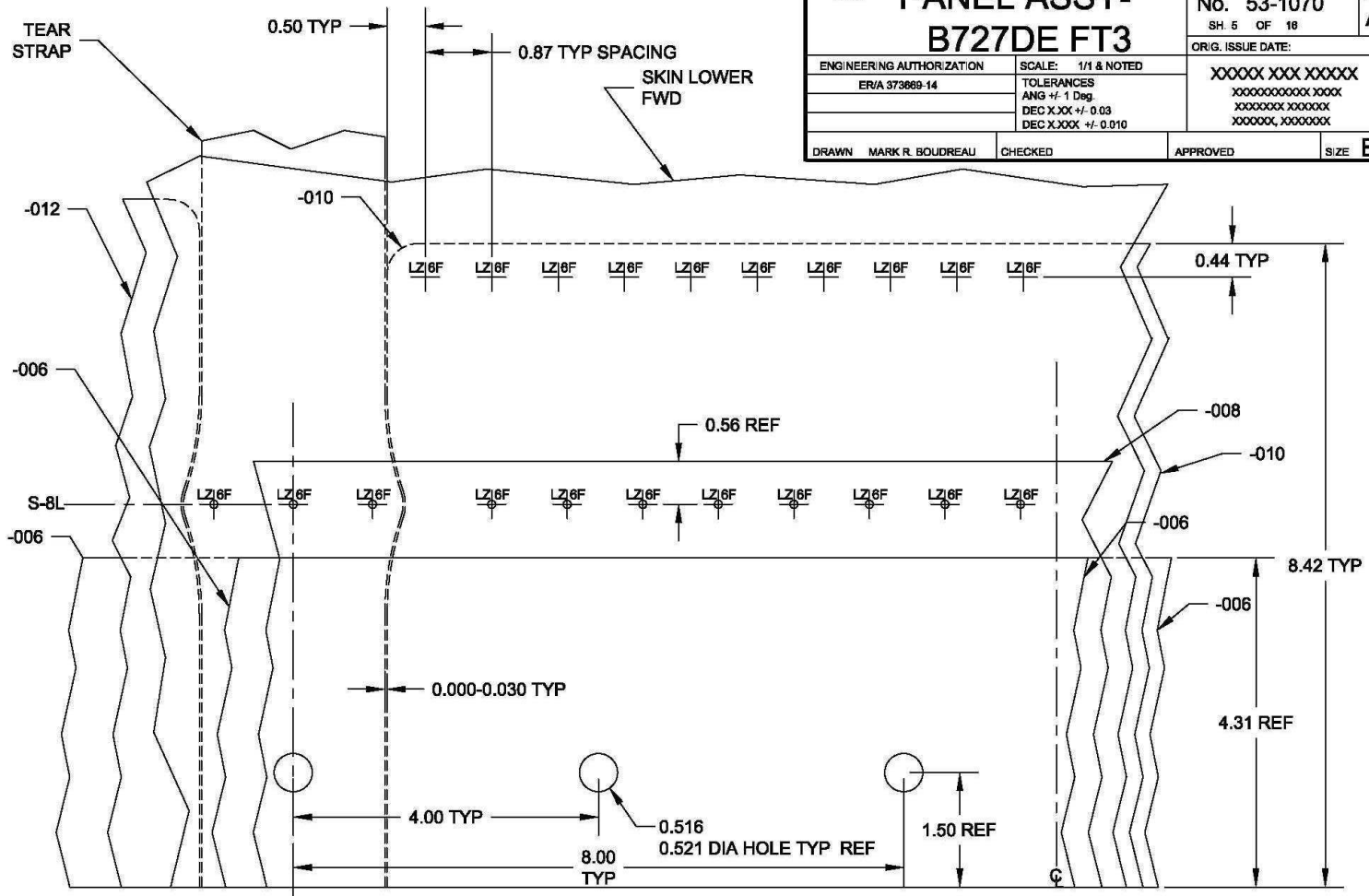
(SCALE: 2/1)

DRAWING FILE NAME XXXXXXXX.DWG


TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 7 OF 16
REV.
A
ORIG. ISSUE DATE:
ENGINEERING AUTHORIZATION
ER/A 373669-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
XXXXX XXX XXXXX
XXXXXXXXXXX XXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
SKIN FWD LOWER
-018
-004
U
TEAR STRAP
-018
0.87 TYP
0.50
0.63
REF
-010
LZ 6F
SKIN FWD
LOWER
1.00 R
REF
0.96 REF
-008
BJ 6
S-8L
9.00 TYP
-006
7.24 TYP
4.31 REF
0.000-0.030 TYP
-006
1.50 REF
0.40 R REF
4.00 REF
BS 720B
0.000-0.030 TYP
DRAWING FILE NAME
XXXXXXX DWG
VIEW E TYPICAL FOR S-8L AND S-1, BS 720B, S-8L SHOWN S-1 OPPOSITE (SCALE: 3/4)


TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 6 OF 16
REV. A
ORIG. ISSUE DATE:
XXXXX XXX XXXXX
XXXXXXXXXXX XXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX
ENGINEERING AUTHORIZATION
ER/A 373668-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
3.50 REF
4.38 REF
0.50 REF
0.50 REF
-020
-022
-024
LOWER AFT SKIN
UPPER RING
STRAP
S-7L
STRINGER
LWR FWD SKIN
OUTER RING & STRAP
BS 740
BJ8
BJ6
LZ6F
LZ6N
VIEW D TYPICAL FOR -020
BS 740, S-7L SHOWN S-2L OPPOSITE (SCALE: 3/4)
DRAWING FILE NAME
XXXXXXXX.DWG

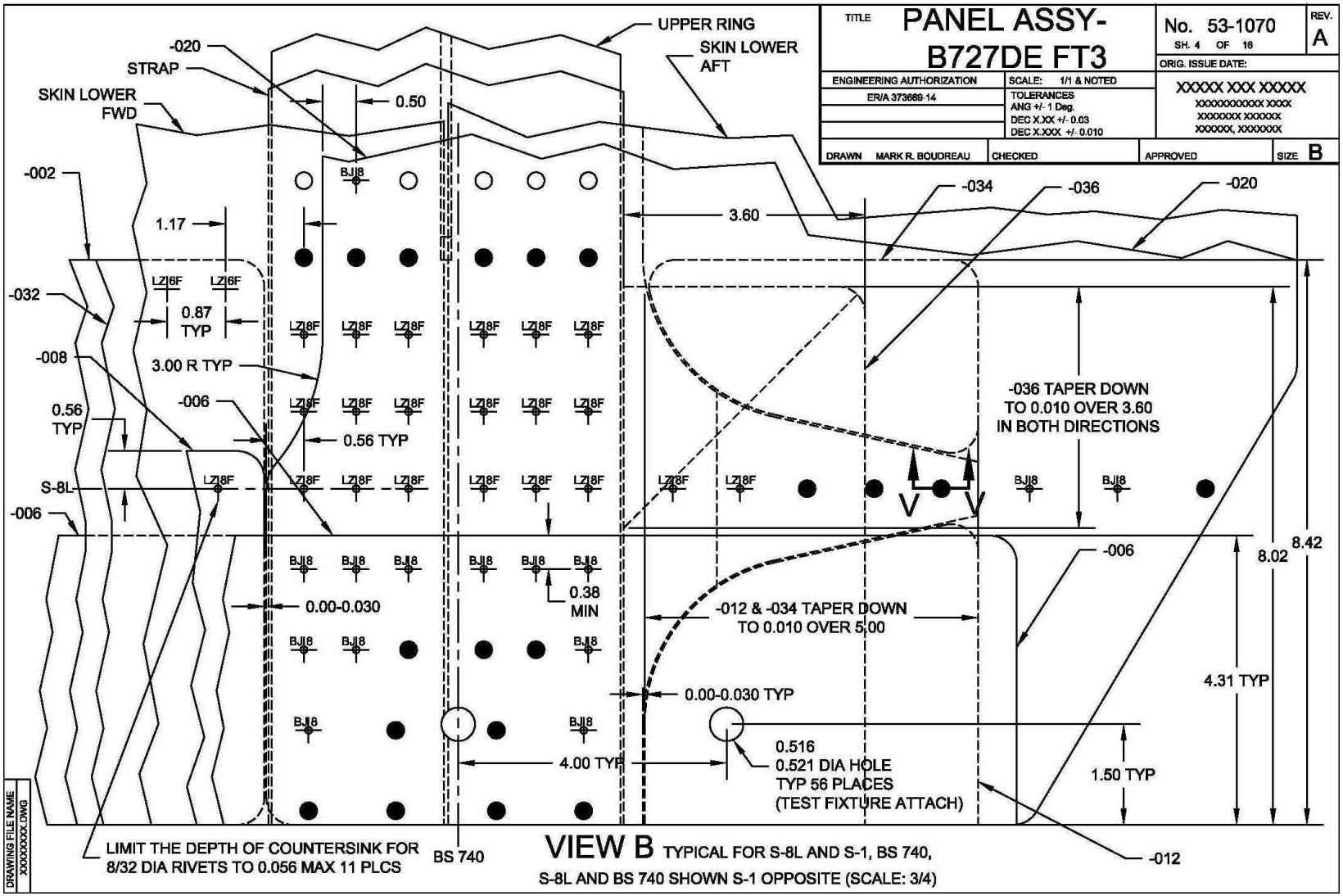
TITLE	PANEL ASSY- B727DE FT3	No. 53-1070 SH. 5 OF 16	REV. A
ENGINEERING AUTHORIZATION	SCALE: 1/1 & NOTED	ORIG. ISSUE DATE:	
ER/A 373669-14	TOLERANCES ANG +/- 1 Deg. DEC X.XX +/- 0.03 DEC X.XXX +/- 0.010	XXXXX XXX XXXXX XXXXXXXXXXX XXXX XXXXXXX XXXXXX XXXXXX, XXXXXXX	
DRAWN MARK R. BOUDREAU	CHECKED	APPROVED	SIZE B



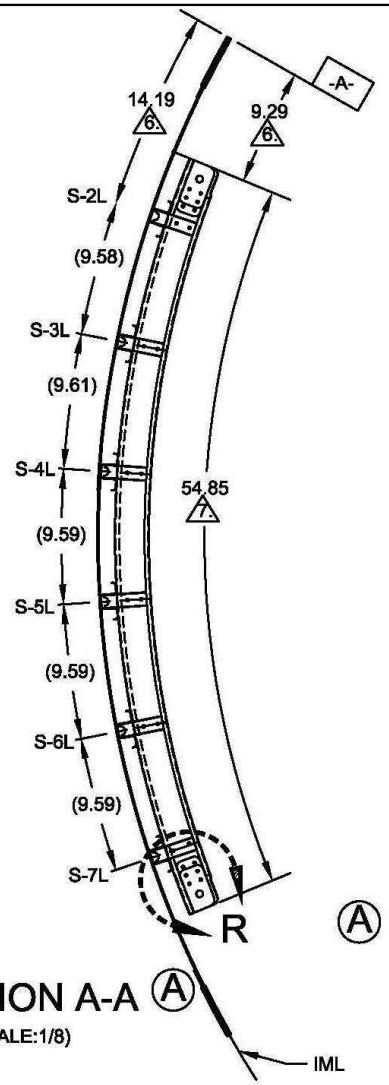
BS 720C **VIEW C** TYPICAL FOR S-8L AND S-1, BS 720B-720F+10, S-8L AND BS 720C SHOWN, S-1 OPPOSITE (SCALE: 3/4)

SYMMETRIC ABOUT BAY CENTERLINE EXCEPT AS NOTED

DRAWING FILE NAME XXXXXXXX.DWG


TITLE
PANEL ASSY-
B727DE FT3
No. 53-1070
SH. 4 OF 16
REV.
A
ORIG. ISSUE DATE:
ENGINEERING AUTHORIZATION
ER/A 373669-14
SCALE: 1/1 & NOTED
TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010
XXXXX XXX XXXXX
XXXXXXXXXX XXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX
DRAWN MARK R. BOUDREAU
CHECKED
APPROVED
SIZE B
UPPER RING
SKIN LOWER AFT
-020
STRAP
SKIN LOWER FWD
0.50
-002
1.17
3.60
-034
-036
-020
-032
0.87 TYP
3.00 R TYP
-008
-006
0.56 TYP
0.56 TYP
S-8L
-006
-036 TAPER DOWN TO 0.010 OVER 3.60 IN BOTH DIRECTIONS
V
V
-006
8.02
8.42
0.38 MIN
0.00-0.030
-012 & -034 TAPER DOWN TO 0.010 OVER 5.00
4.31 TYP
0.00-0.030 TYP
0.516
0.521 DIA HOLE
TYP 56 PLACES
(TEST FIXTURE ATTACH)
4.00 TYP
1.50 TYP
-012
LIMIT THE DEPTH OF COUNTERSINK FOR 8/32 DIA RIVETS TO 0.056 MAX 11 PLCS
BS 740
VIEW B TYPICAL FOR S-8L AND S-1, BS 740,
S-8L AND BS 740 SHOWN S-1 OPPOSITE (SCALE: 3/4)
DRAWING FILE NAME
XXXXXXX.DWG

TITLE	PANEL ASSY-B727DE FT3	No. 53-1070 SH. 2 OF 16	REV. A
ENGINEERING AUTHORIZATION	SCALE: 1/1 & NOTED	ORIG. ISSUE DATE:	
ER/A 373669-14	TOLERANCES ANG +/- 1 Deg. DEC X.XX +/- 0.03 DEC X.XXX +/- 0.010	XXXXX XXX XXXXX XXXXXXXXXX XXXX XXXXXXX XXXXXX XXXXXX, XXXXXXX	
DRAWN MARK R. BOUDREAU	CHECKED	APPROVED	SIZE B



SECTION A-A (A)

(SCALE:1/8)

NOTES (CONTINUED):

6. NOTED DIMENSION IS IN PLANE OF THE IML.

7. NOTED DIMENSION IS IN PLANE OF INNER CHORD INNER SURFACE OF THE FUSELAGE FRAME.

8. 2024-T3 CLAD SHEET, QQ-A-250/5.

9. ALL FASTENERS ARE TO BE INSTALLED PER B727 SRM CHAPTER 51-30-2.

10. DIMENSION WITHIN PARENTHESIS ARE FOR EXISTING BOEING MANUFACTURED PARTS WHICH ARE PART OF THE FT3 PANEL.

11. ALL OUTSIDE RADII TO BE 0.40 INCHES EXCEPT AS NOTED.

12. ● DOUBLE FLUSH PLUG IN EXISTING STACKUP (SKIN, TEAR STRAP, SPLICE AND SPLICE DOUBLER) ONLY USING 1/32 OVERSIZE AD, D OR DD RIVET MATERIAL AND A TOUCH COUNTERSINK OF 0.005 - 0.015 INCHES IN DEPTH. MICROSHAVE FLUSH ON BOTH SURFACES.

13. ○ REFERENCE FASTENER LOCATIONS.

14. INSTALL CONICAL FILLERS AT ALL EXISTING COUNTERSINK LOCATIONS

15. APPLY CHEMICAL FILM TREATMENT TO ALL BARE ALUMINUM SURFACES PER P.S. 900-2-4-1, NO. 02.

16. ALL MODIFICATION PARTS ARE TO BE BONDED INTO PLACE USING EC2216B/A TWO PART EPOXY ADHESIVE PER P.S. 900-7-1-1, NO. 03.

17. AFTER ADHESIVE HAS CURED FOR A MINIMUM OF 48 HOURS, APPLY ONE COAT OF F.R. PRIMER (10-P4-3, YELLOW) TO ALL MODIFICATION PARTS AND CUT EDGES.

18. TI-6AL-4V SHEET, MIL-T9046E, TYP III, COMP C.

DRAWING FILE NAME XXXXXXXX.DWG

USED ON	DASH NUMBER
	-500

TITLE: PANEL ASSY-B727DE FT3

No. 53-1070 SH. 1 OF 16

REV. A

ORIG. ISSUE DATE:

ENGINEERING AUTHORIZATION: ER/A 373669-14

SCALE: 1/1 & NOTED

TOLERANCES
ANG +/- 1 Deg.
DEC X.XX +/- 0.03
DEC X.XXX +/- 0.010

XXXXX XXX XXXXX
XXXXXXXXXXX XXXX
XXXXXXX XXXXXX
XXXXXX, XXXXXXX

DRAWN: MARK R. BOUDREAU | CHECKED | APPROVED | SIZE B

	QTY.	ITEM	PART NUMBER	KEYWORD	SUPERSEDES	MATERIAL	STATUS
	1		-036	SHIM		0.125 X 4 X 9/8.	FS
	1		-037	SHIM		0.125 X 4 X 9/8.	FS
	22		-038	DOUBLER		0.040 X 2 X 5/8.	FS
	22		-040	DOUBLER		0.050 X 2 X 4 /18.	FS
A	4		-042	DOUBLER		0.050 X 2 X 5 /18.	FS
	2		-044	FILLER		0.160 X 2 X 2/8.	FS

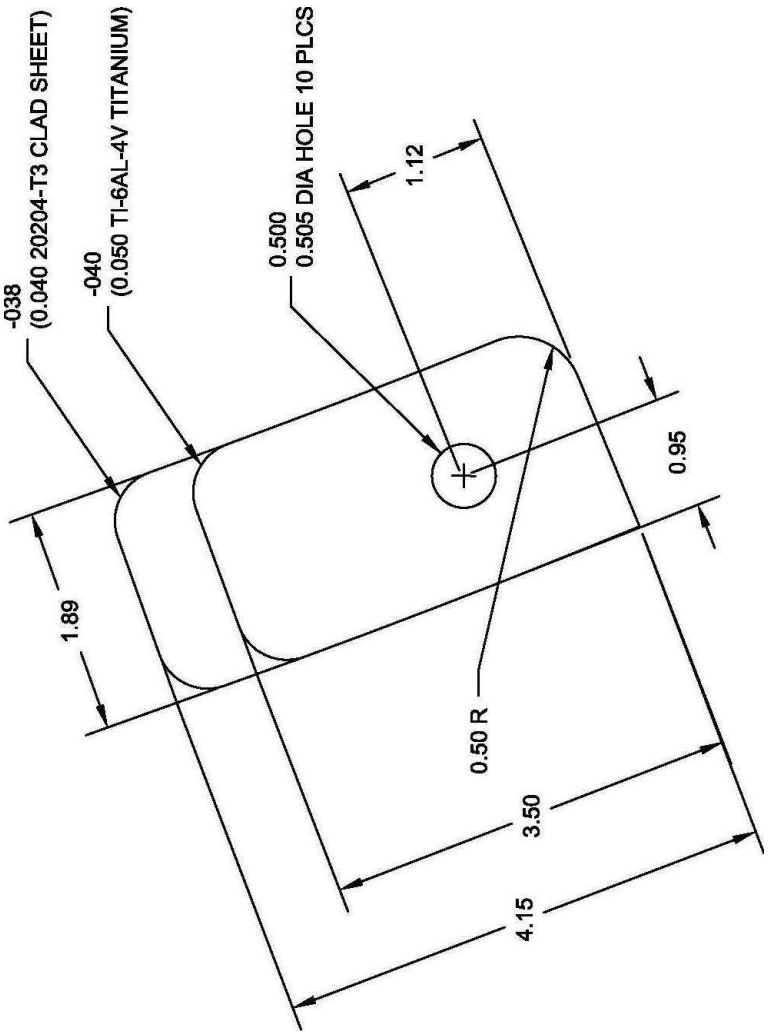
	QTY.	ITEM	PART NUMBER	KEYWORD	SUPERSEDES	MATERIAL	STATUS
	1		-002	FILLER		0.071 X 9 X 22/8.	FS
	1		-003	FILLER		0.071 X 9 X 22/8.	FS
	1		-004	FILLER		0.063 X 9 X 8/8.	FS
	1		-005	FILLER		0.063 X 9 X 8/8.	FS
	2		-006	DOUBLER		0.050 X 6 X 117/8.	FS
	2		-007	DOUBLER		0.050 X 6 X 117/8.	FS
	1		-008	DOUBLER		0.050 X 5 X 97/8.	FS
	1		-009	DOUBLER		0.050 X 5 X 97/8.	FS
	4		-010	FILLER		0.063 X 9 X 18/8.	FS
	4		-011	FILLER		0.063 X 9 X 18/8.	FS
	1		-012	SHIM		0.032 X 5 X 5/8.	FS
	1		-013	SHIM		0.032 X 5 X 5/8.	FS
	1		-014	SHIM		0.032 X 5 X 5/8.	FS
	1		-016	SHIM		0.032 X 5 X 5/8.	FS
	1		-018	DOUBLER		0.063 X 16 X 77/8.	FS
	1		-020	DOUBLER		0.063 X 16 X 77/8.	FS
	2		-022	DOUBLER		0.050 X 5 X 63/8.	FS
	4		-024	DOUBLER		0.050 X 5 X 63/8.	FS
	2		-026	SHIM		0.063 X 2 X 9/8.	FS
	1		-028	SHIM		0.063 X 4 X 14/8.	FS
	1		-030	SHIM		0.063 X 4 X 16/8.	FS
	1		-032	SHIM		0.050 X 3 X 9/8.	FS
	1		-033	SHIM		0.050 X 3 X 9/8.	FS
	1		-034	SHIM		0.032 X 5 X 5/8.	FS
	1		-035	SHIM		0.032 X 5 X 5/8.	FS

NOTES:

1. ALL DIMENSIONS ARE IN INCHES EXCEPT AS NOTED.
2. EXISTING FASTENER LOCATION AND DIAMETER IS ⊕X SYMBOL WITH THE NUMBER IN THE RIGHT HAND UPPER QUADRANT INDICATING THE DIAMETER IN 1/32 INCREMENTS AND THE LETTERS IN THE UPPER LEFT HAND QUADRANT INDICATING THE FASTENER TYPE.
3. ADDED FASTENER LOCATION AND DIAMETER IS ┼X SYMBOL WITH NUMBER IN THE RIGHT HAND UPPER QUADRANT INDICATING THE DIAMETER IN 1/32 INCREMENTS AND THE LETTERS IN THE UPPER LEFT HAND QUADRANT INDICATING THE FASTENTER TYPE.
4. THE IML IS THE INNER MOLD LINE OF THE FUSELAGE SKIN WHICH HAS A CONSTANT RADIUS OF 74 INCHES.
5. BREAK ALL SHARP EDGES 0.015/0.030 R.

REV. & DATE	CHANGE DESCRIPTION	EA AFFECTED	DWN.	CK'D	APPR.
REV. A 08/19/03	REVISED END DETAIL FOR FRAME AND MOVED THE FRAME ATTACHMENT LOCATION. ADDED MISSING FLAG NOTE 18.	ER/A 373669-14	MRB		

DRAWING FILE NAME: XXXXXXXX.DWG


-038
(0.040 20204-T3 CLAD SHEET)
-040
(0.050 TI-6AL-4V TITANIUM)
0.500
0.505 DIA HOLE 10 PLCS
1.12
1.89
0.95
0.50 R
3.50
4.15

APPENDIX B—INITIAL DAMAGE SCENARIOS, PATCH CONFIGURATIONS, AND STRAIN GAGE LOCATION

B.1 INTRODUCTION.

The damage scenario, patch configurations, and strain gage locations for all four test phases are provided in this appendix. Two types of damage scenarios (through-the-thickness notches and surface scribes) were introduced on the fuselage panel. These damages were repaired using both boron/epoxy (B/Ep) and aluminum repair patches.

Strain gages were placed on the fuselage panel skin, repair patches, and the substructure of the panel to monitor the strain distribution and to ensure proper load introduction. The type and location of the strain gages used are provided in the tables and figures of this appendix. All strain gages were 350 Ohms with a Constantan foil alloy. A three-conductor, Teflon®-coated twisted cable was used for connection to the strain gages. The strain gage, coating, cable, and adhesive types for each panel are listed in table B-1.

The substructure strain gages were installed at the start of the tests irrespective of the test phases. The location of these strain gages is provided in table B-2 and figures B-1 through B-3. Seven gages were installed at the flange of the stringers and 12 gages were installed at the outer and inner flanges of the frames. The substructure strain gages were removed at the later stages of the tests due to channel limitations.

The strain gages installed on the fuselage skin and repair patches were decided according to test phase. As the test phases progressed, additional gages were installed for the new patches. The following sections explain the strain gages for each test phase.

B.2 PHASE I.

The damage scenarios of Phase 1 are provided in figure B-4. The strain gages installed during the precracking of the midbay cracks are provided in table B-3 and figures B-5 and B-6. Figure B-7 shows the location of the Phase 1 patches and the patch configurations are provided in table B-4. The location of the strain gages for all the patches in Phase 1 are provided in tables B-5 through B-9 and are shown in figures B-8 through B-12.

B.3 PHASE II.

In Phase 2, the midbay crack was stop-drilled and the midbay B/Ep (C1BE) patch was replaced by an aluminum patch (C1A). The damage scenario and patch configuration are provided in figures B-13 and B-14, respectively. The external and internal strain gages for the C1A patch was the same as the C1BE Phase 1 patch and are shown in figure B-15. In addition to the gages for the C1A patch, additional internal gages were installed for the three lap joint patches (S1BE, S2BE, and S3A), as shown in figures B-16 through B-18 with the details in tables B-10 through B-12.

B.4 PHASE III.

In Phase 3, the lap joint B/Ep patches were removed and a 26-inch-long crack was introduced at the lap joint location. Further, the crack region was repaired using a large aluminum patch (LJC3A). The Phase 3 patch locations are shown in figure B-19. The location of external and internal strain gages for the LJC3A patch is shown in figures B-20 and B-21, respectively, with details in tables B-13 and B-14.

B-5 PHASE IV.

The damage scenario and patch configuration were the same as in Phase 3. In addition to Phase 3 strain gages, additional strain gages were installed on the exterior surface of LJC3A patch. The location of these additional strain gages are explained in table B-15 and shown in figure B-22. The strain gages on the interior surface of fuselage panel under LJC3A patch were the same as Phase 3, as shown in figure B-21.

Table B-1. General Strain Gage Information

Phase	Durability Study	No-Growth Design Study	Large Damage Repair Study	Elevated Temperature Study
Gage No., axial	S-5 – S-23, INS 1 – INS 5, IS 24 – IS 32, F01 – F12, L01 – L07, BF 1 – BF 3, BA 1 – BA 3, AF 1 – AF 3, AA 1 – AA 3	S-5 – S-23, INS 1 – INS 5, IS 24 – IS 32, P 1A – P 1D, P 3A – P 3D, P 5A – P 5D	S-8 – S-32, INS 2 – INS 4, IS 24 – IS 32, P6-1 – P6-12	S-8 – S-37, INS 2 – INS 4, IS 24 – IS 32, P6-1 – P6-12
Vishay micro-measurement part No., axial	CEA-13-062UW-350	CEA-13-062UW-350	CEA-13-062UW-350	CEA-13-062UW-350
Gage No. rosette	R01 – R06	R01 – R04	R01 – R04	R01 – R04
Vishay micro-measurement part No., rosette	CEA-13-062UR-350	CEA-13-062UR-350	CEA-13-062UR-350	CEA-13-062UR-350
Vishay micro-measurement part No., coatings	M-Coat A	M-Coat A	M-Coat A	M-Coat A
Vishay micro-measurement part No., cable	330-FTE	330-FTE	330-FTE	330-FTE
Vishay micro-measurement part No., adhesive	M-Bond 200	M-Bond 200	M-Bond 200	AE-10

Table B-2. Substructure Strain Gage Locations

Strain Gage No.	Location	
L01	Outside of flange S-2	Midway between FS-720D and FS-720E (10″), center of flange (0.44″)
L02	Outside of flange S-3	Midway between FS-720D and FS-720E (10″), center of flange (0.44″)
L03	Outside of flange S-4	Midway between FS-720D and FS-720E (10″), center of flange (0.44″)
L04	Outside of flange S-5	Midway between FS-720D and FS-720E (10″), center of flange (0.44″)
L05	Outside of flange S-6	Midway between FS-720D and FS-720E (10″), center of flange (0.44″)
L06	Outside of flange S-3	Midway between FS-720E and FS-720F (10″), center of flange (0.44″)
L07	Outside of flange S-5	Midway between FS-720E and FS-720F (10″), center of flange (0.44″)
F01	Outside of flange FS-720C	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F02	Inside of flange FS-720C	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F03	Outside of flange FS-720D	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F04	Inside of flange FS-720D	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F05	Outside of flange FS-720E	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F06	Inside of flange FS-720E	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F07	Outside of flange FS-720F	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F08	Inside of flange FS-720F	Midway between S-3 and S-4 (4.8″), center of flange (0.5″)
F09	Outside of flange FS-720D	Midway between S-4 and S-5 (4.8″), center of flange (0.5″)
F10	Inside of flange FS-720D	Midway between S-4 and S-5 (4.8″), center of flange (0.5″)
F11	Outside of flange FS-720E	Midway between S-4 and S-5 (4.8″), center of flange (0.5″)
F12	Inside of flange FS-720E	Midway between S-4 and S-5 (4.8″), center of flange (0.5″)

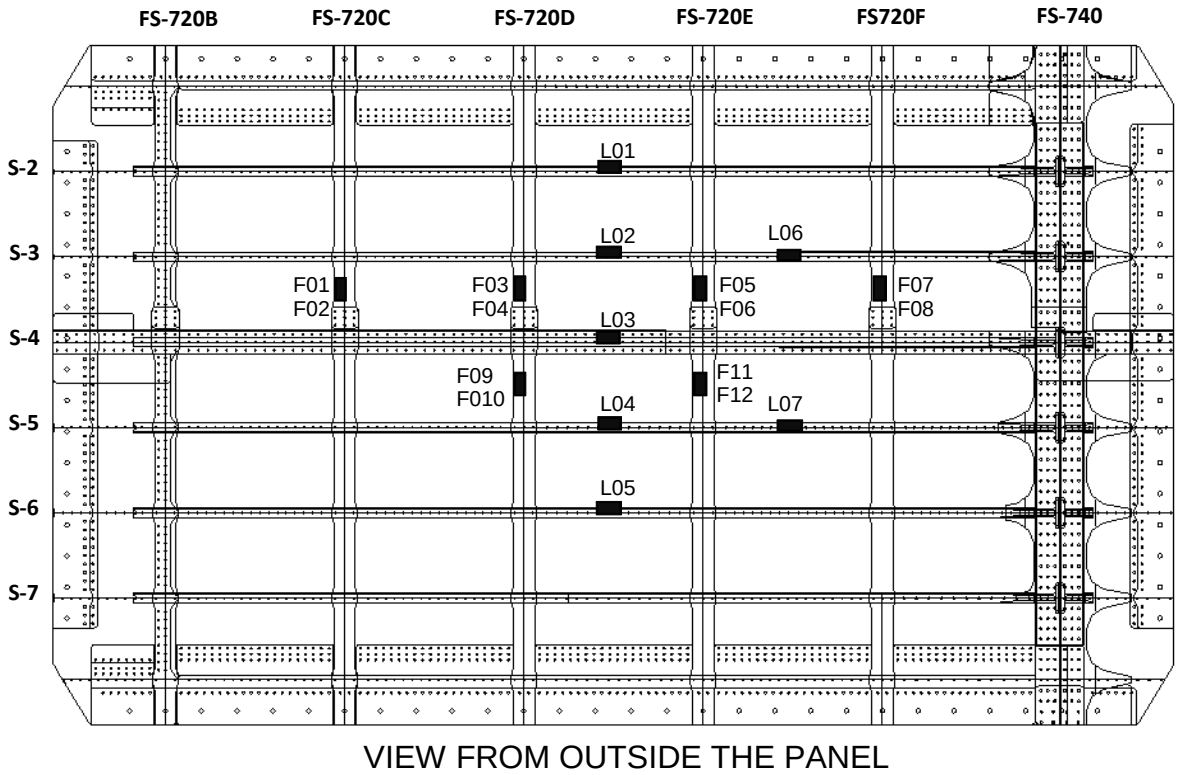


Figure B-1. Substructure Strain Gages

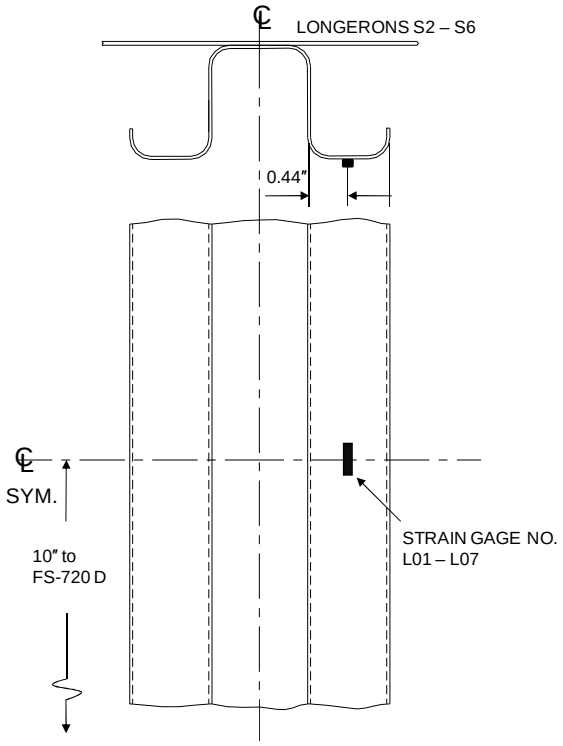


Figure B-2. Placement of Axial Strain Gages at the cap of the Stringers (Longerons) of the Panel

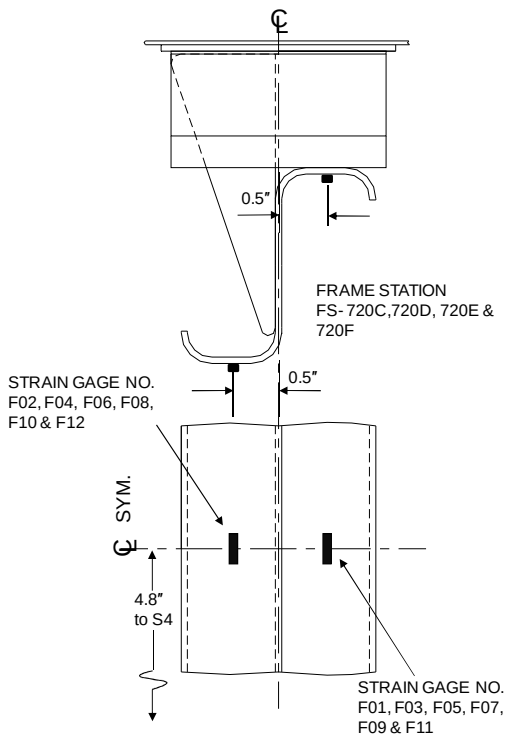


Figure B-3. Placement of Axial Strain Gages at the Inner and Outer cap of the Frames in the Panel

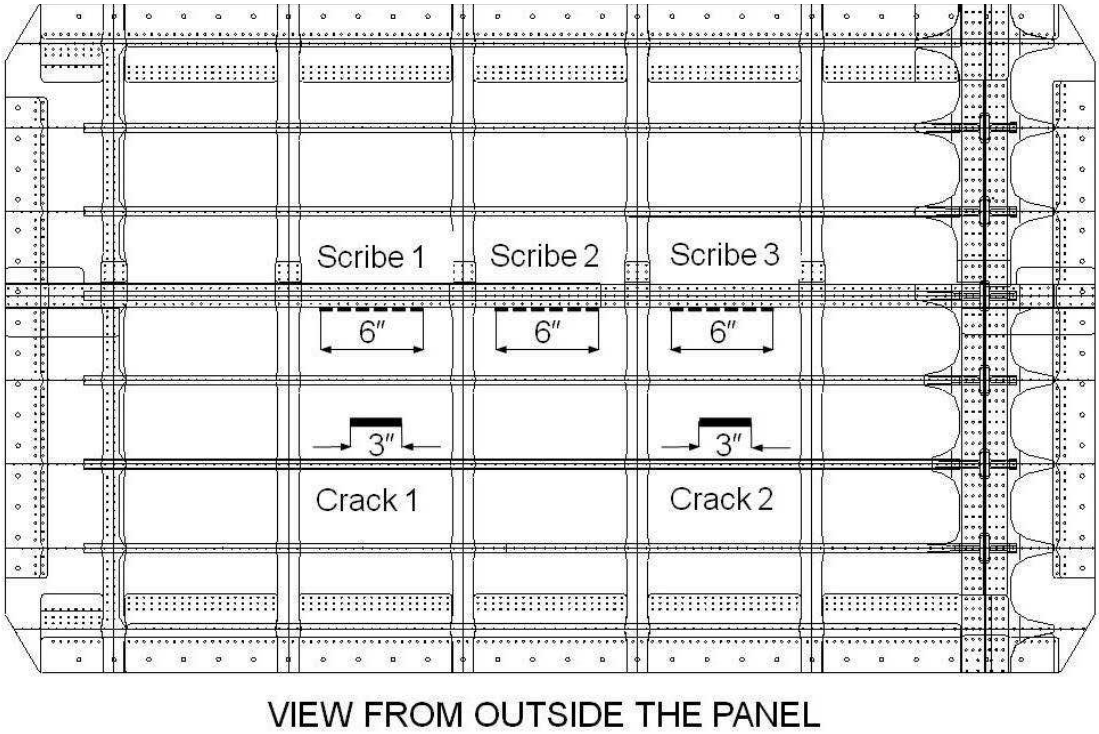


Figure B-4. Damage Scenarios

Table B-3. Precracking Strain Gage Locations

Strain Gage No.	Location	
R01-L R01-45 R01-T	Exterior skin surface	Midway between FS-720C and FS-720D (10″) and S-2 and S-3 (4.8″)
R02-L R02-45 R02-T	Exterior skin surface	Midway between FS-720D and FS-720E (10″) and S-2 and S-3 (4.8″)
R03-L R03-45 R03-T	Exterior skin surface	Midway between FS-720E and FS-720F (10″) and S-2 and S-3 (4.8″)
R04-L R04-45 R04-T	Exterior skin surface	Midway between FS-720D and FS-720E (10″) and S-5 and S-6 (4.8″)
R05-L R05-45 R05-T	Exterior skin surface	Midway between FS-720D and FS-720E (10″) and S-4 and S-5 (4.8″)
R06-L R06-45 R06-T	Exterior skin surface	Midway between FS-720D and FS-720E (10″) and S-3 and S-4 (4.8″)
BF1	Exterior skin surface	0.25″ forward of notch tip between FS-720C and FS-720D and S-5 and S-6
BF2	Exterior skin surface	1.25″ forward of notch tip between FS-720C and FS-720D and S-5 and S-6
BF3	Exterior skin surface	2.25″ forward of notch tip between FS-720C and FS-720D and S-5 and S-6
BA1	Exterior skin surface	0.25″ aft of notch tip between FS-720C and FS-720D and S-5 and S-6
BA2	Exterior skin surface	1.25″ aft of notch tip between FS-720C and FS-720D and S-5 and S-6
BA3	Exterior skin surface	2.25″ aft of notch tip between FS-720C and FS-720D and S-5 and S-6
AF1	Exterior skin surface	0.25″ forward of notch tip between FS-720E and FS-720F and S-5 and S-6
AF2	Exterior skin surface	1.25″ forward of notch tip between FS-720E and FS-720F and S-5 and S-6
AF3	Exterior skin surface	2.25″ forward of notch tip between FS-720E and FS-720F and S-5 and S-6
AA1	Exterior skin surface	0.25″ aft of notch tip between FS-720E and FS-720F and S-5 and S-6
AA2	Exterior skin surface	1.25″ aft of notch tip between FS-720E and FS-720F and S-5 and S-6
AA3	Exterior skin surface	2.25″ aft of notch tip between FS-720E and FS-720F and S-5 and S-6

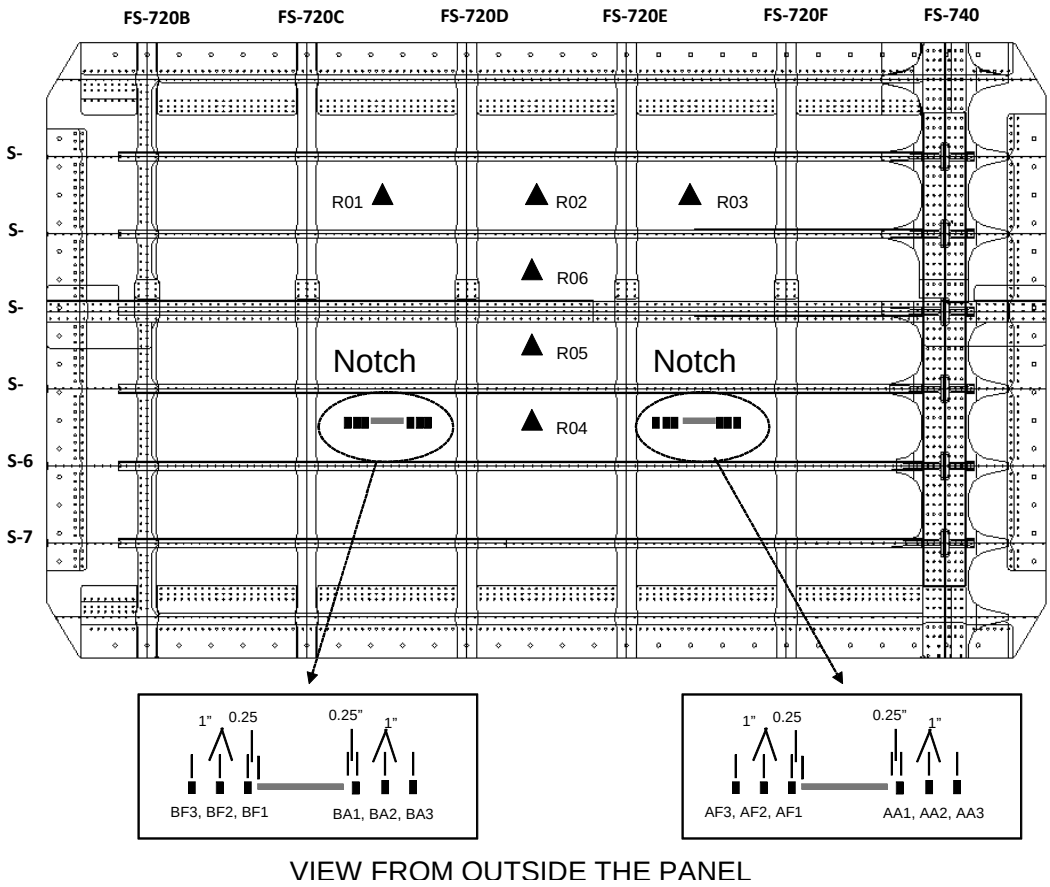


Figure B-5. Rosette and Notch Tip Axial Strain Gages

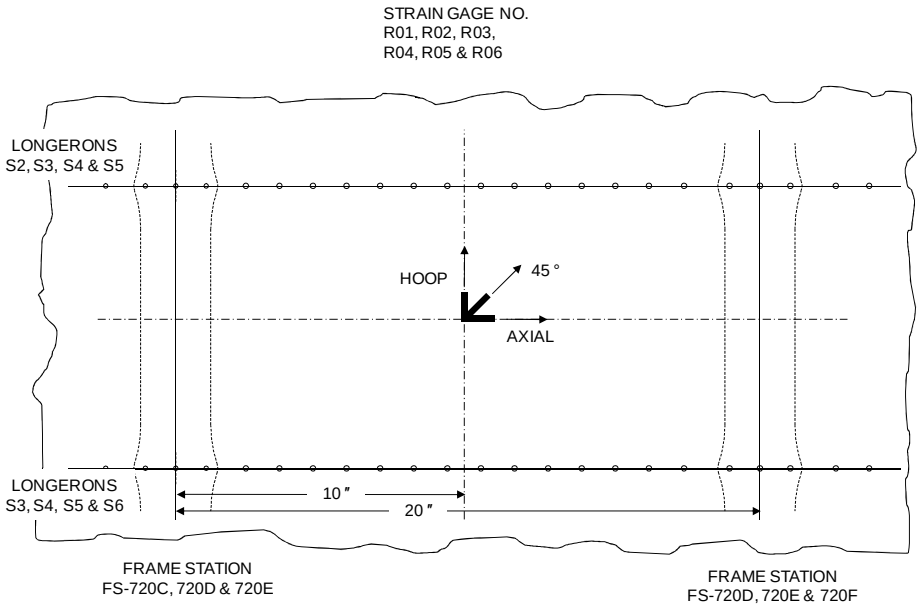


Figure B-6. Placement of Rosette Gages at the Skin Midbay Location in the Panel

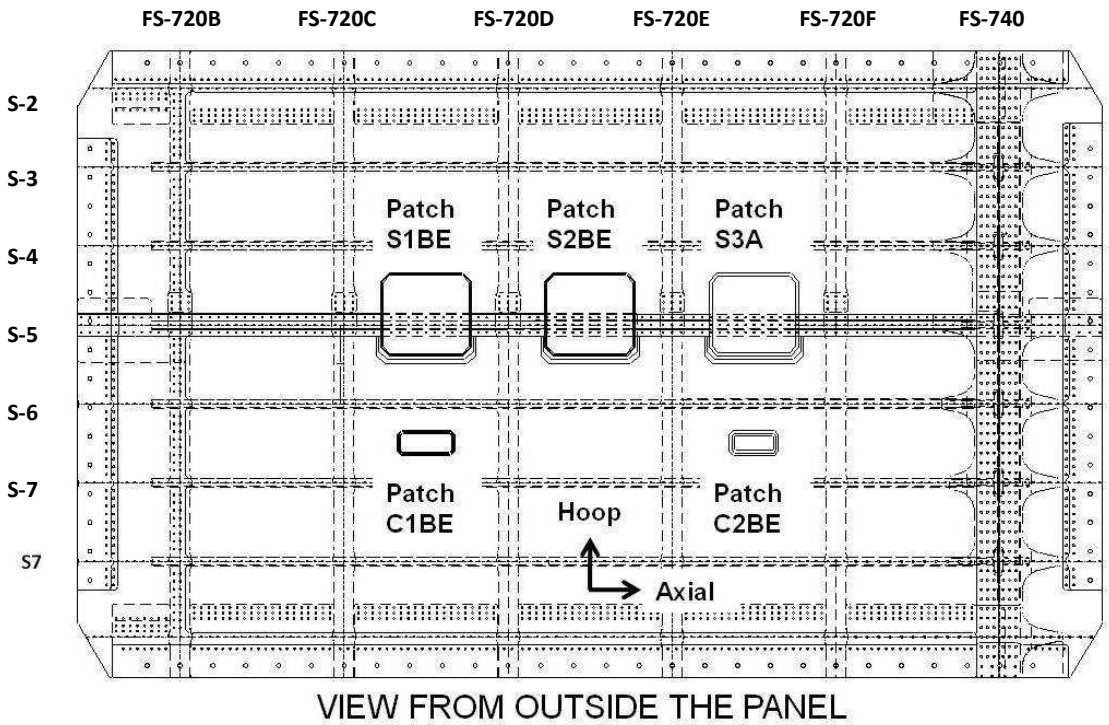


Figure B-7. Phase 1 Patch Locations

Table B-4. Patch Configurations

Patch	Material	Sheets/Plies	Location
S1BE	Boron/epoxy (4 plies)	(Length × width, angle) Ply 1: 11.00″ × 10.00″, +20º Ply 2: 10.85″ × 9.85″, -20º Ply 3: 10.70″ × 9.70″, -20º Ply 4: 10.55″ × 9.55″, +20º Patch thickness: 0.023″ Taper ratio: 20:1 Fiber angles are defined considering axial direction as 0°	Over lap joint between FS-720C and FS-720D and S-3 and S-5
S2BE	Boron/epoxy (4 plies)	(Length × width, angle) Ply 1: 11.00″ × 10.00″, +20º Ply 2: 10.85″ × 9.85″, -20º Ply 3: 10.70″ × 9.70″, -20º Ply 4: 10.55″ × 9.55″, +20º Patch thickness: 0.023″ Taper ratio: 20:1 Fiber angles are defined considering hoop direction as 0º	Over lap joint between FS-720D and FS-720E and S-3 and S-5

Table B-4. Patch Configurations (Continued)

Patch	Material	Sheets/Plies	Location
S3A	Aluminum (2 layers)	(Length × width × thickness) Sheet 1: 11.00″ × 10.00″ × 0.020″ Sheet 2: 10.20″ × 9.20″ × 0.020″	Over lap joint between FS-720E and FS-720F and S-3 and S-5
C1BE	Boron/epoxy (6 plies)	(Length × width, angle) Layer 1: 7.00″ × 3.00″, +20º Layer 2: 6.86″ × 2.86″, -20º Layer 3: 6.72″ × 2.70″, 0º Layer 4: 6.58″ × 2.58″, 0º Layer 5: 6.44″ × 2.44″, -20º Layer 6: 6.30″×2.30″, +20º Patch thickness: 0.034″ Taper ratio: 20:1 Fiber angles are defined considering hoop direction as 0º	Midway between FS-720C and FS-720D and S-5 and S-6
C2BE	Aluminum (3 layers)	(Length × width × thickness) Sheet 1: 6.00″ × 3.00″ × 0.020″ Sheet 2: 5.40″ × 2.40″ × 0.020″ Sheet 3: 4.80″ × 1.80″ × 0.020″	Midway between FS-720E and FS-720F and S-5 and S-6

Table B-5. Strain Gages Locations for S1BE Patch

Strain Gage No.	Location	
S05	Exterior skin surface	0.75″ right of lap joint-compliant B/Ep patch between FS-720C and FS-720D and S-3 and S-4
S06	Exterior S1BE patch surface	Center of the scribe
S07	Exterior skin surface	0.75″ left of lap joint-compliant B/Ep patch between FS-720C and FS-720D and S-4 and S-5
S21	Exterior S1BE patch surface	Above the center rivet row of the lap joint (S-4) between FS-720C and FS-720D
INS1	Interior skin surface	Center of lap joint scribe between FS-720C and FS-720D and S4 and S5

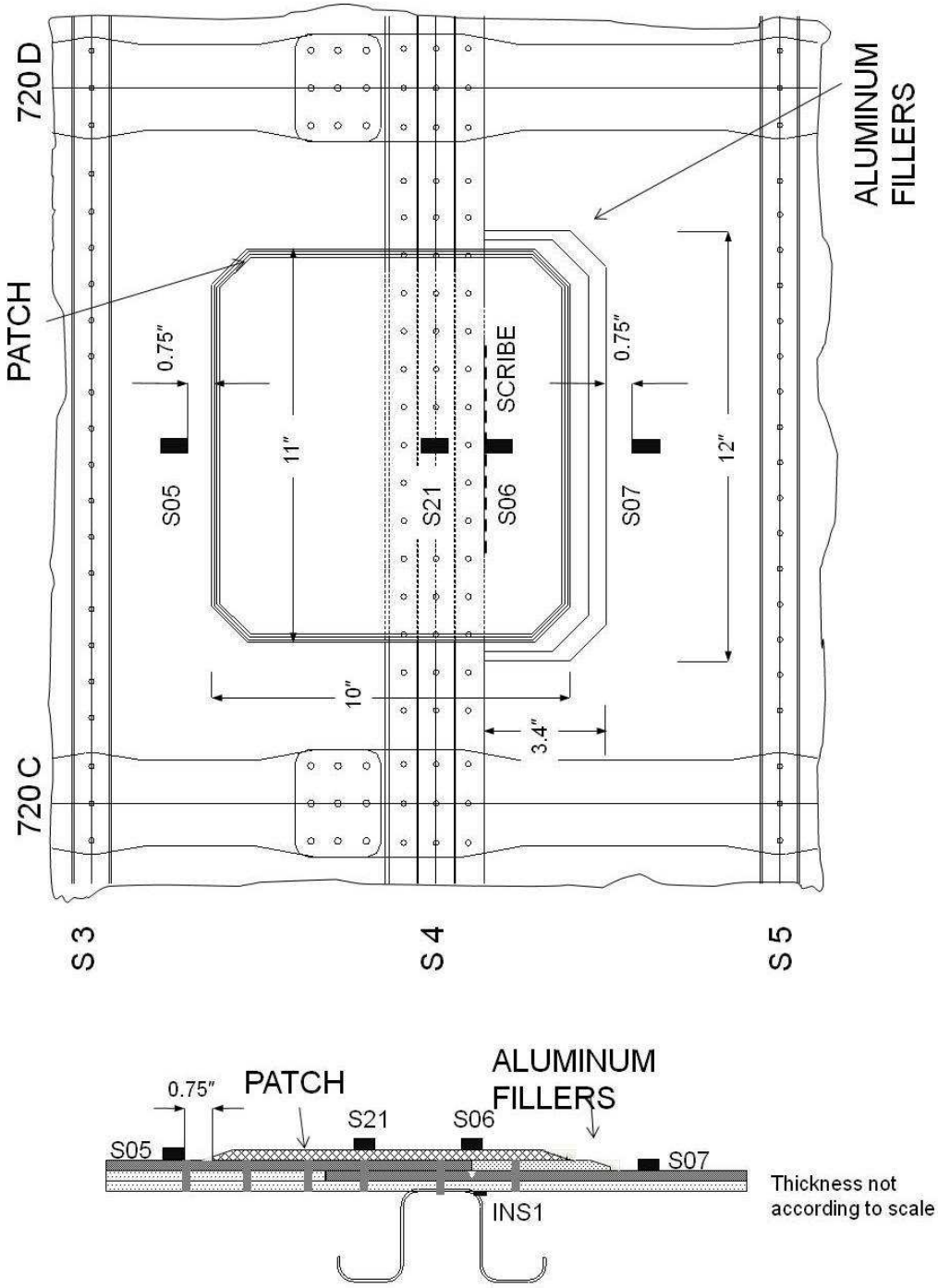


Figure B-8. Placement of Axial Gages for S1BE Patch

Table B-6. Strain Gages Locations for C1BE Patch

Strain Gage No.	Location	
S08	Exterior skin surface	0.75″ right of midbay B/Ep patch between FS-720C and FS-720D and S-5 and S-6
S09	Exterior C1BE patch surface	Center of midbay B/Ep patch between FS-720C and FS-720D and S-5 and S-6
S10	Exterior skin surface	0.75″ left of midbay B/Ep patch between FS-720C and FS-720D and S-5 and S-6
INS2	Interior skin surface	0.5″ aft of midbay notch tip between FS-720C and FS-720D and S-5 and S-6
IS32	Interior skin surface	0.5″ forward of midbay notch tip between FS-720C and FS-720D and S-5 and S-6
IS24	Interior skin surface	1″ right of midbay notch between FS-720C and FS-720D and S-5 and S-6
IS25	Interior skin surface	1″ left of midbay notch between FS-720C and FS-720D and S-5 and S-6
IS26	Interior skin surface	1.75″ right of midbay notch between FS-720C and FS-720D and S-5 and S-6
IS27	Interior skin surface	1.75″ left of midbay notch between FS-720C and FS-720D and S-5 and S-6

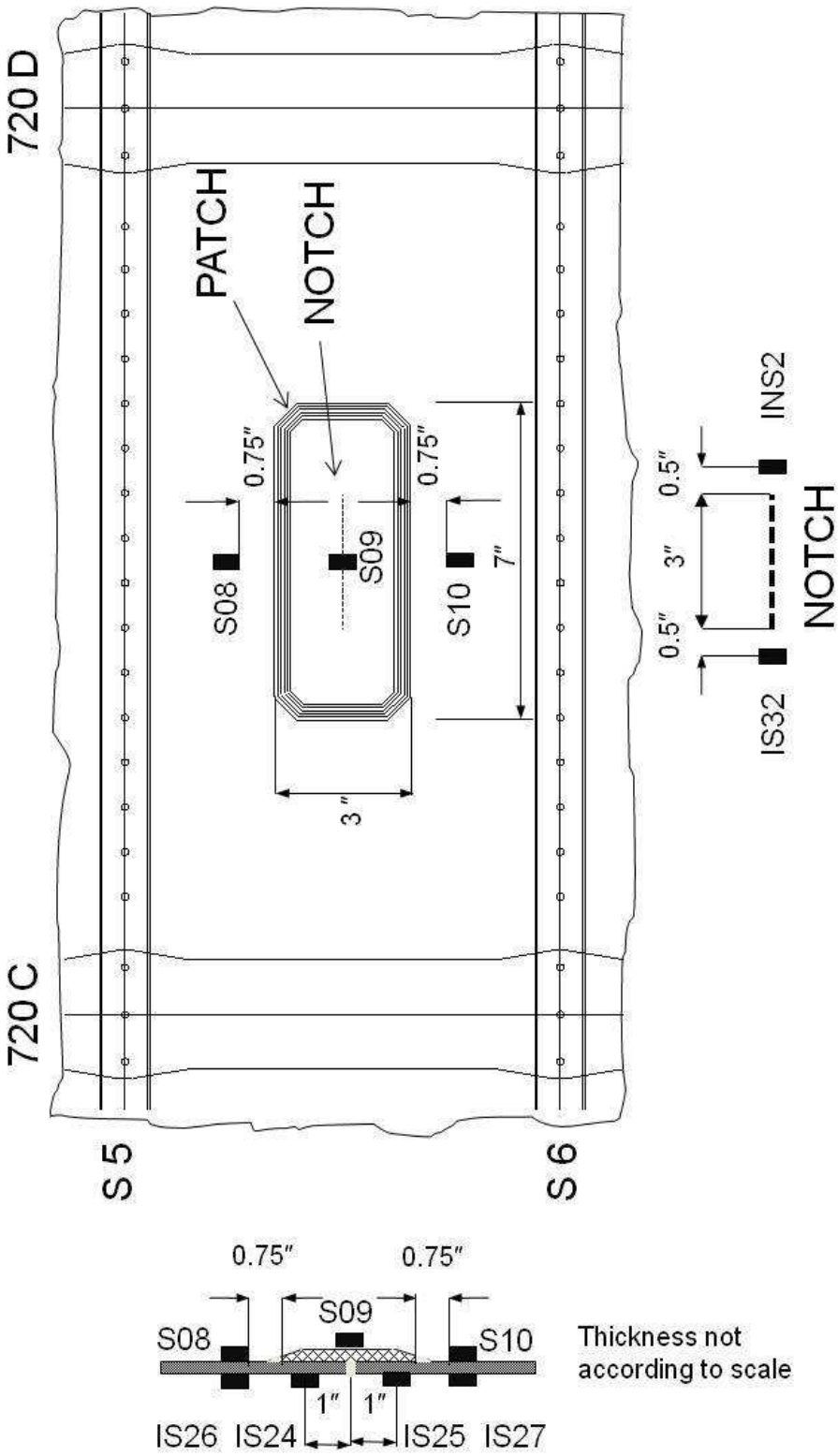


Figure B-9. Placement of Axial Gages for C1BE Patch

Table B-7. Strain Gages Locations for S3A Patch

Strain Gage No.	Location	
S14	Exterior skin surface	0.75″ right of lap joint aluminum patch between FS-720E and FS-720F and S-3 and S-4
S15	Exterior S3A patch surface	Center of the scribe
S16	Exterior skin surface	0.75″ left of lap joint aluminum patch between FS-720E and FS-720F and S-4 and S-5
S22	Exterior S3A patch surface	Above the center rivet row of the lap joint (S-4) between FS-720E and FS-720F
INS3	Interior skin surface	Center of lap joint scribe between FS-720E and FS-720F and S-4 and S-5

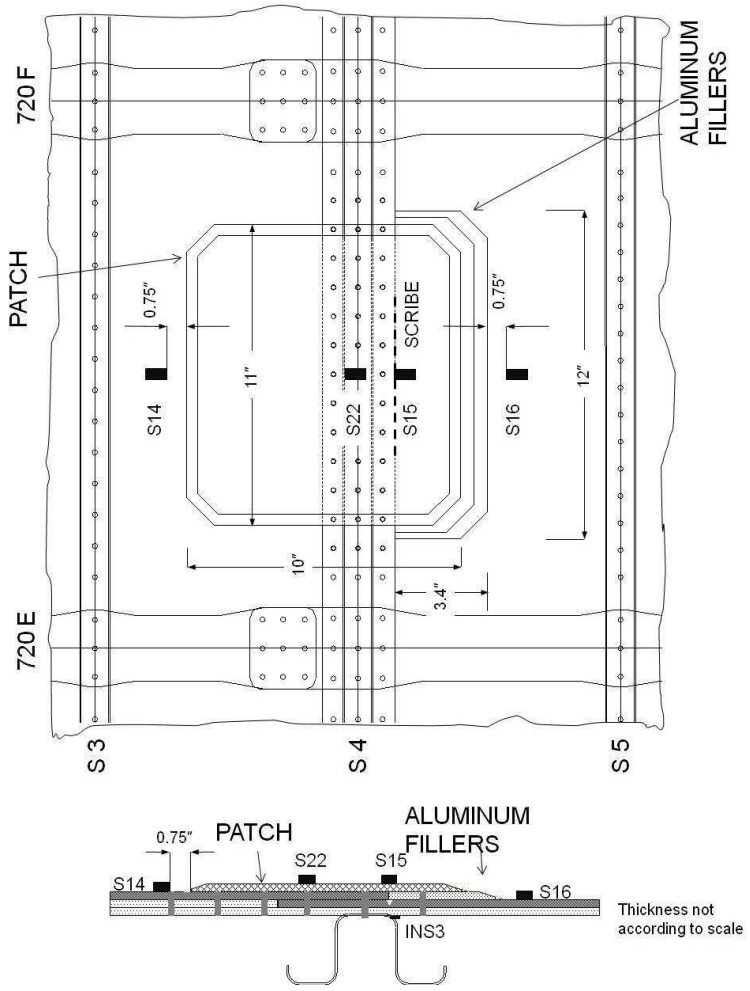


Figure B-10. Placement of Axial Gages for S3A Patch

Table B-8. Strain Gages Locations for C2A Patch

Strain Gage No.	Location	
S17	Exterior skin surface	0.75″ right of midbay aluminum patch between FS-720E and FS-720F and S-5 and S-6
S18	Exterior C2A patch surface	Center of midbay aluminum patch between FS-720E and FS-720F and S-5 and S-6
S19	Exterior skin surface	0.75″ left of midbay aluminum patch between FS-720E and FS-720F and S-5 and S-6
INS4	Interior skin surface	0.5″ aft of midbay notch tip between FS-720E and FS-720F and S-5 and S-6
IS28	Interior skin surface	1″ right of midbay notch between FS-720E and FS-720F and S-5 and S-6
IS29	Interior skin surface	1″ left of midbay notch between FS-720E and FS-720F and S-5 and S-6
IS30	Interior skin surface	1.75″ right of midbay notch between FS-720E and FS-720F and S-5 and S-6
IS31	Interior skin surface	1.75″ left of midbay notch between FS-720E and FS-720F and S-5 and S-6

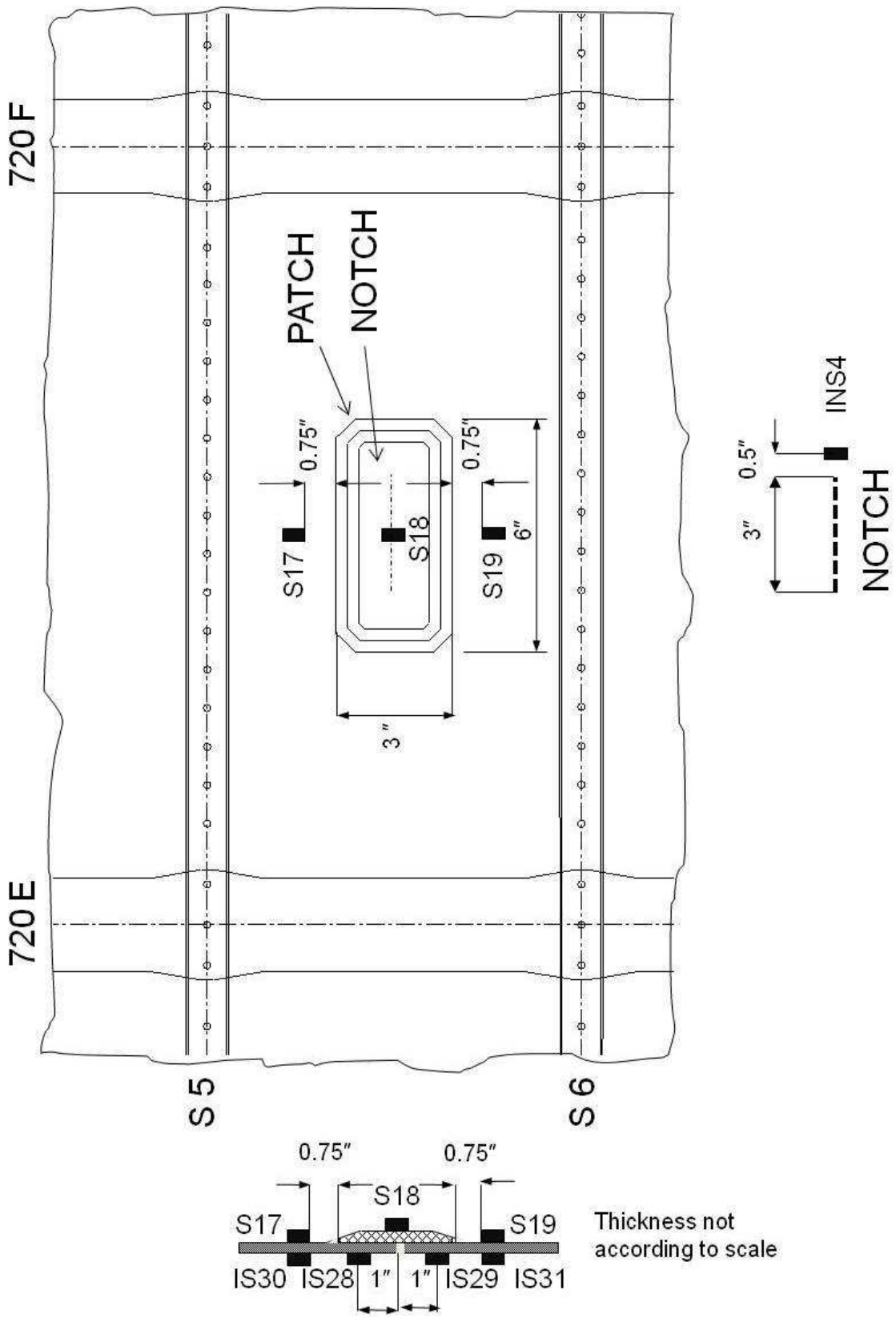


Figure B-11. Placement of Axial Gages for C2A Patch

Table B-9. Strain Gages Locations for S2BE Patch

Strain Gage No.	Location	
S11	Exterior skin surface	0.75″ right of lap joint stiff B/Ep patch between FS-720D and FS-720E and S-3 and S-4
S12	Exterior S2BE patch surface	Center of the scribe
S13	Exterior skin surface	0.75″ left of lap joint stiff B/Ep patch between FS-720D and FS-720E and S-4 and S-5
S23	Exterior S2BE patch surface	Above the center rivet row of the lap joint (S-4) between FS-720D and FS-720E
INS5	Interior skin surface	Center of lap joint scribe between FS-720E and FS-720F and S-4 and S-5

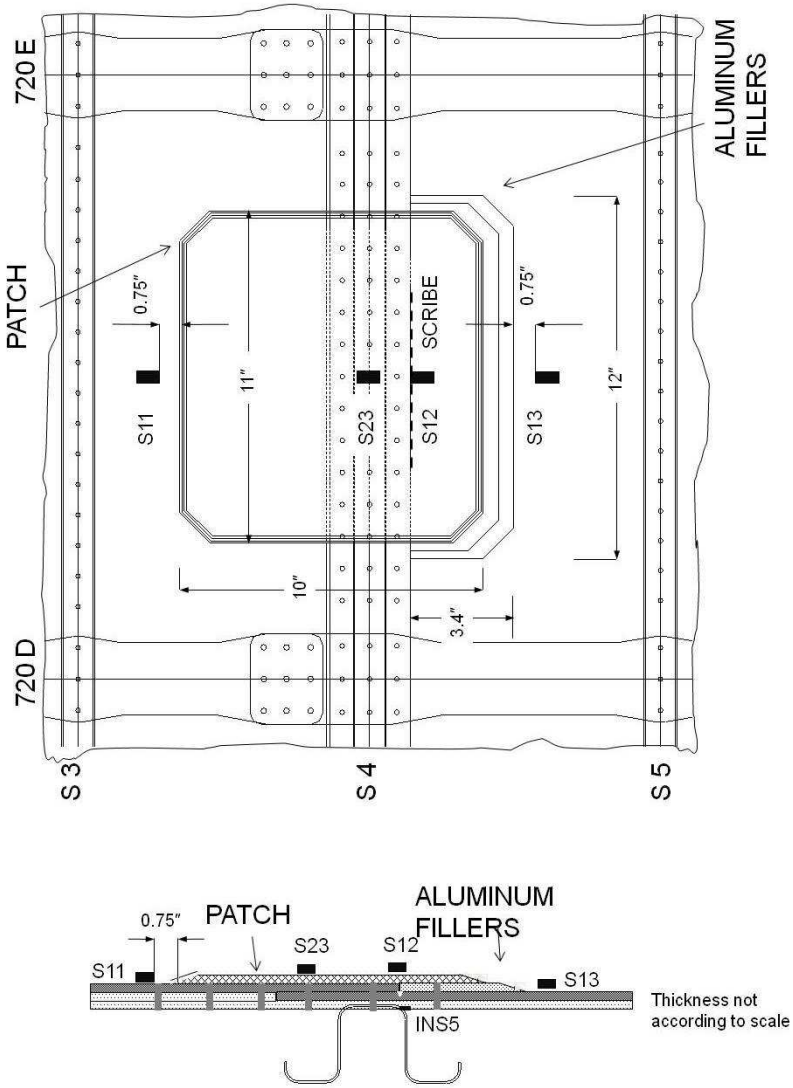


Figure B-12. Placement of Axial Gages for S2BE Patch

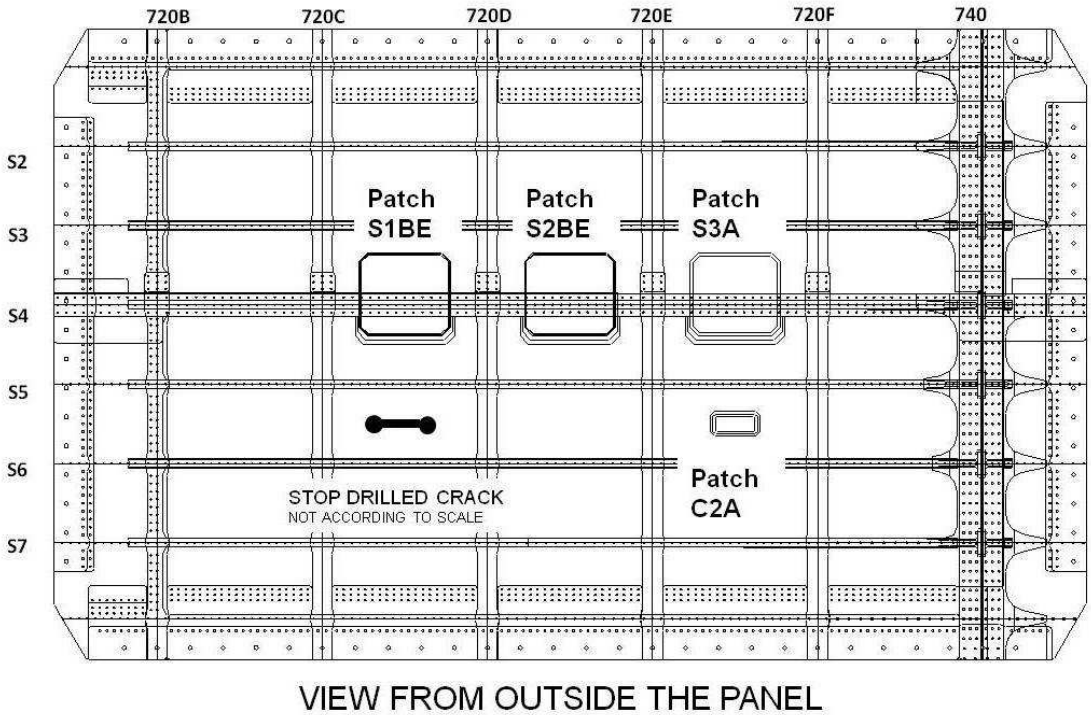


Figure B-13. Phase 2 Damage Scenario

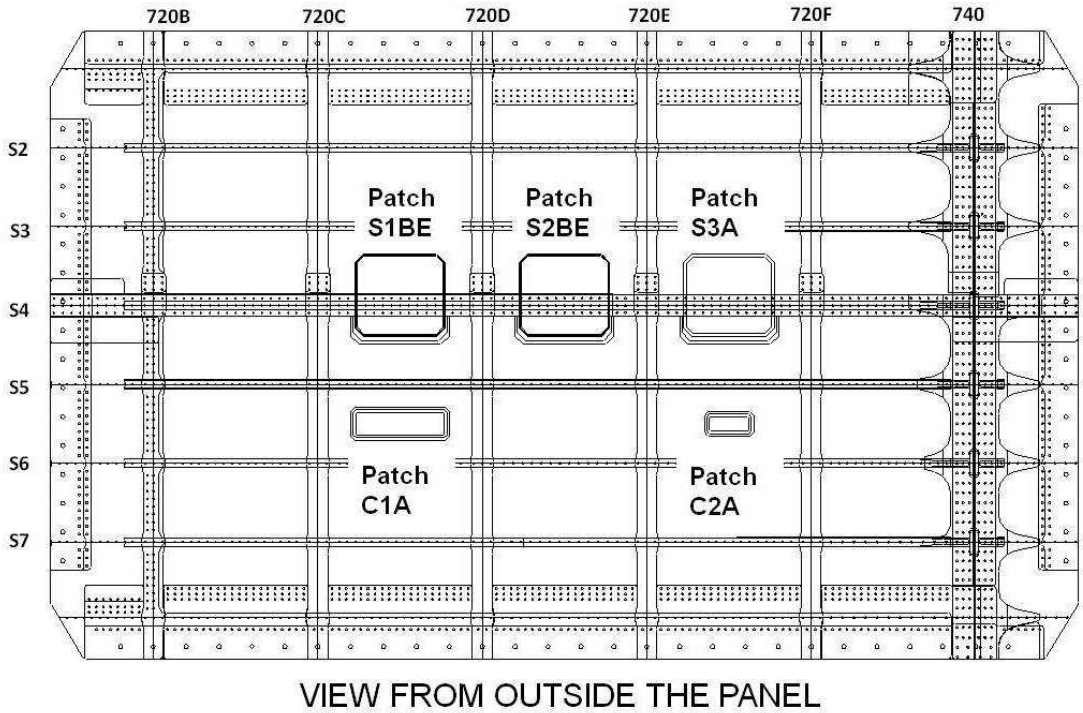


Figure B-14. Phase 2 Patch Locations

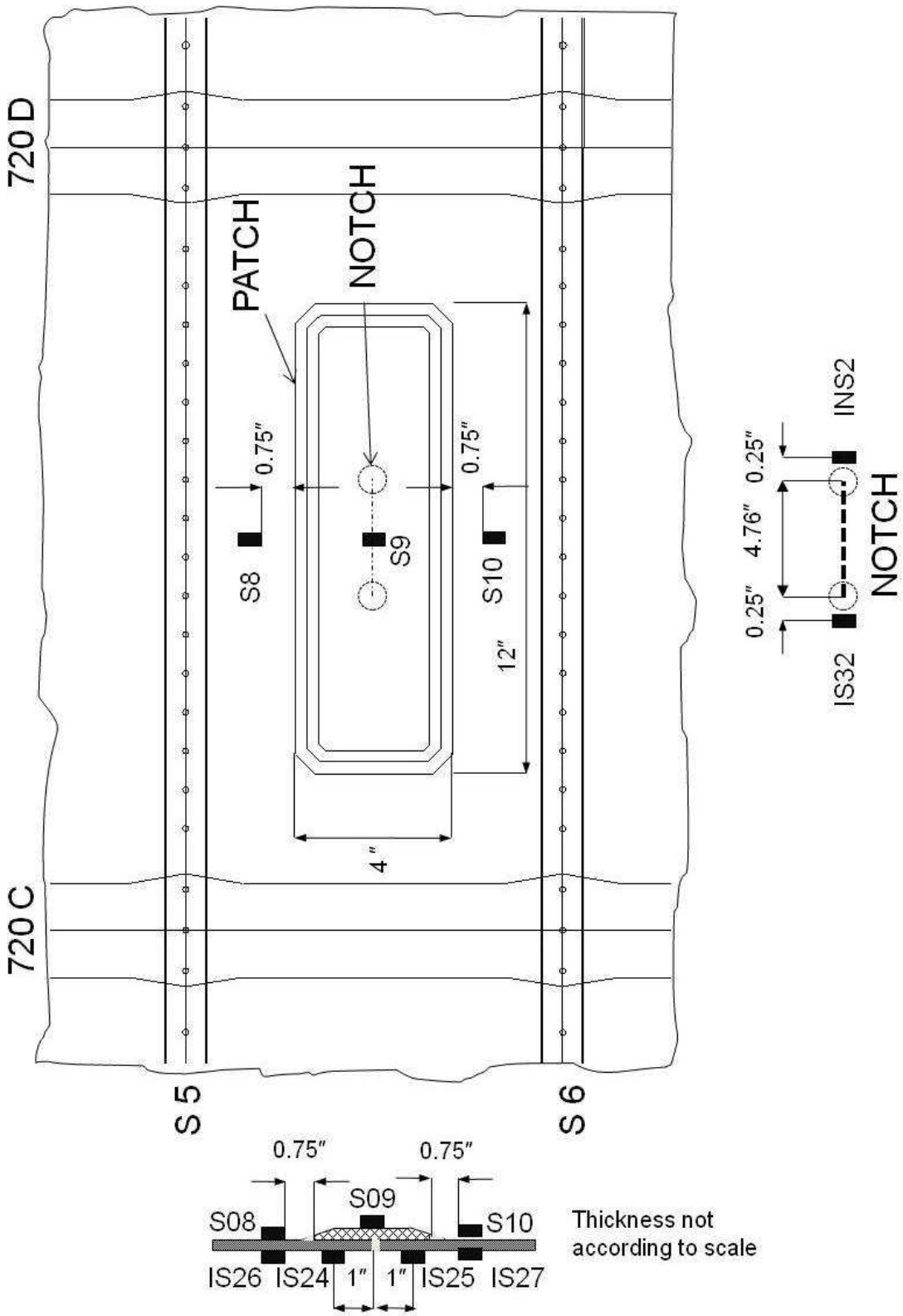


Figure B-15. Placement of Axial Gages for C1A Patch

Table B-10. Internal Strain Gages Locations for S1BE Patch

Strain Gage No.	Location	
P1A	Interior skin surface	Forward tip of lap joint scribe between FS-720C and FS-720D and S-4 and S-5
P1B	Interior skin surface	1.5″ forward of the center of lap joint scribe between FS-720C and FS-720D and S-4 and S-5
P1C	Interior skin surface	1.5″ aft of the center of lap joint scribe between FS-720C and FS-720D and S-4 and S-5
P1D	Interior skin surface	aft tip of lap joint scribe between FS-720C and FS-720D and S-4 and S-5

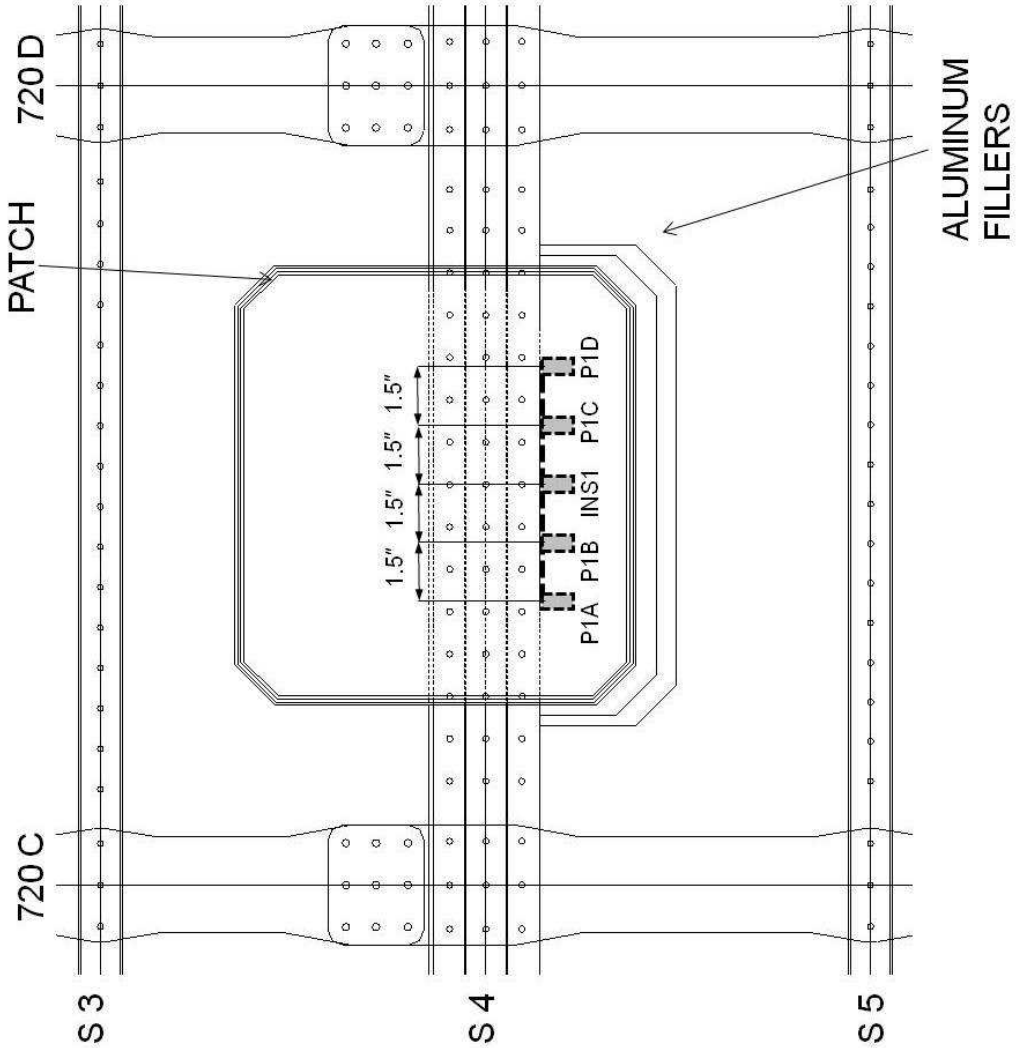


Figure B-16. Placement of Axial Gages at the Internal Skin of the Fuselage Panel Below Patch S1BE

Table B-11. Internal Strain Gages Locations for S3A Patch

Strain Gage No.	Location	
P3A	Interior skin surface	Forward tip of lap joint scribe between FS-720E and FS-720F and S-4 and S-5
P3B	Interior skin surface	1.5″ forward of the center of lap joint scribe between FS-720E and FS-720F and S-4 and S-5
P3C	Interior skin surface	1.5″ aft of the center of lap joint scribe between FS-720E and FS-720F and S-4 and S-5
P3D	Interior skin surface	Aft tip of lap joint scribe between FS-720E and FS-720F and S-4 and S-5

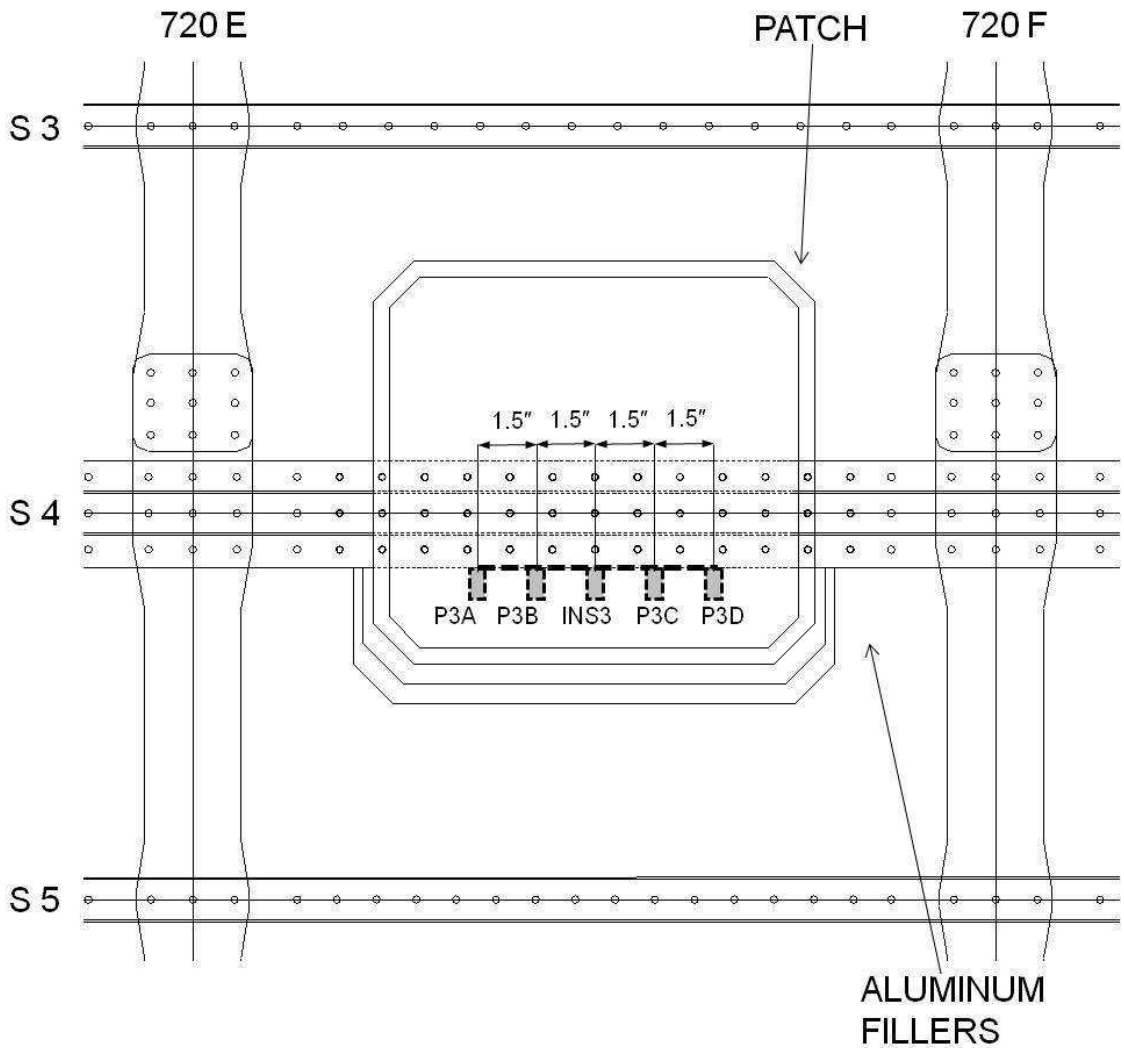


Figure B-17. Placement of Axial Gages at the Internal Skin of the Fuselage Panel Below Patch S3A

Table B-12. Internal Strain Gages Locations for S2BE Patch

Strain Gage No.	Location	
P5A	Interior skin surface	Forward tip of lap joint scribe between FS-720D and FS-720E and S-4 and S-5
P5B	Interior skin surface	1.5″ forward of the center of lap joint scribe between FS-720D and FS-720E and S-4 and S-5
P5C	Interior skin surface	1.5″ aft of the center of lap joint scribe between FS-720D and FS-720E and S-4 and S-5
P5D	Interior skin surface	Aft tip of lap joint scribe between FS-720D and FS-720E and S-4 and S-5

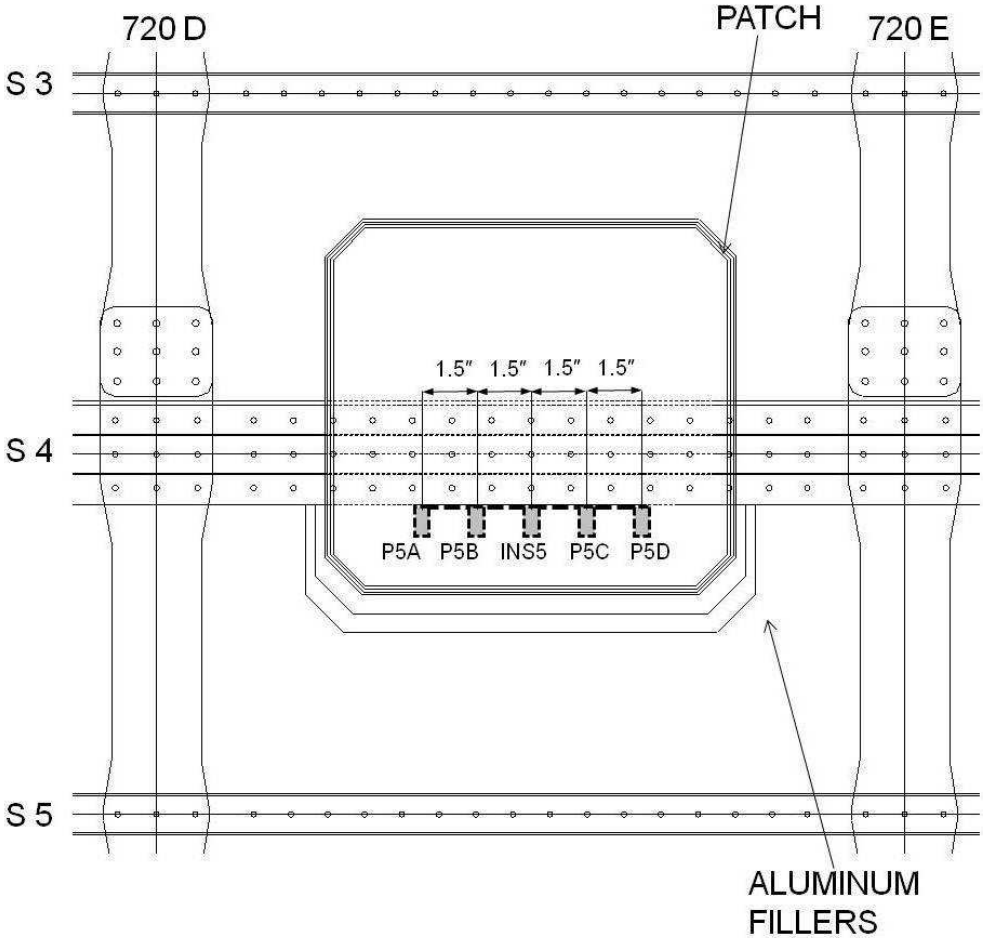


Figure B-18. Placement of Axial Gages at the Internal Skin of the Fuselage Panel Below Patch S2BE

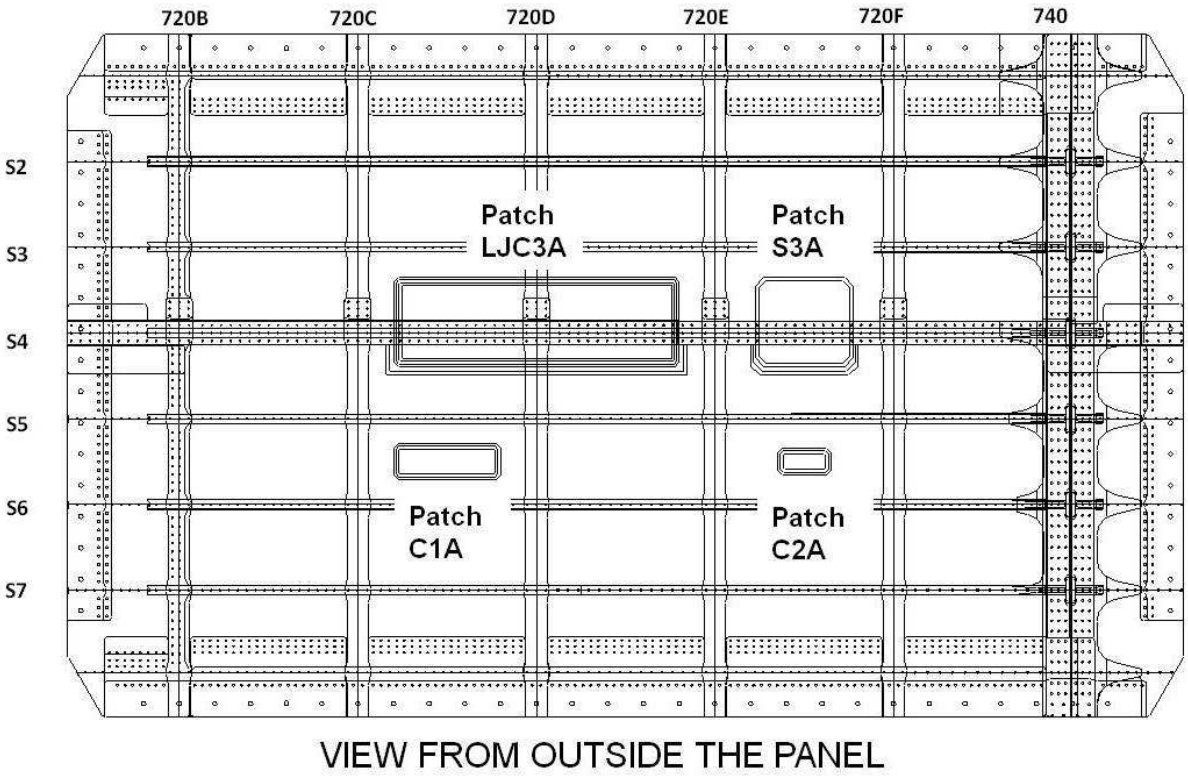


Figure B-19. Phase 3 Patch Locations

Table B-13. External Strain Gages Locations for LJC3A Patch

Strain Gage No.	Location	
S24	Exterior surface of large aluminum patch	0.5″ forward of large notch
S25	Exterior surface of large aluminum patch	6.5″ forward from the center of large notch
S26	Exterior surface of large aluminum patch	Center of large notch above FS-720D
S27	Exterior surface of large aluminum patch	6.5″ aft from the center of large notch
S28	Exterior surface of large aluminum patch	0.5″ aft of large notch
S29	Exterior skin surface	0.75″ left of large aluminum patch and 6.5″ forward of FS-720D
S30	Exterior skin surface	0.75″ right of large aluminum patch and 6.5″ forward of FS-720D
S31	Exterior skin surface	0.75″ left of large aluminum patch on the FS-720D
S32	Exterior skin surface	0.75″ right of large aluminum patch on the FS-720D

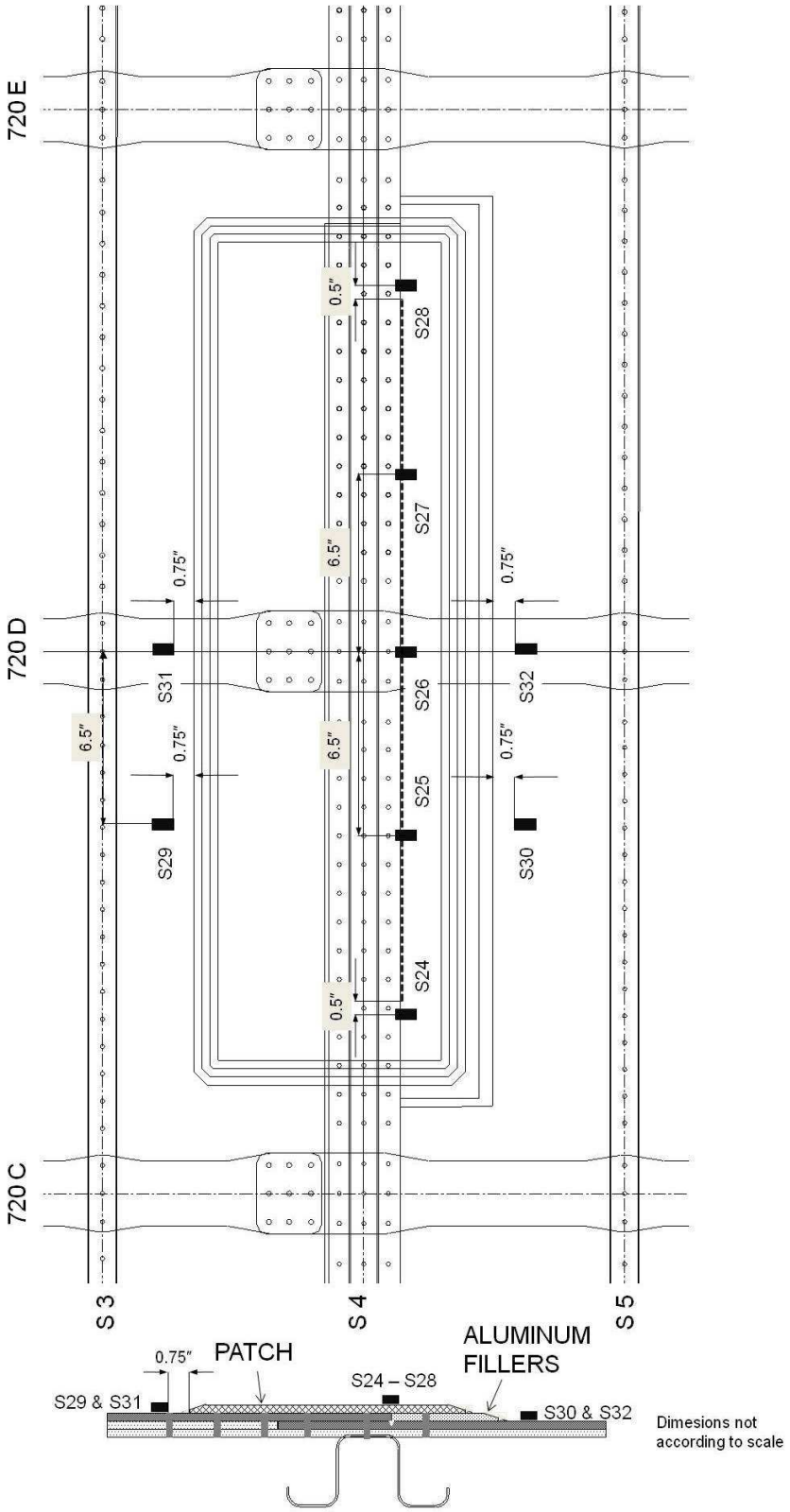


Figure B-20. Placement of Axial Gages for LJC3A Patch

Table B-14. Internal Strain Gages Locations for LJC3A Patch

Strain Gage No.	Location	
P6-1	Interior skin surface	2.5″ forward of lap joint scribe tip between FS-720C and FS-720D and S-4 and S-5
P6-2	Interior skin surface	1.5″ forward of lap joint scribe tip between FS-720C and FS-720D and S-4 and S-5
P6-3	Interior skin surface	0.5″ forward of lap joint scribe tip between FS-720C and FS-720D and S-4 and S-5
P6-4	Interior skin surface	0.75″ right of large aluminum patch and 6.5″ forward of FS-720D
P6-5	Interior skin surface	6.5″ forward from the FS-720D and 7.6″ from the crack
P6-6	Interior skin surface	6.5″ forward from the FS-720D and 1.2″ from the crack
P6-7	Interior skin surface	0.75″ left of large aluminum patch and 6.5″ forward of FS-720D
P6-8	Interior tear strap surface	Center of the long crack under the tear strap
P6-9	Interior tear strap surface	Center of the long crack under the tear strap
P6-10	Interior skin surface	0.5″ aft of lap joint scribe tip between FS-720C and FS-720D and S-4 and S-5
P6-11	Interior skin surface	1.5″ aft of lap joint scribe tip between FS-720C and FS-720D and S-4 and S-5
P6-12	Interior skin surface	2.5″ aft of lap joint scribe tip between FS-720C and FS-720D and S-4 and S-5

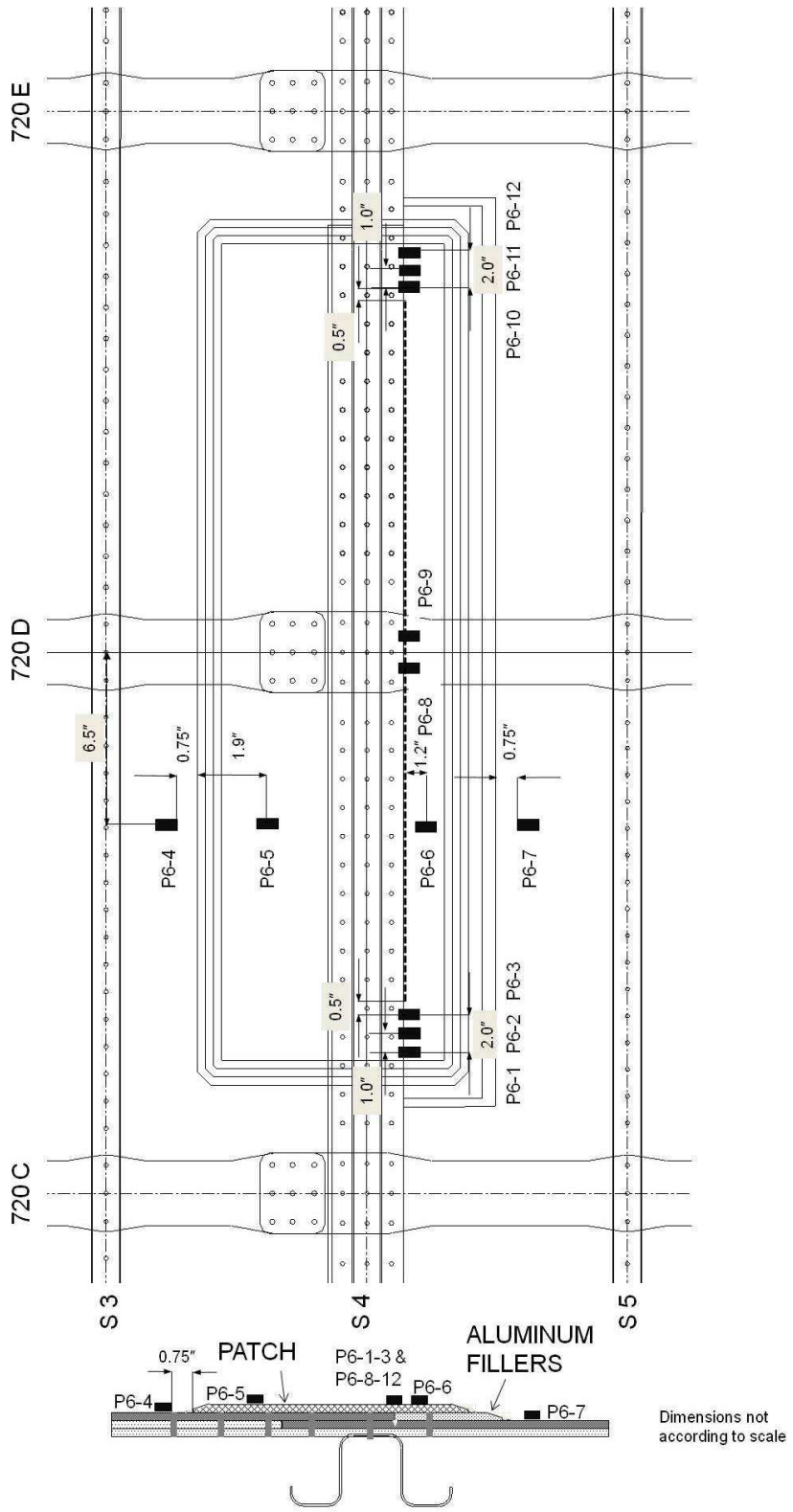


Figure B-21. Placement of Axial Gages at the Internal Skin of the Fuselage Panel Under Patch LJC3A

Table B-15. External Strain Gages Locations for LJC3A Patch

Strain Gage No.	Location	
S33	Exterior surface of large aluminum patch	0.5″ from the edge of top layer of LJC3A patch
S34	Exterior surface of large aluminum patch	0.5″ from the edge of top layer of LJC3A patch
S35	Exterior surface of large aluminum patch	9.75″ forward from the center of large notch
S36	Exterior surface of large aluminum patch	3.25″ forward from the center of large notch
S37	Exterior surface of large aluminum patch	3.25″ aft from the center of large notch

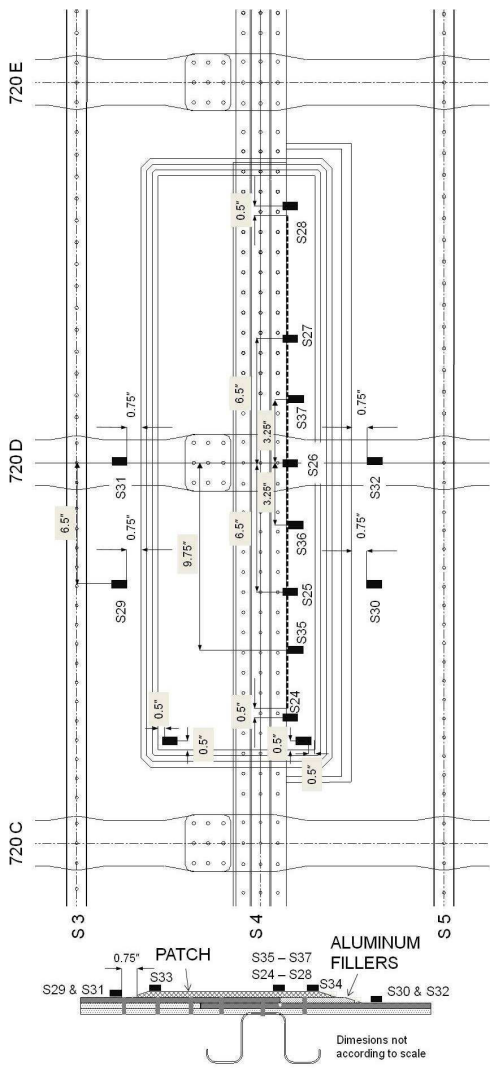


Figure B-22. Placement of Axial Gages for LJC3A Patch During Phase 4

APPENDIX C—PATCH INSTALLATION AND STRAINS MONITORED DURING CURING PROCESS

C.1 INTRODUCTION.

Patch installation procedure involves five steps, as discussed below.

1. Cleaning and preparing the surface

   a. The part surface areas and adjacent surfaces were solvent-cleaned. All contaminants were removed.

   b. All the surface coatings and residual adhesive residues were removed down to bare metal.

   c. The bare metal surface was solvent-cleaned. All contaminants were removed.

2. Grit blast deoxidization

   a. A region slightly larger than the bond area was grit-blasted. Figure C-1 shows the grit-blast procedure.

   b. Loose grit residue was removed with clean, dry compressed air or nitrogen.

Figure C-1. Grit Blasting the Patch Region

3. Application of sol-gel coating

a. Sol-gel solution was applied by brushing with a natural bristle brush, as shown in figure C-2. The surface was kept wet for a minimum of two minutes.

b. Sol-gel parts were left to dry under ambient conditions for a minimum of 60 minutes, as shown in figure C-3.

Figure C-2. Application of Sol-Gel Solution

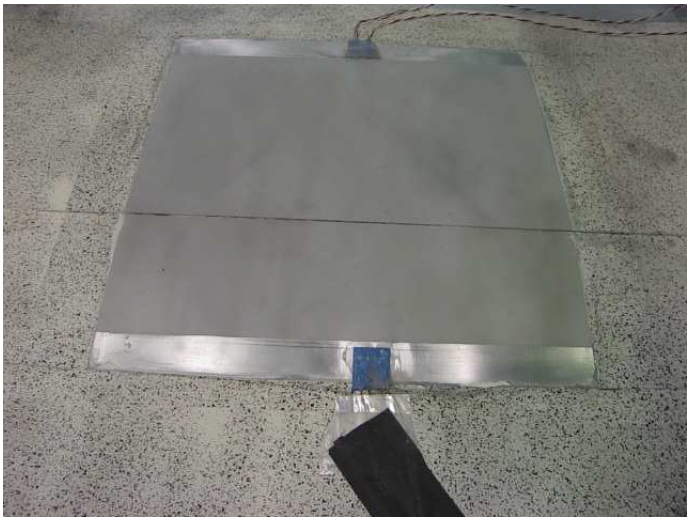


Figure C-3. Patch Region After Sol-Gel Application

4. Application of bond primer

a. Cytec Fiberite, Inc. adhesive primer was thoroughly mixed by agitation in the original container.

b. The primer was transferred to a reservoir with continued agitation during application.

c. The adhesive primer was applied to the bond surface to obtain a cured film thickness of 0.00015 to 0.00040 inch (0.15 to 0.40 mil). Figure C-4 shows the patch region just after application of bond primer.

d. Primed parts were allowed to dry at 135 F using a heat pump for 60 minutes before curing.

Figure C-4. Patch Region Just After Application of Bond Primer

5. Co-curing

The primer and adhesive were cured simultaneously.

a. The Henkel EA9696 OST (one tacky side) mat carrier, grade 10 film adhesive and patch were applied to the sol-gel-treated and primed surface using standard bond procedures, as shown in figure C-5.

b. Both the adhesive and primer were co-cured for 90 minutes at 250° ±10°F, as shown in figure C-6.

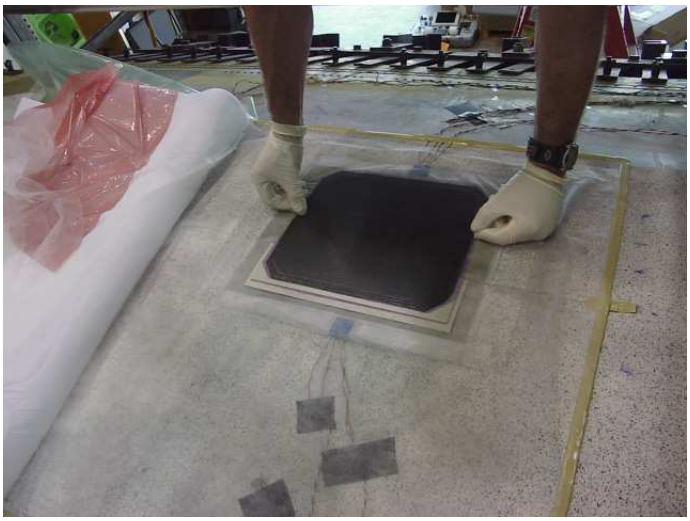


Figure C-5. Placement of Boron/Epoxy Patch

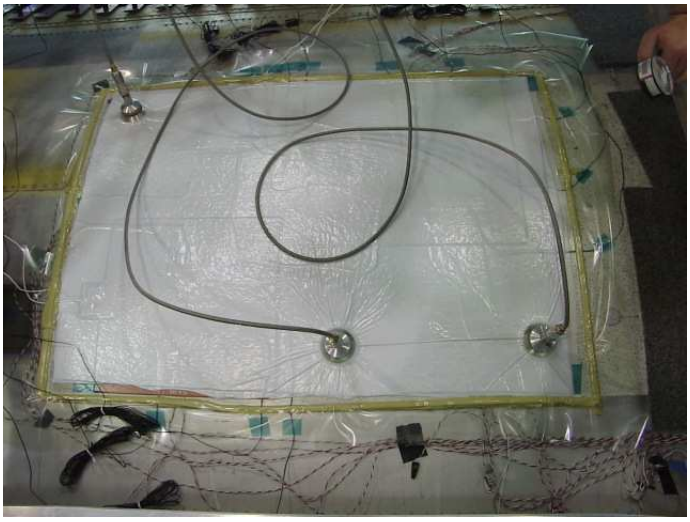


Figure C-6. Co-Cure

During the curing of the patches and adhesive, strain gages were installed on the exterior and the interior surfaces of the aluminum fuselage skin. The strains and the locations of the strain gages for each test phase are provided in the figures below.

C.2 PHASE 1.

Figure C-7 shows the strains during the curing process of C1BE patch region. The figure also shows the location of the strain gages during the curing process both on the exterior and interior surfaces of the fuselage panel. Similarly, figure C-8 shows the strain gage locations with strain readings for the S2BE patch.

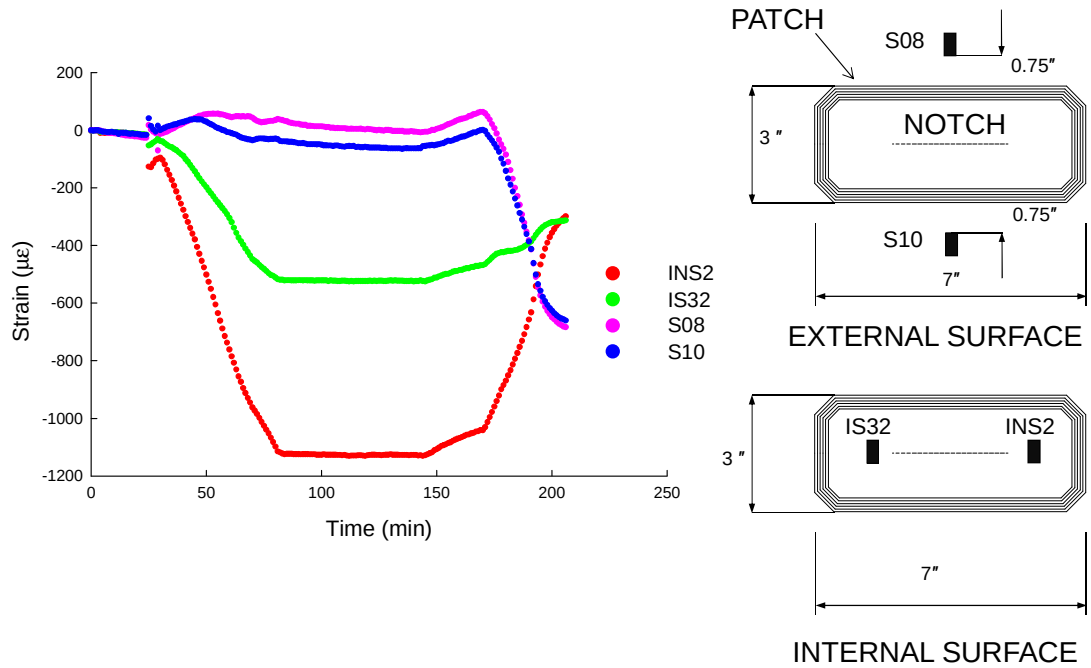


Figure C-7. Strains During Phase 1 C1BE Patch Curing

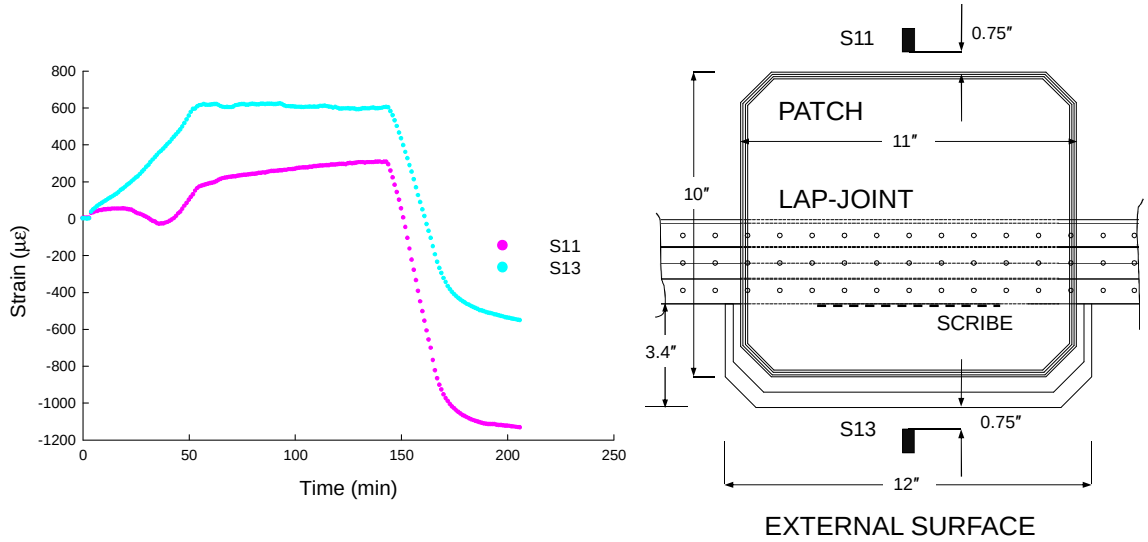


Figure C-8. Strains During Phase 1 S2BE Patch Curing

C.3 PHASE 2.

Figures C-9 and C-10 show the strain readings of the exterior and interior surfaces of the fuselage panel during the C1A patch curing process. The strain gage locations are also shown in these figures.

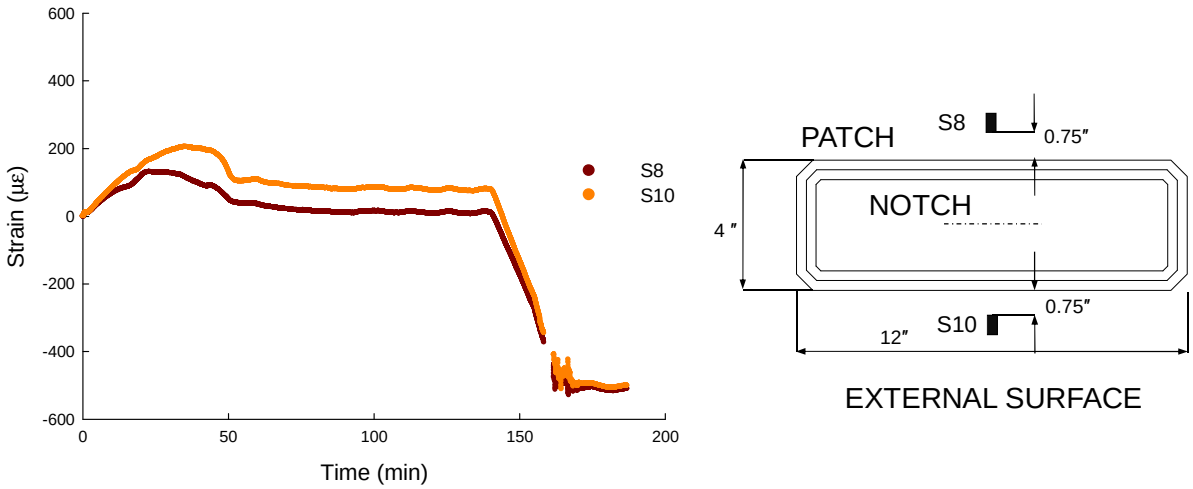


Figure C-9. Strains at the External Surface of Fuselage Skin Monitored During Phase 2 C1A Patch Curing

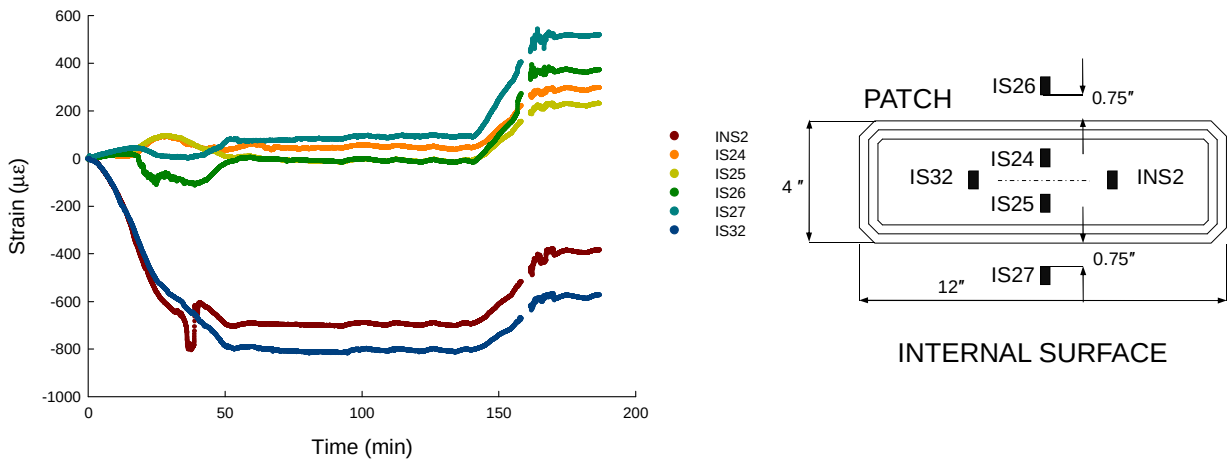


Figure C-10. Strains at the Internal Surface of Fuselage Skin Monitored During Phase 2 C1A Patch Curing

C.4 PHASE 3.

Figures C-11 and C-12 show the strain readings and strain gage locations for the interior and exterior surfaces of the fuselage skin around the LJC3A patch region.

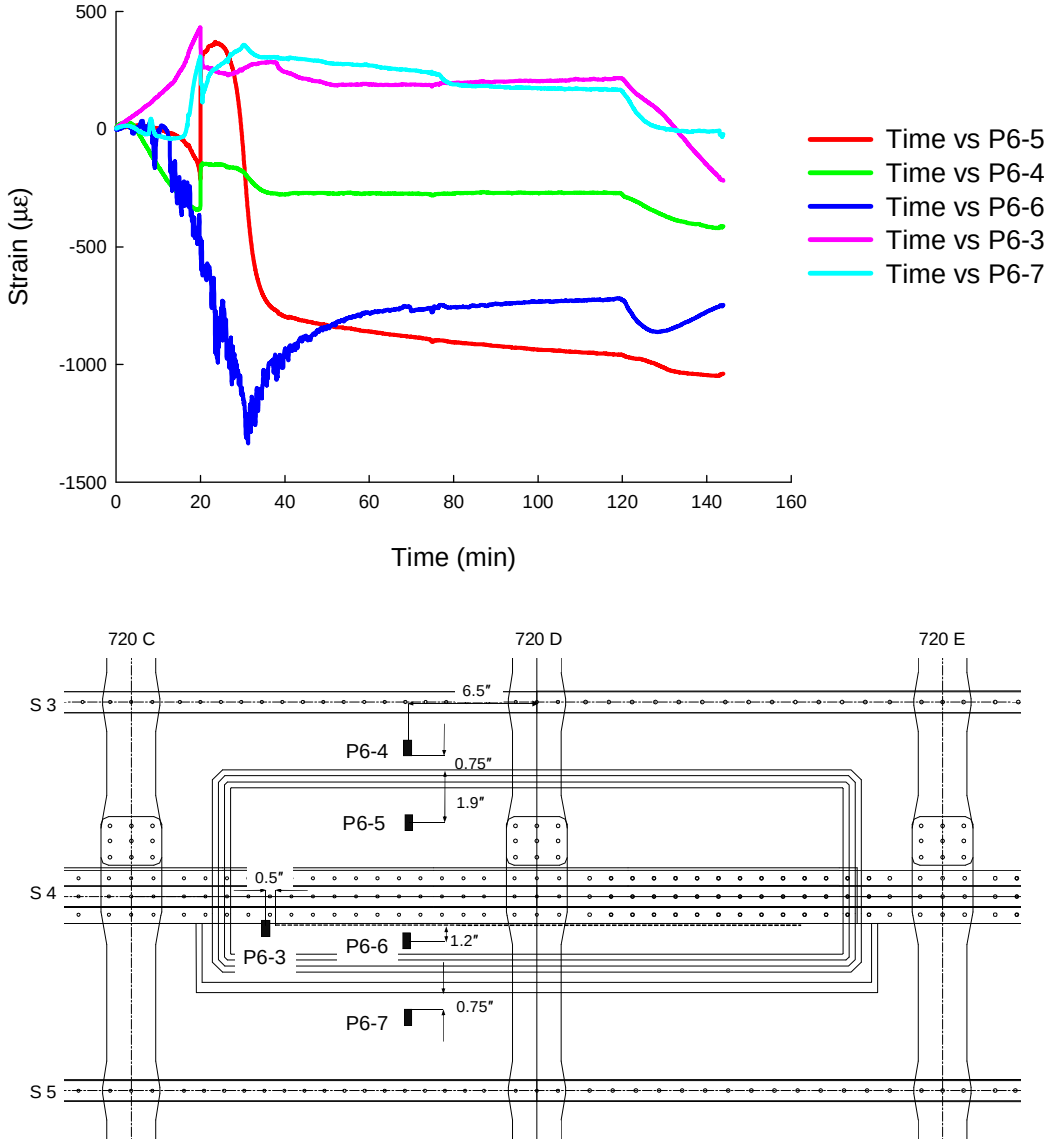
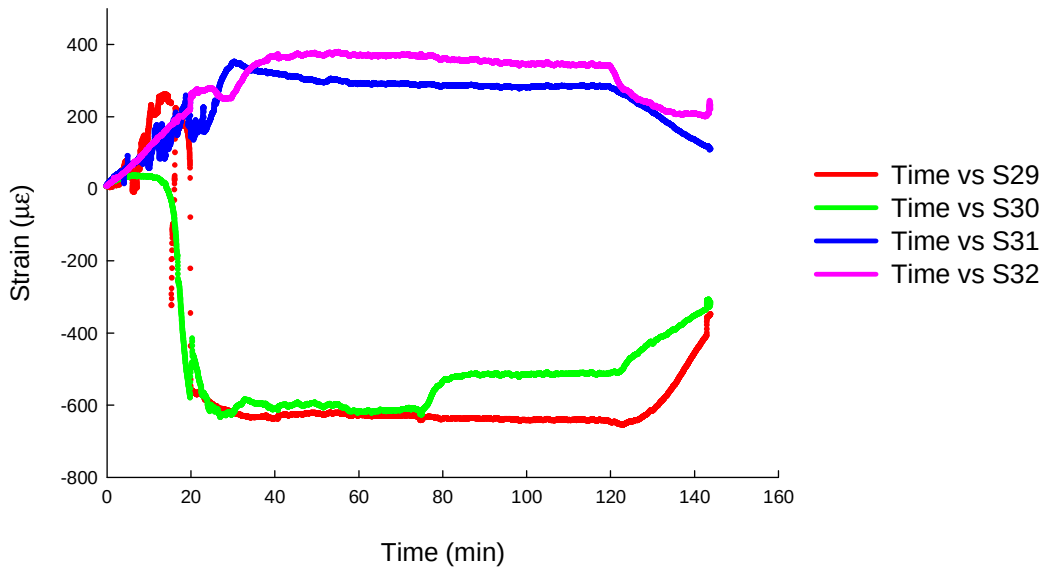


Figure C-11. Strains at the Internal Surface of Fuselage Skin Monitored During Phase 3 LJC3A Patch Curing



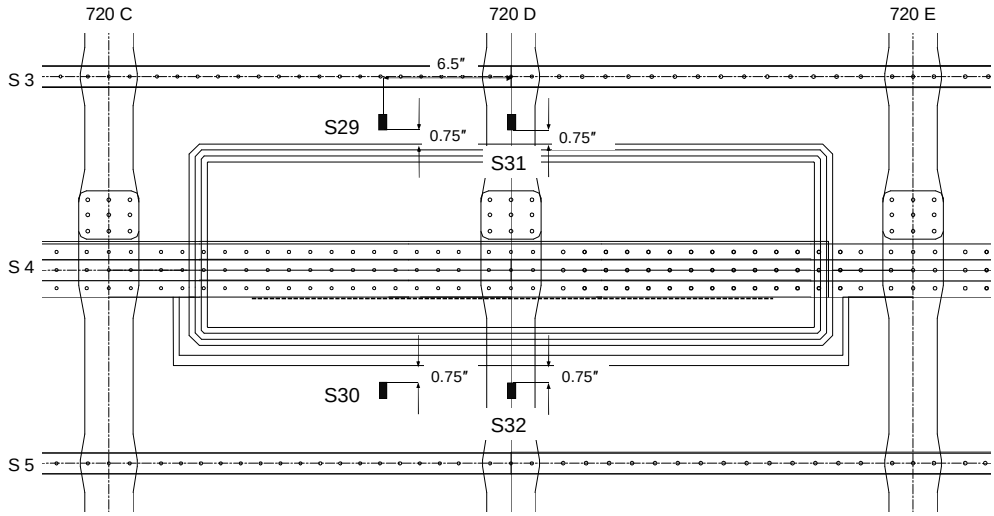


Figure C-12. Strains at External Surface of Fuselage Skin Monitored During Phase 3 LJC3A Patch Curing

APPENDIX D—RAW STRAIN GAGE DATA SUMMARY

D.1 INTRODUCTION.

The strain distribution was measured and predicted at ten equal load increments up to the maximum prescribed values for each test phase. The maximum values of the strain survey were 75% of the maximum fatigue loads to which the panel was subjected in each test phase.

The raw data from the strain survey for the strain gages in each phase is provided in the tables of this appendix. In these tables, for each load condition, applied loads and strains were measured at each gage at each of the ten equal load increments up to the maximum loads listed. For the applied loads, the pressure is in units of psi; the 12 frame load assemblies, frames 1 through 12, are measured in lb; the 14 hoop load assemblies, hoops 1 through 14, are measured in lb; and the longitudinal load assemblies, longitudinal 1 through 8, are measured in lb. The strains measured at the gages are in units of με.

For the entire test, the applied loads were within ±2% of the prescribed values listed in table D-1. Valid strain readings were obtained for most of the gages (with the exception of a few, particularly the substructure and internal skin gages, which short-circuited due to moisture absorption during panel pressurization using water). These gages show scattered readings or the values dropped as the test progressed with fatigue cycling.

Table D-1. Load Conditions for the Strain Survey

Phases	Maximum Load			
	Pressure (psi)	Hoop (lb)	Frame (lb)	Longitudinal (lb)
1	6.7	7,140	1133	6675
2	7.68	8,211	1303	6675
3	6.7	7,140	1133	6675
4	11.84	12,662	2008	8900

The strain survey was conducted every 5000 cycles and repeated three times to check the repeatability of the results. In this appendix, the data are provided for every 20,000 cycles in Phase 1 and 10,000 cycles in Phases 2 and 3 to avoid overcrowding the data. Because Phase 4 was the only static test, the data are only before the final failure of the panel. The details of the data for each test phase are provided below.

D.2 PHASE 1.

The readings of pressure, hoop loads, axial loads, frame loads, and strain gages for Phase 1 are provided in tables D-2 through D-13. Tables D-2 through D-4 show the three runs of the baseline raw strain survey data before starting the fatigue cycles. Similarly, tables D-5 through

D-7, D-8 through D-10, and D-11 through D-13 consist of the raw strain survey data after 20,000, 40,000, and 60,000 cycles, respectively.

D.3 PHASE 2.

Baseline strain survey data for Phase 2 are provided in tables D-14 through D-16. The strain survey data after 10,000 and 20,000 cycles are provided in tables D-17 through D-19 and D-20 through D-22, respectively.

D.4 PHASE 3.

Phase 3 baseline strain survey data are provided in tables D-23 through D-25 and strain survey data after 10,000 and 20,000 cycles are provided in tables D-26 through D-28 and D-29 through D-31, respectively.

D.5 PHASE 4.

During Phase 4, the strain survey was conducted with large aluminum repair (LJC3A) at room temperature, 220°F, and 250°F. Tables D-32 through D-34 provide the strain survey data for Phase 4. The maximum loads of strain survey in this phase were 1.15 and 1.33 times the service loads. These data are indicated by the orange columns. During this test phase, the LJC3A patch was heated; thus, the strain gages within the region of LJC3A patch were under high temperature. The strain readings obtained from these gages are shown in red.

Table D-2. Phase 1 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.03	0.70	1.35	1.98	2.68	3.35	4.01	4.64	5.35	6.03	6.65
Frame-1	-19.55	103.75	218.60	339.07	445.36	574.46	655.88	814.01	921.95	1020.59	1133.34
Frame-2	13.51	89.03	206.71	338.05	448.95	569.23	689.90	786.59	899.12	1017.16	1145.80
Frame-3	-20.57	128.14	217.12	343.37	438.20	567.82	668.76	783.89	912.34	1021.51	1143.70
Frame-4	-0.57	58.71	270.15	437.15	440.09	551.45	642.97	826.63	868.41	1030.46	1114.08
Frame-5	-15.33	104.16	207.01	325.22	449.15	569.38	681.80	786.43	903.83	1000.50	1129.10
Frame-6	3.21	88.42	210.93	340.29	446.92	561.00	673.89	762.37	906.32	1029.14	1131.03
Frame-7	22.81	93.09	221.69	336.02	455.63	560.08	667.71	799.05	905.31	1024.14	1144.73
Frame-8	-9.61	124.55	208.41	336.89	454.07	567.58	676.79	794.10	903.36	1033.48	1142.56
Frame-9	5.74	125.99	218.36	309.62	450.62	550.57	663.32	798.82	922.83	1021.19	1151.96
Frame-10	2.62	97.44	190.79	339.75	441.43	565.20	676.45	776.70	898.03	1014.52	1145.44
Frame-11	4.38	98.54	212.34	330.96	455.09	548.40	661.61	809.94	908.16	1004.29	1142.99
Frame-12	15.00	125.94	201.59	331.31	449.71	559.81	676.32	780.98	914.49	1018.23	1129.98
Hoop-1	-28.14	712.02	1448.72	2245.07	2844.18	3549.66	4318.24	4950.44	5698.49	6457.52	7182.24
Hoop-2	22.37	711.43	1443.99	2084.59	2863.82	3574.62	4257.66	4977.80	5745.97	6420.17	7150.58
Hoop-3	109.14	671.25	1346.56	2078.73	2858.18	3571.47	4280.44	4954.17	5731.60	6409.47	7145.18
Hoop-4	-49.72	714.07	1467.37	2118.37	2853.48	3575.64	4309.68	4832.13	5734.28	6455.73	7134.10
Hoop-5	-12.32	718.13	1443.60	2152.45	2856.32	3570.79	4270.00	4956.02	5719.00	6423.75	7145.27
Hoop-6	-11.19	709.36	1425.19	2137.16	2858.13	3572.03	4283.36	4932.41	5725.16	6417.76	7174.41
Hoop-7	5.30	723.63	1447.75	2149.99	2845.52	3574.79	4272.82	4982.78	5722.70	6435.18	7160.73
Hoop-8	-16.09	713.75	1428.71	2136.58	2844.02	3558.70	4267.56	5004.85	5720.59	6419.81	7135.61
Hoop-9	32.95	702.19	1428.70	2135.76	2829.84	3566.84	4292.83	4962.14	5716.36	6414.96	7178.22
Hoop-10	-8.79	710.00	1428.66	2147.60	2853.69	3566.74	4277.80	4986.02	5726.76	6424.90	7158.60
Hoop-11	-28.97	702.21	1433.25	2139.11	2837.27	3549.84	4254.86	4942.46	5723.40	6413.43	7179.88
Hoop-12	-25.46	717.28	1456.06	2135.94	2861.21	3555.80	4251.94	4977.57	5734.32	6443.46	7169.74
Hoop-13	-2.38	706.19	1385.39	2167.14	2846.20	3568.94	4249.42	4979.97	5725.70	6418.51	7186.22
Hoop-14	-4.89	713.88	1417.84	2136.75	2855.24	3566.25	4264.16	4983.00	5687.74	6434.72	7176.21
Long-1	25.46	676.35	1377.37	1989.11	2677.59	3325.98	4003.34	4694.89	5350.30	6008.57	6687.60
Long-2	-26.79	567.58	1384.10	1999.60	2668.77	3342.70	3983.44	4641.50	5339.04	6022.87	6689.04
Long-3	6.36	652.00	1340.40	2009.25	2675.93	3334.43	3997.12	4663.93	5341.84	6036.96	6675.24
Long-4	-6.48	622.56	1352.96	2002.55	2669.28	3320.68	4016.00	4694.92	5319.73	6009.77	6695.39
Long-5	16.56	680.47	1322.15	2023.80	2672.74	3339.65	3961.18	4644.39	5294.77	6013.55	6646.77
Long-6	-7.82	697.76	1333.51	2021.38	2657.32	3336.29	3977.84	4651.86	5337.89	6002.69	6676.18
Long-7	-0.08	677.20	1330.30	1989.41	2671.89	3338.91	4021.06	4656.25	5374.26	6006.08	6693.05
Long-8	-25.52	705.17	1313.81	1959.16	2692.55	3346.79	4008.68	4655.61	5310.97	6010.36	6679.29
S1-H	-211.93	93.67	234.18	339.07	440.43	532.03	615.37	690.01	776.39	855.28	927.19
S1-A	-31.03	-0.97	26.11	51.52	75.42	97.44	122.11	149.40	174.40	200.00	224.98
S2-H	-152.47	31.61	144.28	231.82	315.75	393.65	463.69	528.30	601.50	667.42	730.52
S2-A	39.40	63.49	86.82	109.80	133.68	154.93	176.43	200.15	225.12	251.65	275.12
S3-H	-145.60	-33.16	58.46	130.74	193.30	246.14	300.57	354.24	413.75	474.13	523.19
S3-A	2673.47	2674.01	2702.33	2718.52	2746.57	2768.38	2792.78	2813.94	2844.67	2877.01	2894.32
S4-H	-84.14	9.61	86.93	154.95	223.68	289.37	348.09	401.18	465.16	520.87	573.44
S4-A	-0.54	27.96	42.68	61.33	82.75	100.24	122.44	139.22	161.55	188.58	213.88
S5	73.60	236.12	376.15	500.87	625.18	737.07	837.02	933.33	1043.89	1138.81	1223.41
S6	-105.81	41.15	252.88	474.17	755.73	1022.59	1278.21	1515.58	1817.23	2085.20	2343.06
S7	-192.69	5.80	145.97	259.29	370.54	471.36	562.55	640.07	733.75	816.38	891.65
S8	-36.35	151.98	301.58	426.85	550.90	662.10	760.16	843.03	942.11	1027.46	1102.62
S9	5145.10	5004.70	4893.83	4802.40	4718.75	4631.82	4570.20	4513.78	4458.87	4428.04	4362.48

Table D-2. Phase 1 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S10	-74.70	85.56	227.83	348.26	468.19	575.70	671.27	755.38	850.32	932.62	1006.10
S11	-229.14	134.48	400.02	610.78	809.16	979.67	1126.47	1254.87	1393.36	1510.92	1616.31
S12	6.18	-24.48	-32.10	-33.55	-30.10	-24.47	-18.31	-14.68	-2.34	8.00	18.52
S13	-183.82	146.22	365.54	533.04	686.60	816.63	925.19	1015.72	1119.37	1211.36	1293.90
S14	66.85	169.88	302.37	383.25	474.22	539.46	618.74	740.59	772.83	840.80	916.88
S15	-48.58	-8.40	23.11	51.08	81.09	108.94	136.11	158.27	189.38	216.18	241.23
S16	-70.00	15.56	89.75	161.39	236.39	309.62	375.05	434.61	503.18	567.06	625.90
S17	-7665.53	-7575.57	-7482.63	-7401.33	-7317.08	-7238.65	-7166.76	-7105.74	-7031.71	-6968.51	-6910.48
S18	-4262.55	-4435.57	-4594.67	-4737.28	-4888.65	-5032.96	-5169.10	-5294.59	-5443.91	-5581.77	-5697.61
S19	-57.77	13.65	79.40	138.50	201.89	262.09	317.36	369.75	429.39	481.42	530.12
S21	263.66	309.83	361.34	415.39	484.19	542.04	600.87	648.65	723.61	790.80	849.04
S22	-27.32	27.35	71.68	106.94	145.44	178.43	210.94	237.76	275.27	306.59	333.27
S23	-40.33	-55.39	-47.87	-31.91	-1.62	26.27	56.37	79.87	117.47	147.40	178.19
INS1	-3.44	48.21	91.91	131.25	176.19	219.15	261.73	298.80	346.49	387.75	426.76
INS2	2168.58	4940.39	5327.86	5361.96	5118.49	-1101.55	4270.08	5069.09	-1019.97	5693.89	1600.67
INS3	31.82	62.75	87.75	111.45	135.17	158.66	182.91	201.26	228.14	251.45	271.39
INS4	-33.15	35.49	109.91	177.30	253.72	324.48	393.84	457.48	537.72	605.59	668.53
INS5	24781.16	26064.94	22479.70	22266.21	22040.08	21964.54	21955.65	21978.59	21903.67	22052.72	21997.93
IS24	-101.54	-19.88	57.47	102.95	136.45	185.87	226.85	246.43	68.52	-8.83	-111.88
IS25											
IS26											
IS27											
IS28											
IS29											
IS30											
IS31											
IS32											
F01	48.80	34.51	31.08	33.43	26.37	22.57	24.20	20.58	21.66	18.04	23.29
F02	-879.89	-697.83	-576.29	-452.61	-329.74	-204.33	-119.77	-13.07	57.58	139.29	222.40
F03	830.69	698.70	651.69	614.75	563.70	532.67	532.24	529.94	529.65	534.77	537.73
F04	-708.57	-551.29	-432.89	-324.18	-228.39	-125.32	-47.98	52.76	116.90	199.43	270.85
F05	701.93	613.32	579.15	568.06	549.20	551.62	569.99	591.74	602.29	619.34	639.64
F06	-506.61	-394.13	-320.46	-237.08	-150.72	-63.52	2.87	87.08	149.79	224.30	290.00
F07	23.10	9.55	8.55	7.79	8.42	8.78	11.90	14.52	17.46	23.65	31.38
F08	-280.24	-212.91	-165.27	-117.29	-60.58	-6.05	36.34	82.54	131.62	181.63	228.68
F09	133.28	113.93	93.29	88.78	62.88	48.57	47.67	48.04	48.39	52.56	54.90
F10	-741.50	-571.36	-446.15	-328.26	-232.63	-123.91	-46.15	57.64	127.42	215.22	288.41
F11	54.52	44.93	31.34	28.45	20.43	18.38	22.37	27.72	30.93	36.05	43.79
F12											
L01											
L02	51.29	54.38	60.19	66.19	67.81	71.25	74.71	79.43	82.14	87.04	90.65
L03	39.24	30.24	39.23	51.12	69.65	86.73	108.54	118.25	151.93	177.81	202.31
L04	42.95	51.41	64.38	80.59	99.87	115.52	134.61	148.49	173.54	198.20	218.69
L05	-1.76	8.40	12.75	22.19	29.44	35.97	43.96	51.22	60.64	68.63	78.78
L06	54.92	53.65	53.47	64.75	67.65	73.27	80.74	83.29	84.18	87.28	89.80
L07	7.11	21.04	28.82	36.06	45.47	50.71	58.14	63.21	77.13	91.98	105.53

Note: Strain gages INS2, INS5, F01, F12, L01, and S6 show faulty readings. Strain gages IS25 through IS32 were installed after 40,000 fatigue cycles.

Table D-3. Phase 1 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.02	0.68	1.30	2.00	2.70	3.32	4.02	4.71	5.36	5.98	6.69
Frame-1	0.50	111.52	229.72	339.52	453.90	577.72	691.17	792.67	923.37	1020.45	1119.38
Frame-2	23.44	112.93	219.26	338.49	450.83	557.78	674.10	781.92	897.26	1018.66	1132.09
Frame-3	-6.67	121.55	230.44	342.25	452.19	570.83	670.74	807.00	913.64	1025.98	1123.19
Frame-4	-53.24	139.03	199.81	333.45	455.86	598.03	666.74	808.15	908.58	1016.37	1142.93
Frame-5	2.87	106.90	216.30	338.79	437.95	566.01	675.73	790.00	900.33	1018.34	1139.92
Frame-6	14.24	106.62	238.55	353.13	442.47	568.76	674.34	796.71	896.75	1027.52	1144.34
Frame-7	21.57	98.48	215.31	347.86	443.85	567.14	695.96	790.48	903.84	1028.40	1117.80
Frame-8	4.36	114.95	221.62	343.18	479.89	559.73	697.24	791.16	910.97	1019.65	1123.46
Frame-9	8.74	113.01	244.37	347.50	451.90	562.92	641.53	790.59	900.47	1008.52	1117.78
Frame-10	25.55	101.26	234.19	347.05	445.59	563.53	671.33	798.23	899.44	1020.03	1129.19
Frame-11	18.19	111.67	225.33	331.16	451.95	563.26	686.35	787.49	888.52	1028.31	1121.14
Frame-12	12.15	96.30	250.16	360.69	440.37	558.04	679.99	787.30	906.79	1028.86	1101.59
Hoop-1	-12.63	716.03	1353.62	2161.31	2845.55	3537.33	4262.90	5023.58	5659.17	6447.83	7158.98
Hoop-2	36.72	690.04	1429.49	2121.86	2870.42	3568.53	4269.28	4984.48	5696.94	6328.65	7206.21
Hoop-3	126.46	726.91	1445.34	2140.78	2866.29	3565.55	4234.43	4827.01	5711.94	6385.18	7082.71
Hoop-4	-36.98	694.20	1430.84	2139.77	2860.19	3565.84	4254.15	4958.95	5711.89	6392.08	7137.74
Hoop-5	-5.12	712.87	1425.46	2150.22	2862.95	3570.08	4288.85	4980.72	5704.04	6423.75	7154.26
Hoop-6	2.54	711.22	1416.47	2135.02	2847.27	3566.17	4296.22	5007.41	5697.14	6422.91	7157.25
Hoop-7	3.51	718.41	1422.58	2145.99	2850.31	3583.01	4271.88	5043.05	5709.63	6422.67	7164.30
Hoop-8	6.02	706.38	1406.74	2144.17	2859.62	3573.80	4296.62	4990.10	5696.77	6427.82	7142.99
Hoop-9	11.41	703.98	1414.49	2159.30	2852.22	3572.57	4310.35	4985.47	5691.33	6415.60	7140.53
Hoop-10	-1.69	715.33	1430.58	2144.26	2861.64	3572.42	4293.35	4994.89	5694.88	6425.53	7149.73
Hoop-11	-25.33	704.03	1427.93	2139.32	2849.03	3573.83	4301.73	4980.66	5685.32	6419.52	7147.14
Hoop-12	-10.18	703.92	1427.57	2166.71	2854.43	3563.79	4381.35	5000.48	5702.06	6444.11	7169.74
Hoop-13	4.93	706.19	1414.75	2152.74	2854.35	3569.30	4300.13	5009.19	5687.47	6426.45	7149.70
Hoop-14	17.11	706.55	1417.98	2151.64	2841.42	3573.94	4322.41	5027.01	5708.04	6428.02	7139.53
Long-1	24.48	662.56	1355.67	2025.18	2666.00	3340.69	4006.28	4663.57	5334.98	6006.99	6680.11
Long-2	139.02	663.06	1275.76	1969.90	2624.42	3335.68	4043.86	4677.10	5334.63	6004.00	6672.10
Long-3	7.58	662.90	1317.12	2009.05	2658.08	3334.43	3989.81	4667.88	5336.59	6011.99	6670.48
Long-4	1.95	692.38	1282.93	2019.22	2737.16	3319.48	4038.90	4678.32	5339.83	6030.86	6675.03
Long-5	21.26	674.52	1317.31	1970.62	2696.66	3349.06	4029.46	4671.71	5352.04	6000.00	6638.68
Long-6	13.52	695.32	1271.71	1948.84	2687.36	3392.02	3987.32	4665.17	5338.67	6030.55	6671.58
Long-7	12.08	654.03	1319.22	1991.64	2677.17	3334.05	4001.60	4671.13	5336.18	6000.62	6665.19
Long-8	26.68	716.96	1293.51	1962.52	2630.08	3329.00	4030.03	4717.54	5330.74	6007.39	6694.85
S1-H	-202.70	95.85	229.50	346.10	445.00	529.15	617.31	699.76	778.52	849.79	932.59
S1-A	-30.48	-2.09	24.43	50.57	72.99	97.07	122.66	148.05	173.11	198.11	220.92
S2-H	-146.72	32.91	140.17	236.79	318.89	389.55	464.77	535.22	601.75	663.43	733.65
S2-A	38.48	66.28	87.56	110.88	131.24	156.05	178.28	202.71	226.08	251.07	273.31
S3-H	-127.01	-39.86	44.30	114.31	187.32	240.18	300.54	360.09	413.05	455.46	521.06
S3-A	2652.39	2661.82	2680.45	2700.57	2723.20	2746.02	2775.36	2801.91	2827.07	2856.60	2885.21
S4-H	-89.57	0.64	74.60	152.10	220.85	281.90	344.50	403.30	462.41	523.06	572.62
S4-A	3.93	32.43	46.78	66.34	86.65	107.88	127.64	144.02	166.78	192.29	215.79
S5	82.09	253.59	388.26	523.88	644.65	749.03	852.70	949.90	1047.08	1129.63	1225.10
S6	-105.83	53.51	260.86	511.13	768.75	1022.59	1291.18	1555.87	1831.97	2076.26	2347.17
S7	-196.18	1.26	134.87	262.49	371.05	464.45	561.77	649.15	734.01	809.20	894.74
S8	-44.63	143.87	287.28	429.00	549.74	651.81	757.61	852.20	942.66	1020.96	1108.10
S9	5118.42	4979.33	4882.68	4792.43	4699.09	4652.43	4559.08	4498.22	4435.15	4379.27	4347.01

Table D-3. Phase 1 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S10	-80.35	79.97	216.43	352.51	469.05	568.62	672.11	765.13	850.95	925.63	1011.38
S11	-228.91	129.16	384.33	621.08	815.47	972.68	1129.04	1269.19	1395.04	1503.69	1622.26
S12	4.37	-21.75	-29.92	-30.64	-27.92	-23.02	-17.94	-11.41	-1.25	6.91	19.79
S13	-178.77	145.30	356.43	543.59	691.98	813.18	928.73	1029.03	1123.84	1205.06	1296.70
S14	60.68	199.89	261.21	402.79	490.01	565.12	640.52	719.44	786.02	923.89	983.87
S15	-52.14	-9.67	20.15	52.16	80.99	107.39	134.50	161.17	188.44	211.66	242.51
S16	-70.78	12.29	85.57	165.06	238.32	304.64	375.46	441.46	505.50	563.19	629.16
S17	-7745.48	-7644.51	-7555.21	-7463.00	-7380.25	-7309.81	-7234.29	-7166.05	-7099.22	-7040.42	-6972.14
S18	-4282.29	-4443.12	-4588.40	-4747.48	-4903.42	-5038.04	-5183.84	-5324.24	-5465.53	-5586.30	-5730.72
S19	-57.92	10.56	75.94	141.51	203.77	258.82	318.24	374.64	429.48	476.60	532.73
S21	272.10	315.74	371.01	430.14	492.85	552.74	608.25	664.59	731.84	790.17	857.37
S22	-28.41	27.17	68.04	110.00	147.06	177.75	210.64	243.00	275.43	302.92	337.79
S23	-42.18	-57.40	-47.13	-26.94	-2.54	23.33	53.24	83.70	116.20	145.00	180.80
INS1	-4.09	45.83	89.06	133.31	177.53	217.06	261.61	303.18	346.24	384.97	427.82
INS2	4199.94	-1251.14	-1221.24	-1192.49	5241.27	-1135.21	3686.24	3069.14	3768.81	3926.95	4292.10
INS3	33.49	63.85	89.04	115.15	140.13	161.81	186.25	208.82	231.59	254.20	279.22
INS4	-32.25	34.77	104.49	179.62	253.83	321.41	392.76	465.32	537.74	599.23	673.16
INS5	15394.42	14470.91	14546.47	14564.26	14702.15	17621.03	18525.31	18229.97	27182.95	29756.18	23120.17
IS24	-862.40	-336.46	-289.00	-220.36	-186.33	-143.57	-81.28	-1.94	174.68	53.30	154.93
IS25											
IS26											
IS27											
IS28											
IS29											
IS30											
IS31											
IS32											
F01	43.75	34.87	26.37	26.73	25.64	23.65	21.30	17.14	17.86	18.59	19.13
F02	-856.51	-700.71	-572.56	-421.23	-323.18	-219.55	-111.61	-6.73	73.16	140.91	218.82
F03	809.34	717.61	636.98	574.25	567.98	552.74	537.06	530.68	524.46	531.46	543.99
F04	-693.30	-552.96	-437.50	-310.88	-223.48	-131.01	-36.59	60.29	135.45	196.24	273.12
F05	688.15	615.78	579.46	548.73	561.08	559.39	577.89	589.76	589.51	617.83	627.66
F06	-490.84	-399.56	-315.32	-217.53	-147.68	-72.83	12.27	94.83	162.28	218.67	283.60
F07	28.26	16.73	14.61	13.75	13.03	12.71	16.78	19.94	24.38	29.21	33.55
F08	-273.41	-216.88	-166.70	-106.93	-63.11	-15.11	38.15	88.50	136.52	176.72	227.64
F09	125.70	108.85	88.21	76.26	70.30	66.13	52.37	46.94	44.95	50.92	61.79
F10	-720.93	-561.49	-447.19	-311.27	-220.61	-122.28	-26.70	74.89	149.42	213.20	292.46
F11	55.71	43.97	32.29	22.82	23.32	21.37	23.46	26.13	26.31	35.37	39.18
F12											
L01											
L02	53.48	58.91	62.18	65.44	68.35	74.87	76.88	80.86	83.78	89.21	91.58
L03	41.39	28.80	35.82	49.68	66.79	85.66	106.72	125.81	152.42	179.81	203.21
L04	40.07	43.48	54.83	71.40	91.56	112.46	132.63	152.60	177.09	201.06	218.91
L05	-5.39	7.67	12.02	20.01	29.44	36.69	42.50	49.03	58.47	69.35	77.34
L06	50.38	49.65	54.56	62.19	70.01	69.27	74.91	78.90	78.74	86.00	89.28
L07	9.64	14.89	19.41	26.28	33.70	44.56	53.79	65.36	78.22	93.41	104.82

Note: Strain gages INS2, INS5, F01, F12, L01, and S6 show faulty readings. Strain gages IS25 through IS32 were installed after 40,000 fatigue cycles.

Table D-4. Phase 1 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.0345574	0.6657251	1.3619796	1.9977118	2.6756461	3.347656	4.0230284	4.6397023	5.3235946	6.0115952	6.7350163
Frame-1	3.9533172	99.671715	227.32936	322.24332	446.36014	569.73785	692.86719	814.17102	903.96991	1014.9773	1119.9264
Frame-2	-10.613256	112.69753	223.42305	336.17621	438.54041	569.48132	682.27118	803.03564	904.25336	1037.6962	1121.235
Frame-3	-0.4376532	119.80356	223.63959	361.4743	460.52072	574.16626	686.05469	793.21198	897.29327	1019.3972	1129.7997
Frame-4	-68.685188	117.06145	261.23868	318.81332	422.38824	528.38074	671.43207	820.57086	909.06329	1029.8673	1110.7891
Frame-5	3.0728936	118.11677	209.0903	329.90057	458.32986	553.2395	670.85303	806.26477	928.63019	1012.9624	1122.4879
Frame-6	-2.8212545	84.640289	220.66486	332.25848	449.42508	565.90503	683.70587	837.20929	905.0401	1006.7781	1129.2317
Frame-7	-13.269528	121.57513	223.3511	338.60117	447.43475	561.61188	673.78766	790.55334	902.82465	1038.1726	1121.1312
Frame-8	1.3959031	117.78268	223.88936	335.00729	456.16669	561.54578	677.04517	806.57373	920.63782	1040.5607	1117.7496
Frame-9	-3.7064302	111.40456	192.02611	327.45621	435.78668	561.80426	681.71484	783.69562	888.33759	1026.2593	1101.4117
Frame-10	-8.3150158	113.79383	215.12584	322.41434	439.11411	572.36383	679.54266	805.31451	909.75842	1032.4205	1126.8126
Frame-11	7.7810979	100.86676	224.62733	330.62625	449.61581	557.53381	692.06091	799.6236	917.64764	1017.3101	1138.1918
Frame-12	-15.350768	108.35073	223.30814	330.96387	462.57642	559.88519	688.87659	793.52185	913.39789	1042.2379	1123.5367
Hoop-1	-1.0047299	700.461	1413.694	2107.2681	2841.3931	3604.791	4329.4375	4931.0615	5674.6675	6422.6182	7180.2998
Hoop-2	33.133991	709.70721	1465.386	2165.1401	2771.4443	3534.0801	4271.5933	4990.3608	5732.835	6413.1133	7199.0356
Hoop-3	117.78905	718.16443	1473.1034	2151.4023	2871.2063	3561.7292	4276.542	4962.8472	5753.5845	6352.373	7171.2061
Hoop-4	-0.6073527	674.12561	1472.6758	2156.3557	2861.7219	3552.7544	4272.8828	4990.3672	5804.6426	6415.8174	7212.3066
Hoop-5	3.8793366	714.59985	1432.6597	2143.2373	2853.6736	3564.3232	4285.7671	4984.8145	5750.8169	6427.4692	7157.8628
Hoop-6	-7.7536535	712.8642	1430.1936	2140.3752	2862.425	3558.9539	4267.4917	4973.5874	5762.3418	6416.2446	7138.3804
Hoop-7	5.2943692	712.97498	1436.8817	2144.4187	2864.3235	3557.6382	4290.2642	5002.4429	5704.2642	6435.3096	7175.0239
Hoop-8	20.770197	706.45136	1413.827	2136.5801	2859.0518	3559.7612	4274.9316	4966.501	5711.5093	6412.4326	7164.3931
Hoop-9	-10.115664	713.02313	1435.7343	2119.6152	2840.8887	3567.9001	4271.3018	4983.9814	5714.6494	6409.5786	7155.9712
Hoop-10	10.728593	720.72461	1432.067	2145.8259	2859.2998	3567.8044	4295.5493	4988.0801	5709.0781	6428.4443	7164.9907
Hoop-11	-3.5098317	745.93475	1422.1935	2193.6731	2872.1079	3563.6294	4280.3315	4980.9941	5687.1377	6437.0737	7133.6973
Hoop-12	5.0903931	728.81171	1440.6451	2128.3027	3060.0723	3549.2224	4274.8525	4968.4468	5663.8804	6435.8271	7169.0229
Hoop-13	19.538805	772.00586	1524.016	2137.9189	2853.7854	3577.3125	4285.9448	4963.873	5694.77	6433.1177	7156.2886
Hoop-14	-4.8919916	721.28601	1425.0337	2114.7515	2855.5266	3567.3188	4293.4976	4981.5132	5810.7144	6427.3823	7138.8198
Long-1	22.51305	675.36682	1369.5254	2008.3173	2685.875	3333.4937	3999.4202	4670.3809	5339.4321	6007.2026	6674.8589
Long-2	64.541428	719.33533	1316.6438	2018.8735	2664.0259	3332.5332	3993.2727	4663.9805	5361.8628	6005.1992	6682.0137
Long-3	0.2712086	666.61621	1331.8755	2012.5059	2661.9966	3336.5369	4003.2136	4679.7695	5389.5034	6009.5352	6687.4189
Long-4	-1.6626748	609.30206	1301.1354	1974.4375	2653.082	3338.4285	4001.5432	4670.8154	5342.7739	6004.3408	6650.8062
Long-5	18.908369	628.67328	1324.5	2036.3406	2645.1292	3307.5349	4001.2046	4659.6943	5356.1025	6007.0845	6711.5103
Long-6	6.4057603	678.78632	1302.6758	2039.9452	2679.324	3344.2561	3989.6941	4680.3276	5314.2944	6016.332	6671.4351
Long-7	5.9983969	666.25879	1313.2738	2019.408	2677.4368	3315.4797	4005.252	4656.2476	5329.4194	6027.3569	6682.105
Long-8	-0.6069295	620.95068	1335.1632	2050.092	2696.7637	3335.782	4011.0498	4678.1475	5324.1494	6044.1768	6655.5664
S1-H	-155.69519	97.399063	243.04678	345.43274	444.95355	536.18488	622.10718	697.784	777.06207	855.85126	940.87921
S1-A	-33.277527	-1.158307	26.85286	55.803192	79.148071	98.757767	122.84969	147.68863	174.56445	202.94899	226.08218
S2-H	-121.52711	34.597153	149.67915	234.38463	317.95584	393.69229	465.8844	531.36096	598.27002	666.72437	739.58142
S2-A	32.126347	56.39397	79.717155	104.17619	125.08091	147.10553	168.01025	189.47491	217.26393	244.13873	267.4408
S3-H	-113.58985	-20.495	59.19799	127.73009	202.9599	259.56848	319.15646	376.50989	429.35126	487.44373	541.75812
S3-A	2640.2063	2646.4326	2661.8169	2685.1865	2703.073	2727.6667	2752.2607	2779.0903	2803.4036	2826.5044	2845.5947
S4-H	-81.159569	3.8169394	86.738312	153.8008	225.33731	285.48029	347.49103	402.03064	459.32596	517.03497	577.30096
S4-A	14.919542	39.141701	55.717964	76.590576	94.290291	116.2752	136.21066	150.74307	174.94623	200.84111	226.1545
S5	95.313332	252.88924	398.99585	517.13123	640.93665	747.20441	850.61725	945.64648	1046.5074	1137.6757	1233.9767
S6	-125.45957	49.153149	263.77032	498.08563	758.56836	1024.8718	1289.7202	1526.192	1798.1365	2082.6016	2364.6477
S7	-170.35127	3.9839375	149.41403	261.05808	371.95993	471.04437	564.31097	643.94214	729.31818	813.48608	902.29016
S8	-16.231256	150.38149	305.71433	429.96249	553.63123	661.20111	760.40137	846.42981	938.0813	1024.8785	1113.8052
S9	5069.5796	4933.6279	4817.2983	4718.9902	4620.9106	4566.896	4510.0381	4449.627	4390.1978	4326.2393	4273.9341

Table D-4. Phase 1 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S10	-57.882732	83.38488	232.43817	350.37073	470.68451	575.75488	672.84064	759.94562	846.42151	930.25171	1016.8834
S11	-187.27824	131.938	410.28583	619.54968	815.74713	982.98926	1132.0775	1260.652	1387.9076	1507.5293	1629.3478
S12	0.0155003	-23.75005	-27.91984	-31.73238	-28.10405	-22.84297	-12.32082	-9.236737	0.7410936	10.899399	23.7763
S13	-132.46022	158.56352	387.46902	552.90686	703.23663	829.41925	941.98505	1034.2163	1130.5104	1222.3694	1314.0969
S14	60.488998	129.47209	259.02838	327.48535	439.23178	510.5748	570.81598	650.53082	731.44653	810.9715	906.05597
S15	-48.632107	-11.99132	23.378942	51.070122	81.714249	109.03936	137.81938	160.05229	186.26758	213.81726	245.70667
S16	-58.677761	14.648894	93.864014	165.03043	238.4536	309.65594	378.5015	437.91989	502.18289	567.48669	635.40076
S17	-7795.5327	-7700.465	-7600.226	-7516.756	-7431.074	-7352.653	-7276.41	-7214.69	-7144.993	-7080.375	-7009.247
S18	-4308.7378	-4461.728	-4627.625	-4769.024	-4918.676	-5062.517	-5200.546	-5333.49	-5470.972	-5599.544	-5745.701
S19	-49.190292	11.741148	80.848793	139.47575	201.36638	260.43967	318.2406	370.86127	426.71097	479.05374	536.47717
S21	288.76288	336.26822	394.76938	448.27087	512.79712	570.4762	628.74481	678.08038	747.29309	815.30414	883.95215
S22	-25.141083	25.174465	72.760445	107.10027	145.42918	179.94339	213.27683	240.29782	272.10538	303.8916	340.41168
S23	-49.880096	-63.46432	-50.61404	-33.3698	-7.495854	20.396629	51.775673	78.016632	110.30215	142.04503	180.00838
INS1	2.4233036	46.117855	93.013626	131.78476	177.43346	220.05751	261.84396	300.55927	343.38162	385.67572	430.81146
INS2	1523.991	1315.9142	4076.2427	4082.5215	4277.7251	4362.1177	4817.8369	4636.5767	4239.8745	-1049.724	-1029.717
INS3	36.078506	63.485737	92.935379	115.87441	141.06766	163.45572	186.24663	206.2644	230.31465	253.32487	279.53931
INS4	-30.086229	34.229862	110.81123	177.44379	252.77063	323.72363	394.74103	461.62839	534.00897	601.6908	677.53345
INS5	29527.918	28955.674	28469.305	28374.703	28045.463	28152.361	28828.184	30260.256	30100.107	29002.953	19451.373
IS24	-265.64099	-15.70908	74.123657	153.46573	229.72119	289.31274	346.54962	395.27341	456.81168	497.38058	545.50159
IS25											
IS26											
IS27											
IS28											
IS29											
IS30											
IS31											
IS32											
F01	35.415802	30.894087	24.737259	22.748619	19.490433	18.766392	16.232246	18.585381	20.755428	14.420699	13.69536
F02	-800.4613	-685.4702	-557.2103	-421.9068	-308.33	-194.5721	-95.12443	-5.277389	82.931061	176.02936	249.72229
F03	750.328	683.14685	627.57959	557.67419	542.4873	528.20441	512.29431	516.09106	509.89294	506.45816	516.16852
F04	-643.41016	-521.5905	-415.7141	-304.1793	-213.7608	-112.5374	-20.89828	64.366325	146.40642	230.98444	301.9256
F05	642.71429	591.80518	559.57452	530.70941	536.85516	541.7356	549.6889	567.22229	575.47949	591.20374	603.61432
F06	-453.6033	-375.0999	-296.9281	-206.7036	-134.4821	-50.46469	25.507994	94.701439	171.47047	246.35098	310.89697
F07	22.021534	15.650296	13.208082	12.03416	11.672546	12.666984	15.876305	17.458364	19.67128	28.66552	32.142487
F08	-250.74548	-205.1233	-154.0264	-99.51871	-55.13943	-4.05796	44.668686	88.142273	142.83224	193.72748	242.60611
F09	103.96466	119.72749	85.860237	71.021713	59.97691	54.182911	44.586605	52.372288	48.927208	45.125278	50.732574
F10	-659.25818	-523.203	-414.4828	-300.2116	-205.3448	-99.02863	-1.435794	82.345009	165.56404	254.78804	328.89645
F11	50.675755	47.328926	33.419735	25.949253	24.228008	23.367386	23.956234	30.025887	33.057404	36.408966	40.299995
F12											
L01											
L02	49.845001	60.370007	61.99622	69.801743	72.703819	74.880371	78.14521	83.405212	86.842735	91.739494	93.181068
L03	34.558762	27.542862	32.75259	51.655453	68.032288	86.217346	106.37546	122.35742	151.88095	179.25076	204.62585
L04	37.360744	45.108044	56.278809	76.074799	94.630943	113.16826	132.44843	152.81303	176.20866	198.75862	218.14636
L05	-6.8413811	4.7685409	12.749557	22.910112	27.989754	32.343731	39.600361	49.75964	59.187336	67.894417	78.770393
L06	46.74474	54.926102	59.281071	68.91732	74.73185	72.733109	72.006287	84.90728	83.990356	88.350822	100.69539
L07	7.1065326	15.249396	17.237974	28.638712	35.514309	43.65646	51.979549	63.016689	79.29306	91.776443	104.7921

*Strain gages INS2, INS5, F01, F12, L01, and S6 show faulty readings. Strain gages IS25 through IS32 were installed after 40,000 fatigue cycles.

Table D-5. Phase 1 (20,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.01	0.66	1.33	2.03	2.67	3.26	4.03	4.71	5.31	5.99	6.70
Frame-1	3.23	107.14	228.83	348.93	449.49	551.70	685.09	802.60	925.87	1006.60	1132.82
Frame-2	-2.39	90.40	226.93	358.69	457.90	573.36	687.41	796.96	930.07	1009.66	1157.30
Frame-3	39.39	271.03	184.49	342.88	471.02	593.08	686.21	790.49	925.93	1017.50	1113.12
Frame-4	-26.83	82.96	198.70	338.08	435.20	596.51	686.00	791.51	922.74	1016.72	1124.34
Frame-5	-4.79	110.18	228.10	336.32	439.69	583.94	680.98	804.60	912.48	1001.08	1138.38
Frame-6	-0.08	79.43	216.20	349.91	457.37	564.86	678.45	800.38	924.66	1019.59	1149.75
Frame-7	-10.54	114.29	238.91	343.05	457.80	562.35	676.82	780.45	927.91	1013.50	1124.73
Frame-8	-0.61	105.25	229.36	347.16	451.51	586.54	678.43	800.28	922.40	1018.91	1116.52
Frame-9	-66.73	137.98	226.48	342.79	441.32	570.51	692.63	784.66	924.50	1027.09	1115.29
Frame-10	9.43	68.24	234.11	337.73	450.20	589.38	681.97	797.77	920.89	1021.94	1128.24
Frame-11	8.21	90.69	227.28	353.16	449.26	579.96	683.46	804.25	928.33	1024.29	1107.75
Frame-12	11.33	126.23	222.57	359.99	461.20	573.05	672.46	783.34	920.58	1036.91	1119.13
Hoop-1	-6.84	553.23	1442.46	2201.76	2868.50	3719.83	4038.79	5057.01	5712.03	6426.50	7099.60
Hoop-2	13.99	701.40	1476.46	2224.52	2818.70	3512.05	4302.69	5005.31	5809.38	6436.92	7177.02
Hoop-3	26.51	724.12	1445.72	2162.06	3010.68	3596.08	4298.04	5050.29	5572.62	6543.75	7125.74
Hoop-4	23.23	699.86	1427.12	2156.13	2818.28	3546.38	4269.44	5065.14	5769.04	6412.28	7191.40
Hoop-5	1.68	712.47	1437.37	2165.80	2865.87	3557.43	4265.58	5061.79	5761.79	6425.15	7186.97
Hoop-6	-2.23	706.44	1419.99	2143.75	2847.36	3585.77	4279.87	5030.58	5704.95	6411.27	7122.30
Hoop-7	7.57	718.90	1429.94	2146.27	2864.82	3571.35	4299.69	5031.53	5737.49	6430.31	7153.00
Hoop-8	6.74	721.99	1451.97	2152.47	2845.59	3560.83	4290.82	5013.94	5729.25	6430.45	7144.41
Hoop-9	3.45	687.18	1426.54	2133.60	2846.05	3580.03	4270.94	5021.57	5701.78	6411.34	7127.89
Hoop-10	-0.21	711.63	1423.47	2149.51	2857.80	3576.74	4288.58	5013.35	5730.58	6418.28	7135.94
Hoop-11	-3.72	705.78	1431.65	2142.97	2848.82	3649.28	4275.09	5017.84	5741.96	6417.60	7140.37
Hoop-12	-21.11	698.86	1432.20	2184.64	2849.23	3544.38	4247.17	4912.25	5760.26	6410.27	7142.34
Hoop-13	1.88	703.28	1441.21	2164.52	2858.61	3574.62	4268.71	5036.37	5745.14	6418.02	7125.44
Hoop-14	0.60	712.18	1453.10	2172.02	2846.92	3580.50	4314.09	5018.83	5730.48	6413.43	7109.06
Long-1	79.55	660.96	1328.65	2027.71	2650.30	3366.03	4012.14	4670.03	5345.56	6002.46	6663.29
Long-2	117.33	678.09	1202.31	2070.84	2769.33	3373.65	3980.79	4743.92	5280.79	6086.08	6696.03
Long-3	-3.83	693.11	1370.55	2012.66	2647.46	3341.96	4006.00	4663.95	5330.43	6015.18	6669.48
Long-4	43.26	632.65	1316.06	2005.49	2670.82	3343.37	4000.26	4665.58	5368.27	6022.75	6635.04
Long-5	20.68	811.88	1447.67	1965.72	2617.99	3422.14	4035.56	4717.26	5397.79	6001.79	6669.36
Long-6	-3.54	658.30	1349.79	2005.70	2641.44	3334.12	4016.12	4667.29	5352.85	6000.45	6667.04
Long-7	-0.01	662.81	1364.55	1998.19	2657.36	3322.62	3996.39	4675.02	5337.85	5998.24	6690.25
Long-8	0.47	610.28	1240.27	2036.35	2692.44	3296.33	3935.80	4683.25	5291.88	6017.96	6717.95
S1-H	-212.82	54.18	197.66	310.95	403.98	483.69	583.45	666.79	737.18	817.23	901.83
S1-A	0.73	27.63	59.39	89.09	111.52	135.61	158.56	182.86	207.00	233.13	259.28
S2-H	-159.35	9.69	123.70	219.43	298.02	365.16	448.11	519.24	580.18	646.93	720.45
S2-A	43.83	69.23	97.61	122.25	142.43	162.58	187.93	210.35	231.31	256.68	280.58
S3-H	-422.23	-329.93	-248.01	-197.58	-126.30	-76.55	-11.87	38.79	95.52	151.58	202.06
S3-A	-298.05	-290.62	-261.55	-237.69	-220.57	-189.23	-161.62	-139.27	-118.42	-81.14	-55.79
S4-H	-136.50	-35.90	42.66	118.42	182.67	236.64	304.78	361.41	408.95	463.09	520.82
S4-A	-27.31	-6.63	12.94	30.65	48.35	68.48	93.06	114.50	137.08	162.41	186.08
S5	-118.87	55.87	198.62	330.16	441.77	539.77	658.90	758.46	841.48	934.24	1031.88
S6	-132.14	48.53	291.50	623.27	923.89	1239.40	1623.32	1968.47	2271.06	2623.12	2997.92
S7	-187.00	-1.15	142.70	271.27	376.43	464.59	573.77	665.30	739.28	824.13	913.42
S8	-141.98	34.28	182.37	320.30	431.70	524.89	640.74	734.67	808.71	893.08	982.48
S9	-285.64	-490.42	-692.32	-865.79	-1036.52	-1155.85	-1303.46	-1411.65	-1500.09	-1616.54	-1716.07

Table D-5. Phase 1 (20,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S10	-82.20	61.37	196.34	324.67	430.91	518.54	628.60	718.51	789.27	869.79	955.65
S11	-154.19	180.83	453.77	686.02	872.15	1025.19	1201.78	1343.34	1456.80	1578.19	1701.63
S12	-71.12	-101.44	-115.41	-121.58	-122.32	-121.40	-114.30	-107.23	-101.99	-93.27	-82.38
S13	-183.99	95.68	307.98	478.33	610.97	715.88	838.12	934.81	1011.65	1095.09	1181.35
S14	-96.09	22.41	124.91	225.04	312.82	389.25	484.36	566.15	635.08	709.84	790.85
S15	-33.07	-4.51	22.59	48.61	72.27	93.36	124.08	149.56	170.15	195.42	225.25
S16	-82.00	4.90	80.62	159.86	229.70	291.57	368.97	437.05	493.82	557.83	625.52
S17	-103.54	17.21	112.90	208.42	290.34	360.22	446.93	519.78	580.18	646.94	716.85
S18	94.80	-38.92	-187.98	-327.18	-456.03	-575.12	-727.50	-861.84	-970.21	-1098.38	-1236.49
S19	-64.02	-1.38	71.69	134.93	192.67	242.55	305.55	362.16	409.22	461.99	516.58
S21	-24.26	26.19	80.55	143.31	202.41	260.29	335.55	403.46	459.27	527.11	600.80
S22	-157.62	-124.38	-84.58	-53.15	-23.17	0.82	35.70	63.32	85.87	108.39	138.92
S23	-68.00	-92.42	-85.44	-72.59	-52.22	-31.29	1.93	32.03	57.19	88.21	123.63
INS1	-7.45	43.42	87.83	129.12	167.58	205.22	251.81	294.14	329.95	370.74	415.05
INS2	-69.06	151.69	340.45	513.67	655.09	779.47	927.26	1047.35	1140.25	1243.83	1352.24
INS3	13.28	41.62	75.51	106.07	135.33	160.89	192.37	220.89	244.97	270.52	298.86
INS4	-51.18	13.69	88.29	163.62	234.62	300.03	384.72	463.65	526.72	600.79	680.25
INS5	-1035.49	-1072.27	-1078.04	-1088.13	-1093.18	-1098.23	-1092.46	-1091.02	-1091.02	-1086.69	-1078.76
IS24	5.76	91.47	158.15	221.39	272.15	314.16	366.64	411.43	442.68	481.96	523.81
IS25											
IS26											
IS27											
IS28											
IS29											
IS30											
IS31											
IS32											
F01	13.16	13.71	10.63	-0.60	-12.55	1.21	-23.95	-28.84	-24.86	-27.94	-34.45
F02	-828.13	-723.66	-584.04	-465.09	-343.18	-288.42	-170.97	-74.60	0.95	81.58	157.14
F03	741.20	717.94	664.77	632.58	602.44	622.63	599.91	591.65	601.17	595.14	591.17
F04	-143.25	-111.70	-76.83	-56.12	-46.94	-45.45	-31.24	-28.39	-31.07	-20.35	-7.50
F05	586.15	584.22	560.35	561.80	559.68	595.43	578.86	590.12	614.65	616.94	623.63
F06	-505.02	-416.78	-349.01	-249.78	-161.37	-112.89	-18.81	53.52	113.39	183.77	251.13
F07	170.98	195.40	208.41	220.70	230.84	261.90	259.68	272.54	296.63	303.29	308.53
F08	-256.23	-221.06	-162.99	-107.59	-52.92	-23.15	45.38	90.31	128.93	180.74	228.98
F09	77.52	92.20	49.82	40.94	24.65	47.47	24.10	17.76	26.46	21.57	20.12
F10	-101.06	-106.34	-108.34	-111.25	-113.80	-119.97	-109.23	-76.34	-110.90	-103.79	-102.16
F11	62.57	63.34	27.55	29.04	20.12	42.32	22.20	28.54	45.22	44.54	44.72
F12	154.06	153.35	145.39	148.29	143.23	139.60	150.43	142.48	138.89	139.60	144.67
L01	-3912.65	3863.90	-3580.55	-701.87	3255.02	3222.82	1298.61	2627.84	4687.26	-1506.65	2722.28
L02	41.17	47.89	61.86	33.37	89.08	11.42	85.79	44.80	65.67	73.29	94.51
L03	46.96	30.58	38.50	48.40	61.54	81.34	103.12	125.63	148.32	174.98	199.96
L04	-64.12	-81.23	-88.43	-96.36	-102.30	-104.10	-106.99	-104.46	-98.52	-88.61	-79.43
L05	-22.91	-11.30	-2.58	-1.86	-0.41	3.95	7.58	6.85	9.76	14.11	20.64
L06	-40.75	-40.02	-23.48	7.05	21.78	37.04	46.12	57.21	70.67	83.39	93.93
L07	61.88	31.42	15.47	10.39	3.87	0.24	-12.81	-20.06	-20.79	-22.96	-25.87

Note: Strain gages INS5 and L01 through L04 show faulty readings. Strain gages IS25 through IS32 were installed after 40,000 fatigue cycles.

Table D-6. Phase 1 (20,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.04	0.66	1.32	2.03	2.72	3.36	4.00	4.67	5.32	5.97	6.69
Frame-1	-2.45	108.27	234.80	328.47	449.81	559.09	683.39	788.74	911.19	1018.24	1133.81
Frame-2	-3.06	129.05	210.00	341.66	463.19	566.16	669.34	797.82	899.20	1013.01	1148.47
Frame-3	67.61	86.51	179.36	327.01	453.08	545.18	681.58	812.64	884.99	1008.48	1135.32
Frame-4	16.44	104.39	187.13	376.59	448.15	552.02	682.74	790.75	899.37	1037.17	1134.67
Frame-5	9.32	108.01	232.39	330.70	448.32	547.26	672.65	782.48	899.51	1019.18	1140.99
Frame-6	-2.35	124.06	214.07	336.79	446.78	560.94	672.17	790.39	896.77	996.37	1142.90
Frame-7	-9.60	112.53	206.54	336.68	452.43	563.12	679.95	786.91	920.98	1029.61	1155.97
Frame-8	1.98	112.61	208.81	335.77	456.64	559.75	678.64	785.52	895.02	1017.51	1140.48
Frame-9	40.42	98.55	231.61	349.22	461.33	561.54	687.25	792.26	903.85	1038.41	1135.63
Frame-10	4.75	107.45	226.57	328.70	464.79	564.84	677.93	794.13	912.74	1013.61	1147.37
Frame-11	1.69	113.00	216.21	376.72	449.76	553.70	676.12	782.24	924.15	1018.40	1144.81
Frame-12	7.74	109.09	222.06	348.68	441.79	543.30	678.82	779.45	894.94	1024.85	1133.73
Hoop-1	10.60	735.32	1246.76	2150.31	2866.56	3570.61	4343.85	4906.81	5716.71	6447.17	7207.41
Hoop-2	40.91	692.36	1399.30	2164.37	2859.97	3591.02	4316.11	4980.99	5731.07	6418.34	7126.05
Hoop-3	56.01	717.10	1454.40	2346.88	2875.35	3408.67	4170.48	4827.21	5606.21	6419.92	7019.19
Hoop-4	45.06	712.52	1439.85	2155.16	2896.47	3591.86	4255.74	4867.73	5724.25	6480.75	7088.83
Hoop-5	5.28	724.99	1428.38	2146.86	2869.47	3573.63	4253.83	5030.20	5703.07	6410.12	7105.28
Hoop-6	2.91	709.80	1419.99	2130.88	2861.08	3549.74	4225.81	4960.96	5712.39	6446.66	7159.34
Hoop-7	-4.94	722.40	1433.51	2141.76	2871.96	3582.07	4168.29	5014.45	5727.42	6427.88	7154.07
Hoop-8	6.74	729.29	1407.59	2137.93	2874.80	3568.21	4290.39	4977.06	5728.68	6443.92	7159.16
Hoop-9	3.45	694.29	1406.66	2155.35	2840.38	3567.46	4306.40	4992.85	5701.21	6417.24	7161.99
Hoop-10	5.11	720.43	1428.65	2126.64	2853.96	3558.99	4297.03	4974.29	5722.91	6436.53	7159.02
Hoop-11	25.39	716.62	1415.14	2143.18	2864.91	3554.68	4287.40	4955.98	5741.39	6434.51	7162.20
Hoop-12	13.26	717.89	1426.33	2146.66	2879.50	3559.66	4391.87	4912.25	5729.13	6409.00	7211.09
Hoop-13	1.88	732.43	1426.45	2135.51	2865.63	3552.70	4290.20	4963.30	5729.96	6431.35	7154.67
Hoop-14	15.27	726.78	1386.94	2142.89	2868.64	3587.84	4313.66	4996.82	5715.24	6441.49	7160.41
Long-1	95.25	658.02	1330.61	1983.59	2707.16	3315.37	4007.06	4658.67	5318.11	5987.76	6697.60
Long-2	110.33	537.55	1185.44	1947.17	2690.63	3341.66	4081.38	4662.39	5310.30	6062.19	6632.78
Long-3	5.92	669.96	1344.97	1980.98	2682.80	3309.39	4038.49	4667.78	5329.21	6027.37	6692.63
Long-4	36.04	660.38	1318.47	2000.67	2668.40	3334.06	4017.93	4640.45	5335.73	6013.11	6691.69
Long-5	24.22	672.95	1333.46	1964.54	2672.15	3318.86	3956.28	4703.36	5356.58	6064.19	6672.90
Long-6	3.58	687.95	1322.51	2019.93	2668.72	3347.50	3999.13	4679.36	5331.50	5995.71	6689.57
Long-7	-1.23	657.95	1320.77	1975.08	2682.90	3330.25	4000.83	4695.88	5346.36	5993.37	6680.52
Long-8	-10.21	619.77	1406.37	1980.59	2661.59	3323.95	4086.11	4652.60	5320.35	5975.25	6729.81
S1-H	-186.55	53.07	195.98	312.04	409.71	496.40	576.61	659.27	737.85	810.82	896.98
S1-A	-1.70	30.81	63.31	86.28	113.01	137.25	163.99	186.39	209.22	236.28	264.51
S2-H	-143.86	7.83	123.52	220.90	303.40	375.50	443.30	513.59	581.24	643.13	718.02
S2-A	49.06	73.72	100.59	123.73	145.40	167.01	192.43	214.81	236.51	260.39	286.55
S3-H	-436.01	-357.38	-273.67	-197.61	-131.22	-78.25	-21.14	22.35	81.63	123.07	178.68
S3-A	-295.06	-290.68	-266.76	-244.38	-216.07	-181.72	-155.67	-128.08	-97.54	-78.15	-56.54
S4-H	-126.60	-41.00	41.26	118.41	186.06	244.42	299.44	354.28	408.91	458.75	515.96
S4-A	-26.75	-4.77	11.82	28.41	48.54	71.62	95.68	120.26	138.18	163.51	194.09
S5	-108.26	50.08	195.22	331.04	448.88	554.02	650.58	749.46	842.58	926.98	1026.85
S6	-151.56	10.22	259.72	599.24	920.89	1267.35	1587.90	1932.69	2270.11	2595.26	2979.76
S7	-175.00	-3.16	141.97	272.15	383.48	479.36	567.83	655.78	741.57	818.05	907.97
S8	-128.80	31.22	182.09	321.09	440.58	543.12	634.86	725.45	812.70	887.32	975.25
S9	-314.07	-501.89	-700.85	-879.92	-1042.10	-1189.62	-1306.44	-1431.41	-1534.07	-1622.06	-1716.07

Table D-6. Phase 1 (20,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S10	-72.63	61.89	199.97	327.18	441.21	537.44	624.67	710.09	793.00	864.98	950.38
S11	-134.04	176.60	450.45	688.59	884.87	1048.98	1194.14	1332.00	1460.15	1571.77	1697.45
S12	-75.66	-103.63	-117.95	-122.66	-123.39	-119.73	-115.76	-110.85	-102.16	-95.62	-85.47
S13	-166.92	96.06	307.62	481.19	619.63	732.91	832.03	926.55	1013.91	1090.07	1176.45
S14	-87.36	17.50	123.27	226.47	318.43	400.41	478.77	558.26	635.56	705.77	787.58
S15	-34.71	-6.70	20.59	48.79	74.44	99.70	122.09	145.91	171.59	193.94	222.70
S16	-77.42	-0.67	78.44	160.26	233.35	300.23	363.80	430.26	494.18	554.28	622.07
S17	-95.37	8.86	110.18	209.67	295.39	370.28	441.16	511.74	580.66	643.25	712.86
S18	85.68	-45.50	-191.26	-329.70	-467.30	-598.48	-723.01	-851.54	-977.23	-1093.89	-1229.74
S19	-62.43	4.77	69.32	136.33	193.79	247.76	301.57	353.57	408.41	457.76	512.94
S21	-27.44	20.12	77.06	142.53	205.11	268.74	328.69	394.53	459.95	519.07	594.09
S22	-153.26	-116.95	-81.31	-53.87	-20.99	3.00	32.07	59.68	84.40	108.38	144.00
S23	-74.79	-90.78	-88.01	-72.58	-51.85	-25.96	-1.55	26.71	58.10	84.16	119.41
INS1	-4.29	41.66	86.43	129.62	170.96	209.11	247.55	289.32	329.69	365.63	411.10
INS2	-66.61	140.75	337.28	510.44	664.36	798.32	915.03	1036.19	1143.04	1231.93	1342.09
INS3	14.40	44.21	74.77	107.55	137.00	163.87	189.82	216.32	244.60	267.75	296.08
INS4	-47.41	13.51	88.11	164.70	239.48	310.87	380.84	452.98	527.98	596.10	673.59
INS5	-1162.64	-1176.11	-1186.93	-1204.96	-1215.78	-1233.21	-1244.15	-1241.39	-1257.60	-1251.83	-1261.21
IS24	8.30	86.95	159.42	222.45	276.29	324.03	363.05	404.50	445.17	475.75	517.47
IS25											
IS26											
IS27											
IS28											
IS29											
IS30											
IS31											
IS32											
F01	10.27	12.62	4.84	0.85	-13.09	-23.95	-27.39	-33.18	-37.90	-39.16	-38.26
F02	-811.55	-701.65	-577.79	-463.23	-342.06	-257.90	-162.65	-81.11	10.19	102.05	179.07
F03	741.38	692.94	653.92	626.01	606.18	586.47	588.39	588.88	583.75	576.46	581.40
F04	-131.40	-107.88	-76.06	-54.76	-44.00	-40.46	-31.65	-26.99	-27.49	-20.16	-5.97
F05	577.29	556.48	549.50	548.90	560.53	557.29	574.58	595.31	597.60	599.52	618.39
F06	-493.27	-427.53	-339.07	-248.58	-164.25	-91.25	-20.21	52.29	115.19	193.56	260.99
F07	164.84	186.58	194.85	216.52	231.00	234.36	250.31	264.56	280.33	289.88	303.47
F08	-250.25	-204.34	-154.83	-98.88	-52.23	-4.35	41.98	90.49	134.67	188.06	237.32
F09	88.57	77.00	43.48	50.36	30.08	13.59	16.49	17.22	13.78	9.79	13.60
F10	-113.42	-118.36	-120.52	-171.95	-151.61	-148.83	-132.14	-122.13	-107.07	-93.42	-66.71
F11	55.41	30.59	20.71	18.94	19.39	11.55	18.76	28.00	28.64	30.67	37.65
F12	158.41	141.07	145.39	143.93	149.01	146.79	141.76	145.36	138.87	126.55	86.02
L01	4770.35	2368.53	2289.10	3575.24	5472.75	1512.11	3700.54	3020.12	-1879.71	783.03	3361.18
L02	15.77	40.82	33.37	-8.00	9.42	46.60	58.95	77.99	79.09	129.70	136.06
L03	43.72	34.72	38.50	45.53	62.43	83.32	105.99	129.77	150.64	175.48	203.56
L04	-75.12	-88.61	-97.26	-105.36	-110.95	-114.02	-113.13	-109.72	-105.36	-94.92	-83.93
L05	-22.18	-10.57	-1.13	-3.31	-0.41	4.67	6.13	11.20	11.93	16.29	20.64
L06	-50.92	-49.30	-32.94	-6.58	11.96	25.58	40.13	53.21	64.12	76.29	89.75
L07	60.43	32.16	15.47	8.22	3.14	-1.93	-12.09	-18.61	-20.79	-23.69	-24.42

Note: Strain gages INS5 and L01 through L04 show faulty readings. Strain gages IS25 through IS32 were installed after 40,000 fatigue cycles.

Table D-7. Phase 1 (20,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.02	0.66	1.34	2.03	2.68	3.33	3.96	4.68	5.28	6.04	6.64
Frame-1	-0.43	111.35	224.16	341.21	455.43	572.05	679.35	790.94	916.94	1038.91	1141.36
Frame-2	2.20	101.10	233.76	334.71	454.03	557.75	683.21	780.45	929.32	1030.38	1124.87
Frame-3	2.56	291.65	300.33	349.44	453.71	564.76	671.75	804.04	923.75	1024.57	1125.56
Frame-4	-16.14	102.63	255.42	347.96	451.87	565.87	689.77	789.75	926.70	1028.80	1121.38
Frame-5	-11.64	124.20	225.13	336.83	455.48	566.66	663.60	807.67	923.17	1030.12	1133.63
Frame-6	-11.32	125.42	230.46	334.84	444.33	574.75	680.81	803.36	914.66	1026.80	1184.28
Frame-7	-7.81	105.03	233.35	340.88	458.88	568.61	689.30	794.57	908.93	1021.74	1133.69
Frame-8	5.41	104.64	223.47	343.31	448.04	571.71	685.44	798.31	908.34	1040.06	1133.67
Frame-9	-40.32	147.22	222.53	347.68	459.14	565.42	685.05	792.67	907.57	1025.28	1136.47
Frame-10	2.24	111.44	224.48	334.20	445.62	571.56	668.64	790.32	913.66	1013.08	1146.78
Frame-11	-13.07	111.23	229.06	384.10	463.98	563.91	676.75	794.78	920.60	1017.83	1169.85
Frame-12	6.56	116.47	227.41	350.06	451.64	576.60	685.61	784.48	923.49	1024.20	1142.33
Hoop-1	0.91	797.33	1448.27	2105.31	2861.03	3647.76	4324.04	5030.81	5704.28	6487.21	7163.55
Hoop-2	5.02	667.23	1431.60	2142.41	2897.94	3522.47	4263.64	5024.06	5687.34	6435.64	7175.22
Hoop-3	12.63	774.36	1431.85	2134.73	2939.84	3543.67	4281.11	4971.21	5786.07	6573.68	7212.51
Hoop-4	-34.96	670.69	1427.12	2147.46	2880.39	3476.92	4268.05	5004.12	5652.63	6403.73	7156.84
Hoop-5	3.48	705.20	1424.78	2133.84	2880.55	3558.88	4287.59	5006.81	5709.60	6429.27	7177.97
Hoop-6	9.78	718.38	1426.85	2159.62	2864.80	3576.84	4290.59	5007.28	5711.81	6427.15	7165.20
Hoop-7	21.87	722.40	1431.73	2152.06	2870.46	3572.78	4289.40	5012.66	5692.81	6429.03	7142.27
Hoop-8	28.86	677.68	1437.23	2152.47	2867.71	3568.56	4306.00	5021.81	5728.11	6413.15	7160.59
Hoop-9	8.83	708.64	1453.46	2156.93	2860.40	3560.64	4285.72	5032.83	5713.20	6417.76	7177.77
Hoop-10	12.21	722.20	1430.57	2156.61	2852.47	3578.87	4290.78	5028.05	5715.24	6421.05	7171.10
Hoop-11	9.02	694.80	1413.46	2159.34	2854.28	3575.05	4275.52	5023.79	5715.35	6429.59	7147.25
Hoop-12	1.81	742.71	1418.84	2322.14	2864.51	3590.57	4285.79	5034.98	5743.83	6507.01	7143.76
Hoop-13	1.88	673.99	1419.29	2164.52	2858.61	3567.67	4283.75	5022.25	5685.55	6444.68	7148.78
Hoop-14	7.94	675.43	1431.10	2157.35	2876.26	3558.85	4233.82	5026.67	5714.67	6432.88	7147.16
Long-1	72.68	659.00	1351.46	1996.33	2695.93	3332.04	4048.65	4671.99	5327.54	6029.16	6696.62
Long-2	163.70	495.39	1264.40	1945.76	2619.47	3248.90	3939.80	4651.16	5258.46	6069.02	6707.27
Long-3	2.26	685.80	1342.80	2027.28	2701.61	3345.95	3957.23	4687.10	5353.96	6035.88	6667.04
Long-4	30.00	629.04	1336.82	2010.31	2680.99	3346.12	3974.93	4698.13	5346.97	6014.31	6677.23
Long-5	13.62	608.20	1341.97	1956.30	2885.83	3334.17	4056.79	4703.13	5329.92	6030.07	6650.53
Long-6	-14.22	685.58	1338.19	2019.93	2633.66	3356.99	4035.12	4668.47	5341.39	6001.65	6652.80
Long-7	9.72	659.16	1334.41	2014.00	2633.56	3332.68	4014.61	4692.05	5369.85	6011.60	6641.60
Long-8	-43.43	632.83	1318.84	2023.30	2621.78	3322.76	4052.10	4730.70	5318.38	5982.37	6688.29
S1-H	-202.41	53.24	197.66	310.77	406.77	492.63	573.32	663.01	732.56	823.86	892.80
S1-A	2.23	30.43	61.26	88.72	110.40	136.17	162.51	186.26	209.20	235.35	261.50
S2-H	-155.26	11.18	124.82	220.74	298.95	373.00	440.36	516.36	576.15	653.39	711.79
S2-A	40.85	66.98	93.87	117.02	139.44	161.83	184.24	208.16	229.77	254.41	278.31
S3-H	-385.39	-291.29	-213.51	-138.77	-72.93	-28.45	43.68	93.15	140.85	195.52	235.24
S3-A	-280.93	-279.41	-257.07	-231.73	-202.67	-185.51	-163.14	-136.32	-114.67	-94.55	-59.51
S4-H	-130.30	-30.76	47.10	121.32	185.47	244.87	300.08	359.99	408.31	469.96	517.41
S4-A	-27.87	-6.63	14.43	31.20	48.35	74.44	92.52	118.25	137.05	162.95	184.38
S5	-111.22	55.46	199.16	330.57	445.71	548.84	647.57	753.35	836.28	941.67	1021.49
S6	-117.98	38.18	284.42	609.10	930.25	1250.30	1588.78	1947.80	2253.90	2644.65	2959.85
S7	-179.74	-0.79	143.06	270.91	378.06	474.05	563.71	660.70	736.22	831.87	904.60
S8	-137.10	30.02	178.98	316.41	431.20	533.54	627.92	728.32	804.93	900.72	972.04
S9	-294.20	-493.21	-680.95	-880.01	-1039.36	-1181.44	-1289.51	-1426.15	-1519.70	-1619.22	-1698.84

Table D-7. Phase 1 (20,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S10	-76.36	61.37	194.88	323.40	430.18	527.80	616.38	712.12	784.94	876.42	945.39
S11	-147.17	173.46	447.64	682.48	872.51	1037.90	1183.68	1335.40	1448.98	1586.34	1688.02
S12	-65.50	-97.07	-112.14	-116.68	-116.87	-116.32	-111.23	-103.81	-98.52	-88.18	-80.74
S13	-178.01	89.31	303.62	477.42	611.70	726.23	826.30	930.64	1007.09	1102.42	1172.16
S14	-95.56	22.59	125.64	225.76	312.82	397.08	474.63	561.71	630.40	716.51	781.86
S15	-32.16	-3.42	22.59	49.34	75.54	98.45	122.29	150.32	169.75	199.40	221.59
S16	-80.51	6.13	81.93	161.27	230.57	298.64	362.29	434.60	491.00	564.07	619.65
S17	-100.82	17.57	113.99	208.60	291.61	366.94	438.12	515.71	576.25	652.69	710.06
S18	84.41	-35.45	-183.60	-325.72	-462.05	-586.62	-716.70	-855.08	-964.55	-1108.30	-1220.31
S19	-61.07	3.04	69.64	135.56	193.90	248.06	301.46	359.91	407.41	467.00	513.20
S21	-21.14	25.69	80.69	144.13	206.04	264.47	328.36	397.92	456.09	532.14	591.85
S22	-151.82	-123.09	-86.04	-52.79	-24.62	0.82	29.16	53.88	79.31	112.01	132.36
S23	-62.86	-90.20	-86.91	-68.37	-47.45	-24.87	1.57	33.51	59.38	94.25	121.60
INS1	-4.01	45.19	90.06	131.54	171.63	209.46	248.79	291.55	329.33	375.13	411.57
INS2	-55.24	149.77	342.49	517.57	663.84	793.71	918.70	1042.76	1141.47	1256.22	1343.77
INS3	14.39	43.29	74.79	107.18	137.21	162.57	190.20	219.78	244.30	273.17	296.82
INS4	-44.33	14.77	88.13	163.98	239.71	307.81	382.14	459.87	525.08	608.66	674.85
INS5	-919.29	-939.58	-952.75	-949.67	-956.35	-971.41	-967.27	-964.10	-959.34	-946.26	-942.46
IS24	9.93	89.47	156.34	219.76	272.51	315.43	361.28	406.62	441.32	485.53	517.78
IS25											
IS26											
IS27											
IS28											
IS29											
IS30											
IS31											
IS32											
F01	17.69	19.68	17.15	1.58	1.94	-14.18	-8.92	-24.86	-21.05	-32.64	-30.11
F02	-849.00	-743.11	-609.68	-479.58	-389.57	-261.24	-209.60	-90.92	-20.07	75.42	141.00
F03	781.60	760.55	706.19	656.81	648.38	621.55	629.32	612.57	621.49	617.15	619.86
F04	-133.00	-102.46	-72.49	-52.18	-47.26	-39.61	-40.25	-31.48	-31.06	-18.76	-19.49
F05	603.56	619.95	595.79	574.99	585.18	580.96	598.68	597.47	622.85	627.01	642.19
F06	-521.80	-421.62	-341.73	-252.90	-183.07	-94.62	-41.91	45.62	100.08	181.54	241.30
F07	183.83	208.93	219.97	236.24	244.58	251.60	270.58	276.39	301.27	307.95	322.23
F08	-266.63	-229.46	-170.33	-109.67	-67.10	-12.28	25.09	84.13	122.88	178.50	220.31
F09	89.85	87.48	65.94	52.17	42.04	24.10	37.14	18.13	28.99	23.01	28.81
F10	-10.35	-19.81	-24.17	-24.35	-28.90	-29.08	-32.90	-22.54	-17.81	-3.81	2.92
F11	65.52	79.37	64.11	38.20	40.01	29.09	40.91	33.76	50.24	48.39	62.11
F12	117.15	120.04	118.60	122.94	116.44	120.77	119.32	120.06	120.76	127.28	125.10
L01	2107.28	2299.01	3075.77	3192.40	86.27	929.44	3518.37	4274.33	620.79	5146.98	3234.09
L02	46.62	46.61	46.98	58.23	-71.32	20.31	112.84	117.75	103.03	78.54	62.21
L03	46.42	27.88	36.34	45.34	61.00	81.71	103.13	126.37	148.29	173.83	197.66
L04	-20.71	-39.62	-50.80	-61.24	-68.27	-74.93	-77.65	-77.45	-74.05	-67.19	-58.53
L05	-22.18	-11.29	-3.31	-1.86	1.77	3.95	9.03	8.30	11.93	15.56	18.46
L06	-28.76	-27.48	-10.40	13.78	28.32	43.58	57.03	67.40	78.29	89.74	100.83
L07	65.51	35.77	19.82	11.12	7.49	-0.48	-9.91	-17.89	-19.34	-21.51	-25.14

Note: Strain gages INS5 and L01 through L04 show faulty readings. Strain gages IS25 through IS32 were installed after 40,000 fatigue cycles.

Table D-8. Phase 1 (40,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.01	0.68	1.31	1.99	2.68	3.35	3.99	4.67	5.34	6.00	6.66
Frame-1	-6.96	124.38	221.86	333.57	469.84	559.88	680.84	779.61	899.80	1027.67	1128.08
Frame-2	-5.09	117.39	235.92	340.75	459.94	571.16	675.31	790.22	893.61	1012.68	1140.60
Frame-3	5.32	209.48	271.31	334.00	458.88	579.37	694.77	786.71	907.48	998.75	1153.16
Frame-4	-17.81	128.19	179.74	333.81	496.97	583.71	688.66	761.76	887.87	1011.84	1127.12
Frame-5	-4.62	101.44	223.14	340.94	453.53	566.29	686.63	794.92	901.43	1005.67	1141.79
Frame-6	-13.82	114.81	231.93	334.33	450.45	562.09	685.68	794.61	903.43	1016.36	1147.09
Frame-7	-8.99	119.17	231.26	333.82	443.27	570.46	692.70	778.21	899.86	1027.75	1121.86
Frame-8	-5.64	103.57	232.50	337.63	460.73	567.39	690.22	783.48	898.04	1006.97	1135.28
Frame-9	-8.19	103.18	217.18	330.41	448.90	571.90	691.50	802.26	907.35	1026.84	1127.72
Frame-10	-7.89	80.66	237.12	338.94	446.10	573.45	684.52	776.73	907.16	1012.46	1127.25
Frame-11	-1.05	124.65	227.47	329.50	459.90	566.45	681.39	786.79	907.21	1005.40	1159.07
Frame-12	-7.05	106.39	225.80	345.92	445.69	551.97	680.62	788.79	907.62	1006.95	1147.27
Hoop-1	4.10	594.78	1415.18	2137.34	2723.89	3553.32	4348.54	5012.15	5760.19	6437.81	7133.52
Hoop-2	-0.16	687.31	1462.74	2146.84	2812.28	3596.61	4271.87	4943.19	5701.24	6402.50	7110.81
Hoop-3	60.55	726.98	1438.54	2188.49	2811.04	3576.32	4196.25	5046.65	5720.59	6402.07	7223.98
Hoop-4	14.55	680.32	1397.03	2161.24	2835.61	3534.06	4251.11	4931.44	5626.88	6406.69	7135.42
Hoop-5	132.55	701.24	1426.50	2133.97	2891.12	3571.32	4259.14	5056.39	5695.83	6397.13	7128.88
Hoop-6	68.03	727.01	1427.18	2143.01	2871.85	3566.80	4234.72	5000.10	5661.36	6391.86	7135.93
Hoop-7	8.77	720.17	1426.20	2152.11	2846.92	3576.12	4261.06	5033.23	5709.44	6418.48	7166.70
Hoop-8	15.05	693.83	1423.97	2176.60	2855.59	3570.91	4257.42	4987.35	5732.46	6419.82	7150.32
Hoop-9	39.07	708.85	1419.64	2145.15	2885.17	3583.31	4274.99	4974.80	5703.76	6414.24	7168.49
Hoop-10	12.61	680.47	1429.76	2150.97	2849.24	3578.92	4275.55	4997.98	5717.28	6418.32	7141.31
Hoop-11	6.49	663.63	1422.41	2136.04	2857.10	3572.13	4278.76	4993.65	5719.88	6410.98	7146.46
Hoop-12	5.09	694.92	1422.69	2145.07	2863.78	3558.99	4270.19	4980.54	5706.61	6395.73	7137.23
Hoop-13	26.24	698.82	1429.59	2146.10	2855.44	3578.83	4288.31	4989.63	5706.00	6430.95	7147.46
Hoop-14	8.15	676.11	1431.87	2136.61	2848.83	3597.17	4294.86	4984.34	5710.96	6431.51	7158.27
Long-1	19.04	668.16	1343.63	2002.89	2666.79	3337.55	4010.67	4676.60	5338.60	6012.38	6671.44
Long-2	59.42	721.42	1306.00	2041.43	2673.99	3250.32	3966.20	4662.09	5336.88	5920.30	6649.92
Long-3	15.05	662.09	1337.03	2003.91	2666.86	3344.44	4028.51	4673.25	5341.15	6009.04	6678.16
Long-4	-3.17	664.64	1346.77	2039.02	2658.66	3420.56	4017.71	4663.94	5345.14	6008.25	6678.59
Long-5	6.29	693.95	1342.62	2024.73	2677.13	3336.59	3984.68	4674.83	5330.83	6008.03	6671.09
Long-6	12.14	745.22	1332.26	1994.50	2669.52	3350.47	4012.84	4659.45	5325.05	6000.14	6682.34
Long-7	31.28	667.40	1327.73	2007.98	2664.85	3359.43	4013.06	4670.00	5335.45	6017.94	6680.96
Long-8	-2.84	722.13	1327.13	1997.85	2656.44	3357.75	4013.18	4657.60	5345.92	6003.40	6652.56
S1-H	-16.85	141.69	247.66	339.00	422.97	503.78	576.11	656.62	728.38	806.65	884.43
S1-A	-16.50	33.43	62.42	92.51	115.52	142.47	168.82	191.80	218.21	244.18	270.17
S2-H	-27.64	84.85	161.78	233.37	300.36	365.02	424.90	491.67	552.29	618.97	685.37
S2-A	-14.04	13.62	36.80	59.96	80.15	101.84	124.26	142.94	164.65	186.31	210.23
S3-H	-19.28	57.66	114.93	167.18	219.09	268.97	314.22	365.53	411.47	464.53	516.96
S3-A	-3.98	5.70	25.38	46.92	69.81	93.24	117.91	140.02	165.04	187.68	209.99
S4-H	-55.47	20.96	82.42	142.34	202.31	256.29	309.46	366.38	415.91	469.83	523.78
S4-A	-5.17	23.97	43.18	59.05	75.45	93.95	113.14	129.06	149.31	169.80	191.38
S5	-55.32	86.98	201.71	312.01	411.51	509.57	595.19	690.95	773.87	861.64	950.21
S6	316.17	644.56	954.29	1292.30	1624.10	1975.46	2315.32	2689.52	3063.48	3453.68	3861.67
S7	-36.12	103.79	212.47	313.31	405.60	493.51	572.32	659.29	736.52	819.07	900.25
S8	-47.22	100.34	220.39	335.55	440.23	537.96	623.96	717.81	797.83	883.43	966.41
S9	-10.33	-254.75	-448.75	-617.34	-762.36	-896.60	-1010.33	-1124.72	-1215.57	-1306.21	-1386.84

Table D-8. Phase 1 (40,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S10	-15.53	115.11	236.52	347.84	450.72	545.99	630.61	722.84	800.58	885.91	967.85
S11	-53.47	243.64	478.27	680.69	852.08	1009.65	1143.33	1280.99	1399.50	1520.06	1636.17
S12	24.22	-0.67	-9.21	-11.93	-14.29	-11.57	-9.20	-2.12	2.97	10.78	20.22
S13	-65.75	116.77	238.23	335.26	412.55	486.77	545.99	611.55	664.04	721.42	777.41
S14	-28.73	79.68	169.09	252.74	333.14	411.92	482.97	560.10	630.67	705.93	781.12
S15	-2.90	27.48	58.56	91.97	119.00	148.68	174.22	205.18	233.29	264.51	295.85
S16	-15.08	61.66	127.80	192.94	256.94	319.97	377.34	441.06	499.29	562.45	625.04
S17	-6.45	93.75	175.38	251.86	325.14	394.98	457.65	526.30	588.03	653.41	718.30
S18	2.72	-113.31	-243.67	-379.68	-497.44	-625.78	-742.44	-873.41	-991.23	-1120.59	-1244.73
S19	-1.72	60.53	116.96	168.71	217.44	269.97	316.47	367.02	414.31	465.04	516.62
S21	9.94	66.60	121.32	174.82	225.28	282.60	334.92	397.26	450.79	511.76	573.14
S22	-6.81	38.32	83.63	130.42	165.19	207.06	242.43	284.35	320.21	363.89	404.97
S23	34.73	20.96	30.20	44.37	57.92	79.72	100.96	128.40	151.18	180.02	209.60
INS1	-2.90	35.87	77.62	117.86	157.38	196.91	234.17	275.89	313.97	355.68	395.20
INS2	53.74	332.67	555.91	753.66	924.90	1091.00	1233.85	1386.64	1508.66	1638.59	1761.04
INS3	-9.36	21.76	52.13	81.96	111.78	142.53	170.33	201.64	228.13	258.14	287.60
INS4	2.82	59.77	127.16	200.18	263.63	334.82	399.75	475.27	543.23	617.31	690.50
INS5	-8.63	51.39	105.39	153.20	197.94	241.23	282.40	325.20	362.28	401.63	440.97
IS24	-8.62	44.70	87.15	125.77	159.33	195.63	225.54	267.59	294.31	330.01	364.11
IS25	0.21	-36.21	-71.69	-100.79	-125.40	-141.36	-154.75	-157.55	-162.79	-160.87	-157.97
IS26	48.13	-18.87	-62.56	-96.23	-119.60	-133.50	-140.24	-136.48	-132.57	-119.97	-103.64
IS27											
IS28	0.05	12.30	34.68	59.36	79.29	102.72	122.77	148.45	169.95	194.21	218.04
IS29	-5.22	11.48	37.07	64.60	88.83	115.02	137.97	165.67	188.98	214.78	239.73
IS30	7.22	-33.77	-51.29	-62.02	-73.31	-76.59	-79.13	-76.71	-74.91	-69.40	-63.03
IS31	-3.92	-17.99	-16.64	-10.62	-7.18	0.65	7.30	18.07	27.26	38.30	50.57
IS32	86.65	385.26	620.55	833.62	1019.85	1197.95	1349.29	1513.32	1643.85	1781.89	1910.83
F01	-52.27	-13.12	12.62	40.17	65.36	89.48	97.44	116.46	129.36	136.96	143.30
F02	-141.69	-136.25	-115.22	-107.22	-94.53	-77.49	-51.00	-31.77	1.78	41.86	87.75
F03	124.69	142.25	180.92	253.88	344.06	403.79	453.22	513.13	559.36	594.60	609.99
F04	33.86	20.41	12.76	2.89	-7.88	-21.60	-33.77	-47.71	-63.48	-83.30	-104.80
F05	51.25	73.69	90.17	106.98	128.35	146.28	160.03	173.04	185.74	192.60	199.12
F06	-194.63	-135.08	-111.85	-103.11	-79.88	-51.56	-18.88	5.82	50.85	100.23	158.33
F07	-40.13	-27.23	-26.37	-17.18	-18.08	-11.34	-13.33	-16.41	-3.96	-2.15	6.99
F08	-97.94	-53.50	-36.64	-27.20	-9.79	4.00	23.95	45.34	69.12	108.83	149.28
F09	-171.13	-200.13	-249.47	-121.80	-58.00	-23.19	-63.80	-14.48	78.35	133.46	107.35
F10	-101.47	-112.02	-113.49	-110.01	-100.01	-98.20	-98.01	-101.46	-92.01	-74.90	-60.34
F11	-21.11	-24.65	-37.71	-51.27	-63.79	-70.37	-77.35	-86.69	-97.59	-112.73	-114.41
F12	-174.00	-112.40	-95.01	-91.37	-71.09	-49.35	-23.25	-5.13	34.74	76.77	126.78
L01	-12.31	8.31	23.04	46.19	67.45	90.30	111.37	131.70	150.40	162.26	173.27
L02	12.86	31.02	45.01	62.93	79.10	94.09	109.20	121.95	138.23	151.02	163.73
L03	-160.50	-163.13	-164.71	-169.49	-176.62	-180.06	-180.62	-181.00	-179.61	-177.76	-175.96
L04	-45.98	-38.04	-32.27	-20.03	-12.82	-2.74	6.63	13.84	20.33	29.70	37.62
L05	-3975.63	-3862.28	-3880.11	-3847.36	-3853.56	-3848.14	-3885.53	-3847.36	-3848.14	-3772.18	-3748.93
L06	-48.79	-39.69	-34.05	-29.13	-25.50	-21.86	-18.22	-14.76	-12.40	-10.03	-7.12
L07	-57.34	-71.66	-87.43	-106.97	-122.93	-137.98	-149.56	-159.87	-161.71	-161.88	-164.78

Note: All frame strain gages, L05, IS27, and IS29 show faulty readings.

Table D-9. Phase 1 (40,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.02	0.66	1.31	1.97	2.65	3.33	4.02	4.66	5.37	6.05	6.69
Frame-1	-0.70	115.39	232.60	347.87	456.82	567.20	674.98	802.11	923.60	1021.75	1139.12
Frame-2	-13.60	89.03	267.63	322.24	487.85	571.83	676.06	779.75	930.00	1001.98	1138.42
Frame-3	-34.63	253.03	221.75	344.11	463.69	566.30	669.55	783.02	923.25	1019.18	1123.67
Frame-4	5.26	129.08	238.31	342.60	536.26	562.47	662.83	792.34	938.46	1015.66	1146.92
Frame-5	-3.39	108.92	232.12	348.51	465.21	570.22	675.96	794.20	911.88	1019.55	1139.63
Frame-6	10.77	98.61	217.11	346.22	491.17	581.43	677.02	781.52	913.29	1026.30	1137.18
Frame-7	5.21	111.67	236.30	324.72	472.61	585.58	651.48	817.93	917.49	1021.11	1133.15
Frame-8	3.23	115.52	227.13	331.09	458.06	558.89	666.61	781.06	919.70	1019.84	1147.18
Frame-9	-5.69	130.84	216.46	338.39	474.36	565.51	674.14	791.67	928.56	1002.32	1148.40
Frame-10	5.95	104.50	237.81	324.32	469.10	578.28	669.76	787.23	934.43	1004.65	1138.37
Frame-11	-2.91	100.16	225.19	313.93	469.30	565.56	682.27	784.37	933.22	1022.75	1134.60
Frame-12	3.37	127.61	229.62	331.64	472.16	574.12	678.42	780.20	918.67	1010.72	1136.23
Hoop-1	-1.37	727.87	1327.67	2037.26	2866.36	3511.74	4224.99	4829.36	5763.26	6428.69	7179.81
Hoop-2	-0.16	554.49	1349.66	2150.64	2900.51	3557.47	4245.37	4951.67	5754.52	6420.45	7206.65
Hoop-3	15.43	716.57	1426.39	2178.30	2901.57	3595.77	4285.19	4992.35	5648.86	6410.75	7245.52
Hoop-4	-7.28	734.89	1387.93	2125.07	2777.68	3528.95	4286.10	5025.53	5793.67	6428.52	7234.36
Hoop-5	78.56	713.84	1428.30	2143.18	2859.02	3654.46	4281.17	4980.31	5758.25	6438.52	7156.58
Hoop-6	31.99	694.40	1416.88	2177.55	2841.24	3594.61	4260.88	4972.15	5731.16	6391.86	7145.22
Hoop-7	-5.53	684.42	1433.35	2100.48	2804.30	3585.41	4277.57	4984.47	5735.68	6454.23	7112.00
Hoop-8	29.80	679.01	1438.87	2125.17	2870.64	3556.51	4264.80	4988.34	5740.40	6419.18	7193.88
Hoop-9	13.93	667.48	1428.76	2139.97	2871.09	3544.17	4274.99	4981.18	5751.01	6431.56	7167.77
Hoop-10	1.96	701.72	1437.00	2131.65	2869.07	3559.73	4277.33	4981.21	5744.49	6426.56	7160.14
Hoop-11	-8.07	667.20	1429.83	2130.80	2879.23	3536.07	4267.84	4976.43	5764.13	6406.70	7163.95
Hoop-12	-2.55	696.77	1432.38	2130.00	2902.28	3566.98	4247.26	4973.89	5714.82	6425.67	7159.45
Hoop-13	-10.31	713.37	1437.04	2117.07	2892.28	3557.25	4273.69	4990.62	5743.12	6423.00	7154.06
Hoop-14	0.81	698.06	1424.68	2136.82	2871.13	3546.15	4272.83	4970.65	5762.91	6445.55	7164.89
Long-1	21.00	670.19	1335.07	1998.97	2673.39	3316.31	3997.53	4667.31	5337.62	6017.28	6673.71
Long-2	31.31	781.94	1275.33	1957.09	2602.04	3339.21	3981.27	4698.17	5411.39	6101.65	6837.62
Long-3	7.73	679.22	1337.30	2001.47	2676.35	3335.02	4003.74	4672.79	5346.02	6015.14	6677.49
Long-4	-0.76	671.93	1350.65	1973.92	2700.59	3314.81	4000.43	4655.04	5347.55	6007.04	6633.32
Long-5	9.83	622.19	1328.76	2023.55	2641.54	3385.21	4001.95	4666.13	5366.16	5993.90	6682.21
Long-6	13.33	624.29	1314.73	2034.83	2656.20	3328.26	3988.71	4681.53	5342.84	6015.56	6663.88
Long-7	45.88	672.34	1329.21	2000.68	2668.23	3336.65	4015.09	4671.96	5334.23	6011.85	6676.64
Long-8	3.09	647.44	1290.61	1974.12	2645.50	3324.86	3997.36	4657.13	5353.05	6002.21	6725.47
S1-H	-56.40	134.42	242.41	332.29	410.99	493.05	575.42	646.55	731.41	812.24	887.13
S1-A	-12.20	29.32	57.37	82.60	108.03	131.78	156.87	184.32	211.25	241.56	270.39
S2-H	-59.58	74.49	152.52	223.71	286.69	352.11	419.71	480.70	551.72	621.16	685.91
S2-A	-8.81	20.35	41.28	60.71	79.40	100.33	122.03	143.68	167.60	193.78	212.50
S3-H	-42.88	49.00	107.37	159.45	205.60	256.20	308.99	356.05	411.69	467.18	518.71
S3-A	-1.48	8.69	25.95	44.82	68.11	93.71	118.27	140.38	164.65	189.83	212.15
S4-H	-77.95	17.22	77.17	137.10	192.55	247.99	303.50	358.89	414.33	471.32	523.83
S4-A	-9.00	17.99	38.36	50.50	62.32	81.70	101.34	118.83	141.95	168.03	187.71
S5	-77.82	78.99	199.51	307.66	404.21	499.31	597.43	682.24	779.52	870.35	953.93
S6	299.41	598.66	915.58	1248.23	1588.97	1934.09	2307.17	2661.84	3068.70	3466.07	3874.44
S7	-63.55	97.39	207.68	305.77	394.21	482.69	571.42	648.89	738.46	823.25	903.84
S8	-80.37	89.07	213.40	326.80	422.64	528.79	625.07	708.10	802.48	889.48	970.68
S9	1.07	-241.66	-436.76	-608.54	-715.29	-877.00	-1005.19	-1109.36	-1220.39	-1313.23	-1392.00

Table D-9. Phase 1 (40,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S10	-40.47	111.11	230.86	342.03	429.24	534.07	628.67	712.31	805.33	892.08	971.77
S11	-95.73	226.73	465.45	665.02	829.32	988.36	1138.99	1264.77	1402.99	1528.51	1640.56
S12	27.13	-2.12	-10.66	-14.29	-16.47	-14.11	-9.39	-6.66	1.88	10.78	20.23
S13	-84.52	119.50	244.57	340.71	414.15	487.22	557.50	611.37	678.27	737.96	791.85
S14	-50.07	74.63	161.70	245.28	320.91	398.82	479.10	549.63	631.59	710.58	783.57
S15	-6.63	24.03	57.69	87.65	114.12	142.46	172.69	199.54	232.51	266.20	297.57
S16	-31.60	58.31	122.57	187.58	246.84	309.37	374.07	432.75	499.55	565.72	626.73
S17	-30.85	87.48	168.14	244.78	314.57	383.45	455.15	517.76	588.46	657.05	721.10
S18	-0.28	-106.21	-242.83	-370.98	-486.28	-613.59	-740.60	-859.02	-1000.27	-1130.89	-1258.30
S19	-15.53	51.37	108.61	160.82	209.85	258.11	310.67	357.27	412.81	465.76	516.99
S21	4.53	59.88	113.32	168.05	218.63	275.69	333.09	385.41	450.70	511.22	573.38
S22	-12.86	27.26	79.58	121.60	157.17	197.10	237.45	273.52	320.64	363.44	406.69
S23	36.49	16.20	26.44	40.39	51.89	75.58	98.57	121.52	152.28	181.06	210.35
INS1	-5.88	36.61	76.12	117.86	156.62	196.87	235.68	273.65	316.14	354.94	396.73
INS2	34.87	314.57	536.94	740.28	879.46	1063.57	1226.17	1360.52	1513.26	1645.12	1765.57
INS3	-12.88	19.72	50.29	81.41	111.40	140.14	169.95	197.36	229.99	258.51	287.57
INS4	3.19	56.90	126.29	196.58	260.54	329.63	400.61	468.20	549.00	623.08	699.44
INS5	-17.76	45.77	99.77	149.88	194.09	238.07	281.34	320.49	364.40	403.25	442.45
IS24	-5.90	46.34	87.33	129.39	152.61	195.95	231.54	259.06	298.96	332.00	366.14
IS25	27.21	-26.97	-62.89	-88.97	-135.99	-135.35	-149.70	-154.78	-153.92	-158.65	-153.18
IS26	73.11	-7.03	-55.52	-86.79	-113.02	-123.43	-132.71	-133.56	-126.67	-118.36	-100.69
IS27											
IS28	-11.89	-0.68	23.28	47.83	69.89	92.76	115.93	137.06	164.56	188.49	214.39
IS29	-5.35	10.84	37.02	63.74	86.83	110.51	134.71	942.85	1067.56	1161.76	1141.51
IS30	23.19	-30.41	-46.83	-56.74	-64.52	-70.71	-74.96	-75.62	-71.44	-69.81	-60.67
IS31	5.58	-14.10	-13.65	-7.72	-2.70	3.28	10.20	18.39	29.16	38.85	53.69
IS32	70.17	364.10	600.51	817.28	957.83	1181.73	1349.43	1489.53	1648.97	1786.79	1914.11
F01	36.91	45.43	70.98	101.06	129.33	138.21	145.13	152.53	166.12	157.80	168.15
F02	-219.87	-149.67	-136.98	-142.04	-147.30	-125.54	-88.38	-56.62	-12.37	58.37	94.65
F03	247.79	199.55	260.33	346.19	460.23	498.20	538.54	582.78	607.76	617.41	637.03
F04	75.73	44.59	37.89	30.78	24.17	13.98	1.45	-17.84	-34.54	-60.57	-87.06
F05	132.33	143.74	151.16	170.14	190.59	200.73	210.00	218.65	227.33	227.54	233.53
F06	-291.95	-167.76	-164.85	-162.66	-158.30	-127.07	-76.26	-37.75	14.53	84.98	135.10
F07	-29.49	-29.31	-17.41	-14.51	-10.39	-8.81	-10.89	-14.42	-0.98	-10.25	-0.16
F08	-150.72	-86.33	-63.48	-66.92	-69.09	-45.88	-15.23	11.07	46.61	98.67	134.96
F09	63.84	-8.68	26.13	121.84	63.83	29.02	69.65	104.44	121.84	89.94	101.56
F10	-107.29	-102.01	-105.11	-114.56	-111.65	-119.29	-106.75	-101.27	-89.45	-60.34	-52.52
F11	-13.40	-6.28	-18.62	-31.18	-45.19	-61.06	-75.00	-84.10	-90.63	-100.26	-106.93
F12	-266.05	-146.46	-144.29	-146.45	-144.27	-118.18	-73.99	-44.26	-0.06	68.80	107.95
L01	-3.88	4.41	21.23	48.19	76.55	101.30	120.13	140.13	154.95	163.76	175.01
L02	21.21	31.93	47.59	64.16	81.18	96.66	112.03	127.35	138.93	153.74	165.97
L03	-144.45	-148.50	-149.53	-151.79	-157.97	-164.70	-168.16	-168.22	-167.53	-166.68	-164.74
L04	-35.17	-33.72	-27.24	-20.75	-9.22	12.40	26.09	35.46	46.99	50.60	58.52
L05	-3850.66	-3809.97	-3801.25	-3742.74	-3792.15	-3789.24	-3804.53	-3765.99	-3713.68	-3716.96	-3728.96
L06	-52.79	-43.69	-37.69	-31.86	-28.23	-22.95	-19.31	-16.58	-13.49	-9.85	-7.31
L07	-37.41	-46.83	-57.70	-67.84	-81.97	-95.02	-108.26	-122.73	-135.78	-144.85	-150.30

Note: All frame strain gages, L05, IS27, and IS29 show faulty readings.

Table D-10. Phase 1 (40,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.01	0.67	1.33	2.02	2.71	3.29	4.00	4.66	5.35	5.98	6.68
Frame-1	8.00	129.28	220.36	352.98	442.33	562.12	684.49	786.37	906.14	1010.88	1112.40
Frame-2	-1.79	164.53	234.44	350.04	458.96	560.33	690.28	793.60	901.46	1010.84	1131.72
Frame-3	-69.30	160.66	178.49	359.44	453.38	552.51	678.31	794.45	887.40	984.86	1141.78
Frame-4	65.05	82.79	193.95	322.42	428.84	556.10	684.29	796.26	895.42	1011.64	1118.60
Frame-5	3.59	117.75	220.03	337.22	446.04	570.07	667.30	793.39	901.15	1012.00	1111.56
Frame-6	-2.87	114.75	207.15	333.84	449.47	568.94	693.76	797.86	882.91	1019.30	1168.13
Frame-7	-14.73	120.93	219.79	375.41	436.72	562.37	667.01	804.67	895.05	1024.85	1117.52
Frame-8	6.65	116.13	228.05	344.83	443.13	564.97	690.63	791.52	900.61	1017.67	1130.70
Frame-9	-2.56	123.02	227.09	350.97	444.00	571.04	676.52	801.23	883.18	1010.07	1140.31
Frame-10	-0.77	120.68	214.57	347.11	449.68	571.08	696.27	791.27	884.03	1016.68	1137.23
Frame-11	3.52	111.35	239.73	365.40	442.52	571.52	684.83	803.80	888.60	1026.54	1142.47
Frame-12	-0.86	126.68	219.81	350.11	441.85	557.16	688.72	806.08	901.00	1023.83	1121.18
Hoop-1	5.92	676.76	1422.33	2206.84	2862.72	3546.73	4235.51	4999.88	5769.88	6434.16	7229.75
Hoop-2	3.43	645.96	1406.96	2138.08	2755.12	3554.24	4173.15	4993.95	5728.73	6416.86	7171.47
Hoop-3	18.90	683.53	1460.96	2134.90	2906.77	3590.92	4309.06	5036.73	5741.99	6440.25	7175.08
Hoop-4	1.82	671.16	1475.10	2183.29	2837.71	3562.05	4247.48	4993.78	5740.24	6448.53	7187.77
Hoop-5	69.57	764.15	1447.95	2164.78	2860.82	3561.24	4215.95	4986.70	5710.80	6415.13	7173.49
Hoop-6	49.16	737.23	1456.21	2122.62	2846.39	3541.77	4203.83	4993.73	5725.43	6422.75	7185.41
Hoop-7	3.41	732.60	1429.63	2136.23	2949.09	3541.08	4262.84	4992.61	5752.92	6434.57	7143.10
Hoop-8	15.05	730.65	1416.60	2147.52	2847.93	3549.13	4309.07	4987.85	5718.84	6441.32	7147.47
Hoop-9	44.46	717.75	1423.23	2129.41	2841.79	3542.37	4282.18	4982.48	5740.81	6418.99	7120.75
Hoop-10	-1.60	708.82	1435.08	2131.86	2852.51	3554.41	4291.54	4993.15	5734.40	6431.89	7145.57
Hoop-11	-0.79	714.52	1426.05	2149.21	2847.71	3565.20	4264.20	4988.68	5724.66	6423.08	7118.14
Hoop-12	12.74	799.94	1449.43	2137.85	2840.56	3551.70	4270.19	4996.33	5738.32	6402.74	7119.10
Hoop-13	11.62	735.30	1436.90	2146.53	2840.53	3535.32	4281.00	4997.44	5721.75	6437.62	7122.69
Hoop-14	8.15	720.08	1431.87	2129.69	2833.86	3575.51	4265.49	4984.84	5719.43	6401.51	7133.40
Long-1	35.71	669.21	1334.22	2001.13	2660.90	3338.53	4016.16	4670.25	5343.42	6012.38	6651.48
Long-2	69.26	614.66	1304.98	1902.46	2692.26	3282.65	3885.69	4619.45	5348.47	5927.33	6699.20
Long-3	8.95	663.38	1339.87	2004.11	2664.43	3331.04	4006.18	4672.79	5344.96	6016.36	6697.54
Long-4	-0.76	675.55	1309.80	1998.23	2645.40	3353.05	4014.89	4670.71	5358.54	5987.75	6647.13
Long-5	25.13	676.36	1334.78	1996.67	2693.62	3328.35	4001.95	4673.19	5365.10	5993.90	6629.73
Long-6	22.82	662.25	1330.29	1988.76	2646.98	3359.96	3989.90	4669.67	5333.48	6019.12	6612.21
Long-7	88.45	661.39	1340.29	1975.33	2662.42	3337.54	4004.14	4707.24	5344.12	6008.21	6665.03
Long-8	0.72	620.15	1332.27	1979.06	2667.12	3355.38	3996.17	4678.49	5342.49	6018.82	6652.42
S1-H	-40.36	129.01	235.68	328.77	412.75	483.03	568.77	648.73	731.74	807.95	888.91
S1-A	-12.39	31.19	56.05	81.49	104.69	131.04	158.33	183.24	207.36	237.26	264.94
S2-H	-47.11	67.44	143.96	217.52	283.81	342.39	413.88	480.89	551.59	616.49	686.77
S2-A	-11.05	15.86	39.78	59.97	80.16	99.59	121.26	140.72	159.41	182.57	207.99
S3-H	-34.05	46.66	100.70	156.40	205.19	248.64	305.03	357.46	411.91	465.56	521.62
S3-A	-2.24	3.69	24.03	43.49	67.68	91.49	114.50	137.55	160.75	183.40	206.07
S4-H	-67.46	5.98	64.42	131.12	186.59	237.53	294.45	355.96	410.67	462.33	522.28
S4-A	-10.26	16.69	32.42	46.02	61.67	78.06	99.40	117.69	140.11	163.73	185.92
S5	-74.19	75.36	195.14	306.24	407.92	492.10	593.68	686.74	779.67	865.99	956.02
S6	292.13	625.07	932.07	1254.00	1602.41	1904.05	2288.31	2668.20	3064.94	3466.79	3879.16
S7	-51.43	91.98	200.21	301.76	393.38	471.25	563.77	650.88	737.97	819.25	905.11
S8	-59.86	92.96	215.12	330.96	435.37	519.59	619.18	711.95	802.18	885.45	973.05
S9	14.79	-243.58	-435.99	-601.13	-752.36	-870.89	-1003.75	-1117.74	-1223.92	-1313.14	-1394.50

Table D-10. Phase 1 (40,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S10	-22.57	114.93	231.56	342.61	442.77	525.22	623.82	716.08	805.49	888.45	975.67
S11	-83.96	222.92	455.50	657.27	832.04	971.46	1128.36	1268.16	1403.09	1522.11	1642.39
S12	26.04	1.33	-8.11	-12.84	-14.11	-15.20	-11.20	-4.66	3.69	11.50	21.13
S13	-60.43	129.13	250.55	347.47	426.77	488.54	561.93	626.40	690.40	744.14	803.05
S14	-42.29	70.76	155.54	242.12	320.48	389.81	473.68	552.48	632.09	706.25	785.81
S15	-6.95	23.12	54.54	83.34	111.78	135.20	166.38	198.72	231.38	262.15	295.35
S16	-27.74	53.59	115.61	183.24	244.53	300.51	367.77	432.71	497.70	560.37	626.26
S17	-25.94	80.48	160.08	239.53	311.18	373.49	447.79	517.68	586.76	651.41	719.94
S18	-8.98	-117.73	-249.72	-369.84	-492.48	-603.72	-735.12	-870.03	-1004.80	-1131.07	-1262.63
S19	-12.79	50.55	106.32	158.88	207.75	252.85	307.92	360.53	414.08	464.44	518.81
S21	1.04	62.88	114.98	167.07	221.80	268.54	328.67	388.72	450.79	509.76	573.32
S22	-11.50	29.63	77.25	115.15	154.20	186.75	230.67	274.85	320.53	362.25	407.02
S23	32.92	22.27	28.88	39.62	56.25	71.33	96.47	122.95	154.03	181.47	211.78
INS1	-4.39	38.85	81.33	122.34	162.62	194.66	238.62	280.42	320.68	361.65	402.65
INS2	14.33	310.03	531.08	726.43	904.67	1050.44	1218.67	1370.41	1516.65	1643.30	1768.84
INS3	-12.14	19.54	49.92	81.60	110.86	137.90	169.58	199.95	230.87	259.07	289.58
INS4	14.72	69.69	141.08	208.86	280.75	482.44	531.28	606.44	676.84	754.85	839.94
INS5	-17.09	46.84	100.30	150.47	196.12	235.17	281.68	324.51	366.81	404.87	445.02
IS24	-12.61	47.06	89.86	128.68	163.70	190.89	226.96	262.20	298.30	329.46	366.28
IS25	-2.19	-39.06	-69.68	-98.54	-119.53	-137.41	-148.94	-153.50	-154.91	-155.71	-150.50
IS26	60.90	-5.73	-49.41	-83.10	-104.81	-119.88	-129.77	-130.03	-124.85	-114.79	-98.09
IS27											
IS28	-18.29	-7.12	16.88	38.44	59.74	80.25	104.15	130.28	155.88	179.23	204.92
IS29	692.47	661.57	672.71	775.58	847.67	959.19	962.86	1008.88	1059.20	1116.08	1140.49
IS30	20.78	-24.81	-39.55	-54.43	-63.81	-68.72	-74.12	-72.23	-69.54	-66.03	-59.34
IS31	4.50	-11.79	-9.48	-6.73	-2.11	3.91	9.34	20.66	30.84	41.20	53.69
IS32	63.13	374.91	611.89	820.44	1013.23	1166.77	1339.35	1497.46	1648.75	1781.89	1914.83
F01	54.85	83.31	114.83	136.59	154.01	170.30	170.11	182.10	182.10	184.08	181.54
F02	-199.01	-179.96	-184.84	-176.15	-176.17	-157.83	-110.85	-75.13	-22.89	23.36	87.39
F03	235.94	245.30	337.19	421.76	518.03	575.42	607.03	647.89	658.57	674.62	676.79
F04	81.80	60.16	60.70	55.59	52.78	42.01	24.39	4.21	-16.44	-44.91	-70.62
F05	159.66	178.49	194.03	210.88	226.83	240.93	246.70	255.61	258.69	263.01	266.63
F06	-274.52	-210.61	-220.75	-203.34	-199.01	-168.48	-111.82	-71.90	-18.88	45.03	121.29
F07	-33.52	-25.51	-22.07	-16.05	-17.14	-3.96	-6.41	-4.69	-1.52	1.15	6.40
F08	-137.48	-101.93	-104.09	-96.67	-95.05	-81.80	-42.61	-15.05	23.77	68.38	117.72
F09	-28.99	2.92	66.73	20.33	49.34	113.15	182.75	235.01	133.47	121.85	145.06
F10	-85.82	-96.55	-118.38	-120.21	-126.23	-124.58	-117.47	-113.67	-98.02	-88.18	-59.43
F11	-9.82	-9.73	-14.49	-26.05	-39.48	-51.05	-62.51	-69.28	-77.95	-86.83	-93.72
F12	-247.21	-186.33	-201.53	-189.22	-185.62	-163.13	-110.21	-77.62	-29.78	26.76	89.81
L01	-10.86	3.60	29.74	53.49	85.45	109.37	126.49	143.33	158.24	168.60	173.23
L02	17.71	29.16	46.81	62.39	80.20	96.99	110.60	124.11	136.69	150.48	160.01
L03	-137.13	-141.21	-142.10	-142.41	-146.02	-152.42	-156.79	-157.95	-158.24	-157.55	-156.20
L04	2.31	-1.29	2.31	0.87	16.00	19.60	26.09	32.57	41.22	48.43	54.91
L05	-3725.68	-3722.77	-3710.78	-3690.80	-3630.13	-3591.98	-3556.75	-3548.74	-3531.30	-3510.60	-3530.95
L06	-54.06	-44.24	-37.32	-32.41	-27.32	-22.95	-19.49	-17.13	-13.49	-10.58	-7.85
L07	-32.70	-42.12	-51.72	-61.87	-78.00	-89.59	-104.62	-119.13	-133.09	-139.59	-146.66

Note: All frame strain gages, L05, IS27, and IS29 show faulty readings.

Table D-11. Phase 1 (60,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.01	0.68	1.40	2.02	2.74	3.29	4.03	4.68	5.31	6.04	6.68
Frame-1	-0.26	97.11	225.34	359.58	455.41	563.59	677.55	795.51	901.99	1026.03	1127.84
Frame-2	1.43	101.92	254.56	316.41	461.27	567.30	673.01	779.24	918.12	1007.69	1141.94
Frame-3	-10.66	38.38	137.11	289.81	450.96	562.95	707.54	801.32	886.01	1036.87	1106.66
Frame-4	13.07	147.96	207.63	379.07	460.99	544.95	675.43	831.43	892.05	1018.04	1152.38
Frame-5	5.74	93.59	223.88	343.46	451.20	565.86	685.18	786.96	900.16	1034.44	1129.87
Frame-6	-4.30	119.46	241.39	317.64	446.17	577.02	665.19	785.13	873.94	1004.33	1122.95
Frame-7	-8.19	114.64	235.04	327.77	451.62	566.21	670.00	787.42	904.86	1027.57	1131.85
Frame-8	9.78	113.08	224.50	331.19	456.91	563.76	679.04	791.90	909.37	1033.89	1126.81
Frame-9	-2.73	150.98	222.80	336.28	442.13	571.07	667.37	787.92	907.09	1011.85	1132.29
Frame-10	2.27	139.56	266.04	365.19	449.63	564.39	671.78	790.93	1005.15	1034.55	1137.97
Frame-11	-5.39	91.11	243.35	338.71	457.15	563.13	693.76	810.09	877.16	1015.35	1124.10
Frame-12	-3.68	113.35	237.06	326.71	460.21	563.77	666.80	796.50	895.48	1026.24	1115.88
Hoop-1	-9.26	716.55	1442.21	2107.99	2983.04	3535.55	4318.24	4866.67	5636.73	6403.21	7147.11
Hoop-2	-8.24	790.76	1449.57	2142.78	2783.50	3487.27	4230.96	5085.11	5618.88	6441.74	7052.09
Hoop-3	59.22	736.27	1435.74	2163.28	2843.52	3567.36	4243.03	5035.89	5784.61	6451.70	7151.17
Hoop-4	-2.94	732.18	1419.84	2113.25	2848.08	3588.58	4229.44	4991.35	5686.93	6458.97	7079.33
Hoop-5	34.08	728.96	1443.49	2142.10	2885.29	3572.90	4307.73	4991.30	5699.27	6315.48	7138.00
Hoop-6	5.78	718.17	1426.99	2141.24	2875.67	3548.51	4312.76	4992.04	5706.65	6438.36	7124.87
Hoop-7	66.98	716.01	1404.23	2167.83	2884.52	3569.24	4322.32	5004.83	5699.05	6486.25	7172.69
Hoop-8	36.98	715.90	1424.47	2139.93	2870.14	3578.79	4242.46	4995.01	5695.93	6425.71	7127.98
Hoop-9	24.99	718.25	1408.05	2144.06	2858.51	3582.51	4273.48	4984.55	5690.24	6434.79	7131.06
Hoop-10	27.23	720.09	1354.47	2150.03	2851.42	3590.69	4286.61	4988.22	5702.26	6420.99	7141.71
Hoop-11	-9.38	733.45	1452.76	2073.26	2844.87	3551.50	4286.55	5011.03	5735.52	6428.41	7208.86
Hoop-12	7.64	718.63	1381.98	2195.82	2868.23	3602.37	4335.79	4954.92	5688.70	6437.13	7095.82
Hoop-13	14.88	724.15	1411.62	2149.78	2866.00	3575.49	4284.26	4993.38	5680.58	6425.62	7143.40
Hoop-14	-6.53	727.64	1381.19	2151.72	2856.17	3568.53	4280.18	4992.18	5704.18	6444.91	7136.24
Long-1	19.37	667.77	1332.85	1998.91	2679.23	3349.66	3990.22	4656.74	5336.52	6113.35	6670.46
Long-2	18.89	807.72	1318.13	2094.30	2501.16	3248.71	3986.91	4711.53	5265.94	6354.16	6642.38
Long-3	9.47	731.13	1322.36	2026.96	2686.99	3358.14	4017.64	4647.12	5343.41	6011.37	6678.12
Long-4	151.49	692.93	1364.61	1973.59	2650.63	3400.17	3982.62	4590.85	5333.90	6015.17	6671.11
Long-5	1.06	603.00	1380.46	1985.94	2676.76	3365.34	4012.04	4606.20	5290.79	6010.46	6692.44
Long-6	6.68	700.88	1366.61	2008.61	2679.62	3330.57	3999.86	4679.11	5328.41	5996.45	6684.65
Long-7	46.09	653.27	1343.19	2023.38	2673.68	3353.34	4000.67	4669.16	5302.12	6007.79	6675.74
Long-8	-0.40	724.86	1361.10	1973.59	2717.20	3360.01	3974.88	4630.57	5289.56	5995.76	6673.47
S1-H	21.47	165.45	283.10	363.85	450.10	511.42	592.36	666.83	737.69	820.66	894.59
S1-A	-8.55	42.88	72.97	94.85	123.29	144.41	165.73	189.62	215.79	244.96	271.16
S2-H	16.22	118.98	206.32	267.86	337.95	387.32	453.11	515.01	575.14	643.90	709.84
S2-A	-3.18	26.72	52.88	72.31	92.51	106.70	123.90	144.05	161.99	193.37	209.84
S3-H	10.85	86.85	159.13	202.07	256.33	290.37	339.70	387.09	433.03	486.13	539.93
S3-A	-2.00	11.60	30.83	55.05	77.15	99.71	123.67	147.82	169.40	201.78	216.52
S4-H	2.97	73.40	147.57	203.76	266.74	309.42	367.12	419.48	471.17	531.10	582.10
S4-A	4.19	35.06	60.61	76.58	94.58	104.19	120.16	133.03	151.80	180.66	200.10
S5	-3738.01	-4164.56	-4428.63	-4780.32	-4862.67	-5025.69	-5014.06	-4989.08	-5099.52	-5241.92	-5171.97
S6	75.83	238.84	398.91	557.00	724.53	864.53	1033.57	1195.08	1362.81	1536.91	1713.92
S7	-6.12	125.06	242.58	331.15	426.11	494.56	582.13	663.39	739.46	824.11	902.44
S8	7.60	143.16	271.51	370.61	475.72	549.19	641.31	724.82	800.97	882.71	958.50
S9	46.86	-233.07	-456.29	-626.29	-784.81	-903.73	-1031.96	-1140.04	-1243.88	-1337.17	-1421.32

Table D-11. Phase 1 (60,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S10	-10.99	117.65	244.81	337.46	436.55	505.55	592.40	672.57	745.41	823.88	897.36
S11	-35.62	259.85	515.15	689.74	865.63	986.40	1130.09	1257.51	1372.62	1494.63	1603.90
S12	26.57	1.99	-6.75	-8.75	-6.39	-4.75	0.71	6.54	11.09	20.37	30.57
S13	-37.52	219.31	424.97	558.83	694.09	782.05	891.00	987.93	1073.76	1171.05	1255.55
S14	-6.75	99.97	204.30	277.37	362.99	421.39	499.43	572.18	641.06	719.77	792.92
S15	-3.06	27.09	59.20	90.08	121.94	144.80	174.77	204.21	228.44	264.37	296.82
S16	-5.37	68.37	147.99	207.29	276.77	324.03	387.87	449.54	505.07	572.13	631.76
S17	5.83	101.43	198.65	270.98	351.74	403.14	475.11	542.25	602.21	673.99	735.12
S18	33.06	-117.62	-268.45	-402.81	-538.01	-655.57	-786.94	-917.94	-1039.44	-1182.58	-1309.77
S19	6.43	76.06	145.63	191.78	249.51	287.81	341.40	394.73	442.93	498.37	549.55
S21	-7.94	50.54	105.73	156.61	212.99	259.95	317.61	371.46	429.38	486.02	547.08
S22	0.53	53.12	98.91	137.80	174.58	206.45	242.06	278.94	315.01	354.98	398.22
S23	25.36	21.05	33.96	44.11	63.01	80.40	102.50	125.13	149.95	175.45	206.90
INS1	-17.88	24.61	66.34	102.12	143.14	175.93	219.16	256.38	293.65	332.40	374.17
INS2	21.15	258.74	456.50	608.05	758.47	875.49	1003.55	1118.52	1230.06	1332.84	1433.10
INS3	-13.16	19.45	53.91	81.33	112.11	138.59	169.16	199.94	229.73	256.96	287.90
INS4	-17.90	56.38	135.89	212.79	290.14	361.03	440.18	521.36	593.55	679.54	757.05
INS5	6.85	68.91	123.94	166.58	212.97	251.46	295.01	337.43	377.58	417.61	459.15
IS24	5.52	64.54	121.37	173.66	218.38	254.49	307.16	351.40	392.97	438.73	485.44
IS25	-45.72	14.89	65.76	110.15	154.76	193.17	238.07	280.96	323.27	362.87	406.21
IS26	13.68	-37.19	-82.90	-104.75	-124.79	-124.41	-125.88	-119.98	-108.23	-98.87	-77.76
IS27	26.28	-31.80	-83.62	-109.05	-130.06	-131.73	-134.45	-128.98	-117.79	-107.86	-86.25
IS28	-7.26	15.52	41.57	67.11	92.64	115.86	141.28	168.38	191.34	217.43	242.55
IS29	-12.38	12.25	40.69	69.00	96.68	121.49	148.62	177.98	201.83	230.23	256.92
IS30	-6.22	-45.11	-75.27	-87.99	-104.18	-103.99	-111.99	-112.33	-113.78	-115.60	-111.25
IS31	-12.79	-28.01	-34.17	-29.18	-26.83	-18.45	-14.92	-5.68	-1.92	6.14	14.48
IS32	4.28	261.51	468.28	633.89	790.76	912.32	1047.04	1166.26	1280.97	1387.49	1491.26
F01	55.65	82.28	86.62	124.67	139.74	179.78	197.35	210.72	228.84	233.55	252.42
F02	-75.52	-76.05	-39.23	-54.10	-39.24	-54.83	-39.96	-23.63	-1.88	48.53	70.84
F03	-53.09	-46.02	-45.16	59.73	112.51	217.08	294.55	363.99	393.13	433.12	464.66
F04	-5100.71	-1209.59	-7183.05	-11880.55	-1801.04	-3583.45	-5096.76	-7521.80	-6237.07	-6512.16	-4554.79
F05	286.64	309.21	321.30	346.82	370.05	397.71	419.60	433.81	453.72	459.69	473.49
F06	-98.22	-38.66	134.89	20.89	55.75	26.70	49.21	84.78	131.24	259.75	214.03
F07	18.66	23.00	6.80	29.42	25.27	51.20	53.19	49.74	72.95	68.92	85.90
F08	-1.23	53.00	115.73	99.78	125.55	106.86	119.19	141.83	160.87	208.02	238.68
F09	29.60	43.56	37.39	156.11	208.72	326.90	407.02	483.06	516.41	553.75	586.79
F10	17.61	7.60	20.34	7.06	14.88	-9.14	6.88	19.79	23.79	58.90	67.46
F11	-857.73	-887.31	-853.85	-285.75	-295.24	-295.94	-294.49	-34.72	-44.87	-57.93	-72.45
F12	162.95	81.75	5844.02	-5639.97	-1924.43	-3185.23	-1185.04	-6152.39	-6561.04	-2984.61	-2567.52
L01	-25.73	2.10	1.42	26.97	47.55	79.72	105.37	120.93	137.79	150.88	165.67
L02	14.60	34.62	47.37	68.80	84.02	101.95	117.61	132.29	145.37	167.47	179.38
L03	125.31	124.10	123.25	120.67	119.35	120.76	123.58	127.08	133.11	142.99	151.07
L04	3.38	7.71	11.31	18.52	22.85	40.14	48.79	56.73	66.81	72.57	71.13
L05	131.17	153.67	172.54	192.88	204.55	217.61	232.14	240.08	248.07	260.42	271.34
L06	25.78	36.33	42.51	50.33	54.71	60.52	65.25	68.51	72.70	78.70	80.71
L07	29.45	21.11	9.33	-0.45	-11.14	-19.11	-27.26	-36.49	-42.65	-51.34	-58.05

Note: All frame strain gages and S5 show faulty readings.

Table D-12. Phase 1 (60,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.01	0.69	1.38	2.03	2.70	3.36	3.95	4.68	5.34	6.02	6.64
Frame-1	0.73	108.90	218.69	312.94	436.46	579.88	663.46	802.16	914.81	1015.91	1144.86
Frame-2	4.04	131.69	275.66	359.89	479.87	564.07	671.84	803.86	927.71	1012.27	1149.02
Frame-3	50.80	156.74	312.61	310.34	453.15	584.04	676.36	810.48	914.49	1013.91	1149.62
Frame-4	-36.01	101.38	179.35	298.70	456.91	577.78	685.27	825.26	891.83	1005.24	1113.83
Frame-5	1.79	108.68	218.79	337.86	451.80	561.00	679.06	788.69	903.22	1019.36	1146.79
Frame-6	-0.24	153.99	189.95	299.85	482.63	561.37	682.91	827.22	906.34	1005.62	1188.88
Frame-7	-2.03	103.95	209.81	346.84	456.37	567.26	673.07	787.28	918.71	1012.49	1093.55
Frame-8	5.59	95.72	228.44	325.34	435.99	566.38	677.70	805.48	916.32	1019.54	1127.68
Frame-9	10.19	75.07	234.77	332.34	450.88	560.95	677.26	810.13	931.63	1002.89	1140.04
Frame-10	1.20	80.86	229.93	314.36	454.20	559.86	666.11	795.05	902.41	1009.81	1133.02
Frame-11	-10.99	123.40	203.90	295.63	438.17	535.81	685.01	820.40	916.82	1001.30	1138.40
Frame-12	2.85	45.19	222.57	326.98	489.79	560.34	683.81	785.60	897.90	1005.63	1136.68
Hoop-1	16.27	1046.63	1383.73	2275.76	2835.34	3515.84	4352.89	4953.36	5644.59	6378.32	7174.78
Hoop-2	-11.83	670.46	1469.17	2329.51	2866.09	3584.57	4295.60	5041.23	5757.71	6492.65	7122.43
Hoop-3	78.31	685.93	1459.90	2211.89	2859.14	3567.72	4286.43	5009.11	5696.64	6530.45	7163.73
Hoop-4	-19.31	710.34	1390.60	2178.76	2822.61	3547.09	4284.02	4968.69	5740.27	6443.24	7108.74
Hoop-5	34.08	678.55	1392.95	2127.70	2854.69	3564.25	4259.12	5030.10	5750.25	6438.51	7165.34
Hoop-6	-4.52	673.54	1414.83	2149.83	2880.82	3578.05	4278.42	4998.18	5695.20	6401.24	7147.60
Hoop-7	34.79	791.10	1473.81	2046.25	2891.67	3546.35	4306.23	5012.98	5774.72	6392.15	7173.05
Hoop-8	66.49	708.45	1402.19	2140.14	2855.67	3527.14	4324.91	4959.11	5690.25	6419.61	7143.44
Hoop-9	-14.52	711.00	1415.10	2137.09	2862.39	3555.58	4292.72	5008.89	5706.31	6423.50	7135.36
Hoop-10	5.91	712.92	1402.30	2153.79	2864.14	3560.49	4303.88	5010.53	5712.85	6425.82	7137.10
Hoop-11	3.36	706.07	1399.82	2102.60	2905.23	3553.32	4313.32	5001.11	5708.10	6429.69	7124.01
Hoop-12	15.28	758.69	1485.05	2165.46	2830.30	3541.22	4275.92	4971.20	5682.75	6392.54	7134.75
Hoop-13	51.43	724.08	1455.35	2106.12	2851.67	3560.86	4300.16	5009.00	5704.21	6426.90	7158.74
Hoop-14	-6.53	698.20	1439.79	2144.59	2812.41	3561.19	4303.48	5007.86	5683.86	6424.17	7136.95
Long-1	33.11	655.02	1308.33	2017.95	2673.35	3308.79	4015.14	4670.42	5332.15	6007.63	6680.94
Long-2	77.96	554.62	1596.54	1972.36	2716.34	3219.50	4022.47	4955.79	5490.04	6043.24	6477.12
Long-3	7.03	662.87	1326.02	1999.32	2682.12	3352.38	4027.79	4687.07	5340.29	6007.69	6672.69
Long-4	-11.32	665.19	1365.82	2042.74	2656.66	3430.66	4007.14	4595.38	5329.61	6000.69	6713.98
Long-5	8.13	647.76	1347.48	1965.12	2708.57	3307.95	4021.87	4760.30	5384.38	5997.52	6630.67
Long-6	28.04	656.98	1374.92	2080.22	2673.68	3316.66	4008.57	4700.22	5344.37	6017.82	6643.79
Long-7	71.65	680.04	1343.19	2021.35	2687.07	3306.21	4013.24	4671.31	5333.06	6021.15	6680.06
Long-8	0.79	708.24	1292.25	2052.34	2685.14	3371.03	4013.27	4712.23	5329.26	6004.07	6640.90
S1-H	-13.04	152.78	273.68	360.38	440.63	513.62	580.17	662.36	739.10	815.66	888.71
S1-A	-6.11	37.65	67.39	95.24	120.69	144.45	170.62	196.22	220.74	247.51	275.73
S2-H	-12.92	106.25	197.93	263.47	328.23	387.58	443.67	510.45	575.46	640.58	705.67
S2-A	-4.67	22.24	52.90	73.82	91.02	108.23	122.43	150.07	165.79	188.99	207.66
S3-H	-6.72	76.62	148.57	198.36	245.54	289.69	329.89	381.94	432.44	483.53	537.28
S3-A	-0.49	7.37	32.67	55.06	78.89	100.90	123.96	151.16	171.93	195.46	211.99
S4-H	-15.76	68.91	145.36	203.80	260.02	314.01	359.70	418.86	472.86	528.37	577.78
S4-A	3.35	33.90	53.85	69.54	88.65	102.02	115.23	135.78	154.15	173.13	196.05
S5	-6333.65	-6351.82	-6280.50	-6175.22	-6108.97	-6171.37	-6156.21	-6093.82	-6023.20	-5971.47	-5929.44
S6	55.60	227.20	376.80	542.91	705.11	855.14	1009.55	1182.69	1356.43	1530.94	1695.31
S7	-41.28	108.90	231.07	327.17	415.75	497.30	570.57	658.78	740.48	821.07	898.67
S8	-42.62	119.31	256.18	365.19	464.40	551.77	628.62	718.41	800.84	879.83	955.47
S9	62.45	-228.18	-449.15	-625.01	-779.70	-907.82	-1023.89	-1142.57	-1250.56	-1339.47	-1422.48

Table D-12. Phase 1 (60,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S10	-40.06	101.85	236.34	338.07	428.06	509.88	582.16	668.05	746.80	823.02	896.54
S11	-81.31	241.50	495.57	688.10	851.99	991.20	1113.21	1250.25	1374.99	1493.75	1602.38
S12	25.48	0.35	-11.12	-10.03	-9.12	-7.66	-4.39	1.62	9.46	18.74	26.76
S13	-83.45	195.91	405.27	553.66	679.24	784.65	875.90	982.22	1076.19	1167.81	1251.93
S14	-23.13	93.42	198.35	277.84	353.29	424.66	488.88	568.21	642.09	716.81	789.07
S15	-13.39	18.82	50.53	84.68	116.49	144.07	169.40	199.90	230.17	263.13	295.18
S16	-18.26	63.38	145.31	208.06	268.31	326.57	378.28	444.96	505.64	568.78	628.54
S17	-17.80	89.81	190.89	267.94	339.05	405.26	463.02	534.96	600.82	667.78	730.25
S18	39.48	-101.19	-246.35	-394.38	-529.91	-653.58	-776.75	-915.07	-1047.88	-1179.57	-1308.25
S19	-7.06	70.10	135.64	194.10	241.29	289.27	333.58	389.42	441.97	497.39	547.52
S21	-7.89	52.31	105.21	158.78	210.60	260.71	312.13	369.85	429.91	487.54	545.24
S22	-16.75	36.70	76.24	126.27	165.77	199.96	235.20	272.57	313.72	354.29	395.52
S23	27.08	18.29	24.18	42.57	59.30	75.57	97.09	121.13	149.78	177.39	206.14
INS1	-17.88	26.10	70.09	106.61	144.65	181.95	218.46	260.19	300.47	335.55	378.01
INS2	6.32	251.32	448.34	610.16	752.47	877.66	995.09	1117.54	1232.91	1336.78	1434.71
INS3	-15.02	23.15	53.73	86.35	113.78	142.49	170.66	200.53	231.79	261.83	291.08
INS4	-22.14	48.13	127.69	211.25	287.21	361.97	437.16	518.76	598.47	680.21	757.67
INS5	4.51	69.09	123.21	170.72	213.33	254.90	295.19	339.30	381.57	423.04	463.78
IS24	-11.19	54.92	113.96	159.53	203.87	247.48	289.05	332.80	375.15	418.24	476.32
IS25	-40.92	27.11	83.57	132.13	176.37	218.40	259.30	303.00	347.58	388.54	430.28
IS26	51.32	-15.71	-65.67	-92.84	-113.05	-120.41	-118.38	-116.71	-105.15	-91.75	-72.83
IS27	48.86	-15.44	-70.72	-100.14	-119.69	-128.09	-126.58	-125.17	-114.02	-99.70	-80.65
IS28	-7.49	12.98	38.81	68.26	92.60	115.99	140.62	166.35	192.15	218.49	243.03
IS29	-12.61	9.17	38.39	70.33	96.38	121.62	147.97	175.49	203.19	231.34	257.59
IS30	11.22	-37.85	-72.20	-81.65	-95.65	-103.48	-103.29	-110.55	-110.37	-108.57	-105.83
IS31	-1.74	-25.02	-28.97	-23.21	-20.63	-16.24	-7.85	-3.55	2.52	11.63	19.29
IS32	-17.63	252.17	459.14	630.02	782.84	915.14	1037.25	1164.07	1283.66	1387.09	1488.25
F01	184.87	209.16	204.10	229.82	254.86	282.07	305.79	314.10	326.09	327.21	336.24
F02	-129.93	-125.21	-69.54	-69.35	-65.18	-54.12	-51.94	-22.92	7.92	48.01	77.39
F03	56.75	81.33	46.21	111.83	194.76	278.71	368.30	418.95	453.94	471.36	499.56
F04	-8639.39	-11487.73	-8221.60	-6765.87	-2038.36	9015.96	-5179.75	-1959.12	-8877.40	1331.52	652.17
F05	440.10	456.93	461.32	475.03	493.36	512.96	528.47	542.00	549.65	559.85	568.12
F06	-79.33	-51.73	-21.96	-19.05	-12.52	2.74	-12.52	137.82	70.28	124.05	169.79
F07	14.04	39.34	8.11	24.41	48.35	51.21	65.78	66.77	77.69	69.73	99.28
F08	-54.19	-1.95	64.62	76.22	81.12	86.03	75.50	113.04	138.81	177.46	211.36
F09	138.38	167.57	131.14	204.91	298.49	389.37	489.42	542.31	579.17	596.09	623.96
F10	7.79	1.05	21.80	9.79	10.33	13.79	0.69	18.16	36.00	54.56	60.75
F11	-670.42	-680.58	-553.64	-100.76	-111.66	-118.20	-79.00	-124.71	-45.62	-57.96	-70.29
F12	1769.04	2119.83	177.44	-3713.18	-2058.00	1116.96	1235.73	-11642.26	-9361.60	-7961.98	-2565.39
L01	-15.58	4.91	4.59	27.61	56.44	80.65	114.32	126.23	145.28	157.44	168.89
L02	19.91	36.94	50.34	66.81	86.17	102.25	122.13	139.19	151.60	166.69	181.21
L03	166.03	163.35	162.64	162.60	160.33	160.15	163.11	168.22	172.87	180.61	188.95
L04	17.80	17.80	19.96	24.29	37.99	43.03	51.68	56.02	64.65	68.26	77.63
L05	230.71	246.69	251.80	262.68	277.24	281.63	285.96	291.02	304.12	304.88	311.39
L06	27.96	37.24	44.89	50.52	57.26	61.27	67.81	72.72	76.00	79.47	83.28
L07	41.76	28.36	17.49	5.89	-2.26	-12.59	-19.47	-29.07	-38.32	-46.48	-52.09

Note: All frame strain gages and S5 show faulty readings.

Table D-13. Phase 1 (60,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.03	0.64	1.33	1.99	2.65	3.33	3.99	4.72	5.37	5.98	6.67
Frame-1	1.83	123.12	233.82	358.20	456.51	568.60	686.96	809.15	899.65	1013.77	1135.14
Frame-2	-21.08	104.87	254.63	355.84	449.04	570.73	664.29	792.93	899.57	1019.86	1132.85
Frame-3	-23.87	145.64	182.77	408.11	448.94	560.01	679.89	797.25	876.29	1017.99	1140.64
Frame-4	-52.19	142.97	299.94	310.48	447.77	548.22	670.23	791.36	894.62	1046.89	1137.44
Frame-5	-5.36	132.59	228.84	343.63	447.10	564.39	679.70	794.14	911.08	1031.87	1133.88
Frame-6	2.34	74.11	194.95	311.65	454.96	546.00	650.76	782.52	912.19	1009.80	1142.32
Frame-7	-2.23	102.37	232.06	350.88	443.68	550.06	669.41	796.25	886.57	1036.80	1118.10
Frame-8	-5.29	97.11	209.16	366.21	442.47	560.49	676.90	790.52	905.35	1028.36	1123.02
Frame-9	-1.18	139.13	203.12	326.43	435.83	586.25	663.98	803.44	899.27	1023.50	1121.83
Frame-10	-4.70	113.28	211.88	340.94	450.18	609.67	648.41	786.89	910.71	1029.29	1137.27
Frame-11	8.23	103.86	191.01	362.55	437.06	573.37	681.22	805.74	880.68	1014.43	1126.36
Frame-12	2.63	95.70	243.04	315.86	453.25	572.80	650.78	796.68	905.32	1020.62	1118.20
Hoop-1	45.45	701.96	1586.43	2069.69	2826.50	3564.37	4244.87	4988.84	5970.46	6328.46	7183.90
Hoop-2	-15.42	763.83	1514.35	2153.55	2819.69	3635.92	4208.99	5054.59	5784.07	6418.40	7136.80
Hoop-3	38.39	738.01	1409.85	2138.97	2831.65	3567.01	4284.27	4976.87	5690.87	6469.05	7096.01
Hoop-4	6.16	723.08	1374.50	2151.46	2806.51	3551.84	4241.75	4980.43	5754.25	6391.66	7132.40
Hoop-5	3.48	797.36	1371.62	2120.50	2885.58	3608.54	4341.50	5009.30	5740.68	6423.47	7145.53
Hoop-6	0.63	779.97	1403.10	2146.39	2851.92	3592.78	4308.90	4993.76	5727.25	6428.06	7145.88
Hoop-7	-6.33	608.73	1461.59	2132.07	2870.50	3593.91	4339.77	4985.16	5711.57	6436.20	7174.83
Hoop-8	29.61	679.00	1468.46	2140.14	2855.67	3534.16	4279.77	4996.01	5726.01	6426.99	7143.44
Hoop-9	5.24	707.47	1425.73	2158.64	2851.61	3580.36	4290.07	4983.75	5710.56	6430.69	7138.95
Hoop-10	5.91	697.00	1423.48	2150.24	2851.70	3586.78	4288.81	4990.99	5713.49	6434.71	7151.31
Hoop-11	-13.02	738.92	1357.81	2255.53	2843.33	3585.73	4265.13	4995.65	5705.14	6431.52	7140.40
Hoop-12	0.00	720.54	1471.52	2211.33	2807.37	3602.01	4405.02	4963.55	5788.64	6407.83	7165.33
Hoop-13	14.88	687.59	1411.34	2157.31	2837.04	3567.82	4270.06	4987.06	5732.32	6426.90	7144.12
Hoop-14	-6.53	588.15	1388.26	2173.96	2856.45	3597.53	4265.92	4993.17	5726.77	6431.51	7151.64
Long-1	25.26	672.68	1338.15	1995.18	2673.80	3328.41	4002.39	4676.83	5329.20	5998.59	6691.10
Long-2	-3.61	631.95	1142.71	1996.07	2613.15	3375.59	3839.66	4652.93	5288.96	6032.19	6671.09
Long-3	-2.72	688.47	1338.61	2004.00	2663.30	3338.97	3983.90	4692.70	5351.26	6007.72	6680.11
Long-4	186.49	642.28	1328.83	2009.97	2693.51	3322.12	3976.99	4686.59	5307.90	5997.08	6677.93
Long-5	14.02	719.62	1179.38	2009.70	2699.79	3508.22	4019.51	4626.69	5409.12	6006.93	6657.91
Long-6	10.24	673.59	1414.50	1995.75	2645.86	3358.20	3984.83	4676.01	5328.94	6015.43	6666.47
Long-7	43.66	770.08	1361.85	2001.68	2671.93	3336.64	4013.24	4670.84	5328.20	6030.91	6672.87
Long-8	13.85	667.89	1404.25	2042.64	2694.10	3289.12	4012.08	4682.08	5312.64	6007.63	6688.52
S1-H	-24.23	149.22	259.07	349.53	427.34	505.12	581.04	663.98	741.53	813.29	893.09
S1-A	-4.80	35.58	67.56	94.67	118.43	139.75	164.62	192.84	215.88	245.54	273.46
S2-H	-24.04	101.66	182.44	254.95	315.45	379.09	443.16	511.52	577.94	638.97	707.65
S2-A	-3.18	23.73	48.40	65.59	88.03	104.47	119.42	144.83	164.29	188.91	216.61
S3-H	-13.93	73.02	134.37	189.03	234.37	280.83	328.57	382.48	433.80	482.63	536.56
S3-A	-1.56	10.58	28.73	53.58	79.20	100.35	120.42	147.71	167.78	193.95	217.50
S4-H	-25.51	69.66	134.09	196.28	248.01	304.21	358.91	418.07	472.11	527.41	579.22
S4-A	3.31	26.14	48.10	65.42	84.86	96.63	110.69	133.80	150.69	175.49	200.94
S5	-7322.79	-7239.21	-7142.56	-6994.31	-7042.98	-6918.70	-6859.83	-6798.10	-6722.42	-6717.50	-6662.15
S6	61.62	207.87	367.07	529.74	678.81	842.03	1007.44	1184.03	1357.71	1525.05	1707.89
S7	-49.74	107.80	219.71	316.28	401.12	486.30	570.88	658.58	741.62	817.65	900.49
S8	-53.17	117.53	244.54	353.29	447.63	539.71	628.37	717.97	801.57	875.53	955.78
S9	47.49	-215.70	-437.65	-622.44	-768.98	-908.73	-1022.97	-1144.45	-1248.56	-1337.66	-1425.61

Table D-13. Phase 1 (60,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S10	-43.70	102.93	222.30	326.23	413.48	498.33	581.55	667.98	747.53	818.52	895.72
S11	-85.87	231.11	474.28	668.12	826.71	975.73	1114.19	1252.49	1378.26	1488.96	1606.22
S12	26.39	1.26	-7.12	-10.94	-10.76	-8.21	-2.38	3.44	12.00	17.10	27.48
S13	-90.50	188.02	381.18	534.69	656.26	769.22	874.36	981.76	1077.47	1162.98	1253.44
S14	-29.83	89.41	181.43	266.89	338.87	413.88	488.38	568.74	644.64	713.79	790.44
S15	-13.61	18.91	51.93	79.99	109.70	137.13	168.70	200.84	232.95	261.26	295.42
S16	-26.20	60.29	129.08	199.65	254.94	316.98	377.38	444.41	506.32	565.51	628.66
S17	-26.34	87.80	175.77	259.55	324.83	394.81	464.07	536.54	602.82	664.24	730.90
S18	30.69	-106.19	-252.63	-378.08	-515.10	-644.57	-773.44	-916.53	-1054.89	-1175.82	-1313.68
S19	-10.61	65.76	128.46	181.50	229.78	282.24	332.27	390.07	444.93	492.82	547.51
S21	-5.17	46.27	98.79	156.54	203.95	258.89	313.28	372.90	431.37	485.89	548.82
S22	-14.71	36.15	83.09	114.43	157.48	193.05	231.58	273.72	317.59	351.79	395.76
S23	29.03	16.02	24.09	38.13	54.35	73.83	97.94	123.57	151.95	175.51	207.03
INS1	-14.90	26.84	69.33	107.35	143.89	183.40	222.17	261.65	301.96	337.65	379.47
INS2	15.62	238.37	431.83	603.07	738.15	874.22	994.04	1119.33	1232.36	1331.21	1434.79
INS3	-12.42	22.78	55.60	83.20	111.54	142.86	172.33	202.74	235.31	260.30	290.77
INS4	-20.02	51.20	130.25	200.68	276.97	356.92	433.37	519.61	603.70	675.93	758.90
INS5	6.85	67.83	120.17	167.48	209.75	253.23	296.78	341.39	383.87	422.64	464.50
IS24	-17.73	52.37	109.58	161.70	203.30	251.25	298.29	342.39	380.96	424.06	509.33
IS25	-20.46	44.17	98.58	148.23	190.29	235.33	280.59	325.24	370.89	413.63	461.88
IS26	58.49	-16.07	-59.23	-87.32	-108.26	-116.71	-114.32	-113.95	-103.50	-91.72	-72.64
IS27	48.54	-17.11	-64.27	-96.55	-116.23	-125.98	-123.90	-122.98	-113.21	-100.34	-80.82
IS28	-6.58	15.25	41.80	64.63	89.50	115.56	140.66	167.33	195.23	216.64	242.91
IS29	-11.93	11.75	40.83	66.28	92.65	121.09	147.45	176.11	205.91	228.98	257.20
IS30	19.04	-31.30	-56.02	-80.55	-89.28	-96.91	-103.09	-107.99	-106.01	-108.71	-106.00
IS31	-0.33	-19.86	-22.44	-23.07	-19.04	-13.47	-8.35	-2.64	5.83	10.90	18.97
IS32	-6.54	241.78	450.32	626.87	771.31	912.41	1036.24	1165.04	1281.84	1383.81	1490.10
F01	270.99	274.01	295.22	308.45	323.52	343.28	351.98	355.93	366.70	372.20	376.81
F02	-108.54	-74.60	-69.52	-49.21	-40.15	-34.16	-14.94	21.34	48.73	94.42	144.86
F03	114.15	77.38	161.24	180.42	256.20	347.08	419.68	436.11	480.37	500.50	513.63
F04	1023.98	133.94	4208.44	-1511.08	614.05	1893.31	704.79	4331.38	3032.36	-2055.31	2022.11
F05	536.26	540.67	553.52	565.65	576.02	593.94	602.99	611.25	620.25	626.39	632.85
F06	-228.24	-116.36	-112.00	43.40	-56.82	-51.01	-42.29	25.97	57.21	125.45	265.64
F07	22.06	41.19	43.14	33.41	49.62	62.70	60.21	66.36	80.49	90.70	101.08
F08	-82.49	-3.95	13.28	41.21	53.73	49.56	62.07	101.60	122.66	169.05	210.07
F09	200.40	165.38	259.10	281.21	364.82	461.63	541.04	556.94	603.83	627.40	637.85
F10	14.34	21.80	15.97	7.60	10.70	4.15	10.88	36.72	46.19	68.37	85.31
F11	-630.57	-599.24	-55.04	-41.25	-5.70	-18.03	-30.37	-41.25	-52.15	-63.74	-77.54
F12	-12771.30	609.33	-2414.14	-4078.06	-15216.87	-2008.51	-5322.19	-12890.49	-7874.20	-7245.75	-5954.20
L01	-10.41	4.82	19.14	41.61	60.88	93.14	118.80	128.39	146.09	159.96	172.14
L02	20.87	38.71	53.19	70.21	87.66	104.82	120.35	136.09	149.83	167.58	182.82
L03	207.37	204.34	203.46	203.39	202.61	201.15	201.03	205.32	208.54	216.73	226.33
L04	17.80	17.80	19.97	29.33	40.14	48.08	51.68	61.06	66.81	74.74	82.69
L05	277.96	288.81	296.80	302.61	313.54	310.63	322.99	329.49	335.37	339.63	345.51
L06	33.60	41.97	49.79	58.34	63.80	69.81	73.99	78.17	82.19	87.07	91.46
L07	55.90	42.67	32.16	18.94	9.88	-2.08	-10.23	-18.20	-27.63	-34.68	-42.30

Note: All frame strain gages and S5 show faulty readings.

Table D-14. Phase 2 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.01	0.71	1.52	2.33	3.04	3.82	4.63	5.35	6.15	6.91	7.68
Frame-1	-34.09	73.81	263.95	465.29	598.87	586.21	787.83	911.07	1032.23	1250.16	1308.91
Frame-2	-21.43	186.11	199.53	381.13	537.43	647.82	779.02	905.40	1023.36	1175.62	1311.40
Frame-3	-50.96	210.63	321.09	388.91	536.46	664.09	788.17	918.61	1033.52	1165.09	1293.53
Frame-4	-26.93	149.29	194.67	377.33	531.15	650.46	728.68	922.67	1064.84	1174.14	1298.96
Frame-5	-19.80	157.30	231.69	381.20	538.10	645.74	777.52	919.19	1037.70	1175.82	1303.99
Frame-6	-11.48	123.82	281.18	365.15	513.93	645.36	751.37	915.24	1046.05	1175.31	1274.90
Frame-7	2.97	107.54	258.28	359.75	534.20	668.15	772.94	928.23	1042.73	1171.90	1297.39
Frame-8	-5.92	134.58	245.89	372.45	540.77	645.09	769.03	921.76	1030.00	1173.53	1305.55
Frame-9	-26.86	142.77	259.23	347.75	531.69	638.93	779.52	918.46	1037.69	1172.44	1288.28
Frame-10	-2.40	132.64	253.52	390.00	541.02	672.35	752.49	910.29	1025.46	1176.22	1289.32
Frame-11	-10.32	107.67	252.32	387.99	528.74	620.24	802.65	917.66	1023.46	1186.22	1298.87
Frame-12	-7.18	125.82	261.80	373.19	540.36	649.30	779.56	912.60	1027.05	1183.14	1283.09
Hoop-1	-82.78	820.39	1681.74	2511.74	3515.60	4123.23	4908.35	5761.27	6551.95	7405.92	8214.47
Hoop-2	-44.11	809.19	1617.73	2481.64	3202.31	4104.20	4958.07	5776.24	6669.72	7379.36	8222.12
Hoop-3	-6.08	808.52	1656.29	2496.77	3259.59	4112.48	4941.55	5765.59	6586.05	7383.36	8231.14
Hoop-4	2.72	825.59	1623.13	2494.99	3318.18	4088.33	4775.20	5762.78	6575.38	7383.76	8177.77
Hoop-5	-12.94	826.37	1620.81	2477.96	3299.59	4117.36	4932.02	5759.54	6563.47	7383.05	8217.20
Hoop-6	-22.18	812.51	1625.03	2471.58	3356.41	4100.15	4942.28	5748.51	6570.11	7385.99	8205.39
Hoop-7	33.73	806.50	1629.54	2484.44	3372.05	4112.71	4959.41	5741.94	6569.04	7399.15	8206.16
Hoop-8	-12.74	806.63	1611.08	2459.64	3294.27	4091.49	4918.24	5773.95	6579.13	7390.38	8195.72
Hoop-9	409.96	794.46	1611.72	2473.72	3291.64	4098.29	4899.54	5750.53	6559.54	7392.40	8183.61
Hoop-10	11.04	816.07	1629.82	2478.95	3295.14	4126.82	4915.86	5738.09	6573.90	7385.31	8212.40
Hoop-11	-37.72	821.89	1657.67	2456.86	3282.36	4085.51	4863.17	5791.41	6516.83	7384.82	8190.53
Hoop-12	-30.70	906.09	1588.46	2513.45	3362.80	4051.07	4930.51	5778.79	6643.52	7453.39	8211.22
Hoop-13	-31.13	839.26	1607.10	2469.84	3311.47	4094.09	4913.28	5753.85	6580.93	7392.07	8190.06
Hoop-14	-41.10	832.82	1618.45	2477.36	3307.71	4093.51	4908.68	5760.00	6561.06	7397.53	8206.10
Long-1	-17.91	683.53	1338.74	2004.01	2698.59	3339.21	4007.69	4670.99	5339.09	5999.40	6681.92
Long-2	-4.70	647.80	1111.75	1978.10	2691.07	3288.72	3906.45	4619.97	5335.34	6001.96	6698.19
Long-3	45.34	678.08	1303.37	2014.27	2737.23	3334.61	4000.67	4673.99	5332.11	6012.46	6674.42
Long-4	-14.53	695.81	1326.43	2006.76	2690.57	3329.76	4016.38	4658.33	5332.28	6004.10	6670.97
Long-5	39.54	602.67	1310.57	2017.55	2608.95	3283.99	4010.09	4666.60	5264.88	6010.69	6679.75
Long-6	85.39	657.44	1327.85	2004.45	2704.67	3356.22	3986.81	4681.41	5319.72	6003.38	6670.29
Long-7	109.16	677.47	1318.65	2019.73	2685.38	3341.30	3981.80	4669.71	5336.36	6002.08	6676.21
Long-8	-3.81	666.92	1342.26	1971.57	2706.39	3298.77	3959.20	4699.11	5312.66	6007.20	6668.35
S1-H	-289.19	69.11	232.84	367.37	468.00	573.05	673.95	761.42	855.98	945.97	1035.03
S1-A	-36.04	1.92	28.28	54.84	83.81	107.01	130.94	157.49	178.43	205.34	231.16
S2-H	-201.15	31.21	159.36	268.19	351.15	437.38	522.45	595.52	674.15	750.28	825.43
S2-A	111.70	143.83	166.24	193.19	221.55	238.76	254.46	276.89	299.31	317.97	344.16
S3-H	3373.96	3488.94	3571.50	3650.45	3705.97	3770.87	3833.60	3887.29	3939.59	3999.04	4057.12
S3-A	-5.66	0.90	15.88	36.01	61.29	83.29	102.92	128.93	150.25	173.97	194.55
S4-H	-111.72	7.43	94.33	183.52	255.41	325.12	397.80	456.99	522.93	588.06	652.55
S4-A	15.50	44.18	62.44	80.01	105.12	121.94	144.97	165.33	184.76	208.33	231.52

Table D-14. Phase 2 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S5	46.70	244.35	418.36	577.42	695.20	821.53	939.08	1039.36	1148.55	1249.80	1348.03
S6	103.78	181.21	399.47	624.70	810.50	1046.99	1268.06	1486.35	1723.50	1952.13	2173.02
S7	-361.71	-156.78	-2.66	139.66	247.04	358.75	462.45	554.29	652.36	745.03	834.41
S8	-213.05	37.09	263.19	479.94	643.42	803.45	951.05	1068.11	1188.81	1299.20	1401.12
S9	236.13	-199.09	-640.10	-1024.73	-1314.21	-1623.10	-1898.81	-2138.51	-2377.11	-2596.00	-2794.86
S10	-126.53	62.30	241.79	416.50	550.40	688.71	817.49	924.59	1037.14	1140.05	1238.23
S11	-480.91	-41.94	244.44	464.54	640.30	866.08	1095.43	1296.76	1497.92	1658.53	1718.36
S12	22.32	-21.57	-33.40	-34.86	-37.77	-24.30	-14.10	-3.91	6.29	20.31	31.24
S13	-318.28	57.34	331.09	549.62	703.37	849.67	978.08	1084.67	1193.80	1293.89	1388.23
S14	-106.85	46.70	167.37	286.28	382.10	482.53	580.14	663.61	752.80	837.95	921.59
S15	-68.20	-30.71	18.59	67.17	102.27	147.03	190.88	230.35	272.38	312.74	352.97
S16	-97.13	16.23	110.24	205.79	282.70	367.04	446.00	516.47	590.39	664.06	735.14
S17	-122.69	29.31	155.39	274.11	365.15	462.69	555.75	633.54	713.51	789.94	864.36
S18	151.98	7.47	-180.16	-374.92	-536.15	-713.40	-885.90	-1044.18	-1209.32	-1360.95	-1511.22
S19	-33.40	58.10	138.93	220.21	287.33	359.35	429.98	492.05	557.07	619.08	680.61
S21	-12.17	32.41	109.67	184.83	244.07	320.32	393.73	462.73	537.86	610.62	680.77
S22	-86.57	-33.66	38.02	107.50	161.05	221.38	280.24	332.96	387.63	437.17	487.07
S23	18.21	-17.09	-4.29	22.70	42.48	80.41	117.47	148.69	183.94	220.39	256.17
INS1	-46.81	15.85	71.19	126.79	170.60	220.80	270.27	315.14	363.64	410.84	457.28
INS2	-71.03	100.40	277.41	471.86	622.44	790.93	945.94	1082.17	1223.43	1357.03	1482.15
INS3	8.26	47.37	87.01	129.09	163.74	201.54	238.26	271.56	308.12	341.85	375.51
INS4	-47.77	24.35	123.73	229.54	320.46	425.94	525.89	621.52	721.00	813.33	905.12
INS5	-9285.22	-9210.70	-9141.46	-9073.63	-9020.74	-8964.97	-8911.71	-8861.73	-8812.60	-8764.38	-8716.41
IS24	1.25	108.81	221.29	323.60	397.74	483.43	560.73	628.60	699.91	764.98	826.75
IS25	-341.73	-216.77	-57.26	-12.37	-14.86	-11.37	-42.10	-55.37	-86.01	-70.16	-36.76
IS26	169.80	64.60	2.84	-38.33	-63.78	-69.19	-64.63	-50.82	-25.89	2.18	35.20
IS27	70.01	32.91	8.43	-9.12	-21.90	-14.51	-2.77	15.68	45.52	77.52	112.98
IS28	-7.86	12.43	45.96	82.42	110.62	145.26	177.89	209.75	242.43	272.26	302.52
IS29	-12.67	10.61	47.53	86.24	115.07	151.96	185.03	218.24	252.49	283.58	315.73
IS30	89.61	11.28	-29.24	-57.60	-77.21	-88.12	-93.94	-92.30	-87.76	-82.66	-75.04
IS31	20.49	-6.02	-9.77	-9.82	-10.91	-4.39	0.10	11.24	23.88	34.84	47.84
IS32	78.59	295.44	511.80	717.60	875.49	1053.34	1215.53	1359.52	1508.98	1646.81	1776.61
P1A	-28.20	42.20	80.67	125.69	160.64	199.07	238.81	272.43	310.73	347.15	384.41
P1B	-23.96	31.81	65.50	100.19	128.51	159.14	190.78	218.41	249.71	279.80	310.78
P1C	50.30	96.74	124.73	154.24	178.53	204.35	232.36	253.73	282.48	306.77	333.34
P1D	-42.86	30.57	86.64	142.56	188.82	236.81	285.51	328.12	374.42	419.02	461.68
P3A	14.39	45.76	76.57	111.09	139.67	170.87	202.24	231.03	261.85	291.34	321.27
P3B	4.11	36.75	66.45	99.48	125.47	155.18	184.51	211.63	240.40	269.15	297.40
P3C	14.46	46.54	75.48	107.96	136.33	167.51	198.67	226.70	257.86	287.34	317.61
P3D	-13.20	24.64	58.88	96.14	127.93	162.60	197.26	230.09	265.07	298.51	331.59
P5A	-17.41	61.80	132.84	197.80	248.99	301.55	352.97	396.29	442.92	487.47	529.54
P5B	-24.61	48.11	112.81	171.89	217.74	264.85	310.19	348.99	390.69	430.50	468.29
P5C	-5.71	54.51	114.91	172.03	215.82	260.78	304.80	343.11	383.81	422.63	460.42
P5D	-12.93	52.84	114.54	173.53	219.18	267.65	314.81	356.45	401.77	444.09	485.59

Table D-15. Phase 2 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.09	0.69	1.48	2.26	3.09	3.82	4.64	5.38	6.15	6.87	7.69
Frame-1	23.59	282.78	292.94	325.19	449.60	701.99	783.74	884.94	1051.76	1249.02	1150.67
Frame-2	11.28	149.12	301.94	414.61	511.36	653.71	788.06	902.31	1055.93	1177.64	1304.08
Frame-3	62.81	84.12	310.00	418.53	525.85	621.09	787.42	908.12	1030.36	1167.05	1291.28
Frame-4	12.18	226.48	270.67	442.16	523.42	668.59	777.95	879.08	1061.58	1155.77	1290.40
Frame-5	-24.76	144.80	280.22	399.98	525.11	658.20	786.59	909.55	1050.67	1171.27	1303.21
Frame-6	46.30	186.70	291.55	369.12	506.14	680.51	764.61	896.69	1061.47	1163.31	1302.15
Frame-7	42.41	142.72	287.93	402.31	512.68	662.01	785.13	906.22	1049.77	1157.76	1291.19
Frame-8	21.88	157.90	284.74	414.22	510.48	658.46	784.92	909.27	1038.94	1170.85	1294.44
Frame-9	20.84	145.94	289.17	402.70	510.98	644.18	780.11	907.05	1058.44	1171.35	1296.26
Frame-10	31.75	159.96	283.91	396.09	504.42	647.89	768.72	905.83	1053.64	1167.96	1291.77
Frame-11	43.82	145.45	266.47	393.06	516.99	663.20	786.83	899.45	1057.61	1162.69	1277.53
Frame-12	54.49	152.35	268.62	389.07	511.45	641.25	778.68	910.81	1042.20	1163.50	1305.70
Hoop-1	-35.33	805.87	1614.39	2473.67	3285.02	4123.23	4916.99	5759.44	6567.72	7432.21	8221.58
Hoop-2	-49.50	820.05	1614.30	2533.99	3322.02	4059.28	4894.69	5758.28	6550.49	7360.33	8229.15
Hoop-3	-51.24	815.55	1639.08	2417.12	3283.25	4098.59	4920.21	5729.11	6529.81	7408.41	8217.14
Hoop-4	-10.02	807.46	1648.78	2455.18	3261.09	4099.25	4891.25	5750.04	6525.57	7379.03	8210.35
Hoop-5	-7.53	812.04	1673.21	2460.20	3291.72	4097.54	4927.93	5746.93	6561.02	7403.60	8222.43
Hoop-6	-29.05	800.57	1656.12	2447.78	3278.47	4091.56	4912.59	5750.23	6554.00	7393.60	8210.46
Hoop-7	-36.05	774.38	1635.07	2466.80	3298.04	4098.40	4923.14	5747.31	6559.44	7414.20	8222.11
Hoop-8	2.03	821.23	1633.38	2459.89	3300.99	4098.47	4940.88	5745.57	6542.87	7391.12	8203.92
Hoop-9	194.37	823.04	1628.05	2445.23	3290.99	4087.10	4921.59	5739.10	6553.01	7405.71	8211.38
Hoop-10	-49.37	796.36	1631.76	2459.65	3285.60	4081.99	4930.57	5751.67	6551.45	7400.26	8220.33
Hoop-11	-28.61	827.19	1650.55	2502.63	3279.88	4054.15	4965.65	5741.57	6528.41	7403.77	8149.46
Hoop-12	1.80	852.39	1716.71	2444.88	3354.49	4096.54	4961.59	5718.76	6521.81	7385.31	8173.80
Hoop-13	-1.87	846.41	1665.77	2477.40	3281.56	4086.37	4921.09	5754.99	6545.01	7378.18	8176.24
Hoop-14	39.67	847.34	1699.40	2499.63	3292.37	4093.10	4938.55	5731.77	6554.37	7376.24	8243.64
Long-1	63.52	675.75	1350.78	2006.96	2667.46	3350.98	3992.18	4668.51	5333.66	6025.67	6710.05
Long-2	14.99	722.40	1373.56	1883.88	2643.52	3295.75	3959.10	4673.87	5322.15	5995.14	6666.52
Long-3	61.19	680.59	1376.79	1985.01	2672.88	3346.80	3991.34	4672.02	5334.02	6011.27	6665.33
Long-4	-21.77	729.66	1391.83	2013.99	2647.42	3380.41	3999.91	4673.26	5325.72	6006.52	6683.70
Long-5	-2.87	664.00	1345.00	2056.43	2703.47	3262.79	3935.08	4714.19	5385.70	5996.53	6617.98
Long-6	102.02	681.24	1315.05	2025.82	2651.52	3307.56	3983.64	4662.89	5338.17	6002.19	6666.20
Long-7	144.48	715.27	1362.73	1986.87	2716.08	3327.92	4005.34	4672.61	5334.61	6004.53	6675.65
Long-8	6.88	690.73	1352.02	1972.75	2648.49	3347.44	3970.29	4654.46	5320.44	5995.32	6584.73
S1-H	-402.14	51.20	225.99	355.36	476.53	571.75	675.39	764.78	855.79	941.03	1036.81
S1-A	-19.95	0.05	31.09	56.52	80.81	106.82	127.79	154.87	179.93	205.59	227.82
S2-H	-256.90	14.63	157.20	260.95	359.98	438.59	525.64	599.07	675.37	747.93	827.57
S2-A	-78.17	-33.32	-10.90	192.40	211.07	232.78	249.28	273.15	291.09	314.32	340.46
S3-H	3296.48	3421.92	3518.50	3600.34	3667.75	3727.95	3789.99	3848.40	3911.14	3969.15	4029.40
S3-A	-4.01	2.14	21.11	37.03	58.61	81.42	101.83	125.36	148.02	171.57	193.54
S4-H	-115.44	-5.31	92.10	176.74	259.88	324.37	400.88	462.99	524.43	585.98	654.87
S4-A	2.61	43.99	62.77	79.43	101.00	123.16	141.96	164.82	186.77	209.05	230.28

Table D-15. Phase 2 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S5	4.18	228.71	406.81	560.05	705.30	817.36	938.72	1041.90	1145.46	1241.27	1349.61
S6	97.29	157.17	371.63	588.91	827.98	1030.36	1266.28	1489.86	1713.15	1937.37	2175.09
S7	-398.97	-176.70	-9.25	126.50	254.87	356.26	464.77	557.16	651.45	738.67	835.94
S8	-257.35	11.64	250.16	458.76	654.99	801.27	954.88	1073.20	1190.26	1293.04	1404.90
S9	320.14	-181.71	-601.90	-978.83	-1336.76	-1616.37	-1894.46	-2142.69	-2372.02	-2581.87	-2797.14
S10	-135.77	48.72	235.20	400.61	563.28	689.44	821.69	929.63	1037.01	1135.03	1240.62
S11	-506.36	-74.13	195.43	446.81	676.06	886.08	1127.66	1274.57	1466.09	1625.38	1897.51
S12	29.23	-26.66	-40.32	-41.59	-33.76	-27.94	-16.65	-5.73	6.47	18.13	31.42
S13	-407.10	24.01	317.15	531.32	713.48	847.67	980.83	1088.12	1193.62	1287.54	1390.19
S14	-123.07	28.50	163.31	277.22	390.84	482.12	583.13	667.47	753.85	834.70	923.78
S15	-82.37	-38.71	13.13	60.43	108.44	145.94	190.37	231.81	271.65	309.56	353.01
S16	-104.83	-0.47	106.27	197.72	289.66	364.96	448.09	518.97	591.34	659.90	735.94
S17	-145.51	4.82	148.37	263.29	374.02	460.15	557.86	635.35	713.87	785.64	865.35
S18	203.98	14.25	-159.73	-348.47	-545.33	-711.89	-888.17	-1047.86	-1206.27	-1352.13	-1512.10
S19	-45.33	51.35	133.90	214.02	293.40	358.12	431.62	493.87	556.62	614.89	681.27
S21	-18.11	24.10	98.84	171.54	250.40	316.10	393.40	465.36	535.68	605.35	681.57
S22	-110.29	-34.38	31.89	99.33	168.86	223.79	283.35	333.41	384.50	433.07	486.62
S23	20.88	-21.40	-12.37	11.86	48.87	77.55	115.32	149.82	184.12	217.37	255.83
INS1	-57.24	16.50	68.50	122.11	175.62	221.17	270.70	317.09	363.59	408.21	458.49
INS2	-143.93	112.90	243.14	436.85	631.27	784.18	943.22	1086.07	1221.98	1349.23	1484.02
INS3	5.86	48.85	85.55	126.31	166.35	201.17	240.06	273.81	308.28	340.30	376.29
INS4	-70.63	18.22	111.18	215.30	327.71	422.88	528.31	623.56	718.23	806.68	905.39
INS5	-9295.09	-9212.70	-9143.45	-9077.05	-9012.65	-8963.53	-8908.84	-8859.21	-8811.36	-8766.51	-8716.71
IS24	-18.07	102.67	209.81	308.65	405.50	480.89	559.75	629.69	697.55	760.13	827.38
IS25	-689.33	-477.12	-303.89	-188.24	-116.13	-63.15	29.78	39.73	38.19	91.39	188.21
IS26	196.02	78.05	0.58	-39.92	-63.02	-70.78	-65.57	-50.37	-28.86	-1.14	35.69
IS27	55.49	34.36	1.49	-15.15	-19.41	-15.92	-3.04	17.18	43.79	74.78	114.35
IS28	-15.17	11.34	40.98	77.27	113.83	144.04	178.84	209.89	240.84	269.49	302.68
IS29	-22.24	7.61	41.37	80.05	118.50	150.06	185.71	218.65	250.58	280.85	316.08
IS30	102.68	27.82	-30.16	-55.77	-75.39	-87.22	-92.14	-90.85	-89.03	-83.42	-74.14
IS31	19.98	-5.15	-12.68	-11.22	-8.37	-5.02	1.55	12.15	21.75	33.85	48.62
IS32	44.12	293.64	500.99	696.23	893.80	1051.71	1216.68	1364.80	1506.98	1637.85	1777.33
P1A	-38.55	43.94	80.32	123.31	164.69	200.35	239.49	273.92	309.05	344.52	385.91
P1B	-33.38	34.55	65.69	99.61	131.83	160.50	191.81	219.78	249.00	278.00	311.55
P1C	50.29	105.57	132.13	160.84	187.36	211.72	240.51	263.32	287.64	312.02	341.48
P1D	-53.78	30.01	86.65	139.94	193.60	238.10	286.86	330.70	374.42	416.38	463.20
P3A	16.60	48.70	76.95	110.33	143.53	172.35	205.24	233.06	262.03	291.06	322.41
P3B	5.76	38.23	66.28	97.62	129.15	156.10	186.95	214.39	242.62	268.86	298.54
P3C	16.11	48.01	74.76	106.83	139.45	167.88	200.55	228.91	258.05	286.69	318.19
P3D	-13.10	25.61	57.15	93.64	131.04	162.97	199.38	232.02	265.21	297.26	332.73
P5A	-31.27	58.62	130.66	193.80	254.68	302.10	354.33	398.87	442.92	485.41	530.89
P5B	-39.06	43.32	108.74	166.20	220.25	262.60	309.60	349.08	388.25	426.40	467.60
P5C	-16.03	53.22	113.64	168.86	220.22	261.15	306.52	345.50	384.18	421.46	461.58
P5D	-25.27	52.65	112.36	169.62	225.05	269.68	318.38	360.87	403.42	444.41	488.95

Note: Strain gage S2-A shows faulty readings.

Table D-16. Phase 2 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.04	0.80	1.48	2.33	3.11	3.81	4.63	5.38	6.13	6.92	7.68
Frame-1	23.90	124.73	339.75	452.94	571.61	628.04	821.57	821.59	1032.51	1184.16	1208.20
Frame-2	-24.25	163.51	252.12	378.64	513.68	638.82	789.78	916.01	1039.97	1167.04	1300.93
Frame-3	25.26	169.84	259.36	374.48	511.31	646.69	779.95	914.74	1035.30	1158.66	1294.42
Frame-4	-15.54	218.32	232.44	374.95	514.69	640.30	781.16	909.36	1040.08	1175.32	1296.77
Frame-5	5.22	139.60	259.79	396.73	522.52	635.08	788.31	906.90	1054.35	1173.78	1296.77
Frame-6	20.17	148.83	283.06	397.00	520.77	638.36	792.71	917.49	1038.54	1157.81	1303.82
Frame-7	48.53	137.82	286.31	392.27	520.36	635.76	781.11	913.04	1047.64	1177.17	1317.53
Frame-8	28.33	131.36	286.09	386.86	513.98	633.87	779.17	911.86	1053.48	1179.08	1305.39
Frame-9	23.99	144.08	284.82	379.10	512.80	649.60	791.59	915.01	1052.19	1185.89	1306.29
Frame-10	26.51	139.77	286.57	390.65	506.30	626.42	805.92	922.44	1057.20	1171.45	1292.02
Frame-11	47.13	132.88	255.84	375.21	499.50	633.16	788.67	921.41	1028.52	1163.27	1306.19
Frame-12	5.74	150.32	311.44	378.49	511.92	644.14	783.63	913.43	1041.46	1173.36	1292.15
Hoop-1	19.41	877.03	1599.63	2495.32	3305.75	4128.71	4948.50	5706.53	6592.75	7368.34	8241.65
Hoop-2	-29.74	802.08	1633.90	2465.47	3290.35	4105.99	4922.13	5774.44	6589.52	7453.77	8182.44
Hoop-3	-9.55	831.18	1647.60	2498.51	3290.86	4133.33	4922.44	5743.01	6586.71	7420.58	8154.61
Hoop-4	-40.98	816.57	1623.13	2513.19	3285.41	4062.84	4944.54	5771.88	6574.21	7397.24	8184.86
Hoop-5	42.91	815.64	1644.23	2476.16	3294.18	4095.74	4932.02	5752.33	6578.54	7421.61	8188.21
Hoop-6	0.15	816.03	1633.62	2468.15	3291.14	4100.15	4926.82	5745.07	6570.77	7410.78	8181.26
Hoop-7	-3.85	806.58	1633.11	2475.50	3291.54	4110.92	4936.15	5745.52	6578.64	7410.62	8202.43
Hoop-8	2.03	799.25	1640.76	2452.75	3309.03	4091.08	4925.13	5730.23	6579.13	7436.89	8203.10
Hoop-9	138.71	823.20	1631.64	2452.66	3293.44	4090.69	4917.02	5742.12	6557.75	7439.53	8194.39
Hoop-10	-12.06	823.18	1631.76	2465.23	3288.03	4105.09	4929.59	5742.22	6573.90	7414.18	8212.40
Hoop-11	11.45	878.35	1641.44	2453.70	3267.79	4066.89	4928.24	5753.75	6575.11	7390.67	8150.47
Hoop-12	13.27	783.74	1709.07	2506.30	3408.69	4157.71	4845.91	5917.02	6513.51	7478.57	8150.04
Hoop-13	20.07	839.26	1643.83	2448.39	3296.84	4071.74	4912.80	5717.85	6588.24	7408.91	8160.80
Hoop-14	69.04	891.57	1633.30	2455.82	3263.65	4085.76	4937.57	5753.23	6575.75	7392.40	8213.44
Long-1	22.32	673.72	1322.32	2004.21	2663.27	3338.87	4010.82	4666.55	5343.47	6003.92	6677.68
Long-2	102.19	650.61	1308.86	1976.89	2655.91	3320.73	4043.47	4526.21	5278.55	5996.93	6665.11
Long-3	69.73	680.52	1326.80	2018.13	2676.27	3308.68	4004.74	4676.90	5342.55	6020.38	6666.55
Long-4	3.56	656.02	1338.76	1993.69	2664.04	3339.08	4003.53	4653.97	5328.13	5984.19	6668.02
Long-5	118.49	702.81	1319.08	2015.40	2653.72	3275.42	3991.63	4618.77	5366.85	6027.78	6660.39
Long-6	105.58	606.40	1354.22	1984.48	2676.18	3327.40	4005.00	4680.69	5338.17	6020.60	6661.46
Long-7	134.74	681.12	1334.74	1998.02	2674.43	3331.23	4004.12	4679.91	5344.35	6019.72	6669.57
Long-8	15.19	631.30	1323.53	1993.13	2662.47	3362.54	4026.08	4682.96	5318.07	6032.73	6705.81
S1-H	-343.88	87.21	229.72	370.54	482.36	575.59	675.82	767.84	856.44	946.44	1036.81
S1-A	-28.56	-5.56	27.73	52.41	78.76	103.85	128.70	153.02	177.70	204.99	230.25
S2-H	-220.65	45.50	159.44	273.94	365.34	442.56	526.23	603.01	676.13	752.45	826.82
S2-A	-186.60	-183.59	-158.92	-180.60	128.87	214.14	184.20	145.34	277.66	299.31	325.51
S3-H	3251.39	3393.76	3467.31	3551.67	3623.05	3681.09	3751.74	3817.01	3871.81	3937.49	3998.71
S3-A	-6.29	-1.69	16.02	36.81	58.30	81.43	106.13	127.74	152.41	174.52	197.87
S4-H	-112.48	11.92	92.10	185.02	260.65	328.18	397.80	463.78	523.73	588.12	649.62
S4-A	17.61	49.60	66.65	82.07	103.34	124.63	144.78	164.74	187.49	210.64	234.85

Table D-16. Phase 2 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S5	17.45	259.28	407.18	572.33	705.55	815.88	934.54	1040.74	1142.85	1243.93	1344.53
S6	69.96	175.50	373.11	608.62	832.68	1033.52	1267.87	1491.68	1721.08	1949.56	2176.94
S7	-383.15	-147.62	-9.43	140.06	259.76	358.37	463.27	558.89	650.47	743.11	833.90
S8	-237.07	53.82	253.06	479.21	661.60	804.34	952.50	1075.49	1188.20	1300.78	1402.71
S9	287.59	-240.17	-611.85	-1012.13	-1347.17	-1622.15	-1894.44	-2143.27	-2372.08	-2589.35	-2795.68
S10	-133.22	77.76	236.38	418.13	567.84	690.31	818.76	929.50	1034.30	1138.75	1238.17
S11	-467.72	131.22	261.18	472.68	691.77	839.51	1084.88	1295.98	1472.97	1711.99	1959.54
S12	20.68	-29.58	-41.42	-40.51	-34.13	-30.68	-22.66	-10.10	1.01	15.03	29.78
S13	-358.38	79.13	323.52	553.81	721.74	851.30	981.90	1092.78	1194.83	1294.74	1389.64
S14	-112.10	52.67	163.45	289.56	394.43	483.67	581.24	668.04	751.51	838.22	922.32
S15	-78.94	-28.17	12.77	66.44	111.91	150.34	193.42	235.11	273.68	315.32	354.65
S16	-99.59	18.86	105.77	207.79	293.05	367.48	447.45	521.24	591.18	665.04	736.35
S17	-139.06	32.18	147.42	274.43	376.78	461.60	556.29	637.42	712.30	788.93	863.72
S18	179.97	-11.77	-171.83	-370.23	-553.84	-712.72	-884.68	-1045.24	-1199.11	-1355.36	-1506.32
S19	-40.29	62.94	134.99	222.22	294.89	358.83	430.53	495.11	555.90	618.23	679.81
S21	-22.98	34.18	99.65	179.24	251.93	317.89	393.00	465.73	537.01	608.50	679.75
S22	-101.86	-24.47	36.21	107.86	171.19	222.20	278.65	332.63	381.90	434.85	485.02
S23	15.35	-18.77	-10.97	16.89	49.73	76.11	109.63	145.25	178.51	216.79	254.19
INS1	-53.86	23.26	67.11	124.88	175.31	219.95	268.08	315.92	361.76	408.46	455.65
INS2	-163.21	50.52	242.05	454.40	635.68	785.06	940.18	1083.32	1218.70	1351.54	1479.48
INS3	7.71	52.37	85.55	130.40	169.67	203.19	240.99	276.22	309.58	343.93	377.21
INS4	-62.92	31.34	116.68	226.41	332.00	424.46	526.69	623.56	716.06	810.71	902.32
INS5	-9289.00	-9201.36	-9140.56	-9069.31	-9011.93	-8961.91	-8909.01	-8858.49	-8812.21	-8764.17	-8717.07
IS24	-14.59	117.58	211.08	317.06	407.00	480.62	556.92	628.48	695.26	761.06	824.29
IS25	-553.27	-412.30	-259.07	-93.62	-19.79	4.02	99.25	75.09	36.25	185.11	197.49
IS26	174.65	59.60	-1.14	-44.71	-65.15	-72.04	-68.30	-51.97	-29.79	-0.92	33.04
IS27	61.17	32.87	4.98	-14.24	-17.37	-15.02	-4.68	16.77	43.84	76.62	113.81
IS28	-15.03	14.24	42.70	81.10	115.12	144.34	178.39	210.64	240.41	271.07	301.32
IS29	-20.70	12.79	43.77	84.56	120.29	150.95	185.17	218.85	250.38	282.70	314.44
IS30	95.44	12.37	-27.98	-57.60	-75.40	-86.51	-91.39	-90.50	-87.95	-82.85	-75.41
IS31	18.86	-4.93	-9.23	-9.01	-5.79	-1.85	4.18	14.51	25.38	36.56	48.93
IS32	64.18	325.57	505.76	716.01	901.30	1055.74	1214.98	1365.12	1505.31	1641.89	1773.88
P1A	-33.06	42.61	78.49	126.07	164.67	200.52	236.93	274.83	310.33	346.82	384.81
P1B	-28.21	39.27	64.59	101.40	131.99	160.22	190.07	219.85	249.29	279.29	310.78
P1C	69.48	125.49	146.87	179.31	202.85	227.24	253.73	279.56	302.41	330.39	356.22
P1D	-46.18	38.87	86.10	144.95	193.80	238.70	286.06	330.37	374.28	417.96	461.91
P3A	15.86	50.37	76.40	112.75	144.47	172.94	204.64	233.82	262.80	293.03	322.22
P3B	7.80	42.85	67.57	102.07	132.11	158.53	187.83	216.26	243.38	271.58	299.46
P3C	15.38	49.13	73.84	108.88	139.46	167.72	198.85	228.38	257.52	287.55	317.45
P3D	-13.20	28.19	56.92	97.06	132.67	164.61	199.61	233.84	265.70	299.83	332.86
P5A	-24.23	69.55	130.70	199.09	255.26	302.16	352.05	397.43	441.67	485.49	528.31
P5B	-38.89	47.29	102.29	164.25	214.38	256.11	300.47	340.74	380.05	419.36	457.66
P5C	-10.14	61.88	114.38	172.77	220.98	261.94	304.98	344.61	382.37	421.75	459.36
P5D	-17.17	63.53	115.49	176.84	228.02	270.83	317.21	360.17	402.17	445.06	486.93

Note: Strain gage S2-A shows faulty readings.

Table D-17. Phase 2 (10,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.03	0.77	1.61	2.35	3.04	3.92	4.62	5.37	6.08	6.86	7.69
Frame-1	-0.89	119.70	272.00	375.64	524.99	653.29	779.58	899.18	1023.09	1175.67	1294.34
Frame-2	-1.05	176.72	327.48	355.88	529.49	654.79	764.53	911.89	1032.39	1189.81	1290.66
Frame-3	-61.09	259.16	328.63	332.01	557.69	608.05	788.23	960.72	984.32	1206.93	1260.51
Frame-4	-13.57	99.81	209.22	414.30	525.27	665.04	794.70	896.20	1029.88	1172.24	1313.68
Frame-5	-2.96	121.39	258.03	391.67	510.17	626.23	782.37	912.29	1034.95	1165.14	1314.05
Frame-6	-8.10	154.82	284.07	387.35	561.98	645.14	776.10	914.75	1020.13	1165.18	1318.53
Frame-7	2.48	110.75	239.81	372.06	514.32	649.83	751.39	913.99	994.70	1165.89	1285.46
Frame-8	-1.51	118.49	269.52	375.09	527.84	656.66	786.37	910.18	1019.47	1167.57	1285.72
Frame-9	4.33	141.26	285.71	384.31	530.23	657.18	797.39	911.28	1014.65	1167.54	1301.46
Frame-10	8.91	122.13	251.63	362.79	554.60	646.52	780.03	919.50	1012.76	1177.73	1278.06
Frame-11	-19.97	152.91	272.46	372.88	533.00	638.25	781.78	924.00	1014.61	1158.20	1312.82
Frame-12	2.03	158.97	270.45	374.48	525.94	641.23	774.11	942.58	1002.69	1141.88	1298.60
Hoop-1	44.16	794.20	1652.07	2535.42	3270.60	3985.97	4910.71	5712.91	6660.13	7352.93	8296.41
Hoop-2	-17.83	815.87	1599.41	2609.29	3268.44	4211.74	4888.63	5746.75	6492.48	7445.91	8207.74
Hoop-3	-1.54	792.38	1638.57	2488.16	3318.31	4054.89	4947.33	5747.52	6588.43	7373.00	8220.77
Hoop-4	-35.82	832.73	1683.24	2440.80	3187.11	4101.18	4960.13	5698.64	6587.31	7360.52	8050.63
Hoop-5	-11.14	803.12	1653.56	2478.70	3278.30	4123.17	4909.91	5739.64	6622.43	7405.40	8136.78
Hoop-6	51.22	805.33	1654.09	2473.57	3263.51	4118.98	4901.82	5739.45	6564.08	7389.69	8152.40
Hoop-7	4.30	827.34	1663.06	2496.92	3271.39	4166.00	4902.66	5748.23	6589.24	7399.09	8227.50
Hoop-8	-6.79	790.43	1639.33	2465.84	3292.18	4097.44	4931.57	5743.56	6503.88	7374.92	8223.81
Hoop-9	-2.30	789.98	1645.13	2464.10	3286.51	4099.20	4914.83	5725.06	6515.54	7385.06	8213.27
Hoop-10	-5.65	804.71	1652.40	2476.73	3283.13	4103.03	4932.94	5732.64	6532.34	7396.01	8211.71
Hoop-11	-3.12	838.28	1654.19	2444.35	3314.48	4085.51	4936.02	5746.46	6531.40	7376.45	8175.96
Hoop-12	7.22	779.60	1680.07	2480.89	3153.47	4110.02	4905.34	5777.14	6343.04	7283.67	8178.41
Hoop-13	-16.50	824.64	1629.20	2484.72	3296.19	4086.78	4905.97	5725.16	6507.78	7348.92	8190.06
Hoop-14	-6.53	838.02	1638.50	2453.43	3319.59	4098.71	4928.57	5758.43	6522.20	7374.09	8211.30
Long-1	69.03	705.72	1325.73	2019.53	2665.12	3320.52	4022.03	4662.71	5296.07	5996.07	6667.81
Long-2	22.25	895.53	1245.68	1996.82	2671.88	3539.62	4012.16	4705.51	5292.50	5968.44	6644.99
Long-3	24.25	700.88	1336.06	2008.01	2687.14	3346.77	3996.64	4674.56	5283.50	5998.69	6689.90
Long-4	-0.19	675.18	1328.84	2005.62	2694.33	3392.68	3987.31	4666.36	5347.16	6019.65	6700.99
Long-5	-5.49	687.23	1375.23	1984.50	2690.24	3346.50	4006.30	4598.93	5355.88	5982.15	6670.07
Long-6	-3.42	683.74	1353.10	1979.92	2714.63	3363.87	4009.55	4656.42	5268.21	5998.83	6689.47
Long-7	7.97	656.58	1330.75	2006.34	2669.63	3325.61	4022.97	4671.65	5301.39	6010.40	6639.50
Long-8	-3.66	659.94	1342.54	1980.22	2672.38	3352.67	3990.22	4655.07	5307.40	6010.91	6681.55
S1-H	16.96	181.26	310.80	405.52	486.58	593.58	680.41	768.80	854.66	948.75	1042.64
S1-A	-257.73	-214.51	-184.56	-166.43	-145.35	-122.34	-102.51	-79.89	-62.88	-36.90	-7.54
S2-H	13.18	126.63	223.41	295.34	360.57	446.72	518.56	593.26	663.53	743.35	824.42
S2-A	-1266.64	-1239.61	-1220.68	-1203.49	-1188.90	-1168.60	-1153.54	-1134.85	-1117.78	-1096.96	-1073.68
S3-H	-1678.69	-1594.88	-1539.36	-1465.67	-1541.93	-1439.13	-1370.63	-1306.46	-1235.08	-1170.18	-1101.69
S3-A	-11.36	2.52	16.03	37.26	60.16	84.50	102.38	125.44	144.37	170.34	198.96
S4-H	-7.55	71.87	149.76	210.43	265.19	339.33	401.48	463.65	521.39	585.88	653.25
S4-A	9221.08	9244.63	9258.14	9270.09	9287.22	9306.23	9318.14	9339.15	9355.78	9382.92	9412.42

Table D-17. Phase 2 (10,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S5	7.03	179.78	336.62	457.62	560.86	691.28	797.60	903.22	1002.64	1110.01	1214.99
S6	80.02	280.17	501.11	699.57	903.47	1166.74	1409.82	1653.21	1908.98	2160.18	2412.79
S7	165.94	317.98	454.50	559.44	648.41	764.52	858.90	952.18	1040.47	1136.55	1230.13
S8	-6.44	177.50	370.08	519.82	648.67	808.55	936.41	1054.18	1161.16	1271.06	1374.90
S9	59.03	-382.00	-743.00	-1002.81	-1235.81	-1493.81	-1704.72	-1902.92	-2080.77	-2264.30	-2422.28
S10	-4.71	151.21	314.65	440.88	549.89	688.17	799.46	907.27	1007.59	1112.21	1212.65
S11	-8.19	300.88	576.46	773.16	926.79	1116.85	1262.74	1400.76	1527.49	1659.14	1786.66
S12	-10.50	-33.80	-37.44	-35.80	-36.90	-27.07	-20.15	-10.86	3.52	13.90	31.01
S13	-5.45	257.84	478.26	626.63	743.22	888.82	1000.57	1106.95	1204.90	1307.79	1407.68
S14	2.03	121.70	234.55	319.90	397.17	500.43	585.05	669.95	751.56	839.69	930.52
S15	-44.43	-14.55	30.88	71.25	98.38	142.26	179.80	215.50	254.77	294.45	338.40
S16	-0.10	85.70	174.96	240.92	304.25	388.07	458.17	528.40	596.60	670.67	748.37
S17	-13.70	102.61	215.06	297.55	371.24	467.16	545.61	622.66	693.23	771.09	850.25
S18	-22.03	-166.33	-342.57	-507.98	-633.70	-809.63	-958.43	-1099.34	-1240.52	-1389.96	-1537.66
S19	-60.07	15.71	96.34	159.02	210.10	284.63	345.55	406.88	464.60	528.99	596.73
S21	-1.00	65.50	135.60	194.56	256.63	336.22	409.58	483.20	557.14	631.92	702.85
S22	-5.61	35.01	93.98	150.73	181.02	236.95	285.40	327.97	378.21	425.37	477.00
S23	-1.79	-10.77	9.05	29.32	45.89	80.95	111.43	143.09	181.39	214.98	253.97
INS1	-4.55	49.21	99.82	141.93	181.20	228.46	270.83	314.14	356.10	403.47	447.45
INS2	-1.89	78.65	145.06	201.03	267.89	374.20	465.46	555.25	608.73	667.62	709.84
INS3	8.86	47.22	87.25	122.84	154.16	194.37	231.07	265.54	300.97	336.70	372.58
INS4	-128.55	-55.99	38.37	142.10	224.68	344.49	455.26	547.24	646.69	749.27	851.74
INS5	2.10	68.78	132.37	184.93	230.63	285.88	333.55	379.51	424.33	470.18	514.28
IS24	14.11	127.95	226.88	301.73	370.53	449.89	517.64	581.62	642.22	704.47	758.96
IS25	13.01	134.33	239.30	318.60	391.13	474.38	545.49	613.20	677.18	742.26	800.49
IS26	22.61	-19.51	-64.53	-88.31	-97.80	-109.07	-103.56	-93.73	-74.96	-52.04	-29.70
IS27	-0.15	-26.54	-52.05	-64.75	-66.08	-58.23	-38.78	-31.25	-6.36	30.09	60.15
IS28	3.16	25.44	58.83	92.08	115.21	148.92	179.53	206.89	236.09	264.88	293.72
IS29	-5.69	19.16	55.79	90.43	114.94	150.66	182.39	211.23	241.54	272.58	303.93
IS30	8.91	-41.61	-71.40	-78.30	-92.32	-103.39	-103.20	-106.65	-100.48	-97.59	-93.76
IS31	0.83	-18.78	-22.00	-14.66	-13.26	-9.41	-0.21	5.31	17.95	26.87	36.20
IS32	23.86	284.43	514.72	693.96	856.86	1043.77	1201.78	1353.00	1496.38	1641.24	1772.16
P1A	-0.65	46.67	89.84	122.30	151.92	187.93	221.96	257.79	291.76	332.47	370.31
P1B	-2.08	31.49	61.75	86.10	106.87	132.63	156.30	181.94	206.34	236.70	264.67
P1C	2.18	24.29	43.45	60.39	75.15	91.36	107.56	124.51	140.00	158.44	175.38
P1D	-8.66	39.85	86.68	126.89	164.19	209.36	249.18	288.28	326.68	369.69	408.20
P3A	7.95	38.94	71.59	103.50	131.03	166.08	199.09	230.45	263.13	294.72	325.32
P3B	1.11	31.72	62.51	89.99	115.84	147.55	177.79	206.19	235.17	264.33	293.27
P3C	1.50	36.34	69.52	99.94	127.81	163.57	197.10	228.63	263.13	297.09	330.80
P3D	-0.91	38.95	75.48	109.68	139.95	178.05	214.80	248.31	285.71	323.02	359.72
P5A	-23.21	42.86	103.15	151.48	195.16	246.19	290.57	332.04	372.25	413.75	450.76
P5B	-291.31	-226.89	-164.64	-108.87	-60.39	-3.13	46.89	94.52	145.24	194.92	249.99
P5C	13.10	64.11	118.78	164.07	203.90	250.84	291.51	330.91	368.51	406.86	443.46
P5D	4.85	65.27	122.72	170.05	209.16	258.69	300.48	340.45	379.16	419.18	457.82

Table D-18. Phase 2 (10,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.02	0.77	1.55	2.30	3.14	3.84	4.60	5.43	6.16	6.90	7.69
Frame-1	7.39	112.04	260.46	390.82	509.29	660.51	765.14	904.06	1037.63	1176.65	1280.32
Frame-2	11.99	165.81	301.10	352.89	520.63	658.51	769.71	908.74	1047.09	1163.09	1293.03
Frame-3	-73.12	88.61	193.86	450.46	490.23	616.22	830.91	950.10	1065.86	1156.38	1321.74
Frame-4	52.06	170.65	273.12	367.70	508.96	623.30	760.58	932.24	1034.52	1148.26	1303.43
Frame-5	15.02	108.80	234.85	390.29	522.65	651.24	776.07	910.79	1046.43	1176.08	1309.86
Frame-6	-17.37	100.88	241.98	401.73	544.01	669.06	784.18	900.73	1051.07	1164.57	1285.01
Frame-7	3.80	106.80	242.56	386.87	520.63	635.75	760.29	896.64	1044.84	1170.98	1316.73
Frame-8	2.95	125.01	264.80	390.69	516.15	644.90	771.34	910.21	1037.16	1166.82	1277.46
Frame-9	6.97	95.56	274.36	397.15	507.04	643.56	800.37	908.56	1030.90	1154.33	1303.66
Frame-10	12.96	111.15	261.31	395.64	521.25	652.43	767.42	898.37	1049.26	1155.83	1285.97
Frame-11	-27.56	121.92	276.81	388.18	533.50	614.77	777.51	925.52	1054.37	1139.52	1324.16
Frame-12	4.93	125.59	244.14	394.74	512.75	629.30	774.31	882.77	1045.17	1148.85	1307.17
Hoop-1	16.78	790.55	1633.82	2416.30	3217.04	3896.94	4930.78	5773.71	6490.40	7385.05	8205.98
Hoop-2	-30.41	858.99	1635.35	2506.37	3246.24	4160.05	5088.05	5718.57	6528.42	7393.07	8213.94
Hoop-3	-5.01	865.34	1678.53	2456.40	3319.38	4109.15	4926.49	5760.26	6555.42	7377.48	8294.55
Hoop-4	-3.04	792.68	1643.18	2463.98	3328.47	3955.90	4958.31	5810.30	6585.49	7394.38	8218.96
Hoop-5	3.28	894.99	1651.76	2458.40	3292.05	4053.32	4906.31	5788.86	6555.77	7350.62	8227.68
Hoop-6	-7.19	875.76	1636.91	2461.05	3297.21	4086.75	4917.28	5791.57	6545.18	7387.24	8196.16
Hoop-7	-20.75	841.65	1646.96	2516.10	3286.84	4112.73	4902.66	5723.75	6574.92	7414.46	8233.68
Hoop-8	-28.94	820.04	1624.57	2473.71	3270.69	4046.17	4931.57	5750.94	6579.00	7389.68	8215.61
Hoop-9	-4.09	827.79	1632.55	2444.83	3305.13	4060.08	4925.60	5735.84	6563.56	7401.23	8210.65
Hoop-10	-10.98	826.12	1631.07	2461.23	3290.89	4053.67	4925.83	5743.30	6574.52	7394.24	8210.89
Hoop-11	-10.40	803.76	1628.69	2433.91	3269.61	4034.92	4919.63	5717.32	6587.35	7370.99	8197.00
Hoop-12	-0.43	846.60	1653.31	2420.20	3207.63	4072.19	4828.87	5815.38	6504.94	7329.55	8177.59
Hoop-13	-9.19	846.66	1636.51	2463.27	3267.59	4087.19	4913.28	5747.11	6574.92	7400.12	8196.55
Hoop-14	8.16	874.82	1623.81	2461.26	3283.54	4062.40	4913.88	5729.06	6574.92	7396.12	8195.79
Long-1	100.45	659.61	1344.51	1993.04	2670.47	3324.77	4014.00	4654.86	5329.88	6015.70	6677.65
Long-2	44.77	563.66	1265.50	2152.92	2706.50	3604.67	3873.70	4692.85	5408.70	6097.83	6634.32
Long-3	38.89	675.28	1337.41	1999.47	2667.10	3334.91	4005.98	4668.46	5340.28	6012.10	6687.03
Long-4	4.64	742.72	1330.18	1976.67	2662.44	3330.29	3984.48	4674.81	5335.77	5999.15	6663.19
Long-5	2.76	762.63	1337.67	2006.89	2657.90	3319.74	3989.42	4649.60	5330.60	6024.56	6649.67
Long-6	3.71	714.60	1340.18	2020.28	2652.38	3309.60	3966.43	4652.86	5337.72	5984.59	6668.92
Long-7	7.97	719.86	1343.06	1990.52	2672.75	3328.38	4001.86	4669.22	5342.24	6017.70	6681.65
Long-8	-2.48	658.75	1369.98	2027.71	2714.58	3301.95	4006.45	4651.51	5323.49	5996.66	6674.05
S1-H	-2.25	182.54	306.95	406.35	504.25	586.05	682.98	782.30	868.00	961.71	1052.79
S1-A	-264.43	-217.48	-186.65	-166.28	-145.90	-125.17	-105.71	-81.39	-55.03	-28.86	-9.04
S2-H	3.52	125.17	220.05	296.24	375.01	441.53	522.59	604.85	676.96	756.64	834.93
S2-A	-1274.73	-1247.70	-1223.91	-1202.98	-1185.79	-1169.58	-1161.24	-1139.45	-1114.68	-1091.84	-1073.57
S3-H	-1706.98	-1616.67	-1545.13	-1483.99	-1420.39	-1372.21	-1448.51	-1355.49	-1285.81	-1191.82	-1129.69
S3-A	-12.38	-7.16	13.67	37.98	57.47	82.38	96.51	119.52	148.01	175.05	191.76
S4-H	-14.29	68.86	141.54	210.47	277.90	331.91	400.81	470.44	530.33	597.93	661.42
S4-A	9223.01	9246.22	9264.20	9280.03	9293.48	9312.95	9322.29	9344.19	9367.45	9396.89	9412.88

Table D-18. Phase 2 (10,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S5	-4.51	180.85	328.65	456.58	579.33	681.79	799.35	917.30	1016.48	1122.53	1227.77
S6	69.84	278.48	485.69	711.53	949.40	1159.40	1433.40	1700.32	1944.27	2210.86	2453.21
S7	161.47	331.07	461.50	569.86	677.59	765.67	870.38	974.57	1062.94	1157.79	1251.90
S8	-25.34	176.75	357.80	518.47	673.32	795.62	937.33	1069.55	1174.85	1286.46	1391.48
S9	80.62	-384.10	-722.10	-1005.55	-1262.64	-1473.70	-1699.20	-1921.47	-2095.29	-2265.62	-2444.40
S10	-16.84	153.69	308.90	440.47	571.86	677.86	802.57	923.71	1023.21	1127.72	1228.97
S11	-34.84	308.80	569.13	771.82	959.20	1105.26	1268.26	1421.97	1547.49	1679.84	1802.09
S12	-13.60	-34.89	-39.45	-40.72	-34.90	-32.17	-20.70	-8.50	2.06	18.09	32.10
S13	-38.01	258.50	468.53	624.57	768.25	878.09	1004.95	1123.43	1222.97	1326.29	1421.18
S14	-8.80	121.01	230.50	322.28	416.16	494.66	591.31	686.13	768.73	858.16	943.90
S15	-48.84	-8.45	31.75	69.17	108.74	139.47	182.34	225.34	261.61	305.86	346.51
S16	-14.53	78.66	165.78	239.74	316.83	379.61	461.53	539.16	609.47	685.08	757.37
S17	-32.05	93.88	202.56	293.43	385.02	454.17	545.72	632.17	706.25	783.53	857.43
S18	-5.11	-173.72	-337.91	-489.21	-652.10	-789.83	-946.25	-1115.60	-1257.31	-1403.92	-1555.24
S19	-68.86	15.53	91.66	152.90	220.11	276.07	346.31	412.89	474.03	539.84	601.28
S21	-5.27	66.04	131.64	198.95	270.36	333.65	416.11	496.14	564.85	640.89	717.67
S22	-6.97	49.42	101.96	142.75	194.33	233.54	284.09	339.73	384.31	437.11	488.59
S23	-5.38	-8.55	8.01	24.38	51.92	74.89	110.95	149.18	181.55	221.71	260.84
INS1	-4.97	51.76	98.96	142.23	185.56	225.66	270.55	319.21	357.46	401.55	453.93
INS2	-16.37	73.01	127.77	190.40	272.08	327.31	404.76	496.16	564.55	627.73	724.66
INS3	7.01	48.89	86.51	119.69	157.83	191.24	232.41	270.73	304.27	339.48	377.33
INS4	-147.37	-54.73	41.18	139.21	245.23	334.94	445.59	557.00	651.87	751.25	855.24
INS5	1.74	72.92	133.27	185.80	238.14	283.75	336.60	386.21	427.93	473.20	521.35
IS24	5.95	127.57	220.04	301.25	378.83	443.09	516.83	589.47	645.96	704.36	769.22
IS25	5.04	134.68	233.01	318.48	400.14	467.60	544.69	621.23	681.28	743.79	811.82
IS26	30.21	-18.10	-64.36	-88.38	-103.84	-108.91	-104.26	-91.60	-79.86	-59.60	-21.74
IS27	16.98	-17.42	-35.65	-52.15	-52.93	-55.97	-47.67	-25.45	-5.96	21.20	60.68
IS28	1.12	27.52	58.11	86.07	117.97	143.86	177.66	209.50	236.52	265.64	296.96
IS29	-10.22	20.25	54.17	84.46	118.02	145.43	180.97	214.15	242.96	273.88	306.62
IS30	20.72	-30.89	-61.78	-82.86	-94.49	-101.96	-103.95	-104.66	-104.47	-99.41	-89.03
IS31	4.27	-13.39	-16.97	-14.84	-11.27	-8.01	1.82	8.21	15.64	27.06	40.00
IS32	13.37	289.71	506.88	697.73	880.01	1032.18	1203.11	1373.47	1508.39	1649.76	1793.77
P1A	0.39	54.02	93.91	124.69	157.25	187.90	222.41	263.69	294.25	330.99	370.19
P1B	-1.16	36.39	63.90	86.12	108.91	131.54	155.52	185.10	206.80	233.45	269.87
P1C	5.13	27.24	44.93	61.14	76.62	92.12	109.06	127.47	139.99	156.25	180.52
P1D	-9.22	41.87	87.44	127.47	169.34	207.38	251.26	294.03	328.49	367.88	416.28
P3A	10.90	43.55	74.56	102.05	135.63	165.00	200.97	235.64	265.32	297.88	331.74
P3B	2.58	34.12	63.26	88.53	118.78	145.19	178.19	209.53	236.99	266.21	297.85
P3C	1.31	37.63	69.35	98.67	131.85	161.02	199.36	234.55	266.42	300.44	335.56
P3D	-1.09	41.11	76.01	108.50	144.82	175.65	217.15	255.29	289.96	327.06	365.49
P5A	-29.47	40.23	97.09	147.54	197.16	239.97	288.60	333.73	369.44	409.56	454.03
P5B	-178.89	-141.37	-102.17	-57.90	-12.20	29.87	73.87	131.07	173.21	227.90	281.26
P5C	12.36	67.23	118.62	163.92	209.40	248.68	292.85	335.18	369.21	407.26	448.39
P5D	0.62	67.11	120.35	164.93	212.46	253.40	299.80	343.80	380.05	418.67	463.12

Table D-19. Phase 2 (10,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.04	0.76	1.54	2.26	3.10	3.79	4.52	5.41	6.24	7.00	7.73
Frame-1	0.90	108.25	261.22	398.96	518.68	660.22	775.64	903.74	1048.14	1194.02	1298.34
Frame-2	-27.05	70.42	262.59	360.92	508.62	656.47	778.36	896.92	1054.51	1177.41	1306.19
Frame-3	76.80	248.59	218.78	326.28	560.95	658.34	760.37	887.74	1022.59	1184.53	1289.94
Frame-4	22.54	132.64	289.46	417.57	514.69	629.18	787.62	900.64	1040.02	1169.72	1306.62
Frame-5	30.00	134.50	258.54	395.04	517.14	662.29	774.88	892.39	1047.35	1183.90	1311.59
Frame-6	4.49	97.28	261.37	356.54	528.00	651.66	797.23	892.64	1036.18	1146.86	1317.68
Frame-7	-10.78	133.64	264.76	407.06	556.42	641.28	843.44	903.60	1052.82	1191.24	1325.36
Frame-8	4.36	116.66	269.86	395.18	526.39	662.93	778.06	905.34	1048.61	1163.73	1323.15
Frame-9	13.89	106.06	298.53	392.85	528.94	655.83	771.54	888.72	1024.68	1208.82	1314.79
Frame-10	0.19	103.36	268.83	398.30	536.33	657.73	780.59	913.64	1051.55	1185.79	1307.25
Frame-11	3.73	228.88	298.22	429.96	537.56	635.44	797.56	908.78	1052.13	1166.40	1337.54
Frame-12	-12.03	132.53	266.12	403.82	527.60	664.29	774.85	897.80	1058.31	1195.00	1330.17
Hoop-1	-3.29	830.61	1573.28	2445.26	3308.27	4114.12	4928.96	5688.61	6571.22	7436.88	8217.12
Hoop-2	-42.98	846.33	1627.84	2459.41	3298.33	4041.45	4929.95	5665.32	6622.33	7388.41	8212.31
Hoop-3	1.94	830.51	1643.45	2464.84	3282.91	4109.15	4924.75	5731.32	6592.33	7399.06	8218.21
Hoop-4	-33.99	896.38	1644.67	2458.27	3279.32	4043.31	4923.72	5745.42	6620.59	7380.55	8142.68
Hoop-5	19.49	777.82	1651.43	2479.76	3265.04	4087.55	4913.52	5636.38	6615.71	7385.58	8080.14
Hoop-6	-0.32	832.73	1645.18	2462.53	3278.32	4081.60	4896.66	5738.88	6554.18	7412.02	8201.40
Hoop-7	15.04	855.88	1668.10	2453.24	3179.51	4100.20	4918.76	5729.76	6573.61	7431.30	8257.09
Hoop-8	7.97	856.78	1661.14	2495.11	3292.50	4133.52	4909.43	5750.37	6585.07	7387.47	8236.94
Hoop-9	114.47	854.57	1639.41	2471.04	3274.26	4084.01	4880.69	5722.70	6580.22	7395.43	8256.54
Hoop-10	3.24	881.04	1637.85	2472.93	3292.34	4151.96	4913.39	5746.28	6564.33	7397.36	8295.36
Hoop-11	-15.86	832.74	1644.75	2491.45	3272.92	4133.86	4930.56	5740.43	6573.29	7376.07	8334.57
Hoop-12	16.78	787.17	1664.45	2388.89	3123.20	4109.20	4951.23	5807.15	6534.23	7411.46	8283.82
Hoop-13	-9.18	831.87	1658.13	2455.22	3296.51	4107.90	4913.28	5702.65	6529.73	7368.66	8232.30
Hoop-14	-13.88	823.25	1630.83	2482.56	3283.21	4090.55	4906.54	5750.52	6610.33	7415.94	8305.11
Long-1	37.63	615.52	1337.64	2006.97	2675.91	3351.26	3996.12	4671.49	5343.09	6019.24	6720.46
Long-2	8.19	614.34	1351.29	2112.35	2676.10	3316.33	4011.76	4671.28	5336.44	6012.64	6679.41
Long-3	36.45	627.79	1345.94	2006.99	2672.51	3325.16	3990.15	4669.39	5330.00	6013.92	6686.91
Long-4	-0.19	654.74	1338.62	2002.20	2726.89	3337.53	4005.00	4667.29	5303.88	5976.83	6708.89
Long-5	9.83	655.49	1350.63	2005.91	2656.08	3350.37	4029.46	4692.95	5353.63	6029.87	6657.77
Long-6	16.76	581.73	1333.05	1993.18	2652.91	3378.45	3988.98	4689.41	5327.69	6065.90	6699.63
Long-7	7.97	610.40	1355.23	2013.84	2669.63	3338.11	4003.10	4675.02	5316.16	6042.64	6659.63
Long-8	-9.60	727.68	1322.49	1969.73	2670.01	3332.82	4017.13	4676.19	5309.90	5952.14	6650.17
S1-H	0.55	175.83	307.14	404.86	507.80	585.75	669.79	773.73	872.37	960.59	1043.68
S1-A	-266.30	-222.90	-189.83	-166.28	-144.59	-124.02	-105.13	-80.46	-59.53	-33.16	-9.23
S2-H	8.51	128.20	224.91	302.69	384.48	449.42	519.50	604.94	688.23	762.37	833.46
S2-A	-1270.25	-1248.45	-1219.43	-1202.23	-1182.05	-1170.10	-1155.78	-1131.23	-1114.26	-1090.87	-1070.80
S3-H	-1867.97	-1887.43	-1779.83	-1717.83	-1649.51	-1595.28	-1548.73	-1476.48	-1411.73	-1346.44	-1295.39
S3-A	-15.01	-8.37	13.89	37.76	59.79	81.25	100.86	130.76	147.87	172.91	200.41
S4-H	-13.54	67.37	144.54	208.22	280.90	331.84	393.24	465.20	534.23	596.31	654.06
S4-A	9224.03	9244.64	9270.78	9287.55	9304.83	9320.89	9331.40	9357.22	9374.89	9396.50	9420.89

Table D-19. Phase 2 (10,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S5	2.39	177.08	329.06	453.94	582.56	682.38	786.11	907.13	1023.41	1124.30	1219.11
S6	77.79	270.71	464.43	687.69	950.88	1163.05	1392.08	1666.31	1938.38	2179.55	2403.98
S7	301.90	463.81	599.84	707.79	820.34	905.13	996.27	1102.78	1207.12	1296.53	1380.42
S8	-19.53	169.48	359.25	517.74	679.87	798.37	922.60	1057.19	1181.75	1286.20	1379.40
S9	72.89	-371.96	-713.83	-993.73	-1259.78	-1475.90	-1682.95	-1898.38	-2103.20	-2272.62	-2427.43
S10	-10.39	151.96	312.30	443.97	580.49	683.41	791.83	913.90	1032.60	1130.72	1220.13
S11	-18.58	303.98	577.26	778.81	972.82	1114.12	1255.11	1414.16	1560.85	1684.04	1795.37
S12	-8.32	-29.43	-35.26	-34.35	-29.80	-24.88	-17.23	-4.67	9.89	21.36	33.38
S13	-31.19	247.22	468.17	625.30	776.25	881.18	989.48	1113.43	1228.43	1324.03	1410.55
S14	5.49	126.97	235.92	328.47	428.62	503.84	586.14	685.08	781.52	865.32	942.68
S15	-51.52	-15.55	30.20	67.67	109.47	139.48	174.44	218.48	262.83	301.20	337.71
S16	-12.44	77.03	160.48	236.52	319.10	380.40	447.91	531.81	612.78	683.58	748.22
S17	-21.51	95.69	202.20	293.79	390.83	460.62	536.89	626.36	715.91	789.19	856.15
S18	-3.34	-162.85	-351.64	-505.67	-667.06	-803.58	-948.24	-1111.37	-1278.43	-1419.15	-1553.32
S19	-76.60	6.55	84.69	149.85	220.84	274.10	332.93	405.32	476.45	537.23	593.79
S21	-5.54	65.22	126.87	194.69	272.99	337.54	407.17	486.65	568.79	638.40	706.19
S22	-12.43	41.28	109.33	155.72	204.43	245.13	289.22	339.83	395.12	439.70	483.50
S23	-13.90	-17.30	2.52	24.02	50.51	76.91	106.21	142.74	183.42	217.50	250.91
INS1	-4.18	52.23	99.89	140.93	182.62	222.45	265.00	309.42	359.57	403.52	448.52
INS2	61.11	146.12	199.28	260.17	339.06	392.30	460.70	554.76	652.61	721.89	788.26
INS3	7.75	49.82	88.37	122.85	161.02	193.65	229.75	267.45	309.25	343.41	375.77
INS4	-162.16	-76.10	25.95	121.51	225.40	312.54	409.68	516.26	630.48	725.67	817.31
INS5	4.84	72.15	133.79	185.06	238.14	282.85	329.77	377.67	429.47	473.24	514.95
IS24	10.48	127.94	218.59	298.17	377.20	443.73	509.84	578.23	648.70	706.76	761.58
IS25	8.49	133.77	231.38	315.76	399.24	467.86	537.70	609.82	684.56	745.63	803.29
IS26	31.89	-11.14	-67.63	-94.11	-113.44	-113.85	-107.61	-104.20	-82.02	-60.17	-31.29
IS27	26.01	0.80	-32.61	-44.90	-53.06	-47.71	-34.79	-21.01	7.47	33.89	65.59
IS28	-1.61	24.94	57.48	86.16	117.42	143.38	173.08	204.23	239.36	266.54	293.29
IS29	-10.40	18.98	53.99	85.37	118.38	145.04	176.22	209.25	246.30	274.91	303.42
IS30	14.72	-31.25	-60.69	-80.68	-98.12	-103.21	-104.11	-110.30	-105.05	-102.30	-95.40
IS31	8.21	-11.45	-17.92	-17.88	-16.52	-13.17	-5.02	-0.49	11.97	19.80	30.68
IS32	24.13	290.44	508.87	696.10	881.28	1036.69	1191.07	1352.59	1514.29	1649.25	1776.69
P1A	-9.89	45.82	88.18	123.53	152.23	182.99	216.53	252.88	294.81	331.56	371.69
P1B	-3.08	35.92	66.04	86.92	105.56	128.16	152.82	178.03	209.73	237.27	268.24
P1C	19.13	42.71	60.41	74.41	86.20	101.68	117.88	132.63	153.30	171.69	191.61
P1D	-7.19	42.98	89.10	127.83	167.68	204.01	244.20	283.14	328.77	368.73	410.64
P3A	5.91	39.86	71.97	100.94	133.05	162.94	195.76	228.26	265.58	295.79	325.16
P3B	5.53	38.36	66.77	92.41	121.73	148.66	178.34	208.24	242.78	270.58	297.17
P3C	5.37	40.40	71.19	100.14	134.25	163.38	195.63	230.50	269.09	301.67	332.68
P3D	2.54	42.63	76.70	109.10	145.83	177.08	212.00	249.67	291.29	325.85	359.25
P5A	1.44	67.55	123.86	172.56	221.68	263.14	306.24	347.55	393.33	432.14	469.23
P5B	-301.26	-237.73	-179.49	-127.76	-73.96	-28.17	17.90	63.51	116.92	166.09	210.80
P5C	8.68	62.44	115.12	159.31	204.25	243.10	283.40	323.76	368.03	404.42	440.19
P5D	8.54	74.11	130.67	175.98	221.48	261.27	303.24	345.09	392.14	430.37	468.37

Table D-20. Phase 2 (20,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.06	0.81	1.56	2.30	3.11	3.83	4.65	5.35	6.11	6.94	7.71
Frame-1	0.59	138.07	263.21	370.15	512.98	648.70	799.00	905.15	1045.43	1171.16	1298.01
Frame-2	34.52	57.75	267.87	381.34	522.57	653.23	775.78	925.96	1048.19	1170.79	1287.83
Frame-3	12.93	306.39	319.00	372.35	516.34	662.84	791.02	902.67	1038.24	1164.94	1282.07
Frame-4	-18.61	109.58	255.43	380.82	523.33	646.39	775.74	912.78	1040.28	1169.67	1310.96
Frame-5	-34.54	125.10	260.55	382.74	508.18	641.02	790.37	914.91	1027.85	1157.58	1314.49
Frame-6	36.83	204.94	278.82	385.23	525.71	653.19	788.31	921.96	1033.56	1187.38	1303.36
Frame-7	-1.07	132.42	257.72	388.63	521.12	652.67	787.13	913.00	1044.50	1180.48	1273.85
Frame-8	8.35	124.37	242.47	375.62	516.54	657.99	791.82	915.09	1035.14	1161.42	1285.55
Frame-9	-23.02	104.78	266.50	383.36	522.72	651.34	810.77	904.59	1035.99	1174.54	1288.75
Frame-10	-0.56	133.36	249.07	385.88	521.52	648.96	800.76	904.16	1035.91	1159.40	1292.14
Frame-11	-86.56	68.95	245.95	377.89	536.87	645.55	772.17	915.36	1015.02	1210.49	1293.21
Frame-12	1.10	121.93	249.31	391.86	522.31	663.96	788.84	924.46	1043.08	1177.25	1289.23
Hoop-1	-41.59	799.52	1612.95	2514.10	3298.83	4063.24	4936.62	5774.49	6555.32	7383.58	8230.09
Hoop-2	64.20	789.96	1662.68	2478.08	3292.02	4062.60	4918.91	5725.90	6562.94	7391.00	8190.32
Hoop-3	-10.12	816.63	1648.27	2577.32	3272.26	4118.04	4947.69	5741.86	6563.32	7395.21	8230.57
Hoop-4	-38.73	829.64	1608.49	2500.35	3228.73	4075.18	4922.96	5738.95	6592.68	7371.77	8178.17
Hoop-5	-24.74	819.97	1642.74	2512.49	3281.72	4095.73	4936.26	5725.55	6588.18	7403.99	8198.19
Hoop-6	-30.47	845.44	1647.17	2576.13	3270.17	4135.69	4875.36	5767.12	6534.75	7420.88	8210.83
Hoop-7	2.91	832.94	1646.54	2503.22	3308.38	4134.74	4930.21	5748.13	6572.70	7406.22	8241.53
Hoop-8	-3.71	822.88	1634.54	2453.91	3273.12	4099.70	4933.67	5754.02	6549.94	7392.03	8210.50
Hoop-9	-13.88	848.28	1631.26	2459.46	3291.09	4092.18	4909.45	5749.41	6563.73	7403.28	8209.03
Hoop-10	-21.24	831.60	1639.86	2460.89	3283.52	4104.38	4928.80	5757.91	6552.75	7395.67	8208.69
Hoop-11	-21.52	847.02	1642.57	2480.33	3307.00	4120.92	4963.97	5746.26	6599.10	7426.51	8172.32
Hoop-12	-31.45	857.38	1692.52	2518.43	3321.24	4208.16	4789.24	5746.11	6616.59	7427.79	8176.34
Hoop-13	-19.34	828.94	1669.74	2408.50	3249.47	4127.00	4938.71	5707.69	6554.84	7433.11	8229.46
Hoop-14	-21.22	852.53	1615.99	2467.87	3275.54	4119.92	4949.62	5736.40	6557.61	7417.42	8202.32
Long-1	132.57	682.93	1345.00	1983.79	2687.91	3352.34	4007.89	4671.37	5336.00	6027.63	6672.84
Long-2	-26.03	859.91	1468.66	2027.09	2745.40	3313.80	3963.26	4715.35	5383.79	5940.66	6600.85
Long-3	35.36	693.70	1333.62	1984.78	2667.24	3344.13	4008.55	4672.54	5331.35	6018.95	6656.01
Long-4	-0.19	742.72	1344.39	1992.15	2633.49	3341.69	3995.34	4671.46	5329.21	6005.79	6660.11
Long-5	60.23	677.54	1310.04	2006.42	2684.73	3336.48	3999.76	4684.93	5380.46	6051.97	6681.74
Long-6	-2.69	638.18	1363.18	1972.15	2667.34	3335.78	3983.77	4687.08	5345.03	6012.01	6644.05
Long-7	8.37	675.24	1335.89	2006.55	2702.35	3359.76	4003.49	4677.21	5346.98	6013.85	6675.30
Long-8	-14.10	685.11	1316.53	2005.19	2689.90	3325.27	4005.51	4653.20	5305.40	6001.05	6693.81
S1-H	-99.74	133.12	257.70	370.62	477.82	568.67	670.72	757.99	849.55	947.54	1038.52
S1-A	-4.45	25.08	48.27	69.57	93.86	116.12	137.63	160.62	183.99	210.37	235.75
S2-H	-75.68	72.61	163.93	255.23	342.00	418.26	500.65	574.36	651.11	735.82	812.41
S2-A	85.86	110.53	129.22	143.40	163.57	180.03	196.49	172.57	216.66	233.88	248.77
S3-H	-56.06	43.27	115.91	193.01	262.69	324.96	393.16	453.29	515.47	587.44	649.65
S3-A	-6.29	5.75	23.51	39.87	65.51	84.65	110.03	131.84	154.59	177.31	200.82
S4-H	-61.81	44.55	114.97	189.85	264.74	329.19	396.64	459.57	525.49	595.22	657.27
S4-A											

Table D-20. Phase 2 (20,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S5	-60.47	138.81	284.09	422.73	555.61	668.27	790.67	894.71	1002.46	1114.87	1217.58
S6	23.32	203.18	393.99	622.67	883.43	1141.03	1413.60	1660.04	1916.85	2190.25	2439.50
S7	-108.97	98.26	232.28	359.23	476.28	576.54	684.54	775.55	869.60	970.19	1061.81
S8	-123.58	101.01	276.94	452.77	625.03	766.83	915.20	1030.79	1144.92	1261.36	1365.05
S9	-23.54	-298.25	-529.70	-744.01	-943.65	-1109.37	-1275.89	-1417.94	-1555.53	-1685.80	-1803.18
S10	-78.32	100.90	247.05	396.33	536.09	657.33	784.19	889.32	995.63	1107.23	1205.09
S11	-138.00	219.44	475.21	705.19	910.18	1074.94	1242.27	1379.87	1514.56	1654.14	1775.22
S12	-4.53	-30.01	-35.84	-32.74	-26.91	-18.72	-7.44	3.48	16.23	32.07	46.99
S13	-164.12	155.15	367.33	553.22	715.03	843.32	973.64	1079.36	1183.80	1293.10	1388.37
S14	-58.84	77.54	180.06	284.69	387.45	477.84	576.62	661.21	749.52	845.10	930.51
S15	-38.74	8.00	48.47	93.74	139.12	180.69	226.18	267.47	310.17	360.59	405.26
S16	-40.60	56.83	134.87	217.63	299.36	373.75	454.86	525.18	598.49	679.77	752.26
S17	-67.92	65.61	166.11	266.54	363.19	446.44	536.80	612.03	690.35	774.19	848.17
S18	68.89	-77.14	-220.75	-378.41	-534.49	-672.71	-827.02	-961.66	-1099.17	-1238.84	-1372.54
S19	-32.33	48.94	121.61	195.87	267.30	330.51	403.30	463.62	527.35	595.71	658.32
S21	-31.68	34.14	96.20	168.92	247.11	323.51	406.41	481.30	560.54	643.47	721.85
S22	-54.83	0.91	53.53	114.22	168.60	218.82	273.18	322.89	373.10	428.21	479.01
S23	-1.57	-18.13	-4.38	21.51	49.54	79.02	113.32	145.98	181.64	221.30	258.63
INS1	-17.55	41.32	85.99	129.66	171.53	207.92	251.58	291.55	335.10	379.53	425.00
INS2	-77.64	138.59	308.01	469.32	620.61	750.12	888.27	1004.96	1124.98	1235.46	1344.02
INS3	-0.53	40.42	80.63	124.55	166.41	207.20	250.64	289.26	330.06	372.49	412.19
INS4	-34.67	57.93	154.71	270.11	385.87	494.59	616.38	725.43	839.41	957.59	1068.68
INS5	1.78	70.70	129.34	186.37	238.93	287.33	338.75	383.95	430.73	480.21	525.73
IS24	-12.53	99.83	186.30	269.81	346.10	412.65	483.38	543.01	604.28	664.70	722.02
IS25	-7.32	109.45	197.99	283.39	362.13	430.96	503.43	565.71	628.90	692.16	751.04
IS26	98.46	19.98	-32.23	-73.51	-106.07	-120.73	-126.42	-120.74	-105.64	-85.77	-56.42
IS27	56.54	21.10	-7.45	-28.16	-41.76	-42.85	-35.29	-19.87	3.34	32.49	67.79
IS28	-11.48	14.79	44.51	77.35	106.88	135.38	167.43	195.29	224.83	254.67	283.56
IS29	-16.05	13.69	45.43	79.88	111.61	141.54	174.93	204.13	235.14	266.18	296.96
IS30	40.29	-19.66	-47.10	-67.98	-89.42	-99.96	-107.24	-108.69	-107.78	-105.61	-99.60
IS31	6.38	-9.51	-14.04	-15.44	-17.93	-15.31	-11.87	-5.35	2.31	11.41	21.91
IS32	-0.06	277.29	501.70	718.49	924.12	1100.10	1284.11	1444.04	1604.70	1764.44	1911.12
P1A	-46.65	11.53	50.08	86.29	117.62	143.75	176.04	207.13	241.01	274.34	311.29
P1B	-30.64	13.95	43.31	70.92	94.16	113.75	139.20	163.87	191.45	219.39	249.77
P1C	-20.94	14.09	34.32	52.01	66.28	78.75	97.36	114.52	134.75	156.62	180.25
P1D	-21.14	36.76	77.16	116.42	152.74	185.59	223.97	258.83	296.08	335.95	375.54
P3A	8.15	39.33	72.91	109.79	143.36	177.32	213.68	246.71	281.58	318.33	352.02
P3B	7.36	37.23	66.37	97.89	127.39	156.73	188.83	217.79	248.22	280.34	310.34
P3C	3.44	38.10	72.95	111.83	149.43	187.05	227.26	264.13	301.93	343.81	381.35
P3D	-4.78	38.52	79.07	123.92	167.31	209.25	254.70	296.25	339.06	385.85	428.07
P5A	-3.32	65.36	119.27	171.29	218.92	262.66	308.66	349.06	391.26	435.16	475.80
P5B	-0.55	67.01	120.86	172.82	220.37	263.75	309.26	349.01	390.75	435.06	474.90
P5C	-1.46	61.88	105.71	155.39	200.50	241.02	284.32	322.07	361.84	402.57	440.42
P5D	-31.49	38.49	95.04	147.14	192.62	233.90	278.31	316.07	356.41	396.42	435.75

Note: Strain gage S4-A shows faulty readings.

Table D-21. Phase 2 (20,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.02	0.81	1.45	2.31	3.02	3.67	4.62	5.42	6.19	6.92	7.72
Frame-1	-44.01	140.57	283.03	387.40	505.57	656.55	792.75	923.84	1049.11	1167.35	1320.45
Frame-2	-6.58	120.74	275.92	400.19	501.86	699.89	784.18	934.95	1056.96	1165.28	1290.58
Frame-3	-97.86	237.55	310.05	391.30	495.87	688.24	785.25	915.38	1049.22	1168.98	1304.29
Frame-4	35.87	196.35	267.84	375.38	477.00	697.29	791.60	916.66	1064.26	1180.05	1310.47
Frame-5	2.96	134.14	262.02	406.55	508.70	664.78	782.39	905.92	1064.53	1178.27	1304.14
Frame-6	5.43	182.41	272.69	396.93	527.98	654.35	780.81	911.71	1058.86	1193.09	1263.96
Frame-7	-23.04	128.69	256.21	395.07	501.24	675.06	778.65	897.35	1038.81	1190.03	1322.41
Frame-8	-31.56	137.23	279.03	383.93	500.19	649.56	784.42	909.28	1059.65	1186.74	1307.70
Frame-9	-7.86	145.87	262.18	382.59	496.52	677.02	788.62	909.09	1064.07	1173.96	1317.40
Frame-10	-7.80	122.61	274.34	383.68	487.67	649.30	805.16	897.47	1058.87	1175.80	1317.01
Frame-11	44.78	132.40	307.22	398.00	486.47	668.70	787.35	888.72	1055.48	1126.15	1311.92
Frame-12	2.43	122.58	267.58	398.69	501.15	650.70	784.43	914.08	1083.19	1167.38	1308.47
Hoop-1	-47.06	797.54	1614.77	2473.72	3260.19	4107.62	4935.28	5749.06	6603.26	7412.04	8241.22
Hoop-2	-25.60	804.17	1628.55	2499.39	3349.16	4205.04	4924.78	5761.90	6538.29	7440.55	8203.05
Hoop-3	19.40	814.73	1622.22	2497.19	3313.61	4083.82	4911.71	5710.63	6539.45	7394.47	8176.84
Hoop-4	-91.51	833.11	1612.13	2423.67	3297.57	4128.55	4954.39	5760.89	6558.60	7436.56	8223.86
Hoop-5	-1.33	814.40	1613.92	2488.83	3266.99	4427.57	4934.95	5783.25	6585.07	7365.44	8232.57
Hoop-6	-64.80	822.95	1600.80	2479.72	3230.35	4139.61	4951.41	5707.03	6603.85	7380.65	8207.48
Hoop-7	6.49	814.89	1617.92	2483.30	3274.07	4226.49	4911.03	5755.35	6607.16	7392.97	8220.22
Hoop-8	-3.71	793.36	1619.62	2483.43	3273.12	4143.99	4933.18	5738.69	6587.50	7383.91	8203.93
Hoop-9	2.28	812.36	1598.77	2423.53	3260.55	4111.94	4898.18	5727.28	6593.12	7389.97	8218.83
Hoop-10	-55.01	806.73	1609.50	2478.65	3267.53	4285.61	4915.87	5734.24	6601.38	7396.71	8202.40
Hoop-11	-25.17	797.86	1615.10	2469.40	3226.88	4324.85	4958.02	5745.69	6588.83	7423.94	8215.01
Hoop-12	-50.57	819.15	1682.79	2503.14	3145.39	4001.72	4964.60	5692.02	6663.13	7350.59	8207.74
Hoop-13	2.60	807.00	1603.78	2510.88	3242.15	4156.25	4894.35	5780.26	6621.31	7366.55	8222.96
Hoop-14	-6.53	801.14	1623.17	2504.58	3238.83	4105.24	4912.42	5728.49	6602.32	7409.33	8217.82
Long-1	190.47	655.34	1341.08	2003.21	2631.28	3329.78	3995.90	4686.09	5356.60	6014.50	6688.54
Long-2	87.89	627.75	1277.43	1904.56	2685.21	3368.64	3971.92	4660.52	5417.54	6045.33	6606.47
Long-3	40.24	652.12	1320.21	2002.87	2629.71	3329.50	4002.47	4667.67	5358.17	6014.67	6675.52
Long-4	-14.66	671.43	1339.56	1991.96	2650.64	3309.13	4007.41	4654.58	5313.53	6035.33	6693.88
Long-5	-22.24	631.47	1326.54	2086.33	2675.58	3371.83	4004.46	4669.61	5379.29	5986.60	6687.63
Long-6	-2.69	674.84	1312.15	2020.60	2633.19	3325.10	3992.08	4664.53	5356.90	6003.12	6679.66
Long-7	-0.15	666.59	1327.37	2019.73	2629.61	3348.80	4005.94	4679.65	5373.75	6015.67	6719.12
Long-8	3.70	727.70	1375.88	1988.38	2635.56	3345.46	3979.38	4685.25	5327.95	6006.40	6680.75
S1-H	-191.71	104.42	234.39	372.90	469.29	558.84	669.42	765.93	856.63	944.18	1038.04
S1-A	-2.02	22.28	49.76	74.81	95.74	108.84	142.68	166.40	192.78	214.63	239.65
S2-H	-146.76	40.78	142.73	256.43	334.01	407.19	501.77	581.44	659.09	731.33	812.28
S2-A	-58.37	-113.10	-11.65	17.31	46.45	26.65	67.19	84.38	115.77	57.85	264.44
S3-H	-105.74	18.07	94.40	189.31	252.32	304.95	391.64	457.70	519.97	579.96	644.52
S3-A	-6.87	-2.63	20.43	42.50	65.87	86.97	108.43	131.79	156.73	182.31	205.17
S4-H	-89.55	23.58	94.75	184.62	252.79	312.74	388.40	455.78	519.50	582.37	647.47
S4-A											

Table D-21. Phase 2 (20,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S5	-85.19	123.93	262.29	425.99	546.13	660.44	786.72	902.88	1010.23	1110.20	1216.37
S6	-25.79	130.63	330.70	598.72	860.42	1112.22	1393.95	1665.15	1921.03	2165.81	2422.71
S7	-157.78	71.80	208.99	361.54	468.33	566.88	680.41	781.29	874.73	962.42	1057.21
S8	-173.78	67.58	245.69	458.63	616.37	754.55	911.57	1039.41	1155.10	1256.02	1361.28
S9	1.81	-277.60	-492.24	-737.94	-922.97	-1094.30	-1270.30	-1428.16	-1564.62	-1685.14	-1803.90
S10	-104.91	82.88	223.07	399.78	528.92	645.32	783.74	900.95	1006.39	1102.97	1204.20
S11	-189.62	195.24	448.13	723.80	909.18	1069.23	1246.81	1396.45	1531.46	1652.54	1779.22
S12	-13.63	-44.39	-50.76	-47.85	-40.93	-32.20	-19.64	-6.16	6.03	19.87	35.15
S13	-227.39	121.02	342.62	569.62	716.37	835.78	980.18	1095.05	1197.61	1291.75	1390.05
S14	-85.25	68.63	168.59	294.09	386.67	470.70	578.03	670.74	758.85	841.80	931.51
S15	-46.57	-3.28	38.97	93.62	136.54	177.98	228.91	274.17	317.49	359.74	406.44
S16	-61.94	48.13	125.39	225.13	298.89	366.48	456.58	533.74	606.16	675.69	750.78
S17	-91.21	57.81	158.48	280.38	368.13	446.31	544.61	626.87	703.61	776.40	854.26
S18	79.92	-60.87	-194.87	-373.31	-516.94	-655.23	-815.65	-966.61	-1102.90	-1230.91	-1364.04
S19	-52.84	39.42	107.76	196.76	262.63	319.56	401.93	468.95	531.73	592.72	656.61
S21	-55.58	11.70	74.53	160.65	239.79	315.56	399.88	482.52	559.64	635.55	715.80
S22	-69.81	-20.23	35.61	107.77	161.93	210.29	273.59	327.95	376.69	426.76	478.19
S23	-12.00	-35.45	-23.34	6.32	34.76	63.79	103.62	142.29	177.05	212.37	250.62
INS1	-18.90	47.71	82.36	128.93	163.53	207.15	246.93	291.33	334.36	375.91	422.31
INS2	-48.59	172.90	319.26	496.72	631.54	765.19	899.33	1031.80	1147.62	1253.58	1362.44
INS3	0.58	46.71	81.18	128.99	169.58	210.35	254.27	295.93	335.06	374.38	415.15
INS4	-40.80	48.38	137.41	266.21	377.58	486.62	610.88	731.38	844.63	954.09	1067.42
INS5	-3.79	69.74	122.86	184.73	234.41	284.54	334.65	384.55	431.36	476.21	523.47
IS24	-19.97	98.76	174.88	267.84	339.97	413.42	479.75	548.21	607.72	662.94	719.95
IS25	-20.72	103.12	182.96	279.26	353.66	428.65	499.08	569.46	631.80	688.76	748.43
IS26	135.01	46.13	-21.77	-82.66	-109.36	-110.73	-133.88	-124.87	-110.37	-89.35	-60.28
IS27	63.23	28.81	-4.64	-36.15	-46.89	-38.51	-42.99	-23.45	-1.06	26.68	62.35
IS28	-10.57	14.70	40.02	74.95	104.31	134.54	164.21	195.23	223.24	251.48	280.36
IS29	-16.78	12.06	39.81	77.34	108.54	139.38	171.48	204.11	233.33	263.22	293.48
IS30	64.10	-5.86	-40.56	-73.80	-88.33	-92.70	-110.33	-112.50	-113.05	-108.14	-102.13
IS31	19.47	-1.54	-8.29	-15.58	-14.22	-7.88	-13.36	-7.43	-0.68	9.60	20.73
IS32	-19.13	266.25	471.02	716.92	908.97	1096.40	1281.39	1460.05	1619.22	1765.18	1914.37
P1A	-49.53	20.36	49.54	89.88	112.58	143.93	172.93	206.23	239.57	272.38	310.75
P1B	-27.67	25.52	45.15	72.54	88.26	114.34	136.26	163.18	190.48	217.17	249.03
P1C	-17.52	26.92	37.39	53.46	62.13	81.65	94.83	113.97	134.57	155.15	179.51
P1D	-24.84	42.85	76.05	118.09	148.52	186.34	221.75	259.54	296.64	333.49	374.58
P3A	7.41	43.94	71.62	109.80	142.45	177.34	214.05	248.90	283.42	316.42	351.80
P3B	6.25	42.03	65.64	99.01	127.04	157.11	188.83	219.43	249.69	278.62	309.76
P3C	2.34	42.71	71.84	113.50	149.63	186.15	227.44	266.32	303.95	340.79	381.13
P3D	-12.10	37.51	72.63	121.86	163.87	205.27	252.72	296.32	338.27	380.21	424.99
P5A	-6.96	67.76	116.04	172.55	216.87	263.83	307.09	351.05	392.00	432.13	474.09
P5B	-6.25	66.93	115.26	171.75	215.83	261.84	306.01	349.34	390.21	429.73	471.60
P5C	-6.61	62.62	101.47	154.67	196.47	239.57	281.37	322.03	361.47	398.44	437.62
P5D	-9.58	67.41	114.75	171.09	214.19	259.34	299.31	340.16	378.14	414.57	453.75

Note: Strain gage S4-A shows faulty readings.

Table D-22. Phase 2 (20,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.02	0.77	1.48	2.33	3.02	3.85	4.59	5.34	6.11	6.89	7.74
Frame-1	-15.14	127.86	261.08	386.02	538.53	633.23	775.60	908.13	1046.13	1161.23	1300.33
Frame-2	-2.33	158.67	236.12	393.95	536.37	673.84	773.56	912.56	1042.33	1162.38	1334.34
Frame-3	40.81	83.53	304.93	380.94	544.46	639.48	749.74	909.96	1051.00	1170.91	1296.32
Frame-4	-41.34	191.97	240.74	377.23	533.42	631.69	761.14	910.92	1044.06	1177.28	1306.95
Frame-5	-15.73	136.07	268.04	383.91	543.28	658.41	783.21	906.40	1051.48	1163.88	1300.46
Frame-6	31.26	87.88	297.00	378.52	537.47	641.63	761.42	903.01	1054.45	1170.16	1302.45
Frame-7	-3.66	121.71	267.17	386.61	518.63	673.66	772.20	911.14	1049.25	1161.03	1331.20
Frame-8	49.87	131.41	252.43	382.65	550.54	640.42	774.58	890.26	1026.41	1176.03	1312.38
Frame-9	30.36	144.70	244.84	384.22	534.22	639.48	774.00	912.57	1037.77	1185.08	1317.50
Frame-10	55.17	131.30	251.08	385.37	531.66	642.61	770.41	892.39	1047.65	1185.65	1298.67
Frame-11	51.33	126.70	237.78	387.76	532.82	643.28	765.74	898.49	1042.35	1160.51	1291.09
Frame-12	36.80	132.04	259.26	391.27	539.55	663.20	768.35	888.70	1048.11	1185.76	1297.83
Hoop-1	95.21	832.11	1631.19	2441.13	3256.54	4137.62	4925.18	5744.16	6588.67	7399.62	8181.84
Hoop-2	44.43	843.60	1607.00	2478.08	3264.75	4218.45	4929.19	5773.25	6579.59	7385.20	8272.12
Hoop-3	-10.12	832.02	1644.80	2469.65	3277.14	4126.31	4921.15	5733.77	6586.33	7398.21	8224.54
Hoop-4	30.42	814.83	1674.01	2456.67	3255.71	4134.84	4960.68	5748.72	6565.88	7336.81	8224.68
Hoop-5	-13.93	832.33	1633.73	2467.47	3277.79	4118.73	4932.17	5758.62	6590.47	7394.58	8231.59
Hoop-6	-32.18	829.73	1657.47	2438.76	3240.66	4152.45	4962.44	5726.48	6530.02	7415.23	8216.89
Hoop-7	-27.49	827.32	1626.86	2463.88	3281.22	4120.02	4935.09	5761.29	6578.55	7387.92	8231.77
Hoop-8	47.95	830.26	1634.70	2468.67	3302.64	4107.49	4947.94	5737.55	6564.70	7384.65	8210.50
Hoop-9	52.57	830.32	1640.40	2452.27	3292.88	4126.72	4943.08	5753.08	6565.52	7363.76	8214.42
Hoop-10	16.07	824.49	1645.36	2464.44	3287.08	4113.68	4933.64	5738.43	6570.52	7399.23	8222.90
Hoop-11	44.02	819.71	1624.53	2467.58	3286.97	4112.22	4923.42	5724.52	6589.99	7404.65	8194.17
Hoop-12	58.38	844.00	1637.25	2424.77	3160.68	4193.29	4949.31	5759.69	6654.82	7458.38	8183.99
Hoop-13	68.41	836.25	1618.72	2474.31	3307.97	4120.10	4923.60	5757.17	6540.21	7389.23	8229.46
Hoop-14	96.25	823.16	1638.18	2460.53	3290.22	4105.64	4934.44	5720.00	6586.98	7424.76	8202.32
Long-1	264.06	667.11	1313.74	2009.30	2671.50	3361.17	4020.83	4673.80	5348.84	6021.75	6689.83
Long-2	13.35	714.92	1305.69	2015.84	2728.80	3305.36	4067.95	4604.73	5293.44	6061.60	6655.03
Long-3	82.91	675.28	1302.05	1998.19	2687.01	3335.60	4015.07	4677.88	5343.39	6005.54	6679.73
Long-4	-11.04	691.93	1337.29	2004.21	2685.61	3333.25	3986.10	4652.63	5335.10	6022.67	6660.65
Long-5	-21.06	703.32	1300.75	2027.63	2685.00	3334.13	3990.72	4651.23	5337.94	6026.06	6699.92
Long-6	-3.88	680.77	1286.17	2000.63	2683.04	3331.03	3992.48	4685.17	5335.41	6006.08	6701.54
Long-7	68.00	655.64	1297.08	2004.11	2714.79	3347.59	4006.34	4670.38	5343.18	6017.50	6678.29
Long-8	-41.41	741.95	1330.91	2047.93	2729.34	3308.65	4002.33	4684.53	5337.33	6004.61	6684.83
S1-H	-190.37	91.37	235.86	370.14	464.86	578.74	668.79	757.54	850.00	940.92	1039.35
S1-A	-0.34	21.53	46.39	70.14	98.56	116.49	142.29	165.84	188.68	213.71	238.53
S2-H	-145.61	27.57	143.28	251.64	330.02	423.95	498.96	573.60	652.06	729.72	814.00
S2-A	-60.60	-61.35	15.07	37.86	24.60	169.56	121.74	163.59	188.28	209.19	271.17
S3-H	-107.94	4.72	94.42	183.38	249.35	325.73	387.93	450.19	513.99	578.54	648.16
S3-A	-8.61	-0.18	17.71	40.14	67.26	85.63	111.32	132.32	156.08	181.04	203.43
S4-H	-90.28	11.59	93.99	180.89	241.57	322.45	386.12	449.04	513.56	578.68	650.47
S4-A											

Table D-22. Phase 2 (20,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S5	-85.72	110.03	265.26	425.13	536.61	678.53	787.46	893.98	1002.25	1107.49	1218.55
S6	-3.23	110.26	331.39	598.97	832.31	1143.21	1393.09	1642.05	1901.40	2155.66	2421.62
S7	-157.38	56.90	209.10	357.53	458.98	583.17	679.62	771.70	867.10	959.56	1059.53
S8	-176.65	48.68	247.11	455.05	602.62	778.46	910.75	1028.50	1144.31	1252.51	1364.91
S9	-15.59	-260.83	-501.42	-742.70	-918.02	-1122.82	-1273.85	-1418.48	-1555.33	-1681.85	-1805.40
S10	-106.79	67.90	224.87	396.55	520.89	669.18	784.29	890.78	998.14	1100.63	1207.92
S11	-184.77	174.21	453.17	720.78	894.73	1098.38	1248.32	1387.00	1523.25	1651.61	1784.31
S12	-16.17	-44.39	-52.94	-50.40	-47.30	-32.01	-21.82	-10.35	2.94	16.23	33.70
S13	-223.71	104.31	344.59	563.50	705.91	862.94	979.72	1085.97	1190.82	1289.70	1393.32
S14	-80.28	53.48	168.17	289.21	375.84	486.76	576.07	662.96	752.37	839.79	934.10
S15	-47.06	-5.05	40.05	92.90	132.91	187.24	228.75	270.58	315.38	358.32	409.53
S16	-57.48	35.97	123.61	219.80	290.44	381.05	453.68	526.35	599.73	673.58	753.36
S17	-83.19	43.09	156.82	274.41	359.45	461.89	541.29	619.24	697.50	773.39	855.72
S18	91.95	-58.78	-197.81	-372.90	-507.08	-681.62	-821.66	-955.66	-1092.46	-1226.63	-1367.86
S19	-55.06	34.23	107.11	190.99	254.50	335.70	399.61	462.57	526.82	589.36	657.61
S21	-46.59	3.59	76.16	160.12	229.07	324.96	399.30	475.27	554.43	633.07	717.97
S22	-78.16	-16.64	38.24	107.06	156.17	223.86	275.02	322.90	374.59	424.44	480.69
S23	-15.36	-33.46	-23.21	4.33	26.87	70.27	103.33	136.26	173.17	209.67	250.80
INS1	-16.76	44.49	86.78	132.43	164.29	212.44	248.44	289.15	332.76	376.14	424.91
INS2	-21.32	169.84	338.20	510.15	629.62	791.50	910.54	1028.51	1145.28	1257.18	1372.16
INS3	-0.90	43.38	83.04	129.93	167.36	216.28	255.59	295.22	335.68	375.09	417.89
INS4	-44.00	45.27	140.45	266.65	366.68	503.42	614.68	723.75	839.76	950.57	1071.99
INS5	-3.03	65.42	124.66	186.01	232.79	290.90	336.02	382.25	429.39	475.57	525.50
IS24	-11.27	90.42	180.12	271.49	335.66	420.80	482.61	544.05	604.88	662.28	722.67
IS25	-12.57	94.25	187.47	282.72	348.99	436.76	501.21	564.21	627.88	687.56	750.96
IS26	144.36	51.73	-16.59	-73.30	-106.46	-121.14	-128.87	-123.46	-109.29	-88.90	-58.01
IS27	69.11	30.58	-1.65	-29.80	-48.57	-45.39	-40.09	-24.68	-1.74	26.00	63.93
IS28	-12.75	14.61	40.83	75.32	99.91	137.06	164.92	193.05	222.22	249.97	281.85
IS29	-18.41	11.70	40.89	77.35	103.65	142.63	171.83	201.75	232.62	261.44	294.75
IS30	57.00	3.77	-37.47	-68.18	-88.89	-98.87	-107.23	-109.77	-109.79	-107.78	-100.50
IS31	21.60	1.63	-6.57	-11.60	-16.62	-13.09	-11.37	-5.89	2.17	9.28	22.50
IS32	-2.97	249.18	482.22	725.17	900.89	1120.98	1287.25	1449.70	1610.30	1763.18	1919.64
P1A	-47.73	18.37	53.50	91.69	114.39	150.41	174.38	205.17	238.72	272.90	312.88
P1B	-28.07	23.99	48.90	75.70	91.51	118.18	137.39	162.38	189.74	218.00	251.49
P1C	-18.96	25.65	41.18	57.62	65.75	83.27	96.09	114.51	135.13	156.25	182.22
P1D	-24.10	39.72	79.92	121.42	150.19	191.67	223.21	258.62	296.85	333.89	377.71
P3A	6.30	41.54	72.53	111.28	141.17	181.56	214.40	247.42	283.08	316.82	354.20
P3B	6.62	39.63	67.11	99.57	125.21	160.42	188.63	217.58	248.80	278.46	311.41
P3C	1.60	38.84	72.39	113.69	147.25	191.47	227.61	264.66	303.06	341.01	382.79
P3D	-13.16	32.26	73.13	121.46	160.62	211.27	252.14	293.33	337.25	379.74	426.46
P5A	-4.01	63.29	118.66	174.87	215.97	268.74	308.67	350.13	392.04	432.72	476.85
P5B	-4.71	62.19	116.97	172.99	214.63	266.46	306.52	346.99	389.34	429.78	473.59
P5C	-5.88	58.20	102.75	156.16	194.65	244.15	281.90	320.19	359.67	398.11	439.64
P5D	-6.63	68.70	121.74	178.48	216.97	267.97	305.17	342.93	382.05	419.77	461.49

Note: Strain gage S4-A shows faulty readings.

Table D-23. Phase 3 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.03	0.69	1.31	1.95	2.66	3.35	4.04	4.67	5.33	6.01	6.73
Frame-1	0.79	130.42	226.27	364.68	450.36	573.71	673.66	807.54	913.71	1018.80	1135.73
Frame-2	-3.11	132.76	187.41	363.08	451.97	550.58	671.65	790.43	912.73	1043.79	1118.09
Frame-3	-12.60	38.97	263.71	330.95	455.48	563.32	672.27	789.82	906.02	1034.85	1139.79
Frame-4	-5.71	164.56	224.39	365.49	448.64	573.91	673.75	793.31	903.72	1020.93	1144.84
Frame-5	13.48	125.30	213.08	368.06	462.32	564.67	681.34	794.06	916.87	1025.51	1141.22
Frame-6	2.83	56.05	265.47	395.47	472.35	553.86	675.39	777.75	909.85	1039.37	1127.24
Frame-7	11.09	112.78	222.30	350.44	452.50	565.90	680.84	787.44	899.16	1048.29	1128.67
Frame-8	2.84	112.86	217.41	369.03	438.24	578.90	678.47	839.44	902.05	1023.90	1125.20
Frame-9	16.69	150.00	239.19	367.28	457.70	585.58	677.23	790.14	909.40	1015.84	1128.67
Frame-10	-2.65	101.11	223.81	367.65	456.25	571.54	679.82	799.70	909.03	1016.71	1145.13
Frame-11	2.24	98.06	190.01	377.44	454.19	575.55	676.07	797.90	901.08	1033.91	1128.65
Frame-12	3.34	105.60	223.82	371.02	459.90	565.40	674.06	793.80	905.17	1031.64	1140.56
Hoop-1	-26.46	744.71	1412.10	2150.53	2866.80	3550.46	4320.23	4967.00	5721.77	6452.83	7152.19
Hoop-2	-15.02	790.93	1419.31	2155.32	2797.71	3521.08	4293.35	5021.68	5694.79	6371.50	7198.26
Hoop-3	-20.43	691.13	1512.17	2143.95	2806.70	3556.44	4254.53	4960.46	5715.40	6423.48	7165.56
Hoop-4	15.88	705.30	1540.39	2138.92	2913.62	3515.73	4291.07	5007.35	5667.66	6386.19	7116.74
Hoop-5	7.69	725.75	1415.16	2136.89	2851.14	3581.80	4284.09	4999.92	5726.98	6468.44	7183.98
Hoop-6	-7.94	705.95	1490.36	2101.35	2868.24	3601.01	4265.57	4973.89	5720.40	6468.62	7087.42
Hoop-7	-3.84	748.66	1363.67	2057.26	2839.95	3574.58	4298.92	5002.74	5721.28	6434.47	7188.05
Hoop-8	7.17	722.62	1452.83	2138.99	2854.52	3570.40	4277.77	5001.10	5715.49	6446.91	7140.31
Hoop-9	5.17	714.24	1435.87	2163.10	2823.77	3588.91	4275.73	4974.52	5700.47	6428.70	7119.88
Hoop-10	-0.10	722.60	1429.33	2154.03	2862.60	3569.75	4277.54	4988.32	5713.51	6440.98	7133.57
Hoop-11	-12.91	709.53	1428.34	2207.42	2869.88	3560.00	4278.09	5024.70	5695.12	6416.96	7134.02
Hoop-12	-19.65	754.03	1374.88	2227.10	2878.58	3582.00	4230.80	4941.93	5643.87	6516.18	7150.47
Hoop-13	-11.40	704.82	1428.36	2130.17	2868.40	3533.88	4271.32	5009.97	5717.81	6427.94	7122.31
Hoop-14	0.72	719.85	1424.31	2173.01	2848.17	3575.07	4278.81	5005.78	5701.83	6436.84	7148.70
Long-1	81.57	682.51	1292.55	2064.04	2647.41	3327.19	3998.47	4678.91	5341.16	6005.08	6677.73
Long-2	-85.42	584.90	1353.85	2223.66	2752.09	3306.14	4074.57	4664.84	5329.07	6046.95	6749.72
Long-3	30.43	676.12	1301.37	1986.00	2657.35	3348.53	4004.92	4684.80	5331.26	6004.95	6667.84
Long-4	183.15	695.34	1323.50	1964.59	2680.53	3349.81	4019.62	4681.33	5329.25	6022.22	6661.09
Long-5	9.95	666.86	1351.13	2090.39	2675.55	3346.99	4022.47	4672.39	5337.08	6018.74	6665.18
Long-6	2.32	671.21	1292.92	2028.17	2690.00	3334.38	3993.52	4692.13	5330.90	6018.77	6679.49
Long-7	105.73	661.46	1320.83	2068.66	2663.38	3333.83	3986.59	4678.60	5350.62	6014.58	6692.06
Long-8	-5.09	684.15	1322.64	2010.63	2684.51	3332.63	4015.67	4669.39	5329.69	5999.95	6666.79
S1-H	-16.11	123.11	203.48	274.07	353.13	423.73	500.33	577.31	654.16	734.12	816.98
S1-A	0.91	2.03	17.36	38.28	50.25	69.30	87.05	105.18	120.88	137.89	159.55
S2-H	-45.56	111.22	204.58	278.45	355.38	424.77	492.71	561.39	632.38	701.81	772.66
S2-A	47.28	63.34	85.39	111.89	130.58	151.29	172.40	193.31	212.01	230.12	254.00
S3-H	-31.66	82.25	156.15	216.55	282.30	339.94	401.18	461.05	521.52	580.89	641.09
S4-H	-23.07	54.05	110.23	160.37	213.56	265.95	319.11	365.72	410.50	465.72	521.46

Table D-23. Phase 3 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S8	-31.07	158.58	303.23	431.77	571.33	691.89	812.50	922.94	1016.05	1118.51	1213.58
S9	-29.70	-324.63	-582.73	-789.56	-1000.14	-1173.94	-1353.29	-1508.60	-1672.80	-1813.53	-1949.43
S10	-11.98	137.26	250.47	351.00	464.98	561.56	663.69	751.57	845.02	938.17	1028.13
S14	-44.02	64.05	148.97	222.19	303.76	377.16	455.03	527.46	595.37	671.48	748.47
S17	-6.31	109.20	197.14	268.30	346.98	417.05	491.33	559.08	621.25	689.55	760.31
S18	-16.54	-136.52	-240.38	-342.32	-451.62	-549.02	-657.00	-762.99	-865.97	-973.97	-1086.68
S19	-744.47	3.17	-448.50	-382.47	-391.48	-432.61	-71.42	-766.25	-112.68	-223.44	175.80
S24	-3.84	-36.97	-56.47	-82.81	-106.36	-126.07	-142.11	-155.79	-168.71	-186.03	-205.87
S25	-24.78	-180.16	-323.64	-466.44	-604.21	-728.42	-844.40	-951.41	-1061.61	-1179.68	-1298.03
S26	-1.76	0.82	-2.41	-11.03	-14.08	-18.50	-18.87	-18.36	-15.92	-16.43	-15.46
S27	-56.50	-138.77	-209.08	-274.73	-336.84	-397.87	-450.00	-500.67	-549.74	-598.08	-649.46
S28	0.52	12.38	13.03	11.50	16.16	17.45	23.04	31.39	38.17	43.67	49.52
S29	-2.85	200.18	374.84	533.48	682.60	811.77	933.15	1040.92	1146.50	1244.49	1338.98
S30	-9.61	123.62	253.67	374.10	499.98	612.47	726.69	830.80	932.37	1033.30	1133.54
S31	-18.23	48.87	100.11	146.78	200.02	249.36	303.71	353.62	408.46	470.17	532.55
S32	-20.98	99.93	171.24	226.31	286.79	342.28	397.39	452.10	502.18	561.60	620.73
INS2	2.17	223.98	419.86	580.89	755.09	900.24	1051.24	1191.58	1330.25	1464.47	1596.00
INS3	-2.29	32.64	63.37	94.76	131.91	165.68	201.23	236.85	271.30	305.79	341.68
INS4	-71.52	-35.24	-5.53	14.68	41.28	54.93	84.72	113.53	149.97	169.99	201.77
IS24	13.42	97.12	174.14	233.71	302.04	356.91	418.86	473.39	523.99	575.08	625.57
IS25	5.46	96.66	182.84	245.78	316.02	375.35	439.05	494.06	549.85	601.97	655.48
IS26	14.01	-64.68	-105.21	-143.96	-166.75	-185.10	-190.69	-191.33	-191.26	-179.62	-164.24
IS27	-3.61	-38.49	-53.05	-70.21	-76.11	-80.99	-75.01	-72.16	-57.08	-37.91	-15.93
IS28	-0.94	22.28	43.42	62.19	85.42	106.59	131.12	155.79	176.13	199.62	225.45
IS29	-5.53	19.67	42.52	62.27	86.57	108.13	134.24	158.89	180.84	205.32	232.67
IS30	-3.39	-52.05	-83.85	-107.08	-124.71	-138.68	-148.12	-151.75	-162.30	-164.30	-163.74
IS31	-6.48	-29.74	-38.94	-48.76	-54.65	-57.58	-56.04	-54.50	-56.55	-52.43	-46.09
IS32	5.77	206.99	381.25	521.43	674.27	799.94	937.30	1060.86	1185.27	1302.31	1417.58
P6-1	-69.04	-37.52	-19.77	0.70	28.24	49.25	75.34	94.17	115.56	133.32	155.04
P6-2	1203.28	1256.37	1283.02	1308.99	1339.03	1364.02	1396.74	1427.50	1457.96	1486.39	1515.88
P6-3	-181.47	-122.78	-82.22	-39.46	9.08	49.65	94.56	129.34	165.58	202.53	243.98
P6-4	-9.94	-164.01	-266.05	-349.88	-407.13	-453.70	-473.43	-494.64	-498.16	-487.37	-465.21
P6-5	45.09	85.31	126.10	166.66	210.53	247.11	302.38	341.70	461.33	503.01	590.48
P6-6	-32.43	27.10	83.37	132.72	182.10	224.72	270.09	309.11	351.43	382.28	414.54
P6-7	4.90	-76.19	-119.66	-158.55	-181.92	-204.89	-211.40	-218.28	-211.06	-215.23	-210.14
P6-8	-38.37	15.06	66.56	111.35	166.92	212.43	263.46	308.04	353.87	395.42	441.54
P6-9	24.82	63.08	99.74	134.90	178.08	215.24	256.59	292.50	328.44	362.00	398.05
P6-10	-6.35	25.30	52.44	77.93	107.60	134.18	161.85	186.27	209.99	233.32	259.70
P6-11	-82.98	-65.83	-49.78	-33.53	-14.04	2.92	20.78	36.84	51.47	63.74	77.99
P6-12	-210.04	-203.50	-189.95	-178.14	-160.22	-146.26	-127.78	-110.57	-97.54	-85.76	-70.18

Table D-24. Phase 3 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.01	0.68	1.34	2.03	2.69	3.33	4.01	4.66	5.34	6.02	6.67
Frame-1	-1.97	119.27	219.67	332.45	454.13	569.17	686.91	793.09	903.53	1017.07	1122.37
Frame-2	8.75	136.33	190.71	342.58	442.71	536.18	679.88	797.26	918.94	1014.28	1122.61
Frame-3	30.26	128.58	233.39	337.53	451.40	562.16	679.96	799.19	908.74	1021.14	1121.40
Frame-4	-25.62	125.77	280.68	305.23	460.11	572.66	687.88	801.40	908.09	1025.54	1133.55
Frame-5	-2.52	132.15	249.18	345.90	443.22	561.71	678.11	800.90	901.79	1010.69	1130.98
Frame-6	-34.03	64.14	218.76	382.03	451.05	557.32	684.84	796.72	931.31	1015.94	1112.98
Frame-7	9.98	120.20	222.15	339.49	458.63	557.61	674.93	787.93	924.90	1020.94	1134.29
Frame-8	10.83	105.43	212.68	345.28	450.80	564.07	675.30	786.56	903.22	1011.87	1128.07
Frame-9	18.38	69.19	216.73	337.22	453.85	573.38	699.44	801.77	895.11	1013.22	1117.29
Frame-10	3.28	91.33	232.24	355.64	475.08	569.05	683.91	787.37	903.02	1029.67	1122.14
Frame-11	-4.88	101.24	222.75	334.71	466.49	567.00	677.45	790.93	912.69	1014.64	1131.47
Frame-12	3.65	105.79	229.84	344.11	457.21	562.73	680.05	789.70	906.35	1021.08	1100.38
Hoop-1	0.89	702.64	1453.75	2137.56	2857.40	3546.46	4314.76	5013.58	5716.86	6401.78	7143.38
Hoop-2	19.09	625.67	1428.00	2128.18	2874.60	3558.42	4289.75	4995.75	5691.77	6421.76	7096.28
Hoop-3	0.40	690.99	1503.19	2152.42	2851.54	3578.64	4315.28	5020.46	5733.32	6393.98	7176.38
Hoop-4	-35.06	668.78	1472.79	2131.43	2793.29	3548.12	4276.52	4917.37	5700.97	6411.65	7100.67
Hoop-5	4.09	695.02	1494.06	2138.48	2838.26	3570.65	4273.29	5024.32	5687.95	6382.05	7151.93
Hoop-6	0.64	734.98	1481.48	2125.17	2869.67	3530.30	4265.57	4976.60	5681.49	6411.99	7094.69
Hoop-7	1.52	762.81	1440.25	2150.01	2862.90	3608.19	4275.68	5001.95	5705.76	6379.06	7140.13
Hoop-8	-22.34	715.32	1415.95	2153.53	2861.61	3562.67	4285.15	5001.10	5709.25	6432.15	7177.90
Hoop-9	-0.22	705.33	1412.53	2146.73	2861.18	3586.76	4297.27	5014.01	5712.38	6412.54	7106.23
Hoop-10	-5.43	717.35	1431.11	2141.38	2856.99	3569.40	4286.42	4993.65	5709.32	6428.55	7136.06
Hoop-11	14.38	704.15	1428.34	2138.05	2878.69	3572.38	4261.72	4988.30	5710.82	6431.52	7109.25
Hoop-12	-6.28	736.91	1470.39	2207.77	2962.35	3497.58	4353.06	5010.70	5652.63	6317.49	7120.61
Hoop-13	3.22	726.82	1399.12	2129.96	2882.73	3540.83	4315.17	5009.97	5645.86	6427.94	7152.25
Hoop-14	0.72	727.26	1453.66	2165.45	2869.90	3567.37	4293.49	5013.12	5695.62	6414.82	7105.38
Long-1	43.32	662.13	1321.97	2006.39	2695.72	3329.14	3993.17	4694.59	5343.65	5992.33	6679.03
Long-2	-71.36	627.24	1460.67	1909.03	2424.87	3503.28	3916.78	4781.49	5234.03	5993.54	6698.46
Long-3	15.80	604.42	1341.58	2006.91	2669.80	3287.84	4019.14	4658.00	5350.06	6040.29	6644.03
Long-4	-7.28	637.68	1317.47	1973.22	2689.24	3346.40	4013.19	4660.84	5358.71	6035.48	6636.32
Long-5	-14.77	672.95	1346.42	1999.93	2658.15	3301.26	4003.24	4666.50	5368.22	5988.12	6678.65
Long-6	-20.21	650.06	1314.27	1982.10	2655.87	3352.36	3983.63	4677.89	5325.50	5991.49	6661.04
Long-7	110.58	642.20	1342.73	2016.56	2675.80	3341.34	3988.63	4685.90	5336.56	6001.20	6675.59
Long-8	10.33	625.02	1335.69	2006.08	2645.63	3319.77	3993.92	4672.94	5334.96	6004.70	6663.75
S1-H	-5.30	125.16	206.59	283.21	352.76	421.12	504.35	580.16	660.24	737.92	813.15
S1-A	-11.42	-10.86	2.97	18.10	34.18	50.43	71.18	91.17	109.29	133.23	153.03
S2-H	-49.28	106.74	199.30	279.94	348.66	415.07	491.31	560.70	633.06	699.64	766.77
S2-A	42.05	53.25	76.22	98.45	117.32	138.78	160.10	182.31	202.46	229.77	250.67
S3-H	-32.40	80.40	153.55	222.45	280.42	334.72	402.29	461.05	521.99	581.27	638.19
S4-H	-47.03	33.83	95.22	146.90	197.08	249.48	308.69	358.45	413.08	467.64	519.08

Table D-24. Phase 3 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S8	-63.75	128.06	275.53	420.87	547.35	665.73	799.58	915.04	1021.03	1120.80	1210.79
S9	-30.74	-318.86	-571.38	-802.65	-989.55	-1167.12	-1348.88	-1514.71	-1675.04	-1807.21	-1945.63
S10	-28.37	116.06	233.46	347.01	446.86	543.45	656.06	753.41	849.47	940.21	1024.92
S14	-68.84	43.01	128.44	213.12	287.08	357.85	445.19	520.30	598.57	674.04	745.14
S17	-17.75	96.85	182.01	263.40	333.90	401.07	483.26	553.32	624.10	693.80	758.21
S18	6.19	-109.62	-224.31	-330.68	-431.26	-537.38	-651.13	-761.98	-872.61	-977.34	-1082.51
S19	-210.28	-186.30	-544.89	-302.15	-110.63	-139.67	-242.54	396.87	225.34	-60.95	307.52
S24	-11.58	-45.54	-74.79	-98.84	-121.02	-141.55	-158.68	-173.41	-187.03	-201.49	-215.43
S25	-53.49	-212.01	-364.41	-511.36	-638.46	-754.56	-883.70	-999.01	-1109.56	-1214.55	-1315.28
S26	-12.51	-10.57	-19.65	-23.25	-29.25	-32.89	-31.28	-30.22	-26.66	-23.81	-20.30
S27	-27.49	-108.99	-185.57	-256.59	-318.83	-374.32	-421.91	-470.34	-518.17	-563.04	-606.83
S28	-9.26	-0.63	-2.34	-0.31	0.75	3.66	12.15	18.42	28.07	36.01	44.27
S29	-4.35	195.55	369.29	535.71	672.08	795.57	932.16	1045.02	1150.06	1248.97	1332.99
S30	-18.27	113.09	240.49	373.06	486.19	595.55	720.72	831.20	938.58	1039.03	1128.94
S31	-36.37	32.13	81.26	133.67	182.14	230.53	293.79	350.93	410.78	471.49	527.34
S32	-42.71	74.21	141.84	207.02	262.29	315.43	384.79	443.40	501.68	563.92	614.91
INS2	-1.44	218.20	409.62	592.45	742.81	890.84	1045.49	1192.42	1338.97	1464.44	1596.70
INS3	-7.28	26.89	61.42	95.95	129.84	161.60	201.49	236.67	273.68	307.47	342.37
INS4	-142.26	-100.08	-63.92	-35.38	-14.08	17.20	44.07	70.95	102.32	131.86	168.98
IS24	10.70	92.40	166.48	236.43	294.80	352.74	415.50	471.27	528.11	574.96	627.08
IS25	2.92	92.86	176.99	248.67	310.23	368.11	434.07	492.66	551.24	600.58	653.37
IS26	37.78	-46.27	-92.49	-130.10	-157.02	-172.01	-186.96	-189.62	-183.46	-179.41	-159.71
IS27	-0.07	-31.56	-51.13	-65.45	-74.84	-76.42	-75.26	-66.86	-52.18	-38.18	-13.39
IS28	-7.88	13.03	37.33	58.24	79.52	102.46	128.06	152.23	177.43	200.41	224.61
IS29	-10.96	11.15	36.34	58.64	80.95	104.51	131.54	156.37	182.45	206.60	231.60
IS30	0.25	-51.51	-76.74	-103.27	-119.62	-131.78	-144.70	-151.77	-156.11	-161.23	-159.76
IS31	-2.36	-25.85	-34.72	-44.77	-50.30	-51.34	-54.24	-52.61	-50.39	-48.18	-42.11
IS32	-10.92	187.94	359.55	518.89	652.68	783.43	922.60	1052.62	1181.70	1291.19	1410.64
P6-1	-84.61	-52.73	-26.47	-3.28	20.81	45.81	69.19	88.93	114.82	130.97	153.24
P6-2	1226.03	1270.77	1306.70	1338.22	1368.83	1400.44	1433.61	1460.64	1489.36	1513.18	1542.56
P6-3	-188.68	-130.02	-77.85	-11.21	17.05	67.03	101.10	139.49	179.32	219.94	253.06
P6-4	-2.99	-153.59	-252.81	-334.35	-390.68	-428.47	-468.59	-486.83	-485.31	-487.24	-459.23
P6-5	46.16	86.21	129.69	174.45	219.78	272.48	330.17	360.22	442.81	490.20	571.51
P6-6	-47.30	11.67	69.19	124.01	168.30	212.02	256.35	296.62	336.87	369.98	405.15
P6-7	17.39	-62.62	-105.32	-140.81	-168.34	-185.34	-208.91	-219.75	-220.45	-225.39	-209.43
P6-8	-33.35	22.74	78.64	134.38	185.53	234.69	285.20	329.79	375.96	414.48	459.34
P6-9	33.88	72.51	114.94	155.58	194.04	231.75	270.25	304.68	340.92	371.65	407.52
P6-10	-2.74	30.36	61.83	90.41	118.46	143.59	172.02	195.70	220.64	241.30	265.52
P6-11	-91.45	-71.24	-50.85	-31.73	-13.50	1.66	21.15	35.22	50.38	63.02	78.35
P6-12	-267.60	-250.78	-233.55	-217.09	-199.35	-181.58	-163.50	-148.81	-131.41	-116.76	-98.99

Table D-25. Phase 3 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.00	0.69	1.34	2.00	2.68	3.36	4.03	4.69	5.35	6.00	6.68
Frame-1	9.41	118.60	220.73	343.02	462.14	573.36	675.22	794.06	905.90	1022.24	1114.06
Frame-2	13.58	99.71	203.22	343.24	458.85	560.07	682.99	788.49	908.26	1019.39	1132.32
Frame-3	21.08	47.73	304.00	359.40	460.30	579.65	682.79	797.06	910.92	1018.35	1127.35
Frame-4	49.33	154.86	209.80	348.08	455.21	582.98	672.09	793.02	907.25	1027.31	1133.45
Frame-5	8.89	146.27	243.69	348.20	459.39	577.47	679.60	787.21	899.28	1015.81	1134.15
Frame-6	34.34	80.62	180.87	337.60	432.19	565.98	675.31	797.65	914.89	1016.18	1134.66
Frame-7	11.42	117.91	227.49	337.21	446.97	570.15	683.14	796.00	909.31	1035.07	1163.20
Frame-8	10.82	121.31	239.66	350.51	447.68	574.23	683.94	793.52	906.64	1017.60	1143.27
Frame-9	7.21	149.36	227.46	335.01	450.99	574.32	683.63	783.04	909.42	1026.83	1136.78
Frame-10	1.87	124.59	236.06	337.76	455.13	560.11	677.80	789.67	906.23	1019.35	1136.28
Frame-11	10.06	127.27	232.75	338.35	455.96	600.87	678.44	791.77	905.57	1015.77	1150.85
Frame-12	-0.96	115.65	233.96	338.60	446.38	576.06	685.71	784.46	917.49	1013.00	1131.04
Hoop-1	-8.23	702.85	1665.21	2128.23	2854.03	3563.22	4274.23	4971.14	5732.13	6413.90	7156.54
Hoop-2	-31.17	769.46	1358.00	2138.74	2853.35	3668.27	4291.12	5034.74	5742.68	6401.37	7123.59
Hoop-3	22.96	717.23	1402.54	2140.06	2855.29	3577.26	4294.02	5013.02	5685.33	6462.76	7150.66
Hoop-4	-15.04	707.19	1427.32	2138.50	2828.13	3573.94	4292.46	5007.85	5681.65	6421.93	7137.46
Hoop-5	11.29	700.63	1420.28	2141.87	2865.54	3592.60	4303.46	5009.42	5722.81	6439.00	7128.91
Hoop-6	7.50	704.31	1407.70	2171.29	2883.68	3542.67	4256.56	4979.54	5757.58	6392.47	7149.91
Hoop-7	-2.06	709.41	1427.74	2140.86	2864.98	3578.16	4298.49	5010.39	5713.57	6432.04	7122.63
Hoop-8	7.17	700.56	1445.60	2139.21	2861.90	3532.81	4292.95	4985.85	5730.81	6440.17	7139.59
Hoop-9	6.96	719.69	1432.42	2141.77	2839.92	3595.38	4292.31	4991.97	5718.99	6432.93	7122.76
Hoop-10	-1.88	710.24	1438.35	2147.14	2860.82	3565.49	4285.07	4989.60	5701.65	6438.07	7141.74
Hoop-11	1.65	767.84	1437.58	2138.48	2846.22	3573.85	4302.18	5011.46	5730.27	6439.44	7131.49
Hoop-12	-52.13	647.11	1348.27	2196.75	2916.79	3512.52	4223.58	4849.74	5606.22	6478.62	7073.34
Hoop-13	3.22	617.19	1428.50	2123.08	2839.16	3562.41	4293.67	5009.47	5703.77	6457.82	7180.06
Hoop-14	0.72	697.91	1431.79	2129.18	2848.17	3567.02	4279.24	4997.94	5717.07	6444.82	7147.99
Long-1	15.87	664.87	1326.16	2005.41	2647.41	3349.75	4029.85	4677.46	5359.34	6013.90	6676.75
Long-2	181.60	753.53	1413.16	1899.20	2964.30	3486.05	4000.08	4609.57	5291.65	6184.70	6718.80
Long-3	112.06	721.20	1335.76	2026.41	2632.98	3361.93	4035.38	4697.74	5374.43	6002.52	6681.25
Long-4	7.18	632.67	1388.87	2003.35	2651.61	3302.80	4028.06	4680.86	5344.24	6008.96	6691.23
Long-5	7.60	670.40	1306.64	2001.11	2669.66	3369.36	3982.44	4675.46	5342.32	6019.91	6680.49
Long-6	-20.21	655.79	1331.14	2002.27	2680.52	3353.36	3999.45	4675.06	5334.99	6016.40	6674.75
Long-7	106.94	662.68	1330.83	2011.70	2680.40	3337.48	4012.13	4687.87	5331.70	6009.71	6673.82
Long-8	-15.77	757.70	1428.53	1997.78	2679.77	3358.73	3997.87	4679.60	5363.44	6041.48	6656.11
S1-H	-18.91	99.26	176.43	259.72	342.85	425.04	507.04	584.70	661.92	733.97	813.92
S1-A	-8.43	-14.78	-3.95	10.07	28.38	46.32	65.94	87.23	108.73	131.32	150.01
S2-H	-65.71	79.13	167.98	256.05	338.92	417.31	494.20	565.07	634.55	698.68	765.87
S2-A	46.72	57.93	77.72	95.46	118.05	138.03	161.19	184.33	208.25	232.50	255.28
S3-H	-45.55	57.25	128.75	201.38	271.01	338.40	403.63	463.97	523.42	578.54	636.59
S4-H	-50.03	21.11	76.52	134.17	191.07	253.22	312.37	361.19	414.57	464.88	519.16

Table D-25. Phase 3 (Baseline, 0 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S8	-83.38	90.29	233.44	383.09	532.04	673.00	802.33	919.94	1024.66	1116.10	1212.00
S9	-11.88	-297.44	-546.99	-775.88	-991.23	-1186.17	-1363.52	-1526.58	-1678.32	-1814.35	-1945.74
S10	-39.77	92.11	202.46	321.45	439.37	553.12	661.56	759.98	854.10	938.02	1026.98
S14	-78.06	21.31	105.85	191.82	276.94	363.06	446.91	525.09	600.43	669.67	744.27
S17	-27.74	74.34	158.98	243.96	325.33	407.24	485.70	557.93	627.00	690.50	758.24
S18	10.37	-102.72	-195.44	-306.32	-425.40	-541.02	-653.19	-763.46	-873.16	-975.59	-1080.12
S19	-338.06	-152.21	84.33	-26.24	-40.95	-34.17	-131.39	-551.63	-161.30	-206.91	333.78
S24	-17.94	-54.25	-81.39	-108.70	-131.14	-151.55	-170.63	-183.83	-196.47	-211.42	-226.35
S25	-61.05	-213.87	-356.57	-509.15	-648.52	-782.18	-908.75	-1022.56	-1128.10	-1230.30	-1337.48
S26	-19.47	-23.67	-29.85	-35.15	-36.72	-36.39	-34.96	-32.75	-29.61	-27.49	-24.17
S27	-15.54	-97.87	-168.42	-240.56	-305.79	-364.57	-423.98	-475.47	-524.67	-569.60	-616.23
S28	-15.45	-11.62	-14.29	-11.34	-6.73	-0.13	6.98	15.19	23.50	31.02	39.83
S29	-12.74	168.49	331.03	494.07	652.87	799.16	933.20	1049.35	1154.51	1245.01	1334.63
S30	-24.13	97.54	217.54	343.71	474.71	602.50	725.29	837.38	942.66	1036.00	1130.34
S31	-44.64	9.04	53.51	107.81	168.06	229.99	292.46	351.95	410.78	465.36	526.15
S32	-64.41	31.96	94.50	167.81	239.54	311.26	380.73	443.04	502.04	556.19	613.61
INS2	-20.23	197.99	388.75	570.78	747.07	909.63	1060.63	1205.55	1344.03	1470.14	1599.27
INS3	-8.82	26.79	56.54	93.95	129.74	167.63	205.45	241.26	275.72	308.78	344.31
INS4	-151.96	-107.92	-76.94	-53.70	-23.13	8.78	29.08	54.92	85.21	116.28	146.85
IS24	4.90	88.79	163.62	232.08	299.48	363.25	421.94	477.88	530.64	578.59	627.68
IS25	-4.13	86.72	169.07	243.61	313.10	378.97	440.49	499.08	551.97	604.02	656.86
IS26	45.56	-20.54	-62.46	-106.64	-141.28	-165.51	-180.83	-185.86	-183.24	-174.86	-159.22
IS27	1.24	-19.96	-34.37	-52.00	-63.73	-70.21	-69.53	-63.27	-50.46	-34.64	-12.08
IS28	-9.88	13.35	31.85	55.79	80.15	105.50	129.94	154.06	177.79	200.31	224.12
IS29	-13.50	10.43	30.55	55.20	80.76	107.04	132.60	157.97	182.27	205.64	230.83
IS30	4.79	-34.99	-68.04	-91.64	-112.53	-129.05	-141.58	-149.74	-155.93	-158.82	-158.82
IS31	0.58	-17.89	-27.57	-35.76	-42.74	-48.53	-50.97	-50.92	-49.80	-46.22	-41.15
IS32	-23.26	173.08	343.29	501.47	655.52	799.76	934.21	1060.75	1183.52	1295.52	1409.45
P6-1	-88.79	-54.01	-27.38	-0.02	25.70	51.06	73.34	92.90	112.29	132.20	155.39
P6-2	1234.61	1280.49	1317.46	1351.50	1383.29	1416.78	1446.32	1470.22	1495.97	1522.83	1551.61
P6-3	-186.55	-122.79	-76.42	-27.15	20.67	67.76	109.78	145.26	182.95	223.49	268.04
P6-4	11.26	-107.36	-191.26	-277.69	-354.82	-412.39	-455.34	-479.60	-485.13	-477.77	-455.48
P6-5	50.70	97.46	143.48	186.41	227.55	269.40	316.87	383.88	427.77	464.86	538.06
P6-6	-51.12	9.32	66.30	116.57	167.20	214.74	255.76	296.38	334.33	367.87	400.35
P6-7	27.53	-29.86	-63.71	-105.88	-143.89	-175.93	-201.81	-216.45	-221.18	-220.61	-210.48
P6-8	-26.95	37.24	96.68	155.34	207.77	258.09	304.51	347.48	389.42	428.31	471.08
P6-9	37.51	85.40	128.75	171.35	209.80	248.07	283.43	317.13	349.45	380.97	416.15
P6-10	-0.75	35.79	66.72	99.09	126.95	154.62	181.03	204.16	226.60	247.74	271.61
P6-11	-95.43	-69.99	-49.96	-28.84	-11.52	5.99	22.41	37.38	50.92	64.63	79.78
P6-12	-288.67	-266.75	-247.91	-228.50	-210.75	-192.27	-175.42	-158.38	-143.18	-128.49	-109.84

Table D-26. Phase 3 (10,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.01	0.61	1.28	1.98	2.71	3.31	4.02	4.70	5.37	6.03	6.66
Frame-1	-10.82	120.76	250.65	308.94	456.38	544.11	685.17	798.39	917.38	1000.76	1138.92
Frame-2	-41.64	161.45	245.27	321.56	454.11	579.12	675.81	824.81	909.22	1020.23	1125.29
Frame-3	22.60	112.30	241.31	305.76	490.32	536.52	651.62	798.55	940.20	1024.77	1114.49
Frame-4	59.96	153.81	252.45	372.02	476.57	563.01	655.18	767.66	946.56	1027.43	1105.74
Frame-5	5.30	136.93	270.35	317.56	468.70	541.74	699.55	814.71	919.21	1001.21	1132.95
Frame-6	1.34	126.40	246.77	338.13	451.84	550.86	678.72	800.40	927.54	1014.68	1122.66
Frame-7	-13.26	127.88	260.18	341.14	448.36	541.85	682.77	809.11	930.04	1011.59	1133.63
Frame-8	0.09	113.53	254.26	330.24	455.23	541.38	683.55	808.86	919.31	994.40	1130.43
Frame-9	2.98	118.43	240.77	338.78	430.01	548.41	684.66	812.43	912.65	1020.98	1138.99
Frame-10	3.26	145.54	256.60	313.17	450.87	537.96	664.63	798.26	912.39	1024.80	1127.14
Frame-11	11.50	131.61	254.54	337.92	445.42	532.80	681.06	805.31	919.49	1012.47	1126.31
Frame-12	-24.04	93.89	253.20	333.53	447.87	547.54	691.44	810.65	933.34	1017.33	1127.32
Hoop-1	-4.40	648.20	1435.56	2155.75	2859.68	3595.50	4317.30	5125.79	5705.54	6400.14	7149.43
Hoop-2	-29.18	688.74	1402.93	2099.45	2867.91	3617.49	4272.52	5086.49	5669.86	6445.29	7163.28
Hoop-3	-12.62	678.04	1389.38	2125.30	2857.89	3634.68	4316.59	5065.45	5709.32	6426.08	7141.11
Hoop-4	-23.55	631.25	1385.94	2119.08	2846.91	3664.75	4317.66	5057.06	5719.19	6459.54	7130.77
Hoop-5	18.98	744.16	1420.62	2154.95	2842.63	3610.36	4333.67	5070.59	5711.27	6409.53	7129.39
Hoop-6	25.99	678.05	1424.33	2150.31	2893.60	3565.60	4277.64	5064.47	5778.36	6409.89	7140.95
Hoop-7	11.05	674.12	1367.43	2148.60	2856.63	3544.09	4317.89	5065.89	5743.33	6417.19	7130.37
Hoop-8	14.84	686.18	1409.15	2146.45	2869.28	3555.24	4292.39	5037.78	5738.48	6402.31	7162.02
Hoop-9	-46.69	710.98	1400.44	2116.41	2873.94	3525.57	4323.96	5063.97	5769.45	6403.12	7124.75
Hoop-10	-2.87	680.91	1423.29	2138.62	2861.32	3573.38	4285.00	5038.32	5739.72	6389.63	7142.52
Hoop-11	41.78	691.57	1423.26	2138.15	2867.87	3533.91	4310.52	5055.23	5786.78	6400.04	7133.40
Hoop-12	-10.85	736.23	1420.25	2126.79	2890.91	3548.06	4334.68	5038.11	5794.59	6375.33	7063.04
Hoop-13	1.38	717.75	1456.05	2150.05	2822.43	3560.57	4356.75	5058.79	5701.93	6388.92	7119.76
Hoop-14	10.50	663.72	1419.69	2109.18	2865.00	3554.78	4280.82	5081.10	5734.18	6379.93	7135.75
Long-1	-12.99	702.74	1345.91	2001.64	2666.58	3317.60	4007.84	4722.59	5367.20	5991.30	6666.17
Long-2	234.92	754.92	1504.00	1938.08	2524.32	3321.19	4004.21	4795.45	5406.27	6078.59	6557.18
Long-3	-2.51	651.79	1419.39	2016.22	2609.79	3376.18	4015.85	4687.21	5383.61	6083.52	6676.23
Long-4	-4.21	680.40	1330.06	1933.72	2772.80	3326.04	4023.90	4688.02	5375.71	6012.65	6683.33
Long-5	61.37	699.51	1367.08	2060.36	2671.62	3346.27	4013.84	4703.79	5368.48	5993.02	6657.58
Long-6	16.75	679.78	1409.22	2003.25	2641.57	3278.50	3961.69	4676.90	5346.51	5980.42	6653.45
Long-7	276.47	694.84	1347.93	2033.66	2688.17	3344.91	4017.47	4687.59	5330.42	5974.32	6672.96
Long-8	7.91	760.10	1411.44	1952.25	2676.16	3335.80	3944.44	4647.98	5384.21	6055.07	6692.69
S1-H	23.95	118.84	197.28	276.20	354.95	421.94	503.96	585.30	662.16	738.73	812.66
S1-A	-26.44	-12.42	-2.33	4.59	15.98	31.69	49.82	70.94	92.04	114.49	134.85
S2-H	5.22	120.21	206.04	287.50	363.56	427.11	501.77	574.26	642.09	708.68	774.32
S2-A	-8.23	12.13	32.67	45.19	64.04	84.60	109.44	132.99	156.68	180.44	201.71
S3-H	-3.43	78.59	146.39	213.41	277.17	329.72	393.49	455.06	512.48	568.41	622.87
S4-H	-23.35	36.56	97.20	158.65	217.00	262.73	321.70	379.22	433.25	487.07	537.95

Table D-26. Phase 3 (10,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S8	-32.12	106.69	252.71	394.51	536.08	651.73	779.64	899.64	1004.10	1103.87	1191.69
S9	3.93	-262.32	-513.48	-761.21	-971.79	-1155.69	-1346.30	-1521.39	-1674.04	-1807.42	-1937.42
S10	-7.58	97.75	204.62	316.15	423.90	516.01	621.43	722.97	813.70	902.99	983.17
S14	-26.77	63.00	145.39	229.81	312.41	380.98	461.99	540.84	613.94	686.24	752.95
S17	-18.65	75.09	165.88	253.32	335.15	404.98	484.00	560.53	628.90	698.43	761.57
S18	-19.28	-106.01	-201.25	-310.06	-411.23	-506.95	-615.50	-724.86	-826.17	-919.80	-1016.26
S19	-14.04	46.99	106.00	166.88	226.07	278.68	337.48	396.77	448.29	503.54	554.04
S24	-11.64	-52.56	-101.62	-145.52	-189.16	-222.97	-252.10	-278.67	-302.66	-320.98	-340.25
S25	-28.72	-180.45	-335.98	-485.80	-624.47	-742.63	-868.67	-986.66	-1090.40	-1182.38	-1274.38
S26	-14.79	-21.57	-34.85	-44.31	-53.48	-60.22	-64.14	-67.19	-68.56	-68.21	-69.86
S27	-54.10	-144.46	-241.82	-339.09	-433.08	-510.97	-596.01	-674.20	-741.32	-799.94	-857.64
S28	-1.74	-3.63	-12.16	-14.43	-21.85	-23.56	-26.80	-26.75	-25.18	-21.95	-11.38
S29	8.84	195.76	372.45	537.13	688.24	811.78	949.30	1071.08	1173.07	1267.73	1347.86
S30	-6.77	118.50	248.94	386.36	517.66	630.50	758.99	879.27	983.07	1080.32	1166.42
S31	-14.89	36.66	85.61	139.55	194.00	241.55	301.54	363.11	421.11	481.46	535.51
S32	-48.17	42.91	118.39	188.63	255.87	310.63	378.98	443.61	503.89	563.92	616.63
INS2	19.53	217.53	411.12	605.65	777.42	932.95	1090.30	1246.15	1383.73	1513.56	1640.05
INS3	2.95	31.45	63.67	99.68	137.16	169.96	207.43	244.68	278.09	312.59	347.76
INS4	132.83	203.96	267.12	324.82	411.19	486.47	587.64	681.21	769.63	866.17	941.91
IS24	-6.86	75.04	152.20	233.43	303.29	364.78	428.75	489.50	543.57	594.24	643.11
IS25	-34.89	49.81	126.53	206.22	269.85	325.66	383.58	437.20	486.33	569.70	600.78
IS26	13.26	-31.12	-69.80	-98.01	-123.30	-134.56	-147.06	-149.80	-146.77	-138.80	-121.24
IS27	4.58	-7.46	-17.60	-21.18	-25.61	-22.54	-19.37	-9.73	3.86	20.62	44.11
IS28	6.91	12.12	22.27	38.58	53.07	69.21	85.06	108.45	123.88	138.58	156.46
IS29	2.22	18.03	39.04	64.83	88.59	111.93	135.99	161.37	182.76	205.54	228.39
IS30	-48.31	-92.99	-126.84	-149.63	-167.52	-178.32	-192.17	-191.19	-200.37	-206.35	-202.66
IS31	5.72	-12.24	-19.88	-21.20	-23.97	-20.75	-22.25	-19.25	-17.88	-14.79	-6.38
IS32	65.36	218.17	354.75	513.12	646.87	763.33	891.27	1008.43	1118.74	1214.43	1311.22
P6-1	-4.03	20.97	51.95	84.94	114.80	137.11	156.86	175.90	194.89	210.33	224.80
P6-2	8.20	48.10	98.48	151.63	201.11	242.17	278.83	314.20	346.17	374.57	402.13
P6-3	11.76	72.70	145.23	219.29	287.41	344.79	397.76	448.59	492.75	532.04	571.16
P6-4	33.98	-97.18	-206.84	-279.65	-338.92	-378.08	-417.63	-437.22	-438.76	-433.81	-403.25
P6-5	21.55	62.19	104.98	148.55	188.77	220.91	250.30	277.36	300.88	319.27	340.46
P6-6	6.44	49.71	90.24	131.55	168.60	199.54	232.27	262.66	288.43	312.31	334.64
P6-7	28.83	-52.33	-110.65	-157.43	-198.86	-227.71	-264.49	-288.80	-302.51	-310.72	-300.54
P6-8	60.76	114.15	171.26	223.13	267.78	303.56	344.45	383.79	420.57	450.60	484.57
P6-9	29.21	73.65	130.40	189.40	247.56	297.85	348.28	397.12	438.93	480.38	525.87
P6-10	11.80	53.41	104.40	156.00	206.41	248.60	292.38	333.48	368.33	401.51	428.79
P6-11	8.72	38.14	72.23	107.63	140.98	168.81	197.86	224.24	246.21	267.74	284.14
P6-12	3.39	19.29	40.35	63.37	86.90	105.58	124.24	141.83	155.93	170.82	180.77

Table D-27. Phase 3 (10,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	-0.10	0.61	1.37	2.02	2.61	3.33	4.00	4.69	5.29	6.01	6.66
Frame-1	7.72	131.08	244.78	333.90	450.32	554.93	687.46	789.34	921.82	1030.89	1116.19
Frame-2	53.45	134.12	184.05	317.10	449.44	567.06	658.41	750.35	924.88	1037.14	1133.69
Frame-3	33.66	171.78	267.69	402.96	401.47	543.48	661.30	793.23	911.00	1011.71	1107.13
Frame-4	-24.19	124.58	242.37	363.06	447.13	576.49	694.83	774.65	916.23	1007.65	1126.27
Frame-5	-42.05	130.85	189.35	316.38	442.67	552.62	673.91	795.81	895.54	1019.78	1123.33
Frame-6	-12.22	111.30	233.46	344.71	453.82	564.24	671.55	788.70	930.17	1013.69	1136.87
Frame-7	-19.83	120.91	224.54	342.84	445.60	555.84	686.10	782.09	910.87	1013.27	1122.14
Frame-8	25.22	112.29	231.97	342.71	449.29	559.16	662.66	788.04	931.18	1016.00	1136.64
Frame-9	-29.96	107.53	235.81	326.48	456.61	550.74	671.11	805.94	912.27	1025.38	1141.88
Frame-10	-45.98	89.04	250.26	323.42	450.81	565.91	676.37	800.17	941.69	1020.72	1141.43
Frame-11	-47.59	116.94	240.16	335.19	433.63	563.68	675.53	804.34	916.18	1009.72	1138.38
Frame-12	48.76	134.12	218.58	329.22	431.03	576.22	684.21	803.51	914.47	1020.62	1138.18
Hoop-1	-122.90	571.70	1397.42	2112.21	2820.84	3568.51	4313.66	5015.08	5855.03	6434.78	7096.97
Hoop-2	-84.82	566.75	1415.63	2101.45	2768.63	3535.28	4294.05	5009.81	5714.73	6398.62	7133.14
Hoop-3	-106.34	768.35	1394.73	2122.04	2833.03	3527.45	4295.77	5059.01	5724.94	6420.88	7124.07
Hoop-4	-16.27	685.88	1407.90	2139.30	2851.80	3472.32	4283.11	5015.72	5728.29	6412.25	7098.44
Hoop-5	-42.21	620.06	1431.56	2146.16	2843.86	3562.13	4299.49	5006.30	5722.07	6425.73	7136.97
Hoop-6	17.42	818.83	1439.92	2112.77	2822.68	3552.23	4311.96	4968.86	5653.09	6433.91	7089.77
Hoop-7	-81.90	759.98	1424.76	2143.45	2845.34	3562.31	4283.93	4993.10	5725.45	6431.49	7136.10
Hoop-8	-81.05	693.41	1423.62	2146.67	2825.59	3562.61	4270.69	5023.03	5708.98	6433.73	7124.43
Hoop-9	-120.29	658.78	1405.55	2157.91	2840.40	3566.85	4275.92	4995.76	5756.88	6453.52	7165.33
Hoop-10	-27.73	684.32	1430.11	2140.60	2851.24	3573.38	4283.65	5017.02	5713.09	6423.51	7122.28
Hoop-11	-61.95	636.84	1437.54	2151.10	2819.30	3583.04	4276.37	4997.00	5706.71	6438.35	7129.05
Hoop-12	-154.13	722.71	1515.49	2148.01	2713.79	3494.57	4235.77	4938.77	5809.87	6369.59	7092.90
Hoop-13	-100.93	681.07	1433.83	2121.03	2844.92	3567.88	4306.03	4985.71	5694.62	6434.69	7082.51
Hoop-14	-92.23	648.91	1441.42	2153.43	2836.22	3613.48	4266.57	4993.04	5712.17	6440.56	7142.38
Long-1	76.22	626.26	1341.01	1994.97	2654.55	3352.90	4020.59	4667.17	5333.41	6023.05	6658.32
Long-2	35.35	532.87	1301.62	2035.24	2654.76	3245.30	4015.46	4701.76	5464.43	6158.08	6635.87
Long-3	29.17	654.22	1360.91	2099.27	2649.74	3384.71	4041.44	4691.33	5296.42	5981.79	6700.59
Long-4	-0.59	582.77	1345.73	2018.29	2637.55	3376.66	3967.25	4635.45	5336.47	6020.48	6680.92
Long-5	-22.23	691.27	1342.36	2014.65	2693.73	3329.78	4016.20	4676.00	5344.28	6013.62	6669.35
Long-6	17.93	607.42	1333.31	2014.13	2649.61	3373.39	4010.32	4693.98	5364.84	6009.47	6662.94
Long-7	221.72	626.73	1330.90	1993.73	2644.13	3346.13	4010.17	4677.11	5350.41	6021.15	6674.18
Long-8	43.50	558.41	1358.05	2054.48	2665.22	3370.21	4057.15	4675.73	5330.17	5988.03	6659.48
S1-H	-68.88	66.64	175.73	264.24	342.53	427.58	505.78	580.46	650.36	732.13	808.56
S1-A	-1.58	-17.28	-5.32	9.82	25.71	44.59	63.26	81.57	101.78	122.33	144.76
S2-H	-75.42	73.17	188.20	274.78	350.20	430.88	501.72	569.61	632.51	703.38	772.08
S2-A	2.42	6.53	30.81	53.03	74.14	99.93	121.94	141.35	163.06	188.45	210.49
S3-H	-50.84	48.20	134.97	206.39	268.06	333.84	393.81	451.36	503.03	563.21	619.84
S4-H	-66.04	9.60	84.51	148.14	206.56	264.44	322.23	375.55	424.72	481.78	534.95

Table D-27. Phase 3 (10,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S8	-96.80	62.35	233.91	382.84	519.47	662.70	785.37	894.28	991.21	1096.49	1188.06
S9	70.81	-231.04	-521.32	-758.50	-955.64	-1164.71	-1347.75	-1516.26	-1654.62	-1808.79	-1937.05
S10	-35.00	72.87	199.85	313.44	415.23	527.10	627.13	719.44	803.56	897.00	981.80
S14	-63.71	36.25	135.24	222.49	299.65	385.28	462.26	532.70	601.41	677.11	748.42
S17	-63.52	47.48	152.32	243.30	322.32	407.02	484.86	556.19	619.03	690.00	757.03
S18	10.91	-88.19	-201.70	-309.12	-410.22	-522.46	-624.72	-725.73	-816.33	-922.62	-1017.40
S19	-43.74	23.99	95.15	157.12	216.56	277.98	336.72	391.10	440.68	496.02	548.58
S24	-6.99	-58.05	-112.63	-159.56	-197.44	-233.09	-258.02	-279.69	-302.68	-324.54	-344.91
S25	-12.51	-163.51	-341.27	-497.35	-630.85	-770.19	-887.78	-997.97	-1090.44	-1194.37	-1285.56
S26	-32.09	-37.21	-46.99	-55.84	-62.44	-67.24	-69.90	-72.61	-76.00	-76.09	-76.73
S27	-41.59	-129.61	-244.48	-349.73	-438.89	-528.02	-604.56	-676.79	-742.38	-808.38	-866.85
S28	-19.78	-16.04	-20.06	-23.20	-24.21	-22.83	-22.59	-21.81	-23.11	-19.50	-14.80
S29	-25.05	151.89	354.35	532.99	687.65	841.95	968.12	1076.84	1168.32	1265.34	1349.31
S30	-31.04	92.14	238.23	380.79	511.32	651.08	772.71	879.59	975.14	1078.22	1167.87
S31	-52.19	0.54	65.49	126.29	183.69	247.24	305.14	360.46	411.94	474.15	532.24
S32	-127.07	-24.71	78.30	161.67	237.94	314.24	380.89	438.95	493.53	554.44	612.69
INS2	-26.00	201.63	420.68	605.59	764.57	939.54	1092.00	1240.90	1368.29	1513.41	1639.15
INS3	0.33	32.81	67.97	101.45	135.24	171.86	207.61	242.52	275.71	311.47	345.95
INS4	123.59	199.44	287.76	374.45	463.26	567.55	665.28	739.92	826.36	910.42	1000.54
IS24	-27.70	70.51	159.33	232.51	294.29	363.01	425.99	483.37	534.08	590.38	639.12
IS25	-58.79	47.64	136.72	225.74	278.60	343.79	402.36	454.44	495.85	546.48	592.09
IS26	54.00	7.98	-45.86	-88.77	-122.78	-146.21	-155.59	-156.35	-150.67	-139.79	-124.10
IS27	4.90	8.98	-5.65	-16.97	-25.76	-28.34	-23.35	-13.93	0.42	20.39	42.48
IS28	2.20	12.39	25.45	37.09	50.99	68.90	86.14	101.94	114.97	133.40	151.66
IS29	-6.39	15.54	39.05	62.42	84.84	109.32	134.25	157.02	178.49	201.85	224.41
IS30	-28.29	-75.96	-122.22	-144.17	-162.06	-181.20	-183.84	-192.40	-199.22	-208.33	-213.87
IS31	12.18	-0.28	-13.97	-19.61	-24.43	-27.48	-26.20	-23.84	-20.75	-16.93	-11.01
IS32	-48.07	156.64	341.64	490.02	611.79	751.43	874.31	988.89	1085.38	1201.06	1297.42
P6-1	-20.15	25.50	60.85	86.93	105.22	128.79	145.25	163.35	179.35	198.17	214.66
P6-2	-6.84	55.07	112.02	158.67	197.19	238.39	272.11	304.57	333.96	366.67	397.00
P6-3	-9.28	64.00	142.39	206.93	259.17	312.90	359.99	403.48	441.33	484.10	521.83
P6-4	94.93	-15.73	-154.12	-257.13	-340.17	-401.79	-436.63	-448.19	-445.20	-429.83	-402.80
P6-5	25.00	76.52	120.26	158.15	188.08	222.75	250.09	275.28	296.59	319.23	338.46
P6-6	4.44	52.44	96.10	134.08	166.09	201.02	231.52	260.77	283.76	310.10	331.92
P6-7	98.04	28.11	-59.77	-129.70	-190.57	-240.96	-274.79	-294.51	-303.65	-307.43	-301.81
P6-8	70.16	140.90	200.57	243.67	275.96	317.24	354.17	391.66	423.95	462.39	495.10
P6-9	37.37	95.96	153.86	207.16	253.23	302.60	349.33	396.09	439.57	484.69	528.04
P6-10	11.44	59.56	113.13	161.41	203.92	246.64	287.47	325.24	360.08	395.50	427.88
P6-11	9.44	45.00	80.21	111.59	138.67	165.94	192.61	216.59	239.40	262.30	282.87
P6-12	11.64	33.02	53.23	70.25	86.01	102.15	118.79	133.82	150.53	164.46	179.14

Table D-28. Phase 3 (10,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.01	0.70	1.28	1.94	2.61	3.32	3.94	4.68	5.29	5.99	6.69
Frame-1	-14.91	135.53	259.62	353.38	432.69	538.65	678.95	777.52	916.45	1006.09	1141.27
Frame-2	-21.20	92.99	246.02	342.88	453.12	563.89	682.49	797.40	924.44	1027.09	1168.58
Frame-3	-52.32	88.10	181.47	399.74	404.88	526.94	665.55	809.56	928.74	996.39	1146.93
Frame-4	-42.41	138.38	296.94	350.20	430.33	537.52	731.92	752.40	889.24	1023.05	1143.98
Frame-5	14.31	101.13	251.43	350.38	443.08	555.99	673.43	783.94	888.54	1027.73	1135.37
Frame-6	-7.21	121.78	230.38	327.37	438.65	556.57	683.68	769.70	923.52	1016.62	1143.57
Frame-7	-18.21	93.19	220.40	338.01	427.21	550.10	680.18	755.86	916.48	1039.37	1179.27
Frame-8	-6.66	115.12	236.78	336.10	434.50	543.96	689.99	775.67	930.98	1031.28	1144.93
Frame-9	-25.54	126.94	241.52	338.53	436.09	546.59	675.13	770.87	921.87	1015.61	1142.50
Frame-10	-15.80	135.86	246.00	318.54	441.30	550.32	691.74	778.69	924.48	1009.35	1143.52
Frame-11	-5.57	128.68	244.88	355.64	446.04	518.87	696.35	786.24	942.90	1003.76	1131.55
Frame-12	-13.94	104.80	229.45	353.21	454.54	545.54	702.45	777.21	920.42	1031.38	1154.23
Hoop-1	2.89	715.72	1402.89	2141.38	2819.30	3557.93	4311.30	5030.99	5727.42	6448.18	7161.08
Hoop-2	19.29	737.27	1428.20	2180.43	2831.73	3636.15	4160.70	5063.16	5750.63	6411.82	7133.47
Hoop-3	-21.30	716.29	1415.55	2149.81	2852.40	3564.24	4303.99	4928.35	5711.06	6471.85	7124.46
Hoop-4	-9.00	651.32	1411.54	2128.39	2837.53	3565.44	4297.12	5026.13	5711.91	6451.09	7151.49
Hoop-5	-4.42	717.24	1409.97	2133.57	2781.16	3522.89	4226.98	4995.01	5716.67	6473.16	7185.90
Hoop-6	-6.61	702.14	1407.32	2159.11	3047.75	3715.61	4392.19	4951.20	5709.72	6417.39	7169.12
Hoop-7	28.93	720.66	1430.12	2138.09	2856.35	3548.37	4236.95	4997.97	5711.15	6424.98	7148.95
Hoop-8	14.84	678.60	1350.00	2139.50	2862.19	3562.61	4277.64	5000.90	5723.73	6417.70	7132.51
Hoop-9	-12.59	712.56	1369.78	2116.83	2831.14	3574.03	4275.50	4882.67	5771.24	6457.62	7164.25
Hoop-10	2.46	714.44	1419.60	2140.82	2847.40	3557.40	4279.68	4983.28	5736.17	6424.01	7153.18
Hoop-11	-20.10	691.36	1386.72	2127.65	2833.58	3573.94	4266.85	4940.58	5746.74	6446.17	7173.44
Hoop-12	-37.60	699.71	1364.71	2226.57	2709.70	3586.27	4136.03	4854.72	5611.20	6482.95	7215.86
Hoop-13	16.00	710.23	1397.43	2143.17	2859.25	3582.50	4283.68	4941.86	5723.86	6411.49	7156.30
Hoop-14	17.84	700.21	1412.21	2131.62	2879.97	3569.46	4258.81	4978.36	5697.49	6417.26	7128.41
Long-1	116.44	661.56	1315.65	1981.05	2645.01	3347.35	3991.17	4657.42	5318.18	5998.16	6702.13
Long-2	100.01	764.76	1172.44	1912.78	2648.00	3414.28	3872.10	4692.39	5336.00	6099.67	6736.32
Long-3	-4.94	677.37	1343.99	2091.76	2701.18	3331.43	3912.29	4703.80	5288.58	5953.15	6663.49
Long-4	-3.00	656.30	1310.91	2002.42	2631.78	3314.31	4028.72	4629.71	5415.48	5998.18	6679.18
Long-5	10.74	679.49	1287.15	1994.43	2679.87	3343.07	4017.37	4689.19	5328.45	6011.86	6674.73
Long-6	12.01	688.08	1370.22	1985.46	2613.10	3281.20	3986.60	4643.23	5361.93	5972.11	6690.89
Long-7	167.03	700.92	1316.44	1980.15	2667.50	3336.73	3998.01	4653.07	5343.80	6016.88	6694.30
Long-8	-6.33	752.98	1366.49	2085.12	2686.84	3261.39	4001.38	4683.11	5299.98	5954.22	6724.21
S1-H	-76.90	58.62	151.85	245.46	336.57	425.94	498.93	582.32	648.56	731.09	809.68
S1-A	-4.76	-16.34	-6.44	9.07	22.72	39.17	56.54	76.92	98.77	120.85	144.01
S2-H	-80.66	66.44	164.28	259.90	345.72	428.68	494.31	569.03	629.40	704.20	772.82
S2-A	4.29	10.26	23.90	47.07	70.22	94.89	116.35	140.65	162.66	183.80	208.06
S3-H	-53.25	41.67	116.65	192.33	263.03	332.13	387.84	451.92	502.48	564.40	621.57
S4-H	-69.79	5.10	68.02	133.94	202.07	262.59	314.96	375.47	424.45	483.51	538.14

Table D-28. Phase 3 (10,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S8	-84.45	63.08	201.91	358.21	514.38	660.59	773.10	894.55	986.66	1095.87	1190.24
S9	47.30	-238.05	-471.18	-715.60	-941.98	-1158.79	-1322.51	-1514.49	-1649.57	-1803.70	-1942.32
S10	-26.01	76.36	179.17	294.34	411.59	526.60	617.57	722.06	802.08	899.50	985.25
S14	-58.73	34.03	114.96	205.62	292.94	381.33	452.56	535.44	600.16	678.72	751.14
S17	-62.61	42.02	130.14	227.18	317.60	406.33	477.28	554.54	617.27	690.98	757.39
S18	-6.91	-100.73	-187.67	-292.27	-405.49	-520.15	-611.69	-726.86	-815.07	-924.53	-1024.54
S19	-38.18	24.49	83.43	145.12	212.32	277.46	330.24	390.39	439.73	498.03	551.31
S24	-17.77	-67.81	-117.00	-160.93	-200.90	-234.63	-258.41	-285.03	-306.58	-326.27	-347.99
S25	-25.96	-180.43	-326.87	-482.35	-629.38	-771.05	-879.17	-997.94	-1092.70	-1195.64	-1291.82
S26	-35.96	-43.43	-53.17	-59.73	-64.00	-68.03	-72.81	-74.20	-78.89	-77.20	-77.84
S27	-50.81	-141.42	-237.36	-344.76	-437.89	-528.76	-603.39	-680.52	-744.48	-809.06	-869.51
S28	-21.35	-20.10	-24.31	-27.03	-25.46	-24.08	-25.96	-23.71	-25.22	-19.23	-15.90
S29	-13.71	159.95	322.42	505.73	676.86	836.27	957.87	1078.43	1167.40	1264.78	1350.27
S30	-16.39	98.62	214.07	360.12	505.69	649.83	764.39	885.30	976.67	1078.69	1169.32
S31	-55.05	-3.22	48.33	112.38	179.70	245.86	300.45	362.38	412.22	475.29	533.33
S32	-131.30	-30.60	53.79	144.39	234.27	314.55	379.16	442.39	494.11	555.45	612.51
INS2	-11.55	199.44	377.99	569.57	755.18	932.41	1071.69	1235.31	1360.61	1509.76	1642.94
INS3	6.35	36.17	66.08	96.96	134.76	171.84	204.03	240.94	273.87	311.91	347.16
INS4	201.08	272.01	339.37	391.06	510.91	575.76	668.54	776.51	844.19	950.33	1042.27
IS24	-14.11	72.68	143.19	217.69	289.04	360.32	412.80	480.44	529.98	590.07	642.74
IS25	-29.83	51.98	115.71	187.41	243.84	308.34	363.30	431.40	470.41	532.05	586.30
IS26	47.36	2.21	-42.45	-89.20	-126.24	-150.37	-164.88	-161.85	-157.18	-142.03	-124.37
IS27	7.17	7.25	-3.93	-16.61	-25.12	-27.89	-28.02	-14.39	-4.20	18.85	43.16
IS28	7.14	13.89	22.32	31.56	47.32	64.14	76.27	96.67	112.69	133.28	151.98
IS29	-3.22	15.17	34.61	56.91	82.40	108.51	128.60	155.39	176.24	203.00	226.49
IS30	-22.43	-72.14	-106.67	-141.97	-161.74	-166.32	-192.08	-202.95	-209.31	-212.98	-218.46
IS31	12.23	-3.28	-13.20	-19.71	-25.30	-27.80	-30.30	-25.71	-23.43	-16.16	-9.92
IS32	-18.67	160.80	303.31	454.18	599.27	741.88	847.72	983.02	1077.91	1194.46	1301.78
P6-1	-9.46	29.49	59.03	81.87	105.22	127.35	139.47	160.50	174.60	197.28	216.83
P6-2	2.53	58.75	108.02	152.38	197.30	238.70	266.36	303.17	331.31	367.09	399.60
P6-3	-2.03	69.80	136.57	198.27	260.62	314.38	354.22	402.15	439.07	482.69	525.45
P6-4	104.74	-18.26	-127.62	-237.27	-328.92	-394.35	-437.31	-440.48	-449.37	-428.19	-396.45
P6-5	36.79	79.96	113.72	149.11	182.46	216.60	238.69	268.83	291.09	316.91	339.55
P6-6	12.08	54.98	88.82	127.20	163.00	198.86	225.36	257.39	279.70	307.76	332.46
P6-7	107.83	32.09	-40.02	-115.77	-185.50	-239.35	-279.71	-296.59	-310.30	-308.36	-301.27
P6-8	106.85	164.87	212.74	254.33	291.41	332.18	361.43	404.75	434.79	475.86	513.35
P6-9	46.44	100.49	151.48	205.02	253.96	304.26	344.47	395.12	435.49	484.37	529.31
P6-10	19.22	63.35	110.40	156.92	203.92	248.47	284.60	324.80	358.74	396.44	430.05
P6-11	17.02	48.96	80.20	109.45	139.75	167.58	190.47	216.84	238.63	263.05	284.32
P6-12	20.43	39.44	57.57	71.35	88.55	104.88	118.26	134.58	149.41	166.29	180.59

Table D-29. Phase 3 (20,000 Cycles) Strain Survey Raw Data (Run 1)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.00	0.65	1.34	2.02	2.70	3.34	4.04	4.60	5.33	6.01	6.65
Frame-1	-29.20	79.35	204.09	350.73	450.36	582.74	664.41	789.02	902.59	1035.05	1156.27
Frame-2	8.68	105.51	221.90	330.62	438.26	578.44	679.68	771.05	917.27	1011.84	1121.29
Frame-3	-39.77	42.29	211.97	357.96	437.84	587.31	679.39	746.00	905.36	1021.60	1127.48
Frame-4	-21.67	131.61	237.91	338.46	461.43	584.24	669.82	753.82	910.50	1024.10	1117.55
Frame-5	-50.82	171.03	264.97	334.84	454.45	568.94	662.46	788.65	905.96	1017.37	1142.05
Frame-6	-6.77	88.68	222.85	332.67	443.01	587.51	679.26	768.13	911.94	1034.75	1122.00
Frame-7	-3.35	107.04	235.15	328.51	502.07	567.14	685.77	778.75	909.51	1025.52	1109.74
Frame-8	-13.89	120.55	234.00	335.25	458.39	583.26	679.08	754.02	906.85	1016.70	1128.16
Frame-9	-25.18	102.55	206.92	330.82	456.63	565.82	681.98	766.36	906.81	1016.24	1128.52
Frame-10	-8.36	115.25	262.01	346.29	445.27	585.49	684.64	761.22	899.30	1015.69	1112.23
Frame-11	-23.12	105.60	236.17	345.82	458.98	587.30	669.20	759.04	907.28	1014.89	1124.08
Frame-12	-4.33	91.79	232.87	320.17	451.04	580.52	688.50	758.40	903.86	1025.93	1146.52
Hoop-1	50.30	712.22	1454.37	2143.85	2862.36	3554.64	4280.73	5001.49	5728.56	6448.28	7154.50
Hoop-2	33.15	729.74	1462.23	2105.17	2834.15	3562.41	4318.60	4956.44	5695.62	6431.19	7230.63
Hoop-3	-23.24	724.91	1410.57	2155.46	2841.19	3588.70	4283.39	4990.38	5720.67	6516.99	7144.07
Hoop-4	5.85	719.06	1459.56	2102.02	2849.87	3560.62	4354.24	4940.58	5720.62	6433.29	7136.12
Hoop-5	-1.53	731.07	1438.48	2135.29	2860.77	3589.13	4278.89	4963.39	5740.50	6459.98	7128.30
Hoop-6	-0.42	717.05	1439.67	2147.06	2842.29	3596.88	4266.65	4982.90	5734.21	6452.97	7158.85
Hoop-7	-6.34	748.11	1429.25	2135.64	2863.34	3576.02	4271.83	4978.49	5730.66	6445.26	7155.52
Hoop-8	65.35	699.93	1437.52	2145.96	2854.82	3577.29	4278.21	4994.87	5711.25	6441.25	7140.88
Hoop-9	48.80	722.24	1513.89	2099.42	2864.94	3579.03	4272.15	4908.79	5719.35	6442.57	7109.27
Hoop-10	59.98	715.47	1438.18	2131.05	2861.65	3569.80	4282.06	4982.89	5710.08	6457.45	7141.78
Hoop-11	107.92	730.54	1467.55	2115.72	2853.52	3593.81	4276.43	4958.21	5721.65	6462.09	7150.70
Hoop-12	121.93	739.22	1474.69	2092.06	2746.13	3645.61	4165.37	4838.96	5749.30	6322.10	7115.77
Hoop-13	248.11	708.75	1483.45	2134.24	2858.56	3581.73	4283.55	4935.17	5710.82	6448.77	7120.05
Hoop-14	73.29	711.97	1453.12	2135.91	2863.16	3581.93	4279.26	4984.91	5697.63	6460.60	7149.30
Long-1	155.59	710.68	1346.47	2001.74	2678.32	3361.32	4006.97	4657.15	5348.63	6023.60	6672.63
Long-2	-15.64	730.85	1415.77	1929.00	2752.70	3306.98	4159.66	4891.66	5292.75	6068.57	6550.96
Long-3	93.12	645.22	1336.54	2009.44	2629.67	3397.92	4000.54	4569.40	5349.74	6087.10	6641.65
Long-4	-12.72	669.69	1371.65	2030.08	2666.52	3348.12	3986.46	4627.58	5338.00	6021.60	6646.14
Long-5	5.05	642.20	1357.36	2001.71	2665.82	3323.39	4004.64	4681.59	5323.70	6029.18	6672.21
Long-6	75.62	684.26	1341.82	2003.99	2655.21	3328.33	4014.62	4640.80	5324.45	5988.87	6652.08
Long-7	223.25	680.65	1337.85	1990.05	2672.41	3361.38	4000.62	4646.32	5348.56	6017.65	6680.69
Long-8	21.78	659.07	1371.41	2036.13	2673.29	3318.10	4024.75	4623.80	5319.52	6025.66	6672.43
S1-H	-179.58	-16.61	91.55	179.37	266.11	342.72	430.63	496.32	579.71	659.03	733.00
S1-A	23.02	5.44	16.29	32.55	49.19	69.57	85.47	107.88	130.92	149.97	169.21
S2-H	-167.21	1.59	117.37	206.99	289.93	362.35	440.87	498.99	574.65	644.75	708.92
S2-A	-16.53	-8.87	10.74	30.55	53.16	74.83	100.26	123.39	145.87	169.76	186.18
S3-H	-96.80	12.70	100.87	174.80	242.29	303.56	368.96	418.33	482.68	538.78	594.06
S4-H	-25.85	39.32	114.24	183.90	252.10	314.25	381.75	431.07	492.69	544.29	599.67

Table D-29. Phase 3 (20,000 Cycles) Strain Survey Raw Data (Run 1) (Continued)

S8	-81.32	52.44	210.93	363.57	517.01	648.53	788.99	886.88	1002.86	1098.63	1186.48
S9	36.53	-221.57	-505.40	-744.79	-966.80	-1152.19	-1349.02	-1487.67	-1654.10	-1795.89	-1923.11
S10	-36.97	61.76	168.81	277.70	388.59	486.73	596.29	676.08	774.33	857.02	938.90
S14	-65.27	25.83	117.72	201.79	283.53	358.83	441.54	503.62	582.75	644.54	713.36
S17	-82.14	7.08	109.76	203.51	290.40	367.96	451.45	513.82	588.73	652.22	714.30
S18	-8.44	-96.47	-190.16	-291.27	-407.72	-505.90	-624.97	-716.27	-825.90	-928.88	-1025.59
S19	-40.04	25.57	90.04	150.40	212.15	267.94	330.83	377.97	436.37	484.03	536.51
S24	-464.08	-516.68	-569.52	-611.04	-650.84	-681.38	-711.30	-736.34	-765.00	-788.12	-810.17
S25	-32.06	-188.62	-356.09	-501.94	-644.20	-766.07	-889.66	-984.20	-1094.13	-1190.53	-1279.93
S26	-40.84	-57.68	-68.66	-77.74	-84.86	-90.16	-91.70	-94.53	-96.04	-97.92	-98.88
S27	5.58	-97.68	-215.18	-320.66	-418.60	-502.12	-584.50	-647.62	-719.58	-783.20	-840.00
S28	-16.93	-26.03	-35.87	-41.45	-43.02	-45.09	-41.64	-40.15	-37.07	-34.99	-30.69
S29	-24.09	143.37	335.97	511.38	678.87	822.89	962.13	1064.26	1172.05	1261.32	1342.38
S30	-6.90	98.67	235.98	375.33	518.84	649.40	785.16	886.03	999.25	1093.46	1180.48
S31	-57.90	-22.13	37.29	96.97	158.63	216.63	283.23	335.25	397.50	450.08	506.14
S32	-162.74	-75.89	20.84	108.78	190.40	263.68	336.83	392.86	456.01	509.79	562.70
INS2	-5.05	195.19	412.08	600.71	786.56	945.51	1117.60	1244.65	1400.25	1535.52	1662.77
INS3	-3.71	33.04	63.74	95.56	131.45	164.92	203.32	233.05	271.85	306.40	340.42
INS4	-0.52	59.59	137.02	227.59	333.48	427.61	542.91	632.37	742.21	844.35	943.72
IS24	-1.01	72.17	150.99	220.36	288.68	345.90	412.28	457.99	516.70	567.51	613.10
IS25	-14.39	71.07	160.17	237.64	313.72	375.97	447.75	496.86	557.91	610.67	662.76
IS26	78.37	35.97	-19.37	-63.40	-99.17	-122.06	-130.27	-134.14	-125.19	-108.76	-90.35
IS27	11.12	10.85	8.23	2.65	-0.25	-2.28	5.05	10.99	26.40	42.43	64.80
IS28	-8.55	-0.03	8.53	21.27	37.86	51.00	71.99	86.20	106.18	124.42	141.59
IS29	6.56	21.74	40.91	63.79	89.58	110.55	138.63	158.79	184.56	206.77	229.95
IS30	60.99	21.87	-22.71	-54.73	-76.57	-96.57	-108.60	-117.67	-123.18	-124.79	-124.78
IS31	39.77	18.43	4.33	-1.18	-3.36	-7.50	-5.09	-3.91	-0.04	3.74	11.38
IS32	55.90	192.59	366.72	512.64	653.57	762.97	889.50	975.63	1087.70	1180.26	1269.27
P6-1	-22.53	7.91	36.19	57.75	80.05	96.18	117.95	132.59	151.68	168.87	182.63
P6-2	5.93	58.35	111.79	156.34	200.15	234.79	275.99	305.28	343.42	378.02	409.52
P6-3	-10.90	65.09	147.62	217.09	283.70	337.96	394.49	438.34	494.62	544.83	590.73
P6-4	151.82	25.47	-115.71	-230.50	-321.22	-390.18	-427.98	-449.85	-445.46	-430.97	-396.79
P6-5	44.82	91.27	131.93	168.21	204.52	232.81	264.43	285.58	312.02	333.73	354.93
P6-6	26.77	69.33	109.72	145.90	182.30	213.02	246.53	270.29	300.05	325.64	349.07
P6-7	160.03	70.68	-31.35	-115.44	-185.59	-243.39	-282.77	-310.23	-323.40	-320.80	-315.15
P6-8	-14.19	48.62	98.79	138.18	178.46	211.20	250.97	277.24	317.17	350.10	377.31
P6-9	36.16	101.30	163.91	221.24	278.60	327.20	381.71	420.97	473.41	521.95	567.62
P6-10	6.22	56.37	110.56	160.71	208.85	248.81	292.46	323.30	363.42	398.27	430.61
P6-11	3.73	41.65	77.04	108.45	139.33	163.87	192.07	210.61	236.16	259.22	279.78
P6-12	11.03	35.25	55.65	75.13	93.35	107.55	125.06	135.58	152.03	166.57	180.22

Table D-30. Phase 3 (20,000 Cycles) Strain Survey Raw Data (Run 2)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.00	0.69	1.27	1.96	2.68	3.35	4.00	4.68	5.36	6.02	6.73
Frame-1	5.03	128.30	278.19	330.69	451.60	554.68	677.29	781.58	921.82	1014.08	1146.88
Frame-2	6.84	146.26	213.81	353.01	454.15	560.30	674.44	783.47	915.24	1000.79	1131.77
Frame-3	16.04	152.57	230.40	390.92	466.23	565.95	686.73	778.49	911.00	1006.80	1150.60
Frame-4	-28.12	125.20	194.26	309.86	417.22	573.15	689.83	781.29	910.12	1021.35	1143.16
Frame-5	-42.83	100.42	268.32	327.76	439.21	558.96	678.50	791.29	882.63	1001.39	1147.66
Frame-6	-10.08	121.13	249.55	319.86	458.18	560.89	671.24	796.89	916.19	1008.65	1136.46
Frame-7	-8.06	106.96	213.40	342.56	440.86	566.82	673.85	765.13	918.02	1002.70	1147.46
Frame-8	4.04	105.22	258.40	328.69	453.44	570.72	681.80	790.01	909.70	1006.40	1144.98
Frame-9	27.52	156.96	229.19	306.63	443.70	566.91	669.08	786.79	916.41	1016.59	1139.80
Frame-10	9.74	101.07	260.41	335.81	453.38	572.43	678.57	796.30	904.83	1027.42	1135.16
Frame-11	6.40	126.45	257.10	279.59	451.14	569.03	670.36	794.31	908.58	1018.25	1142.06
Frame-12	1.43	120.93	252.74	344.24	450.64	554.08	692.72	796.26	906.75	1006.36	1162.02
Hoop-1	143.31	730.31	1423.37	2138.16	2842.02	3587.46	4265.72	4988.23	5690.26	6418.46	7149.74
Hoop-2	133.70	726.00	1359.90	2160.62	2833.86	3589.34	4248.16	4977.49	5776.41	6505.96	7199.03
Hoop-3	53.14	719.56	1417.51	2143.09	2811.40	3580.02	4307.27	4975.99	5692.90	6431.27	7144.78
Hoop-4	67.72	746.20	1419.53	2147.30	2858.69	3562.44	4277.40	4958.29	5762.47	6425.37	7238.73
Hoop-5	12.87	716.53	1416.88	2154.88	2849.68	3567.53	4283.86	4982.69	5724.29	6452.14	7193.82
Hoop-6	1.29	761.53	1400.19	2127.97	2847.15	3590.02	4310.85	5016.74	5742.79	6393.96	7169.87
Hoop-7	9.75	703.27	1420.31	2128.27	2863.05	3567.08	4280.34	4988.73	5739.59	6423.17	7166.96
Hoop-8	146.52	729.37	1408.29	2109.28	2846.59	3577.65	4271.68	5000.76	5665.28	6418.48	7178.49
Hoop-9	205.04	722.17	1435.18	2088.86	2842.54	3574.00	4303.53	4984.52	5740.99	6420.38	7185.40
Hoop-10	152.35	702.97	1418.93	2125.94	2851.92	3564.82	4284.69	4995.61	5706.59	6394.63	7178.02
Hoop-11	215.34	692.24	1400.48	2106.83	2819.90	3566.86	4253.61	4971.29	5716.29	6399.55	7156.87
Hoop-12	225.14	733.42	1333.57	2128.58	2858.04	3577.17	4212.07	4913.94	5739.94	6367.34	7139.41
Hoop-13	328.56	737.92	1454.50	2127.14	2850.39	3574.78	4313.65	4977.56	5709.11	6411.57	7157.32
Hoop-14	198.10	711.90	1431.38	2114.09	2854.97	3574.95	4294.79	4976.09	5681.25	6408.57	7179.37
Long-1	237.98	695.13	1315.93	1974.08	2657.46	3347.59	4025.02	4654.72	5337.39	6008.28	6686.71
Long-2	33.57	618.51	1322.84	2046.91	2711.66	3446.18	3939.33	4714.02	5374.82	6157.94	6749.12
Long-3	236.95	735.55	1396.13	1954.39	2743.97	3413.76	4035.07	4710.34	5327.11	5981.66	6723.43
Long-4	-4.28	739.76	1353.43	2004.55	2693.99	3361.39	4013.38	4692.23	5327.68	6006.53	6646.26
Long-5	2.69	674.14	1354.87	1992.09	2671.44	3332.81	4008.57	4650.50	5331.30	6030.94	6698.27
Long-6	98.17	657.11	1304.90	1971.75	2657.32	3304.59	4026.88	4649.83	5361.76	6028.61	6673.58
Long-7	355.86	690.52	1327.99	1957.01	2642.95	3346.78	3996.15	4655.59	5357.61	6017.05	6723.39
Long-8	28.90	662.76	1386.70	1987.27	2705.06	3377.45	4013.28	4712.36	5347.34	6017.93	6692.75
S1-H	-213.33	-13.81	77.75	170.98	259.90	346.45	424.39	507.98	585.69	661.39	742.43
S1-A	30.31	9.18	22.45	34.79	52.17	68.44	87.89	106.22	127.71	149.20	170.31
S2-H	-181.40	2.34	100.18	198.03	282.40	362.35	435.55	508.80	578.21	645.43	714.08
S2-A	-15.41	-6.45	13.73	31.48	52.40	75.20	98.00	123.42	145.08	167.50	192.89
S3-H	-104.08	13.25	87.18	164.45	236.10	303.04	364.96	426.17	484.76	540.76	599.87
S4-H	-28.10	52.81	109.74	182.40	252.80	320.24	383.92	443.89	500.78	553.97	611.59

Table D-30. Phase 3 (20,000 Cycles) Strain Survey Raw Data (Run 2) (Continued)

S8	-87.14	52.44	186.92	346.12	505.28	650.72	777.20	900.88	1006.19	1100.70	1197.26
S9	22.82	-232.63	-469.37	-722.72	-959.38	-1157.86	-1333.77	-1508.14	-1662.77	-1794.48	-1933.09
S10	-40.83	61.27	150.09	263.53	378.29	487.09	585.46	686.93	777.69	859.70	948.80
S14	-70.35	28.28	101.20	189.72	274.68	356.88	433.02	510.39	583.30	645.88	719.87
S17	-85.96	14.71	96.12	194.06	282.89	367.78	444.82	519.74	590.19	653.43	721.68
S18	-3.16	-81.93	-172.50	-279.45	-399.09	-509.90	-613.21	-726.78	-830.02	-928.42	-1033.49
S19	-40.72	23.43	79.33	143.56	205.46	267.44	324.93	382.01	436.78	485.53	541.38
S24	-463.48	-517.98	-564.34	-606.66	-647.99	-681.29	-709.45	-738.34	-764.81	-788.41	-812.03
S25	-40.71	-192.69	-337.64	-487.39	-637.26	-765.89	-882.12	-995.08	-1098.64	-1190.55	-1286.16
S26	-48.49	-58.33	-69.07	-76.68	-84.43	-89.14	-92.74	-94.32	-96.06	-98.37	-99.10
S27	2.74	-98.98	-202.64	-310.99	-412.56	-501.48	-578.80	-654.99	-721.93	-784.36	-845.74
S28	-22.01	-26.03	-37.52	-41.31	-43.57	-43.25	-42.69	-39.42	-37.57	-34.66	-31.06
S29	-20.28	145.52	313.24	494.09	668.47	821.39	951.50	1072.10	1173.65	1263.05	1351.82
S30	-1.91	99.95	215.26	359.71	508.20	647.95	773.39	895.43	1002.03	1095.71	1190.71
S31	-65.85	-20.05	27.61	89.48	152.74	216.31	275.91	339.13	398.10	451.12	513.17
S32	-184.03	-75.17	4.67	97.45	179.76	260.96	329.38	396.88	456.14	511.19	570.89
INS2	7.97	198.82	383.13	585.53	781.35	952.02	1103.82	1264.06	1409.41	1537.90	1673.26
INS3	-0.90	30.38	58.34	91.79	128.54	164.96	201.25	237.47	272.96	306.68	341.94
INS4	-0.66	53.50	123.77	219.66	325.59	431.81	533.34	642.96	746.62	846.80	951.86
IS24	5.33	75.08	140.29	214.38	287.54	349.88	407.31	467.50	521.07	568.72	617.93
IS25	-10.04	72.53	146.39	231.12	312.20	379.59	442.59	507.10	563.54	612.78	667.76
IS26	92.27	38.48	-12.96	-57.45	-93.11	-118.20	-130.51	-129.39	-121.93	-108.70	-89.70
IS27	20.45	13.16	10.90	5.19	4.51	2.34	4.69	16.29	30.74	44.73	67.92
IS28	-12.54	-9.10	0.74	16.37	32.87	50.23	66.68	86.40	105.24	122.82	141.53
IS29	7.60	19.02	37.19	62.11	87.66	112.55	136.24	161.18	185.09	207.52	231.38
IS30	66.99	13.87	-17.79	-49.82	-73.64	-92.75	-106.58	-116.05	-121.87	-124.05	-126.76
IS31	42.95	17.07	6.46	1.60	-1.63	-4.27	-4.86	-2.77	1.10	4.87	10.51
IS32	-29.06	130.70	269.02	428.04	580.84	709.97	822.88	946.60	1055.43	1143.83	1247.00
P6-1	-26.52	5.38	26.22	50.14	74.96	94.00	109.41	131.53	149.82	164.68	180.98
P6-2	8.90	63.44	106.27	152.98	200.50	239.22	273.98	312.48	347.73	379.52	412.40
P6-3	-6.56	70.17	137.47	212.02	284.37	343.75	390.97	448.01	499.36	546.58	594.84
P6-4	166.31	22.03	-103.70	-218.73	-310.33	-380.81	-424.82	-441.66	-436.59	-429.39	-397.88
P6-5	55.34	90.73	126.47	165.49	204.66	236.62	261.66	290.54	314.82	333.88	355.44
P6-6	33.68	70.06	103.34	141.72	180.62	213.93	243.58	274.34	301.60	325.42	350.31
P6-7	187.76	70.51	-18.30	-104.56	-174.86	-236.50	-281.08	-306.30	-320.59	-323.85	-320.74
P6-8	22.78	79.27	121.01	163.58	206.58	240.76	273.61	308.66	340.85	370.13	401.94
P6-9	50.31	105.84	159.36	219.97	280.00	332.10	380.19	430.49	478.17	523.89	570.65
P6-10	11.74	55.61	105.22	157.27	207.18	250.98	291.50	329.70	366.03	398.77	432.74
P6-11	9.33	40.03	72.88	106.28	138.40	165.86	191.49	215.53	238.79	259.56	280.83
P6-12	17.40	34.89	54.37	74.22	93.34	109.74	124.67	139.62	153.63	166.74	179.83

Table D-31. Phase 3 (20,000 Cycles) Strain Survey Raw Data (Run 3)

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.01	0.65	1.38	2.07	2.62	3.36	4.02	4.63	5.36	6.01	6.70
Frame-1	-4.06	63.24	237.69	340.96	468.22	543.05	697.78	782.15	891.80	1004.53	1116.11
Frame-2	20.72	42.01	211.33	376.60	462.40	545.47	712.93	805.17	904.94	1019.01	1125.53
Frame-3	-1.42	41.05	203.63	374.67	451.30	567.33	696.56	757.82	924.16	1008.57	1129.77
Frame-4	-53.94	111.56	244.99	351.13	472.02	574.60	703.16	755.16	948.73	1016.89	1123.15
Frame-5	5.50	136.89	205.23	338.33	449.10	573.60	687.58	796.63	905.09	1019.64	1131.57
Frame-6	-4.69	112.29	214.29	335.86	480.15	584.10	684.47	786.52	915.72	1022.91	1101.03
Frame-7	-17.39	100.16	215.50	360.36	470.01	553.72	686.16	781.38	900.05	1012.97	1117.57
Frame-8	-8.84	128.57	225.50	341.32	476.52	581.34	703.91	779.67	907.56	1011.11	1127.25
Frame-9	-19.15	142.00	236.86	346.19	448.02	586.41	687.93	773.10	896.31	1019.50	1137.50
Frame-10	-16.40	129.80	205.92	337.85	461.95	582.33	694.93	772.38	914.20	1023.25	1129.94
Frame-11	-10.70	120.93	221.85	344.29	518.63	579.43	672.59	772.22	904.99	1016.89	1126.17
Frame-12	-3.84	110.61	216.67	346.31	456.91	590.89	696.58	793.48	884.63	1032.59	1110.33
Hoop-1	135.99	693.98	1429.12	2154.15	2880.03	3581.99	4281.15	5026.02	5717.62	6414.82	7179.64
Hoop-2	126.50	665.11	1453.55	1820.94	2858.71	3522.92	4304.67	5034.44	5638.17	6400.03	7162.03
Hoop-3	40.98	717.97	1433.42	2179.11	2864.92	3606.05	4304.65	4975.50	5670.33	6427.80	7117.71
Hoop-4	51.33	728.16	1456.21	2177.79	2802.01	3566.08	4274.61	5068.77	5682.41	6332.57	7157.56
Hoop-5	3.87	713.07	1451.37	2140.05	2872.80	3590.93	4299.12	4993.00	5735.10	6408.94	7142.32
Hoop-6	-7.29	706.75	1448.54	2127.54	2848.59	3607.18	4303.12	5035.12	5658.69	6435.16	7113.93
Hoop-7	-0.97	710.56	1427.75	2154.66	2853.83	3577.81	4284.77	4997.17	5725.29	6424.95	7142.64
Hoop-8	117.01	714.69	1437.66	2131.20	2869.00	3585.39	4293.39	5008.63	5724.30	6409.82	7148.26
Hoop-9	160.15	716.85	1404.51	2133.54	2862.57	3576.15	4290.54	4932.95	5789.47	6420.90	7164.93
Hoop-10	132.81	715.47	1440.10	2138.16	2864.63	3588.27	4294.92	5015.64	5708.37	6420.00	7152.44
Hoop-11	189.86	701.41	1438.57	2124.82	2845.67	3581.79	4285.96	4979.07	5692.63	6409.19	7143.42
Hoop-12	185.01	731.58	1480.57	2088.23	2896.54	3554.59	4265.16	5067.30	5709.36	6496.00	7192.21
Hoop-13	328.56	723.37	1447.04	2134.24	2850.68	3582.45	4298.60	4926.88	5738.35	6424.91	7156.61
Hoop-14	176.08	711.97	1438.58	2121.22	2862.59	3589.99	4301.71	5005.94	5703.27	6421.97	7163.98
Long-1	218.39	665.63	1362.88	2003.70	2673.95	3350.85	4003.84	4684.15	5346.75	6002.02	6683.42
Long-2	34.98	685.94	1279.13	1968.37	2694.19	3273.99	3955.19	4597.33	5328.96	6075.60	6650.77
Long-3	197.96	666.00	1304.58	2075.27	2754.54	3353.36	3979.39	4643.30	5403.22	6028.58	6656.28
Long-4	-0.66	663.73	1332.80	2037.31	2691.18	3381.21	4051.16	4692.23	5345.09	5995.07	6682.31
Long-5	1.52	689.38	1357.09	1984.04	2719.36	3350.99	3968.92	4663.45	5367.17	6005.63	6683.98
Long-6	118.35	691.45	1314.27	2011.11	2652.18	3318.17	3979.81	4623.72	5363.49	5980.56	6677.00
Long-7	325.48	680.72	1357.05	1994.92	2680.24	3352.20	4020.89	4665.32	5338.68	6011.56	6673.39
Long-8	37.21	700.68	1333.16	1985.09	2717.74	3350.67	3989.94	4616.22	5344.31	6031.59	6662.94
S1-H	-202.31	-21.82	95.65	188.12	251.54	347.19	428.21	499.44	585.50	658.29	738.96
S1-A	27.69	12.36	17.97	34.60	53.67	68.63	86.03	106.19	129.57	150.71	171.64
S2-H	-177.65	-7.37	119.60	211.45	274.96	362.35	437.88	499.69	578.96	642.51	713.40
S2-A	-15.79	-6.63	10.18	33.16	53.34	74.45	101.01	122.63	145.83	167.52	189.92
S3-H	-101.76	3.94	101.81	177.40	228.90	304.37	366.41	419.54	484.94	538.61	597.58
S4-H	-22.86	48.30	129.21	201.11	252.07	325.49	388.49	442.26	504.53	556.27	614.65

Table D-31. Phase 3 (20,000 Cycles) Strain Survey Raw Data (Run 3) (Continued)

S8	-82.04	39.35	218.18	371.53	492.24	651.44	778.81	886.07	1006.19	1098.63	1195.93
S9	24.77	-210.88	-518.79	-751.12	-930.96	-1152.64	-1331.44	-1484.07	-1657.32	-1790.12	-1925.51
S10	-43.64	52.26	172.34	283.66	365.21	486.64	587.57	674.56	776.19	855.84	944.90
S14	-72.11	13.95	115.99	201.13	264.09	355.38	433.29	500.49	580.72	642.05	715.86
S17	-84.13	-1.28	116.65	207.12	274.38	368.68	446.55	513.04	588.37	650.58	719.75
S18	-4.43	-88.82	-193.60	-296.15	-386.40	-508.44	-614.42	-713.65	-829.47	-925.24	-1029.23
S19	-41.22	19.37	90.58	149.75	199.56	267.71	326.28	378.03	435.23	482.43	539.47
S24	-463.02	-518.79	-569.92	-612.54	-645.93	-679.90	-708.81	-736.18	-764.31	-787.89	-810.36
S25	-39.97	-186.03	-357.53	-507.04	-624.24	-765.89	-881.74	-985.53	-1099.65	-1190.03	-1283.11
S26	-46.28	-59.42	-68.52	-77.60	-85.59	-89.23	-92.07	-94.80	-96.75	-98.84	-98.51
S27	2.87	-93.69	-215.34	-325.03	-406.28	-501.38	-580.61	-648.15	-722.30	-783.25	-843.25
S28	-19.06	-27.83	-32.12	-40.66	-44.73	-43.53	-42.38	-40.33	-38.40	-35.59	-30.09
S29	-18.10	135.28	338.66	520.54	656.06	822.71	955.10	1063.34	1175.65	1260.82	1349.01
S30	-1.68	90.26	237.90	379.51	494.46	648.13	776.00	884.99	1002.22	1093.46	1187.38
S31	-64.66	-26.90	39.60	100.41	147.04	217.35	278.87	334.31	398.65	449.53	511.40
S32	-180.80	-85.71	23.20	113.53	173.25	263.05	332.98	391.73	457.68	509.75	568.91
INS2	7.96	181.43	419.99	607.15	756.12	945.51	1100.61	1242.54	1403.44	1535.16	1666.56
INS3	-2.49	29.42	63.00	94.93	124.63	165.38	201.09	234.12	271.72	305.13	340.60
INS4	0.52	56.12	143.27	230.44	315.66	432.08	534.89	633.52	744.66	844.17	949.14
IS24	3.88	67.82	156.95	224.14	276.88	347.53	406.67	457.94	518.36	567.33	616.00
IS25	-10.04	65.27	165.94	242.69	299.92	377.41	441.23	495.36	560.64	611.40	664.93
IS26	84.72	39.56	-17.55	-67.44	-96.07	-121.97	-133.54	-135.08	-126.47	-110.94	-91.62
IS27	22.99	12.25	13.98	3.88	1.38	-0.25	3.38	10.62	28.20	43.42	66.25
IS28	-13.85	-6.78	5.50	16.01	29.70	48.96	66.46	83.06	102.75	120.48	141.50
IS29	7.88	20.24	44.08	63.56	84.63	112.55	136.18	159.05	183.96	205.82	230.81
IS30	66.26	26.05	-21.80	-56.54	-72.01	-92.94	-107.15	-114.75	-123.32	-124.79	-125.87
IS31	43.67	20.38	9.42	-0.91	-1.95	-4.50	-5.27	-2.59	-0.27	3.46	10.88
IS32	-69.71	80.04	273.56	420.20	528.25	677.65	800.17	901.49	1029.47	1122.89	1226.07
P6-1	-28.33	1.75	32.38	52.49	67.90	89.11	108.16	124.06	146.02	161.44	179.18
P6-2	9.35	61.10	118.92	161.25	195.43	238.35	274.13	306.89	346.34	377.87	411.14
P6-3	-6.56	67.98	155.56	223.58	277.16	342.30	391.77	440.82	498.09	545.01	593.45
P6-4	163.40	27.27	-113.48	-238.49	-309.10	-386.42	-429.20	-448.90	-444.78	-433.51	-400.73
P6-5	54.61	86.91	133.73	168.92	200.14	234.26	261.71	285.19	312.65	335.18	354.38
P6-6	32.58	66.96	110.25	146.80	175.55	213.02	243.44	270.44	300.51	324.55	349.43
P6-7	180.67	74.66	-31.17	-122.86	-175.42	-242.84	-286.39	-312.91	-328.56	-328.78	-323.85
P6-8	46.63	99.76	156.48	195.19	222.64	262.67	294.59	323.11	360.05	388.74	420.78
P6-9	50.31	102.19	170.79	226.84	273.86	330.83	380.26	424.37	475.63	521.95	567.99
P6-10	11.01	54.51	113.49	163.77	203.04	251.52	291.38	325.80	364.76	398.27	430.43
P6-11	8.25	40.20	78.30	109.88	135.35	166.22	191.53	212.57	237.53	258.50	279.23
P6-12	15.94	34.88	58.20	76.04	91.52	109.92	125.06	137.57	152.17	165.66	179.31

Table D-32. Phase 4 (Room Temperature) Strain Survey Raw Data

Load Step	0	1	2	3	4	5	6	7	8	9	10	11
Pressure	0.00	1.17	2.42	3.52	4.69	5.94	7.11	8.24	9.46	10.29	10.63	11.87
Frame-1	-9.40	275.81	393.24	585.73	801.39	1024.83	1231.22	1397.80	1597.70	1715.46	1800.30	2052.31
Frame-2	20.98	151.41	397.65	574.45	792.52	1020.19	1204.48	1422.55	1610.34	1724.99	1800.66	2001.18
Frame-3	44.59	259.47	411.83	586.54	826.53	1028.30	1226.43	1410.53	1593.60	1720.51	1810.94	1980.05
Frame-4	17.32	169.72	359.30	618.55	871.89	1020.28	1213.20	1386.84	1597.16	1733.03	1828.67	2015.21
Frame-5	-3.37	201.53	389.76	588.66	796.17	1032.98	1214.82	1389.52	1602.76	1739.28	1805.40	2005.17
Frame-6	5.60	208.17	383.84	594.89	793.71	1020.17	1207.08	1404.45	1603.90	1734.61	1827.67	2001.88
Frame-7	-2.70	193.30	391.71	595.45	819.82	1033.64	1201.71	1401.45	1612.51	1727.99	1805.11	1984.71
Frame-8	8.15	211.30	372.75	581.01	800.30	1016.11	1214.26	1392.37	1593.07	1737.42	1814.00	2004.45
Frame-9	-18.97	222.32	368.25	580.65	804.60	1022.62	1213.26	1420.43	1603.66	1737.82	1810.96	1994.60
Frame-10	26.34	182.36	421.77	585.21	747.71	1027.77	1201.82	1412.48	1601.80	1729.34	1825.42	1996.71
Frame-11	26.89	161.61	388.52	589.56	801.41	1023.29	1211.42	1399.36	1601.95	1737.38	1836.33	1969.06
Frame-12	2.50	189.87	387.55	590.74	789.74	1005.29	1216.80	1401.95	1620.70	1746.96	1812.13	1997.53
Hoop-1	7.96	1018.56	2642.35	3782.57	5118.52	6456.56	7524.35	8854.32	10091.42	11011.82	11261.78	12785.28
Hoop-2	-47.06	1262.25	2629.31	3782.48	5180.46	6174.48	7572.51	8711.32	9839.51	11108.58	11552.30	12585.23
Hoop-3	38.78	1271.72	2579.59	3869.97	5107.01	6328.67	7682.04	8840.43	10280.47	10932.52	11375.42	12705.87
Hoop-4	143.47	1222.81	2437.09	3880.60	4949.62	6432.14	7685.06	8844.60	10180.92	10928.13	11401.46	12661.25
Hoop-5	-26.44	1228.66	2529.04	3712.23	5074.22	6326.60	7631.00	8774.57	10098.45	11062.82	11372.61	12748.63
Hoop-6	-19.41	1266.72	2573.71	3813.59	5076.31	6375.35	7552.15	8869.31	10147.28	10939.74	11405.18	12621.14
Hoop-7	18.30	1279.19	2520.65	3795.98	5073.60	6313.90	7596.91	8818.57	10097.69	10955.33	11391.81	12672.63
Hoop-8	-7.71	1320.46	2501.32	3778.35	5062.00	6316.52	7607.93	8862.45	10124.34	10922.42	11385.10	12670.27
Hoop-9	-21.35	1180.05	2870.21	3739.84	5063.12	6343.67	7602.67	8841.91	9765.05	11043.11	11387.50	12654.82
Hoop-10	2.15	1243.86	2617.27	3831.06	5047.63	6330.32	7607.68	8863.72	10000.74	10996.71	11513.23	12573.22
Hoop-11	-0.59	1237.34	2653.95	3781.32	4920.69	6357.20	7593.43	8756.84	10552.02	11019.21	10800.38	13084.58
Hoop-12	-2.27	1159.66	2084.83	3769.03	5083.60	6138.62	7614.12	8737.94	9984.09	10986.69	11550.17	12545.18
Hoop-13	75.85	1274.91	2598.51	3878.51	4909.12	6386.15	7599.95	8769.87	10159.16	10964.57	11444.94	12652.56
Hoop-14	30.68	1322.70	2548.89	3819.39	5081.78	6300.51	7599.99	8862.76	10088.83	10948.90	11438.57	12702.48
Long-1	2.80	1996.85	3984.63	6006.16	7961.17	10001.52	11933.00	14049.31	16051.36	17288.94	18042.30	20078.73
Long-2	-4.62	1797.82	3820.62	6061.30	8032.66	9951.00	11983.81	13828.58	15936.18	17411.36	17940.06	19863.61
Long-3	-23.59	1979.08	4100.79	5995.98	7985.44	9908.08	11946.07	13964.95	16069.66	17312.24	18043.65	20023.36
Long-4	6.31	2032.02	3948.81	6008.07	8068.95	9950.37	11988.12	14010.60	16022.67	17333.87	18020.03	19986.85
Long-5	40.19	1971.87	4045.66	5992.47	8058.63	10041.33	12006.00	13987.56	15997.73	17364.59	17988.91	19991.46
Long-6	-12.38	1960.88	3972.89	6123.95	8061.80	9972.55	11958.87	14002.54	15931.48	17272.83	18002.64	19998.63
Long-7	89.96	1992.83	3998.73	6026.71	7952.90	9987.60	12024.29	14000.55	15966.34	17328.30	18026.74	20006.47
Long-8	7.21	2075.95	3975.76	6002.77	7928.09	9977.06	11965.10	14084.12	16053.92	17295.94	18054.44	19996.38
S1-H	-35.58	100.20	219.91	312.22	414.27	531.77	646.47	748.12	858.73	939.01	967.45	1080.95
S2-H	-22.30	137.57	251.10	339.25	431.92	535.76	633.62	719.54	821.72	878.56	896.22	1002.78
S3-H	4987.80	5110.08	5343.33	5388.34	5510.11	5714.68	5844.40	5927.41	6027.47	6074.78	6106.92	6183.13
S4-H	-3.76	74.16	152.82	221.75	292.95	373.87	447.30	509.49	584.30	628.69	646.61	717.86
S8	-0.12	231.82	446.27	612.76	767.69	926.19	1062.89	1171.95	1288.03	1356.77	1382.08	1487.66
S9	41.93	-501.37	-912.31	-1215.29	-1483.36	-1748.98	-1976.40	-2158.69	-2329.97	-2425.29	-2466.34	-2598.50

Table D-32. Phase 4 (Room Temperature) Strain Survey Raw Data (Continued)

S10	-3.72	107.83	256.47	384.82	515.72	659.39	785.84	889.36	1003.39	1070.52	1096.48	1199.03
S14	-29.69	117.32	244.30	343.62	445.30	554.84	657.49	742.76	839.79	900.47	920.56	1014.46
S17	-32.44	120.59	241.80	334.12	426.48	526.80	618.40	695.46	782.00	838.04	858.31	939.47
S18	11.11	-189.55	-405.82	-596.63	-778.44	-971.32	-1154.15	-1314.93	-1478.09	-1577.55	-1616.55	-1765.68
S19	-12.61	77.57	161.62	226.64	293.60	371.53	444.53	505.40	576.51	623.49	640.38	707.84
S24	-11.23	-138.15	-240.16	-315.26	-382.97	-437.47	-489.47	-543.32	-594.84	-626.38	-642.54	-686.13
S25	-18.35	-416.48	-749.03	-1004.08	-1228.99	-1437.91	-1619.19	-1782.33	-1932.09	-2030.41	-2078.16	-2197.39
S26	-67.77	-254.75	-448.51	-624.27	-791.88	-944.58	-1076.65	-1205.90	-1330.41	-1411.62	-1453.43	-1551.18
S27	-2.84	-281.47	-515.49	-698.66	-866.33	-1018.62	-1153.49	-1275.70	-1390.44	-1463.71	-1498.64	-1592.22
S28	-26.27	-54.48	-76.22	-98.38	-118.01	-131.13	-143.27	-157.68	-165.63	-169.14	-175.41	-176.58
S29	-1.37	388.59	740.89	974.36	1150.76	1304.77	1428.51	1525.92	1625.28	1687.87	1710.76	1805.35
S30	-5.04	267.18	553.10	764.48	947.44	1120.62	1262.24	1370.82	1476.20	1538.93	1562.57	1648.43
S31	-66.06	47.40	167.56	262.21	361.21	473.63	579.87	673.75	779.65	849.63	874.43	979.13
S32	-139.21	84.07	248.31	368.56	482.98	610.31	725.60	826.15	934.81	1005.97	1033.42	1137.58
S33	-16.95	-63.74	-94.26	-119.08	-135.85	-147.67	-158.81	-172.76	-182.55	-188.95	-194.09	-201.05
S34	-11.67	-65.51	-106.96	-135.57	-161.01	-177.58	-195.09	-216.37	-235.27	-246.63	-254.33	-270.71
S35	4.48	-124.15	-217.75	-280.79	-331.12	-369.09	-400.07	-430.00	-452.91	-467.20	-475.18	-489.07
S36	-20.68	-245.88	-442.34	-602.16	-744.91	-873.64	-984.48	-1092.29	-1193.57	-1261.03	-1296.56	-1372.39
S37	-25.12	-159.55	-280.54	-385.46	-483.68	-571.81	-649.33	-725.90	-797.20	-845.78	-871.62	-926.94
S38	10.75	-87.67	-160.49	-212.12	-253.54	-291.04	-324.11	-354.95	-379.74	-396.66	-405.18	-421.30
INS2	-20.59	379.41	708.23	966.17	1210.16	1467.38	1695.53	1891.64	2095.67	2216.50	2271.64	2453.74
INS3	-0.24	40.83	87.87	129.09	171.52	220.00	264.86	302.83	346.69	372.93	383.22	426.46
INS4	282.47	294.55	298.89	302.55	305.57	308.42	309.98	311.77	314.45	316.69	320.21	322.68
IS24	-5.51	131.36	237.21	318.79	394.24	473.46	540.72	592.75	649.73	680.56	692.64	740.94
IS25	-9.23	147.96	265.46	354.91	436.43	523.00	596.34	653.38	722.05	755.95	769.82	823.69
IS26	14.69	-80.61	-151.74	-178.26	-185.69	-171.27	-147.44	-121.14	-74.46	-45.04	-30.16	27.61
IS27	-14.83	20.53	9.65	3.76	3.44	19.45	43.43	69.23	110.56	135.62	149.26	202.10
IS28	-3.17	0.28	18.62	36.95	50.16	70.81	88.05	96.22	111.04	119.56	119.41	135.67
IS29	-1.90	15.79	44.94	71.88	97.96	127.44	154.56	174.20	198.46	213.04	217.28	240.88
IS30	31.48	-64.66	-119.17	-152.46	-182.24	-206.13	-225.99	-244.30	-255.92	-261.81	-265.79	-267.49
IS31	18.36	-22.22	-40.07	-45.82	-52.66	-57.87	-61.22	-67.20	-66.74	-65.72	-65.80	-59.92
IS32	-117.42	140.24	337.21	473.92	600.34	726.72	830.39	906.47	998.69	1044.93	1055.36	1155.52
P6-1	-14.63	15.60	39.57	54.75	72.88	82.17	88.83	90.28	96.47	93.55	87.16	92.56
P6-2	16.48	93.45	157.33	205.01	253.54	291.56	325.03	353.22	388.94	407.99	415.83	451.37
P6-3	11.39	137.60	239.51	314.99	388.07	448.87	502.62	548.00	599.23	629.07	640.76	688.56
P6-4	35.34	-352.22	-609.08	-731.06	-768.85	-749.83	-689.38	-614.08	-503.74	-424.69	-395.20	-260.06
P6-5	3923.83	3291.71	2981.71	2666.25	2361.17	2134.51	2133.06	2136.14	2113.60	2181.87	2324.18	2452.07
P6-6	9.04	81.68	147.58	194.25	236.22	272.36	299.60	317.57	334.03	341.76	343.54	355.38
P6-7	65.39	-216.91	-407.06	-512.02	-575.51	-613.10	-618.30	-603.32	-560.95	-528.06	-510.58	-445.19
P6-10	17.67	104.13	177.41	237.30	294.51	347.72	394.77	431.87	472.50	495.81	506.44	541.06
P6-11	8.27	59.19	101.26	135.02	167.18	196.79	221.71	239.05	259.58	268.51	272.27	290.36
P6-12	-1.98	1.92	4.77	5.72	7.53	4.86	-1.08	-14.40	-25.32	-38.10	-45.31	-53.02

Note: The pressures for load steps 9 and 11 were 1.15 and 1.33 times service load, respectively.

Table D-33. Phase 4 (220°F) Strain Survey Raw Data

Load Step	0	1	2	3	4	5	6	7	8	9	10	11
Pressure	0.07	1.18	2.36	3.56	4.72	5.92	7.10	8.28	9.47	10.23	10.65	11.84
Frame-1	15.32	206.91	395.38	593.54	790.66	1017.93	1244.57	1403.88	1603.27	1743.48	1857.92	2002.31
Frame-2	-8.15	149.78	430.72	552.91	795.00	1010.00	1211.25	1422.20	1596.31	1728.28	1841.82	2031.40
Frame-3	6.86	233.72	388.06	636.13	807.55	1047.66	1253.90	1464.59	1609.34	1752.42	1808.12	2029.26
Frame-4	-16.79	332.27	417.49	649.53	866.43	1032.42	1254.06	1438.07	1632.20	1728.37	1830.49	2020.64
Frame-5	-7.95	196.63	427.81	599.87	795.38	1009.65	1210.13	1390.83	1598.54	1747.47	1784.37	2005.94
Frame-6	-5.15	198.82	378.07	605.43	803.77	1005.84	1219.75	1433.57	1609.19	1719.16	1815.44	2018.23
Frame-7	5.62	185.34	398.59	597.52	783.84	1002.19	1204.37	1416.63	1587.96	1750.22	1823.81	2006.71
Frame-8	1.65	198.35	412.03	603.01	791.40	995.20	1221.64	1409.87	1612.98	1737.96	1826.06	2009.31
Frame-9	-43.02	230.01	453.03	606.40	807.64	1006.27	1206.05	1416.93	1600.95	1762.00	1809.44	2008.79
Frame-10	4.84	193.02	398.59	597.24	796.26	1032.40	1208.67	1423.17	1611.82	1725.45	1829.57	2013.94
Frame-11	-7.90	195.26	412.08	599.16	803.14	1016.26	1214.17	1412.02	1631.93	1722.96	1795.82	2011.21
Frame-12	-11.65	235.20	422.43	611.39	800.78	1022.62	1210.41	1416.54	1614.64	1762.79	1815.07	1990.10
Hoop-1	190.62	1321.39	2269.56	4011.53	5108.67	6415.33	7651.88	8965.97	10112.41	11117.54	11348.77	12785.39
Hoop-2	77.45	1210.52	2634.24	3830.43	4862.12	6215.10	7594.19	8625.85	10192.78	10616.65	11463.90	12472.52
Hoop-3	76.49	1192.86	2501.70	3793.68	5056.89	6469.15	7451.83	9030.87	10066.80	11021.90	11417.29	12508.86
Hoop-4	17.98	1226.31	2621.82	3759.44	5170.79	6374.45	7595.52	8919.43	10066.96	11000.69	11329.70	12741.29
Hoop-5	3.78	1278.44	2551.04	3687.33	4917.96	6101.62	7693.14	8605.07	10141.86	10962.99	11436.10	12762.44
Hoop-6	281.13	1324.93	2516.13	3824.57	5152.67	6372.28	7670.16	8855.58	10175.26	11008.07	11380.13	12627.77
Hoop-7	105.62	1271.48	2522.93	3774.88	5081.23	6306.88	7606.86	8873.76	10121.21	10908.14	11392.35	12695.38
Hoop-8	-2.27	1266.24	2535.52	3781.90	5087.05	6363.07	7608.83	8864.36	10147.88	10929.79	11399.63	12626.40
Hoop-9	20.01	1289.02	2569.58	3793.70	4983.48	6430.34	7644.86	8829.48	10050.27	10888.67	11475.24	12606.76
Hoop-10	-3.08	1269.97	2481.61	3852.34	5107.37	6343.25	7608.57	9020.12	10334.27	11186.69	11624.79	12827.59
Hoop-11	35.20	1263.42	2455.98	3758.82	5072.31	6377.09	7648.34	8752.75	9908.42	10700.09	11047.32	12727.51
Hoop-12	4.98	1202.63	2408.64	3722.83	5204.86	6129.45	7656.94	8865.90	10157.40	10998.03	11293.82	12679.27
Hoop-13	1.18	1272.71	2647.34	3772.69	5095.13	6352.17	7586.54	8896.38	10153.55	11001.41	11415.75	12719.05
Hoop-14	2.95	1279.65	2527.75	3789.77	5080.89	6372.39	7626.43	8824.18	10093.79	10930.41	11383.15	12669.70
Long-1	-19.86	1211.71	2391.07	3522.24	4691.22	5947.77	7124.97	8290.61	9458.14	10219.05	10670.10	11794.20
Long-2	28.01	1027.36	2251.36	3373.55	4779.68	6022.66	7459.04	8372.46	9379.09	10206.96	10660.95	11897.38
Long-3	2.60	1129.75	2339.53	3564.76	4588.74	5822.37	7184.49	8332.13	9607.17	10338.29	10642.93	11918.68
Long-4	-0.20	1122.05	2344.11	3736.97	4689.62	5881.04	7053.72	8299.87	9479.22	10294.08	10620.75	11822.50
Long-5	6.35	1154.42	2443.54	3543.92	4687.63	5883.26	7137.05	8348.46	9478.17	10242.36	10647.42	11879.10
Long-6	5.42	1176.21	2346.76	3495.59	4707.08	5890.20	7090.42	8257.42	9460.69	10218.68	10620.81	11825.98
Long-7	8.23	1163.73	2327.51	3586.98	4748.94	5928.02	7130.75	8293.31	9448.02	10225.25	10644.87	11825.83
Long-8	8.12	1164.99	2388.07	3562.14	4642.26	5934.85	7167.42	8277.79	9475.47	10247.90	10634.71	11858.01
S1-H	-101.92	27.54	168.75	303.04	429.57	559.62	687.42	815.15	941.27	1033.09	1082.94	1210.32
S2-H	43.96	89.42	184.07	288.36	397.19	500.78	608.83	715.32	817.59	887.72	923.68	1037.61
S3-H	-1038.92	-932.81	-815.82	-716.46	-614.89	-526.18	-430.93	-334.42	-238.94	-180.73	-148.93	-55.98
S4-H	-669.70	-523.29	-403.76	-317.03	-200.46	67.11	150.82	235.25	297.28	339.91	369.06	453.56
S8	271.92	614.25	875.41	1094.15	1278.12	1435.14	1572.76	1703.32	1826.06	1902.94	1941.93	2057.63
S9	-523.07	-910.58	-1198.27	-1395.76	-1544.35	-1679.01	-1777.55	-1865.93	-1932.89	-1959.03	-1965.20	-2027.65

Table D-33. Phase 4 (220°F) Strain Survey Raw Data (Continued)

S10	-287.37	-120.41	94.43	278.94	457.89	623.72	773.91	909.66	1041.85	1124.51	1165.92	1288.25
S14	-97.09	-60.19	-30.51	-9.52	4.96	17.99	27.40	37.53	44.77	42.60	36.09	46.95
S17	-63.84	112.72	273.17	406.57	534.78	653.71	761.76	869.55	970.34	1034.61	1070.51	1164.72
S18	-12.25	-195.70	-367.39	-560.05	-716.53	-884.03	-1035.46	-1170.13	-1302.14	-1385.20	-1425.17	-1551.08
S19	-241.50	-127.58	-11.18	89.81	184.54	276.36	359.72	447.72	531.99	582.63	609.08	684.83
S24	525.05	491.23	461.53	453.58	448.59	452.02	452.40	448.23	442.82	439.24	438.63	429.20
S25	722.26	296.14	-73.29	-314.62	-490.79	-613.12	-708.02	-788.29	-843.74	-865.73	-863.24	-882.24
S26	763.03	319.97	-101.45	-352.83	-505.27	-631.58	-693.12	-747.36	-780.64	-774.41	-767.92	-793.23
S27	780.25	489.83	271.03	208.43	255.21	367.27	587.39	781.05	992.60	1206.27	1336.53	1594.28
S28	27.62	50.45	34.33	34.19	43.34	61.33	86.69	111.82	143.71	174.21	150.15	221.07
S29	-303.70	-81.52	464.50	856.02	1046.71	1194.07	1322.80	1446.76	1565.44	1641.39	1685.03	1800.78
S30	-162.80	172.57	619.10	919.30	1105.55	1238.03	1337.81	1416.39	1486.83	1526.56	1548.30	1618.28
S31	473.76	550.15	607.27	656.11	701.83	779.72	861.78	949.18	1035.58	1091.66	1131.52	1216.42
S32	57.90	156.30	288.30	398.92	516.84	636.72	748.91	858.71	965.33	1031.24	1061.98	1162.08
S33	-585.86	-582.40	-592.78	-602.87	-607.90	-611.50	-615.74	-618.43	-623.89	-627.25	-629.64	-636.47
S34	102.02	91.60	77.04	71.47	70.95	70.22	72.19	73.44	74.54	75.26	73.81	77.23
S35	317.16	114.46	-50.66	-161.70	-235.87	-307.13	-376.04	-449.43	-537.32	-606.82	-657.83	-735.86
S36	616.67	169.59	-187.56	-392.43	-528.40	-650.18	-745.42	-834.13	-920.19	-983.53	-1042.56	-1107.42
S37	-161.35	-251.16	-295.66	-325.00	-353.33	-360.87	-369.82	-381.04	-373.40	-368.51	-365.48	-369.27
S38	-206.28	-282.83	-349.90	-395.72	-424.95	-447.36	-467.42	-481.42	-498.00	-502.75	-515.31	-512.65
INS2	155.17	516.46	855.67	1143.17	1397.46	1637.23	1852.99	2051.18	2246.04	2364.49	2426.56	2595.29
INS3	73.91	129.39	194.71	264.77	327.96	395.56	460.22	524.14	588.00	630.42	652.35	714.66
INS4	-216.12	-213.41	-211.19	-211.63	-211.68	-213.10	-213.46	-215.04	-216.75	-219.63	-221.38	-223.95
IS24	-3.85	105.73	214.78	305.71	390.01	471.21	544.09	611.12	676.58	717.15	737.77	800.42
IS25	-10.09	119.42	239.01	337.42	428.50	514.66	592.34	663.80	732.98	776.05	797.72	864.64
IS26	203.12	-17.55	-124.28	-183.80	-193.98	-169.29	-131.54	-80.71	-16.83	28.18	56.50	137.10
IS27	51.44	44.93	13.82	2.96	11.65	37.70	79.67	130.31	191.82	236.34	261.12	341.30
IS28	-65.80	-41.50	-10.95	27.08	58.45	94.49	123.28	154.95	184.51	201.55	211.55	240.19
IS29	-68.96	-35.54	2.46	44.52	82.21	123.83	158.80	196.01	230.88	252.66	265.74	299.20
IS30	-79.87	-151.42	-194.13	-207.93	-219.42	-215.84	-211.53	-199.37	-183.01	-169.79	-160.32	-136.59
IS31	-69.07	-98.81	-116.53	-119.91	-119.10	-107.94	-98.41	-82.09	-63.79	-50.06	-39.40	-15.68
IS32	-82.45	25.48	109.52	170.00	220.73	268.72	305.85	339.50	366.49	372.68	367.25	397.90
P6-1	63.24	60.18	53.58	68.86	85.31	115.80	158.66	201.17	249.20	277.80	296.54	354.00
P6-2	98.82	163.69	213.44	282.60	342.93	413.45	493.69	572.44	656.67	711.01	748.22	842.76
P6-3	149.89	332.16	506.99	666.19	797.92	934.49	1075.31	1217.64	1362.27	1462.90	1523.38	1665.05
P6-4	95.03	-264.79	-690.61	-723.39	-583.18	-387.12	-209.39	-47.33	102.82	195.40	249.56	385.85
P6-5	38.27	23.20	62.67	121.80	157.21	201.21	249.49	301.98	362.97	400.58	423.56	493.42
P6-6	-4.47	78.99	155.72	218.31	258.25	286.69	304.11	307.60	303.73	293.87	288.49	277.14
P6-7	238.92	30.55	-228.74	-328.12	-329.41	-263.13	-172.06	-79.57	18.46	72.67	102.28	201.24
P6-10	-59.92	79.24	216.81	332.53	430.81	521.75	601.90	678.74	752.02	797.59	822.68	892.64
P6-11	81.47	148.74	220.00	280.53	333.11	382.33	424.30	466.94	505.67	526.43	533.28	571.52
P6-12	127.47	153.79	189.93	225.30	258.23	291.01	320.30	351.68	382.15	398.96	404.34	433.81

Notes: The pressure for load steps 9 and 11 was 1.15 and 1.33 times service load, respectively.
The red strain gage readings represent the readings from the region that was heated to 220°F.

Table D-34. Phase 4 (250°F) Strain Survey Raw Data

Load Step	0	1	2	3	4	5	6	7	8	9	10	11
Pressure	0.06	1.18	2.38	3.55	4.74	5.92	7.09	8.28	9.48	10.23	10.66	11.84
Frame-1	12.20	197.48	455.14	622.82	798.67	998.45	1182.89	1422.61	1569.48	1749.91	1755.93	2064.05
Frame-2	11.58	171.44	325.15	596.78	791.56	992.18	1231.48	1417.97	1636.20	1746.12	1815.34	2011.18
Frame-3	-58.08	259.83	361.49	590.50	795.26	1008.49	1201.51	1407.70	1594.80	1758.35	1816.91	2022.67
Frame-4	-58.88	238.88	357.24	583.62	799.06	1031.03	1206.18	1387.14	1604.67	1782.93	1808.31	2018.52
Frame-5	15.10	206.87	341.68	624.17	760.79	1016.37	1194.34	1394.78	1599.17	1739.12	1798.81	2002.07
Frame-6	29.22	210.10	394.32	600.53	781.81	1004.46	1206.35	1406.22	1602.02	1745.48	1807.36	2014.56
Frame-7	0.90	196.82	398.86	585.21	791.42	1006.19	1204.50	1389.66	1589.11	1743.13	1814.10	2003.72
Frame-8	2.78	190.60	384.86	594.63	796.33	1011.61	1192.79	1410.46	1594.36	1738.12	1826.51	2012.27
Frame-9	34.79	207.57	401.64	607.10	795.42	1004.52	1194.99	1410.48	1604.85	1742.59	1793.10	2007.31
Frame-10	27.14	208.52	401.71	637.67	789.53	1002.23	1210.19	1405.27	1578.89	1746.88	1798.78	1998.24
Frame-11	9.65	237.02	400.40	587.96	802.00	996.45	1193.37	1402.14	1639.10	1753.02	1755.88	1997.66
Frame-12	0.22	184.40	419.66	613.69	787.33	991.52	1221.28	1423.28	1582.07	1730.70	1778.67	2013.05
Hoop-1	205.15	1322.95	2555.61	3744.88	5053.75	6431.11	7547.92	9045.28	10262.58	10753.14	11312.99	12567.66
Hoop-2	95.37	1161.81	2418.54	3776.19	5050.49	6158.82	7727.07	8488.44	9956.32	11058.77	11464.55	12762.70
Hoop-3	105.97	1157.91	2567.41	3862.74	4995.86	6317.47	7304.25	8750.50	9978.73	10992.57	11591.49	12739.00
Hoop-4	96.21	1171.49	2672.50	3859.14	5066.85	6331.97	7768.40	9069.54	10114.90	10910.06	11246.69	12591.37
Hoop-5	88.37	1283.58	2446.39	3805.77	5013.20	6464.65	7487.90	8850.78	10189.24	11096.53	11442.17	12644.69
Hoop-6	351.41	1257.73	2584.54	3621.63	5006.44	6378.51	7498.49	8919.98	10124.16	10989.33	11317.20	12738.56
Hoop-7	30.51	1283.75	2492.29	3838.87	5047.03	6327.71	7658.71	8808.49	10225.46	10933.50	11448.43	12628.48
Hoop-8	5.10	1273.62	2512.64	3913.12	5116.55	6296.69	7683.34	8856.10	10124.74	10958.21	11414.38	12660.77
Hoop-9	11.03	1280.05	2497.01	4176.23	5227.62	6378.28	7582.79	8808.85	10088.76	10991.70	11468.06	12667.07
Hoop-10	4.03	1275.30	2527.04	3778.02	5146.44	6316.62	7614.65	8884.27	10091.75	11008.00	11134.75	12832.14
Hoop-11	17.00	1287.07	2513.47	3722.76	4941.29	6266.08	7738.27	8868.34	10165.84	10378.75	11391.22	12157.27
Hoop-12	35.54	1107.13	2522.53	3698.43	5036.75	6251.71	7329.13	8910.87	10102.90	11180.32	11393.14	12905.96
Hoop-13	183.83	1287.33	2580.78	3741.96	5102.44	6279.09	7682.30	8822.41	10072.15	10993.00	11357.29	12409.60
Hoop-14	2.95	1250.30	2519.66	3817.60	5110.24	6321.02	7575.83	8852.65	10092.78	11164.14	11375.81	12740.55
Long-1	-7.11	1218.21	2369.74	3579.38	4672.59	5877.56	7049.48	8335.41	9356.21	10280.78	10685.79	11893.83
Long-2	30.82	1124.01	2536.91	3672.22	4448.01	5736.76	7266.52	8420.51	9640.97	10104.75	10697.49	11710.89
Long-3	321.79	1159.87	2312.96	3501.91	4761.76	5936.32	7091.90	8233.87	9417.36	10244.67	10645.37	11857.82
Long-4	-6.22	1183.17	2315.41	3533.74	4731.81	5908.18	7065.77	8268.98	9416.80	10290.65	10667.76	11847.87
Long-5	8.71	1201.16	2343.69	3542.03	4692.34	5834.40	7164.13	8324.21	9408.93	10263.71	10662.73	11846.12
Long-6	58.79	1179.41	2314.97	3529.30	4766.39	5894.36	7111.77	8248.39	9441.96	10253.25	10656.39	11826.00
Long-7	36.20	1170.68	2347.20	3575.32	4744.07	5877.56	7123.45	8266.98	9478.70	10233.96	10647.30	11846.59
Long-8	49.64	1185.99	2401.36	3653.97	4708.70	5898.67	7152.00	8317.41	9408.08	10243.32	10659.63	11853.28
S1-H	-165.92	-11.53	136.75	275.88	405.99	532.83	658.71	785.09	913.56	1004.81	1046.48	1180.31
S2-H	-26.82	38.75	134.88	236.95	347.30	456.81	564.81	670.68	775.68	839.47	878.97	982.08
S3-H	-3012.29	-2899.92	-2783.81	-2680.12	-2575.54	-2477.56	-2384.40	-2289.39	-2199.37	-2136.59	-2104.89	-2016.18
S4-H	-783.36	-634.02	-499.43	-388.77	-290.18	-11.37	79.81	182.21	274.86	339.16	364.57	464.68
S8	168.97	495.41	777.50	1009.12	1205.17	1371.13	1505.52	1678.29	1830.78	1914.19	1954.26	2074.99
S9	-377.23	-804.64	-1131.35	-1341.15	-1519.10	-1633.64	-1748.52	-1847.61	-1914.02	-1944.70	-1960.49	-2021.08

Table D-34. Phase 4 (250°F) Strain Survey Raw Data (Continued)

S10	-315.08	-135.48	74.04	260.73	440.67	605.23	750.78	896.07	1026.13	1108.88	1148.16	1271.86
S14	-216.53	-183.27	-156.47	-136.19	-118.84	-110.14	-99.27	-86.98	-80.45	-81.18	-80.46	-73.21
S17	-63.12	113.47	267.92	405.12	533.02	651.35	762.05	868.00	970.34	1036.61	1070.69	1167.38
S18	3.53	-164.88	-356.50	-532.47	-695.73	-853.90	-1004.42	-1147.57	-1275.37	-1358.30	-1400.35	-1524.19
S19	-312.29	-194.52	-77.23	28.90	128.87	223.82	315.37	401.50	487.04	543.31	572.27	654.11
S24	493.28	486.84	457.66	444.44	437.37	432.67	427.95	422.73	418.28	413.43	410.40	401.70
S25	446.35	219.02	-136.10	-320.86	-440.98	-517.96	-568.66	-607.18	-629.77	-625.80	-621.82	-629.14
S26	979.06	617.42	235.68	-2.39	-170.88	-286.86	-385.37	-466.19	-518.89	-536.11	-537.63	-529.94
S27	-1958.91	-2133.96	-1288.92	-101.53	1078.31	2096.95	2894.92	3423.50	3753.48	3804.07	3803.34	4050.35
S28	108.83	99.66	110.11	163.09	222.92	242.88	290.77	302.40	339.42	359.20	358.16	376.20
S29	-123.75	80.83	738.31	953.31	1108.32	1240.74	1362.96	1486.08	1604.57	1676.68	1719.13	1833.38
S30	176.20	496.34	925.70	1106.69	1221.78	1311.75	1387.00	1464.27	1536.05	1573.89	1595.81	1658.88
S31	408.05	493.92	554.87	606.30	664.94	731.54	807.54	882.98	974.18	1025.72	1048.19	1137.02
S32	-49.98	89.83	224.30	327.91	441.04	530.81	626.53	721.74	811.71	867.79	899.07	987.75
S33	-775.29	-740.35	-724.31	-725.37	-720.69	-716.51	-714.77	-710.42	-701.55	-698.87	-698.96	-688.93
S34	94.63	83.14	69.30	65.54	66.97	68.95	70.40	69.86	74.34	74.52	73.80	77.58
S35	126.04	-192.30	-424.51	-546.18	-621.17	-671.57	-708.76	-733.25	-742.76	-735.60	-731.62	-719.25
S36	609.11	99.20	-339.83	-596.22	-780.25	-921.78	-1014.15	-1079.18	-1087.83	-1039.75	-1012.16	-959.93
S37	-292.06	-409.91	-487.24	-509.74	-509.35	-501.57	-505.85	-525.11	-526.87	-520.41	-514.90	-507.48
S38	-270.27	-345.83	-407.15	-470.49	-510.30	-531.85	-548.15	-560.58	-575.16	-574.00	-571.15	-570.37
INS2	200.25	563.12	902.77	1177.71	1435.11	1673.99	1885.50	2091.28	2282.25	2404.39	2462.03	2630.23
INS3	44.78	92.93	153.90	214.83	275.27	337.48	396.57	457.64	517.26	533.94	539.74	596.52
INS4	-155.00	-148.32	-143.55	-139.48	-139.39	-136.56	-137.31	-138.06	-138.13	-140.61	-143.32	-144.45
IS24	-0.78	107.01	214.24	301.92	389.15	469.04	540.24	613.53	677.48	719.50	737.95	800.98
IS25	-16.23	110.23	229.26	324.24	416.44	500.21	575.84	653.21	719.61	763.76	782.91	849.12
IS26	183.54	-28.45	-135.17	-186.70	-183.83	-156.23	-113.38	-48.77	19.47	70.29	94.25	182.08
IS27	64.47	41.32	15.99	5.86	13.09	44.93	84.73	142.63	200.50	246.83	268.00	348.47
IS28	-105.23	-86.20	-50.42	-16.61	16.76	50.39	83.16	114.99	145.04	165.69	175.79	207.55
IS29	-89.46	-60.38	-17.36	22.81	61.77	101.21	139.92	176.66	211.02	235.52	247.51	283.40
IS30	-112.27	-184.58	-213.25	-230.63	-239.47	-235.69	-227.69	-214.88	-199.86	-183.52	-177.00	-149.97
IS31	-93.61	-129.24	-139.75	-143.49	-142.34	-132.16	-117.92	-101.44	-83.31	-65.52	-58.15	-30.45
IS32	-243.27	-125.94	-52.04	-5.67	43.60	80.54	114.22	155.89	184.66	200.62	207.68	238.81
P6-1	87.56	64.42	65.40	86.11	110.52	152.88	195.17	252.54	309.25	342.48	366.30	429.32
P6-2	302.06	310.90	372.28	446.95	519.36	607.79	691.96	789.70	884.59	943.20	983.26	1084.27
P6-3	71.16	95.96	165.41	229.30	249.74	238.82	137.26	52.63	-70.03	-300.94	-353.82	-402.21
P6-4	-116.62	-321.76	-649.01	-528.00	-370.31	-211.75	-72.63	64.97	193.94	266.74	309.92	430.17
P6-5	68.70	55.26	100.99	137.96	179.62	236.66	292.76	359.87	428.04	467.48	491.67	561.16
P6-6	14.22	88.83	198.28	247.37	267.83	276.60	269.94	265.40	254.93	242.72	239.54	231.92
P6-7	54.07	-168.77	-352.17	-328.14	-244.00	-142.47	-43.71	62.14	162.70	224.43	263.91	361.42
P6-10	-96.26	39.27	153.31	242.64	325.24	398.73	486.68	584.21	684.15	761.67	806.26	955.45
P6-11	2.90	25.06	44.47	54.64	65.14	62.70	82.01	114.53	145.14	166.77	181.22	255.37
P6-12	57.74	46.50	43.01	36.23	28.82	6.71	3.50	12.09	14.71	7.89	9.79	50.06

Notes: The pressure for load steps 9 and 11 was 1.15 and 1.33 times service load, respectively.
The red strain gage readings represent the readings from the region that was heated to 250°F.

APPENDIX E—STRAIN GAGE DATA REDUCTION PROCEDURE

The raw strain gage data in appendix D was reduced to remove the strain gage offset due to preloading after the panel was installed in the fixture. In the strain gage data reduction, the first two data points were removed to minimize the effects of preloading and free play. A second-order regression using a least squares method was used to curve-fit the remaining data set to a second-order polynomial

$$\varepsilon = Ax^2 + Bx + C$$

where ε is the dependent strain value, x is the independent load increment variable, A is the quadratic coefficient, B is the linear coefficient, and C is the constant term or ordinate intercept. Parameter C was used to define the zero load offset, which was used to shift all data in the set and, finally, to obtain the shifted values. Table E-1(a) shows all the raw readings of strain gage S08, and table E-1(b) shows the raw readings of strain gage S08 with the first two data points removed. The data in table E-1(b) is plotted with strain readings as ordinate and pressure as abscissa, as shown in figure E-1. The data after shifting to zero load offset is shown in figure E-2. Following the procedure defined above, the raw strain gage data documented in appendix D can be reduced. For example, tables E-2 through E-6 show the reduced strain gage data for all the patches in Phase 1 at 60,000 cycles in terms of the nine equal load increments up to the maximum loads for each load sequence. These values were obtained by following the data reduction procedure explained above. Figures E-3 through E-7 show the hoop strains with increasing pressure at different locations for all Phase 1 patches. The reduced results from the strain gages on the exterior surface of the patches and fuselage panel skin and also the interior surface of the panel skin are shown in these figures. The locations of these strain gages and the maximum load applied for these strain survey are also shown.

Table E-1. Raw Data for Strain Gage S08 With the Increasing Pressure (a) Readings of all the Data Points and (b) Readings With First two Data Points Removed

(a)

	Pressure	S08
RUN 1	-0.01	7.60
	0.68	143.16
	1.40	271.51
	2.02	370.61
	2.74	475.72
	3.29	549.19
	4.03	641.31
	4.68	724.82
	5.31	800.97
	6.04	882.71
	6.68	958.50
RUN 2	-0.01	-42.62
	0.69	119.31
	1.38	256.18
	2.03	365.19
	2.70	464.40
	3.36	551.77
	3.95	628.62
	4.68	718.41
	5.34	800.84
	6.02	879.83
	6.64	955.47
RUN 3	-0.03	-53.17
	0.64	117.53
	1.33	244.54
	1.99	353.29
	2.65	447.63
	3.33	539.71
	3.99	628.37
	4.72	717.97
	5.37	801.57
	5.98	875.53
	6.67	955.78

(b)

	Pressure	S08
RUN 1	1.40	271.51
	2.02	370.61
	2.74	475.72
	3.29	549.19
	4.03	641.31
	4.68	724.82
	5.31	800.97
	6.04	882.71
	6.68	958.50
RUN 2	1.38	256.18
	2.03	365.19
	2.70	464.40
	3.36	551.77
	3.95	628.62
	4.68	718.41
	5.34	800.84
	6.02	879.83
	6.64	955.47
RUN 3	1.33	244.54
	1.99	353.29
	2.65	447.63
	3.33	539.71
	3.99	628.37
	4.72	717.97
	5.37	801.57
	5.98	875.53
	6.67	955.78

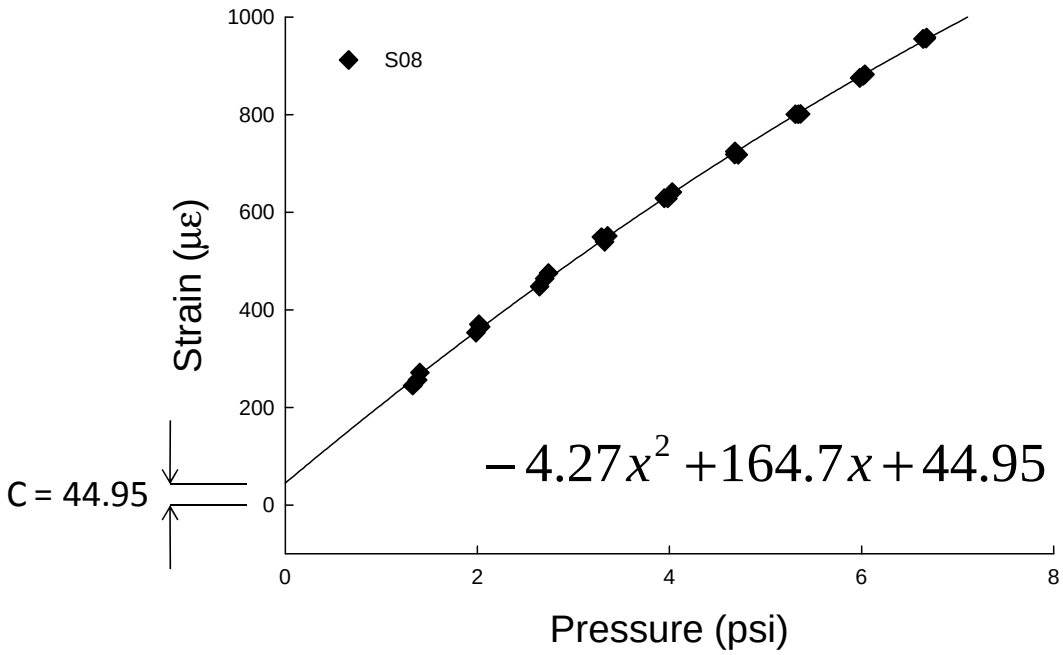


Figure E-1. Raw Strain Gage Reading With Increasing Pressure Showing Y-Intercept

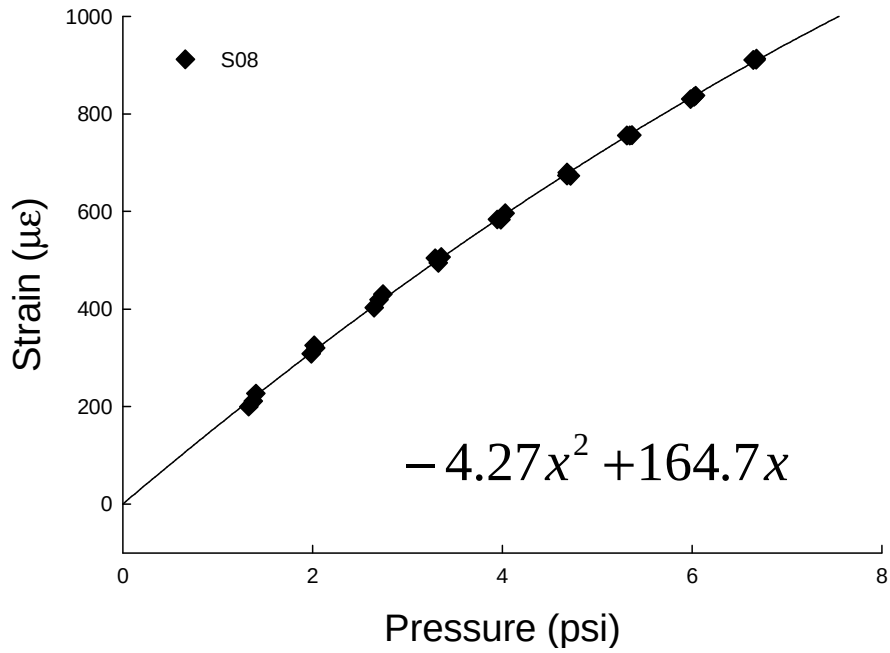


Figure E-2. Strain Gage Reading With Increasing Pressure After Shifting to 0-Load Offset

Table E-2. Strain Gages Reading for Patch S1BE After Data Reduction

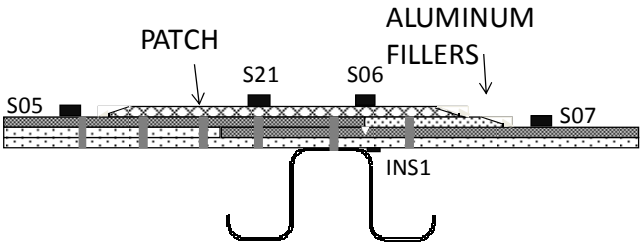
		S07	
Load Step	Run1	Run 2	Run 3
0			
1			
2	194.90	183.39	172.03
3	283.46	279.48	268.60
4	378.42	368.06	353.44
5	446.88	449.61	438.61
6	534.45	522.89	523.20
7	615.71	611.09	610.89
8	691.78	692.80	693.93
9	776.42	773.38	769.97
10	854.76	850.99	852.81

		S21	
Load Step	Run1	Run 2	Run 3
0			
1			
2	102.80	102.29	95.87
3	153.69	155.85	153.61
4	210.06	207.68	201.03
5	257.03	257.79	255.96
6	314.68	309.21	310.35
7	368.54	366.92	369.97
8	426.45	426.99	428.44
9	483.10	484.61	482.96
10	544.15	542.32	545.90

		INS1	
Load Step	Run1	Run 2	Run 3
0			
1			
2	74.57	78.31	77.55
3	110.34	114.84	115.57
4	151.36	152.87	152.11
5	184.15	190.17	191.62
6	227.38	226.68	230.39
7	264.60	268.41	269.87
8	301.87	308.69	310.19
9	340.62	343.77	345.87
10	382.39	386.23	387.69

Note: Strain gages S05 and S06 readings were faulty.

Load Condition	Max. Load
Pressure	6.675 psi
Hoop	7140 lb
Axial	6675 lb
Frame	1132.5 lb



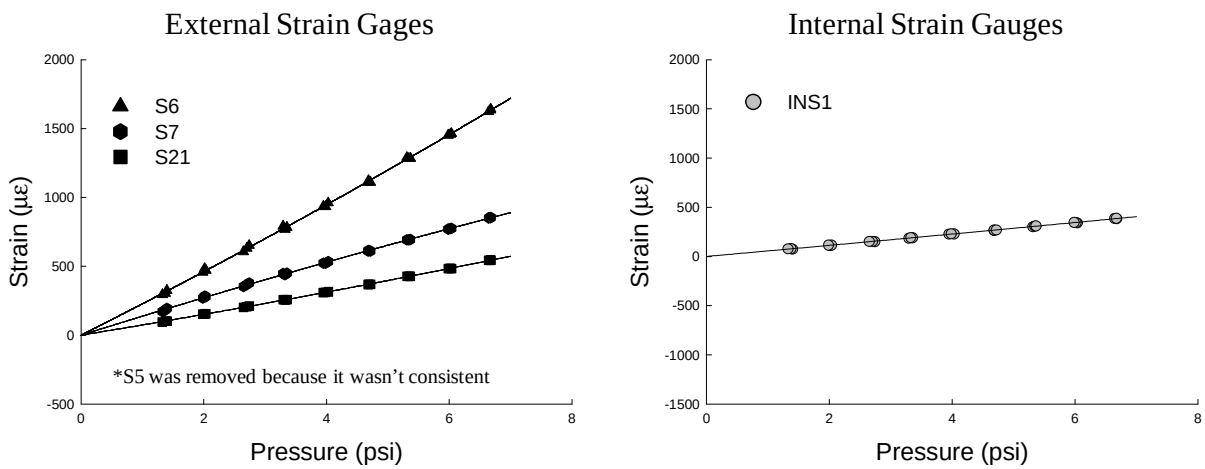


Figure E-3. Strain vs Pressure for Patch S1BE Gages After Data Reduction

Table E-3. Strain Gages Reading for Patch C1BE After Data Reduction

		S08	
Load Step	Run1	Run 2	Run 3
0			
1			
2	226.56	211.23	199.59
3	325.66	320.24	308.34
4	430.77	419.45	402.68
5	504.25	506.82	494.76
6	596.36	583.67	583.43
7	679.88	673.46	673.02
8	756.02	755.89	756.62
9	837.76	834.88	830.58
10	913.55	910.52	910.83

		S09	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-371.61	-364.47	-352.96
3	-541.61	-540.32	-537.76
4	-700.12	-695.02	-684.30
5	-819.04	-823.14	-824.04
6	-947.27	-939.20	-938.28
7	-1055.36	-1057.88	-1059.77
8	-1159.19	-1165.88	-1163.87
9	-1252.48	-1254.79	-1252.98
10	-1336.64	-1337.79	-1340.92

		S10	
Load Step	Run1	Run 2	Run 3
0			
1			
2	205.40	196.93	182.89
3	298.05	298.66	286.82
4	397.15	388.65	374.07
5	466.14	470.48	458.93
6	552.99	542.75	542.15
7	633.16	628.64	628.57
8	706.00	707.39	708.12
9	784.48	783.62	779.11
10	857.95	857.13	856.32

		IS24	
Load Step	Run1	Run 2	Run 3
0			
1			
2	89.70	82.29	77.91
3	142.00	127.87	130.03
4	186.71	172.20	171.64
5	222.83	215.82	219.58
6	275.49	257.39	266.62
7	319.73	301.13	310.72
8	361.31	343.48	349.30
9	407.06	386.57	392.40
10	453.77	444.66	477.66

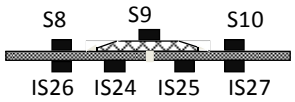
		IS25	
Load Step	Run1	Run 2	Run 3
0			
1			
2	73.30	91.12	106.12
3	117.70	139.68	155.77
4	162.31	183.92	197.84
5	200.72	225.95	242.88
6	245.62	266.85	288.14
7	288.51	310.55	332.79
8	330.82	355.12	378.44
9	370.41	396.09	421.18
10	413.76	437.83	469.43

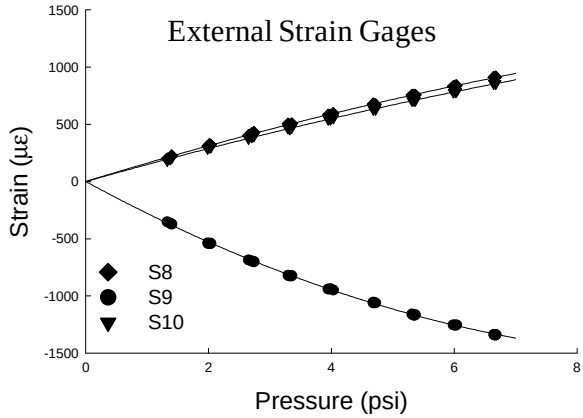
		IS26	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-74.42	-57.18	-50.74
3	-96.27	-84.35	-78.84
4	-116.31	-104.57	-99.78
5	-115.93	-111.92	-108.23
6	-117.40	-109.89	-105.84
7	-111.50	-108.23	-105.46
8	-99.75	-96.67	-95.02
9	-90.38	-83.27	-83.23
10	-69.28	-64.34	-64.15

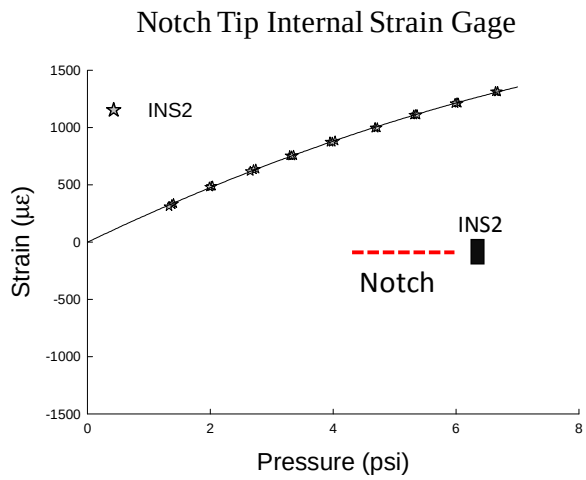
		INS2	
Load Step	Run1	Run 2	Run 3
0			
1			
2	336.54	328.37	311.87
3	488.08	490.20	483.11
4	638.50	632.50	618.18
5	755.52	757.69	754.25
6	883.59	875.12	874.07
7	998.55	997.57	999.36
8	1110.09	1112.94	1112.39
9	1212.87	1216.81	1211.24
10	1313.13	1314.74	1314.82

		IS27	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-75.29	-62.39	-55.94
3	-100.72	-91.81	-88.22
4	-121.74	-111.37	-107.91
5	-123.40	-119.77	-117.66
6	-126.12	-118.26	-115.57
7	-120.65	-116.84	-114.65
8	-109.46	-105.70	-104.88
9	-99.53	-91.38	-92.02
10	-77.92	-72.32	-72.50

Load Condition	Max. Load
Pressure	6.675 psi
Hoop	7140 lb
Axial	6675 lb
Frame	1132.5 lb







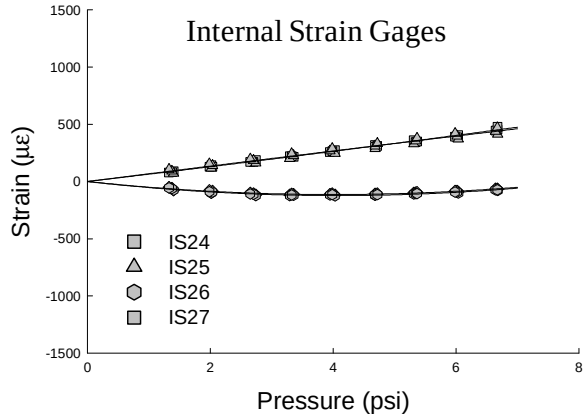


Figure E-4. Strain vs Pressure for Patch C1BE Gages After Data Reduction

Table E-4. Strain Gages Reading for Patch S2BE After Data Reduction

		S11	
Load Step	Run1	Run 2	Run 3
0			
1			
2	387.74	368.16	346.87
3	562.32	560.69	540.70
4	738.22	724.57	699.29
5	858.99	863.79	848.31
6	1002.67	985.80	986.78
7	1130.10	1122.84	1125.08
8	1245.20	1247.57	1250.85
9	1367.22	1366.33	1361.55
10	1476.48	1474.97	1478.81

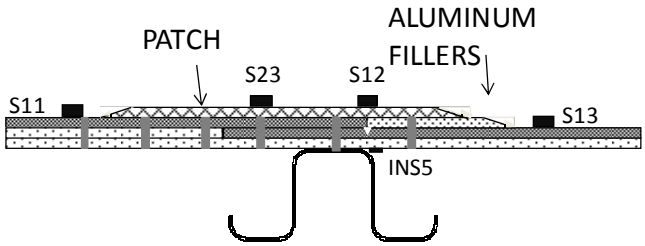
		S12	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-3.63	-8.01	-4.00
3	-5.64	-6.91	-7.82
4	-3.27	-6.00	-7.64
5	-1.63	-4.55	-5.09
6	3.83	-1.27	0.74
7	9.66	4.74	6.56
8	14.21	12.57	15.12
9	23.49	21.86	20.22
10	33.69	29.87	30.60

		S13	
Load Step	Run1	Run 2	Run 3
0			
1			
2	299.44	279.74	255.65
3	433.30	428.13	409.16
4	568.56	553.71	530.73
5	656.52	659.12	643.69
6	765.47	750.37	748.83
7	862.40	856.69	856.23
8	948.23	950.66	951.94
9	1045.52	1042.29	1037.45
10	1130.02	1126.40	1127.91

		S23	
Load Step	Run1	Run 2	Run 3
0			
1			
2	31.01	21.23	21.13
3	41.15	39.62	35.18
4	60.05	56.34	51.40
5	77.44	72.62	70.88
6	99.55	94.13	94.98
7	122.17	118.18	120.61
8	146.99	146.83	149.00
9	172.49	174.44	172.55
10	203.94	203.19	204.08

		INS5	
Load Step	Run1	Run 2	Run 3
0			
1			
2	93.82	93.09	90.06
3	136.47	140.60	137.37
4	182.85	183.21	179.64
5	221.34	224.79	223.12
6	264.90	265.08	266.67
7	307.32	309.18	311.27
8	347.46	351.46	353.76
9	387.49	392.93	392.53
10	429.03	433.67	434.39

Load Condition	Max. Load
Pressure	6.675 psi
Hoop	7140 lb
Axial	6675 lb
Frame	1132.5 lb



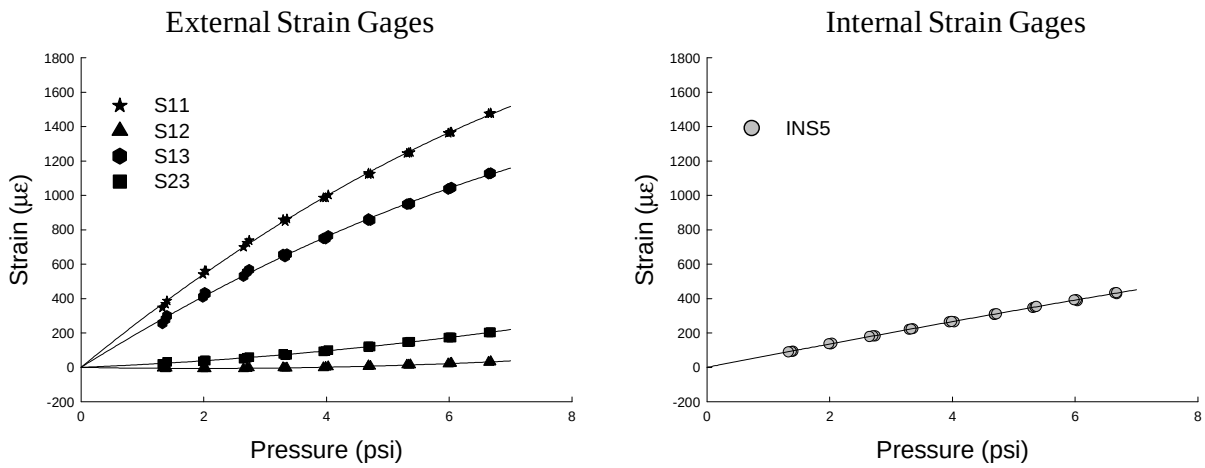


Figure E-5. Strain vs Pressure for Patch S2BE Gages After Data Reduction

Table E-5. Strain Gages Reading for Patch C2A After Data Reduction

		S17	
Load Step	Run1	Run 2	Run 3
0			
1			
2	158.74	150.98	135.86
3	231.07	228.03	219.64
4	311.83	299.14	284.93
5	363.23	365.35	354.91
6	435.20	423.11	424.16
7	502.34	495.05	496.63
8	562.30	560.91	562.91
9	634.08	627.87	624.33
10	695.21	690.34	690.99

		S18	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-282.09	-259.99	-266.27
3	-416.44	-408.01	-391.71
4	-551.64	-543.54	-528.73
5	-669.20	-667.21	-658.20
6	-800.57	-790.39	-787.08
7	-931.57	-928.70	-930.16
8	-1053.08	-1061.51	-1068.52
9	-1196.21	-1193.21	-1189.45
10	-1323.40	-1321.88	-1327.31

		S19	
Load Step	Run1	Run 2	Run 3
0			
1			
2	108.43	98.44	91.26
3	154.58	156.90	144.30
4	212.32	204.09	192.58
5	250.61	252.07	245.04
6	304.20	296.39	295.08
7	357.53	352.22	352.87
8	405.73	404.77	407.73
9	461.18	460.19	455.62
10	512.35	510.32	510.32

		IS28	
Load Step	Run1	Run 2	Run 3
0			
1			
2	52.43	49.67	52.66
3	77.98	79.13	75.49
4	103.50	103.46	100.37
5	126.73	126.85	126.42
6	152.14	151.49	151.52
7	179.25	177.21	178.19
8	202.21	203.01	206.09
9	228.30	229.36	227.50
10	253.41	253.89	253.78

		IS29	
Load Step	Run1	Run 2	Run 3
0			
1			
2	56.44	54.13	56.58
3	84.74	86.07	82.03
4	112.43	112.12	108.39
5	137.23	137.36	136.84
6	164.36	163.71	163.20
7	193.72	191.24	191.85
8	217.58	218.93	221.65
9	245.97	247.09	244.72
10	272.67	273.33	272.94

		IS30	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-40.35	-37.28	-21.09
3	-53.07	-46.72	-45.62
4	-69.26	-60.73	-54.36
5	-69.07	-68.55	-61.99
6	-77.06	-68.36	-68.17
7	-77.40	-75.62	-73.06
8	-78.86	-75.45	-71.09
9	-80.67	-73.64	-73.78
10	-76.32	-70.91	-71.08

		INS4	
Load Step	Run1	Run 2	Run 3
0			
1			
2	159.47	151.27	153.83
3	236.37	234.83	224.26
4	313.73	310.80	300.55
5	384.61	385.55	380.50
6	463.76	460.74	456.95
7	544.94	542.34	543.19
8	617.13	622.06	627.28
9	703.12	703.80	699.51
10	780.64	781.25	782.49

		IS31	
Load Step	Run1	Run 2	Run 3
0			
1			
2	-0.07	5.13	11.66
3	4.92	10.89	11.03
4	7.27	13.47	15.06
5	15.65	17.86	20.63
6	19.18	26.25	25.75
7	28.42	30.55	31.46
8	32.18	36.62	39.93
9	40.24	45.73	45.00
10	48.58	53.38	53.07

Load Condition	Max. Load
Pressure	6.675 psi
Hoop	7140 lb
Axial	6675 lb
Frame	1132.5 lb

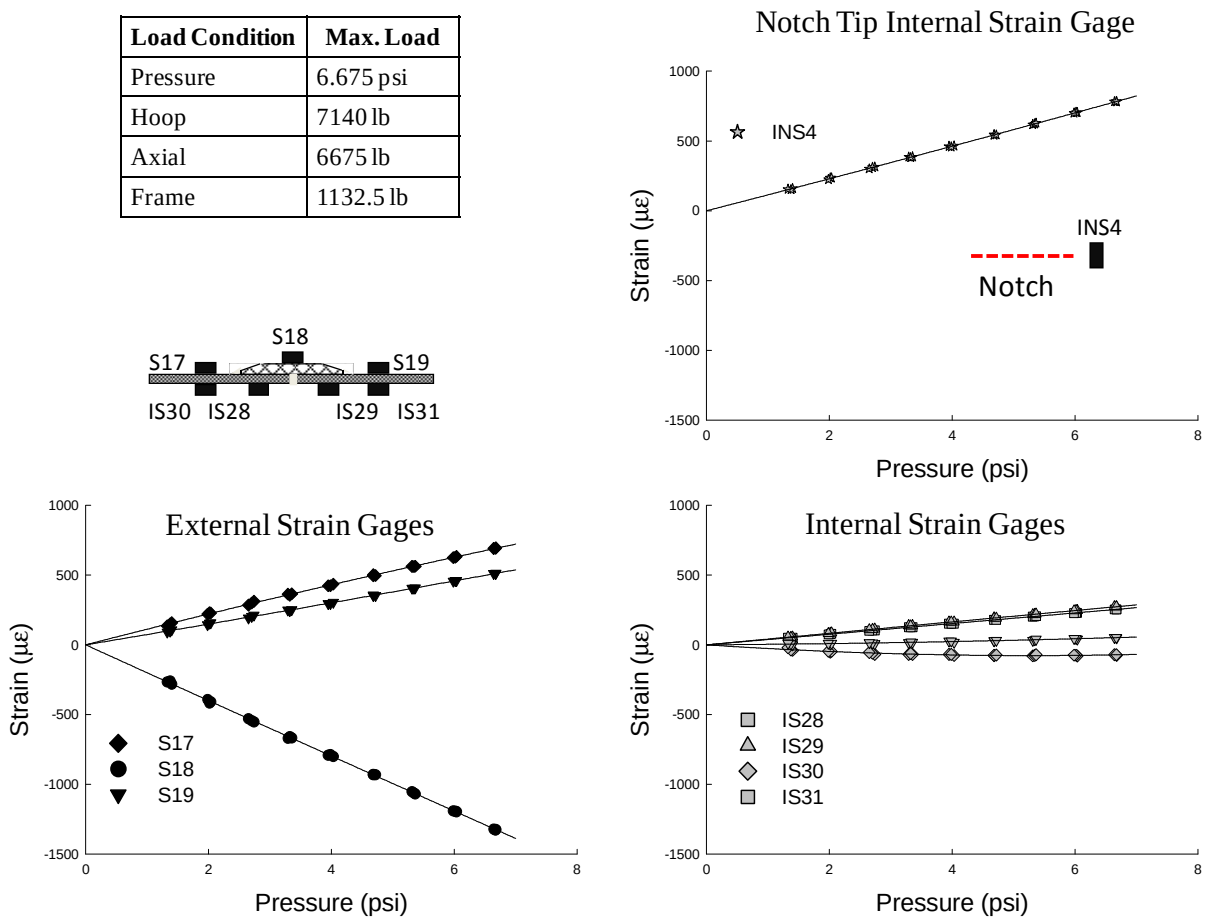


Figure E-6. Strain vs Pressure for Patch C2A Gages After Data Reduction

Table E-6. Strain Gages Reading for Patch S3A After Data Reduction

		S14	
Load Step	Run1	Run 2	Run 3
0			
1			
2	163.19	157.25	140.32
3	236.27	236.74	225.79
4	321.89	312.19	297.77
5	380.29	383.55	372.77
6	458.33	447.78	447.28
7	531.08	527.11	527.64
8	599.96	600.99	603.54
9	678.67	675.71	672.69
10	751.82	747.97	749.34

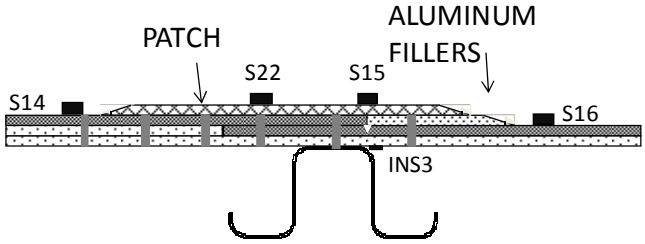
		S15	
Load Step	Run1	Run 2	Run 3
0			
1			
2	61.21	52.54	53.93
3	92.09	86.69	82.00
4	123.94	118.50	111.71
5	146.81	146.08	139.14
6	176.78	171.40	170.70
7	206.21	201.91	202.84
8	230.45	232.18	234.95
9	266.37	265.14	263.26
10	298.83	297.19	297.43

		S16	
Load Step	Run1	Run 2	Run 3
0			
1			
2	128.94	126.26	110.03
3	188.24	189.01	180.59
4	257.71	249.25	235.89
5	304.97	307.52	297.92
6	368.82	359.23	358.33
7	430.48	425.90	425.36
8	486.02	486.58	487.26
9	553.07	549.72	546.46
10	612.70	609.49	609.61

		S22	
Load Step	Run1	Run 2	Run 3
0			
1			
2	85.38	62.71	69.56
3	124.27	112.74	100.90
4	161.05	152.25	143.95
5	192.92	186.43	179.52
6	228.54	221.67	218.05
7	265.42	259.04	260.20
8	301.48	300.20	304.06
9	341.45	340.77	338.26
10	384.70	382.00	382.23

		INS3	
Load Step	Run1	Run 2	Run 3
0			
1			
2	59.64	59.46	61.33
3	87.07	92.09	88.93
4	117.85	119.51	117.27
5	144.32	148.23	148.60
6	174.89	176.39	178.06
7	205.67	206.27	208.47
8	235.46	237.52	241.04
9	262.69	267.56	266.03
10	293.63	296.81	296.50

Load Condition	Max. Load
Pressure	6.675 psi
Hoop	7140 lb
Axial	6675 lb
Frame	1132.5 lb



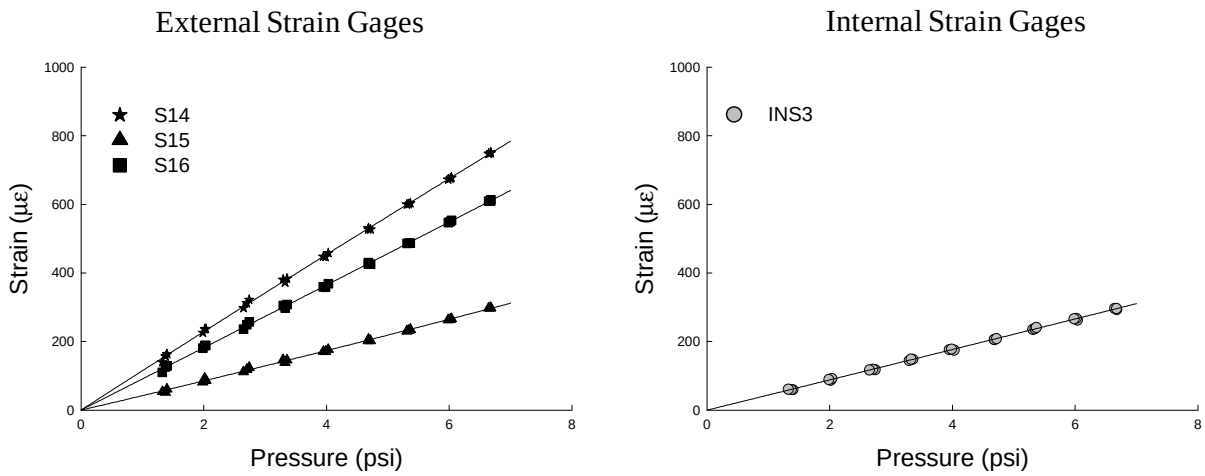


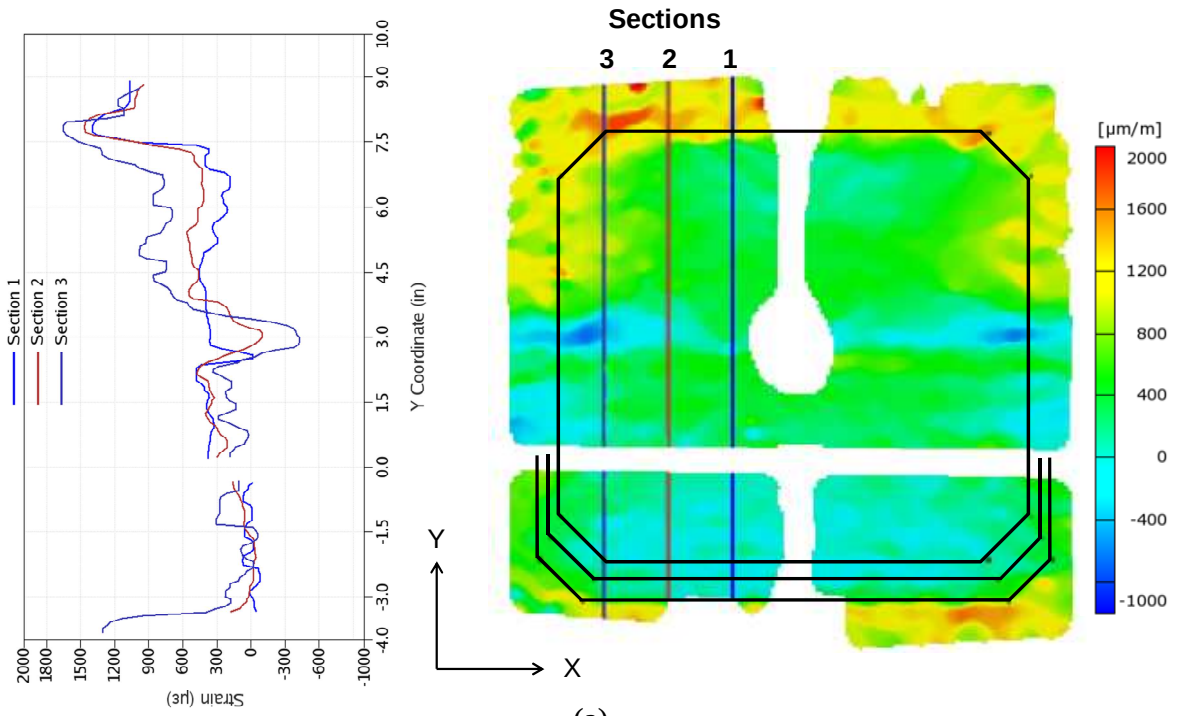
Figure E-7. Strain vs Pressure for Patch S3A Gages After Data Reduction

APPENDIX F—ARAMIS™ STRAIN SURVEY RESULTS

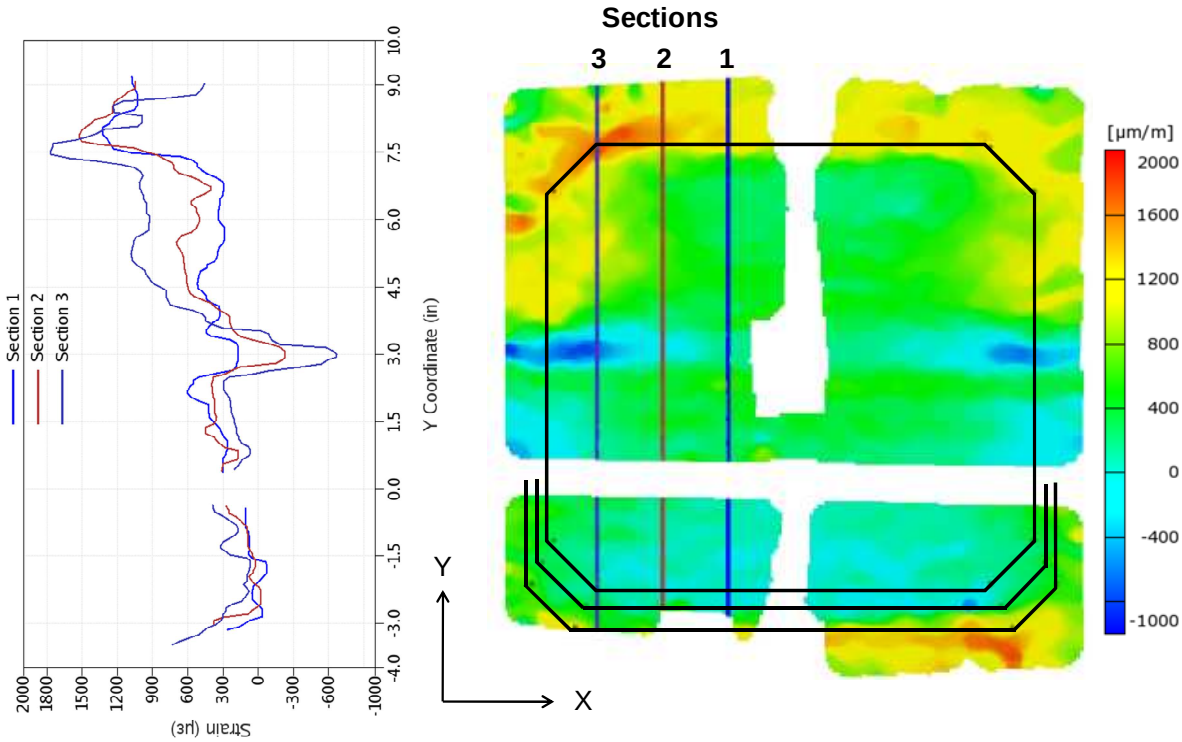
During the strain survey, the ARAMIS snapshots were also captured for all the patches for all test phases except Phase 4. The colored fringe pattern in all the figures of this appendix shows the hoop strain distribution. The accompanying plots show the value of hoop strains along the vertical sections drawn in the figures. All the results are obtained at the maximum strain survey load of each test phase as listed in table F-1. Figures F-2 through F-5 show the ARAMIS strain survey results for test Phase 1 patches at the start and end of test Phase 1, and figure F-6 shows the comparison of lap joint patches at the end of Phase 1 fatigue cycling. Similarly, test Phase 2 C1A patch results are shown in figure F-7 at 0 and 20,000 fatigue cycles. The ARAMIS results of the LJC3A patch are shown in figures F-8 and F-9 at the start and end of test Phase 3 fatigue cycling. In all the figures, the white regions indicate areas where data could not be processed because of interference from strain gage wires.

Table F-1. Load Conditions for the Strain Survey

Test Phase	Maximum Load			
	Pressure (psi)	Hoop (lb)	Frame (lb)	Longitudinal (lb)
1	6.7	7140	1133	6675
2	7.68	8211	1303	6675
3	6.7	7140	1133	6675

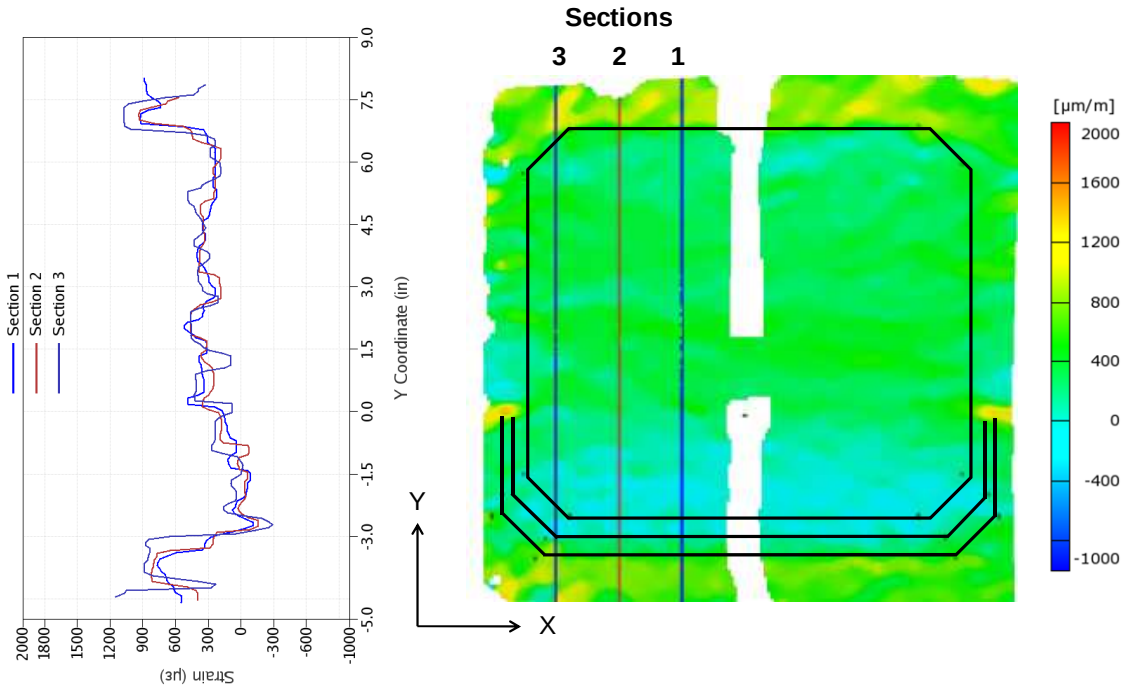


(a)

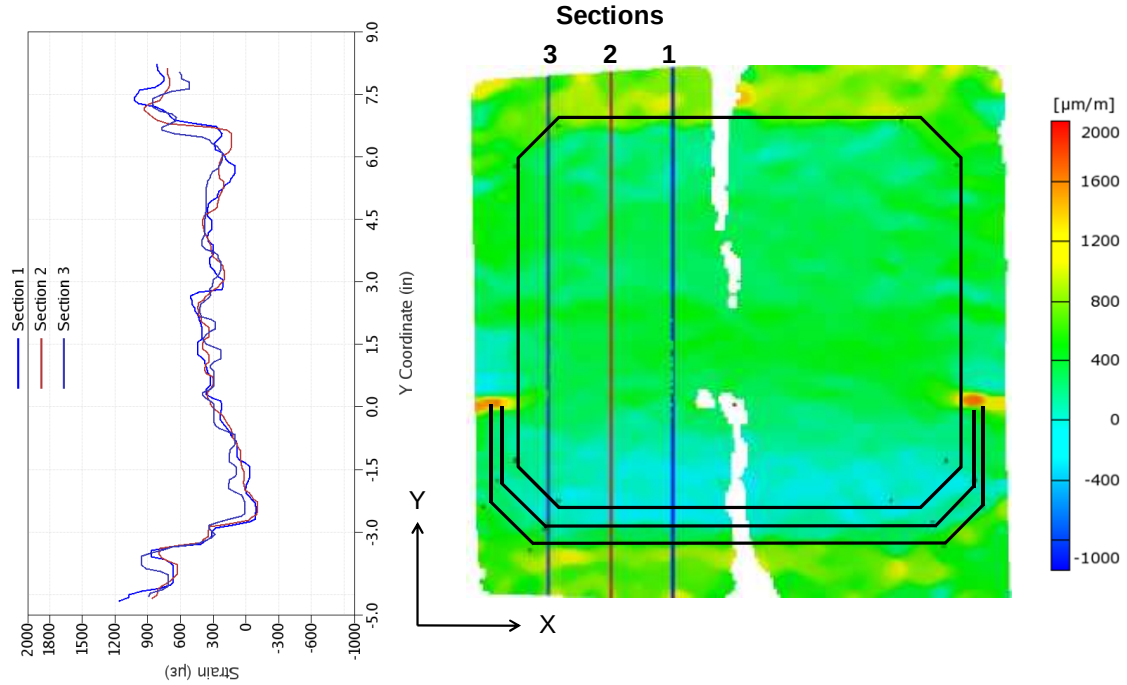


(b)

Figure F-1. ARAMIS Results for S1BE Patch at (a) 0 Fatigue Cycles and (b) 60,000 Fatigue Cycles

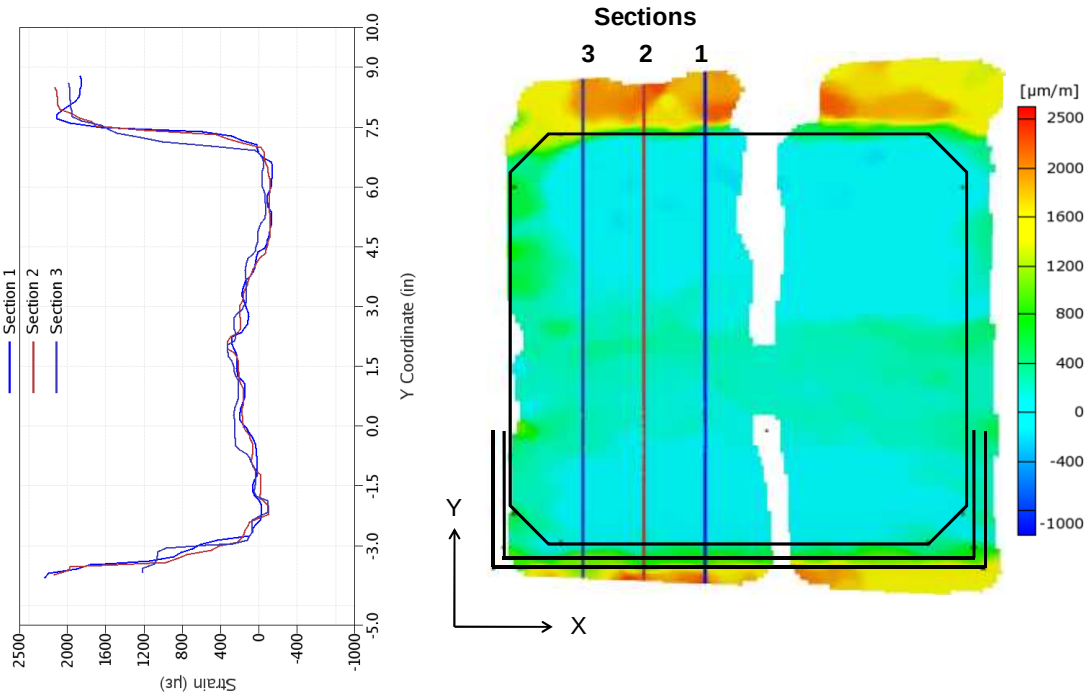


(a)

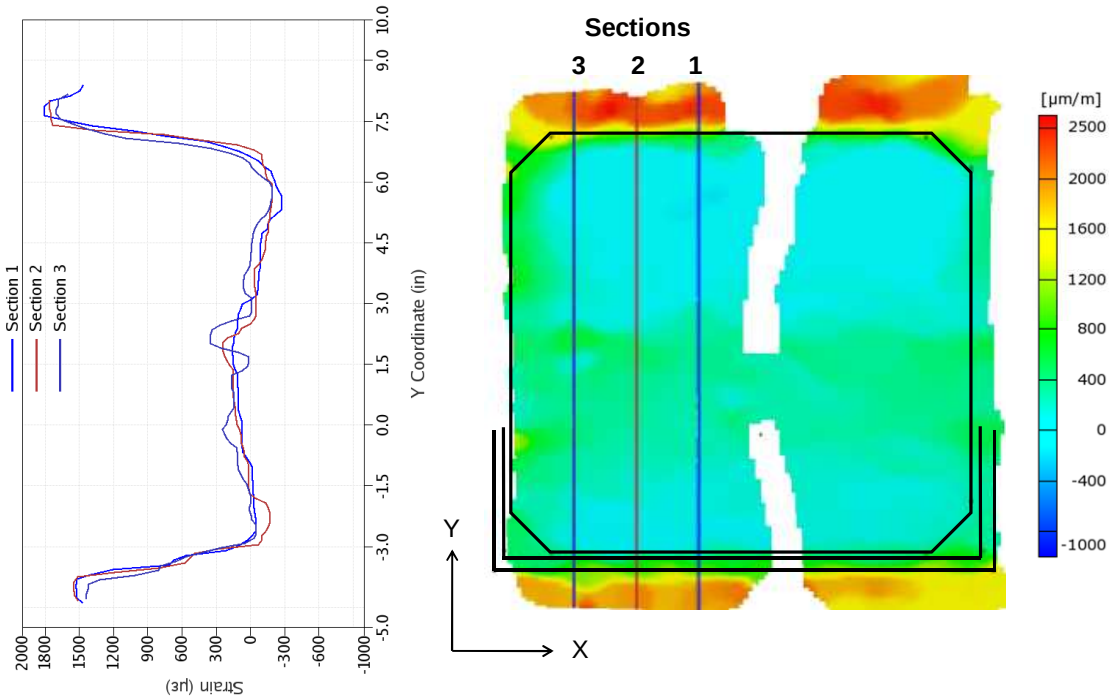


(b)

Figure F-2. ARAMIS Results for S3A Patch at (a) 0 Fatigue Cycles and (b) 60,000 Fatigue Cycles

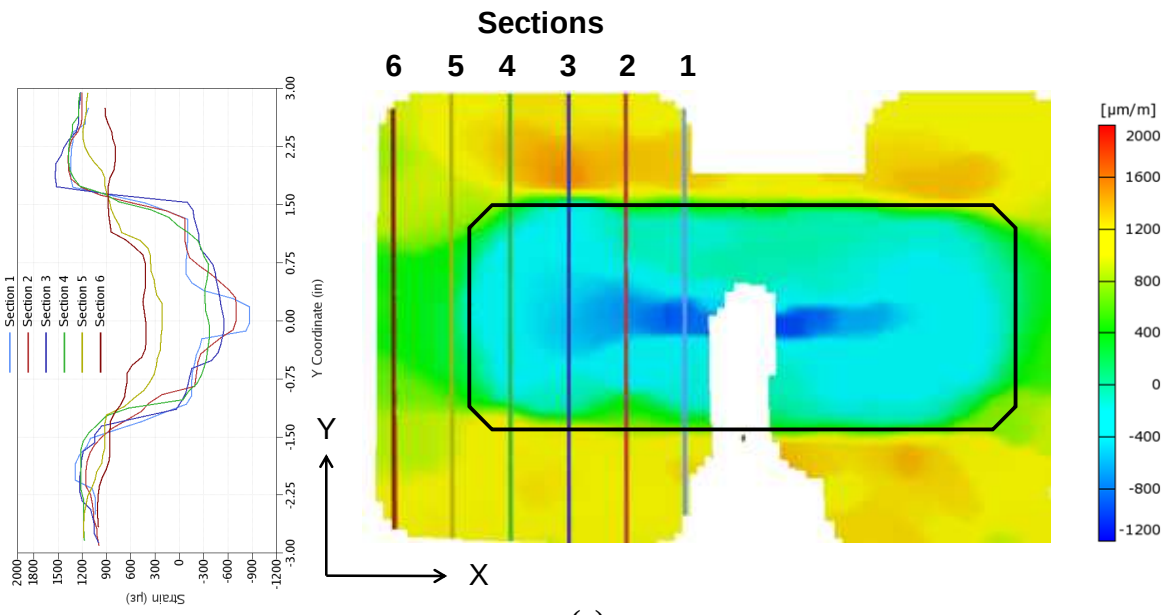


(a)

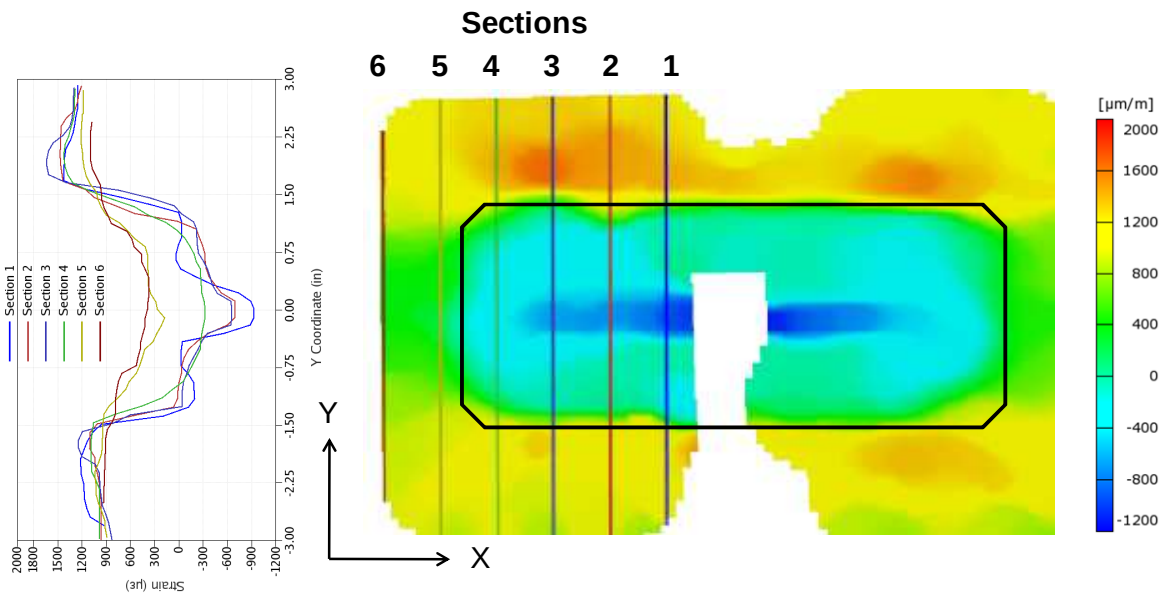


(b)

Figure F-3. ARAMIS Results for S2BE Patch at (a) 0 Fatigue Cycles and (b) 60,000 Fatigue Cycles

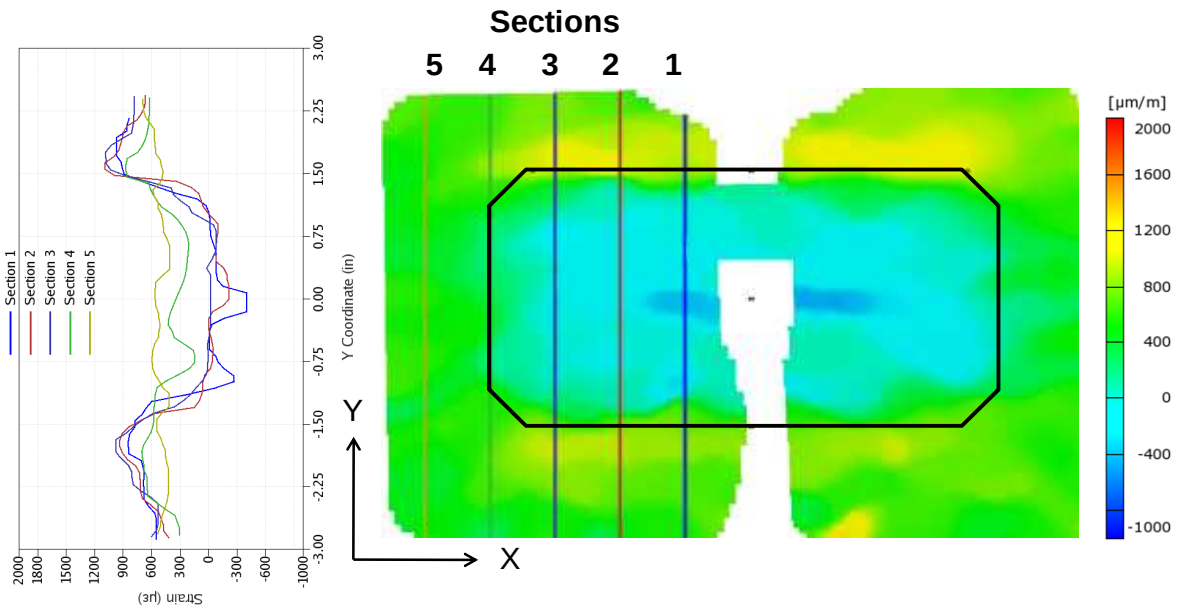


(a)

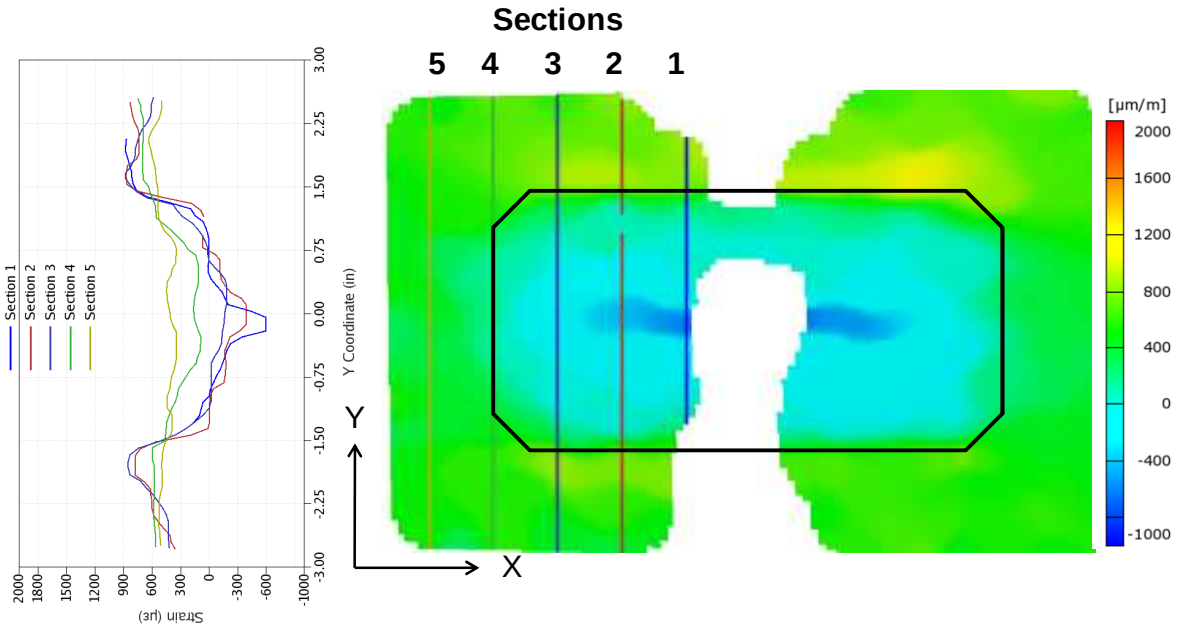


(b)

Figure F-4. ARAMIS Results for C1BE Patch at (a) 0 Fatigue Cycles and (b) 60,000 Fatigue Cycles



(a)



(b)

Figure F-5. ARAMIS Results for C2A Patch at (a) 0 Fatigue Cycles and (b) 60,000 Fatigue Cycles

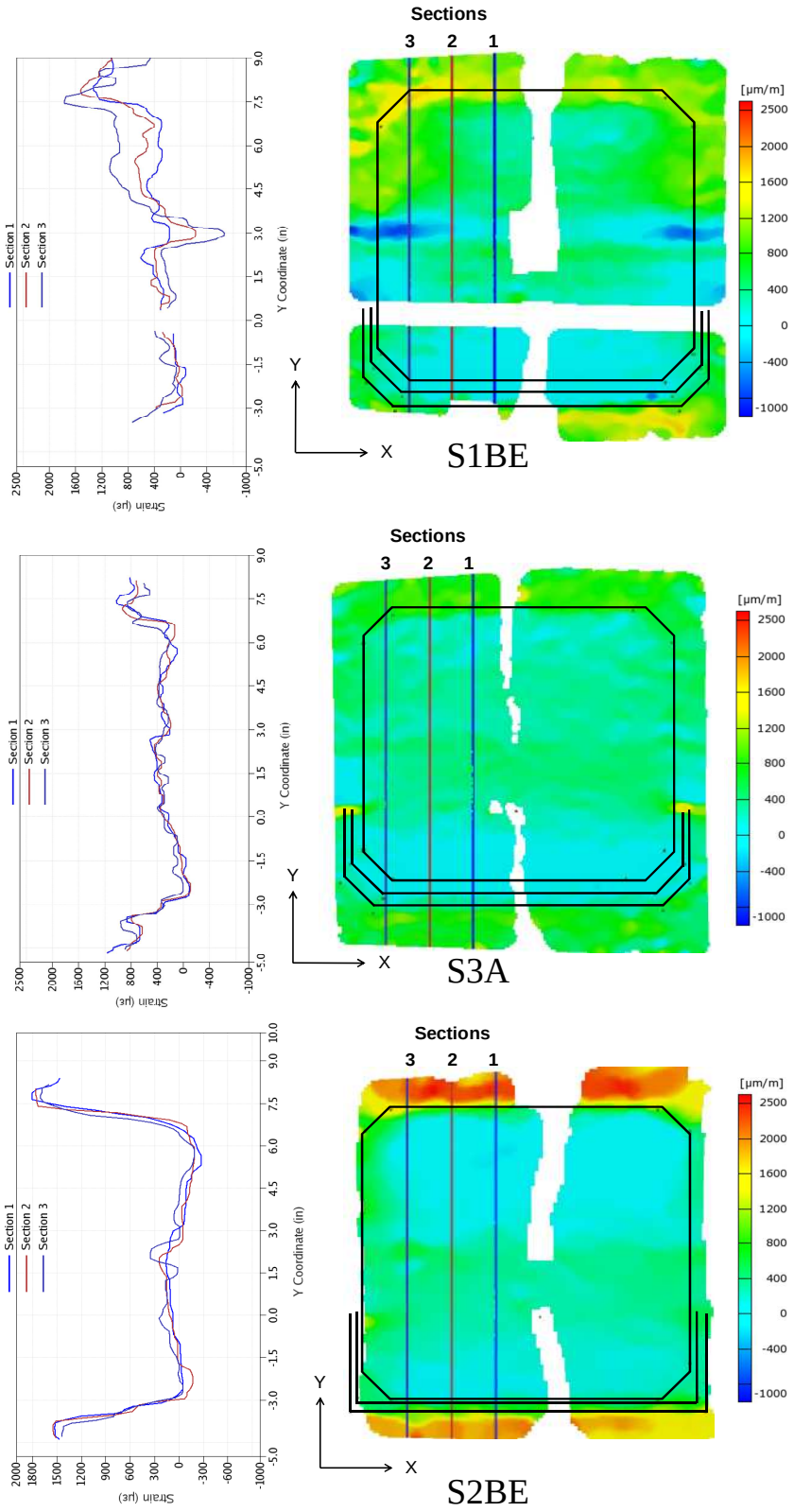
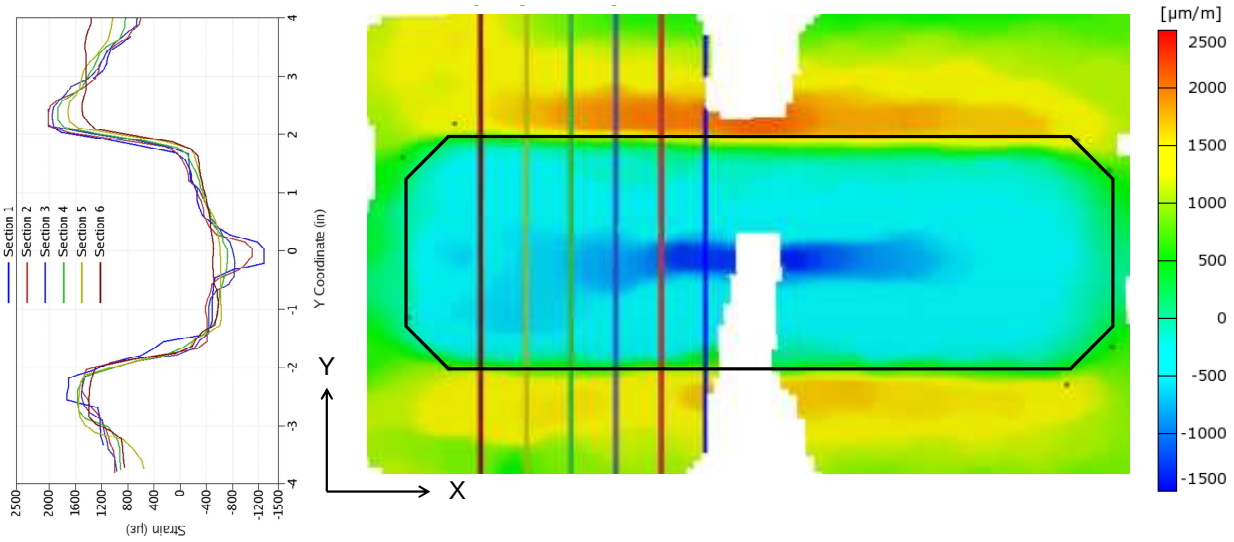
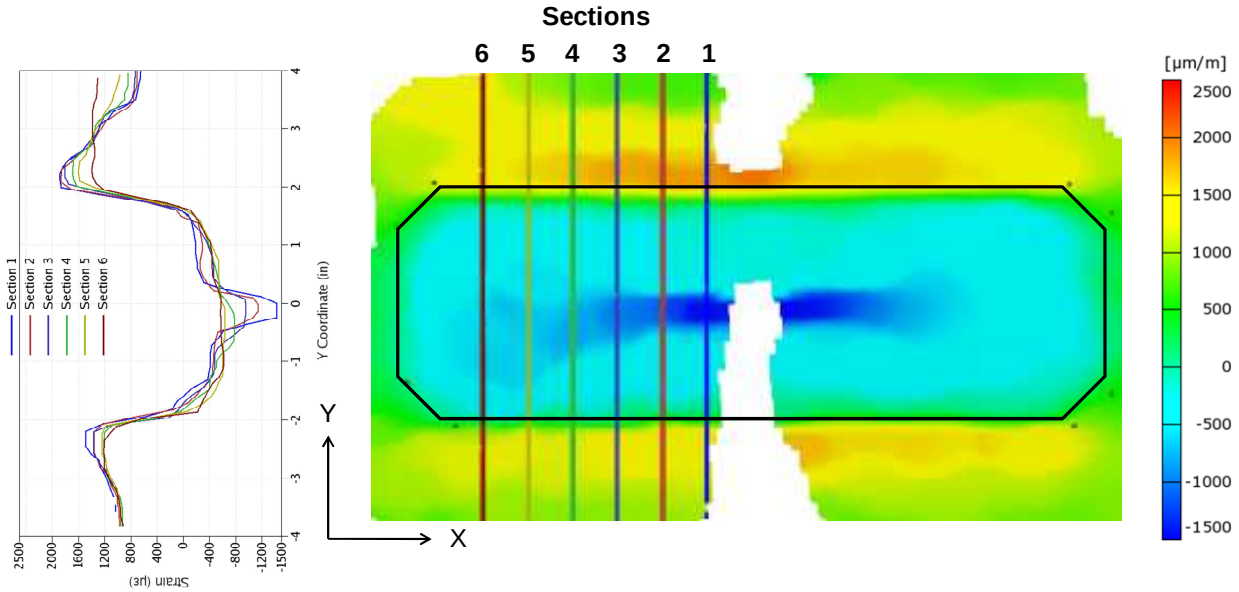


Figure F-6. Section Plots Showing Higher Strain Gradient at the Patch Boundary for S2BE Patch Than for S1BE and S3A Patches



(a)



(b)

Figure F-7. ARAMIS Results for C1A Patch at (a) 0 Fatigue Cycles and (b) 20,000 Fatigue Cycles

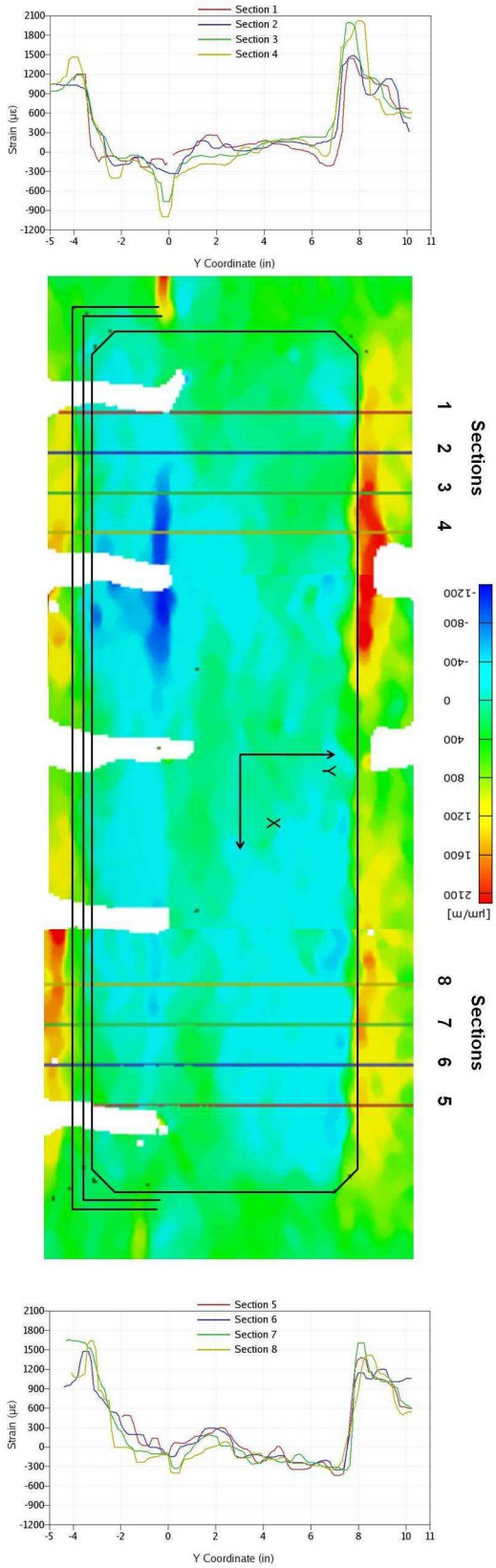


Figure F-8. ARAMIS Results for LJC3A Patch at 0 Fatigue Cycles

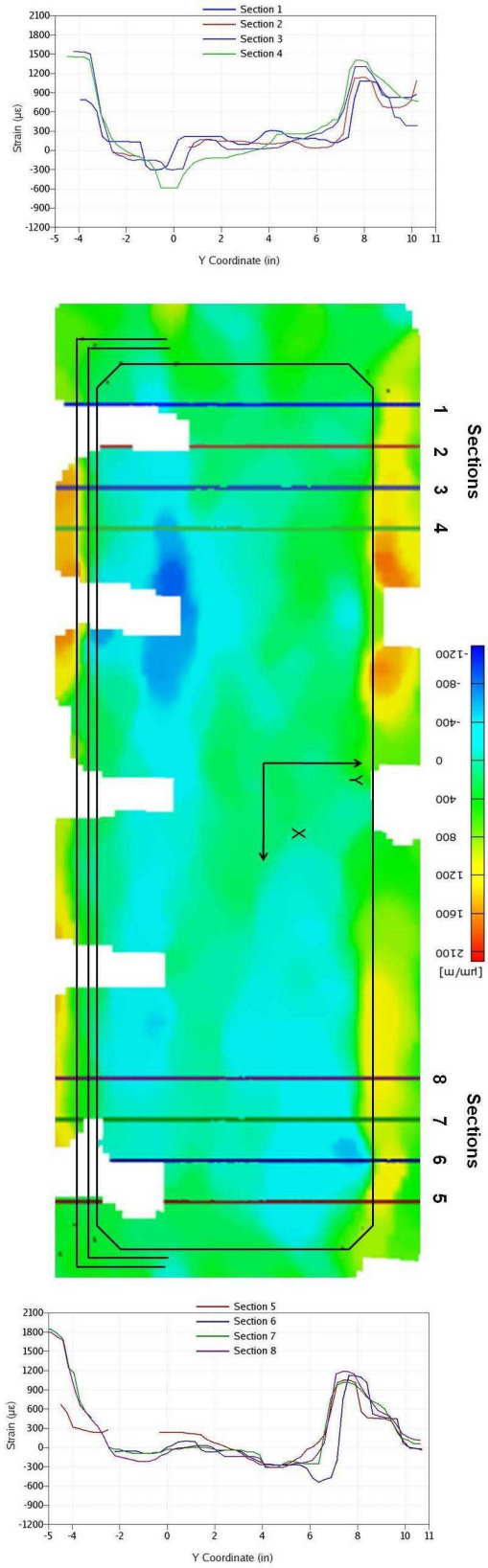


Figure F-9. ARAMIS Results for LJC3A Patch at 20,000 Fatigue Cycles

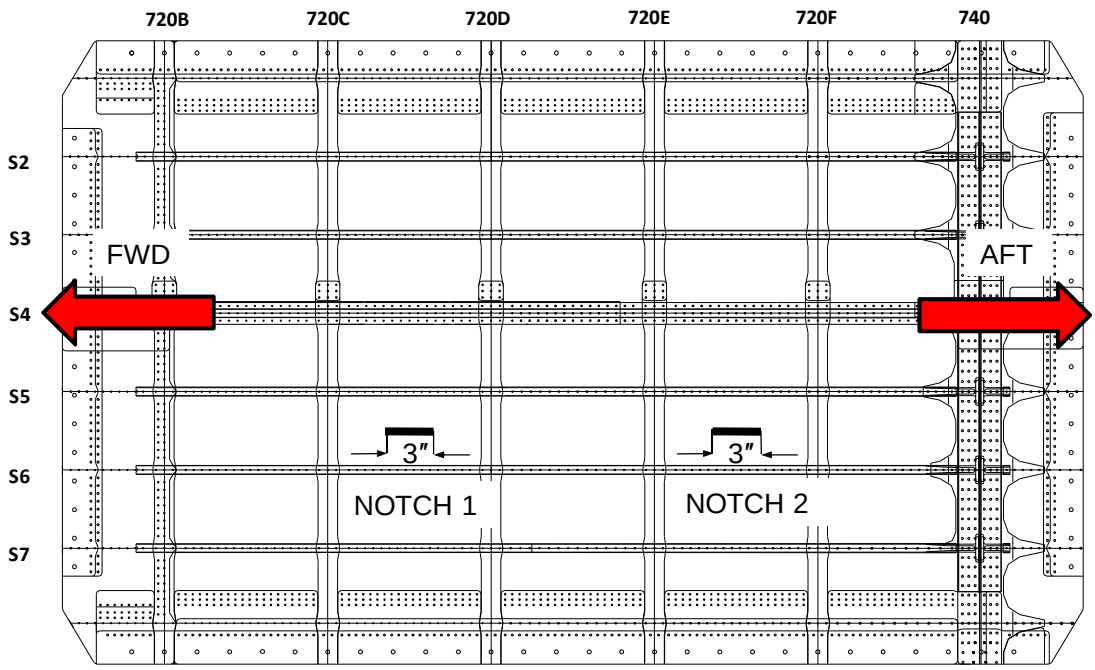
APPENDIX G—CRACK GROWTH DATA

The initial notches introduced at two midbay panel locations were 3 inches in length (2a = 3″). These notches were fatigue presharpened using cyclic loads that were 75% of applied fatigue loads. Fatigue presharpening was applied until a natural crack extended from the notches to a length of 0.04 to 0.157 inch. This appendix summarizes the crack growth data for the notches under C1BE and C2A patches numbered notch 1 and notch 2, respectively. The location of these notches during the precracking phase is shown in figure G-1(a). Figure G-1(b) also shows the location of the patches during Phase 1 fatiguing. These figures also indicates the forward (fwd) and aft ends of the panel.

The crack extension data for both notches during precracking is shown in table G-1 and plotted with increasing cycles in figure G-2. These data were collected using the remote control crack-monitoring camera system. Figure G-2 shows the crack extension (Δa) of the notches on both the fwd and aft ends of the initial notch. The open symbol represents the crack extension for notch 1 and the closed symbol represents notch 2. The solid lines represent the analysis predictions.

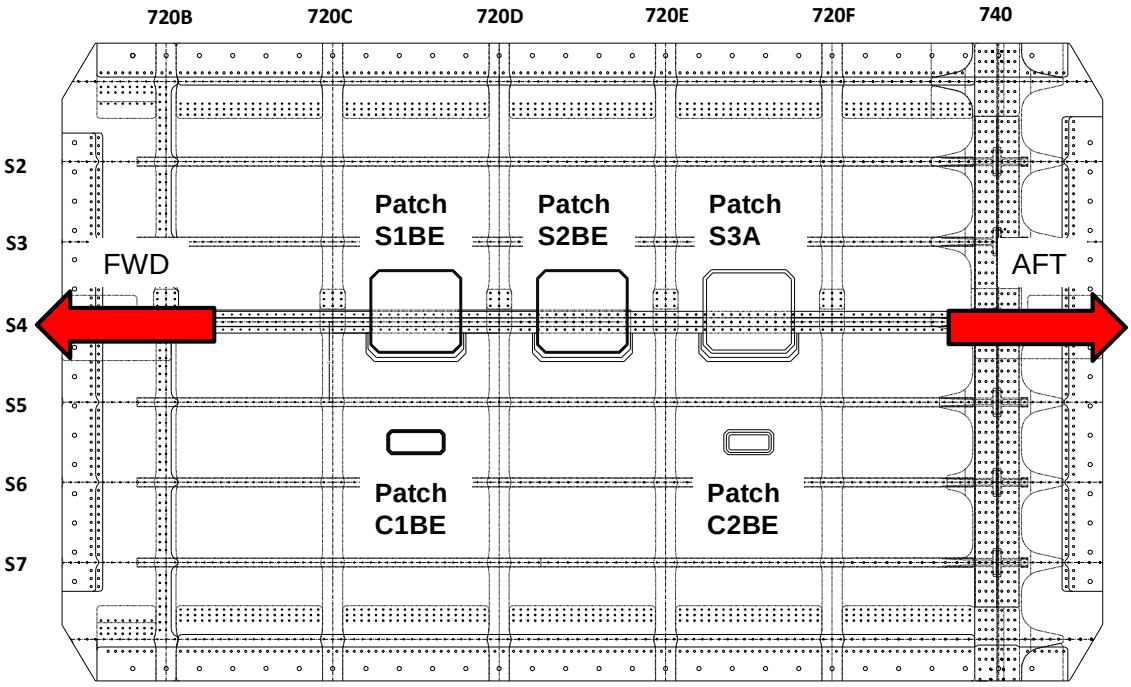
During fatigue cycling, crack extension data were collected after every 100 cycles using the underwater camera system, which is indicated as visual measurements in this appendix. Also, an eddy-current system was used every 5000 cycles to measure crack extension. The eddy-current system was used from both the external surface of the patch and the internal surface of the panel. Crack growth data for C1BE patch is shown in table G-2 in terms of half-crack length. Table G-2 shows the measurements from a visual, internal, and external eddy-current system for both the aft and fwd ends of the patch. The half-crack length measurements from the visual and internal eddy-current systems are plotted in figure G-3. The external eddy current was not included in this plot because of the inability to exactly locate the center of the notch, as the crack could not be visually observed from above the patch. To compare external eddy-current results with the visual and internal eddy-current results, the average of the aft and fwd half-crack lengths was calculated, as shown in table G-2. The comparison of the average of half-crack lengths for all three methods is shown in figure G-4.

Patch C2A was subjected to 110,000 cycles and during these cycles, the crack growth data were collected using the internal eddy-current system at 5000-cycle intervals. Table G-3 shows the half-crack length measurements from all test phases. Similarly, figure G-5 shows the half-crack length measurements for patch C2A during all test phases.



VIEW FROM OUTSIDE THE PANEL

(a)



VIEW FROM OUTSIDE THE PANEL

(b)

Figure G-1. Damage and Patch Locations in Phase 1 (a) During Precracking and (b) During Fatigue Cycling

Table G-1. Crack Extension Data for Notches 1 and 2 During Fatiue Precracking

NOTCH 1			NOTCH 2		
CYCLES	VISUAL		CYCLES	VISUAL	
	Δa_{AFT} (inches)	Δa_{FWD} (inches)		Δa_{AFT} (inches)	Δa_{FWD} (inches)
1000		0.019			
1100		0.023			
1162	0.028	0.027			
1250	0.028	0.030			
1396	0.037	0.034			
1500	0.041	0.037			
1595	0.045	0.038			
1662	0.046	0.038			
1750	0.047	0.049	1662	0.010	0.001
1830	0.052	0.049	1750	0.011	0.006
1940	0.057	0.051	1830	0.015	0.009
2000	0.059	0.062	2000	0.016	0.009
2145	0.060	0.067	2145	0.018	0.013
2250	0.070	0.072	2250	0.018	0.015
2375	0.076	0.077	2375	0.018	0.016
2500	0.082	0.082	2500	0.018	0.018
2625	0.083	0.088	2625	0.020	0.022
2750	0.091	0.089	2750	0.028	0.026
2875	0.096	0.098	2875	0.028	0.026
3000	0.101	0.101	3000	0.035	0.027
3125	0.107	0.108	3125	0.035	0.030
3170	0.108	0.109	3170	0.036	0.030
3250	0.115	0.111	3250	0.038	0.030

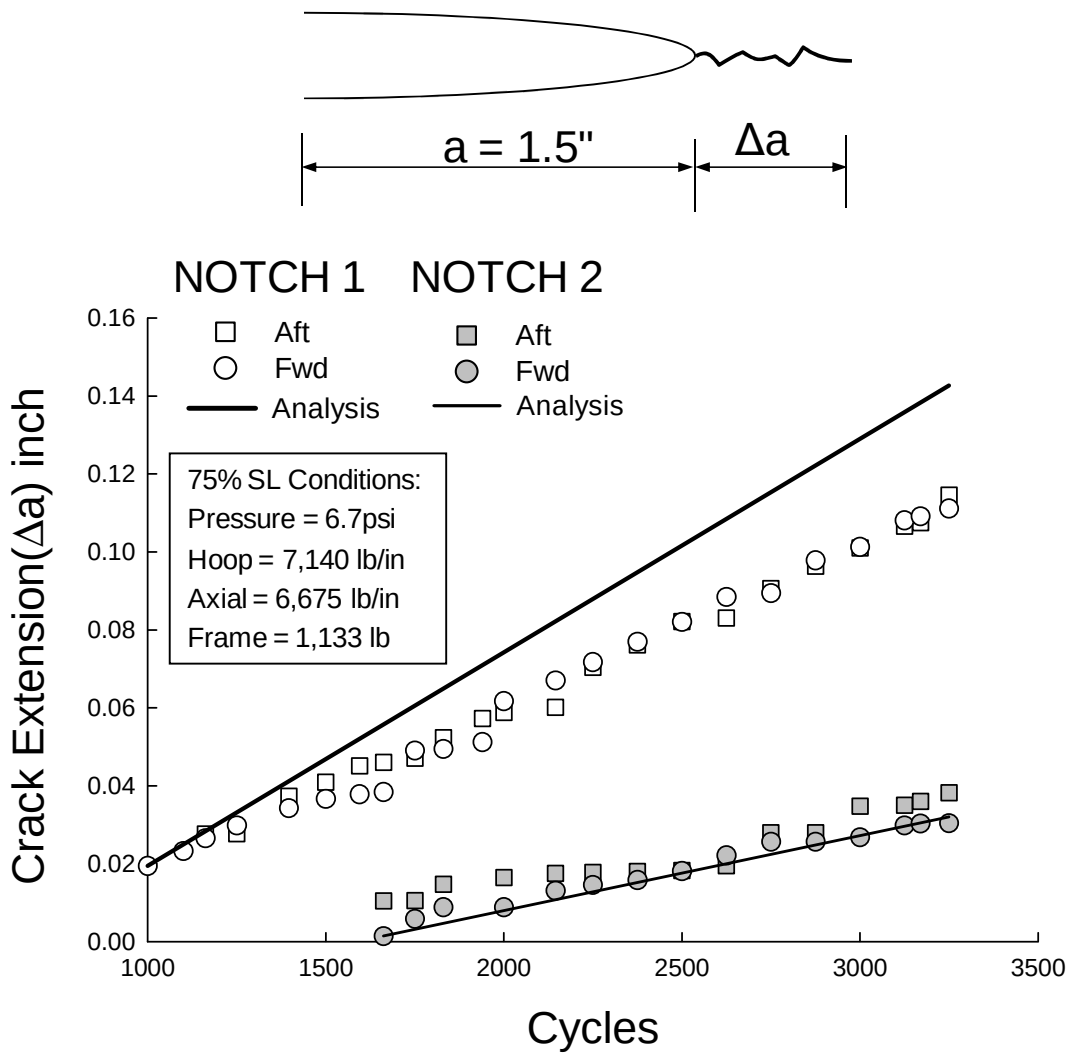


Figure G-2. Crack Extension for Notches 1 and 2 During Fatigue Precracking

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
0	1.712	1.782	1.747	1.759	1.782	1.770			
100	1.712	1.782	1.747						
200	1.712	1.782	1.747						
300	1.712	1.782	1.747						
400	1.712	1.782	1.747						
500	1.712	1.782	1.747						
600	1.712	1.782	1.747						
700	1.712	1.782	1.747						
800	1.712	1.782	1.747						
900	1.712	1.782	1.747						
1000	1.712	1.782	1.747						
1100	1.712	1.782	1.747						
1200	1.712	1.782	1.747						
1300	1.712	1.782	1.747						
1400	1.712	1.782	1.747						
1500	1.712	1.782	1.747						
1600	1.712	1.782	1.747						
1700	1.712	1.782	1.747						
1800	1.712	1.782	1.747						
1900	1.712	1.782	1.747						
2000	1.712	1.782	1.747						
2100	1.712	1.782	1.747						
2200	1.712	1.806	1.759						
2300	1.712	1.806	1.759						
2400	1.712	1.806	1.759						
2500	1.712	1.806	1.759						
2600	1.712	1.806	1.759						
2700	1.712	1.806	1.759						
2800	1.712	1.806	1.759						
2900	1.712	1.806	1.759						
3000	1.712	1.806	1.759						
3100	1.712	1.806	1.759						
3200	1.712	1.806	1.759						
3300	1.712	1.806	1.759						
3400	1.712	1.806	1.759						
3500	1.712	1.806	1.759						
3600	1.712	1.806	1.759						
3700	1.712	1.806	1.759						
3800	1.712	1.806	1.759						
3900	1.712	1.806	1.759						
4000	1.712	1.806	1.759						
4100	1.712	1.806	1.759						
4200	1.712	1.806	1.759						
4300	1.712	1.806	1.759						
4400	1.712	1.806	1.759						
4500	1.712	1.806	1.759						
4600	1.712	1.806	1.759						
4700	1.712	1.806	1.759						
4800	1.712	1.806	1.759						
4900	1.712	1.817	1.764						
5000	1.712	1.817	1.764	1.806	1.829	1.817			

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
5100	1.782	1.829	1.806						
5200	1.782	1.829	1.806						
5300	1.782	1.829	1.806						
5400	1.782	1.829	1.806						
5500	1.782	1.829	1.806						
5600	1.806	1.841	1.823						
5700	1.806	1.841	1.823						
5800	1.806	1.841	1.823						
5900	1.806	1.841	1.823						
6000	1.806	1.841	1.823						
6100	1.806	1.841	1.823						
6200	1.806	1.853	1.829						
6300	1.806	1.853	1.829						
6400	1.806	1.853	1.829						
6500	1.806	1.853	1.829						
6600	1.806	1.853	1.829						
6700	1.806	1.853	1.829						
6800	1.806	1.853	1.829						
6900	1.806	1.853	1.829						
7000	1.806	1.853	1.829						
7100	1.806	1.853	1.829						
7200	1.806	1.853	1.829						
7300	1.806	1.864	1.835						
7400	1.806	1.864	1.835						
7500	1.806	1.864	1.835						
7600	1.806	1.864	1.835						
7700	1.806	1.864	1.835						
7800	1.806	1.864	1.835						
7900	1.806	1.864	1.835						
8000	1.806	1.864	1.835						
8100	1.806	1.864	1.835						
8200	1.806	1.864	1.835						
8300	1.806	1.864	1.835						
8400	1.806	1.864	1.835						
8500	1.806	1.864	1.835						
8600	1.806	1.876	1.841						
8700	1.806	1.876	1.841						
8800	1.806	1.876	1.841						
8900	1.806	1.876	1.841						
9000	1.806	1.876	1.841						
9100	1.806	1.876	1.841						
9200	1.806	1.876	1.841						
9300	1.806	1.888	1.847						
9400	1.806	1.888	1.847						
9500	1.806	1.888	1.847						
9600	1.806	1.888	1.847						
9700	1.806	1.888	1.847						
9800	1.806	1.888	1.847						
9900	1.806	1.888	1.847						
10000	1.806	1.888	1.847	1.876	1.888	1.882			

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
10100	1.806	1.888	1.847						
10200	1.829	1.888	1.858						
10300	1.829	1.888	1.858						
10400	1.829	1.500	1.665						
10500	1.853	1.900	1.876						
10600	1.853	1.900	1.876						
10700	1.853	1.900	1.876						
10800	1.853	1.900	1.876						
10900	1.876	1.900	1.888						
11000	1.876	1.900	1.888						
11100	1.876	1.900	1.888						
11200	1.876	1.900	1.888						
11300	1.876	1.900	1.888						
11400	1.876	1.900	1.888						
11500	1.876	1.900	1.888						
11600	1.876	1.900	1.888						
11700	1.876	1.900	1.888						
11800	1.876	1.911	1.894						
11900	1.876	1.911	1.894						
12000	1.876	1.911	1.894						
12100	1.876	1.911	1.894						
12200	1.876	1.911	1.894						
12300	1.876	1.911	1.894						
12400	1.876	1.911	1.894						
12500	1.876	1.911	1.894						
12600	1.876	1.911	1.894						
12700	1.876	1.923	1.900						
12800	1.876	1.923	1.900						
12900	1.876	1.923	1.900						
13000	1.900	1.923	1.911						
13100	1.900	1.923	1.911						
13200	1.900	1.923	1.911						
13300	1.900	1.923	1.911						
13400	1.900	1.923	1.911						
13500	1.900	1.935	1.917						
13600	1.900	1.935	1.917						
13700	1.900	1.935	1.917						
13800	1.900	1.935	1.917						
13900	1.900	1.935	1.917						
14000	1.900	1.935	1.917						
14100	1.900	1.947	1.923						
14200	1.900	1.947	1.923						
14300	1.900	1.947	1.923						
14400	1.900	1.947	1.923						
14500	1.900	1.947	1.923						
14600	1.900	1.947	1.923						
14700	1.900	1.947	1.923						
14800	1.900	1.947	1.923						
14900	1.900	1.947	1.923						
15000	1.900	1.947	1.923	1.947	1.994	1.970	0.440	0.320	0.380

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
15200	1.900	1.958	1.929						
15300	1.900	1.958	1.929						
15400	1.900	1.958	1.929						
15500	1.911	1.958	1.935						
15600	1.911	1.958	1.935						
15700	1.911	1.958	1.935						
15800	1.923	1.958	1.941						
15900	1.923	1.958	1.941						
16000	1.923	1.958	1.941						
16100	1.923	1.970	1.947						
16200	1.923	1.970	1.947						
16300	1.923	1.970	1.947						
16400	1.923	1.970	1.947						
16500	1.923	1.970	1.947						
16600	1.923	1.970	1.947						
16700	1.923	1.970	1.947						
16800	1.935	1.970	1.952						
16900	1.935	1.970	1.952						
17000	1.935	1.970	1.952						
17100	1.935	1.970	1.952						
17200	1.935	1.970	1.952						
17300	1.935	1.970	1.952						
17400	1.935	1.970	1.952						
17500	1.935	1.970	1.952						
17600	1.935	1.970	1.952						
17700	1.935	1.970	1.952						
17800	1.935	1.970	1.952						
17900	1.935	1.970	1.952						
18000	1.935	1.970	1.952						
18100	1.935	1.970	1.952						
18200	1.935	1.982	1.958						
18300	1.935	1.982	1.958						
18400	1.935	1.982	1.958						
18500	1.935	1.982	1.958						
18600	1.935	1.982	1.958						
18700	1.935	1.982	1.958						
18800	1.935	1.982	1.958						
18900	1.935	1.994	1.964						
19000	1.935	1.994	1.964						
19100	1.947	1.994	1.970						
19200	1.947	1.994	1.970						
19300	1.947	1.994	1.970						
19400	1.947	1.994	1.970						
19500	1.947	1.994	1.970						
19600	1.947	1.994	1.970						
19700	1.947	1.994	1.970						
19800	1.947	1.994	1.970						
19900	1.947	1.994	1.970						
20000	1.947	1.994	1.970	1.970	2.064	2.017	0.500	0.406	0.453

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
20100	1.947	2.005	1.976						
20200	1.947	2.005	1.976						
20300	1.947	2.005	1.976						
20400	1.947	2.005	1.976						
20500	1.947	2.005	1.976						
20600	1.947	2.017	1.982						
20700	1.947	2.017	1.982						
20800	1.947	2.017	1.982						
20900	1.947	2.017	1.982						
21000	1.947	2.017	1.982						
21100	1.947	2.017	1.982						
21200	1.947	2.052	1.999						
21300	1.947	2.052	1.999						
21400	1.947	2.052	1.999						
21500	1.947	2.052	1.999						
21600	1.947	2.052	1.999						
21700	1.947	2.052	1.999						
21800	1.947	2.052	1.999						
21900	1.947	2.052	1.999						
22000	1.947	2.052	1.999						
22100	1.947	2.052	1.999						
22200	1.947	2.052	1.999						
22300	1.947	2.052	1.999						
22400	1.947	2.052	1.999						
22500	1.970	2.052	2.011						
22600	1.970	2.064	2.017						
22700	1.970	2.064	2.017						
22800	1.970	2.064	2.017						
22900	1.970	2.064	2.017						
23000	1.970	2.064	2.017						
23100	1.970	2.064	2.017						
23200	1.970	2.064	2.017						
23300	1.970	2.064	2.017						
23400	1.970	2.064	2.017						
23500	1.994	2.064	2.029						
23600	1.994	2.064	2.029						
23700	1.994	2.064	2.029						
23800	1.994	2.064	2.029						
23900	1.994	2.064	2.029						
24000	1.994	2.064	2.029						
24100	1.994	2.064	2.029						
24200	1.994	2.064	2.029						
24300	1.994	2.064	2.029						
24400	1.994	2.064	2.029						
24500	1.994	2.064	2.029						
24600	1.994	2.064	2.029						
24700	1.994	2.064	2.029						
24800	1.994	2.064	2.029						
24900	2.005	2.064	2.035						
25000	2.005	2.064	2.035	2.017	2.088	2.052	0.563	0.438	0.500

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
25100	2.005	2.064	2.035						
25200	2.017	2.064	2.041						
25300	2.017	2.064	2.041						
25400	2.017	2.064	2.041						
25500	2.017	2.064	2.041						
25600	2.017	2.064	2.041						
25700	2.017	2.064	2.041						
25800	2.017	2.064	2.041						
25900	2.017	2.064	2.041						
26000	2.017	2.064	2.041						
26100	2.017	2.064	2.041						
26200	2.017	2.064	2.041						
26300	2.017	2.064	2.041						
26400	2.017	2.064	2.041						
26500	2.017	2.064	2.041						
26600	2.017	2.064	2.041						
26700	2.017	2.064	2.041						
26800	2.017	2.064	2.041						
26900	2.017	2.064	2.041						
27000	2.017	2.064	2.041						
27100	2.017	2.064	2.041						
27200	2.017	2.088	2.052						
27300	2.017	2.088	2.052						
27400	2.017	2.088	2.052						
27500	2.017	2.088	2.052						
27600	2.017	2.088	2.052						
27700	2.017	2.088	2.052						
27800	2.017	2.088	2.052						
27900	2.017	2.088	2.052						
28000	2.017	2.088	2.052						
28100	2.017	2.088	2.052						
28200	2.017	2.088	2.052						
28300	2.017	2.088	2.052						
28400	2.017	2.088	2.052						
28500	2.017	2.088	2.052						
28600	2.017	2.088	2.052						
28700	2.017	2.088	2.052						
28800	2.017	2.088	2.052						
28900	2.017	2.088	2.052						
29000	2.017	2.088	2.052						
29100	2.017	2.088	2.052						
29200	2.017	2.088	2.052						
29300	2.017	2.088	2.052						
29400	2.064	2.088	2.076						
29500	2.064	2.088	2.076						
29600	2.064	2.088	2.076						
29700	2.064	2.088	2.076						
29800	2.064	2.088	2.076						
29900	2.064	2.088	2.076						
30000	2.064	2.088	2.076	2.064	2.111	2.088	0.594	0.469	0.531

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
30100	2.088	2.111	2.099						
30200	2.088	2.111	2.099						
30300	2.088	2.111	2.099						
30400	2.088	2.111	2.099						
30500	2.088	2.111	2.099						
30600	2.088	2.111	2.099						
30700	2.099	2.111	2.105						
30800	2.099	2.111	2.105						
30900	2.099	2.111	2.105						
31000	2.099	2.111	2.105						
31100	2.099	2.111	2.105						
31200	2.099	2.111	2.105						
31300	2.099	2.111	2.105						
31400	2.099	2.111	2.105						
31500	2.099	2.111	2.105						
31600	2.099	2.111	2.105						
31700	2.099	2.111	2.105						
31800	2.099	2.123	2.111						
31900	2.099	2.135	2.117						
32000	2.099	2.135	2.117						
32100	2.099	2.135	2.117						
32200	2.099	2.135	2.117						
32300	2.099	2.135	2.117						
32400	2.099	2.135	2.117						
32500	2.099	2.135	2.117						
32600	2.099	2.135	2.117						
32700	2.099	2.135	2.117						
32800	2.099	2.135	2.117						
32900	2.099	2.135	2.117						
33000	2.099	2.135	2.117						
33100	2.123	2.135	2.129						
33200	2.123	2.135	2.129						
33300	2.123	2.135	2.129						
33400	2.123	2.135	2.129						
33500	2.123	2.135	2.129						
33600	2.123	2.135	2.129						
33700	2.123	2.135	2.129						
33800	2.135	2.135	2.135						
33900	2.135	2.146	2.140						
34000	2.135	2.146	2.140						
34100	2.135	2.146	2.140						
34200	2.135	2.146	2.140						
34300	2.135	2.146	2.140						
34400	2.135	2.146	2.140						
34500	2.135	2.146	2.140						
34600	2.135	2.146	2.140						
34700	2.135	2.146	2.140						
34800	2.135	2.158	2.146						
34900	2.135	2.158	2.146						
35000	2.135	2.158	2.146	2.135	2.182	2.158	0.656	0.578	0.617

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
35100	2.135	2.158	2.146						
35200	2.135	2.158	2.146						
35300	2.135	2.158	2.146						
35400	2.135	2.170	2.152						
35500	2.135	2.170	2.152						
35600	2.135	2.170	2.152						
35700	2.135	2.170	2.152						
35800	2.135	2.170	2.152						
35900	2.135	2.170	2.152						
36000	2.135	2.170	2.152						
36100	2.135	2.170	2.152						
36200	2.135	2.170	2.152						
36300	2.135	2.170	2.152						
36400	2.135	2.170	2.152						
36500	2.135	2.170	2.152						
36600	2.135	2.170	2.152						
36700	2.135	2.170	2.152						
36800	2.135	2.170	2.152						
36900	2.135	2.170	2.152						
37000	2.135	2.170	2.152						
37100	2.135	2.170	2.152						
37200	2.135	2.193	2.164						
37300	2.135	2.193	2.164						
37400	2.135	2.193	2.164						
37500	2.135	2.193	2.164						
37600	2.135	2.193	2.164						
37700	2.146	2.193	2.170						
37800	2.146	2.193	2.170						
37900	2.146	2.193	2.170						
38000	2.146	2.193	2.170						
38100	2.146	2.193	2.170						
38200	2.146	2.193	2.170						
38300	2.146	2.193	2.170						
38400	2.146	2.193	2.170						
38500	2.146	2.193	2.170						
38600	2.146	2.217	2.182						
38700	2.146	2.217	2.182						
38800	2.146	2.217	2.182						
38900	2.146	2.217	2.182						
39000	2.146	2.217	2.182						
39100	2.146	2.217	2.182						
39200	2.146	2.217	2.182						
39300	2.146	2.217	2.182						
39400	2.146	2.229	2.187						
39500	2.146	2.229	2.187						
39600	2.146	2.229	2.187						
39700	2.146	2.229	2.187						
39800	2.146	2.229	2.187						
39900	2.146	2.252	2.199						
40000	2.146	2.252	2.199	2.205	2.252	2.229	0.672	0.688	0.680

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
40100	2.146	2.252	2.199						
40200	2.158	2.252	2.205						
40300	2.158	2.252	2.205						
40400	2.158	2.252	2.205						
40500	2.158	2.252	2.205						
40600	2.158	2.252	2.205						
40700	2.158	2.252	2.205						
40800	2.158	2.252	2.205						
40900	2.158	2.252	2.205						
41000	2.158	2.252	2.205						
41100	2.158	2.252	2.205						
41200	2.158	2.252	2.205						
41300	2.158	2.252	2.205						
41400	2.158	2.252	2.205						
41500	2.158	2.252	2.205						
41600	2.158	2.252	2.205						
41700	2.158	2.252	2.205						
41800	2.158	2.264	2.211						
41900	2.158	2.264	2.211						
42000	2.158	2.264	2.211						
42100	2.158	2.264	2.211						
42200	2.158	2.264	2.211						
42300	2.158	2.264	2.211						
42400	2.158	2.264	2.211						
42500	2.158	2.264	2.211						
42600	2.158	2.264	2.211						
42700	2.158	2.264	2.211						
42800	2.158	2.264	2.211						
42900	2.158	2.264	2.211						
43000	2.158	2.264	2.211						
43100	2.158	2.264	2.211						
43200	2.158	2.264	2.211						
43300	2.170	2.276	2.223						
43400	2.170	2.276	2.223						
43500	2.170	2.276	2.223						
43600	2.170	2.276	2.223						
43700	2.170	2.276	2.223						
43800	2.170	2.276	2.223						
43900	2.170	2.276	2.223						
44000	2.170	2.276	2.223						
44100	2.170	2.276	2.223						
44200	2.170	2.276	2.223						
44300	2.170	2.276	2.223						
44400	2.170	2.276	2.223						
44500	2.170	2.276	2.223						
44600	2.170	2.276	2.223						
44700	2.170	2.276	2.223						
44800	2.170	2.276	2.223						
44900	2.170	2.276	2.223						
45000	2.170	2.276	2.223	2.252	2.346	2.299	0.719	0.719	0.719

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
45100	2.205	2.276	2.240						
45200	2.217	2.276	2.246						
45300	2.217	2.276	2.246						
45400	2.217	2.276	2.246						
45500	2.217	2.276	2.246						
45600	2.229	2.276	2.252						
45700	2.229	2.276	2.252						
45800	2.229	2.276	2.252						
45900	2.229	2.276	2.252						
46000	2.229	2.276	2.252						
46100	2.229	2.276	2.252						
46200	2.229	2.276	2.252						
46300	2.229	2.276	2.252						
46400	2.229	2.276	2.252						
46500	2.229	2.276	2.252						
46600	2.229	2.276	2.252						
46700	2.229	2.276	2.252						
46800	2.229	2.287	2.258						
46900	2.229	2.287	2.258						
47000	2.229	2.287	2.258						
47100	2.229	2.287	2.258						
47200	2.229	2.287	2.258						
47300	2.229	2.287	2.258						
47400	2.229	2.287	2.258						
47500	2.229	2.287	2.258						
47600	2.229	2.287	2.258						
47700	2.229	2.287	2.258						
47800	2.229	2.287	2.258						
47900	2.229	2.287	2.258						
48000	2.240	2.287	2.264						
48100	2.252	2.299	2.276						
48200	2.252	2.299	2.276						
48300	2.252	2.299	2.276						
48400	2.252	2.311	2.281						
48500	2.252	2.311	2.281						
48600	2.252	2.311	2.281						
48700	2.252	2.323	2.287						
48800	2.252	2.323	2.287						
48900	2.252	2.323	2.287						
49000	2.252	2.323	2.287						
49100	2.252	2.323	2.287						
49200	2.252	2.323	2.287						
49300	2.252	2.323	2.287						
49400	2.252	2.323	2.287						
49500	2.252	2.323	2.287						
49600	2.252	2.323	2.287						
49700	2.252	2.323	2.287						
49800	2.252	2.323	2.287						
49900	2.252	2.323	2.287						
50000	2.252	2.323	2.287	2.299	2.393	2.346	0.813	0.766	0.789

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
50100	2.252	2.323	2.287						
50200	2.252	2.323	2.287						
50300	2.264	2.323	2.293						
50400	2.276	2.323	2.299						
50500	2.276	2.323	2.299						
50600	2.276	2.323	2.299						
50700	2.276	2.323	2.299						
50800	2.276	2.323	2.299						
50900	2.276	2.323	2.299						
51000	2.276	2.334	2.305						
51100	2.276	2.334	2.305						
51200	2.276	2.334	2.305						
51300	2.276	2.334	2.305						
51400	2.276	2.334	2.305						
51500	2.276	2.334	2.305						
51600	2.276	2.346	2.311						
51700	2.276	2.346	2.311						
51800	2.276	2.346	2.311						
51900	2.276	2.346	2.311						
52000	2.276	2.358	2.317						
52100	2.276	2.358	2.317						
52200	2.276	2.358	2.317						
52300	2.276	2.358	2.317						
52400	2.276	2.358	2.317						
52500	2.276	2.358	2.317						
52600	2.276	2.358	2.317						
52700	2.276	2.358	2.317						
52800	2.276	2.358	2.317						
52900	2.276	2.358	2.317						
53000	2.276	2.358	2.317						
53100	2.276	2.358	2.317						
53200	2.276	2.358	2.317						
53300	2.276	2.370	2.323						
53400	2.276	2.370	2.323						
53500	2.276	2.370	2.323						
53600	2.276	2.370	2.323						
53700	2.276	2.370	2.323						
53800	2.276	2.370	2.323						
53900	2.276	2.370	2.323						
54000	2.276	2.370	2.323						
54100	2.276	2.370	2.323						
54200	2.276	2.370	2.323						
54300	2.276	2.370	2.323						
54400	2.276	2.370	2.323						
54500	2.276	2.370	2.323						
54600	2.276	2.370	2.323						
54700	2.299	2.370	2.334						
54800	2.299	2.370	2.334						
54900	2.299	2.370	2.334						
55000	2.299	2.370	2.334	2.299	2.440	2.370	0.844	0.813	0.828

Table G-2. Half-Crack Length Data for C1BE Patch During Fatigue Cycling (Continued)

CYCLES	VISUAL			INTERNAL EDDY CURRENT			EXTERNAL EDDY CURRENT		
	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)	a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
55100	2.299	2.370	2.334						
55200	2.299	2.370	2.334						
55300	2.299	2.370	2.334						
55400	2.299	2.370	2.334						
55500	2.299	2.370	2.334						
55600	2.299	2.370	2.334						
55700	2.299	2.370	2.334						
55800	2.299	2.370	2.334						
55900	2.299	2.370	2.334						
56000	2.299	2.370	2.334						
56100	2.311	2.370	2.340						
56200	2.311	2.370	2.340						
56300	2.311	2.370	2.340						
56400	2.323	2.370	2.346						
56500	2.323	2.370	2.346						
56600	2.323	2.381	2.352						
56700	2.323	2.381	2.352						
56800	2.323	2.381	2.352						
56900	2.323	2.381	2.352						
57000	2.323	2.393	2.358						
57100	2.323	2.393	2.358						
57200	2.323	2.393	2.358						
57300	2.323	2.393	2.358						
57400	2.323	2.393	2.358						
57500	2.323	2.393	2.358						
57600	2.323	2.393	2.358						
57700	2.323	2.393	2.358						
57800	2.323	2.393	2.358						
57900	2.334	2.393	2.364						
58000	2.334	2.393	2.364						
58100	2.334	2.393	2.364						
58200	2.334	2.393	2.364						
58300	2.334	2.393	2.364						
58400	2.334	2.393	2.364						
58500	2.334	2.393	2.364						
58600	2.334	2.393	2.364						
58700	2.334	2.393	2.364						
58800	2.334	2.393	2.364						
58900	2.334	2.393	2.364						
59000	2.334	2.417	2.375						
59100	2.334	2.417	2.375						
59200	2.334	2.417	2.375						
59300	2.334	2.417	2.375						
59400	2.334	2.428	2.381						
59500	2.334	2.428	2.381						
59600	2.334	2.428	2.381						
59700	2.334	2.428	2.381						
59800	2.334	2.428	2.381						
59900	2.334	2.428	2.381						
60000	2.334	2.428	2.381	2.393	2.487	2.440	0.906	0.844	0.875

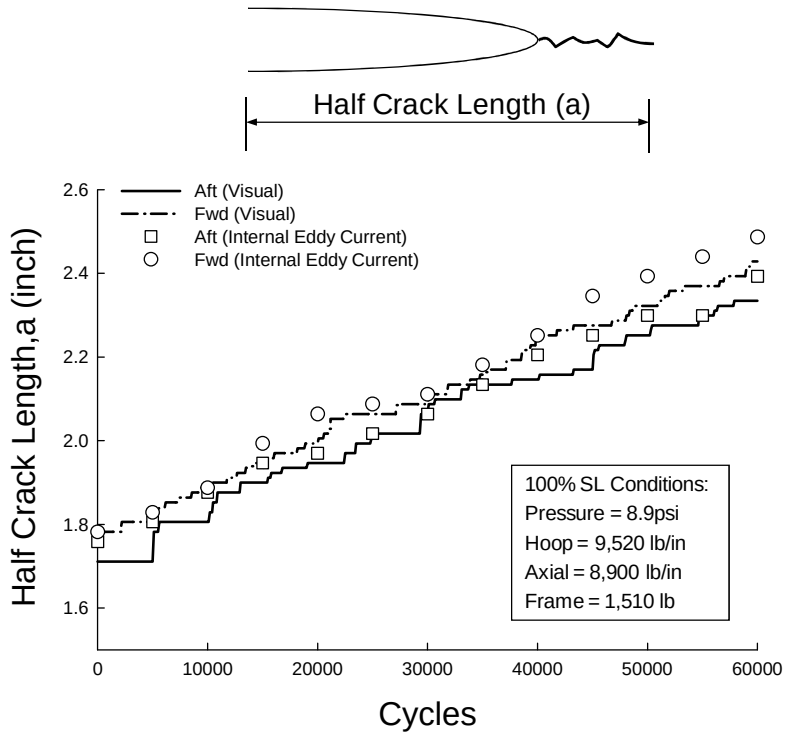


Figure G-3. Crack Length Measurements From Visual and Internal Eddy-Current Inspections of Patch C1BE

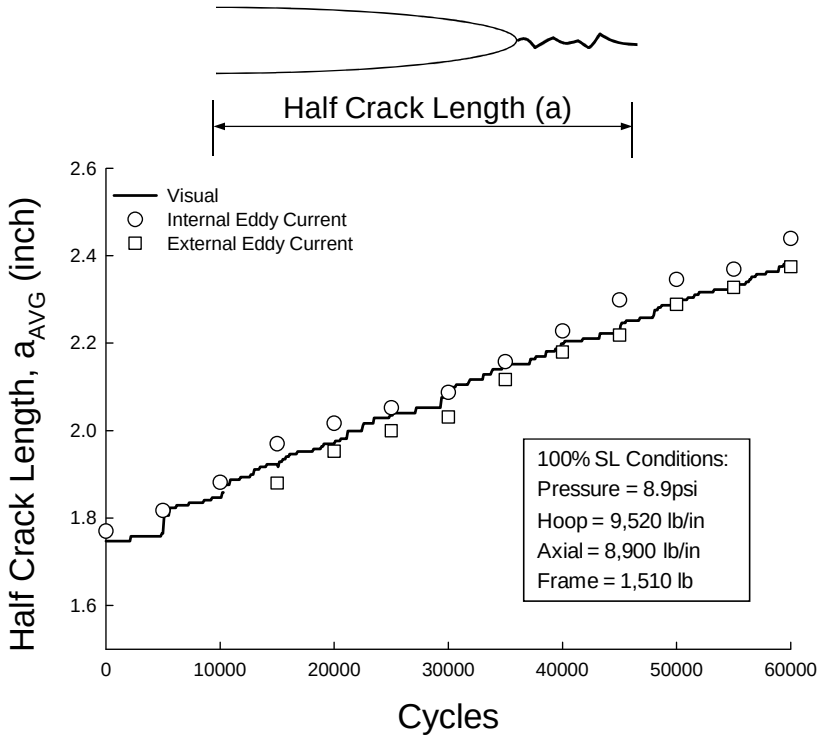


Figure G-4. Crack Length Measurements From Visual, Internal Eddy-Current, and External Eddy-Current Inspections of Patch C1BE

Table G-3. Half-Crack Length Data for C2A Patch During Fatigue Cycling of all Test Phases

	CYCLES	INTERNAL EDDY CURRENT		
		a_{AFT} (inches)	a_{FWD} (inches)	a_{AVG} (inches)
PHASE 1	0			
	5000	1.594	1.594	1.594
	10000	1.594	1.594	1.594
	15000	1.618	1.594	1.606
	20000	1.618	1.594	1.606
	25000	1.618	1.641	1.629
	30000	1.618	1.641	1.629
	35000	1.641	1.688	1.665
	40000	1.641	1.688	1.665
	45000	1.688	1.688	1.688
	50000	1.688	1.688	1.688
	55000	1.688	1.688	1.688
	60000	1.712	1.688	1.700
	65000	1.735	1.688	1.712
PHASE 2	70000	1.735	1.688	1.712
	75000	1.759	1.735	1.747
	80000	1.829	1.759	1.794
	85000	1.853	1.806	1.829
PHASE 3	90000			
	95000	1.876	1.829	1.853
	100000	1.876	1.829	1.853
	105000	1.876	1.853	1.864
	110000	1.876	1.876	1.876
PHASE 4	110003	1.900	1.900	1.900
	110006	1.876	1.900	1.888
	110009	1.923	1.900	1.911

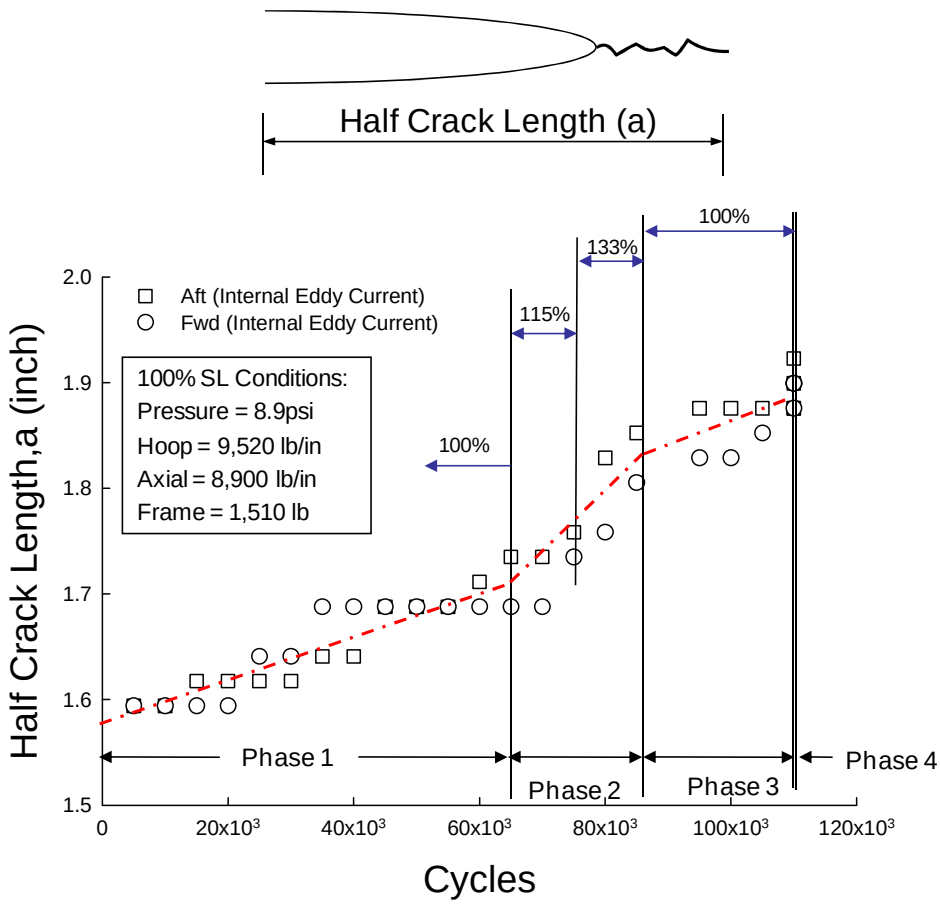


Figure G-5. Crack Length Measurements From Internal Eddy-Current Inspections of Patch C2A

APPENDIX H—RESIDUAL STRENGTH TEST

At the end of Phases 1, 3, and 4, residual strength tests were conducted. There was no residual strength test after Phase 2 because the fatigue loads were already elevated to 1.33 times the service load. The load configurations for the three phases are listed in table H-1. The raw data from the residual strength test for the strain gages in test Phases 1 and 3 are provided in tables H-2 and H-3. For test Phase 4, the strain gage readings for the LJC3A patch are provided for approximately the last 50 minutes when the patch was heated to 250°F (before final failure). Because the data were so extensive, it is reported in graphical rather than tabular form. Figures H-1 and H-2 show the location of the strain gages on the exterior surface of the LJC3A patch and the exterior and interior surfaces of the fuselage panel, respectively. Figures H-2 and H-3 show the readings from strain gages on the exterior surface of the LJC3A patch and the exterior surface of the fuselage panel. Figures H-5 and H-6 show the readings from the strain gages on the interior surface of the fuselage panel. Figures H-3 through H-6 also include the loading for the last 50 minutes before failure (shown by the black curve). During this period, the panel was loaded three times, as shown in the figures. The first peak is approximately 11.84 psi, which is 1.33 times the service load. In the second peak, pressure reaches approximately 17 psi and could not be loaded higher due to pressure leakage. Finally, the panel was loaded to failure, which occurred at 20.5 psi, shown by the third peak.

Table H-1. Load Configuration for the Residual Strength Test

Test Phase	Maximum Load			
	Pressure (psi)	Hoop (lb)	Frame (lb)	Longitudinal (lb)
1	10.24	10,948	1737	8900
3	24.73	26,446	4193	8900
4	20.5	21,923	3477	8900

Table H-2. Phase 1 Residual Strength Test Raw Data

Load Step	0	1	2	3	4	5	6	7	8	9	10
Pressure	0.03	1.00	2.06	3.04	4.09	5.14	6.18	7.18	8.18	9.27	10.22
Frame-1	75.46	178.00	392.38	555.40	685.97	857.80	1127.86	1214.14	1457.03	1566.31	1553.66
Frame-2	-34.78	135.38	330.62	523.53	666.23	866.46	1041.95	1205.80	1386.82	1529.66	1712.45
Frame-3	33.50	137.29	336.73	531.16	695.63	851.27	1044.59	1212.08	1381.84	1558.45	1723.94
Frame-4	-0.62	222.62	305.70	591.33	650.77	865.22	1048.21	1221.66	1383.37	1567.98	1725.15
Frame-5	11.08	178.68	366.54	524.18	697.07	863.70	1044.88	1212.73	1396.14	1551.17	1723.23
Frame-6	-21.12	174.55	340.99	528.70	676.31	856.85	1026.32	1209.69	1384.50	1552.38	1739.89
Frame-7	0.09	204.27	334.40	525.29	716.14	861.26	1046.36	1220.18	1397.33	1567.25	1737.47
Frame-8	-5.92	179.95	347.32	523.76	687.96	860.43	1036.87	1213.64	1384.77	1574.20	1733.47
Frame-9	-19.86	190.10	339.91	521.70	683.95	857.98	1038.42	1213.55	1383.51	1560.51	1666.51
Frame-10	-13.70	185.39	317.80	532.29	684.42	866.98	1044.69	1214.11	1388.21	1558.23	1566.47
Frame-11	16.57	171.45	347.02	524.03	677.08	863.64	1037.65	1214.98	1376.32	1567.52	1718.76
Frame-12	-10.22	173.34	329.17	512.48	701.96	853.70	1046.29	1216.13	1384.89	1546.06	1727.40
Hoop-1	15.76	1079.58	2203.39	3292.98	4400.59	5483.20	6590.27	7736.97	8736.15	9857.38	10966.70
Hoop-2	-17.16	1141.64	2181.64	3263.40	4384.46	5462.96	6569.11	7678.36	8831.00	9836.11	10926.52
Hoop-3	11.29	1105.64	2180.66	3301.28	4378.25	5476.62	6586.05	7686.37	8786.90	9880.26	10957.13
Hoop-4	-42.79	1102.41	2127.24	3298.15	4405.13	5430.71	6564.45	7688.58	8787.50	9837.05	10985.79
Hoop-5	6.88	1111.05	2175.38	3265.36	4374.94	5472.45	6576.08	7675.62	8771.82	9846.19	10926.84
Hoop-6	-13.59	1101.15	2191.64	3280.84	4371.54	5473.09	6575.27	7678.75	8765.25	9836.08	10942.13
Hoop-7	-0.27	1101.77	2185.71	3284.39	4379.27	5487.23	6579.78	7671.85	8769.55	9840.20	10949.28
Hoop-8	-5.36	1109.39	2179.41	3294.27	4372.43	5464.49	6572.40	7679.00	8770.62	9856.61	10948.01
Hoop-9	212.38	1099.98	2200.92	3286.25	4375.39	5478.03	6570.98	7676.99	8750.45	9881.34	10949.19
Hoop-10	9.26	1100.52	2207.32	3300.47	4377.83	5473.87	6578.11	7675.71	8780.20	9868.66	10955.16
Hoop-11	-6.76	1118.86	2167.56	3286.00	4375.52	5467.81	6579.41	7669.66	8799.76	9862.41	10908.52
Hoop-12	26.65	1108.86	2230.78	3309.27	4372.69	5419.94	6644.18	7714.15	8783.90	9824.81	10955.53
Hoop-13	-1.87	1088.06	2177.55	3296.84	4357.84	5469.17	6603.53	7670.75	8774.32	9872.33	10982.99
Hoop-14	-4.39	1097.31	2176.53	3300.37	4350.98	5474.16	6591.10	7684.68	8792.73	9865.82	10922.25
Long-1	-1.23	887.50	1783.90	2663.99	3555.03	4446.36	5350.33	6243.44	7126.56	8015.02	8903.75
Long-2	-63.75	975.35	1761.19	2617.68	3484.19	4444.21	5475.43	6218.71	7082.76	7879.32	8976.08
Long-3	61.18	891.34	1798.12	2673.56	3544.30	4433.84	5348.65	6223.38	7130.85	8014.13	8894.27
Long-4	-1.26	857.34	1801.37	2672.21	3485.34	4430.41	5341.40	6236.85	7122.48	8020.38	8947.71
Long-5	3.02	943.04	1736.82	2744.16	3609.15	4515.82	5365.67	6205.03	7132.56	8013.21	8897.87
Long-6	37.92	875.72	1766.74	2666.42	3563.91	4444.07	5354.79	6226.47	7130.01	8030.22	8906.00
Long-7	188.23	884.26	1774.78	2671.73	3583.47	4457.99	5374.77	6229.64	7128.14	8015.90	8909.03
Long-8	41.29	898.32	1768.21	2671.70	3584.87	4445.09	5356.05	6229.16	7119.89	8015.60	8901.11
S1-H	-63.68	159.57	320.71	452.52	592.45	725.80	852.06	973.38	1089.38	1213.70	1323.79
S1-A	-30.24	15.95	49.23	79.70	111.68	144.40	181.05	210.76	247.22	282.58	316.40
S2-H	-47.85	105.73	229.88	336.91	452.18	564.99	671.07	772.59	871.62	975.36	1066.77
S2-A	123.66	150.56	179.71	202.86	229.79	256.70	286.60	315.73	346.37	380.04	409.90
S3-H	6401.22	6388.16	6475.57	6557.69	6644.88	6736.51	6822.99	6900.18	6980.97	7063.86	7138.14
S3-A	-3.52	10.98	34.80	60.62	86.77	115.68	146.82	177.40	203.81	237.69	272.37
S4-H	-44.28	61.37	159.53	247.17	346.85	440.51	530.42	616.53	698.19	783.68	858.52
S4-A	47.31	56.88	73.51	87.89	109.52	138.20	167.86	193.80	224.49	258.51	295.05
S5	123.55	329.02	521.59	681.76	849.15	1004.48	1149.64	1288.31	1412.56	1544.96	1660.34
S6	79.38	275.85	541.65	785.00	1083.41	1390.61	1692.45	2001.66	2293.86	2611.27	2894.89
S7	-198.18	-15.11	148.23	289.37	438.38	578.41	710.23	788.50	904.81	1026.81	1130.81
S8	-85.79	152.70	400.64	617.25	833.26	1021.58	1185.90	1335.55	1464.96	1597.43	1706.33
S9	174.11	-362.36	-867.31	-1266.70	-1675.84	-2037.93	-2360.38	-2654.92	-2900.96	-3139.68	-3347.03

Table H-2. Phase 1 Residual Strength Test Raw Data (Continued)

S10	-50.39	148.88	350.91	525.73	711.56	879.85	1032.51	1173.02	1298.19	1427.04	1534.27
S11	-327.80	61.95	326.90	591.20	893.36	1180.18	1473.91	1769.83	1922.96	2001.90	2109.00
S12	9.21	-20.29	-28.12	-26.84	-15.01	0.28	15.21	29.59	48.35	68.38	92.04
S13	-132.87	192.30	463.72	666.63	863.50	1034.47	1184.16	1320.98	1441.01	1566.84	1671.80
S14	-37.81	102.50	239.06	361.67	495.23	624.61	746.57	859.39	971.64	1088.28	1186.92
S15	-52.37	-9.24	45.52	96.26	155.95	214.16	267.83	315.65	374.40	432.84	485.37
S16	-43.40	60.65	168.61	268.46	379.20	488.06	589.48	690.42	779.76	879.67	963.75
S17	-56.16	87.84	229.37	350.70	480.19	599.00	709.33	797.39	909.16	1010.30	1095.25
S18	112.41	-77.12	-292.70	-503.54	-740.73	-970.36	-1191.76	-1471.78	-1590.11	-1789.88	-1966.15
S19	10.53	102.99	192.53	276.53	372.30	463.89	552.47	633.52	718.86	804.96	874.96
S21	-7.77	66.91	157.48	237.40	337.66	437.90	535.32	635.49	725.37	819.87	904.40
S22	-51.08	10.28	80.38	145.82	225.16	303.39	374.35	429.26	510.17	579.49	638.47
S23	7.64	-5.57	15.03	40.89	89.12	137.71	185.39	231.46	281.18	332.02	382.25
INS1	-37.17	33.37	103.07	167.16	237.06	304.70	369.04	433.24	491.19	551.76	608.45
INS2	-173.89	100.22	367.60	581.72	811.25	1017.77	1207.15	1387.64	1542.85	2210.73	2248.46
INS3	14.38	61.07	109.24	156.87	208.77	260.26	308.28	349.01	399.56	444.62	481.12
INS4	-30.95	69.60	187.13	309.43	449.57	586.00	717.50	920.98	962.71	1086.67	1195.02
INS5	-9278.00	-9193.63	-9110.68	-9039.27	-8961.91	-8889.76	-8821.77	-8759.32	-8695.84	-8634.17	-8581.47
IS24	12.32	153.99	287.64	395.20	510.29	613.54	708.62	798.36	874.93	949.42	1014.64
IS25	9.95	163.48	307.23	422.97	545.13	655.34	756.86	852.19	933.47	1014.32	1084.45
IS26	78.06	23.91	-21.64	-46.69	-51.17	-40.37	-13.58	27.41	69.90	121.09	174.86
IS27	38.49	15.09	-1.82	-9.75	-1.32	19.63	53.13	98.24	144.21	198.27	253.88
IS28	-7.36	27.49	68.02	109.72	156.34	200.49	243.43	312.79	324.49	364.55	399.78
IS29	-11.85	26.57	70.85	115.30	164.53	210.21	255.03	327.26	340.01	382.41	420.25
IS30	46.18	-6.89	-45.78	-65.76	-78.49	-85.40	-83.22	-44.32	-62.68	-47.96	-31.42
IS31	-2.21	-13.44	-10.95	-3.39	5.99	15.46	27.96	69.85	63.46	83.76	105.36
IS32	94.68	371.30	630.71	852.35	1089.16	1306.62	1505.16	1690.99	1853.33	2017.15	2163.48
P1A	-14.66	50.89	107.97	151.11	206.76	261.63	312.71	363.00	410.90	459.43	507.18
P1B	-15.67	35.84	79.88	122.19	166.85	211.15	252.80	293.71	332.64	373.74	413.53
P1C	20.08	64.30	100.42	138.00	176.34	213.19	250.05	285.40	318.56	353.24	384.89
P1D	-22.01	49.01	116.53	179.05	248.98	314.65	376.08	437.28	492.25	548.93	599.60
P3A	18.63	59.23	97.98	137.27	180.47	224.39	264.98	301.49	345.04	383.64	414.79
P3B	12.22	51.70	88.77	126.02	166.80	208.31	247.60	281.69	322.83	359.75	389.04
P3C	19.80	56.87	94.48	132.46	175.07	218.22	259.89	297.48	340.07	380.67	414.01
P3D	3.88	45.77	88.54	130.41	178.07	227.00	273.59	315.08	362.35	408.05	446.03
P5A	4.34	90.37	171.84	241.02	315.00	383.38	445.31	505.35	560.64	615.07	663.29
P5B	3.88	85.39	159.73	223.17	289.47	350.23	405.92	460.33	510.03	559.24	601.70
P5C	10.50	79.74	149.91	211.04	273.67	332.98	387.49	439.20	489.11	538.33	580.08
P5D	4.39	81.95	153.43	216.23	283.86	347.79	406.92	461.96	519.80	575.12	623.33

Table H-3. Phase 3 Residual Strength Test Raw Data

Load Step	0	1	2	3	4	5	6	7	8	9	10	11
Pressure	0.00	1.17	2.42	3.52	4.69	5.94	7.11	8.24	9.46	10.29	10.63	11.87
Frame-1	-9.40	275.81	393.24	585.73	801.39	1024.83	1231.22	1397.80	1597.70	1715.46	1800.30	2052.31
Frame-2	20.98	151.41	397.65	574.45	792.52	1020.19	1204.48	1422.55	1610.34	1724.99	1800.66	2001.18
Frame-3	44.59	259.47	411.83	586.54	826.53	1028.30	1226.43	1410.53	1593.60	1720.51	1810.94	1980.05
Frame-4	17.32	169.72	359.30	618.55	871.89	1020.28	1213.20	1386.84	1597.16	1733.03	1828.67	2015.21
Frame-5	-3.37	201.53	389.76	588.66	796.17	1032.98	1214.82	1389.52	1602.76	1739.28	1805.40	2005.17
Frame-6	5.60	208.17	383.84	594.89	793.71	1020.17	1207.08	1404.45	1603.90	1734.61	1827.67	2001.88
Frame-7	-2.70	193.30	391.71	595.45	819.82	1033.64	1201.71	1401.45	1612.51	1727.99	1805.11	1984.71
Frame-8	8.15	211.30	372.75	581.01	800.30	1016.11	1214.26	1392.37	1593.07	1737.42	1814.00	2004.45
Frame-9	-18.97	222.32	368.25	580.65	804.60	1022.62	1213.26	1420.43	1603.66	1737.82	1810.96	1994.60
Frame-10	26.34	182.36	421.77	585.21	747.71	1027.77	1201.82	1412.48	1601.80	1729.34	1825.42	1996.71
Frame-11	26.89	161.61	388.52	589.56	801.41	1023.29	1211.42	1399.36	1601.95	1737.38	1836.33	1969.06
Frame-12	2.50	189.87	387.55	590.74	789.74	1005.29	1216.80	1401.95	1620.70	1746.96	1812.13	1997.53
Hoop-1	7.96	1018.56	2642.35	3782.57	5118.52	6456.56	7524.35	8854.32	10091.42	11011.82	11261.78	12785.28
Hoop-2	-47.06	1262.25	2629.31	3782.48	5180.46	6174.48	7572.51	8711.32	9839.51	11108.58	11552.30	12585.23
Hoop-3	38.78	1271.72	2579.59	3869.97	5107.01	6328.67	7682.04	8840.43	10280.47	10932.52	11375.42	12705.87
Hoop-4	143.47	1222.81	2437.09	3880.60	4949.62	6432.14	7685.06	8844.60	10180.92	10928.13	11401.46	12661.25
Hoop-5	-26.44	1228.66	2529.04	3712.23	5074.22	6326.60	7631.00	8774.57	10098.45	11062.82	11372.61	12748.63
Hoop-6	-19.41	1266.72	2573.71	3813.59	5076.31	6375.35	7552.15	8869.31	10147.28	10939.74	11405.18	12621.14
Hoop-7	18.30	1279.19	2520.65	3795.98	5073.60	6313.90	7596.91	8818.57	10097.69	10955.33	11391.81	12672.63
Hoop-8	-7.71	1320.46	2501.32	3778.35	5062.00	6316.52	7607.93	8862.45	10124.34	10922.42	11385.10	12670.27
Hoop-9	-21.35	1180.05	2870.21	3739.84	5063.12	6343.67	7602.67	8841.91	9765.05	11043.11	11387.50	12654.82
Hoop-10	2.15	1243.86	2617.27	3831.06	5047.63	6330.32	7607.68	8863.72	10000.74	10996.71	11513.23	12573.22
Hoop-11	-0.59	1237.34	2653.95	3781.32	4920.69	6357.20	7593.43	8756.84	10552.02	11019.21	10800.38	13084.58
Hoop-12	-2.27	1159.66	2084.83	3769.03	5083.60	6138.62	7614.12	8737.94	9984.09	10986.69	11550.17	12545.18
Hoop-13	75.85	1274.91	2598.51	3878.51	4909.12	6386.15	7599.95	8769.87	10159.16	10964.57	11444.94	12652.56
Hoop-14	30.68	1322.70	2548.89	3819.39	5081.78	6300.51	7599.99	8862.76	10088.83	10948.90	11438.57	12702.48
Long-1	2.80	1996.85	3984.63	6006.16	7961.17	10001.52	11933.00	14049.31	16051.36	17288.94	18042.30	20078.73
Long-2	-4.62	1797.82	3820.62	6061.30	8032.66	9951.00	11983.81	13828.58	15936.18	17411.36	17940.06	19863.61
Long-3	-23.59	1979.08	4100.79	5995.98	7985.44	9908.08	11946.07	13964.95	16069.66	17312.24	18043.65	20023.36
Long-4	6.31	2032.02	3948.81	6008.07	8068.95	9950.37	11988.12	14010.60	16022.67	17333.87	18020.03	19986.85
Long-5	40.19	1971.87	4045.66	5992.47	8058.63	10041.33	12006.00	13987.56	15997.73	17364.59	17988.91	19991.46
Long-6	-12.38	1960.88	3972.89	6123.95	8061.80	9972.55	11958.87	14002.54	15931.48	17272.83	18002.64	19998.63
Long-7	89.96	1992.83	3998.73	6026.71	7952.90	9987.60	12024.29	14000.55	15966.34	17328.30	18026.74	20006.47
Long-8	7.21	2075.95	3975.76	6002.77	7928.09	9977.06	11965.10	14084.12	16053.92	17295.94	18054.44	19996.38
S1-H	-35.58	100.20	219.91	312.22	414.27	531.77	646.47	748.12	858.73	939.01	967.45	1080.95
S2-H	-22.30	137.57	251.10	339.25	431.92	535.76	633.62	719.54	821.72	878.56	896.22	1002.78
S3-H	4987.80	5110.08	5343.33	5388.34	5510.11	5714.68	5844.40	5927.41	6027.47	6074.78	6106.92	6183.13
S4-H	-3.76	74.16	152.82	221.75	292.95	373.87	447.30	509.49	584.30	628.69	646.61	717.86
S8	-0.12	231.82	446.27	612.76	767.69	926.19	1062.89	1171.95	1288.03	1356.77	1382.08	1487.66
S9	41.93	-501.37	-912.31	-1215.29	-1483.36	-1748.98	-1976.40	-2158.69	-2329.97	-2425.29	-2466.34	-2598.50

Table H-3. Phase 3 Residual Strength Test Raw Data (Continued)

S10	-3.72	107.83	256.47	384.82	515.72	659.39	785.84	889.36	1003.39	1070.52	1096.48	1199.03
S14	-29.69	117.32	244.30	343.62	445.30	554.84	657.49	742.76	839.79	900.47	920.56	1014.46
S17	-32.44	120.59	241.80	334.12	426.48	526.80	618.40	695.46	782.00	838.04	858.31	939.47
S18	11.11	-189.55	-405.82	-596.63	-778.44	-971.32	-1154.15	-1314.93	-1478.09	-1577.55	-1616.55	-1765.68
S19	-12.61	77.57	161.62	226.64	293.60	371.53	444.53	505.40	576.51	623.49	640.38	707.84
S24	-11.23	-138.15	-240.16	-315.26	-382.97	-437.47	-489.47	-543.32	-594.84	-626.38	-642.54	-686.13
S25	-18.35	-416.48	-749.03	-1004.08	-1228.99	-1437.91	-1619.19	-1782.33	-1932.09	-2030.41	-2078.16	-2197.39
S26	-67.77	-254.75	-448.51	-624.27	-791.88	-944.58	-1076.65	-1205.90	-1330.41	-1411.62	-1453.43	-1551.18
S27	-2.84	-281.47	-515.49	-698.66	-866.33	-1018.62	-1153.49	-1275.70	-1390.44	-1463.71	-1498.64	-1592.22
S28	-26.27	-54.48	-76.22	-98.38	-118.01	-131.13	-143.27	-157.68	-165.63	-169.14	-175.41	-176.58
S29	-1.37	388.59	740.89	974.36	1150.76	1304.77	1428.51	1525.92	1625.28	1687.87	1710.76	1805.35
S30	-5.04	267.18	553.10	764.48	947.44	1120.62	1262.24	1370.82	1476.20	1538.93	1562.57	1648.43
S31	-66.06	47.40	167.56	262.21	361.21	473.63	579.87	673.75	779.65	849.63	874.43	979.13
S32	-139.21	84.07	248.31	368.56	482.98	610.31	725.60	826.15	934.81	1005.97	1033.42	1137.58
S33	-16.95	-63.74	-94.26	-119.08	-135.85	-147.67	-158.81	-172.76	-182.55	-188.95	-194.09	-201.05
S34	-11.67	-65.51	-106.96	-135.57	-161.01	-177.58	-195.09	-216.37	-235.27	-246.63	-254.33	-270.71
S35	4.48	-124.15	-217.75	-280.79	-331.12	-369.09	-400.07	-430.00	-452.91	-467.20	-475.18	-489.07
S36	-20.68	-245.88	-442.34	-602.16	-744.91	-873.64	-984.48	-1092.29	-1193.57	-1261.03	-1296.56	-1372.39
S37	-25.12	-159.55	-280.54	-385.46	-483.68	-571.81	-649.33	-725.90	-797.20	-845.78	-871.62	-926.94
INS2	-20.59	379.41	708.23	966.17	1210.16	1467.38	1695.53	1891.64	2095.67	2216.50	2271.64	2453.74
INS3	-0.24	40.83	87.87	129.09	171.52	220.00	264.86	302.83	346.69	372.93	383.22	426.46
INS4	282.47	294.55	298.89	302.55	305.57	308.42	309.98	311.77	314.45	316.69	320.21	322.68
IS24	-5.51	131.36	237.21	318.79	394.24	473.46	540.72	592.75	649.73	680.56	692.64	740.94
IS25	-9.23	147.96	265.46	354.91	436.43	523.00	596.34	653.38	722.05	755.95	769.82	823.69
IS26	14.69	-80.61	-151.74	-178.26	-185.69	-171.27	-147.44	-121.14	-74.46	-45.04	-30.16	27.61
IS27	-14.83	20.53	9.65	3.76	3.44	19.45	43.43	69.23	110.56	135.62	149.26	202.10
IS28	-3.17	0.28	18.62	36.95	50.16	70.81	88.05	96.22	111.04	119.56	119.41	135.67
IS29	-1.90	15.79	44.94	71.88	97.96	127.44	154.56	174.20	198.46	213.04	217.28	240.88
IS30	31.48	-64.66	-119.17	-152.46	-182.24	-206.13	-225.99	-244.30	-255.92	-261.81	-265.79	-267.49
IS31	18.36	-22.22	-40.07	-45.82	-52.66	-57.87	-61.22	-67.20	-66.74	-65.72	-65.80	-59.92
IS32	-117.42	140.24	337.21	473.92	600.34	726.72	830.39	906.47	998.69	1044.93	1055.36	1155.52
P6-1	-14.63	15.60	39.57	54.75	72.88	82.17	88.83	90.28	96.47	93.55	87.16	92.56
P6-2	16.48	93.45	157.33	205.01	253.54	291.56	325.03	353.22	388.94	407.99	415.83	451.37
P6-3	11.39	137.60	239.51	314.99	388.07	448.87	502.62	548.00	599.23	629.07	640.76	688.56
P6-4	35.34	-352.22	-609.08	-731.06	-768.85	-749.83	-689.38	-614.08	-503.74	-424.69	-395.20	-260.06
P6-5	3923.83	3291.71	2981.71	2666.25	2361.17	2134.51	2133.06	2136.14	2113.60	2181.87	2324.18	2452.07
P6-6	9.04	81.68	147.58	194.25	236.22	272.36	299.60	317.57	334.03	341.76	343.54	355.38
P6-7	65.39	-216.91	-407.06	-512.02	-575.51	-613.10	-618.30	-603.32	-560.95	-528.06	-510.58	-445.19
P6-10	17.67	104.13	177.41	237.30	294.51	347.72	394.77	431.87	472.50	495.81	506.44	541.06
P6-11	8.27	59.19	101.26	135.02	167.18	196.79	221.71	239.05	259.58	268.51	272.27	290.36
P6-12	-1.98	1.92	4.77	5.72	7.53	4.86	-1.08	-14.40	-25.32	-38.10	-45.31	-53.02

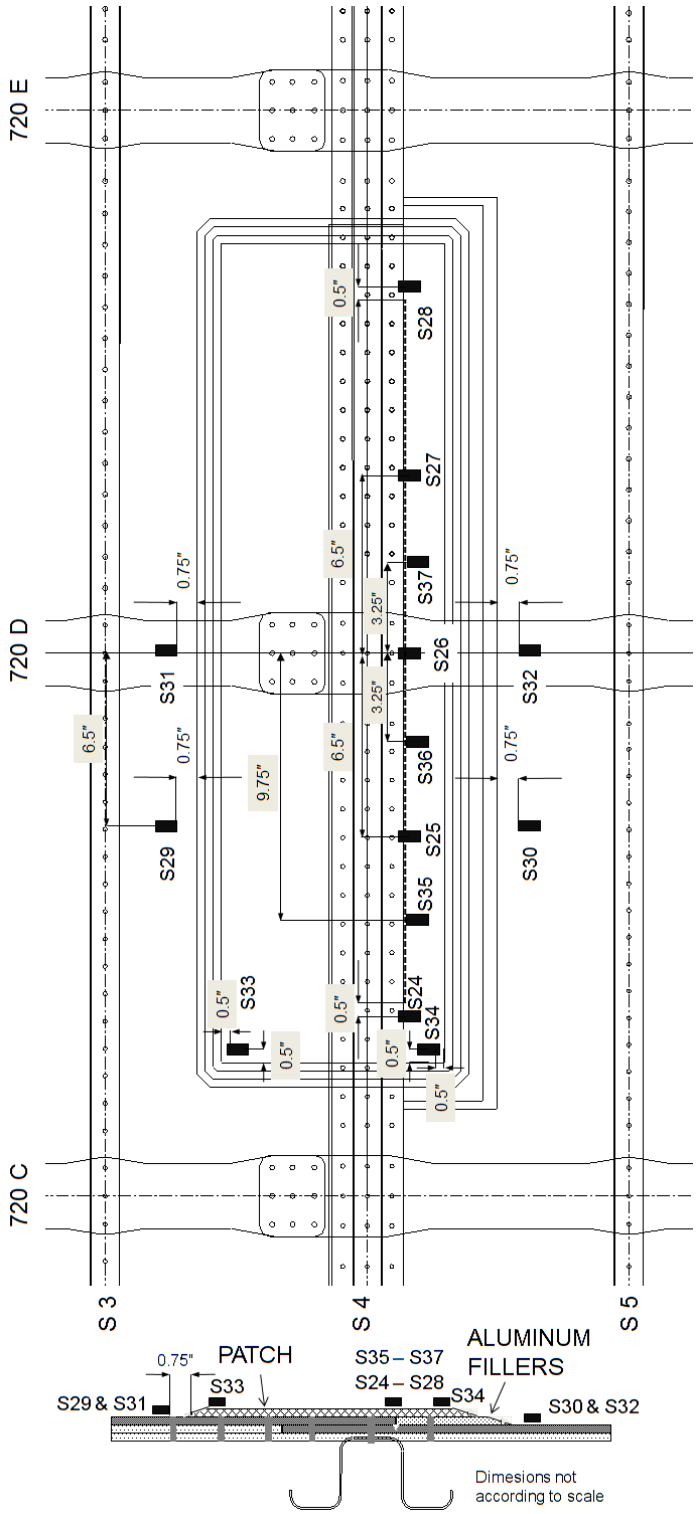


Figure H-1. External Strain Gage Map for LJC3A Patch

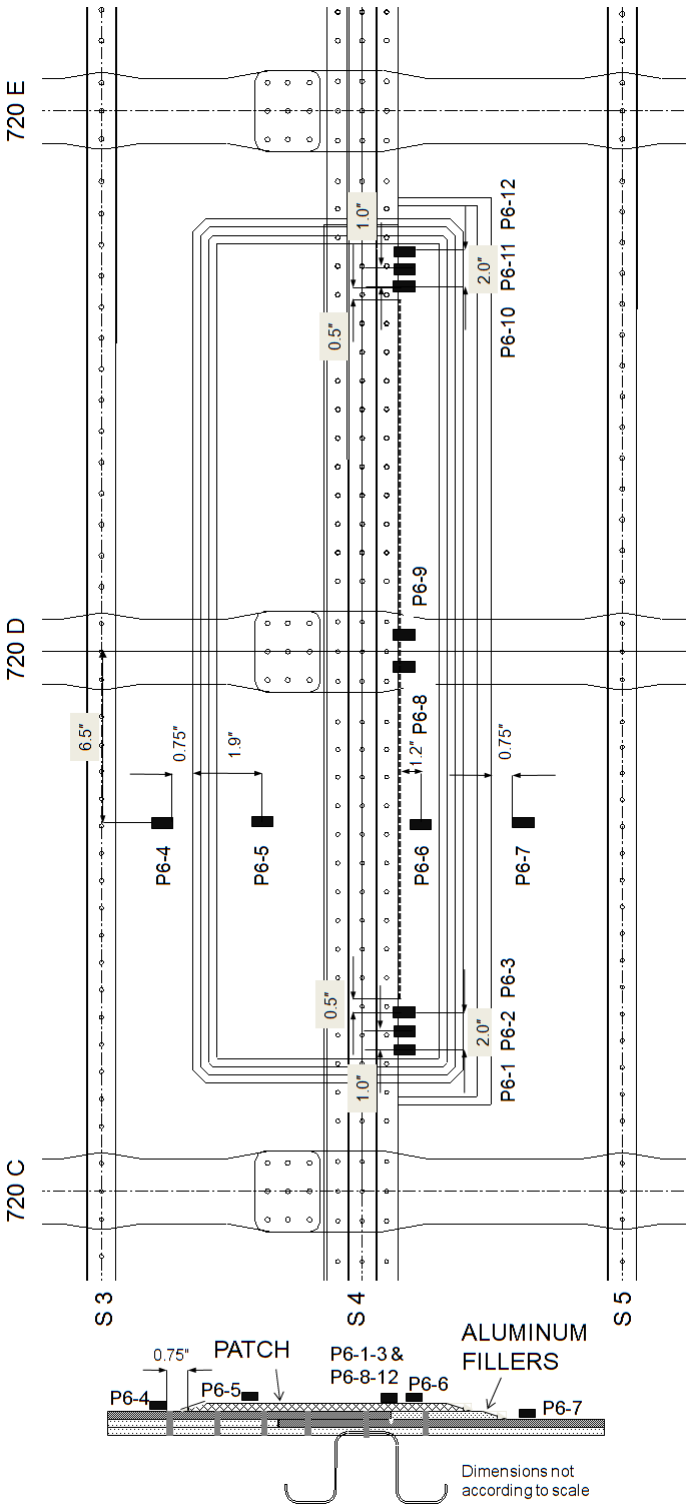


Figure H-2. Internal Strain Gage Map for LJC3A Patch

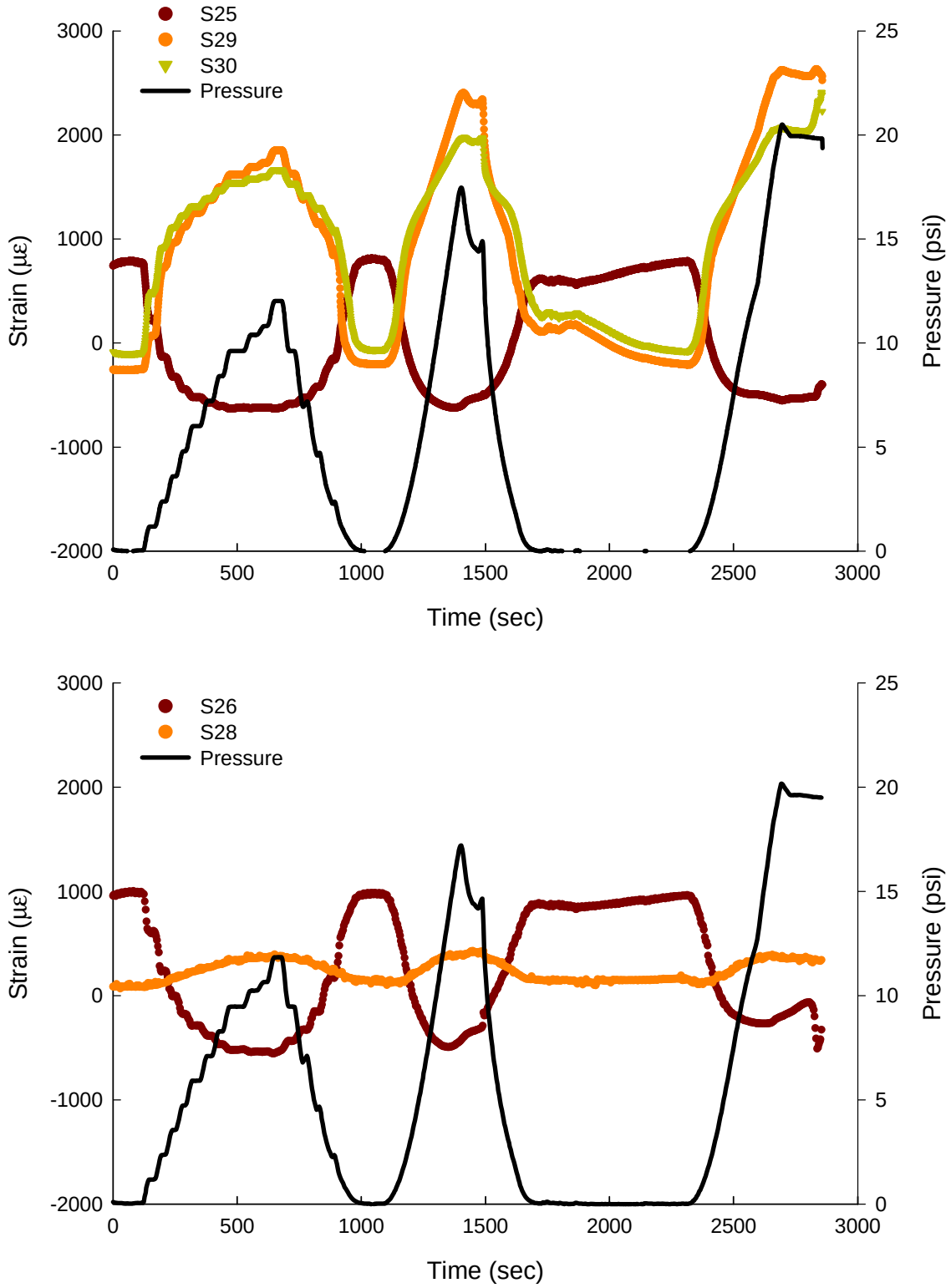
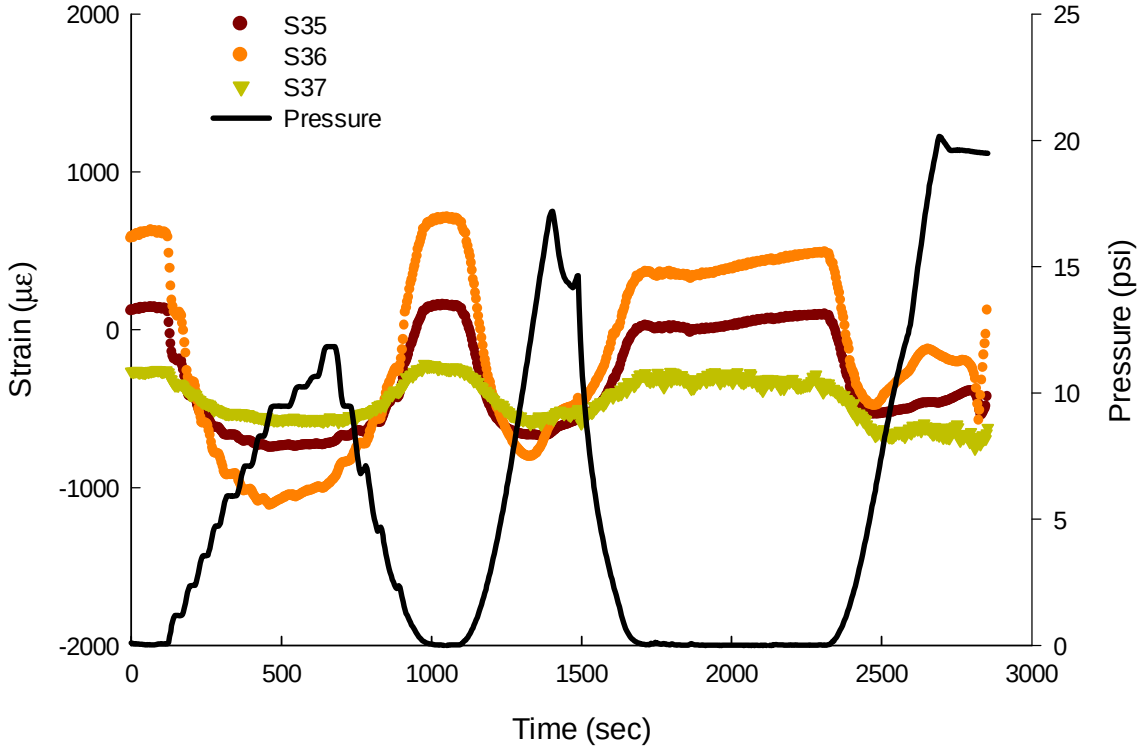


Figure H-3. External Strain Gages for LJC3A Patch



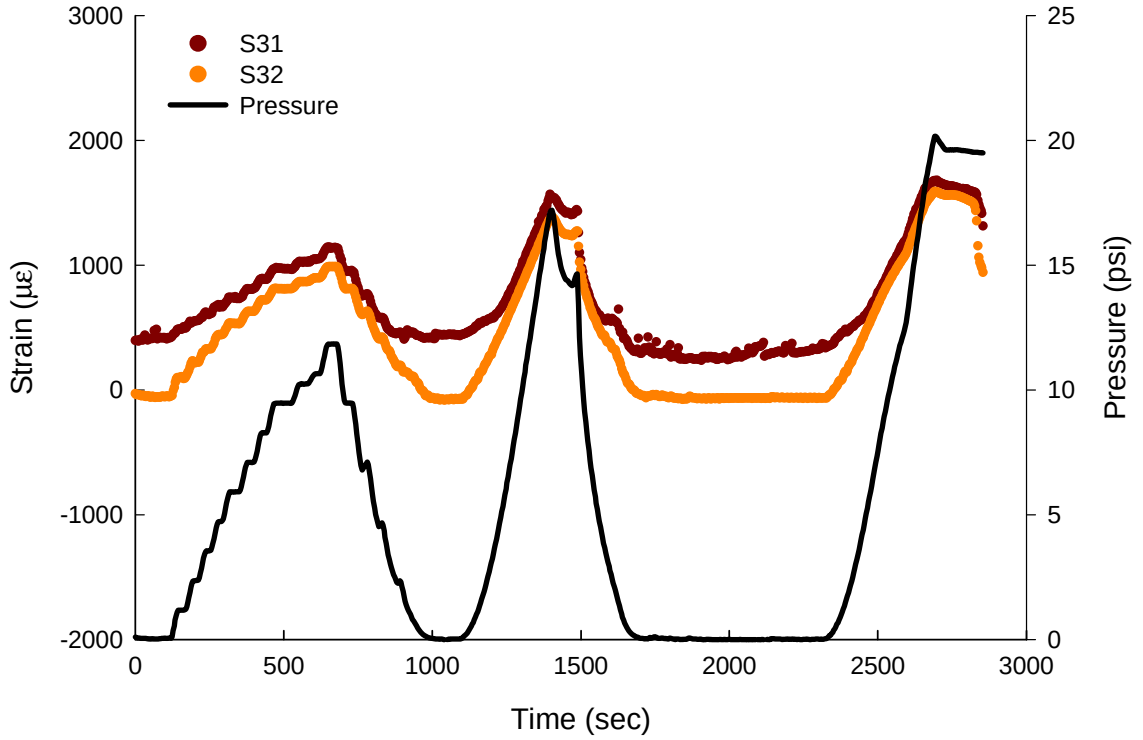


Figure H-3. External Strain Gages for LJC3A Patch (Continued)

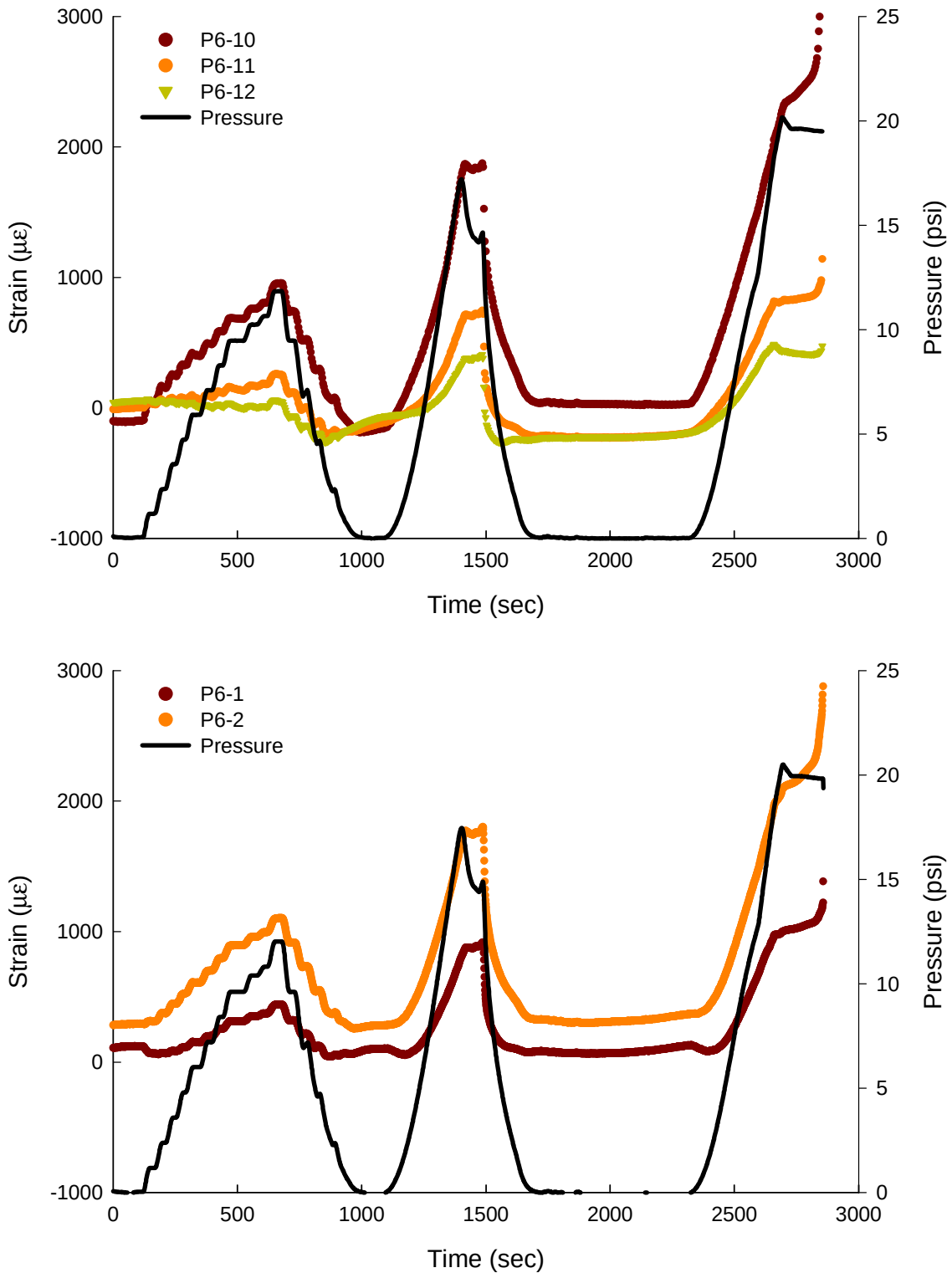


Figure H-4. Internal Notch Tip Strain Gages for LJC3A Patch

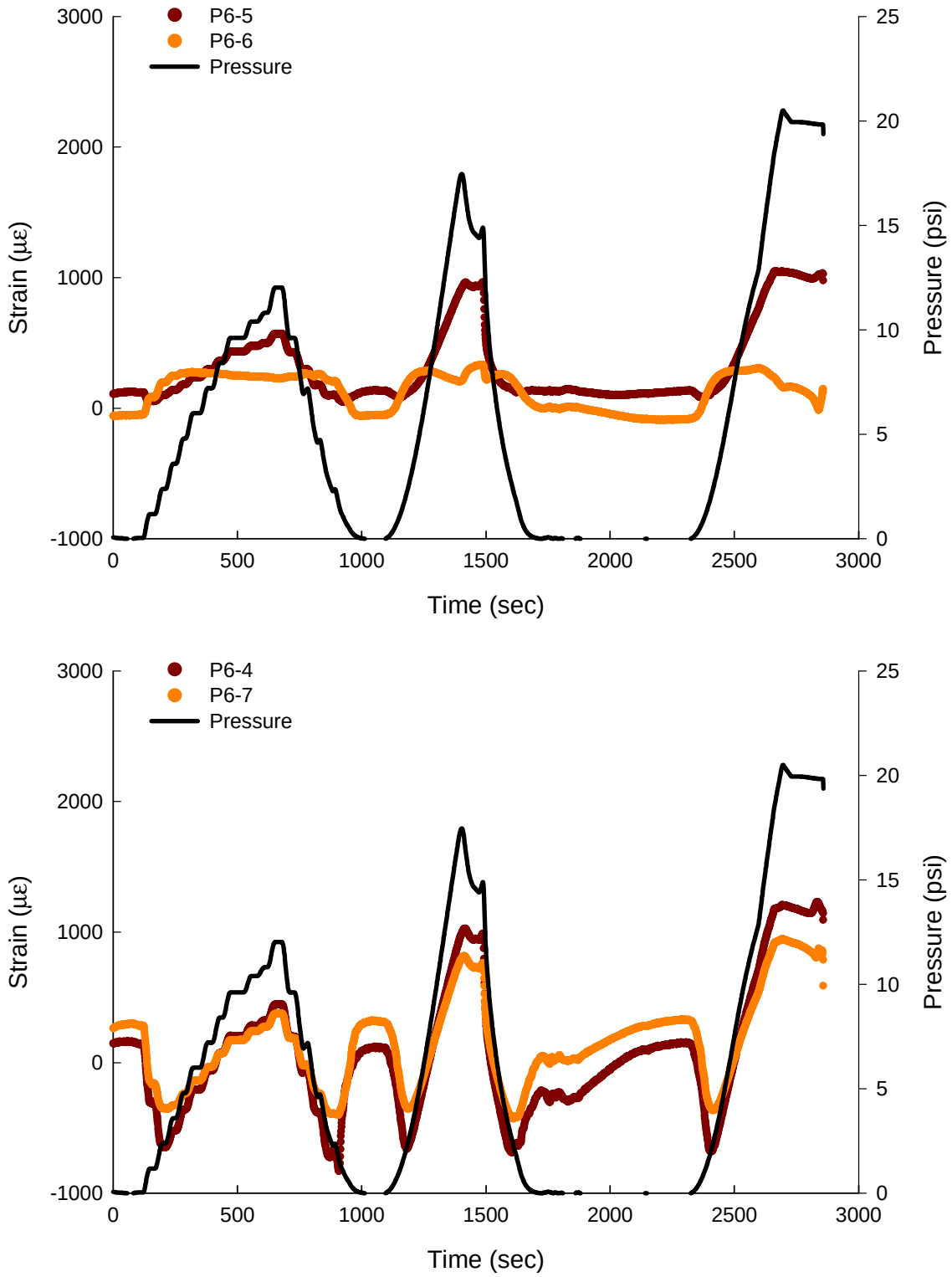


Figure H-5. Internal Strain Gages for LJC3A Patch

APPENDIX I—INSPECTION RESULTS

I.1 INTRODUCTION.

Flash thermography, computer-aided tap tester (CATT), and through-transmission ultrasonic nondestructive inspection (NDI) were used for disbond detection during the tests. In this appendix, the results from all the three inspections are shown. For thermography, the images shown are second derivative of temperature versus time. The CATT results show the tap duration for various patches at different cycles. Microsoft® Excel® was used to create the colored patterns from the amplitudes obtained using thorough-transmission ultrasonic NDI.

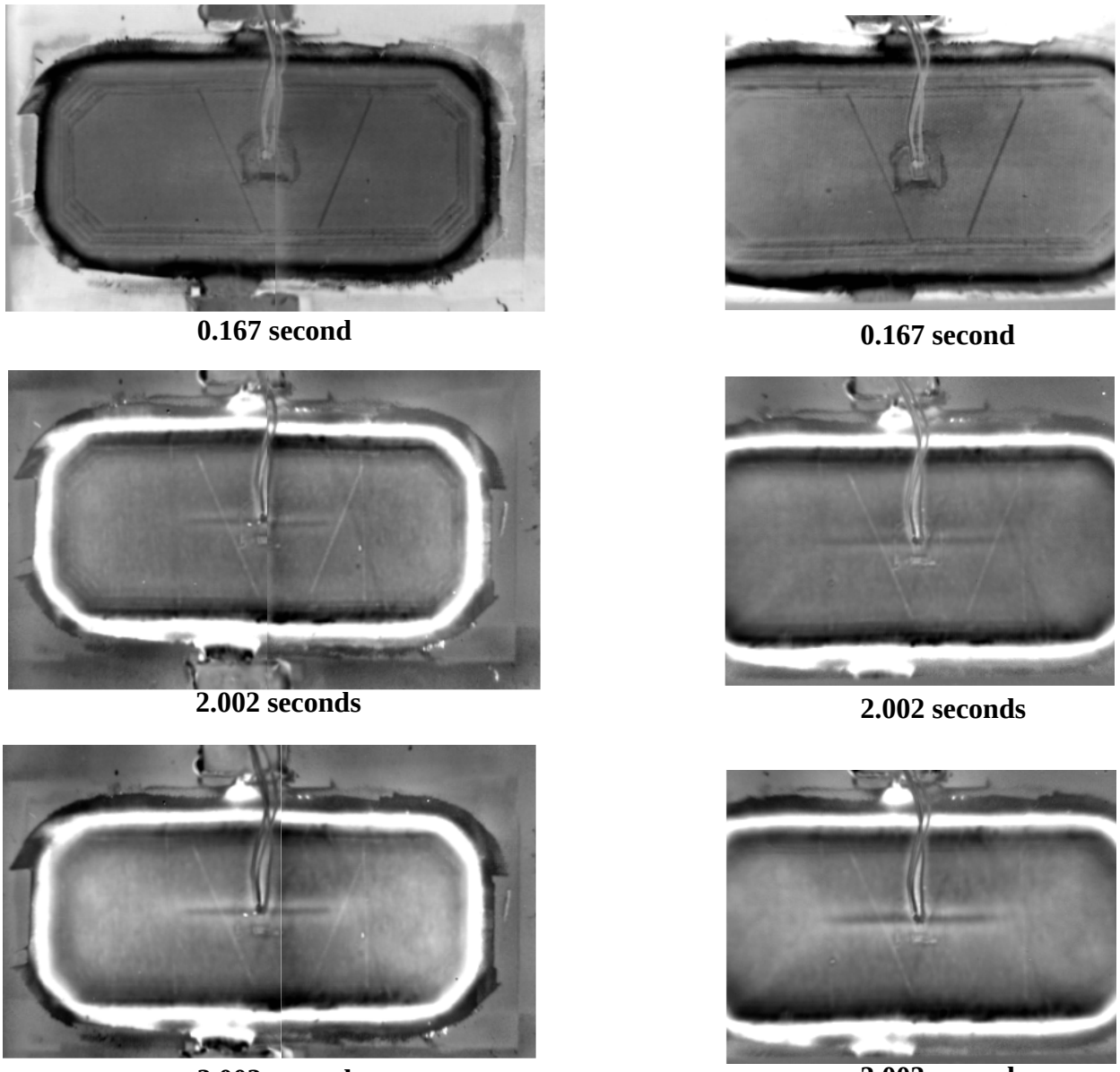
I.2 TEST PHASE 1.

Figure I-1 shows the result for the C1BE patch at 10,000 and 40,000 fatigue cycles. The images have been captured at three different times (0.167, 2.002, and 3.003 seconds). The 0.167-second image clearly shows the plies at the patch boundary. At 2.002 seconds, the crack starts appearing, and the patch layup is no longer clearly visible. At 3.003 seconds, the crack on the aluminum fuselage is clearly visible. This trend was observed throughout fatigue cycling. Figure I-2 shows the thermography image for the C2A patch at a 1.001-second time slice. The crack under the patch is not visible, as the heat passes through the structure very quickly.

During Test Phase 1, a CATT was also used to detect any disbonds. Figures I-3 through I-7 show the tap duration for all the patches. For lap joint patches, tapping was done every 0.75 inch; for midbay patches, tapping was done every 0.5 inch. Since the strain gages were installed at various locations on the patch, the areas covered by the strain gages and the wires could not be tapped, which caused random red or blue colors along the center vertical section of the patches, as shown in the figures.

I.3 TEST PHASE 3.

During Phase 3, through-transmission ultrasonic NDI was used for the LJC3A patch. The patch was divided into a 0.5- by 0.5-inch grid, and two 1-MHz, 0.5-inch transducers were used to interrogate the bonds. Each grid point was tested with the resulting amplitude value recorded on an Excel spreadsheet. The spreadsheet image represents a coarse c-scan of the testable areas of the patch at 0 and 20,000 cycles, respectively. These are shown in figure I-8 for 0 fatigue cycles and in figure I-9 for 20,000 fatigue cycles. The areas that could not be tested due to the interference from a tear-strap, strain gage, crack, or stringer are defined with different colors in the figure.



(a) (b)

Figure I-1. Images of C1BE Patch Captured by the Flash Thermography System at (a) 10,000 and (b) 40,000 Fatigue Cycles at Different Time Slices

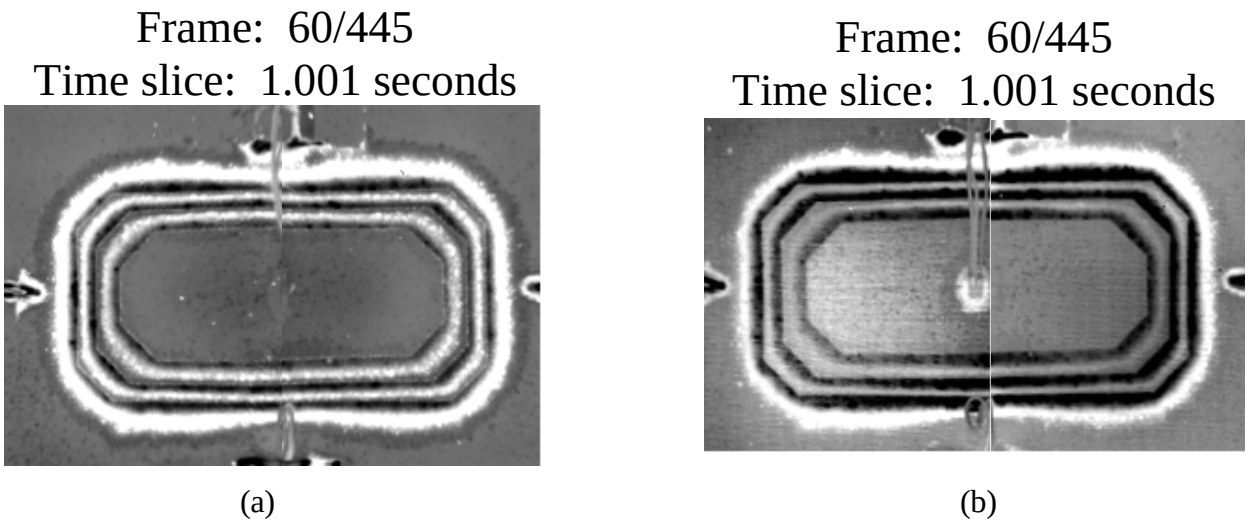


Figure I-2. Images of C2A Patch Captured From Flash Thermography System at (a) 10,000 and (b) 40,000 Fatigue Cycles

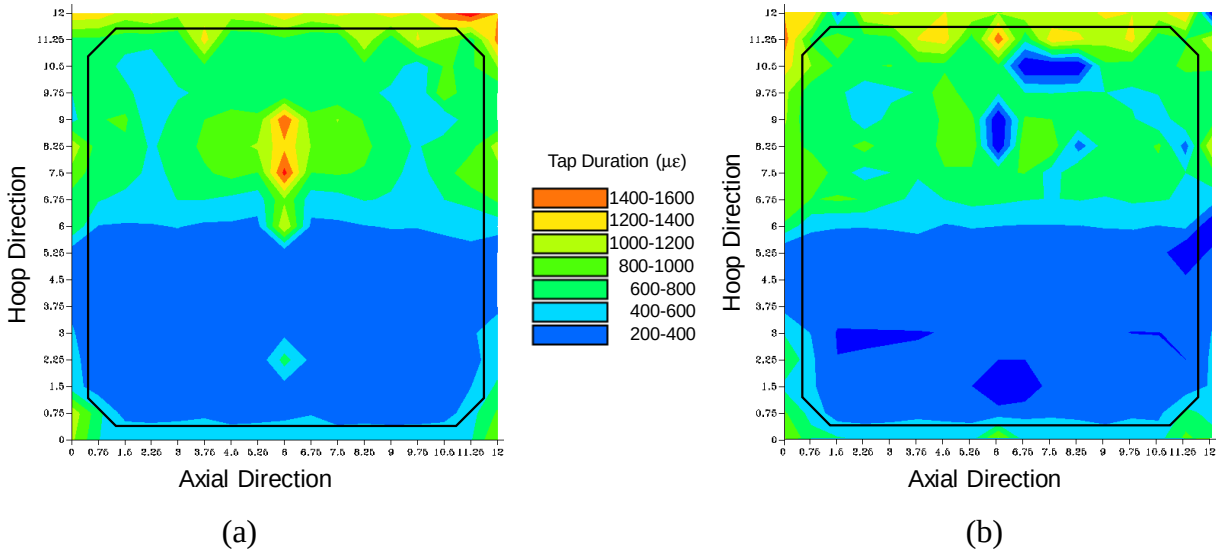
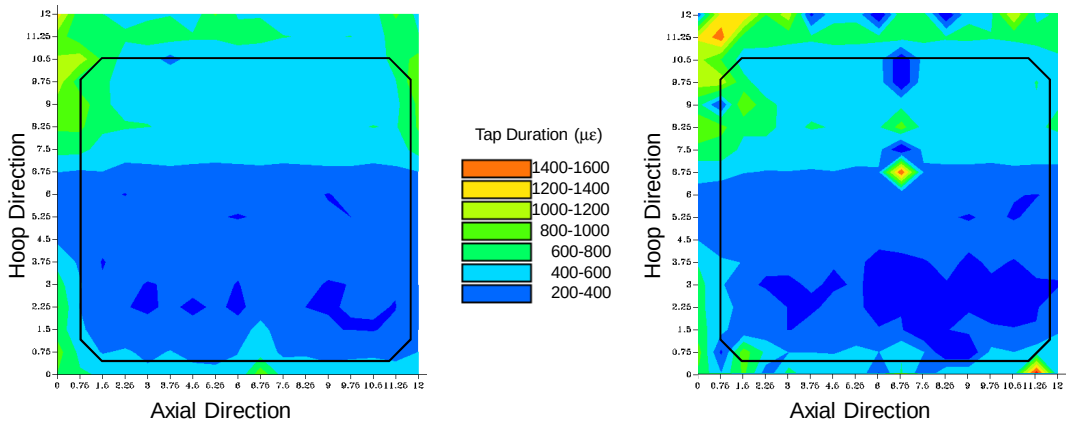
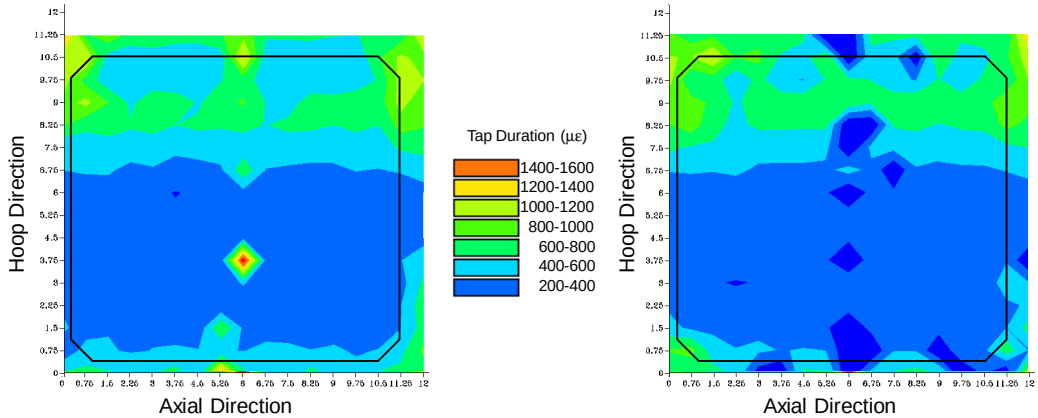


Figure I-3. Images of S1BE Patch Showing the Tap Duration Obtained Using CATT at (a) 10,000 and (b) 40,000 Fatigue Cycles



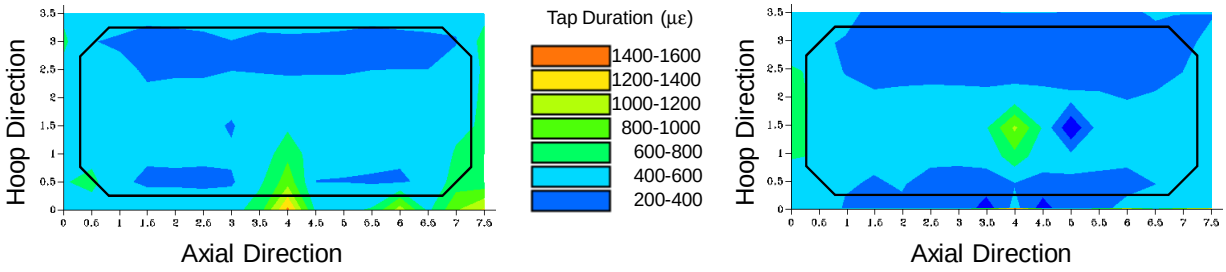
(a) (b)

Figure I-4. Images of S2BE Patch Showing the Tap Duration Obtained Using CATT at (a) 10,000 and (b) 40,000 Fatigue Cycles



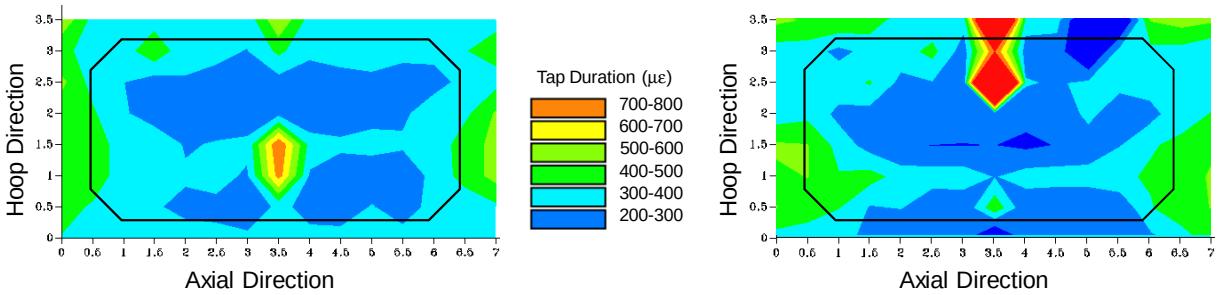
(a) (b)

Figure I-5. Images of S3A Patch Showing the Tap Duration Obtained Using CATT at (a) 10,000 and (b) 40,000 Fatigue Cycles



(a) (b)

Figure I-6. Images of C1BE Patch Showing the Tap Duration Obtained Using CATT at (a) 10,000 and (b) 40,000 Fatigue Cycles



(a) (b)

Figure I-7. Images of C2A Patch Showing the Tap Duration Obtained Using CATT at (a) 10,000 and (b) 40,000 Fatigue Cycles

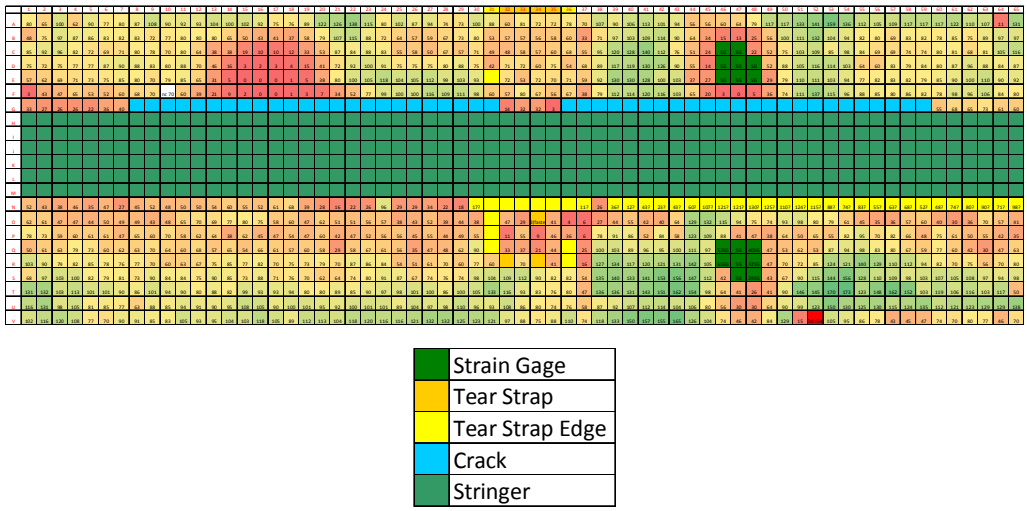


Figure I-8. Through-Transmission Ultrasonic NDI Results for LJC3A Patch at 0 Fatigue Cycles

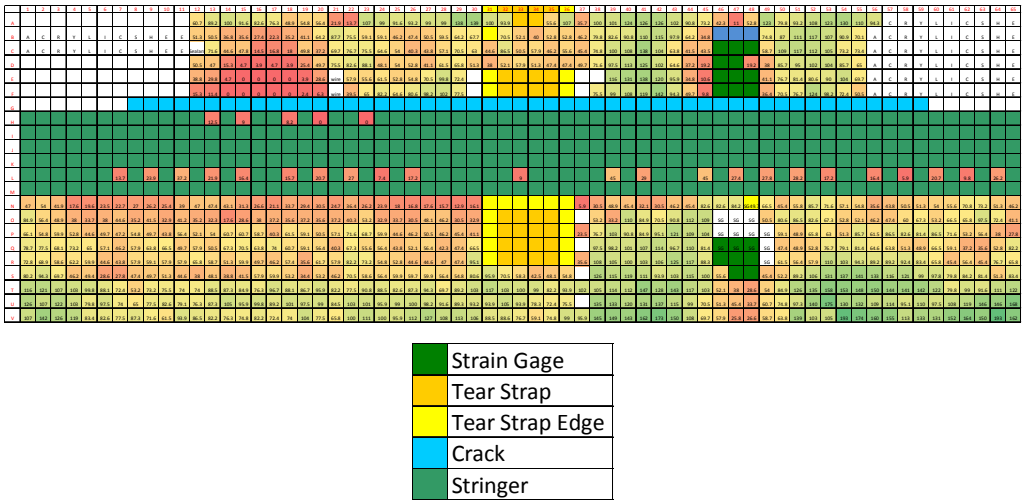


Figure I-9. Through-Transmission Ultrasonic NDI Results for LJC3A Patch at 20,000 Fatigue Cycles