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QUICK REACTION EVALUATION OF MATERIALS AND PROCESSES

Delivery Order 0011: Engineering Properties, Fatigue, and Crack Growth Data on SCS-6/Ti-6Al-4V Titanium Matrix Composite (16 Ply) Panels

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14. ABSTRACT

This report documents tension, compression, and shear properties as well as fatigue and crack growth data that were generated on titanium matrix composite panels manufactured using SCS-6 fiber as the reinforcement and Ti-6Al-4V powder as the matrix. This testing effort evaluated 120 panels and the test matrix was designed so that a robust data base and B-basis design allowables could be generated. The design allowables will be generated by Materials Sciences Corporation (MSC) and will be published at a later date in the Composite Materials Handbook (CMH-17). The data in this report were generated from a total of 8 lots of panels in order to achieve a statistical basis in the static properties. A total of 314 tensile tests, 172 compression tests, 120 shear tests, 20 material property tests, 618 fatigue tests and 64 crack growth tests were performed throughout the course of the program.

15. SUBJECT TERMS

titanium matrix composites, SCS-6 fiber, Ti-6Al-4V matrix, B-basis allowables, longitudinal, transverse, laminate, fatigue, crack growth, crack bridging

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PREFACE

This technical effort was initiated on 3 April 2006 using AFRL Materials and Manufacturing Directorate Contract F33615-03-D-5607, DO 0011. The task is entitled, "Titanium Matrix Composite (TMC) Testing and Data Analysis". The work was managed by the Air Force Research Laboratory, Materials and Manufacturing Directorate, Systems Support Division, Wright-Patterson AFB, OH. Mr. John Kleek (AFRL/RXSC) was the AF program manager.

This work was conducted by the University of Dayton Research Institute under the supervision of Ms. Alisha Hutson, program manager. Mr. John Ruschau was the UDRI Principal Investigator. The authors wish to extend recognition to Mr. Steve Spear of FMW Composite Systems who provided all test materials and for his input regarding TMC manufacturing. Special thanks are also given to Mr. Ken Combs, Mr. Don Woleslagle, and Ms. Patricia Youngerman of UDRI who performed the mechanical testing and data reduction. Finally, Ms. Lou Cooper of UDRI was responsible for the organization and final preparation of this final report. This report was submitted by the author on 28 May 2009.

It is also noteworthy to list all the individuals who participated in this effort including their role and/or contributions. Without the contributions of those individuals listed below, this effort nor the data generated would not have been possible to achieve.

PROGRAM PARTICIPANTS

Name	**Affiliation**	**Role or Contributions**
Mr John Kleek	Air Force Research Lab	AF Program Manager
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SECTION 1

INTRODUCTION

The Air Force is interested in transitioning Titanium Matrix Composite (TMC) materials to AF weapon systems in order to save weight and to significantly improve structural performance in designs where compression and buckling properties are critical. The manufacturing process of these materials have matured significantly over the last decade and have seen some applications as exhaust nozzle compression links in military engines, but have not seen widespread use as structural materials due to cost as well as the lack of credible mechanical property data in engineering design handbooks. The overall goal of this effort is to provide a robust data package to the composite materials handbook secretariat (CMH-17) in order to generate B-basis design allowables on these materials and to publish static property data, B-basis allowable, and fatigue data in CMH-17 handbook for use by aircraft design engineers.

Figure 1 below shows how the program was structured as well as the participants and their roles in generating engineering static properties including tension, compression, and shear data. This program also generated a robust data package on both fatigue and crack growth properties for use in aircraft structural designs. The program was lead by the Materials and Manufacturing Directorate of the Air Force Research Laboratory at Wright-Patterson Air Force Base. The manufacture of the TMC panels used in testing was FMW Composite Systems located in Bridgeport, WV. Mechanical testing was performed by two tests labs. Touchstone Research Laboratory located in Wheeling, WV conducted two thirds of the testing and UDRI conducted one third, but also collected all the data and performed all the data reduction before sending the data to Materials Sciences Corp (MSC). MSC is responsible for the publication of design data in CMH-17. They performed the statistical analysis of the static property data and generated B-basis allowables, which is the goal of the program.

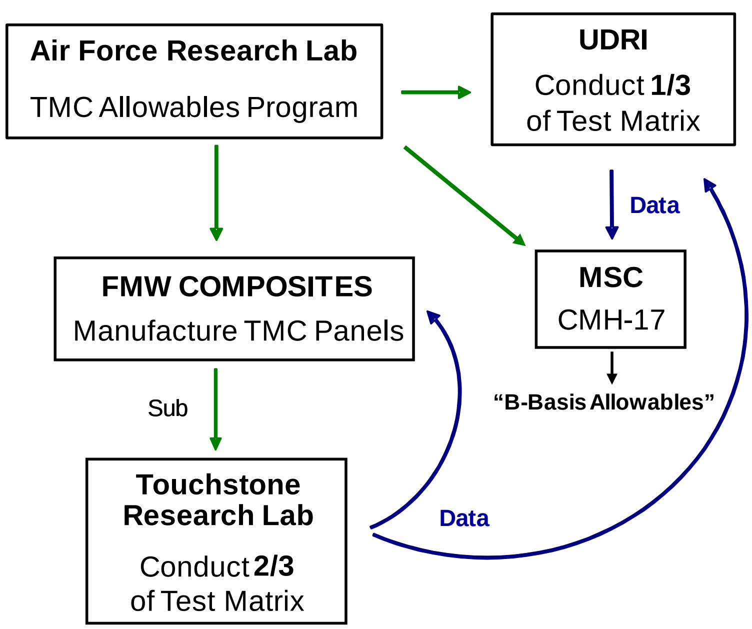


Figure 1. TMC Allowables Program Structure, Participants, and Roles

BACKGROUND

Titanium Matrix Composite (TMC) materials have seen significant aerospace opportunities over the past decade as a high strength / high stiffness material that also offers significant weight savings in many applications [1,2]. Figure 2 below is an example of where TMC's are currently being used [3-6]. They are in use as exhaust nozzle compression links on F-110 engines where they replaced a Ni base superalloy achieving a 44% weight savings. Figure 3 shows where TMC's have potential in components where high compression loads are required [7-9]. TMC's offer very high compression strengths as well as superior fatigue and crack growth properties over conventional titanium and steel alloys they seek to replace.

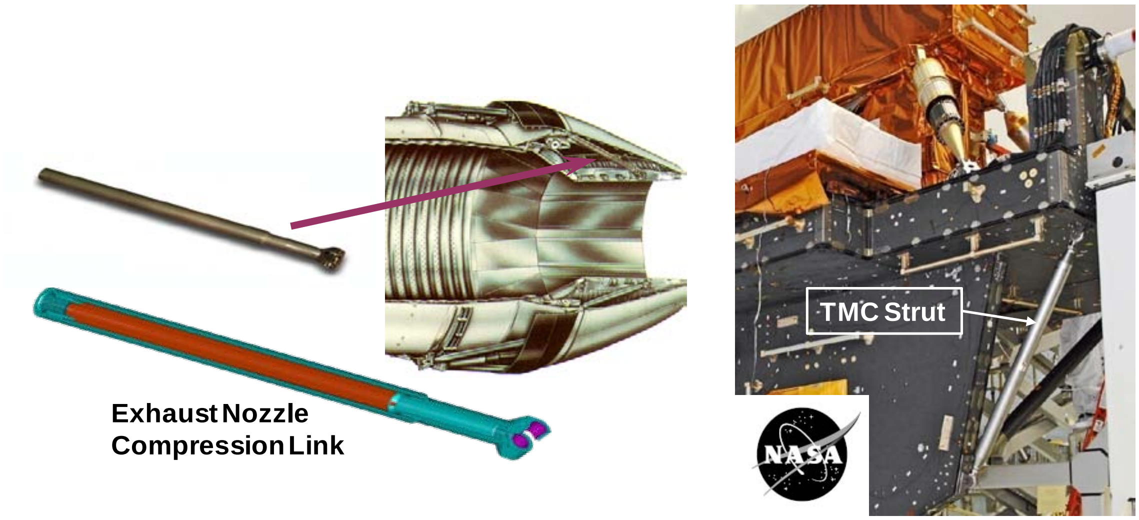


Figure 2. Current Applications of TMC's - GE F110 Engines (left) (Courtesy of FMW Composites) and on a Payload Pallet for a Hubble Telescope Mission (right) [Ref 6]

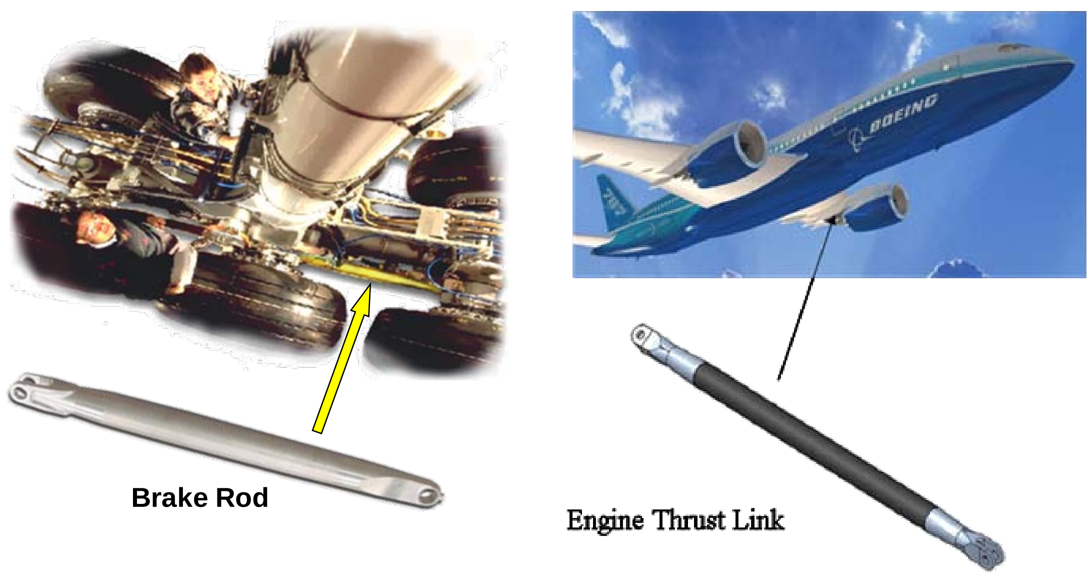


Figure 3. Examples of Potential Applications of TMC Components - Landing Gear Brake Rods (left) and Engine Thrust Links (right) (Courtesy of FMW Composites)

SECTION 2
PROGRAM APPROACH AND MATERIALS FOR EVALUATION

2.1 TEST MATRIX DEVELOPMENT AND DISCUSSION OF DESIGN ALLOWABLES

The test matrix developed for this program covers a range of static property tests including tension, compression and shear at both room and elevated temperatures. The test matrix also includes dynamic property tests including fatigue under both tension dominated and tension-compression loading conditions and fatigue crack growth testing conducted at both room and elevated temperatures. Thermal conductivity and CTE material property tests were also conducted. The full test matrix consists of over 1400 tests is shown in Table 1, including the appropriate test standard for each type of experiment. A range of temperatures, from -65°F to 600°F, were selected for mechanical testing to cover as many possible application temperatures as possible. Some panels were consolidated without fibers to provide a basis for comparison of composite material properties and are referred to as "fiberless" or unreinforced in the table.

Table 1. Test Matrix

Test Type	Test Condition	Test Standard	Orientation	-65F	73F	400F	600F	Total
Static Properties	Tension	ASTM D3552-96	L - Clad Specimen		48		48	**96**
			L - dog bone	12	**120**	12	48	**192**
			T - dog bone	12	48	12	48	**120**
			Fiberless Specimen		3		3	**6**
	Compression	ASTM D3410-03	L - straight sided	12	48	12	48	**120**
			T - straight sided	12	30		10	**52**
	Shear	ASTM D5379-98	L - "v" notched	12	48	12	48	**120**
	CTE	ASTM E228-95	L	5				**5**
			LT	5				**5**
	Thermal Conductivity	ASTM E1461-01 & ASTM D792	L	5				**5**
			LT	5				**5**
Fatigue	R = 0.1	ASTM E466-96	L - dog bone	24	72		72	**168**
			T - dog bone	15	45		45	**105**
	R = -1	ASTM E466-96	L - Clad Specimen		72			**72**
			L - dog bone	24	72		72	**168**
			T - dog bone	15	45		45	**105**
Crack Growth	Center Notched Specimen	ASTM E647-00	L - straight		18		36	**54**
			T - straight		2		4	**6**
	Compact Tension		Fiberless Specimen		2		2	**4**
			Fiberless Specimens	0	5	0	5	**10**
			Clad Specimens		120		48	**168**
			Standard Specimens	158	548	48	476	**1230**
			Total Specimens	**158**	**673**	**48**	**529**	**1408**

Legend:
- 100% TRL
- 100% UDRI
- 2/3 TRL & 1/3 UDRI

The test matrix incorporates both longitudinal and transverse specimens cut from uni-directional TMC panels. In addition, longitudinal fatigue and tension specimens were cut from panels carefully constructed to eliminate cut fibers on the sample edges that might bias the results. These specimens were called “clad” specimens and will be discussed later. The test matrix was developed in order to obtain B-basis design allowable on only the static property tests. B-basis values were generated by Materials Sciences Corporation and will be shown later for various panel orientations. These values are defined as less than the 10th percentile of a normal distribution of a given mechanical property test with 95% confidence. This is illustrated below in Figure 4 [10]. A-basis is even more conservative and these values are typically used for metallic material. For obtaining B-basis values a large number of lots (8 total) and tests were chosen to 1) obtain a robust allowables data base that would randomize the fiber spools that went into the panels and 2) ensure the manufacturing process was stable and did not vary from lot to lot.

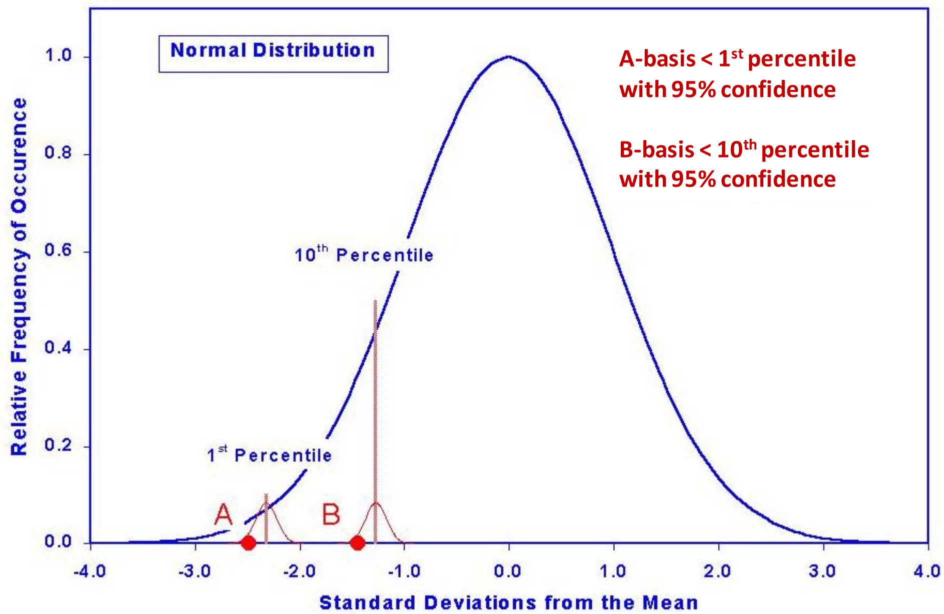


Figure 4. Schematic Representation of A-basis & B-basis Design Allowables [Ref 10]

The various classes of data that CMH-17 has defined are shown in Table 2 including the number of batches (lots) and the number of specimens that are required to achieve the value of interest [11]. For this program, it was decided that only B-basis values will be generated, where a minimum of 5 lots and 30 specimens are required for a robust sampling. In some instances, namely for the room temperature longitudinal tests, a total of 8 lots were used and 120 tests were performed, which is enough to generate A-basis allowable at a reduced sampling. The number and lots of tests that went into the test matrix was based on what the end users needed for the applications of interest. In addition, more emphasis was placed on the longitudinal orientation since incorporation of MMCs in component design is likely to focus on the longitudinal properties to take advantage of fiber-dominated strength characteristics.

In addition, the test matrix encompasses testing from two test labs. The blue highlighted cells are tests that were solely done by Touchstone Research Labs (TRL), whereas the red highlighted cells were tests done by the University of Dayton Research Institute (UDRI) including high temperature compression testing and all the FCG tests. The purple highlighted cells are tests where both labs participated due to the large number of tests and since the AF was interested in having two sources of test data. As shown in the legend, TRL conducted two-thirds of those tests and UDRI conducted one-third.

Table 2. CMH-17 Data Classes [Ref 11]

			Minimum Requirements (for data submittal to CMH-17)	
Designation	**Symbol**	**Description**	**total # of batches**	**total # of specimens**
A75	A	A-basis – Robust Sampling	10	75
A55	A	A-basis – Reduced Sampling	5	55
B30	B	B-basis – Robust Sampling	5	30
B18	B	B-basis – Reduced Sampling	3	18
M	M	Mean	3	18
I	I	Interim	3	15
S	S	Screening	1	5

In addition, the number of static test replicates conducted for each material lot is as follows. Tension tests at ambient temperature were performed for each panel and thus, fifteen replicates from all eight lots are represented. For all other static tests at 73°F and 600°F, six replicates per lot were conducted. In most cases for these temperatures all eight lots are represented. The 73°F transverse compression test condition included five lots, and fewer replicates (two per lot) were conducted for the 600°F transverse compression test condition. For the -65°F and 400°F temperatures, six replicates per lot were tested for each of two lots. Note that only one neat material lot was manufactured, so all neat tension tests were taken from it.

For fatigue testing, five repeats were conducted at five stress levels on longitudinal samples at 73°F and 600°F over three material lots; three replicates conducted at five stress levels on transverse specimens over three material lots. Cold fatigue tests were conducted with the same number of stress levels and replicates at the corresponding orientations for RT and HT testing, but specimens were taken from only one material lot.

For longitudinal crack growth experiments, three conditions of temperature and stress ratio (73F/R=0.1, 600F/R=0.1 and 600F/R=0.5) were examined. For each of these conditions, specimens were taken from two material lots. Three replicates at three different stresses were conducted to establish the level of repeatability on FCG behavior. The transverse and unreinforced (fiberless) crack growth tests addressed the same temperature and stress ratio (R) conditions as the longitudinal crack growth tests, but with only two replicates conducted, which were taken from a single material lot.

2.2 TITANIUM MATRIX COMPOSITE (TMC) PANELS

2.2.1 SCS-6 (Silicon Carbide) Fiber

The fibers used in manufacturing the TMC panels for testing and developing B-basis allowables were SCS-6 fibers manufactured by Specialty Materials, Inc. The fibers were continuous monofilaments of silicon carbide (SiC) that was chemically deposited on a carbon monofilament. The fibers were 0.0056 inches in diameter, had a tensile strength of over 500 ksi, and a modulus of 56 msi. For more information on these fibers, refer to Specialty Materials web-site [12].

For this program, approximately 125 spools of SiC fiber were used to manufacture 120 TMC panels. FMW conducted approximately 6500 tensile tests on the fiber from the 125 spools. They ran from 20 to 30 tests on each spool both at the beginning and end of the spool. Figure 5 below shows the results of their testing. The data below represent a typical distribution of fiber data and the mean tensile strength of the fiber was measured to be 577 ksi, however the fiber can typically achieve strengths between 600 and 625 ksi.

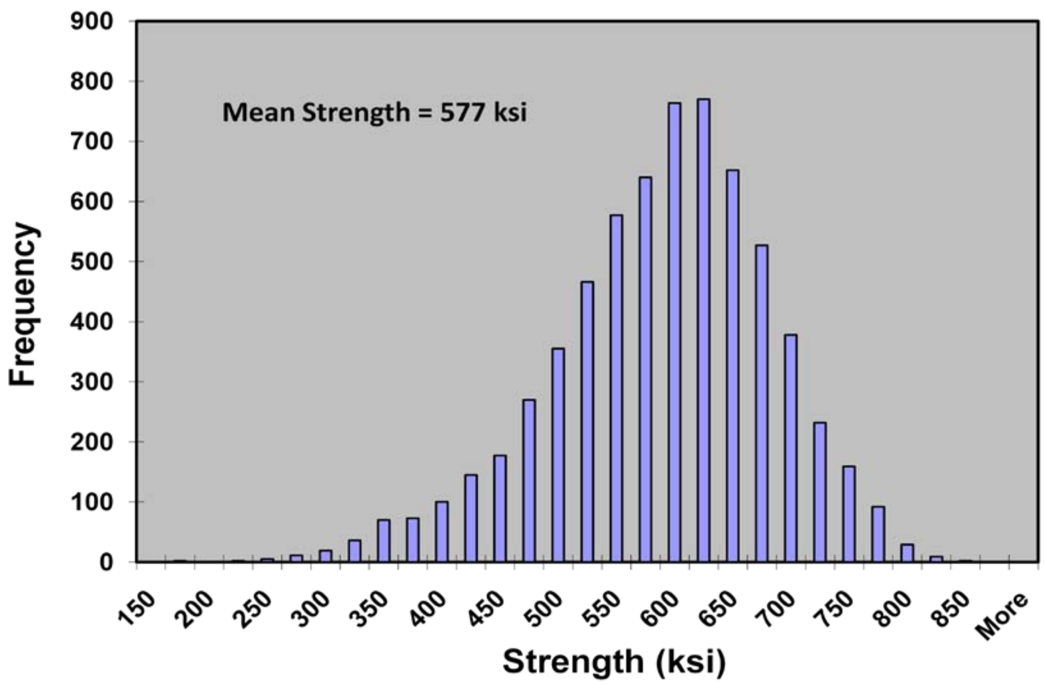


Figure 5. SCS-6 Fiber Strength Test Results (Courtesy of FMW)

2.2.2 Ti-6Al-4V Matrix

The matrix used to manufacture the TMC panels was Ti-6Al-4V powder for each ply and Ti-6Al-4V sheet cladding (AMS 4911) for the top and bottom of the finished panel. Powder was combined with SCS-6 (silicon carbide) fibers using FMW's proprietary process to form what is referred to as a tape cast mat. Details of the panel manufacture will be discussed later. Chemical composition analysis was performed on both the as-received powder and the clad material and the results are shown below in Table 3. The results indicate that the composition was in the expected range and that the interstitials including oxygen, nitrogen, and hydrogen are well within the desired limits [13].

Table 3. Chemical Composition of Ti-6Al-4V Powder and Sheet Cladding (weight %)

Element	***As-received powder chemistry***	***As-received sheet chemistry***	***Nominal / Limits***
Titanium	89.5	89.6	90.0
Aluminum	6.25	6.11	6.0
Vanadium	4.04	3.92	4.0
Iron	0.039	0.200	≤ 0.300
Oxygen	0.108	0.150	≤ 0.200
Nitrogen	0.009	0.006	≤ 0.050
Carbon	0.057	0.012	≤ 0.080
Hydrogen	0.003	0.002	≤ 0.015

Tensile testing of the unreinforced "fiberless" matrix was conducted and the properties obtained are shown below in Table 4. These properties were obtained from panels that were processed according to the same procedure used to make the TMC panels, but without the reinforcing fibers. The tensile properties obtained are typical of ASTM Grade 5 Titanium (Ti-6Al-4V) sheet [14].

Table 4. Average Tensile Properties of the Unreinforced Ti-6Al-4V Matrix

Temp	**0.02% YS ksi**	**0.06% YS ksi**	**0.2% YS ksi**	**UTS ksi**	**Modulus msi**	**%El**
RT	122.7	126.1	128.3	138.0	16.5	14.4
600F	72.3	79.3	81.3	99.4	15.7	19.7

2.2.3 TMC Panel Manufacture and NDE Evaluation

FMW Composites, Inc., the TMC panel manufacturer, provided the program with 120 panels to be used to make over 1400 test specimens for testing. The panels were manufactured by incorporating 16 plies (preforms) of SiC fibers that were impregnated in a matrix of Ti-6Al-4V powder to form a tape cast mat. The tape cast mats were then combined with thin sheets (cladding) of Ti-6Al-4V on the top and bottom surface, and then consolidated via a HIP (hot iso-static pressing) process to form a 16 ply TMC panel. A cross section of a fully consolidated TMC panel is shown in Figure 6. A close up of the fiber and matrix microstructure is illustrated in Figure 7. Due to the surface cladding layer, the microstructure adjacent to the fibers is slightly different from that on the material surface.

There were a total of 8 different lots of panels manufactured using approximately 125 different spools of SiC fiber in order to randomize the fibers that went into making the panels, since the fiber is the controlling factor in the resulting panel property due to its very high strength. The total number of panels that were manufactured was 120. In addition, there were other panels made that had thicker cladding, which is more representative of actual components and this provided the program with additional information for the end user. The overall panel dimensions were 6 inches by 9 inches. This size was chosen since the number of specimens to be used is maximized and they could be easily cut from the panels.

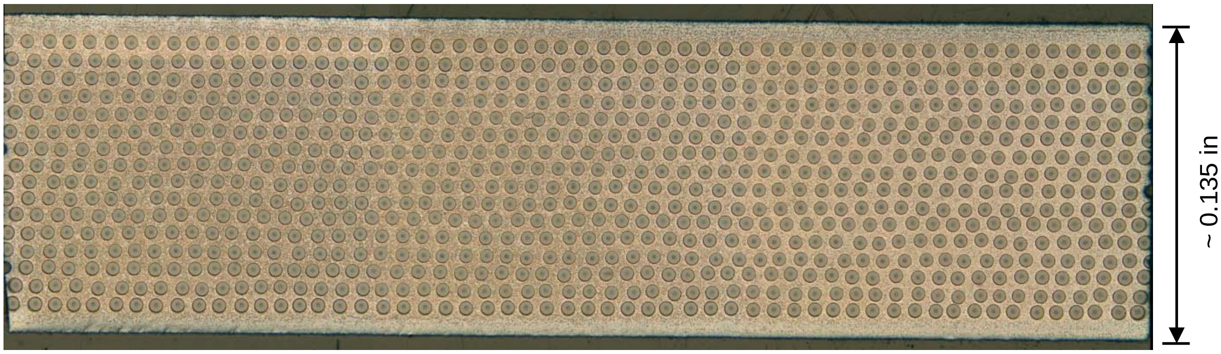


Figure 6. Representative Cross-Section of a 16 ply TMC Panel (Photo from FMW)

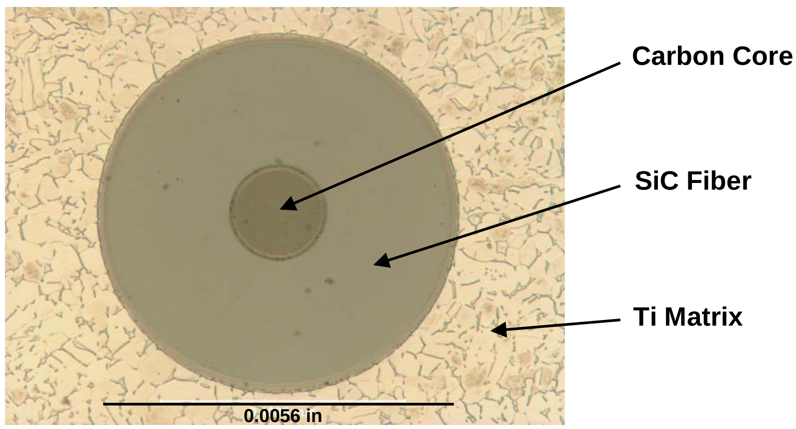


Figure 7. Representative Cross-Section of a SCS-6 Fiber and Surrounding Ti-6Al-4V Microstructure (Photo from FMW)

After consolidation, both top and bottom surfaces of each panel was chem-milled to remove enough material to achieve the target fiber volume fraction of 0.34. Interstitial elemental analysis was then performed to ensure that embrittlement from O_2, N_2 and H_2 was minimized. Results of that analysis are shown below in Table 5. The results indicate that the oxygen, nitrogen or hydrogen levels were low enough as to not affect the material properties. All intersitials particularly oxygen were well below the acceptable level. No major pickup was observed.

Table 5. Post Processing Interstitial Analysis Results for Ti-6Al-4V Matrix

Element	*Lot 1*	*Lot 2*	*Lot 3*	*Lot 4*	*Lot 5*	*Lot 6*	*Lot 7*	*Lot 8*
Oxygen	0.124	0.121	0.132	0.134	0.154	0.130	0.156	0.125
Nitrogen	0.010	0.010	0.011	0.011	0.012	0.011	0.008	0.010
Hydrogen	0.009	0.055	0.013	0.010	0.009	0.011	0.011	0.008

After processing, all 120 panels underwent NDE analysis to identify spurious fiber breakage due to the consolidation process that would adversely affect material properties. Inspections were performed using an underwater pulse echo ultrasonic immersion scanning technique. Panels were immersed individually and scanned such that the entire width and length of the panel was characterized, including regions at the panel edges. The equipment shown in Figure 8 was used for all of the panel scans. The scanning method is known to have some depth limitations, so that damage on the back face of the panel may not appear. To insure that all regions of the panel were inspected, each panel was scanned on the back face as well. A representative scan image of the standard used in this study is shown in Figure 9. All of the panels from which specimens were cut showed no indications of fiber breakage corresponding to greater than or equal to a 0.048” flat-bottom hole. Only one panel out of 120 showed one minor indication that was greater than 0.048” and was not used in any mechanical or material property testing. Figure 10 shows where the indication was found on the panel.

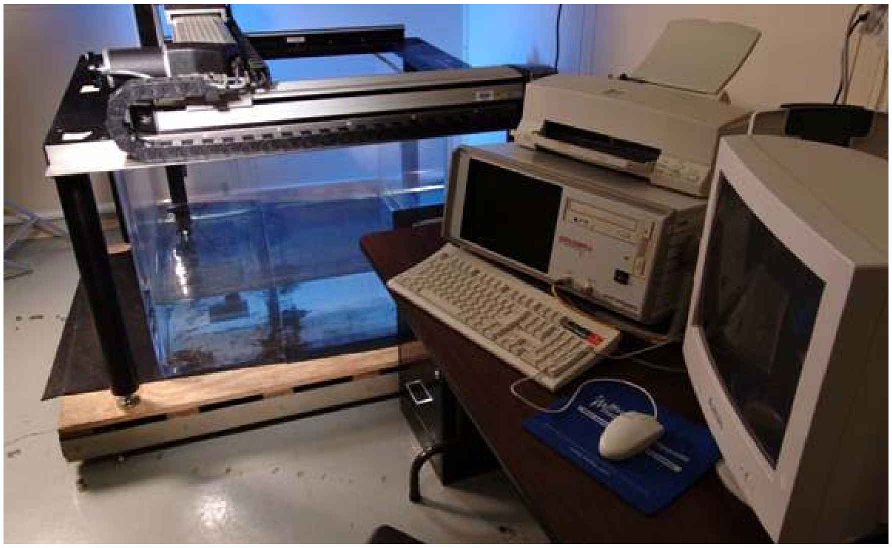
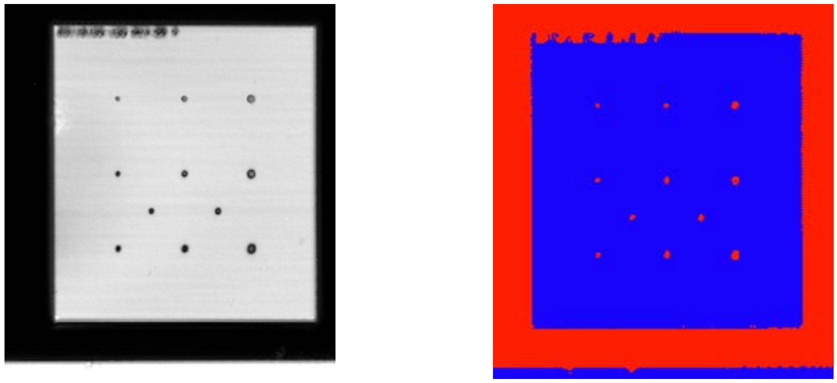
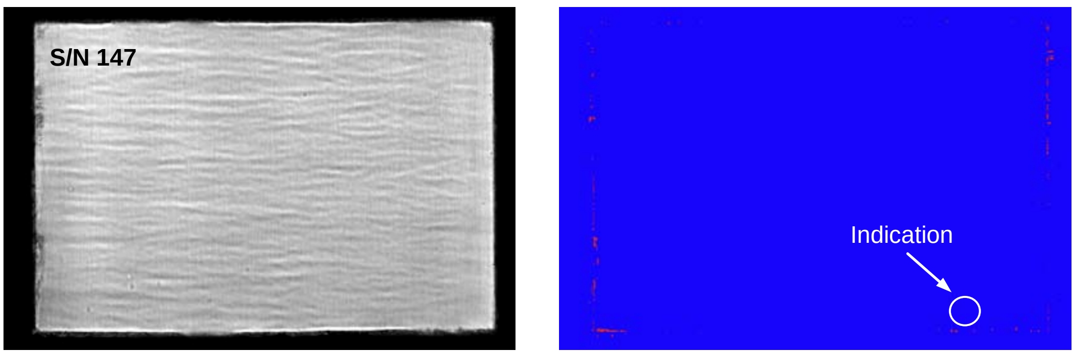


Figure 8. Ultrasonic NDE System (Photo from FMW)



Back Attenuation Go-No-Go

Figure 9. Results of NDE Flat Bottom Hole Standard



Back Attenuation Go-No-Go

Figure 10. Representative NDE Scan Image Showing a "Minor" Indication on One Panel

2.2.4 Coefficient of Thermal Expansion (CTE) and Thermal Conductivity

This effort also called for conducting coefficient of thermal expansion (CTE) and thermal conductivity experiments on the consolidated panels. In lieu of discussing the test procedures and the results in the report, the test results of those experiments can be found in Appendix A along with the test specimen cut plans. The tests were conducted by Anter Laboratories in Pittsburgh, PA.

2.3 TEST SPECIMENS

A variety of test specimens were used in this program to obtain B-basis allowables on static properties, which is the primary objective, but to also obtain a robust fatigue and crack growth property data base. Figure 11 shows the specimens used in this program which are commonly used in obtaining mechanical property data on TMC's. The shear specimen at the top is referred to a "v" notched specimen. The crack growth specimen is a center crack specimen that was EDM notched. The compression sample is referred to as a straight sided specimen. The tensile and fatigue specimens have the same geometry and are referred to as a "dog bone" specimen. What is interesting to note is that cut fibers are clearly visible on the edge of the fatigue sample shown below. This will be discussed more later in this section when discussing the "clad" sample.

All of the test specimens were prepared by TRL at the request of FMW including cutting, polishing, and placing tabs on the specimens. The specimens were cut from the panels using a lubricated diamond saw. The reduced width of the fatigue (dogbone) specimens and the v-notch for the shear specimens where formed by using a lubricated diamond grinder. The tension and compression specimens required tabs along the grip sections to prevent crushing of the composite and thus minimizing grip failures. For the tension specimens, a 0.5” by 1” sheet of 0.05” Ti-6Al-4V material was bonded to each grip face using an epoxy-based adhesive. Since only the gage section of the tension specimens was heated for the elevated temperature tests, no special accommodations were required to keep the tabs in place during the high temperature tests. However, for the compression tests, the entire fixture was heated for the elevated temperature tests, and the epoxy-based adhesive was insufficient for the temperature application. Therefore tabs were bonded to the specimen using a TIG welding process to ensure adhesion of the tabs throughout the experiment. The shear specimens and the crack growth specimens did not require tabs since the loads that were required to fail the specimens were much lower than for the other tests.

Figure 11. Photograph of Test Specimens used in Testing (Starting from the Top is Shear, Crack Growth, Compression, Fatigue, and Tensile)

Representative cut plans generated by FMW for the removal of the specimen blanks are illustrated in Appendix A. In general, there were several cut plans to accommodate the nearly 1400 specimens that were cut from the 120 panels. The following figures (Figures 12 through 15) are schematic drawings including specimen dimensions of all the mechanical test samples used in the program. In general, the geometries were selected in accordance with the applicable ASTM test method (described in the next section). The tension specimen gage length was 0.9 inches rather than the 1.0 inch length stated by ASTM D3553 for tension testing of metal matrix composite materials. The 10% decrease in gage length did not affect the test results since valid data were taken from the half inch in the gage center via a half-inch extensometer.

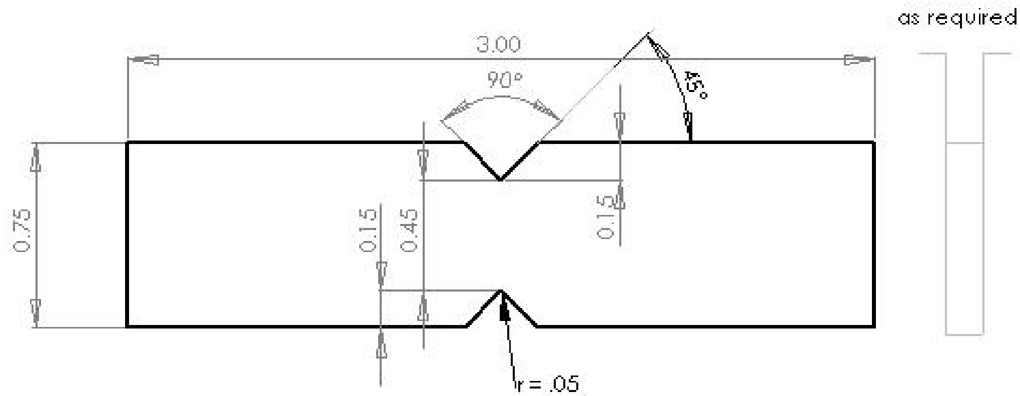


Figure 12. Shear Test Specimen Geometry (Courtesy of TRL)

Another variance from the specimen geometries given by ASTM is the total specimen length for the Iosepescu shear specimens. The nominal length for the specimens used here was 2.875" instead of the 3.0" given by the standard. The variances in length for both the shear and tension specimens were dictated by the panel final short dimension. Although the panel dimensions from edge to edge were 6" by 9", the panel thickness was not uniform all the way to the edges. An eighth inch had to be cut from all edges, resulting in panel dimensions of 5.75" by 8.75" and requiring that all longitudinal specimens be no longer than 5.75" long. Transverse specimen geometries were kept the same as the longitudinal geometry, for consistency.

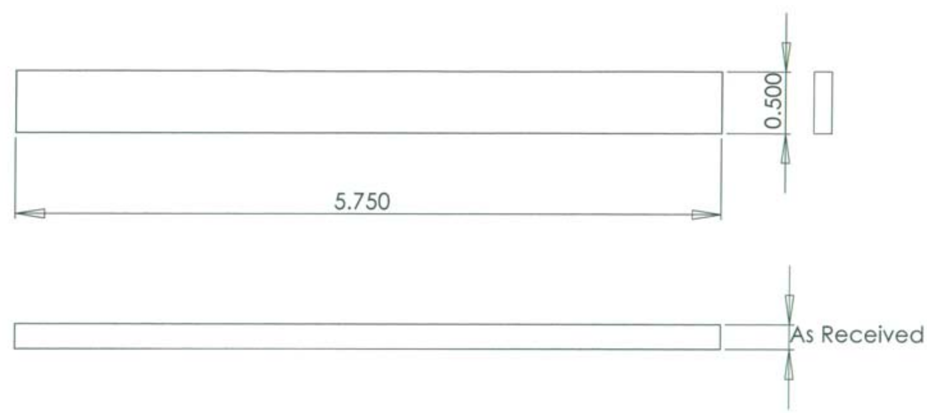


Figure 13. Compression Test Specimen Geometry (Courtesy of TRL)

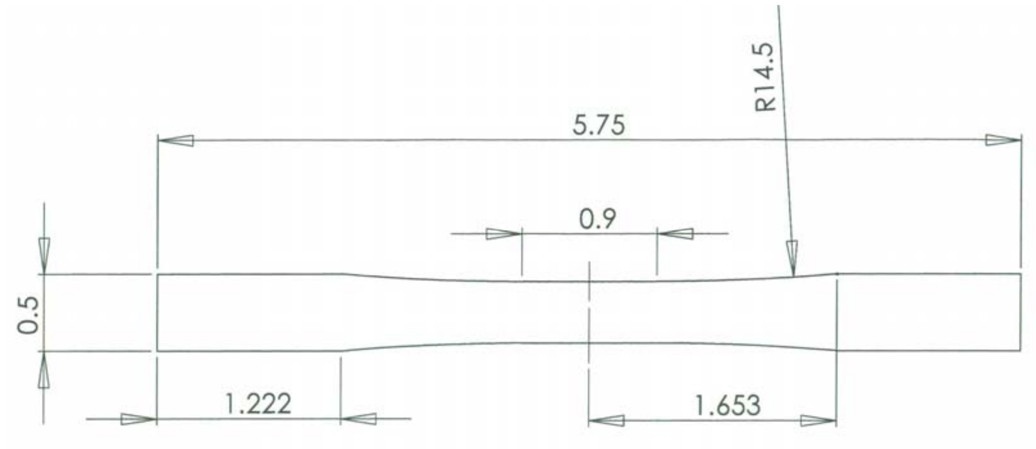


Figure 14. Tension and Fatigue Test Specimen Geometry (Courtesy of TRL)

Finally, a modified "clad" specimen was introduced into the program and is shown in Figure 16. Note that extra Ti cladding and a strategic placement of fibers were used so that the TMC section did not have any cut fibers in the test section of the sample. This specimen was designed by FMW in order to eliminate any cut fibers that was shown above for the dog bone specimens used for the tension and fatigue tests since such features are known to serve as crack initiation sites. This specimen is also more representative of actual components currently being used and planned for use, since component designs do not include any exposed fibers in the component. The compression link shown in Figure 2 is a good example. However, in this program, B-basis allowables were not generated on these samples; only screening data and will be presented later and will be compared to the standard test specimens.

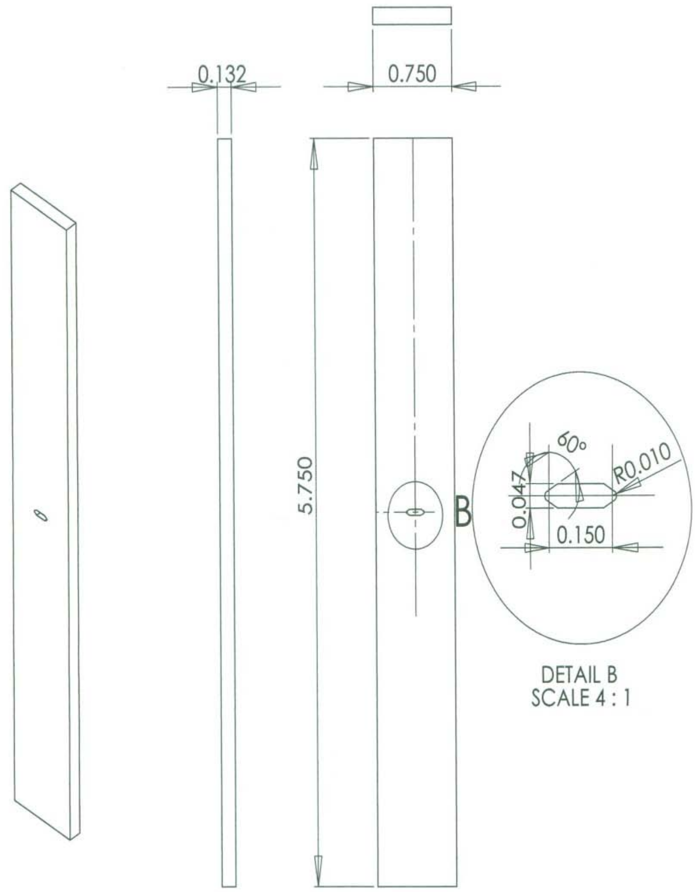


Figure 15. Fatigue Crack Growth Test Specimen Geometry with Notch Details (Courtesy of TRL)

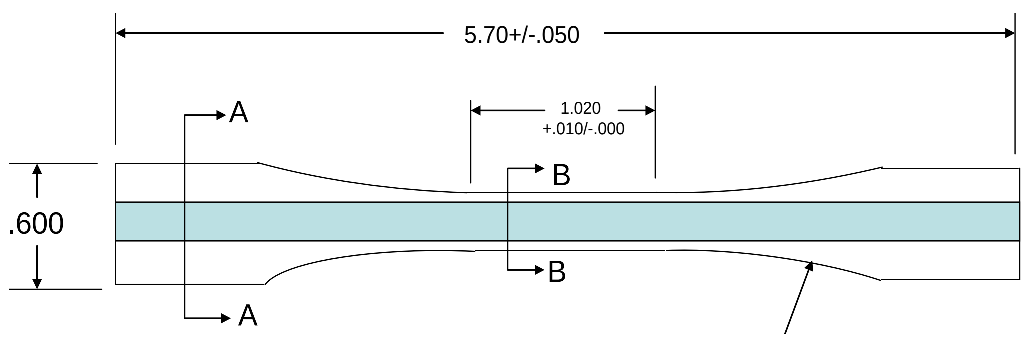


Figure 16. Schematic of “Clad” Test Coupons with TMC Section Highlighted in Blue (Courtesy of FMW)

SECTION 3
TESTING PROCEDURES

3.1 ASTM TEST STANDARDS

TMC specimens were tested in accordance with the appropriate standard from ASTM International, as shown in Table 6. Specific descriptions of the testing procedures are included in the following subsections. Testing was performed in laboratory air at -65F, RT, 400F, or 600F according to the test matrix shown in Table 1.

Table 6. Test Methods

Test	ASTM Standard
Tension (Apparent Modulus, Yield and Ultimate Strength)	**ASTM D 3553-96** Standard Test method for Tensile Properties of Fiber Reinforced Metal Matrix Composites
Compression (Modulus and Yield Strength)	**ASTM D 3410-03** Standard Test Methods for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
Iosepescu Shear (Modulus and Yield Strength)	**ASTM D 5379-98** Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method
Fatigue (Max Stress vs Cycles to Failure)	**ASTM E 466-96** Standard Practice for Conducting Constant Amplitude Axial Fatigue Tests of Metallic Materials
Fatigue Crack Growth (da/dN vs Delta K)	**ASTM E 647-00** Standard Test Method for Measurement of Fatigue Crack Growth Rates

3.2 TENSION TESTING PROCEDURE

All of the tension tests were conducted on servo-hydraulic test frames with a maximum tension load capacity of ~20 kips and a grip capacity of 3000 psi under displacement control of 0.05 inch/minute. Initially, a grip pressure of ~1500 psi was used for the longitudinal tests, and some slipping in the grips was noted. The issue was resolved by increasing the grip pressure to ~2000 psi. Grip slippage was observed as jumps in the stress-strain curve, where a relatively large increase in strain was present with either a slight decrease or no change in the stress. These jumps were corrected after completion of the test to allow calculation of the yield strengths. Strain-to-failure for these tests was considered invalid and was not reported. A representative stress-strain curve showing grip slippage is shown in Figure 17, which includes the raw stress-strain data as well as the “corrected” stress-strain data.

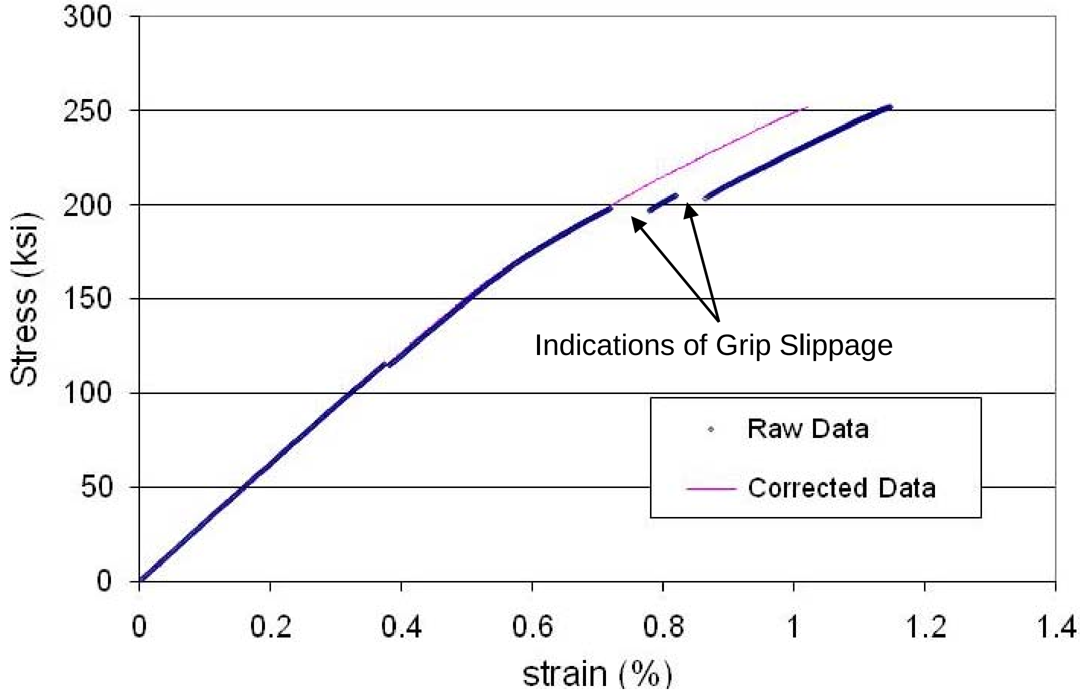


Figure 17. Representative Raw and Corrected Data in which Grip Slippage was Observed and Corrected

ASTM D 3553 allows for strain measurement by either extensometers or strain gages. Initially, strain gages were used to record strain during the tension tests, but it was noted after some early tests that the gages were delaminating prior to specimen fracture. Therefore, to obtain more accurate strain-to-failure readings on as many tests as possible, an extensometer was used instead of strain gages and any change in obtaining strain measurements was noted for each test. For tests in which strain gages were used, strain-to-failure was reported only for those tests where the gage remained bonded throughout the test. For the elevated temperature experiments, a clamshell furnace was used that accommodated the use of a high temperature extensometer.

3.3 COMPRESSION TESTING PROCEDURE

Compression testing was conducted using a displacement control of 0.05 inch/minute. The ITRII gripping system is shown in Figure 18 which used serrated grip inserts. Specimens were gripped to allow an unsupported gage length of 0.5 inches between the grips, as per the ASTM standard.

Initially, the specimens were tested until fracture; however, such fractures on longitudinal specimens were extremely energetic and caused damage to the grip faces. Further, fracture of transverse specimens was not a true compression failure, therefore the property values for ultimate compression strength and strain-to-failure would not be valid. Since the parameters of interest for these tests were 0.2% offset yield strength and compression modulus, appropriate interruption points were selected for each orientation and test condition. For the longitudinal specimens, a suitable stress for each test temperature was selected so that the desired yield strength would always be obtained, and tests were truncated at that stress rather than loading to fracture. For the transverse specimens, the test was interrupted at a point chosen based on strain level, since the yield and failure stresses were relatively low. For the longitudinal tests, a stress of 600 ksi was used for room temperature and a stress of 400 ksi was used for 600°F to interrupt the test to avoid extensive damage to the grips. The data prior to that stress level was what was needed for this program. The transverse tests were stopped at ~1% strain.

Figure 18. IITRI Compression Test Fixture (Photo from TRL)

For each test, strain gages were applied to both specimen faces and strain measurements were acquired from both gages to eliminate specimen bending issues in the post-test data analysis. Appropriate high temperature gages were used for the elevated temperature tests. Some problems were encountered in the early tests at high temperature due to strain gage wires contacting the test fixture and resulting in an electrical short circuit. High temperature Kapton™ tape applied to the wires and adjacent fixture surfaces eliminated this issue.

3.4 IOSEPESCU SHEAR TESTING PROCEDURE

Shear testing was conducted using an Iosepescu shear fixture as shown in Figure 19 with a displacement control of 0.05 inch/minute. The Iosepescu shear fixture described in ASTM D5379/ D5379M-05 was used without grip inserts since the samples were of sufficient thickness to maintain alignment during sample loading. Only one material orientation was used for shear testing and is referred to as “longitudinal”. Fibers in these specimens were oriented perpendicular to the shear loading plane in the specimen, which is between the specimen notch root. SCS-6 fibers were of sufficient strength that they would not fracture in shear in the composite configuration, so the tests were stopped at ~5% strain.

Strain gage rosettes were used on both specimen faces so that any bending inherent in the specimens due to the nature of the manufacturing process might be taken into account. As with the elevated temperature compression tests, the strain gage wires on the elevated temperature shear tests required insulation from the test fixture, which was provided by using high temperature Kapton™ tape.

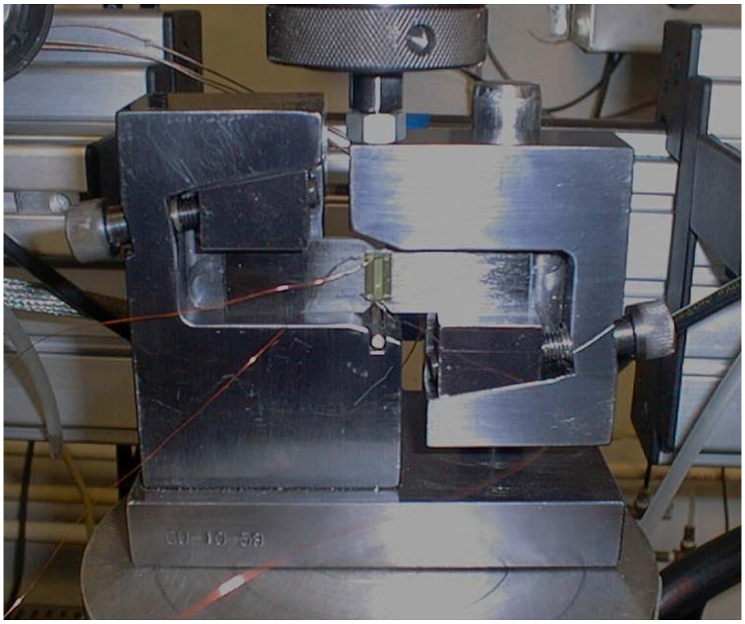


Figure 19. Iosepescu Shear Test Fixture with Specimen Installed (photo from TRL)

3.5 FATIGUE TESTING PROCEDURE

All the fatigue tests were conducted on servo-hydraulic test frames with a maximum tension load capacity of ~20 kips and a grip capacity of 3000 psi. A grip pressure of ~2000 psi was used for tests at both stress ratios, R = 0.1 and R = -1. Periodic stress-strain hysteresis loops were acquired throughout each experiment at the 1, 2 and 5 mark per decade up to 100,000 cycles. Test frequencies were kept at or below 5 Hz for both stress ratios up to a cycle count of 100,000 to facilitate stress-strain measurements. For tests in which higher frequencies could be employed without affecting test results, the extensometer was removed after 100,000 cycles and the frequency increased to an appropriate level. For R=0.1, test frequencies up to 20 Hz were used; for R=-1, test frequencies did not exceed 10 Hz due to potential heating of the sample from friction at the fiber / matrix interface. Use of the higher frequency at R=-1 (beyond 5 Hz) was limited to lower applied stresses and there was no effect of frequency on ambient specimen temperature prior to use. Figure 20 below illustrates the test setup for the fatigue tests.

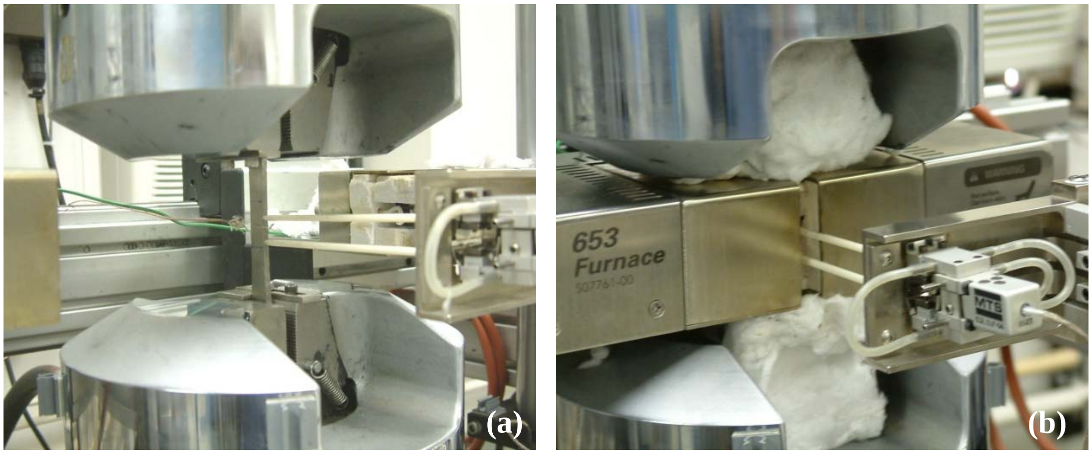


Figure 20. Fatigue Specimen Installed along with a High Temperature Extensometer (a) and Fatigue Test Setup for Elevated Temperature Tests (b) (Photos from TRL)

The fatigue specimen geometry was known to be susceptible to buckling during fully-reversed loading (R = -1) at the loads employed in the testing of the longitudinal specimens, so TRL and FMW developed a tab configuration designed to prevent buckling as shown in Figure 21. Analysis of the stress-strain curves from early longitudinal tests as shown in Figure 22 suggested that the tabs were insufficient to prevent buckling entirely. As shown in the figure, there was significant bending at the lower portion of the cycle at N=2,000 and N=5,000. A buckling calculation for both material orientations revealed that the transverse orientation was not buckling critical. The remaining longitudinal experiments were conducted using an anti buckling guide as shown in Figure 23. Thin sheets of Teflon tape having good lubricity were placed between the buckling guide and the specimen. The bolts were hand tightened just enough to keep the guide in place, which had no discernible impact on the results.

Figure 21. Fatigue Specimen with Extended Tabs

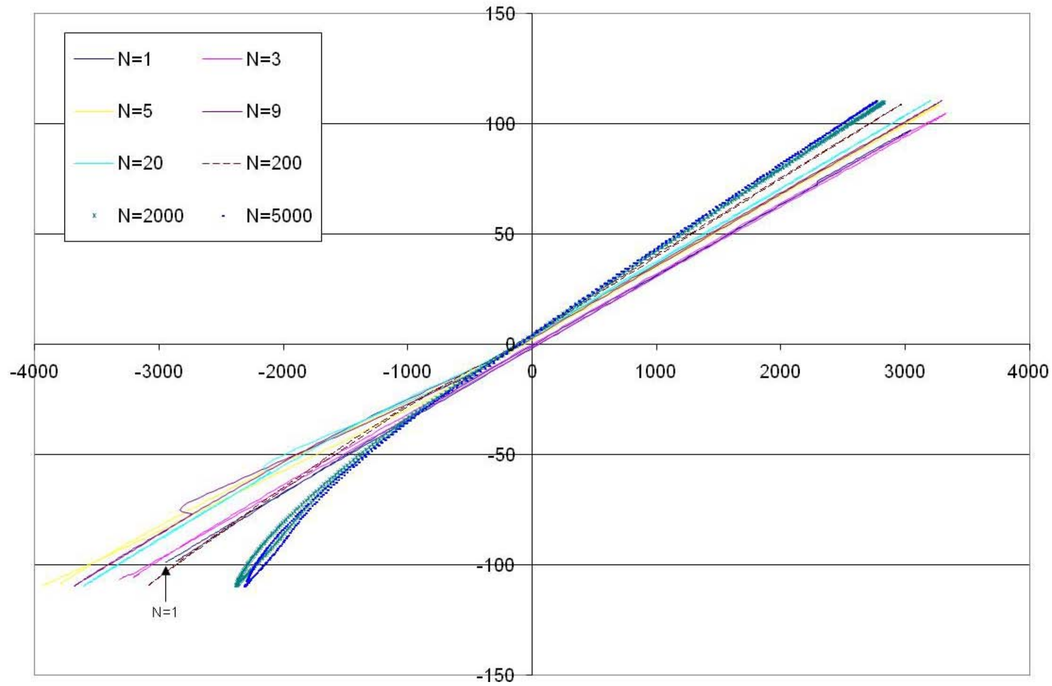


Figure 22. Stress vs Strain for Several Cycles of a Test at R = -1, with Bending Evident at the Lowest Portion of the Cycle for N = 2,000 and N = 5,000

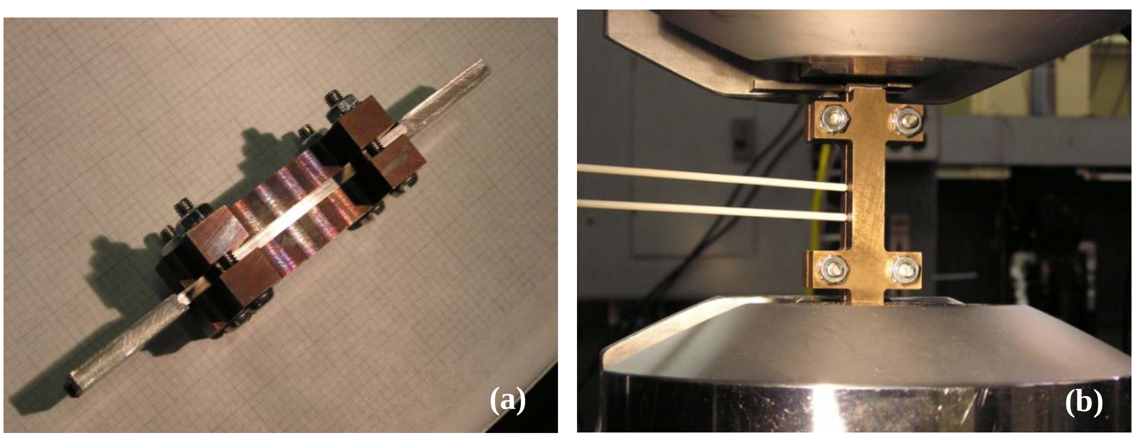


Figure 23. Fatigue Specimen with an Anti Buckling Guide Clamped on the Gage Section (a) and a Fatigue Specimen in Test Frame with the Guide and Extensometer in place (b)

For the elevated temperature experiments, a clamshell furnace was used that accommodated the use of a high temperature extensometer as shown in Figure 20b. A single thermocouple wire bonded on the specimen was used to measure temperature. The experiment was stopped via a feedback control loop if the temperature exceeded or fell below the ASTM designated tolerance.

3.6 FATIGUE CRACK GROWTH TESTING PROCEDURE

Fatigue crack growth (FCG) testing was performed on one of two servo-hydraulic test machines, one with a 10 kip load capacity, the other with a 20 kip load capacity. A desktop computer was used for control and data acquisition. ASTM Standard E 647-00 “Standard Test Method for Measurement of Fatigue Crack Growth Rates” was followed wherever possible, however the nature of TMC’s precludes the use of some of the validity requirements that the standard imposes. These issues are discussed below. Crack length measurements were made both optically and using an electrical potential drop (EPD) system. Visual observations were made periodically throughout the test based on crack extension observed by the EPD, as well as at the beginning and end of each test. Any differences in electronically obtained versus visual crack lengths were resolved during post-test analyses.

One issue that limits the application of E647 to the measurement of FCG rates in TMC’s is the constraint of E647 section 8.8.3, which requires that both measured crack lengths (front and back) remain within a given tolerance. In the processing of the TMC panels, it was not possible to ensure equal removal of material from both panel faces during the chem-milling process. Thus, some panels were slightly bowed upon completion due to redistribution of internal residual stresses from the HIP consolidation process. Although the deviation from flatness seemed minor, it resulted in several test samples having significant variation in crack lengths from front to back, as shown below in Figure 24. This variation in crack lengths for the monolithic (unreinforced) samples was not observed since the samples can be machined to eliminate this and other sources of surface thickness variation. Face machining of the TMC material would only worsen the curvature by causing further redistribution of residual stresses and would likely cause fiber breakage in the process. Thus, the specimens are left untouched and the surface length variations are accounted for in the post-test analysis process. (Note that the issue of flatness does not apply to tube shapes, which is the most common form of TMC components to date.)

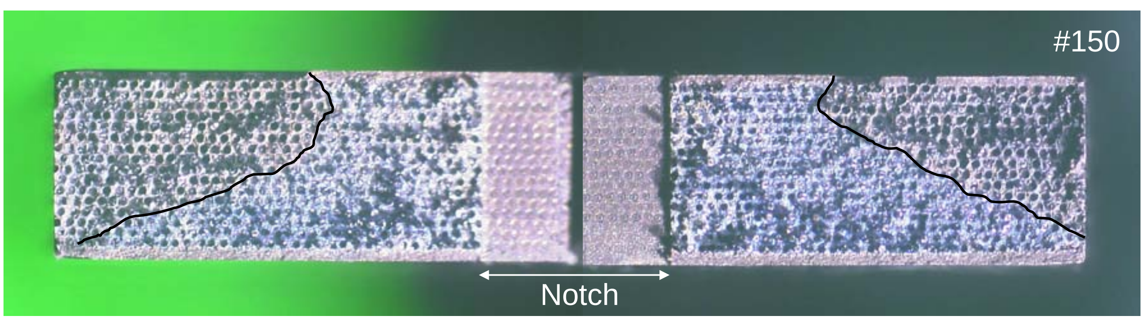


Figure 24. FCG Specimen Fracture Surface with Crack Front Profile Highlighted

It should be noted that this constraint is necessary when the testing control method requires an accurate *in situ* crack length measurement. Such methods include pre-cracking, threshold or other K-controlled methods, which are not viable in FCG testing of TMCs with multiple plies that may remain intact in the crack wake. Such behavior referred to as fiber bridging, shields the crack tip from the full effect of far field loading and makes it impossible to know the state of stress at the crack tip, or even the location of the crack tip in the specimen interior prior to fracture. Figure 25 below illustrates the three modes of crack tip behavior observed in TMC's, which have been well documented [15-17]. (Note the pronounced effect of "reverse tunneling" of the crack front in Figure 26 below).

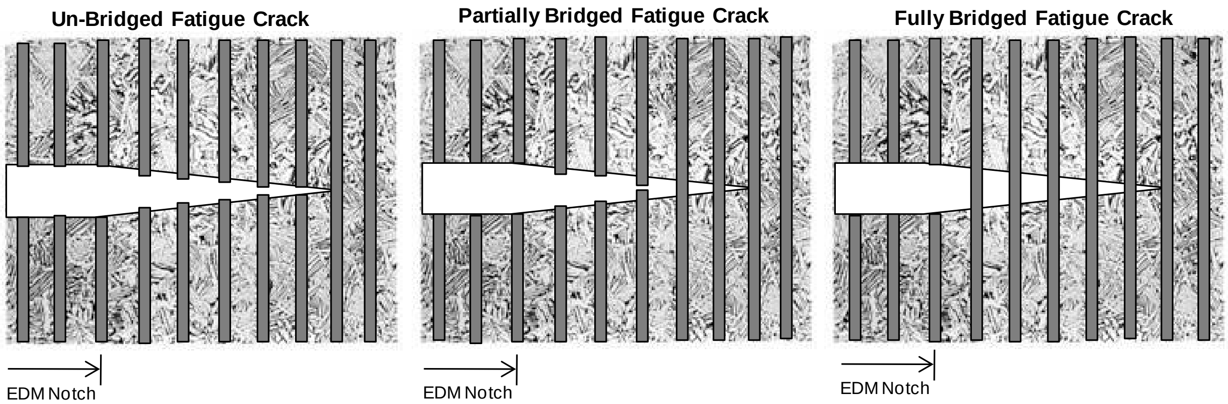


Figure 25. Schematic Illustrating Fatigue Crack Bridging Behavior Observed in TMC's.

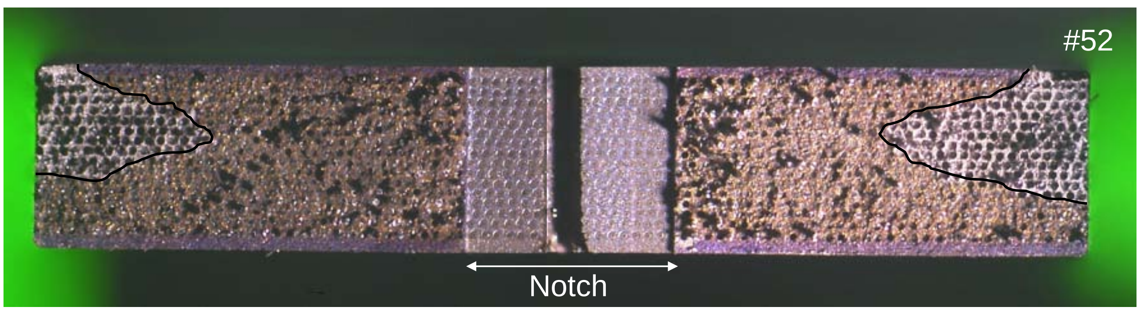


Figure 26. FCG Specimen Fracture Surface Exhibiting "Reverse Tunneling" with Crack Front Profile Highlighted

Furthermore, crack measurement methods such as electrical potential drop (EPD) and compliance measurements are disrupted by the presence of the fibers and do not accurately reflect actual crack lengths that are present in TMCs. Since neither crack length nor the level of crack bridging can be measured directly during the test, K-controlled methods cannot be used. Displacement control is not recommended in E647, so load control is the only method that should be used for TMCs.

All FCG experiments were conducted using load control for the $[0]_{16}$ orientation and so a relatively large number of experiments were required. Eighteen tests were planned for room temperature, and all to be tested at a load ratio, R = 0.1. Thirty-six tests were planned for 600°F, which are to be divided equally between two load ratios, R = 0.1 and 0.5. Each lot of eighteen specimens was taken from two material lots, so that three stresses at each condition could be evaluated with three replicates at each stress. Stress levels for each condition as shown in Table 7 were selected based on results from similar material tested in prior work at comparable temperatures [18]. The range of applied stresses was selected in an effort to encompass the full range of possible behavior including fully bridged, partially bridged, and un-bridged crack propagation. Some individual tests at intermediate stresses were conducted to help establish suitable stresses for this effort (e.g. For the 600°F and R=0.1 condition, tests were also conducted at 65 and 85 ksi.).

Table 7. FCG Test Matrix with Stresses and Number of Replicates in Parentheses

Test Condition	*Fully bridged Stress Level (ksi)*	*Partially bridged Stress Level (ksi)*	*Un-bridged Stress Level (ksi)*
75F, R=0.1	55 (6)	80 (6)	96 (6)
600F, R=0.1	65 (6)	85 (6)	105 (6)
600F, R=0.5	65 (6)	95 (6)	110 (6)

The data acquired during each test included EPD crack length versus cycles, surface optical crack length versus cycles, and crack front curvature at the final cycle. In TMCs one could argue what is the “real” crack length at any given time and for any given condition. As stated before, the EPD crack length is biased by the presence of unbroken fibers in the crack wake. The surface optical crack lengths may or may not reflect the “actual” crack length depending on the applied loading.

The FCG data reduction process begins by correcting the surface optical crack lengths by a factor based on the crack front curvature measured for the final cycle. First, the four surface crack lengths are averaged and treated as a single crack, $a_{optical}$ The crack front curvature is then obtained by measuring the crack length from the fracture surface at five equally spaced interior points (ASTM recommends three as a minimum) and subtracting that value from the average of the two crack lengths at the surface, which are also measured on the fracture surface. Both left and right sides are measured independently and the two resulting curvatures are averaged and treated as a single parameter. A linear increase in curvature from the initial notch is assumed, where the curvature is zero at N=0, and the value at $N=N_f$ is taken as the value measured from the fracture surface. Curvature corrections for crack lengths measured at $N < N_f$ are interpolated from this linear fit. For this material, it should be noted that the interior crack lengths can be either longer (as is typical for monolithic materials) or shorter than the surface lengths (see Figure 27), so curvature corrections can be positive or negative. Corrected optical crack lengths, $a_{corrected}$, are assumed to reflect the average crack length in the matrix.

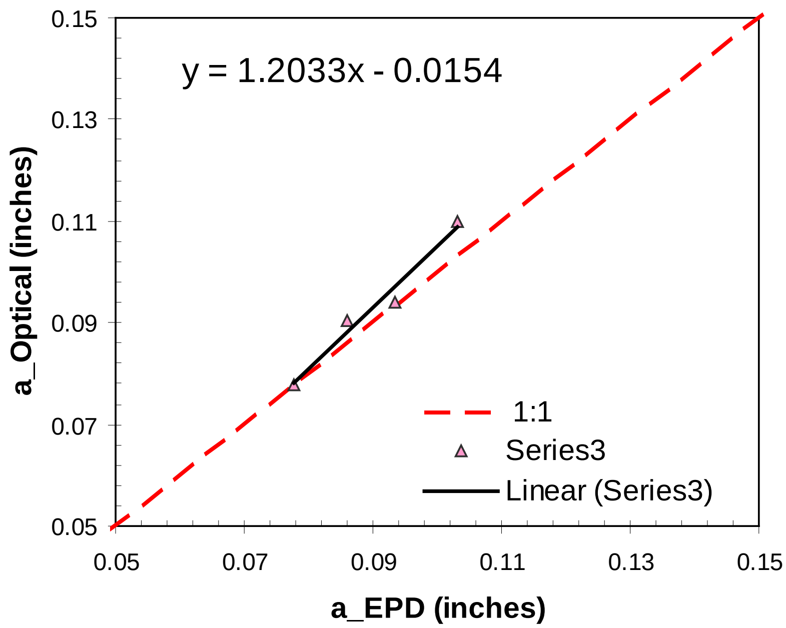


Figure 27. a_{EPD} vs $a_{corrected}$ plot and fit to data used to interpolate intermediate a_{EPD} data

EPD crack lengths, a_{EPD}, are then corrected so that $a_{EPD} = a_{corrected}$ at the cycle counts where optical data was obtained and assuming a linear trend in the difference between a_{EPD} and $a_{corrected}$ to allow corrections to be made to intermediate a_{EPD} data (see Figure 26). This correction may be applied in a piecewise manner, depending on the trends observed when a_{EPD} versus $a_{corrected}$ is plotted.

After correcting the EPD crack length data, the a_{EPD} (corrected) vs. N data are used compute the growth rate data, da/dN. A data reduction code called SMOOTH, which was developed at AFRL was used to perform the data reduction. This code includes a K solution appropriate for the M(T) specimen geometry as well as a regression analysis based on a sliding 7-point polynomial regression. The code also employs a crack extension criterion, whose value is set by the user to ensure that measurement errors are approximately uniform for any crack length. Thus, the interval from which each growth rate point is computed, it will contain either a minimum of seven points or a minimum level of crack growth as indicated by the user. The crack length at the middle of the interval is used to compute K. For the TMC FCG data, a minimum crack extension of 0.05 inch was used. The SMOOTH code includes the output crack length versus cycles (used for the regression) as well as crack growth rate versus K results (K_{max} and ΔK). Therefore, the crack length data from this analysis were compared with those data in the input file as validation of the growth rate results, which is depicted in Figure 28 below.

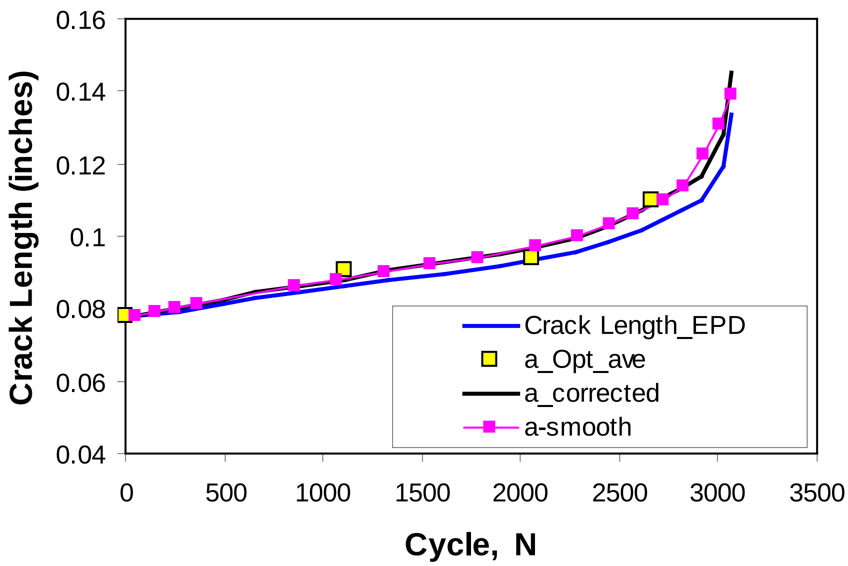


Figure 28. Crack Length versus Cycles. (Data from Original EPD, Corrected Optical, Corrected EPD, and SMOOTH Sources for Specimen #70 (75°F at 96 ksi))

SECTION 4
RESULTS AND DISCUSSION

4.1 DATA REDUCTION METHODOLOGY FOR TENSION, COMPRESSION, AND SHEAR DATA

All the static test data from this program were reduced using an Excel® Macro developed in-house specifically for TMC's. In this Macro, stress and strain test data were entered as ksi and in/in respectively. The data was divided into ten segments based on percentage of maximum stress. The slope of the data was computed for the first segment (data from 0 to 10% of maximum stress), and then for subsequent segments from 0 to 20%, 0 to 30% and so one. Slopes were then compared in sequence and the modulus was defined as the value just prior to a decrease in slope of greater than two percent. The slopes, given in ksi, were plotted as a function of "% of Maximum Stress" as shown in Figure 29 for evaluation. In this example, the decrease in slope occurs at 60% of Maximum Stress. Note that the macro allows the user to enter values other than two percent to discriminate between slopes. For all of the results presented here, a value of two percent was maintained throughout.

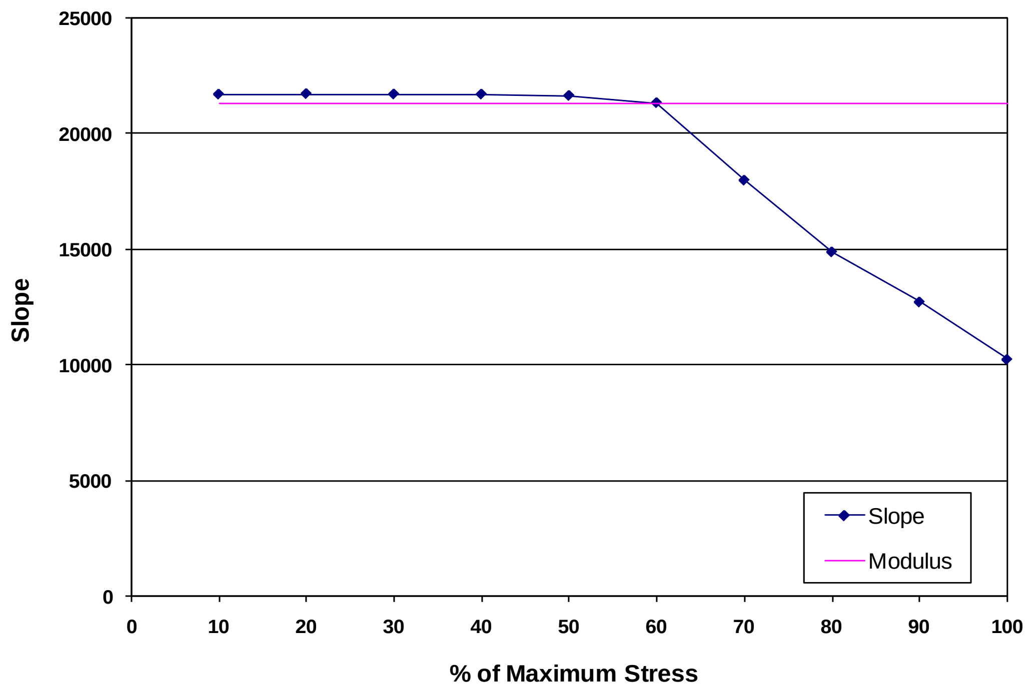


Figure 29. Representative Plot of Slope (Modulus) vs. % of Maximum Stress from the Data Reduction Analysis Macro

Once a modulus value is determined, the proportional limit is computed and offset lines are established to compute the yield stress values of interest. Proportional limit is identified as the first data point that deviates from the modulus line by more than two percent. As with the modulus discriminator, a value other than two percent may be employed to determine the proportional limit.

The macro computes a yield stress for 0.02%, 0.06% and 0.2% offset lines. Since the behavior of the longitudinal orientation is dominated by the fibers, tension samples often fracture before reaching a strain high enough to allow computation of the 0.2% offset yield strength. Therefore, 0.02% and 0.06% offset yield strengths were computed to provide intermediate yield properties between the proportional limit and fracture under such conditions. Figure 30 shows a condition were a tension test sample did reach 0.2% strain in the longitudinal orientation. However, most of the samples did not reach 0.2%. A yield strength value of 0.06% was determined in this program since FMW believed that this value was an important property in the design of TMC components based on input received from end users and based on a mathematical derivation of TMC intrinsic behavior. A representative stress-strain curve for tension test sample tested in the transverse orientation is shown below in Figure 31, along with the resulting properties of interest that were computed from the Excel® Macro.

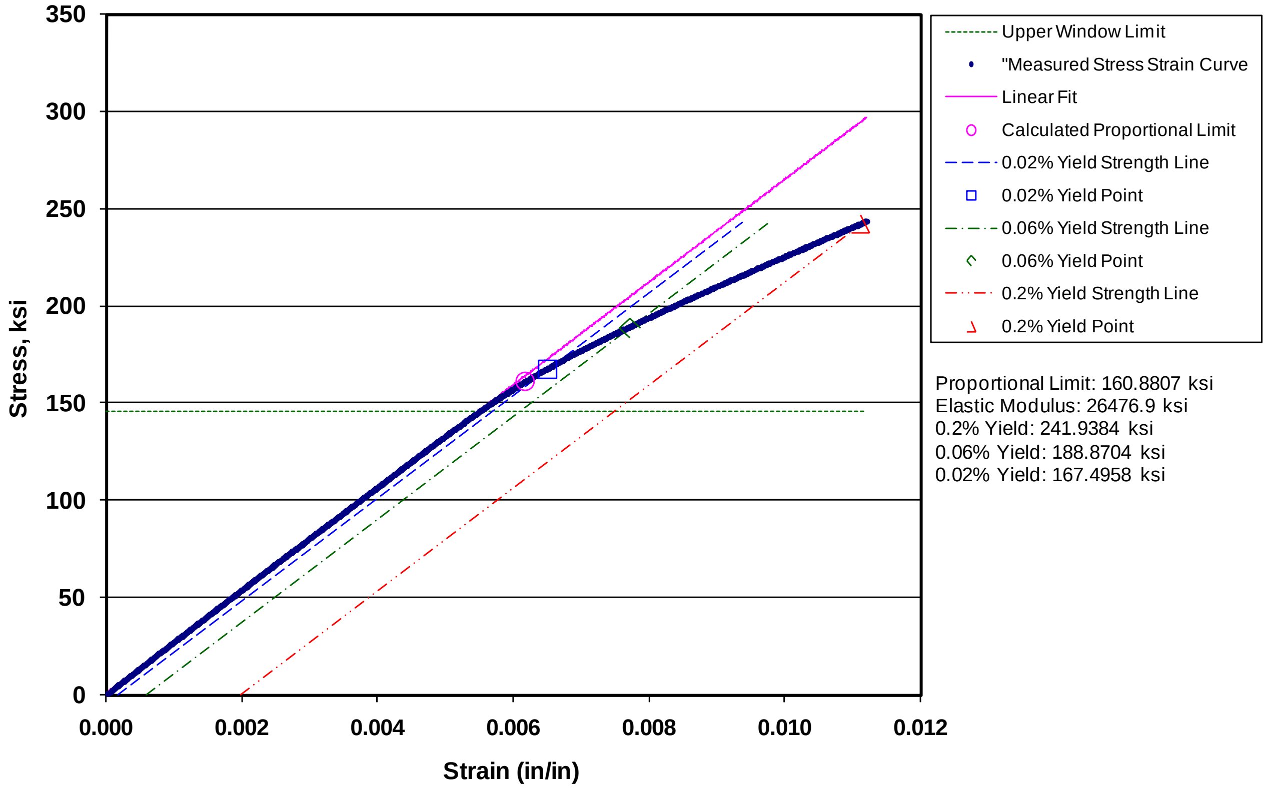


Figure 30. Stress-Strain Curve from a Longitudinal Tension Test Including Experimental Data, Computed Modulus, and Yield Stress Values

For all the tension tests conducted, a single extensometer was used to collect the data. The stress and strain data was then computed directly from the data reduction macro. For tests such as compression and shear tests, where strain gages were applied to both specimen faces, the average of the two strain gauges were entered in the macro to determine modulus and yield stress values.

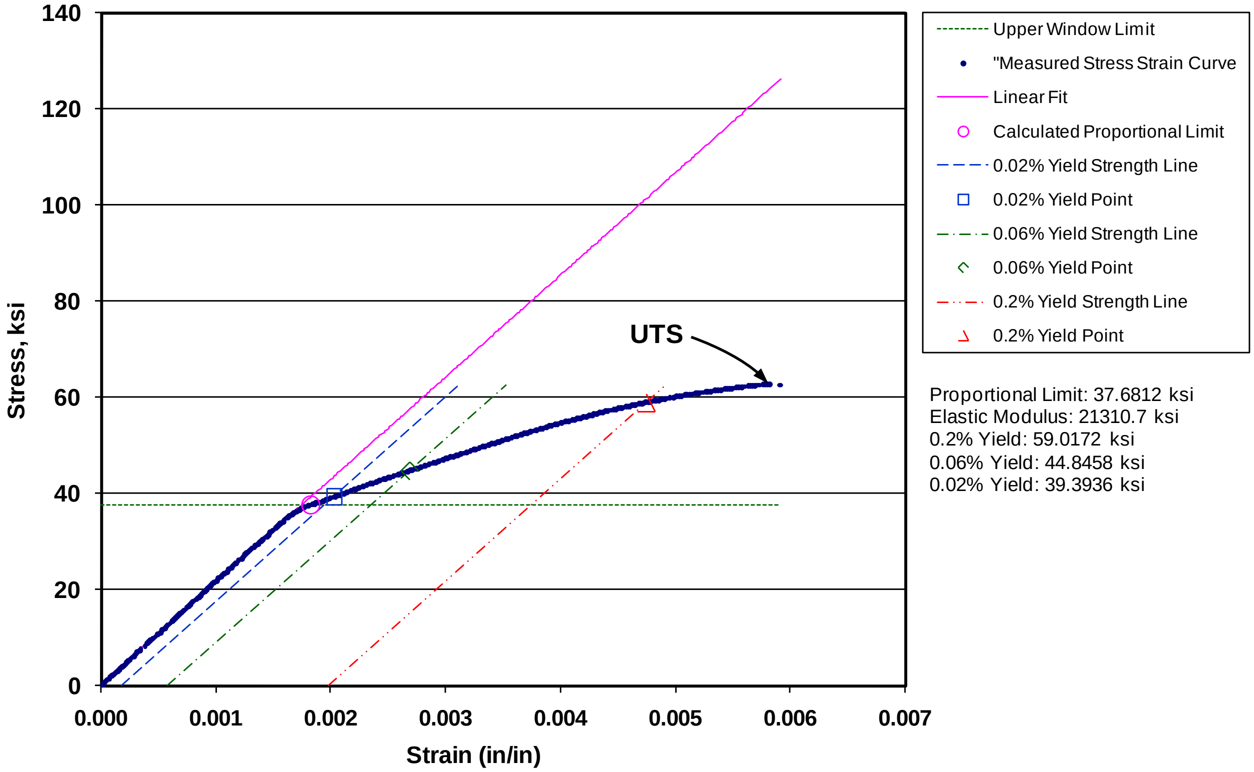


Figure 31. Representative Stress-Strain Curve from a Transverse Tension Test Including Experimental Data, Computed Modulus, and Yield Stress Values

4.2 TENSION DATA RESULTS

The tensile yield strength (0.06% offset), ultimate tensile strength (UTS), and elastic modulus results are shown in Table 8 for the longitudinal orientation and Table 9 for the transverse orientation. The tables list average property values for several individual tests for each of the eight material lots evaluated and the four test temperatures examined. The number of specimens tested per lot is also listed. All the raw data collected for each individual specimen and test can be found in Tables B1 and B2 in Appendix B.

Tensile yield strength (TYS) values are listed for the longitudinal specimens and are based on the intersection of the stress-strain curve with a line offset by 0.06% from the proportional limit line. A lower offset value was used here because the limited ductility of the material prevents elongation sufficient to reach the historical 0.2% offset intersection point commonly used with un-reinforced metals. Yield strengths reported for transverse specimens were computed using the traditional 0.2% offset intersection point.

Ultimate Tensile Strength (UTS) values are listed for individual specimens and they correspond to the value computed from the maximum load recorded during the experiment. For longitudinal specimens, this point is equivalent to the failure stress. For transverse specimens, this point normally occurs prior to reaching the failure stress, as often occurs in un-reinforced ductile materials.

Apparent Tensile Modulus (E_T) values were determined from stress-strain curves by computing slopes of the linear portion of the stress-strain data beginning with the first 10% of the points and increasing the number of points by an additional 10% until the resulting slope decreases by 2% from the previous value. The slope computed just prior to the change of $\geq$ 2% is reported as the tensile modulus. These apparent modulus values show considerable variation. However, the average of the longitudinal values is consistent with a rule-of-mixtures estimate of the modulus, which is 30.1 msi, a difference of only 1.3%.

Table 8. Longitudinal $[0]_{16}$ Tensile Property Results Summary (Lot Averages)

Lot #	Number of Tests	Orientation	Temperature (°F)	0.06% Offset Yield Strength (ksi)	Ultimate Strength (ksi)	Modulus (msi)
4	6	$[0]_{16}$	-65	220.4	248.2	26.7
5	6	$[0]_{16}$	-65	215.1	250.7	25.9
TOTAL	**12**		**AVG** →	**216.6**	**249.5**	**27.2**
1	18	$[0]_{16}$	70	197.2	251.3	29.6
2	13	$[0]_{16}$	70	193.8	255.1	29.1
3	15	$[0]_{16}$	70	200.5	250.5	31.3
4	15	$[0]_{16}$	70	198.7	233.8	31.0
5	15	$[0]_{16}$	70	196.2	236.3	30.6
6	15	$[0]_{16}$	70	191.4	232.5	29.5
7	15	$[0]_{16}$	70	189.3	238.0	28.1
8	15	$[0]_{16}$	70	191.1	243.4	28.6
TOTAL	**121**		**AVG** →	**194.7**	**242.4**	**29.7**
2	6	$[0]_{16}$	400	153.3	234.1	25.6
6	6	$[0]_{16}$	400	155.0	202.5	27.8
TOTAL	**12**		**AVG** →	**154.2**	**218.3**	**26.7**
1	7	$[0]_{16}$	600	158.2	208.0	30.1
2	6	$[0]_{16}$	600	144.0	219.3	26.6
3	6	$[0]_{16}$	600	151.0	202.5	27.8
4	6	$[0]_{16}$	600	148.9	191.0	30.7
5	6	$[0]_{16}$	600	143.1	200.2	26.7
6	6	$[0]_{16}$	600	141.9	193.1	27.2
7	6	$[0]_{16}$	600	140.5	192.6	26.3
8	6	$[0]_{16}$	600	141.9	204.4	25.7
TOTAL	**49**		**AVG** →	**146.1**	**201.4**	**27.6**

The following series of tension data plots (Figures 32 through 35) were generated by MSC to illustrate average property values, normalized average values, B-basis values, and normalized B-basis values of all the tension data generated by both test labs as a function of fiber orientation and temperature. All the test data was computed by AFRL (UDRI) and was sent to MSC for analysis and generation of B-basis values. MSC will publish all the tensile property data and fatigue data contained in this report in their CMH-17 handbook [11] sometime in 2010. The following are some noteworthy observations pertaining to the figures generated by MSC:

- Figure 32 reveals that the ultimate tensile strength of TMC's in the longitudinal orientation is markedly higher than unreinforced Ti-6Al-4V sheet material value at room temperature. However, in the transverse orientation, the strengths are woefully inferior, which is no surprise and is the reason why only the longitudinal orientation is were TMC's have been used and are being considered for potential future applications.

- Figure 32 shows that "normalized" average values are slightly higher than average values.

Table 9. Transverse $[90]_{16}$ Tensile Property Results Summary (Lot Averages)

Lot #	Number of Tests	Orientation	Temperature (°F)	0.06% Offset Yield Strength (ksi)	Ultimate Strength (ksi)	Modulus (msi)
2	6	$[90]_{16}$	-65	49.7	75.0	19.3
6	6	$[90]_{16}$	-65	52.3	75.6	19.6
TOTAL	**12**		**AVG** →	**50.9**	**75.3**	**19.4**
1	6	$[90]_{16}$	70	44.4	61.8	21.1
2	6	$[90]_{16}$	70	44.7	64.8	20.9
3	6	$[90]_{16}$	70	45.1	64.1	22.8
4	6	$[90]_{16}$	70	46.1	64.7	22.4
5	6	$[90]_{16}$	70	47.3	66.7	21.4
6	6	$[90]_{16}$	70	45.3	65.1	20.7
7	6	$[90]_{16}$	70	45.1	62.2	20.0
8	6	$[90]_{16}$	70	44.6	59.8	20.8
TOTAL	**48**		**AVG** →	**45.3**	**63.7**	**21.3**
3	6	$[90]_{16}$	400	33.7	51.6	21.2
7	6	$[90]_{16}$	400	33.7	51.4	19.1
TOTAL	**12**		**AVG** →	**33.7**	**51.5**	**20.2**
1	6	$[90]_{16}$	600	27.7	45.9	19.9
2	6	$[90]_{16}$	600	27.8	45.2	18.4
3	6	$[90]_{16}$	600	28.1	45.2	20.4
4	6	$[90]_{16}$	600	28.9	45.5	19.2
5	6	$[90]_{16}$	600	29.3	45.6	18.6
6	6	$[90]_{16}$	600	27.1	44.7	17.6
7	6	$[90]_{16}$	600	26.2	44.0	18.0
8	6	$[90]_{16}$	600	27.9	44.9	17.7
TOTAL	**48**		**AVG** →	**27.9**	**45.1**	**18.7**

- Figure 32 includes B-basis values for those conditions were sufficient data was available. In general, the B-basis value is approximately 25 ksi less than the average value for the longitudinal lay-up at room temperature.

- Figure 32 also includes clad material properties and the conclusion to be made here is that clad material properties are approximately 45 ksi lower than unclad material.

- Figure 33 shows that the average strain to failure of the longitudinal lay-up is ~ 1.0%, whereas the transverse value is ~ 0.6%.

- Figure 34 illustrates the large increase in modulus or stiffness that can be achieved in TMC materials over unreinforced sheet material. As with the strength properties, the normalized data is also slightly higher. It is interesting to note that the modulus for the transverse orientation is somewhat higher than unreinforced sheet material.

- Figure 35 depicts the average and B-basis values for 0.06% off-set yield strengths, where the yield strengths of TMC materials are significantly higher than unreinforced Ti-6Al-4V sheet material data at room temperature.

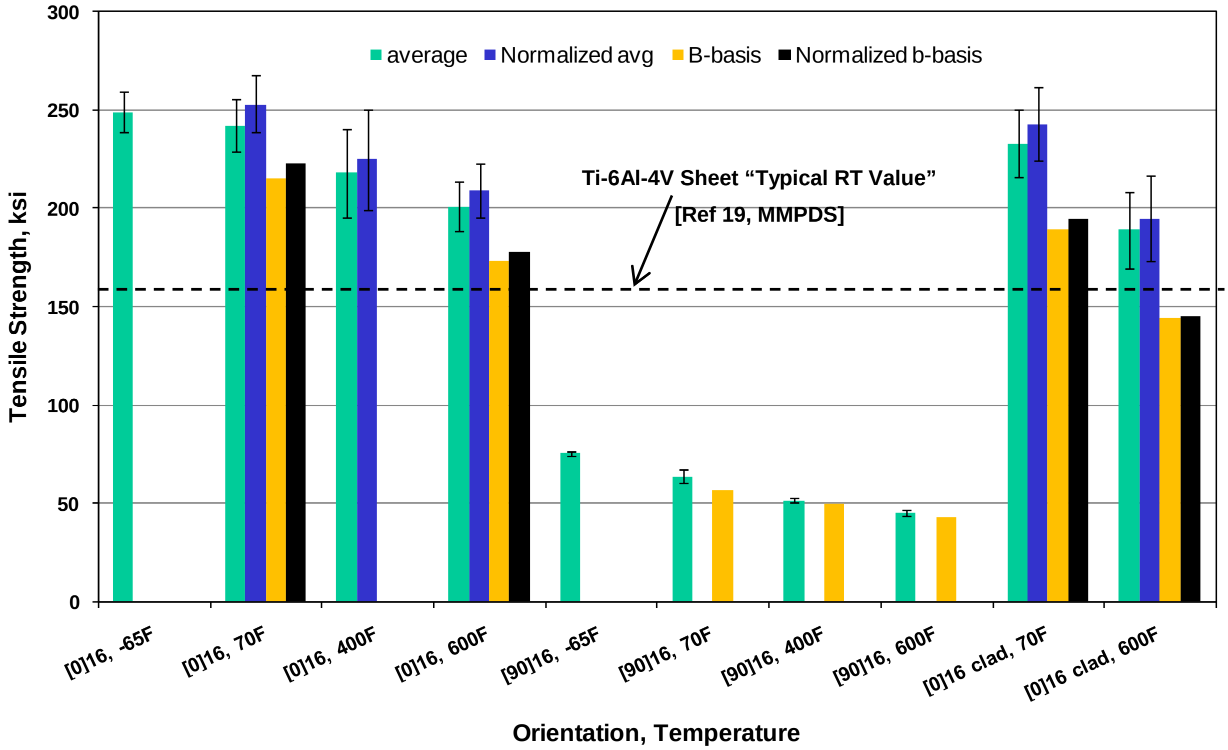


Figure 32. Average and B-basis Tensile Strength Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

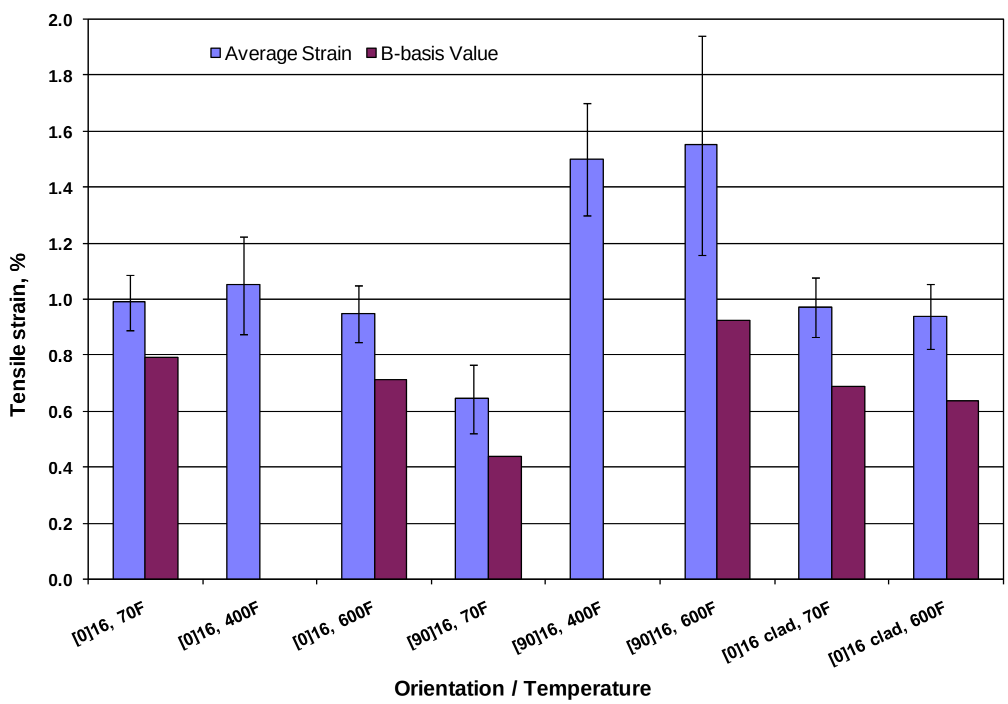


Figure 33. Average and B-basis Tensile Strain Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

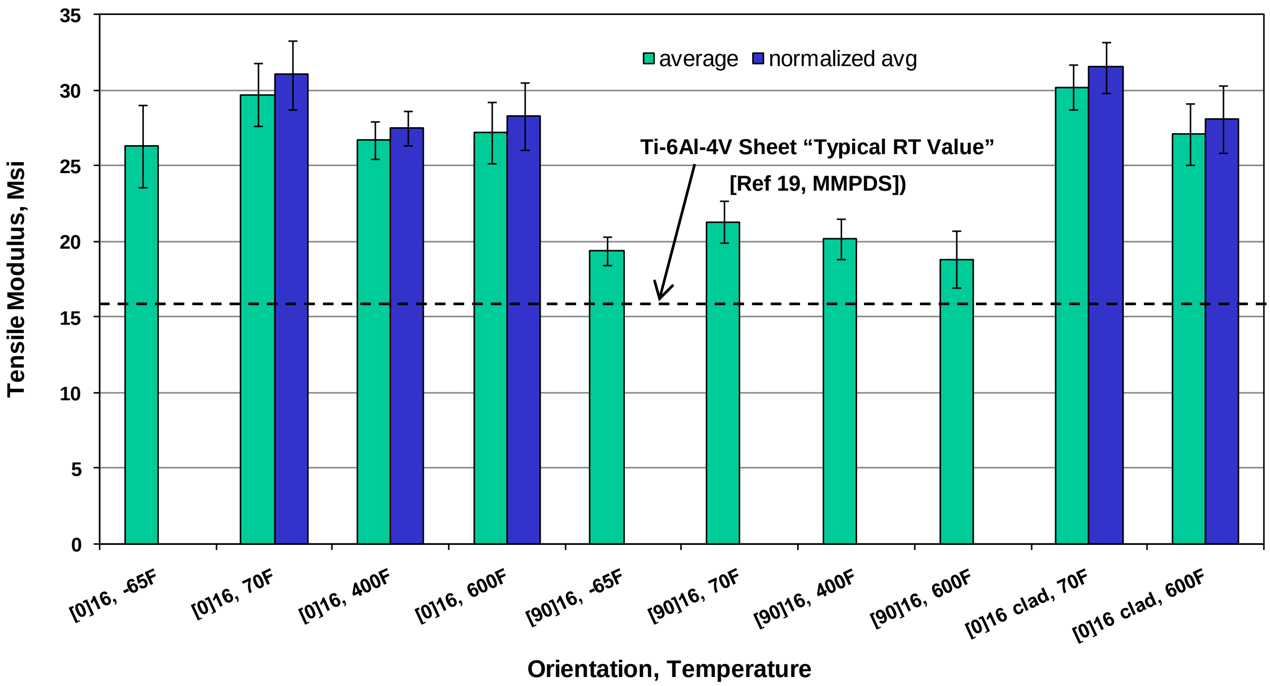


Figure 34. Average and Normalized Average Tension Modulus Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

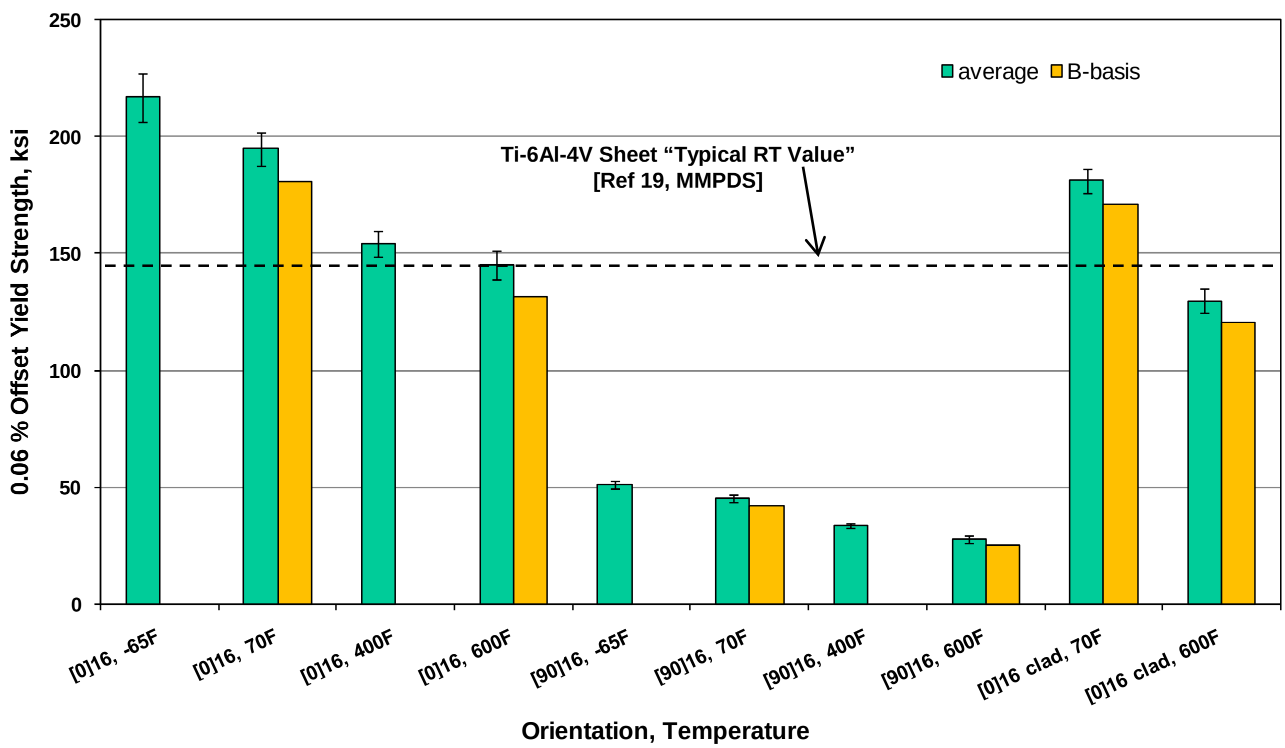


Figure 35. Average and B-basis 0.06% Tensile Yield Strength Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

Another objective of the program was to look at variability of material properties across panel lots to ensure that the manufacturing process was robust and that it was repeatable. Figure 36 below illustrates that the modulus did vary across the lots, particularly within lots 4 and 5. In general, the modulus varied from roughly 26 msi to 34 msi. It is speculated that the variability in fiber properties is the primary reason for the variability in the panel properties as shown below.

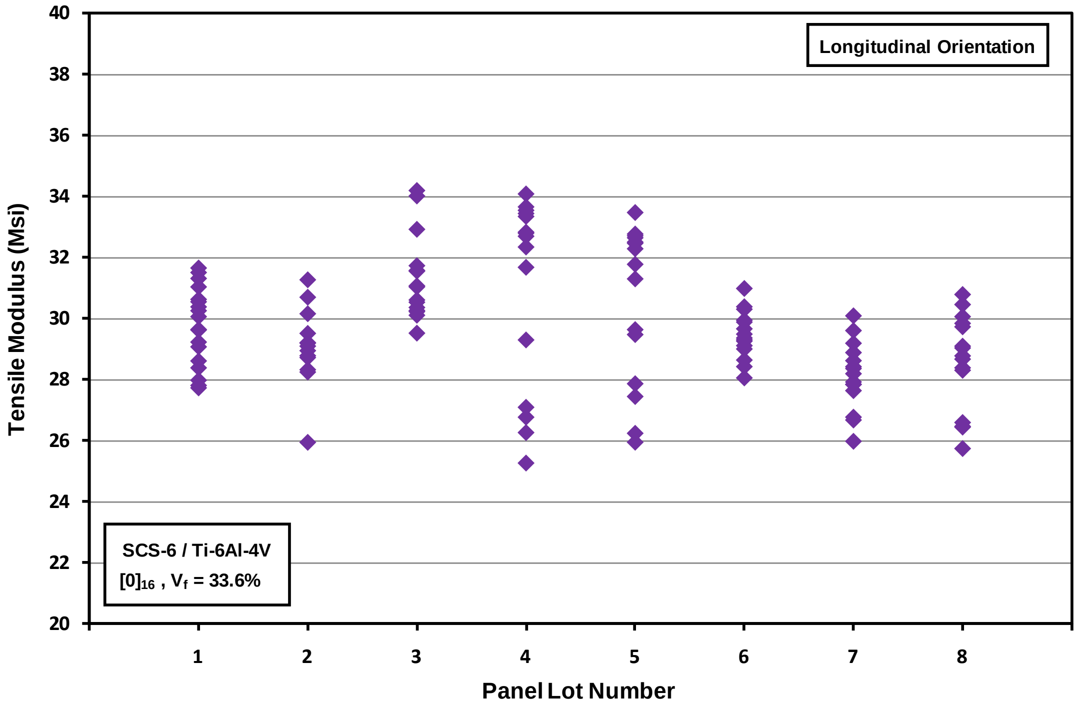


Figure 36. Tensile Modulus Variability versus Panel Lot at Room Temperature

The variability in tensile strength properties for both UTS and 0.06% yield strength is shown in Figure 37 as a function of panel lot. It appears that the tensile strength dips significantly in lots 4 through 8. Lots 1 through 3 appear to have the highest strengths. This is same trend was observed for the tensile modulus. In regard to the yield strength, it appears that the trend of lower strengths mirrors that of the tensile modulus for lots 4 through 8. It may also be worth looking into if there were any unusual processing variations regarding HIP consolidation temperatures for the later lots.

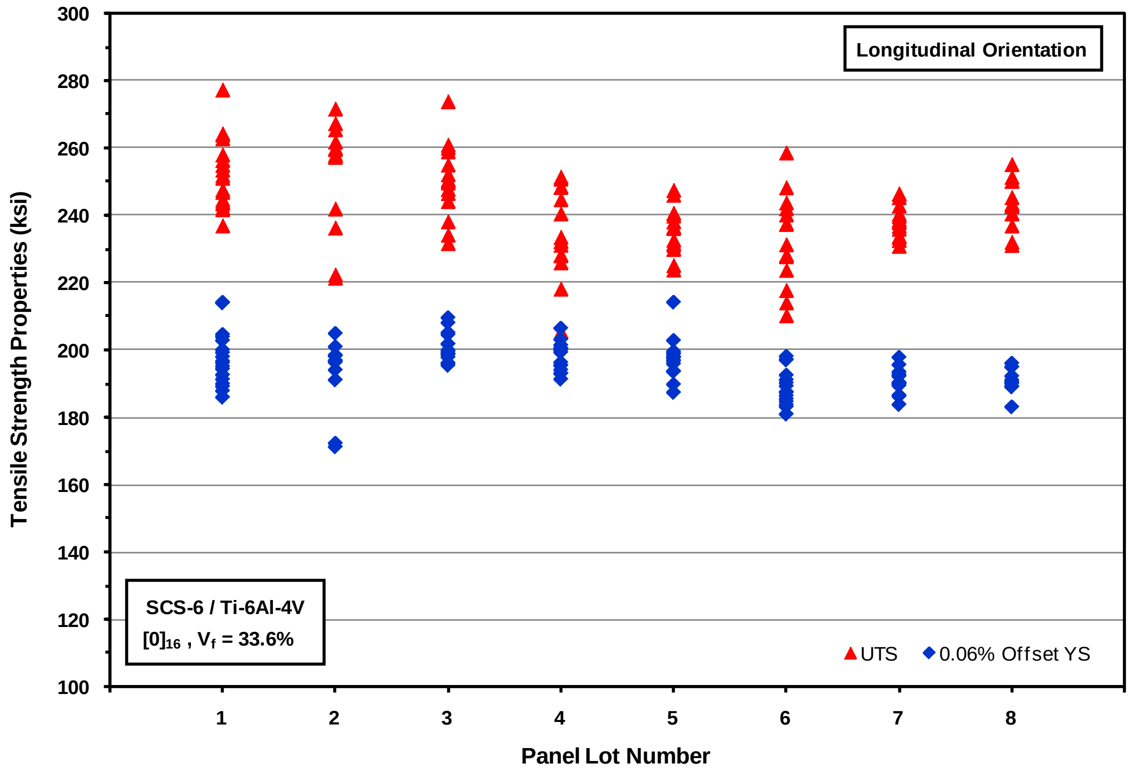


Figure 37. Tensile Strength Properties versus Panel Lot at Room Temperature

4.3 COMPRESSION DATA RESULTS

The compressive yield strength (0.2% offset) and elastic modulus results are shown in Table 9 for the longitudinal orientation and Table 10 for the transverse orientation, as determined from the stress-strain curves. The tables list average property values for several individual tests for each of the eight material lots evaluated and the four test temperatures examined. The quantity of specimens tested per lot is also listed. All the raw data collected for each individual specimen and test can be found in Tables C1 through C2 in Appendix C.

Compressive yield strengths (CYS) are listed and were computed based on the intersection of the stress-strain curve with a line offset by 0.2% from the proportional limit line for both longitudinal and transverse specimens. Computation of the 0.06% offset YS values were also conducted for the longitudinal specimens and are graphically displayed in Figure C1 in Appendix C.

Ultimate Compressive Strength (UCS) values were not reported for individual specimens since most were not loaded to fracture, therefore no ultimate strength data are listed in the summary tables. As discussed earlier in the test procedures, the loads that were necessary to reach failure approached the capability of the test frame and caused a local and confined explosion of the sample, which resulted in damage to the grips. Since these strength values were well beyond any design requirement, it was decided that the yield strength values obtained were sufficient for potential component designs. For the few specimens that were loaded to fracture, the ultimate strengths and strain-to-failure data are included with the individual test results in

Appendix D. The reported values for individual specimens correspond to the value computed from the maximum compressive load recorded during the experiment.

Apparent Compressive Modulus (E_C) values were determined from stress-strain curves using the same algorithm that was used for the tension data (see Section 4.1). As with the apparent tensile modulus data, considerable scatter in the individual results was observed. However, the overall average modulus compares well with the estimated modulus based on a rule of mixtures calculation.

The next series of compression data plots (Figures 38 through 40) were generated by MSC to illustrate average property values and B-basis values from compression data that were generated by both test labs, as a function of fiber orientation and temperature. All the test data was computed by AFRL (UDRI) and was sent to MSC for analysis and generation of B-basis values for longitudinal orientations only. All the data including, transverse compression data, can be found in Appendix C. MSC will publish all the compressive property data contained in this report in their CMH-17 handbook (Ref) sometime in 2010. The following are some important observations pertaining to the figures generated by MSC:

- Figure 38 illustrates that the compressive modulus values are approximately the same as the tensile modulus, although a bit higher. What is interesting to note is that the modulus decreases from -65°F to 400°F and then increases between 400°F and 600°F to the same value measured at room temperature. While an insufficient number of experiments were conducted at 400°F to characterize this trend conclusively, such behavior may be related to an unlocking of residual stresses at the fiber matrix interface with temperature.

- Figures 39 and 40 clearly show why TMC’s are of interest to the AF and the commercial markets. They clearly exhibit compressive yield strength properties that are 2 to 3 times higher than unreinforced “monolithic” Ti-6-4 sheet material. The strengths do decrease with increasing temperatures, but are still significantly above corresponding values for monolithic material.

Table 10. Longitudinal $[0]_{16}$ Compressive Property Results Summary (Lot Averages)

Lot #	Number of Tests	Orientation	Temperature (°F)	0.2% Offset Yield Strength (ksi)	Modulus (msi)
2	5	$[0]_{16}$	-65	543.2	30.9
7	6	$[0]_{16}$	-65	523.5	30.4
TOTAL	**11**		**AVG** →	**532.2**	**30.6**
1	8	$[0]_{16}$	70	529.9	31.0
2	8	$[0]_{16}$	70	488.4	30.2
3	7	$[0]_{16}$	70	517.4	31.5
4	9	$[0]_{16}$	70	484.7	29.9
5	11	$[0]_{16}$	70	481.3	29.4
6	8	$[0]_{16}$	70	452.6	28.5
7	11	$[0]_{16}$	70	483.3	30.1
8	7	$[0]_{16}$	70	464.6	29.4
TOTAL	**69**		**AVG** →	**489.4**	**30.0**
7	6	$[0]_{16}$	400	293.7	28.6
8	6	$[0]_{16}$	400	293.1	28.7
TOTAL	**12**		**AVG** →	**293.5**	**28.7**
1	6	$[0]_{16}$	600	332.1	31.2
2	8	$[0]_{16}$	600	292.2	29.8
3	9	$[0]_{16}$	600	288.5	30.2
4	8	$[0]_{16}$	600	290.7	30.0
5	7	$[0]_{16}$	600	276.9	29.5
6	7	$[0]_{16}$	600	266.7	28.4
7	6	$[0]_{16}$	600	278.7	28.6
8	6	$[0]_{16}$	600	290.2	29.0
TOTAL	**57**		**AVG** →	**287.0**	**29.6**

Table 11. Transverse $[90]_{16}$ Compressive Property Results Summary (Lot Averages)

Lot #	Number of Tests	Orientation	Temperature (°F)	0.2% Offset Yield Strength (ksi)	Modulus (msi)
1	6	$[90]_{16}$	-65	191.5	21.6
7	6	$[90]_{16}$	-65	192.0	21.4
TOTAL	**12**		**AVG** →	**191.7**	**21.5**
2	6	$[90]_{16}$	70	165.4	20.6
3	6	$[90]_{16}$	70	164.0	20.7
4	6	$[90]_{16}$	70	167.4	22.5
6	6	$[90]_{16}$	70	160.7	21.9
8	6	$[90]_{16}$	70	161.7	23.1
TOTAL	**30**		**AVG** →	**163.8**	**21.8**
2	2	$[90]_{16}$	600	102.5	20.6
3	2	$[90]_{16}$	600	98.1	20.2
5	2	$[90]_{16}$	600	103.6	20.9
6	2	$[90]_{16}$	600	98.1	20.9
8	2	$[90]_{16}$	600	102.3	21.5
TOTAL	**10**		**AVG** →	**100.9**	**20.8**

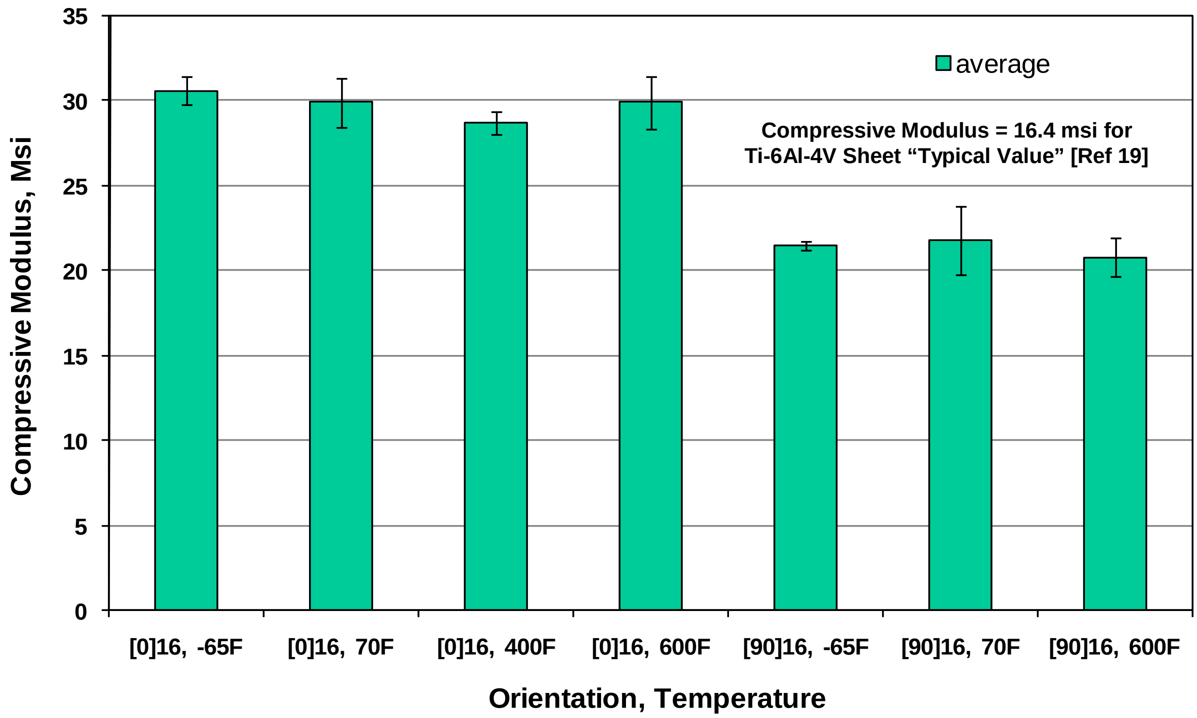


Figure 38. Average and Compression Modulus Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

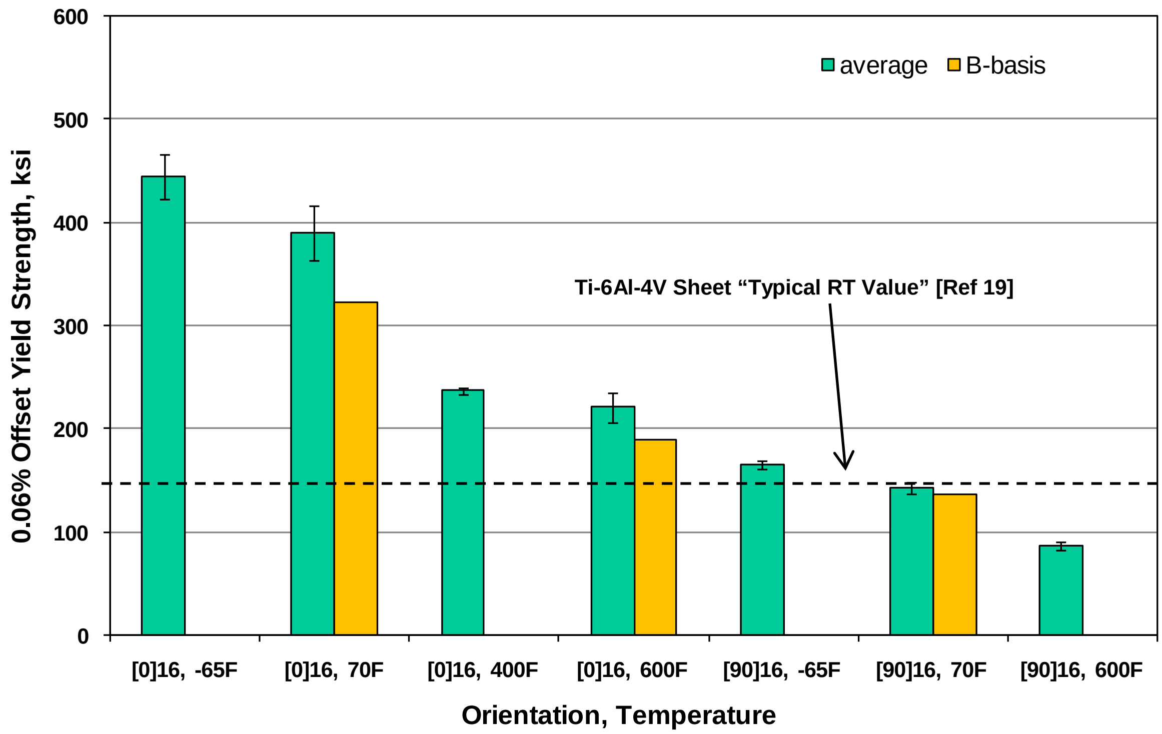


Figure 39. Average and B-basis 0.06% Compression Yield Strength Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

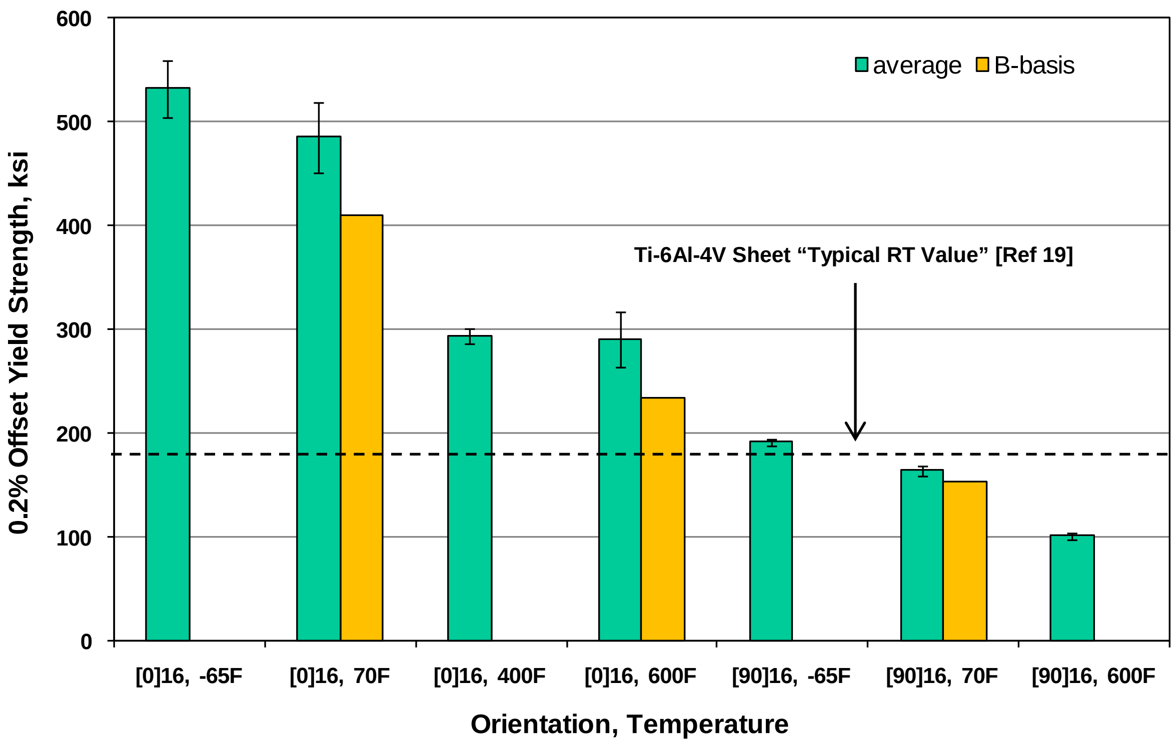


Figure 40. Average and B-basis 0.2% Compression Yield Strength Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

4.4 SHEAR DATA RESULTS

The shear yield strengths and elastic modulus results are shown in Table 12, which were determined from the stress-strain curves as discussed earlier. The table lists average property values for several individual tests for each of the eight material lots evaluated and the four test temperatures examined. The number of specimens tested per lot is also listed. All the raw data collected for each individual specimen and test can be found in Table D in Appendix D.

Shear yield strengths (SYS) are listed and were computed based on the intersection of the stress-strain curve with a line offset by 0.2% from the proportional limit line.

Ultimate Shear Strength (USS) values were not reported due to the unacceptable failure mode of the specimens in these experiments, therefore none of the test specimens were loaded to fracture. An acceptable failure mode is shown schematically in Figure 41, which was taken from ASTM D5379 test standard.

Apparent Shear Modulus (E_S) values were determined from stress-strain curves using the same algorithm that was used for the tension data (see Section 4.1). As with the apparent tensile modulus data, considerable scatter in the individual results was observed, particularly at the 600°F condition. No rule of mixtures calculation was possible due to lack of shear data for either the fibers or the matrix material.

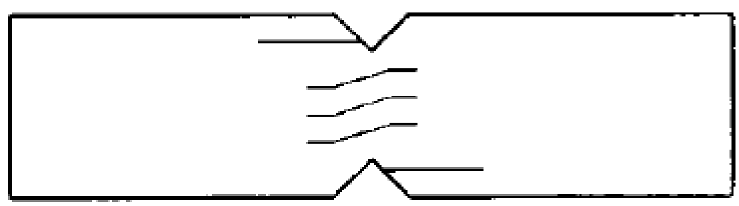


Figure 41. Acceptable Shear Failure Mode According to ASTM D5379 for a Unidirectional Laminate

Table 12. Shear Property Results Summary (Lot Averages) for a $[0]_{16}$ Laminate

Lot #	Number of Tests	Orientation	Temperature (°F)	0.2% Offset Yield Strength (ksi)	Modulus (msi)
2	6	$[0]_{16}$	-65	74.4	7.7
7	6	$[0]_{16}$	-65	75.3	7.9
TOTAL	**12**		**AVG** →	**74.8**	**7.8**
1	8	$[0]_{16}$	70	61.1	7.7
2	6	$[0]_{16}$	70	65.3	7.6
3	6	$[0]_{16}$	70	66.1	7.9
4	6	$[0]_{16}$	70	62.1	7.4
5	6	$[0]_{16}$	70	65.4	7.9
6	6	$[0]_{16}$	70	66.9	7.9
7	6	$[0]_{16}$	70	68.1	7.9
8	6	$[0]_{16}$	70	65.9	7.8
TOTAL	**50**		**AVG** →	**64.8**	**7.8**
4	6	$[0]_{16}$	400	50.4	7.6
8	6	$[0]_{16}$	400	50.3	7.6
TOTAL	**12**		**AVG** →	**50.4**	**7.6**
1	6	$[0]_{16}$	600	32.4	7.1
2	6	$[0]_{16}$	600	42.6	7.9
3	6	$[0]_{16}$	600	45.0	8.9
4	6	$[0]_{16}$	600	44.5	8.3
5	6	$[0]_{16}$	600	45.7	10.6
6	6	$[0]_{16}$	600	44.1	7.6
7	6	$[0]_{16}$	600	44.9	7.3
8	6	$[0]_{16}$	600	42.7	9.1
TOTAL	**48**		**AVG** →	**43.8**	**8.4**

The following two shear data plots (Figures 42 and 43) were generated by MSC to illustrate average property values and B-basis values from shear data that was generated by both test labs as a function of fiber orientation and temperature. All the test data was reduced by AFRL (UDRI) and was sent to MSC for analysis and generation of B-basis values for longitudinal orientations only. All the shear data can be found in Appendix E. MSC will publish all the shear property data contained in this report in their CMH-17 handbook [10] sometime in 2010. The following are some important observations pertaining to the figures generated by MSC:

- Figure 42 depicts a linear decrease in shear yield strengths with increasing temperature.

- Figure 43 shows an increase in shear modulus versus monolithic material and a slight increase in shear modulus at 600°F.

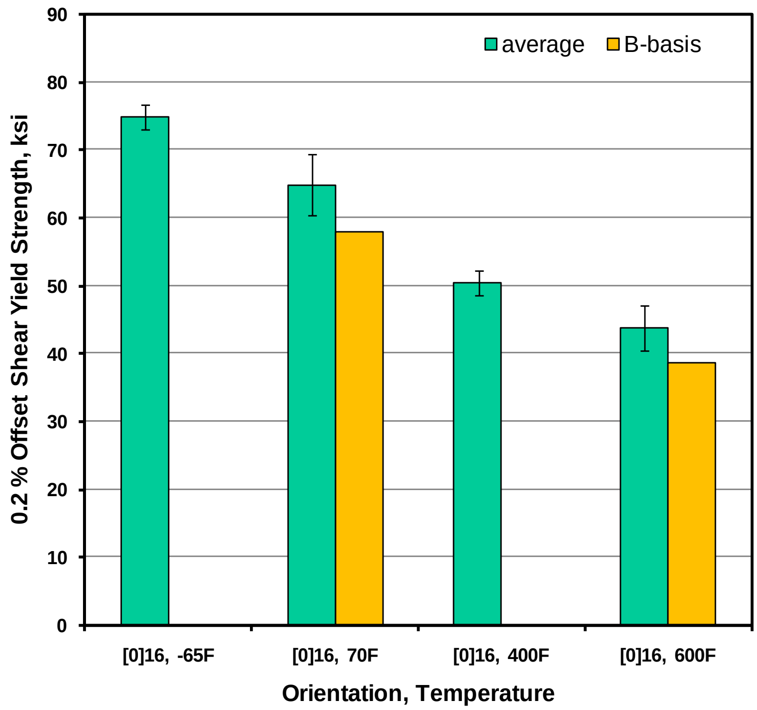


Figure 42. Average and B-basis 0.2% Compression Yield Strength Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

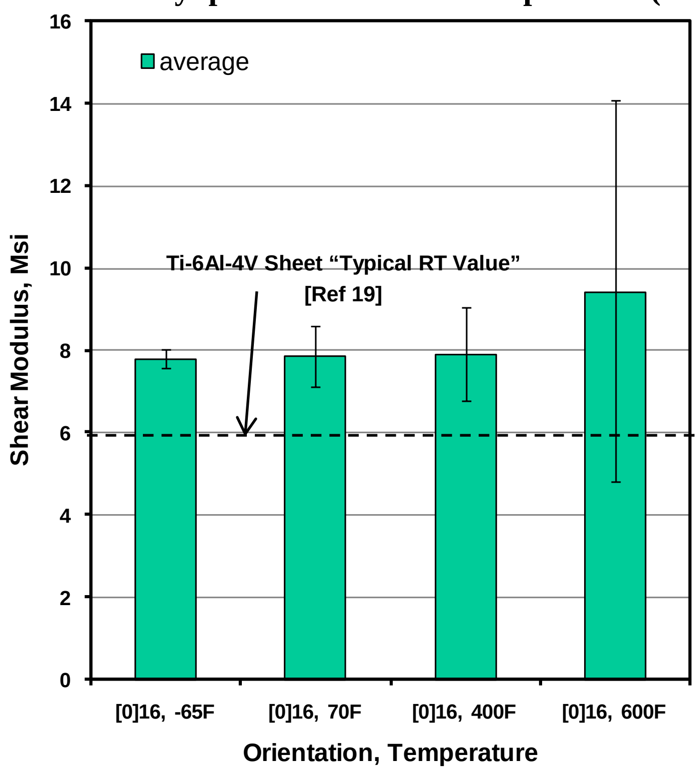


Figure 43. Average Shear Modulus Values of SCS-6/Ti-6-4 Composite Panels versus Layup Orientation and Temperature (Courtesy of MSC)

4.5 FATIGUE TEST RESULTS

Fatigue test results for this effort are shown in Figures 44 through 47 for longitudinal orientations at R=0.1 and R=-1. The transverse orientation results are shown in Figures 48 through 51 at R=0.1 and R=-1. For each "stress versus cycles to failure" (S-N) curve, all the data are plotted for all the temperatures tested. Following each S-N curve is a plot of modulus vs temperature. Modulus measurements were taken at the first load cycle of the fatigue test to provide supporting information in obtaining reliable modulus data. This data will be compared with data obtained from tensile testing. An evaluation of the overall fatigue life of these composites under the various loading conditions will be provided followed by a discussion of the modulus measurement results.

For longitudinal test results at R=0.1 as shown in Figure 44, the stress levels selected for -65°F and 73°F were the same. This selection was based on the tension test results, which indicated a negligible change in strength properties over that temperature range. As with the tensile results, only a small difference was noted between the -65°F and 73°F fatigue life data. Although slightly lower stress levels were used for the 600°F tests, the results in Figure 44 suggest no discernable difference between the 600°F experiments and the 73°F or -65°F fatigue lives. This similarity suggests that the fatigue behavior for the longitudinal orientation in the range of test temperatures examined is dominated primarily by the high strength fibers, which are largely unaffected by the higher temperature. The modulus results at the first load cycle, as shown in Figure 45, indicate a similar level of scatter as observed in the tensile results, with the mean at room temperature being somewhat higher than either the -65°F or 600°F data.

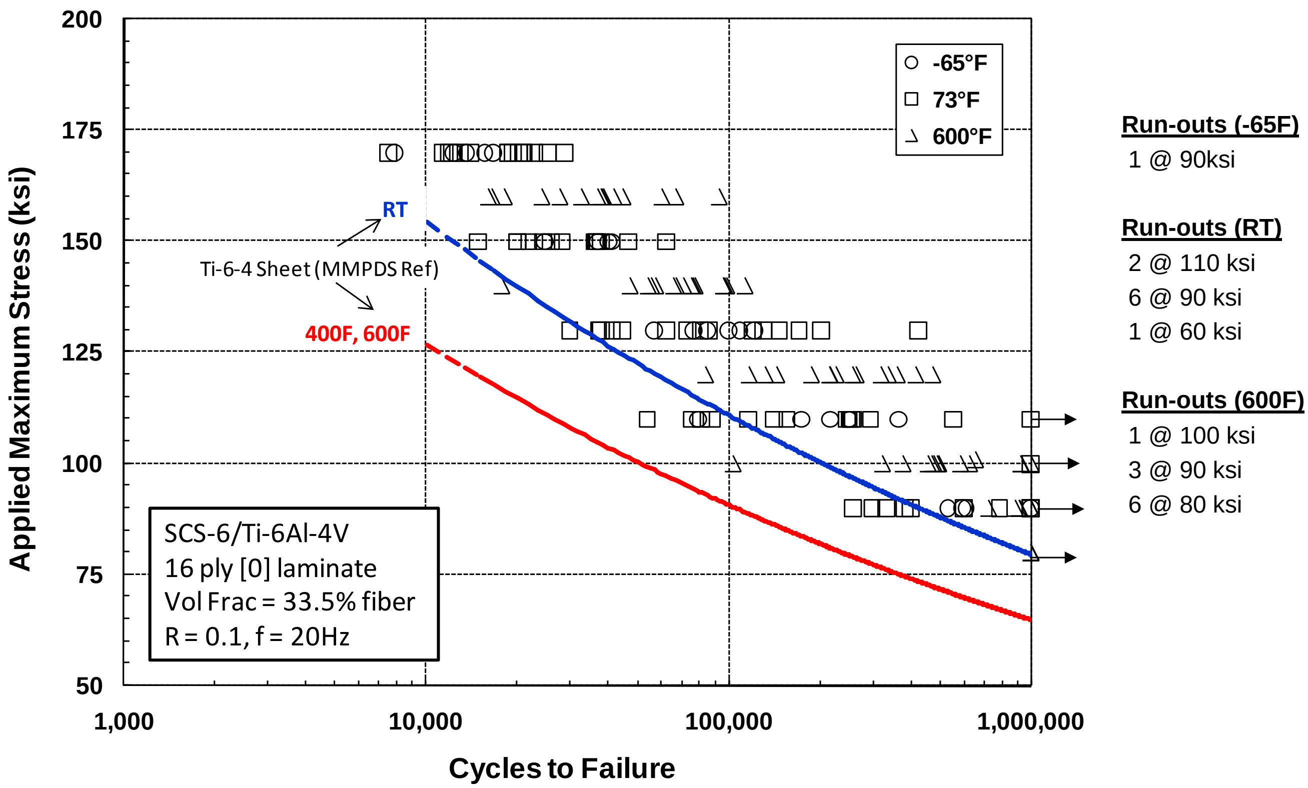


Figure 44. Fatigue Lives of $[0]_{16}$ Laminate for all Test Temperatures at R = 0.1 (Arrows at 10^6 Cycles Indicate Tests Stopped Prior to Failure)

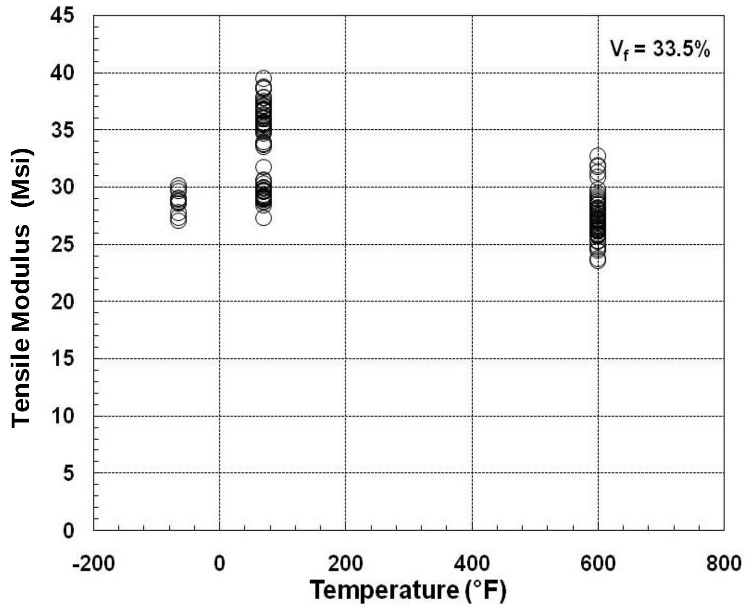


Figure 45. Tensile Modulus from the First Load Cycle of the $[0]_{16}$ Laminate (R = 0.1)

For longitudinal test results at R=-1, as depicted in Figure 46, the stress levels selected for -65°F and 73°F were the same. Unlike the R=0.1 fatigue results, the -65F data here exhibited a steeper slope than the 73°F data. No fatigue run-outs were obtained at the 60 ksi stress level. It is speculated that greater damage of the fiber/matrix interface is occurring under the fully reversed loading condition. As with the R=0.1 fatigue data, little difference was noted between the 600°F and 73°F fatigue data. Based on this, the stress levels selected could have been the same for these two conditions. The modulus results at the first load cycle, as shown in Figure 46, indicate a similar decrease in the mean values between 73°F and 600°F, and less scatter is noted for these data than for the data from the R=0.1 fatigue tests. Note that modulus data were very difficult to obtain for the -65°F experiments due to icing of the extensometer rods during testing.

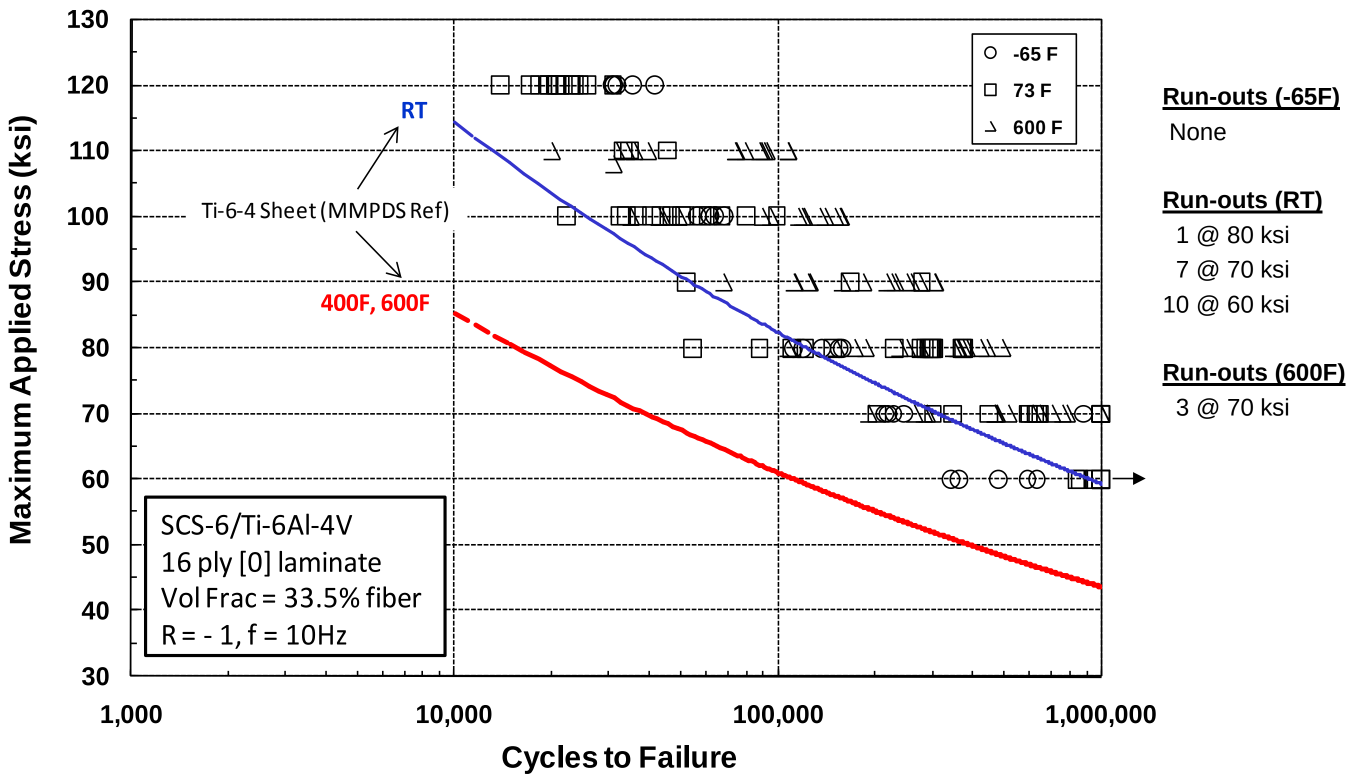


Figure 46. Fatigue Lives of $[0]_{16}$ Laminate for all Test Temperatures at R = -1 (Arrows at 10^6 Cycles Indicate Tests Stopped Prior to Failure)

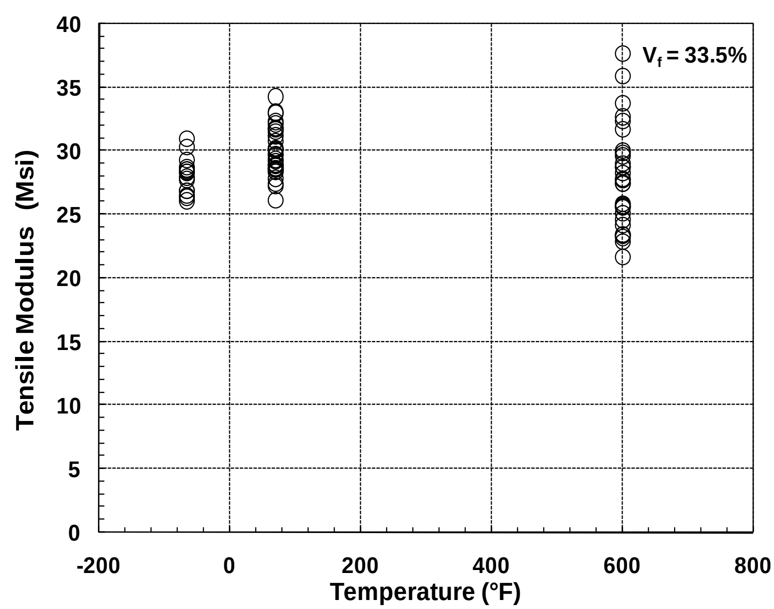


Figure 47. Tensile Modulus from the First Load Cycle of the $[0]_{16}$ Laminate (R = -1)

For transverse test results at R=0.1, as illustrated in Figure 48, the stress levels were selected based on trends observed in the transverse tension tests. Therefore, lower stress levels were selected for higher temperatures. In general, the data followed the expected S-N trends, but the level of scatter is quite high compared to the longitudinal data. Many of these tests resulted in a run-out condition, indicated by the arrows shown at 1,000,000 cycles. In most cases, several test results are represented by a single arrow, making the level of scatter very difficult to quantify. Such behavior is expected and can be explained by the bond between the fiber and the matrix. De-bonding at the fiber/matrix interface is evident when looking at the bi-linear region of the stress-strain curve from transverse tension tests. As shown in Figure 30 on page 26, the stress-strain curve exhibits two distinct linear portions, with the knee in the stress-strain curve corresponding to the point at which the fibers de-bond from the matrix. The precise location of this knee in the stress-strain curve tended to vary and can be related to a "go-no go" situation in fatigue. If the peak stress falls below the knee in the curve, then a run-out condition is reached. For confirmation on this situation, see Appendix E, Tables E3 and E4 on individual test results for each stress level. Also of note is that the -65°F results are slightly better than the 75°F results. Since potential applications for this material include high altitude and space applications, the beneficial (rather than detrimental) effect of cold temperatures is of specific interest. As with the longitudinal tests, the modulus results at the first load cycle, as shown Figure 49, indicate a similar trend in the mean values between 75°F and 600°F. Again, modulus data were very difficult to obtain for the -65°F experiments due to icing of the extensometer rods during testing.

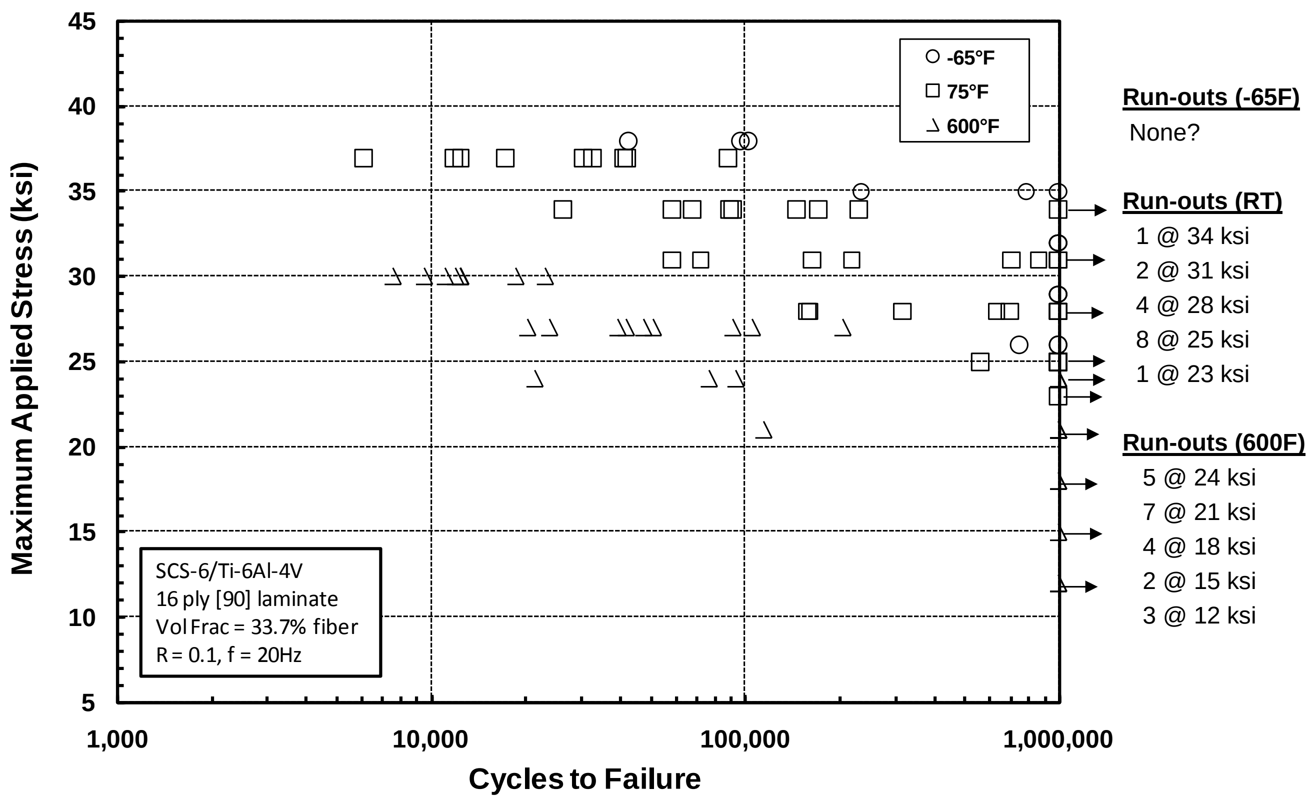


Figure 48. Fatigue Lives of $[90]_{16}$ Laminate for all Test Temperatures at R = 0.1 (Arrows at 10^6 Cycles Indicate Tests Stopped Prior to Failure)

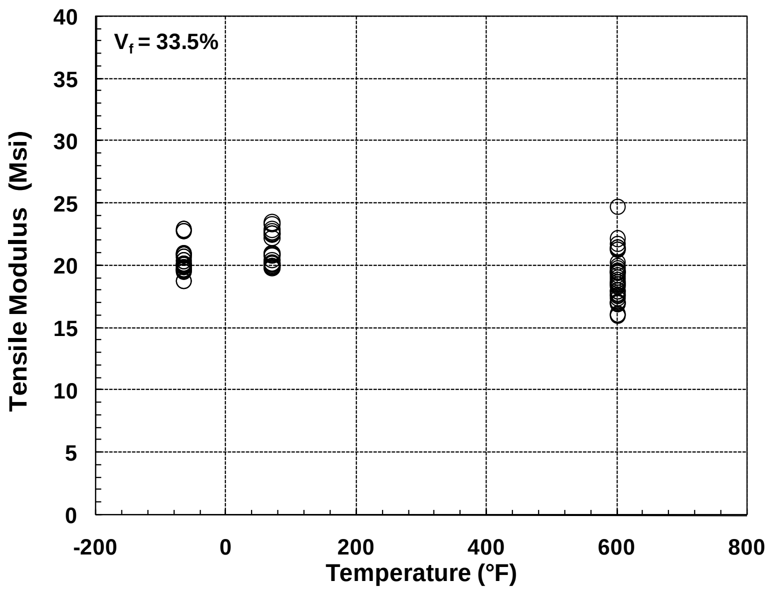


Figure 49. Tensile Modulus from the First Load Cycle of the $[90]_{16}$ Laminate (R = 0.1)

For transverse test results at R=-1, as shown in Figure 50, the stress levels again were selected based on trends observed in the transverse tension tests. The trends of higher fatigue properties with lower temperatures is even more pronounced for this stress ratio than for the R=0.1 condition. Stress levels as high as 35 ksi were employed at -65°F, which had longer fatigue lives than the 32 ksi stress at 75°F. In addition, the level of scatter was considerably less than for R=0.1. There was a significant drop in properties between 75°F and 600°F, possibly related to a corresponding drop in strength. The modulus results at the first load cycle (Figure 50) indicates a similar decrease in the mean values between 75°F and 600°F, and less scatter is noted for these data than for the data from the R=0.1 fatigue tests. Again, the modulus data was very difficult to obtain for the -65°F experiments due to icing of the extensometer rods during testing.

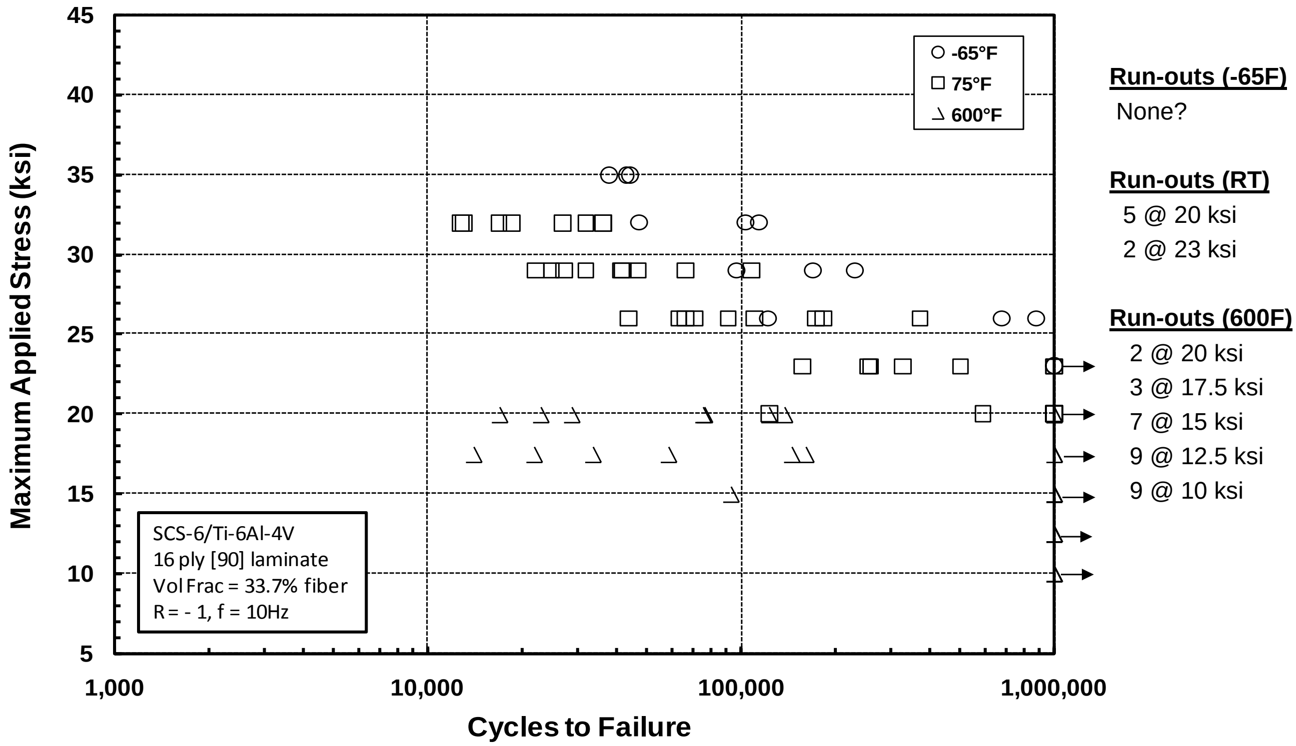


Figure 50. Fatigue Lives of $[90]_{16}$ Laminate for all Test Temperatures at R = -1 (Arrows at 10^6 Cycles Indicate Tests Stopped Prior to Failure)

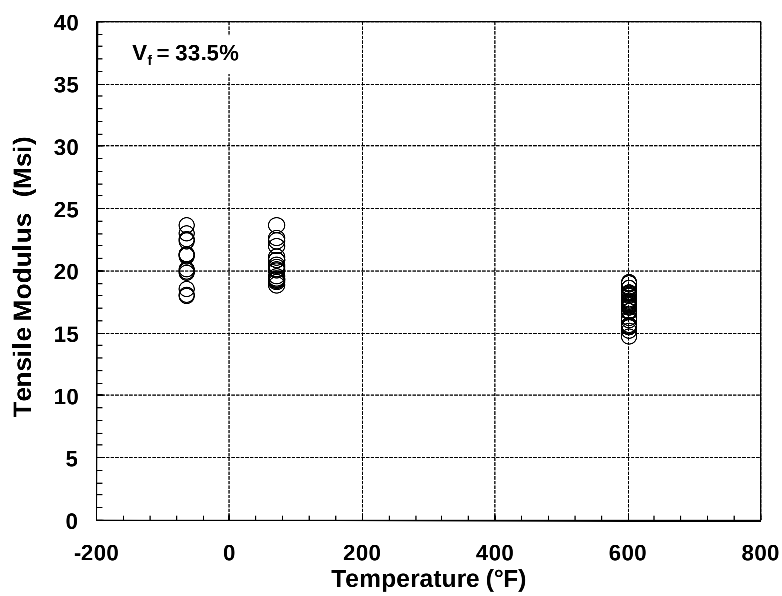


Figure 51. Tensile Modulus from the First Load Cycle of the $[90]_{16}$ Laminate (R = -1)

4.6 FATIGUE CRACK GROWTH TEST RESULTS

Fatigue crack growth test results for 75°F and 600°F are shown in Figures 52 through 54. Under all test conditions, the data appear to layer with far field applied stress, as expected. Further, initial growth rates appear to compare favorably with data for un-bridged (stiffness corrected matrix data) composite behavior from prior work [15].

The room temperature FCG data was difficult to reduce since the crack front curvature was hard to delineate and measure. The fibers that were bridging the crack wake tend to hold the crack closed, so oxidizing (heat tinting) the fracture surface after testing was not a good indication of how well the crack front was progressing. Some of the specimens had very little oxidation (heat tinting) on the fracture surface, so the crack front could not be located accurately. In some cases, the sample fractured before the test could be stopped, so heat tinting could not be used. In other tests, surface cracks extended past the edges of the specimen (see Figure 24, lower-right corner and Figure 26, both lower corners). For cases where the crack front curvature corrections were difficult to determine, efforts were made to deduce a suitable curvature correction using information obtained from specimens with useable curvature data.

Despite all the challenges in delineating the post test crack fronts, all of the room temperature crack growth tests were reduced and plotted, as illustrated in Figure 52. The applied stress of 96 ksi tests clearly exhibited un-bridged FCG behavior in which the FCG rate increases with increasing stress intensity (ΔK). Some of the tests conducted at an applied stress of 80 ksi also behaved in an un-bridged manner (e.g. specimen #34), while others were partially bridged (e.g. specimen #91). Fully bridged behavior was clearly demonstrated by the data from all of the experiments conducted at an applied stress of 55 ksi. The different types of FCG behavior that were demonstrated in these experiments was previously illustrated in a schematic (refer to Figure 25). This behavior has been well documented in the literature [15-18].

The repeatability of crack growth behavior from lot to lot appears to be quite good for the fully bridged and un-bridged conditions. All of the experiments performed at 55 ksi exhibited similar trends and growth rates, as did all of the experiments at 96 ksi. Tests performed at 80 ksi produced results that were either partially bridged or un-bridged and did not trend with material lot. Also, #34 and #91 (both from Lot 1), which exhibited dissimilar bridging behavior, appeared to have similar growth rates where the growth rates were increasing. This behavior is consistent with some of the elevated temperature results at R=0.1 and 105 ksi in which partially bridged crack growth was observed for some tests, while others propagated so quickly that no crack growth data could be obtained.

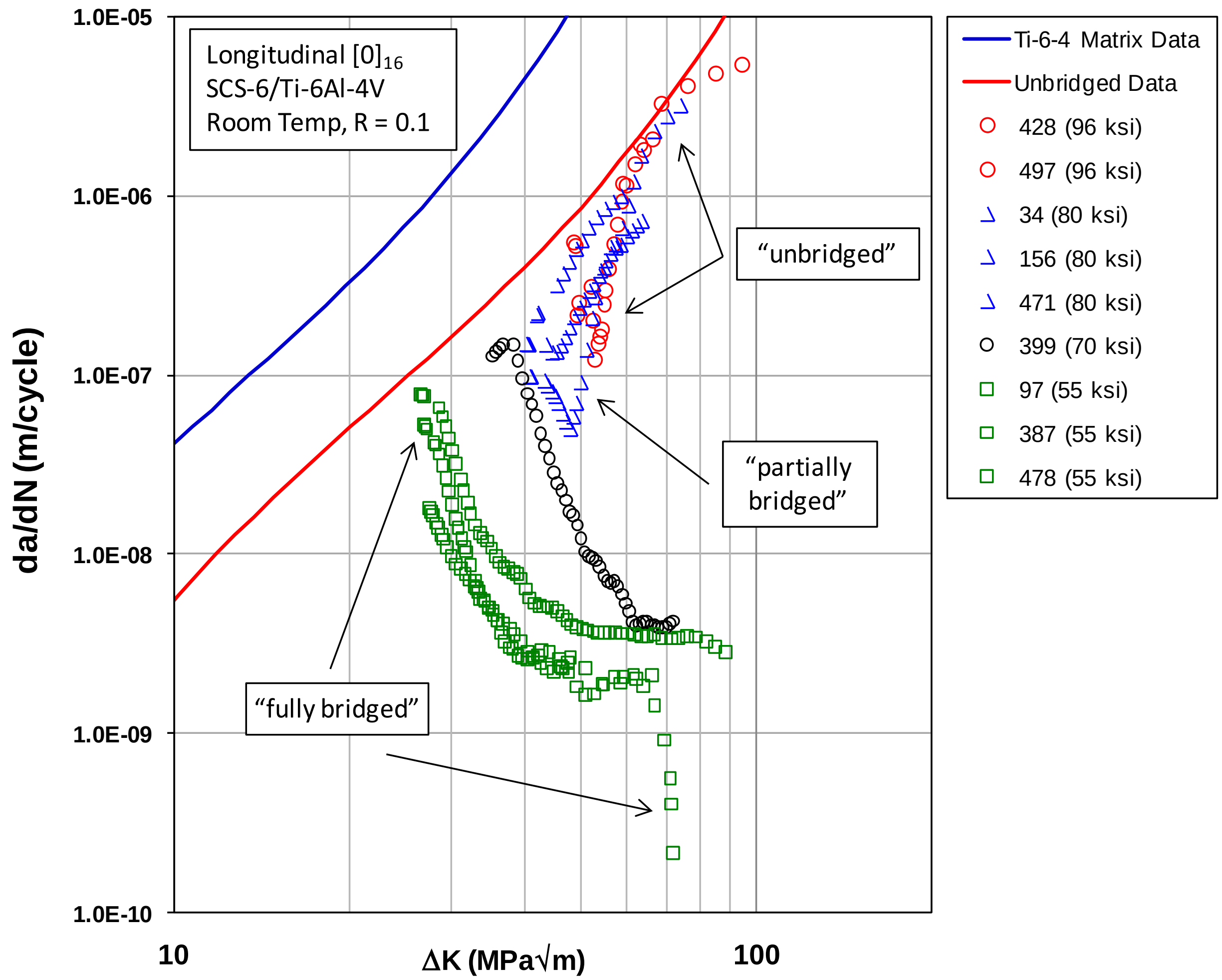


Figure 52. Crack Growth Results at RT and R=0.1 for "Selected" Stresses including Unreinforced Matrix Data and Stiffness Corrected Unreinforced or "Unbridged" Behavior

The 600°F fracture surfaces were much easier to inspect since they were exposed to elevated temperature during testing. Here the crack faces tended to oxidize (heat tinted) while the crack was held open under load. The visibility of those surfaces further improved after an hour in the furnace after testing, so the crack front curvature was measured directly for all experiments performed at the 600°F condition.

There was less data available in the literature to provide a basis for selecting suitable stress levels for the 600°F testing. Since the applied stress of 55 ksi provided fully-bridged behavior at room temperature, this stress was used initially in the hope of obtaining fully bridged behavior at 600°F. Based on the results in Figure 52, fully bridged behavior was easily achieved. Therefore, subsequent selection of applied stresses was conducted at 10 ksi intervals to determine where partially bridged and un-bridged crack growth behavior commences.

All of the stress levels above 55 ksi that were tested (65, 75, 85, 95 and 105 ksi) exhibited partially bridged behavior with decreasing levels of crack bridging with increasing stress level. The 65 ksi stress level was selected as the replicate stress level since this seemed to better represent the threshold at which fully bridged behavior may be expected with some experiments being fully bridged and some being partially bridged.

An interesting observation is that even at an applied stress level of 105 ksi, the crack growth behavior was still partially bridged at 600°F. However, at room temperature with an applied stress of 95 ksi, un-bridged behavior was observed, two experiments performed at the same stress resulted in partial bridging. Attempts to conduct tests at 110 ksi resulted in either failure on loading or the accumulation of only a few hundred cycles, which was insufficient to obtain meaningful crack growth data. The above issue is likely the result of reduced clamping stresses on the fibers at elevated temperature, allowing greater slip between the fibers and matrix at the notch root region. Although un-bridged behavior was not observed for those tests in which crack extension was measurable at the 105 ksi stress level, it was identified for replication of the "un-bridged" condition. The results from "failure on loading" experiments were considered to be valid as they are indicative of the behavior of the composite in this geometry at this loading condition and they provide some measure of the variability in behavior that can be expected at higher stress levels.

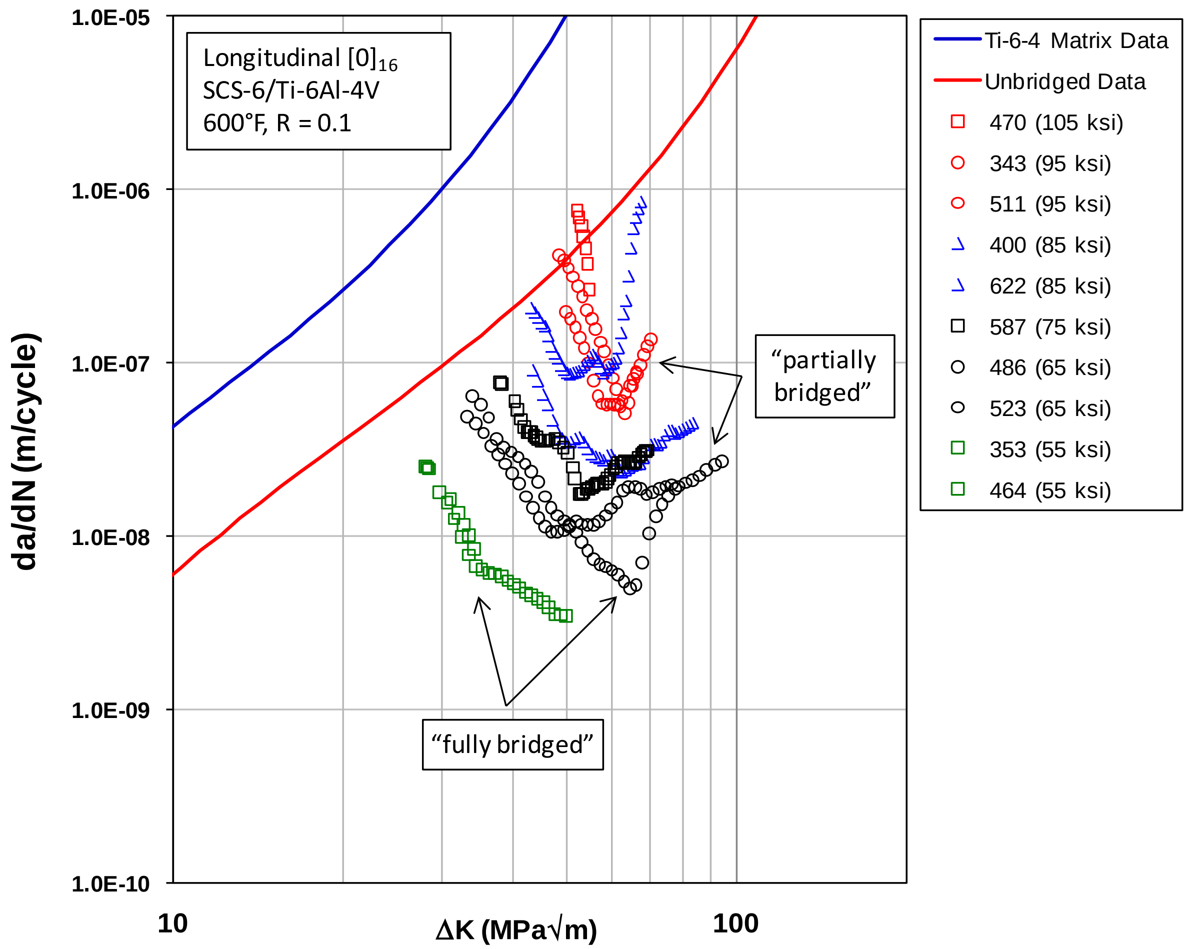


Figure 53. Crack Growth Results at 600°F and R=0.1 for "Selected" Stresses including Unreinforced Matrix Data and Stiffness Corrected Unreinforced or "Unbridged" Behavior

Virtually no data was available in the literature to provide a basis for selecting suitable stress levels for testing at the R=0.5 condition. Since 65 ksi provided a useful threshold for fully-bridged behavior at 600°F and R=0.1, this stress was used in the hope of obtaining a fully bridged condition at R=0.5. Based on the results in Figure 53, fully bridged behavior was achieved. Subsequent experiments at 75 ksi resulted in partial bridging. Tests were then conducted at 10 ksi intervals to establish stress levels for partial and un-bridged behavior.

All of the stress levels above 65 ksi that were evaluated included 75, 85, 95, and 105 ksi, where they all exhibited partially bridged behavior with decreasing levels of bridging with increasing stress level. Experiments at 65 ksi and at R=0.5 were more consistent than at R=0.1 with no partial bridging observed, so it was identified as the fully bridged stress level for this test condition. An effort was made to test as high a stress as possible for the purpose of identifying an un-bridged condition, so tests were conducted at 110 and 115 ksi. The results from these tests was that failure of the specimen on loading was observed at 115 ksi, but tests at 110 ksi exhibited crack propagation and growth rate data was obtained. Thus the 110 ksi stress level was selected for testing. For the partially bridged condition, replicate tests were conducted at 95 ksi.

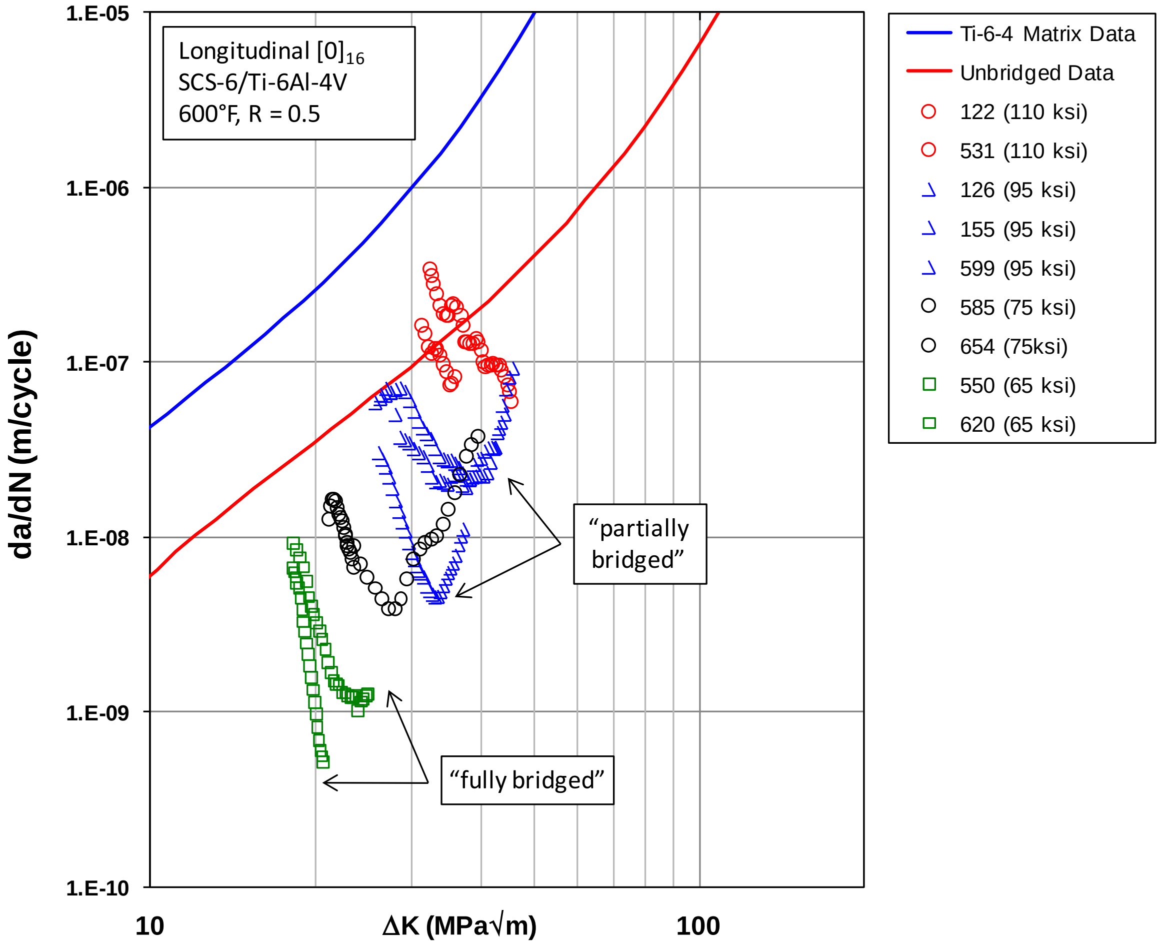


Figure 54. Crack Growth Results at 600°F and R=0.5 for "Selected" Stresses including Unreinforced Matrix Data and Stiffness Corrected Unreinforced or "Unbridged" Behavior

SECTION 5
CONCLUSIONS

5.1 ENGINEERING (STATIC) PROPERTY DATA CONCLUSIONS

5.1.1 Tensile Properties of 16 ply TMC Panels

- Average tensile properties and B-basis allowables were generated from approximately 270 tensile tests that were conducted on 8 lots of TMC material for both longitudinal and transverse orientations.

- Allowables data was generated on 0.06% yield strengths (YS) and ultimate tensile strengths (UTS) for longitudinal orientations. The 0.06% YS value is more representative for TMC materials and is what most end users are interested in.

- The traditional 0.2% offset YS was computed for all transverse tests, since sufficient strain did accumulate in all of the tests.

- The room temperature UTS of TMC panels in the longitudinal orientation are approximately 50% higher than Ti-6-4 sheet material, whereas the transverse UTS are approximately 2.5 times lower than sheet material. This means that TMCs are best suited for applications where high unidirectional loads dominate. There was some scatter in tensile strengths in general over all the lots. The tensile strengths in the longitudinal orientation did vary somewhat with panel lot number with an average high of 255 ksi in Lot 2 to an average low of 233 ksi in Lot 6.

- The tensile failure strain of the TMC panels tested in the longitudinal orientation is approximately 1% strain, which is significantly low when compared to 14% plastic strain seen in unreinforced Ti-6-4 (Grade 5 annealed). This is no surprise nor is it a problem in many designs due to the materials high tensile and compressive strengths and its superior fatigue properties. The tensile failure strain for the transverse orientation is approximately 1.5%. In addition, the dominant feature of TMC's that control the properties is the ceramic SiC fiber and the failure strain of the fiber is less than 1%. In the longitudinal orientation, the ductility is controlled by the ceramic fibers; in the transverse orientation it is controlled by the local distribution of the stresses to the matrix ligaments between the fibers.

- The tensile modulus of TMC panels is approximately 90% higher than monolithic sheet material in the longitudinal orientation and approximately 25% higher in the transverse orientation. Longitudinal tension modulus measurements indicated little variation in the overall mean values with temperature. In all cases the mean modulus value expected from a rule-of-mixtures calculation was well represented despite the observed variability.

- For both tension and compression, a decrease in strength was observed with increasing temperature. This behavior is thought to be related to a relaxation of residual stresses between the fiber/matrix interface. The decrease in strength can also be due to the reduction in matrix strength at higher temperstures.

5.1.2 Compressive Properties of 16 ply TMC Panels

- Average compressive properties and B-basis allowables were generated from 156 compressive tests that were conducted on 8 lots of TMC material for both longitudinal and transverse orientations.

- Allowables data was generated on both 0.06% and 0.2% compressive yield strengths for the longitudinal orientation, where end users have expressed a specific interest in these values. The 0.2% compressive yield strength properties and the 0.06% YS values do provide a basis for comparison with tensile YS properties, where sufficient ductility was present to obtain the 0.2% offset value.

- The average 0.2% longitudinal compression strengths at room temperature reached an incredible 489 ksi, which is 3.2 times higher than monolithic Ti-6-4 sheet material. This property has strong appeal to aircraft structural designers and is why tube type applications where high compressive loads dominate are of key interest.

- The compressive modulus exhibits a similar trend to the tensile values in the longitudinal orientation, where a small dip is observed at 400°F, but rebounds some at 600°F. The unlocking of residual (clamping) stresses at the fiber/matrix interface at intermediate temperatures may provide an explanation for these observations.

5.1.3 Shear Properties of 16 ply TMC Panels

- Average shear properties and B-basis allowables were generated from 98 shear tests that were conducted on 8 lots of TMC material for longitudinal orientations only.

- An interesting observation was that the average shear yield strengths at 0.2% offset was similar to the transverse tensile strengths within a few ksi over the temperature range evaluated. Data was not collected for the ultimate tensile strength due to the unacceptable failure mode of the samples tested. The typical ultimate tensile strength for monolithic sheet material is approximately 54% higher than the average room temperature 0.2% offset shear yield strength value of TMC's.

- The shear modulus values overall were much lower than the tensile and compressive modulus values. This is not unusual since in monolithic sheet material, the shear modulus is also significantly lower. The modulus values were about the same through the temperature range studied. However, there were a few spurious results at 600F on specimens that were tested by TRL. It is unknown at the time of this report why those specimens exhibited such large deviations in shear modulus values.

5.2 FATIGUE DATA CONCLUSIONS ON 16 PLY TMC PANELS

- Fatigue data was collected on samples both in the longitudinal and transverse orientations and over a wide temperature range. Tests were conducted both at R=0.1 (tension dominated) and R=-1 (equal amount of tension and compression loading).

- B-basis allowables were not determined on fatigue data since there is not an applicable method to determine allowables on fatigue data.

- Fatigue results did not vary much with test temperature in the longitudinal orientation. A slight trend was noted at the R=-1 condition, with the -65F tests indicating shorter lives at the lowest test stress than at room temperature. This effect may be related to the quantity of -65F data that were obtained in this effort.

- The modulus results obtained after the first load cycle were consistent with values and level of scatter expected as were demonstrated in the tensile results. It is expected that the fatigue properties of this material are dominated by the fibers and the orientation with respect to the loading direction, which tend to be insensitive to temperature range evaluated in this effort.

- Fatigue results obtained from the transverse orientation did exhibit a measurable effect of temperature on fatigue behavior. A significant difference was observed between the room temperature and 600F fatigue lives at all stress levels and stress ratios evaluated. A similar but less pronounced effect was observed between -65F and room temperature. The magnitude of the effect was greater at R=-1 than at R=0.1.

- The increase in fatigue resistance overall with decreasing temperature is consistent with the strength properties obtained from tension testing at the same temperatures. Such an effect would be expected as a result of the decreasing residual compressive stresses around the fibers with increasing temperature. Trends in the modulus values obtained from the first load cycle of each test were consistent with the tension test results.

5.3 FATIGUE CRACK GROWTH DATA CONCLUSIONS ON 16 PLY TMC PANELS

- Fatigue crack growth data was collected on 16 ply TMC panels in the longitudinal orientation at room and elevated temperatures. The results demonstrated that the fatigue crack growth behavior of TMC's in general are markedly superior to monolithic material due to the intrinsic crack bridging phenomena that occurs at stress levels that are normally much higher than those stresses used to test monolithic materials.

- At room temperature, experiments were conducted exclusively at R=0.1. A stress of 55 ksi was identified as the threshold stress to obtain fully bridged crack growth behavior, which all or nearly all of the fibers in the crack wake remained intact. A stress of 80 ksi was identified as the highest stress at which partially bridged behavior was observed and sustained. Finally, a stress of 96 ksi was identified as the stress level at which fibers would fracture as the crack tip moved past, resulting in un-bridged behavior similar to a unreinforced monolithic material of similar stiffness to the TMC.

- Similar observations were observed for elevated temperature testing, both at R=0.1 and R=0.5. For R=0.1, a stress of 65 ksi was identified as the fully bridged condition and 85 ksi was identified as the partially bridged condition. The un-bridged condition could not be identified because the observed behavior transitioned from partial bridging at 105 ksi to failure on loading at 110 ksi. Thus replicate tests were conducted at 105 ksi, some of which were partially bridged and some of which failed within a few hundred cycles. A similar behavior was witnessed in the R=0.5 experiments. For this condition, stress levels of 65 ksi, 95 ksi and 110 ksi were identified for the fully bridged, partially bridged and un-bridged conditions, respectively. As in the R=0.1, 105 ksi tests, the results of the 110 ksi tests were divided between those that were partially bridged and those that fractured within a very few cycles.

- From the individual test results it is concluded that (a) reduction of the clamping stresses around the fibers at elevated temperature resulted in enhanced sliding between the fiber and matrix allowing improved load transfer to the matrix and (b) the conservative design methodology requires that the engineer use the stiffness corrected da/dN vs. ΔK curve (which can provide a factor of 10 decrease in growth rate for a given value of ΔK and that any fiber bridging produced at low applied stresses should provide an added factor of safety.

SECTION 6
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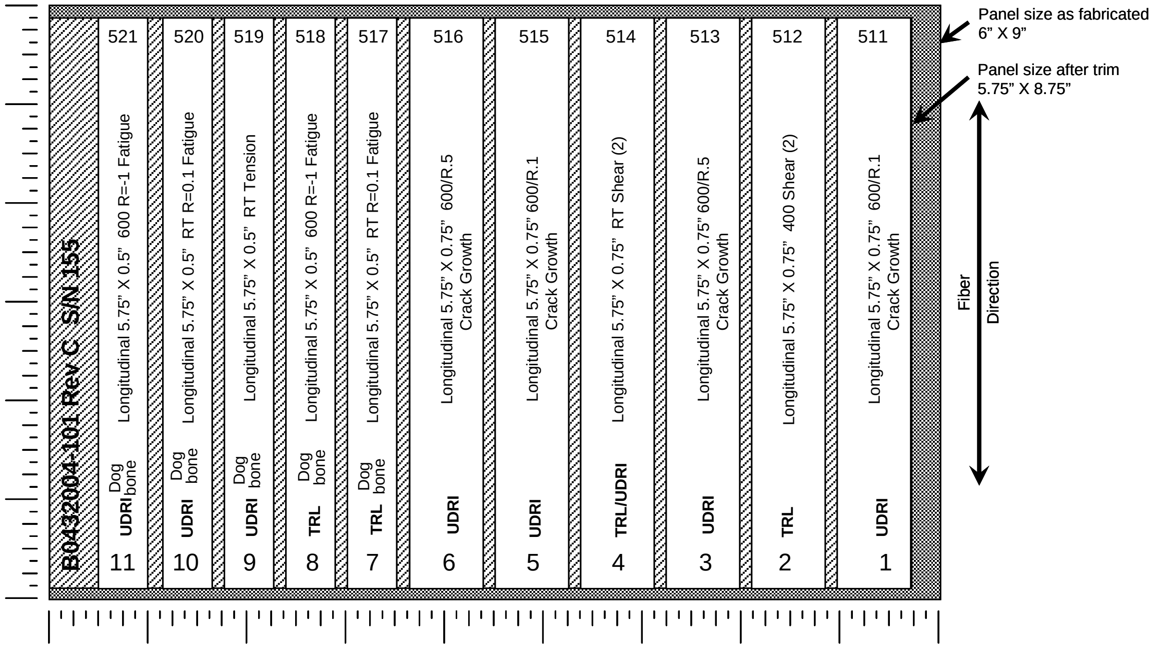
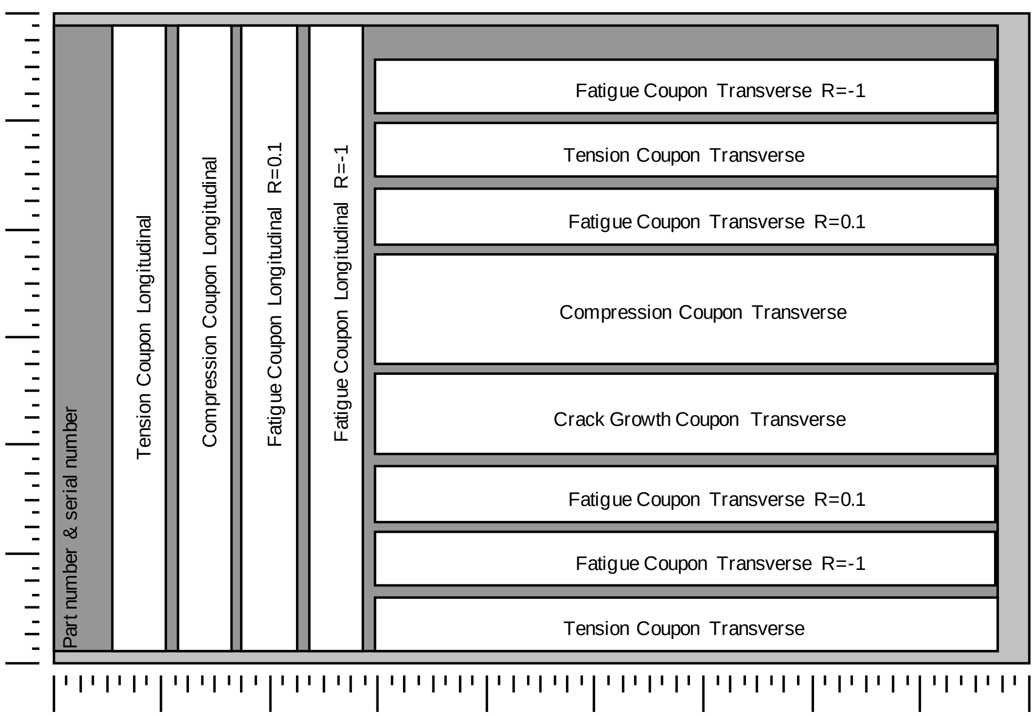
APPENDIX A.1
REPRESENTATIVE TEST SPECIMEN CUT PLANS



scale for specimen layouts is in inches



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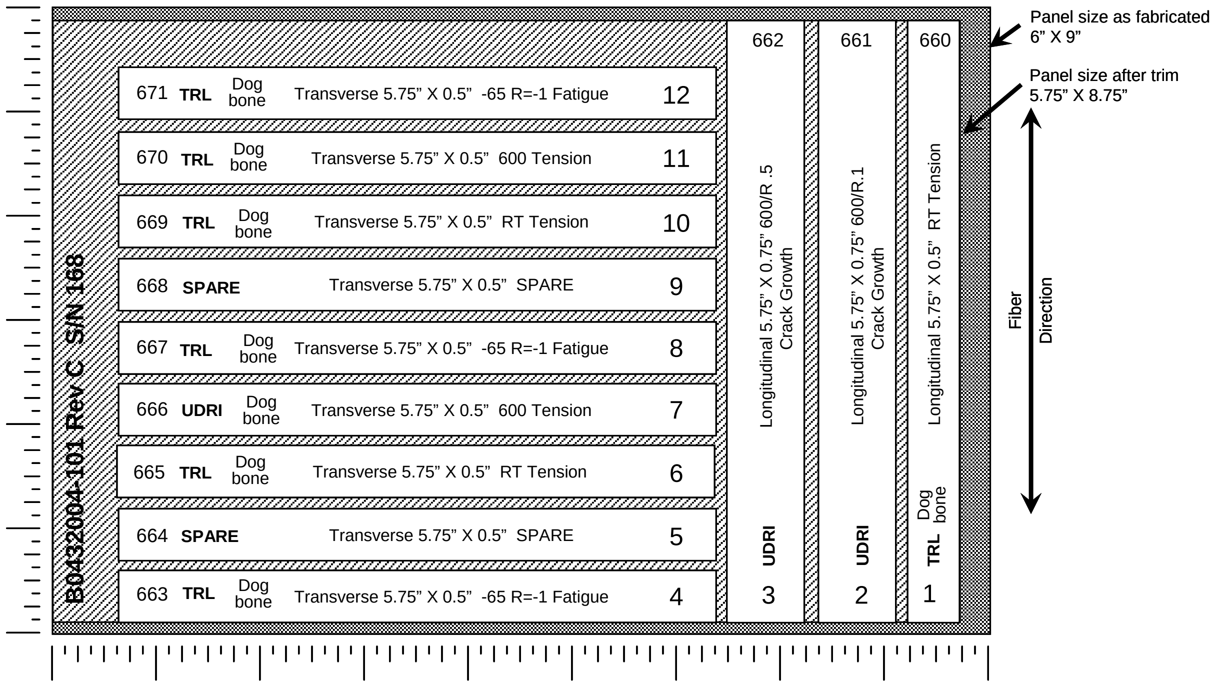

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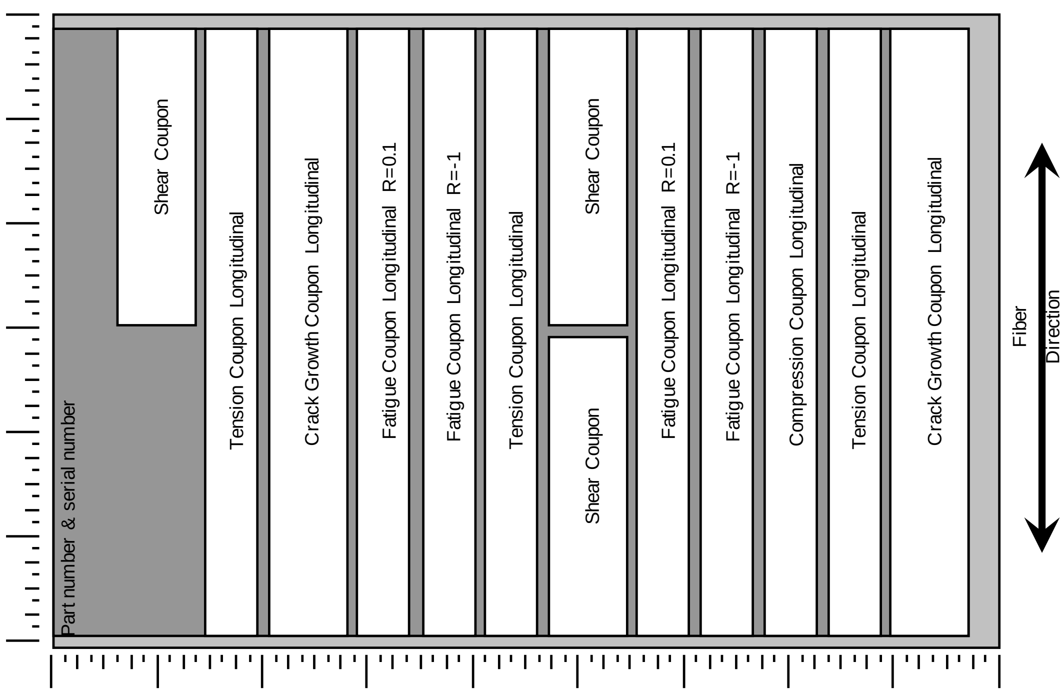
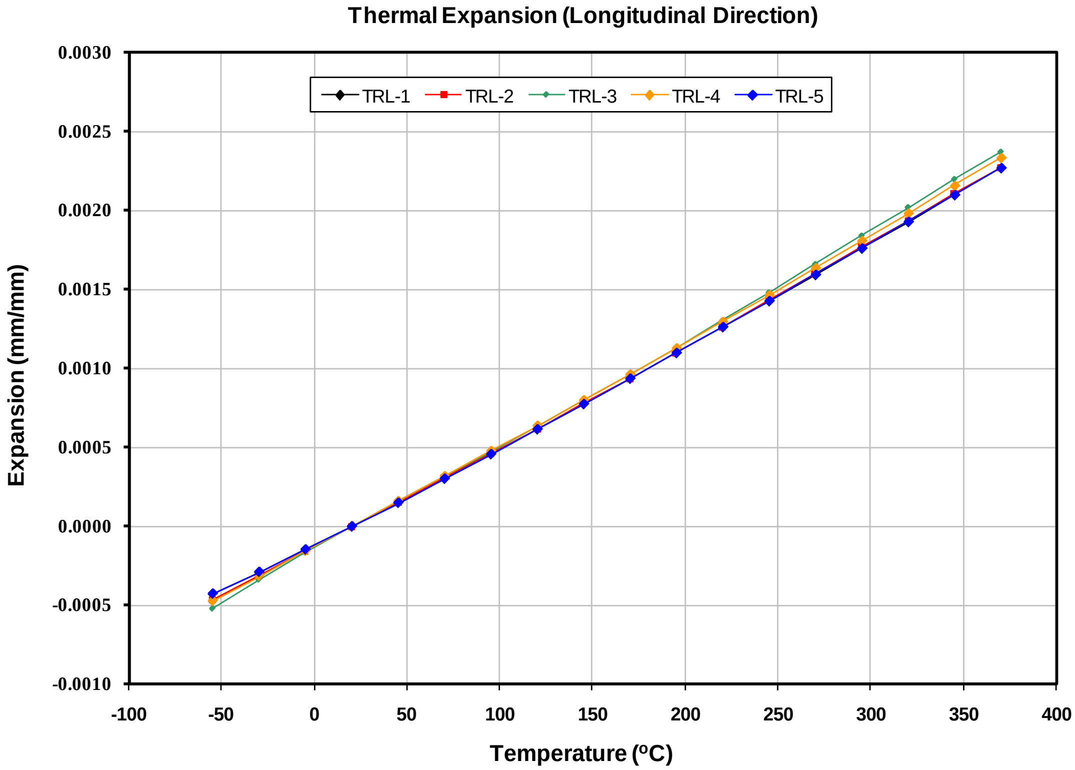
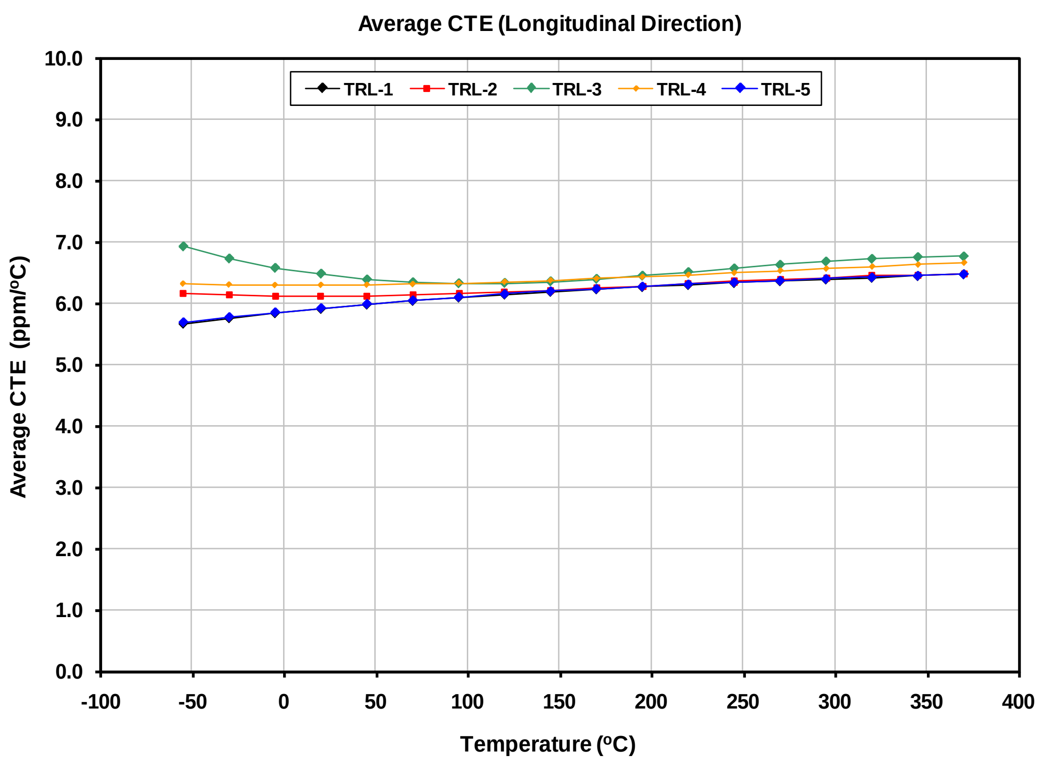


APPENDIX A.2
COEFFICIENT OF THERMAL EXPANSION (CTE) RESULTS





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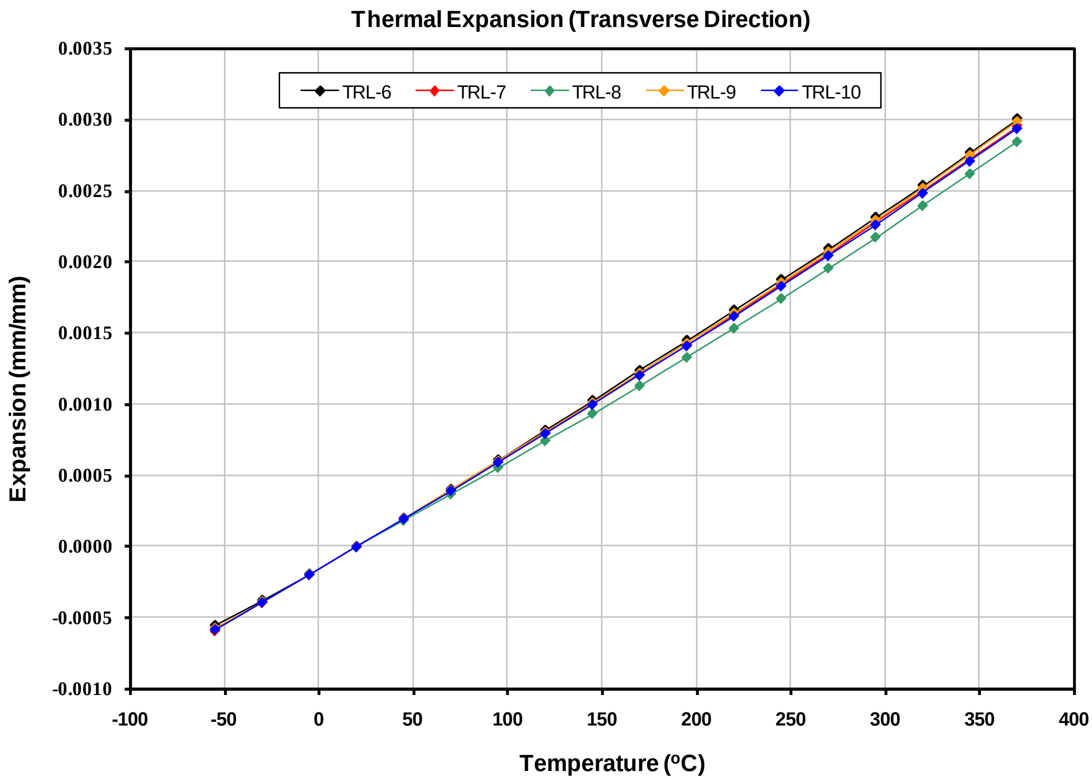

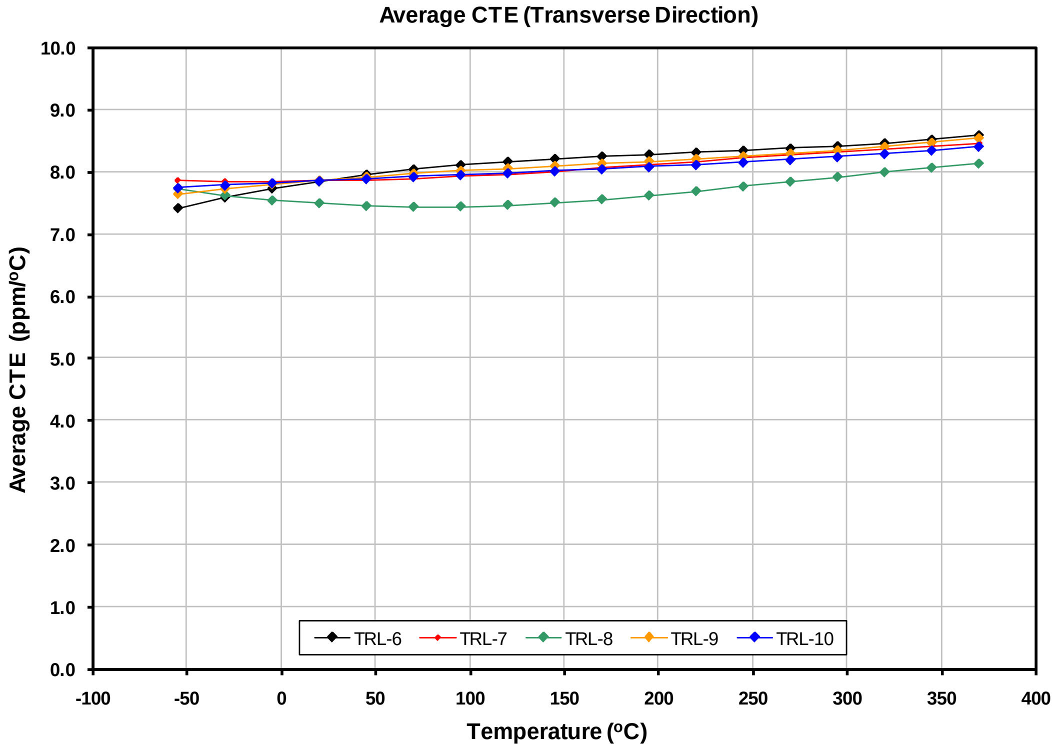

APPENDIX A.3
THERMAL CONDUCTIVITY RESULTS

Temperature (°C)	Specific Heat Capacity (J/(g-C))	Thermal Diffusivity (cm^2/s)	Density (g/cc)	Thermal Conductivity (W/cm-K)	Thermal Conductivity (W/m-K)
-55	0.4233	0.0323	3.905	0.053	5.3
-18	0.4958	0.0319	3.905	0.062	6.2
20	0.5302	0.0314	3.905	0.065	6.5
196	0.6342	0.0322	3.905	0.080	8.0
371	0.6863	0.0347	3.905	0.093	9.3
-55	0.4231	0.0316	3.905	0.052	5.2
-18	0.4926	0.0310	3.905	0.060	6.0
20	0.5233	0.0307	3.905	0.063	6.3
196	0.6661	0.0318	3.905	0.083	8.3
371	0.6854	0.0342	3.905	0.092	9.2
-55	0.4238	0.0307	3.905	0.051	5.1
-18	0.4944	0.0304	3.905	0.059	5.9
20	0.5213	0.0299	3.905	0.061	6.1
196	0.6607	0.0312	3.905	0.080	8.0
371	0.6912	0.0341	3.905	0.092	9.2
-55	0.4265	0.0313	3.905	0.052	5.2
-18	0.5031	0.0309	3.905	0.061	6.1
20	0.5385	0.0307	3.905	0.065	6.5
196	0.7038	0.0315	3.905	0.087	8.7
371	0.7450	0.0345	3.905	0.100	10.0
-55	0.4236	0.0316	3.905	0.052	5.2
-18	0.4915	0.0311	3.905	0.060	6.0
20	0.5337	0.0308	3.905	0.064	6.4
196	0.6871	0.0319	3.905	0.086	8.6
371	0.6944	0.0346	3.905	0.094	9.4

Temperature (°F)	Avg Thermal Conductivity (W/m-K)	Std Dev	%COV
-67	5.2	0.09	1.8%
0	6.0	0.12	2.0%
68	6.3	0.17	2.7%
385	8.3	0.30	3.6%
700	9.4	0.36	3.8%

APPENDIX B
INDIVIDUAL TENSION TEST RESULTS

Table B1. Longitudinal Tension Data of SCS-6/Ti6Al-4V (Table 1 of 6)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.400 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)	**TENSION**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07	

Lot I.D. (Panel)	Fiber Vol %	Specimen No.	Test Temp. (°F)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-109	33.9%	111-01	70	0.01	extensometer	29.7	161.3	192.4	Note 7	251.1	0.860	TRL (B. Stockings)
B0432004-101-110	33.4%	112-05	70	0.01	extensometer	30.6	155.3	194.2	251.5	251.8	Note 4	TRL (B. Stockings)
B0432004-101-111	33.5%	113-08	70	0.01	strain gage	29.1	169.1	199.9	Note 3	241.7	0.975	UDRI (A. Hutson)
B0432004-101-112	34.0%	121-02	70	0.01	extensometer	31.7	166.6	204.4	Note 3	262.8	Note 4	TRL (B. Stockings)
B0432004-101-113	33.6%	122-01	70	0.01	extensometer	28.0	159.1	189.8	Note 3	244.0	1.059	UDRI (A. Hutson)
B0432004-101-113	33.1%	122-07	70	0.01	extensometer	30.4	155.2	187.7	Note 3	244.6	Note 4	TRL (B. Stockings)
B0432004-101-114	33.8%	123-10	70	0.01	strain gage	28.6	166.4	195.0	Note 3	236.9	0.991	UDRI (A. Hutson)
B0432004-101-115	33.6%	131-03	70	0.01	extensometer	30.1	162.8	197.8	Note 3	258.0	Note 4	TRL (B. Stockings)
B0432004-101-116	33.2%	132-10	70	0.01	extensometer	31.5	Note 4	Note 4	Note 4	Note 4	Note 4	TRL (B. Stockings)
B0432004-101-117	33.1%	133-01	70	0.01	strain gage	31.3	Note 7	Note 7	Note 7	243.4	0.834	UDRI (A. Hutson)
B0432004-101-118	33.0%	141-04	70	0.01	extensometer	28.4	241.9	Note 4	Note 4	253.5	Note 4	TRL (B. Stockings)
B0432004-101-119	33.5%	142-04	70	0.01	extensometer	29.2	171.6	203.7	263.9	263.9	Note 4	TRL (B. Stockings)
B0432004-101-120	32.5%	143-01	70	0.01	strain gage	30.6	168.5	202.7	Note 3	256.4	1.052	UDRI (A. Hutson)
B0432004-101-121	33.0%	151-03	70	0.01	extensometer	27.8	190.1	213.8	Note 3	254.9	Note 4	TRL (B. Stockings)
B0432004-101-122	33.7%	152-01	70	0.01	extensometer	27.7	155.7	185.8	Note 4	264.3	Note 4	TRL (B. Stockings)
B0432004-101-123	32.9%	153-11	70	0.01	strain gage	29.6	163.4	196.5	Note 3	242.2	1.012	UDRI (A. Hutson)
B0432004-101-124	34.1%	211-05	70	0.01	extensometer	29.0	168.2	196.0	250.3	277.3	1.232	TRL (B. Stockings)
B0432004-101-124	34.2%	211-14	70	0.01	strain gage	29.1	161.3	189.0	241.5	265.5	0.969	UDRI (A. Hutson)
B0432004-101-125	33.7%	212-09	70	0.01	extensometer	31.3	177.9	214.0	Note 3	261.8	0.983	TRL (B. Stockings)
B0432004-101-126	33.5%	213-01	70	0.01	strain gage	28.3	176.1	196.7	Note 3	221.4	0.890	UDRI (A. Hutson)
B0432004-101-135	33.4%	243-06	70	0.01	extensometer	29.5	166.7	196.6	Note 3	258.0	1.068	TRL (B. Stockings)
B0432004-101-138	33.7%	253-01	70	0.01	extensometer	30.7	163.6	196.6	253.0	260.0	1.061	TRL (B. Stockings)
B0432004-101-130	33.3%	231-07	70	0.01	extensometer	30.2	171.0	204.7	268.0	271.6	1.098	TRL (B. Stockings)
B0432004-101-131	34.4%	232-13	70	0.01	extensometer	29.2	167.4	196.7	256.1	267.3	1.142	TRL (B. Stockings)
B0432004-101-132	33.8%	233-01	70	0.01	strain gage	28.3	164.3	172.2	Note 3	236.3	0.988	UDRI (A. Hutson)
B0432004-101-133	33.4%	241-08	70	0.01	extensometer	28.8	167.8	198.3	Note 3	257.5	1.089	TRL (B. Stockings)
B0432004-101-134	33.2%	242-11	70	0.01	extensometer	28.7	161.4	191.0	249.7	257.3	1.112	TRL (B. Stockings)
B0432004-101-136	33.4%	251-01	70	0.01	strain gage	26.0	142.8	171.1	Note 3	222.3	1.035	UDRI (A. Hutson)
B0432004-101-137	33.6%	252-01	70	0.01	extensometer	29.2	165.5	196.2	253.1	259.6	1.102	TRL (B. Stockings)
B0432004-101-139	33.6%	311-09	70	0.01	extensometer	30.1	158.9	193.9	Note 3	241.9	0.980	TRL (B. Stockings)
B0432004-101-140	33.8%	312-08	70	0.01	strain gage	30.4	166.8	200.8	Note 3	252.1	0.999	UDRI (A. Hutson)
B0432004-101-141	34.1%	313-01	70	0.01	extensometer	30.2	164.2	198.0	Note 3	255.0	1.027	TRL (B. Stockings)
B0432004-101-142	33.2%	321-10	70	0.01	extensometer	30.6	169.5	201.6	Note 3	249.7	0.979	TRL (B. Stockings)
B0432004-101-143	34.8%	322-01	70	0.01	strain gage	31.0	166.3	199.4	Note 3	247.8	0.949	UDRI (A. Hutson)
B0432004-101-144	32.9%	323-10	70	0.01	extensometer	31.6	164.9	195.3	Note 3	231.7	0.873	TRL (B. Stockings)
B0432004-101-145	33.9%	331-10	70	0.01	extensometer	30.5	170.7	205.0	Note 3	260.0	1.029	TRL (B. Stockings)

Table B1. Longitudinal Tension Data of SCS-6/Ti6Al-4V (Table 2 of 6)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.400 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07

SCS-6 / Ti-6Al-4V
LONGITUDINAL
TENSION
$[0]_{16}$

Lot I.D. (Panel)	Fiber Vol %	Specimen No.	Test Temp. (°F)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-146	33.2%	332-10	70	0.01	strain gage	29.5	168.2	198.6	Note 3	234.2	0.927	UDRI (A. Hutson)
B0432004-101-147	32.8%	333-08	70	0.01	extensometer	34.0	160.9	197.7	Note 3	246.5	0.887	TRL (B. Stockings)
B0432004-101-148	33.5%	341-06	70	0.01	extensometer	34.2	172.2	209.4	Note 3	273.8	0.982	TRL (B. Stockings)
B0432004-101-149	34.5%	342-02	70	0.01	strain gage	31.6	173.1	207.9	Note 3	258.9	0.984	UDRI (A. Hutson)
B0432004-101-150	34.2%	343-01	70	0.01	extensometer	31.1	165.4	204.4	Note 3	260.9	1.016	TRL (B. Stockings)
B0432004-101-151	35.0%	351-02	70	0.01	extensometer	30.3	165.8	201.6	Note 3	250.6	0.997	TRL (B. Stockings)
B0432004-101-152	34.6%	352-01	70	0.01	strain gage	31.7	161.5	198.8	Note 3	250.1	0.960	UDRI (A. Hutson)
B0432004-101-153	33.3%	353-11	70	0.01	extensometer	32.9	161.9	195.9	Note 3	244.2	0.917	TRL (B. Stockings)
B0432004-101-154	32.8%	411-11	70	0.01	extensometer	32.8	168.9	199.8	Note 3	238.1	0.886	TRL (B. Stockings)
B0432004-101-155	32.5%	412-09	70	0.01	extensometer	26.3	174.1	196.0	245.9	248.5	1.150	UDRI (A. Hutson)
B0432004-101-156	32.7%	413-01	70	0.01	extensometer	32.4	166.9	198.4	Note 3	205.5	0.707	TRL (B. Stockings)
B0432004-101-157	32.9%	421-12	70	0.01	extensometer	33.7	161.7	199.1	Note 3	232.3	0.828	TRL (B. Stockings)
B0432004-101-158	33.3%	422-11	70	0.01	extensometer	27.1	180.0	206.3	Note 3	218.2	0.910	UDRI (A. Hutson)
B0432004-101-159	33.6%	423-10	70	0.01	extensometer	34.1	165.3	200.4	Note 3	228.1	0.808	TRL (B. Stockings)
B0432004-101-160	33.5%	431-13	70	0.01	extensometer	32.7	171.4	202.9	Note 3	244.7	0.896	TRL (B. Stockings)
B0432004-101-161	33.1%	432-08	70	0.01	extensometer	26.8	165.9	192.9	Note 3	233.5	1.046	UDRI (A. Hutson)
B0432004-101-162	33.3%	433-08	70	0.01	extensometer	31.7	163.5	195.2	Note 3	231.2	0.864	TRL (B. Stockings)
B0432004-101-163	34.2%	441-01	70	0.01	extensometer	33.6	165.6	199.8	Note 3	251.4	0.918	TRL (B. Stockings)
B0432004-101-164	33.7%	442-03	70	0.01	strain gage	29.3	163.8	192.8	Note 3	232.2	0.947	UDRI (A. Hutson)
B0432004-101-165	33.2%	443-10	70	0.01	extensometer	33.4	168.8	200.2	Note 3	240.5	0.858	TRL (B. Stockings)
B0432004-101-166	34.6%	451-02	70	0.01	extensometer	32.8	173.8	201.3	Note 3	248.3	0.920	TRL (B. Stockings)
B0432004-101-167	33.5%	452-09	70	0.01	extensometer	25.3	169.0	195.3	Note 3	226.0	1.029	UDRI (A. Hutson)
B0432004-101-168	34.5%	453-01	70	0.01	extensometer	33.4	165.4	199.8	Note 3	228.3	0.794	TRL (B. Stockings)
B0432004-101-169	33.9%	511-03	70	0.01	extensometer	32.7	162.0	196.1	Note 3	250.8	0.965	TRL (B. Stockings)
B0432004-101-170	33.6%	512-01	70	0.01	extensometer	27.5	161.5	191.2	Note 3	230.0	0.994	UDRI (A. Hutson)
B0432004-101-171	34.1%	513-02	70	0.01	extensometer	32.3	164.9	193.9	Note 3	231.2	0.853	TRL (B. Stockings)
B0432004-101-172	33.2%	521-12	70	0.01	extensometer	32.5	168.2	198.5	Note 3	240.6	0.895	TRL (B. Stockings)
B0432004-101-173	34.2%	522-11	70	0.01	extensometer	26.0	170.4	196.5	Note 3	238.1	1.084	UDRI (A. Hutson)
B0432004-101-174	34.6%	523-01	70	0.01	extensometer	31.3	163.1	197.5	Note 3	223.8	0.840	TRL (B. Stockings)
B0432004-101-175	33.3%	531-06	70	0.01	extensometer	32.5	167.0	199.4	Note 3	232.7	0.851	TRL (B. Stockings)
B0432004-101-176	34.8%	532-02	70	0.01	extensometer	26.3	163.9	193.4	Note 3	239.8	Note 4	UDRI (A. Hutson)
B0432004-101-177	33.4%	533-10	70	0.01	extensometer	32.7	164.7	197.6	Note 3	231.7	0.850	TRL (B. Stockings)
B0432004-101-178	34.0%	541-07	70	0.01	extensometer	33.5	169.9	202.7	Note 3	240.6	0.852	TRL (B. Stockings)
B0432004-101-179	33.8%	542-11	70	0.01	extensometer	27.9	172.0	193.5	Note 3	246.0	1.074	UDRI (A. Hutson)
B0432004-101-180	34.0%	543-01	70	0.01	extensometer	31.8	167.1	197.8	Note 3	236.1	0.887	TRL (B. Stockings)
B0432004-101-181	33.3%	551-08	70	0.01	extensometer	32.8	164.0	195.7	Note 3	225.1	0.809	TRL (B. Stockings)

Table B1. Longitudinal Tension Data of SCS-6/Ti6Al-4V (Table 3 of 6)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.400 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07

SCS-6 / Ti-6Al-4V LONGITUDINAL TENSION $[0]_{16}$

Lot I.D. (Panel)	Fiber Vol %	Specimen No.	Test Temp. (°F)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-182	33.8%	552-08	70	0.01	extensometer	29.6	159.1	189.6	Note 3	230.0	0.943	UDRI (A. Hutson)
B0432004-101-183	34.2%	553-11	70	0.01	extensometer	29.5	173.4	198.9	Note 3	247.5	1.011	TRL (B. Stockings)
B0432004-101-184	34.0%	611-09	70	0.01	extensometer	31.0	163.2	196.8	222.2	236.6	1.096	TRL (B. Stockings)
B0432004-101-185	32.9%	612-01	70	0.01	extensometer	28.6	159.1	187.2	Note 3	214.1	0.902	UDRI (A. Hutson)
B0432004-101-186	34.3%	613-10	70	0.01	extensometer	28.1	100.2	214.0	Note 3	237.4	0.953	TRL (B. Stockings)
B0432004-101-187	35.0%	621-11	70	0.01	extensometer	29.9	171.4	197.9	Note 3	243.7	0.998	TRL (B. Stockings)
B0432004-101-188	33.2%	622-03	70	0.01	extensometer	29.0	152.5	180.8	Note 3	210.3	0.872	UDRI (A. Hutson)
B0432004-101-189	33.7%	623-01	70	0.01	extensometer	30.0	156.4	186.2	Note 3	217.7	0.862	TRL (B. Stockings)
B0432004-101-190	35.3%	631-12	70	0.01	extensometer	30.4	157.7	190.1	232.1	240.2	1.493	TRL (B. Stockings)
B0432004-101-191	33.8%	632-11	70	0.01	extensometer	29.3	154.9	184.5	227.8	228.2	0.982	UDRI (A. Hutson)
B0432004-101-192	33.8%	633-10	70	0.01	extensometer	28.4	156.5	187.2	244.0	258.6	1.160	TRL (B. Stockings)
B0432004-101-193	34.9%	641-13	70	0.01	extensometer	29.7	169.5	197.0	Note 3	242.0	0.975	TRL (B. Stockings)
B0432004-101-194	34.0%	642-11	70	0.01	extensometer	29.5	152.8	183.6	Note 3	223.7	0.937	UDRI (A. Hutson)
B0432004-101-195	34.2%	643-10	70	0.01	extensometer	29.3	167.2	196.8	Note 3	231.3	0.987	TRL (B. Stockings)
B0432004-101-196	35.1%	651-01	70	0.01	extensometer	30.3	148.8	192.4	222.1	228.2	0.987	TRL (B. Stockings)
B0432004-101-197	33.8%	652-08	70	0.01	extensometer	29.4	154.0	185.3	Note 3	227.8	0.970	UDRI (A. Hutson)
B0432004-101-198	34.2%	653-01	70	0.01	extensometer	29.1	173.9	191.0	212.1	248.2	1.308	TRL (B. Stockings)
B0432004-101-199	32.7%	711-12	70	0.01	extensometer	28.9	152.7	183.0	228.8	237.5	1.053	TRL (B. Stockings)
B0432004-101-200	33.2%	712-12	70	0.01	extensometer	26.0	165.1	189.1	Note 3	233.8	1.081	UDRI (A. Hutson)
B0432004-101-201	33.5%	713-03	70	0.01	extensometer	27.6	161.6	187.4	Note 3	230.9	1.015	TRL (B. Stockings)
B0432004-101-202	33.1%	721-04	70	0.01	extensometer	27.9	163.6	189.8	Note 3	233.5	1.005	TRL (B. Stockings)
B0432004-101-203	34.3%	722-01	70	0.01	extensometer	26.7	153.4	183.6	223.3	235.9	1.127	UDRI (A. Hutson)
B0432004-101-204	34.3%	723-01	70	0.01	extensometer	28.4	159.6	190.0	Note 3	242.8	1.036	TRL (B. Stockings)
B0432004-101-205	32.8%	731-13	70	0.01	extensometer	26.8	166.6	189.8	220.9	237.9	1.153	TRL (B. Stockings)
B0432004-101-206	33.1%	732-04	70	0.01	extensometer	27.8	167.1	193.3	Note 3	236.8	1.024	UDRI (A. Hutson)
B0432004-101-207	33.1%	733-01	70	0.01	extensometer	30.1	153.6	186.4	Note 3	232.6	0.955	TRL (B. Stockings)
B0432004-101-208	33.1%	741-06	70	0.01	extensometer	27.9	168.5	192.6	236.3	240.4	1.070	TRL (B. Stockings)
B0432004-101-209	33.9%	742-12	70	0.01	extensometer	28.4	166.2	197.7	Note 3	245.3	1.026	UDRI (A. Hutson)
B0432004-101-210	33.3%	743-10	70	0.01	extensometer	28.2	155.9	186.0	Note 3	238.7	1.031	TRL (B. Stockings)
B0432004-101-211	33.4%	751-07	70	0.01	extensometer	29.6	158.6	190.2	232.7	239.7	1.023	TRL (B. Stockings)
B0432004-101-212	34.0%	752-12	70	0.01	extensometer	28.6	158.1	189.2	Note 3	238.2	1.013	UDRI (A. Hutson)
B0432004-101-213	33.2%	753-08	70	0.01	extensometer	29.2	162.4	192.1	Note 3	246.3	1.041	TRL (B. Stockings)
B0432004-101-214	33.6%	811-08	70	0.01	extensometer	30.1	161.1	192.0	Note 3	246.4	1.011	TRL (B. Stockings)
B0432004-101-215	34.8%	812-01	70	0.01	extensometer	26.6	160.9	189.8	Note 3	242.7	1.104	UDRI (A. Hutson)
B0432004-101-216	33.2%	813-09	70	0.01	extensometer	28.3	171.9	195.4	Note 3	245.3	1.042	TRL (B. Stockings)
B0432004-101-217	33.4%	821-10	70	0.01	extensometer	29.1	167.6	194.8	Note 3	236.9	0.975	TRL (B. Stockings)

Table B1. Longitudinal Tension Data of SCS-6/Ti6Al-4V (Table 4 of 6)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.400 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07

SCS-6 / Ti-6Al-4V LONGITUDINAL TENSION $[0]_{16}$

Lot I.D. (Panel)	Fiber Vol %	Specimen No.	Test Temp. (^oF)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-218	34.3%	822-09	70	0.01	extensometer	26.5	161.9	189.1	Note 3	240.5	1.098	UDRI (A. Hutson)
B0432004-101-219	34.2%	823-01	70	0.01	extensometer	30.8	158.1	190.4	Note 3	243.5	0.975	TRL (B. Stockings)
B0432004-101-220	32.9%	831-11	70	0.01	extensometer	29.0	163.4	190.9	Note 3	232.0	0.956	TRL (B. Stockings)
B0432004-101-221	33.6%	832-01	70	0.01	extensometer	28.4	169.9	195.9	Note 3	242.7	1.034	UDRI (A. Hutson)
B0432004-101-222	35.7%	833-10	70	0.01	extensometer	29.9	162.4	194.7	Note 3	251.3	1.030	TRL (B. Stockings)
B0432004-101-223	33.1%	841-12	70	0.01	extensometer	28.8	161.2	189.9	Note 3	250.2	1.036	TRL (B. Stockings)
B0432004-101-224	33.7%	842-01	70	0.01	extensometer	25.8	164.3	190.1	243.3	255.1	1.226	UDRI (A. Hutson)
B0432004-101-225	34.7%	843-01	70	0.01	extensometer	30.5	145.1	182.9	Note 3	231.1	0.948	TRL (B. Stockings)
B0432004-101-226	33.6%	851-13	70	0.01	extensometer	28.7	162.2	192.1	Note 3	250.2	1.070	TRL (B. Stockings)
B0432004-101-227	33.2%	852-08	70	0.01	extensometer	26.5	160.9	188.9	241.9	243.2	1.120	UDRI (A. Hutson)
B0432004-101-228	34.1%	853-11	70	0.01	extensometer	29.7	157.9	188.9	Note 3	240.5	0.997	TRL (B. Stockings)
AVERAGE	**33.7%**					**29.7**	**164.3**	**194.7**	**240.0**	**242.4**	**0.993**	
B0432004-101-124	34.5%	211-01	400	0.01	extensometer	25.5	128.9	155.4	212.8	247.4	1.264	TRL (B. Stockings)
B0432004-101-124	33.8%	211-04	400	0.01	extensometer	25.0	129.7	157.5	207.7	242.5	1.272	TRL (B. Stockings)
B0432004-101-135	33.5%	243-02	400	0.01	extensometer	26.0	119.5	149.2	203.4	229.8	1.157	TRL (B. Stockings)
B0432004-101-135	33.6%	243-05	400	0.01	extensometer	25.7	121.5	149.2	208.4	223.8	1.111	TRL (B. Stockings)
B0432004-101-133	33.4%	241-03	400	0.01	extensometer	25.7	124.8	153.1	208.9	232.8	1.198	TRL (B. Stockings)
B0432004-101-133	33.3%	241-06	400	0.01	extensometer	25.8	115.4	155.4	215.4	228.3	1.111	TRL (B. Stockings)
B0432004-101-184	33.9%	611-07	400	0.01	extensometer	27.5	128.1	154.1	198.0	211.7	1.028	TRL (B. Stockings)
B0432004-101-186	34.3%	613-08	400	0.01	extensometer	28.0	133.7	160.4	212.2	222.8	1.025	TRL (B. Stockings)
B0432004-101-190	35.3%	631-09	400	0.01	extensometer	26.6	117.3	143.5	Note 3	164.9	0.707	TRL (B. Stockings)
B0432004-101-190	35.1%	631-11	400	0.01	extensometer	27.9	140.3	164.9	Note 3	193.1	0.827	TRL (B. Stockings)
B0432004-101-193	37.2%	641-10	400	0.01	extensometer	28.6	127.6	152.6	210.9	212.2	0.943	TRL (B. Stockings)
B0432004-101-193	34.7%	641-12	400	0.01	extensometer	28.4	126.7	154.6	Note 3	210.3	0.923	TRL (B. Stockings)
AVERAGE	**34.4%**					**26.7**	**126.1**	**154.2**	**208.6**	**218.3**	**1.047**	
B0432004-101-109	33.9%	111-02	600	0.01	extensometer	26.3	98.9	139.6	Note 3	200.8	Note 7	TRL (B. Stockings)
B0432004-101-109	34.2%	111-06	600	0.01	strain gage	46.6	121.5	189.8	Note 3	210.3	Note 7	UDRI (A. Hutson)
B0432004-101-112	33.9%	121-03	600	0.01	extensometer	29.0	127.9	154.8	Note 3	212.8	Note 7	TRL (B. Stockings)
B0432004-101-112	33.8%	121-07	600	0.01	extensometer	27.2	120.9	156.4	223.1	224.4	1.026	TRL (B. Stockings)
B0432004-101-115	33.6%	131-04	600	0.01	strain gage	29.0	Note 4	Note 4	Note 4	Note 4	Note 4	UDRI (A. Hutson)
B0432004-101-115	34.0%	131-08	600	0.01	extensometer	25.3	110.0	156.6	Note 4	207.2	0.970	TRL (B. Stockings)
B0432004-101-116	33.1%	132-05	600	0.01	extensometer	27.7	116.3	152.0	Note 3	192.4	0.863	UDRI (A. Hutson)
B0432004-101-124	33.7%	211-03	600	0.01	extensometer	24.9	117.8	144.9	198.4	234.2	1.259	TRL (B. Stockings)
B0432004-101-124	34.1%	211-06	600	0.01	strain gage	28.8	114.1	145.3	Note 4	220.1	Note 4	UDRI (A. Hutson)
B0432004-101-135	33.2%	243-04	600	0.01	extensometer	25.2	114.6	141.4	196.5	219.5	1.135	TRL (B. Stockings)
B0432004-101-135	33.4%	243-11	600	0.01	extensometer	24.7	117.8	141.4	198.1	218.5	1.133	TRL (B. Stockings)

Table B1. Longitudinal Tension Data of SCS-6/Ti6Al-4V (Table 5 of 6)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.400 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)	**TENSION**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07	

Lot I.D. (Panel)	Fiber Vol %	Specimen No.	Test Temp. (^oF)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-133	33.2%	241-05	600	0.01	strain gage	30.1	115.0	149.9	Note 3	210.9	0.878	UDRI (A. Hutson)
B0432004-101-133	33.3%	241-09	600	0.01	extensometer	25.6	110.8	141.0	198.9	212.5	1.076	TRL (B. Stockings)
B0432004-101-139	34.0%	311-06	600	0.01	extensometer	25.5	117.9	145.1	Note 3	190.8	0.918	TRL (B. Stockings)
B0432004-101-139	33.6%	311-10	600	0.01	strain gage	32.4	121.1	159.6	Note 3	195.4	0.720	UDRI (A. Hutson)
B0432004-101-142	33.4%	321-07	600	0.01	extensometer	26.0	120.2	147.4	Note 3	195.0	0.919	TRL (B. Stockings)
B0432004-101-142	33.6%	321-11	600	0.01	extensometer	25.6	122.9	148.6	Note 3	200.9	0.962	TRL (B. Stockings)
B0432004-101-145	34.4%	331-01	600	0.01	strain gage	30.2	122.2	158.4	Note 3	227.6	0.923	UDRI (A. Hutson)
B0432004-101-145	33.5%	331-09	600	0.01	extensometer	27.0	116.7	146.6	Note 3	205.2	0.946	TRL (B. Stockings)
B0432004-101-154	33.7%	411-02	600	0.01	extensometer	31.0	117.3	146.5	Note 3	186.5	0.766	TRL (B. Stockings)
B0432004-101-154	32.8%	411-10	600	0.01	strain gage	Note 4	Note 4	Note 4	Note 4	199.4	Note 4	UDRI (A. Hutson)
B0432004-101-157	32.8%	421-03	600	0.01	extensometer	30.6	118.8	150.9	Note 3	195.5	0.830	TRL (B. Stockings)
B0432004-101-160	33.5%	431-04	600	0.01	extensometer	29.0	114.9	142.3	Note 3	191.5	0.825	TRL (B. Stockings)
B0432004-101-160	33.6%	431-10	600	0.01	strain gage	32.1	118.0	156.2	Note 3	184.1	Note 4	UDRI (A. Hutson)
B0432004-101-163	33.2%	441-05	600	0.01	extensometer	30.6	118.5	148.7	Note 3	189.2	0.758	TRL (B. Stockings)
B0432004-101-169	33.2%	511-06	600	0.01	extensometer	26.3	123.2	146.6	200.6	205.3	0.997	TRL (B. Stockings)
B0432004-101-169	33.2%	511-12	600	0.01	extensometer	26.9	106.5	143.1	202.9	203.1	0.950	UDRI (A. Hutson)
B0432004-101-171	33.1%	513-07	600	0.01	extensometer	25.6	107.1	135.5	Note 3	192.5	0.952	TRL (B. Stockings)
B0432004-101-171	33.4%	513-13	600	0.01	extensometer	27.2	113.7	140.1	197.3	202.4	0.958	TRL (B. Stockings)
B0432004-101-172	33.6%	521-01	600	0.01	extensometer	27.5	110.6	142.2	Note 3	196.9	0.905	UDRI (A. Hutson)
B0432004-101-172	33.6%	521-08	600	0.01	extensometer	27.0	124.3	151.0	Note 3	201.2	0.914	TRL (B. Stockings)
B0432004-101-184	34.2%	611-10	600	0.01	extensometer	28.6	120.2	147.2	203.4	214.2	0.997	TRL (B. Stockings)
B0432004-101-186	33.1%	613-11	600	0.01	extensometer	25.1	116.9	141.6	Note 3	186.7	0.949	UDRI (A. Hutson)
B0432004-101-187	34.6%	621-02	600	0.01	extensometer	26.2	123.8	144.6	201.1	206.4	1.014	TRL (B. Stockings)
B0432004-101-187	35.1%	621-12	600	0.01	extensometer	28.2	111.5	145.3	198.2	198.4	0.903	TRL (B. Stockings)
B0432004-101-193	33.0%	641-01	600	0.01	extensometer	27.2	101.3	132.4	Note 3	171.7	Note 4	UDRI (A. Hutson)
B0432004-101-193	34.5%	641-03	600	0.01	extensometer	27.9	113.0	140.4	166.0	181.4	0.925	TRL (B. Stockings)
B0432004-101-199	33.2%	711-03	600	0.01	extensometer	27.4	115.7	142.2	190.7	191.5	0.891	TRL (B. Stockings)
B0432004-101-199	32.9%	711-04	600	0.01	extensometer	26.4	114.1	145.8	Note 3	189.8	0.868	UDRI (A. Hutson)
B0432004-101-202	33.2%	721-05	600	0.01	extensometer	26.7	109.1	135.0	Note 3	188.0	0.891	TRL (B. Stockings)
B0432004-101-202	33.2%	721-09	600	0.01	extensometer	26.7	119.9	144.3	Note 3	199.8	0.926	TRL (B. Stockings)
B0432004-101-206	33.1%	732-01	600	0.01	extensometer	24.0	112.9	139.2	Note 3	188.1	0.949	UDRI (A. Hutson)
B0432004-101-206	33.3%	732-03	600	0.01	extensometer	26.5	104.7	136.5	192.5	198.7	0.958	TRL (B. Stockings)
B0432004-101-216	34.3%	813-02	600	0.01	extensometer	25.4	115.1	139.4	197.6	209.5	1.062	TRL (B. Stockings)
B0432004-101-216	33.2%	813-04	600	0.01	extensometer	26.1	118.5	141.3	Note 3	197.6	0.930	UDRI (A. Hutson)
B0432004-101-218	34.3%	822-10	600	0.01	extensometer	25.8	124.0	145.6	205.9	206.4	1.000	TRL (B. Stockings)
B0432004-101-221	34.3%	832-02	600	0.01	extensometer	25.9	109.0	136.0	188.7	202.6	1.020	TRL (B. Stockings)

Table B1. Longitudinal Tension Data of SCS-6/Ti6Al-4V (Table 6 of 6)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.400 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)	**TENSION**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07	

Lot I.D. (Panel)	Fiber Vol %	Specimen No.	Test Temp. (°F)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-224	33.8%	842-11	600	0.01	extensometer	24.3	118.9	147.1	Note 3	197.4	0.986	UDRI (A. Hutson)
B0432004-101-226	34.1%	851-12	600	0.01	extensometer	27.0	116.4	142.0	202.0	212.7	1.019	TRL (B. Stockings)
AVERAGE	**33.6%**					**27.6**	**115.8**	**146.1**	**197.9**	**201.4**	**0.948**	

Compiled By:
A. Hutson (University of Dayton Research Institute)
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Apr-08

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value
Note 10: Did not reach 0.06 offset before failure

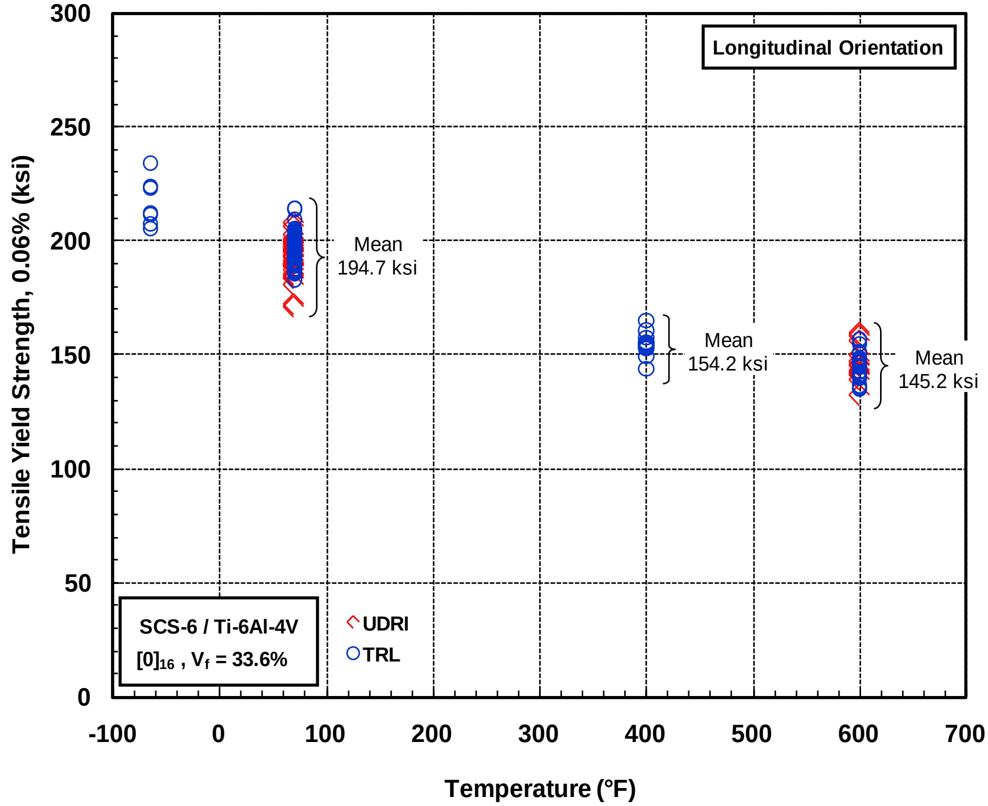

Figure B1. Longitudinal Tensile Yield Strength (0.06%-offset) of $[0]_{16}$ Laminate

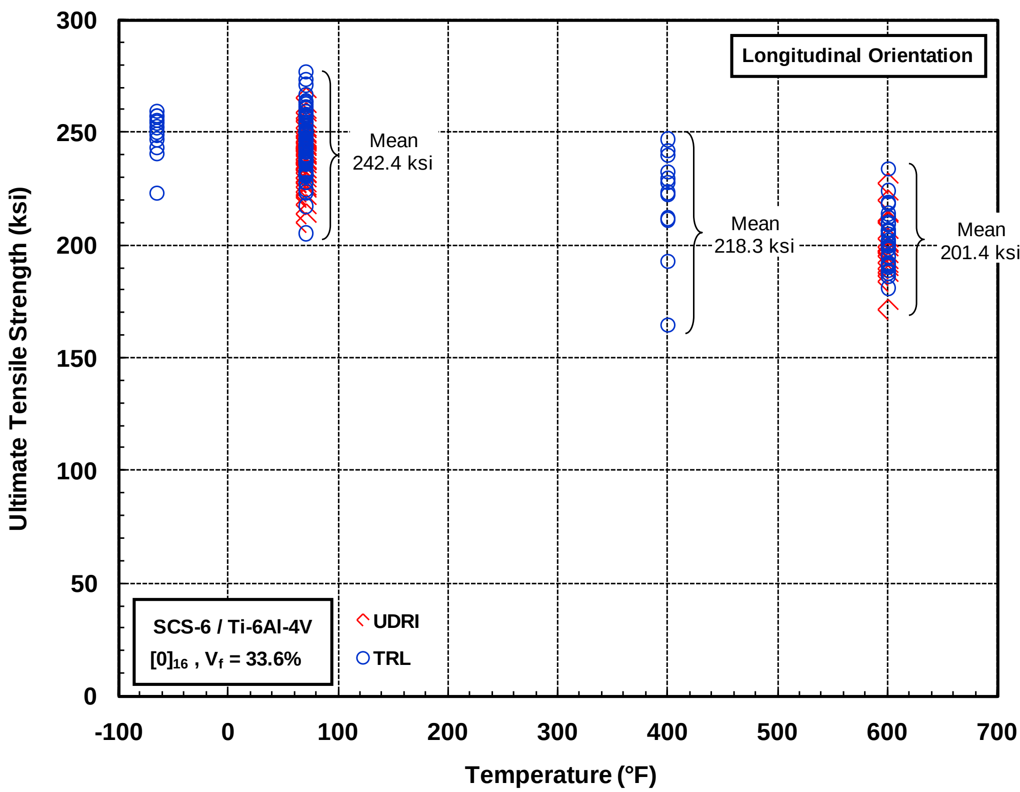

Figure B2. Longitudinal Ultimate Tensile Strength of $[0]_{16}$ Laminate

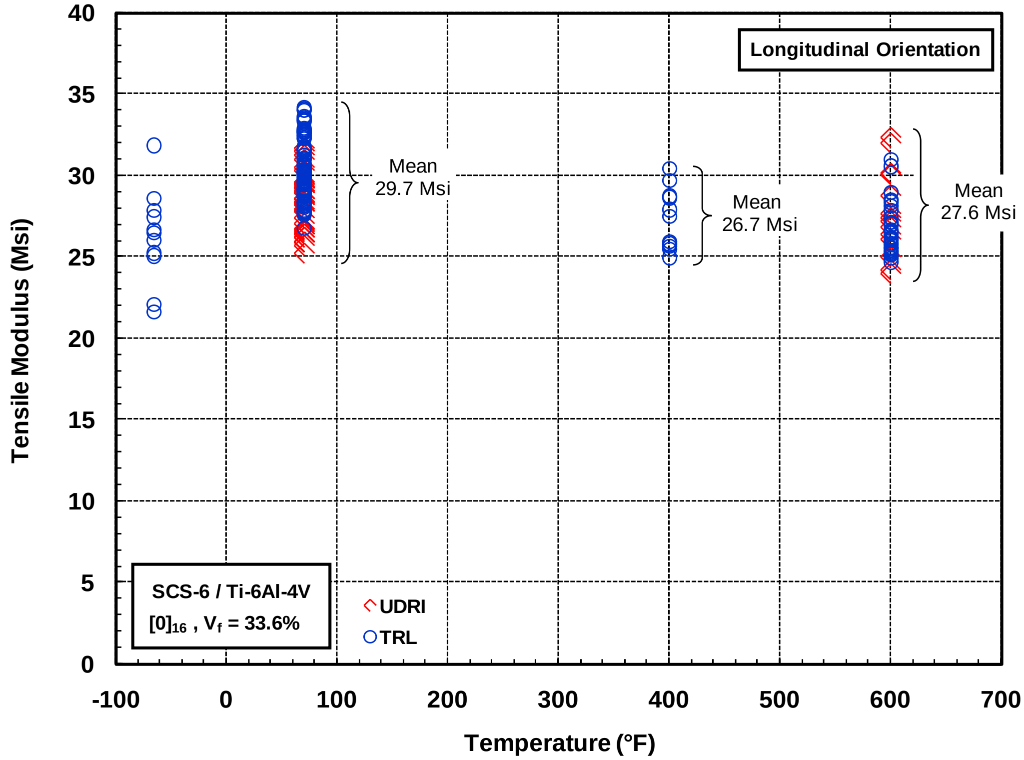

Figure B3. Longitudinal Tensile Modulus of $[0]_{16}$ Laminate

Table B2. Transverse Tension Data of SCS-6/Ti6Al-4V (Table 1 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.136 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.402 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07

SCS-6 / Ti-6Al-4V TRANSVERSE TENSION $[90]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.20% (ksi)	UTS (ksi)	$\square_f$ (%)	Test Facility (Engineer)
B0432004-101-114	32.8%	123-01	70	0.01	strain gage	20.5	28.5	42.2	58.4	65.3	0.762	UDRI (A. Hutson)
B0432004-101-114	33.3%	123-05	70	0.01	extensometer	21.3	37.2	44.8	59.6	61.9	0.542	TRL (B. Stocking)
B0432004-101-117	32.7%	133-04	70	0.01	extensometer	20.4	35.3	43.3	Note 3	56.7	0.475	TRL (B. Stocking)
B0432004-101-117	33.3%	133-08	70	0.01	extensometer	21.6	36.3	44.7	58.8	60.5	0.518	TRL (B. Stocking)
B0432004-101-120	33.3%	143-03	70	0.01	extensometer	22.8	36.2	46.4	Note 10	Note 10	Note 10	TRL (B. Stocking)
B0432004-101-123	32.6%	153-09	70	0.01	extensometer	19.8	35.5	45.1	60.4	64.8	0.621	TRL (B. Stocking)
B0432004-101-125	34.5%	212-05	70	0.01	strain gage	21.4	34.3	42.4	56.4	62.4	0.663	UDRI (A. Hutson)
B0432004-101-126	33.1%	213-04	70	0.01	strain gage	20.4	35.4	44.7	60.0	66.3	0.646	UDRI (A. Hutson)
B0432004-101-138	33.7%	253-10	70	0.01	extensometer	21.4	35.9	44.0	58.6	64.7	0.671	TRL (B. Stocking)
B0432004-101-138	33.7%	253-12	70	0.01	extensometer	21.3	37.7	44.8	59.0	62.8	0.591	TRL (B. Stocking)
B0432004-101-132	33.5%	233-05	70	0.01	extensometer	19.9	36.6	44.5	59.4	65.3	0.709	TRL (B. Stocking)
B0432004-101-134	35.4%	242-09	70	0.01	extensometer	21.1	38.3	47.6	62.3	67.3	0.642	TRL (B. Stocking)
B0432004-101-141	33.1%	313-09	70	0.01	strain gage	21.7	34.0	44.6	59.4	67.4	0.832	UDRI (A. Hutson)
B0432004-101-150	32.6%	343-04	70	0.01	extensometer	22.6	34.0	44.3	58.8	61.8	0.546	TRL (B. Stocking)
B0432004-101-150	33.1%	343-08	70	0.01	extensometer	24.3	36.8	44.9	59.5	61.1	0.487	TRL (B. Stocking)
B0432004-101-152	33.1%	352-07	70	0.01	extensometer	22.5	37.0	46.0	60.7	67.3	0.690	UDRI (A. Hutson)
B0432004-101-153	32.8%	353-06	70	0.01	extensometer	23.0	34.7	46.0	60.5	64.4	0.573	TRL (B. Stocking)
B0432004-101-153	33.4%	353-10	70	0.01	extensometer	22.6	35.2	45.0	59.0	62.4	0.565	TRL (B. Stocking)
B0432004-101-156	34.6%	413-09	70	0.01	strain gage	21.6	34.9	44.8	58.0	64.9	0.736	UDRI (A. Hutson)
B0432004-101-159	34.0%	423-02	70	0.01	extensometer	22.9	33.6	43.6	57.4	60.9	0.574	TRL (B. Stocking)
B0432004-101-165	33.5%	443-03	70	0.01	extensometer	23.3	36.2	46.4	61.5	66.5	0.627	TRL (B. Stocking)
B0432004-101-165	33.8%	443-07	70	0.01	strain gage	19.6	38.8	47.6	63.5	70.2	0.794	UDRI (A. Hutson)
B0432004-101-168	34.3%	453-06	70	0.01	extensometer	23.2	38.0	46.9	62.1	63.1	0.489	TRL (B. Stocking)
B0432004-101-168	33.8%	453-10	70	0.01	extensometer	24.2	38.4	47.1	61.3	62.5	0.491	TRL (B. Stocking)
B0432004-101-170	33.7%	512-08	70	0.01	extensometer	19.3	37.9	46.5	60.5	68.1	0.905	UDRI (A. Hutson)
B0432004-101-173	33.4%	522-04	70	0.01	extensometer	23.5	36.7	46.2	60.6	63.7	0.542	TRL (B. Stocking)
B0432004-101-180	33.1%	543-05	70	0.01	extensometer	20.9	37.7	46.8	61.1	66.7	0.716	TRL (B. Stocking)
B0432004-101-180	33.1%	543-09	70	0.01	extensometer	20.2	41.4	48.6	63.0	68.9	0.687	UDRI (A. Hutson)
B0432004-101-182	33.5%	552-04	70	0.01	extensometer	23.7	38.5	48.6	63.6	69.6	0.710	TRL (B. Stocking)
B0432004-101-183	34.1%	553-07	70	0.01	extensometer	21.0	38.2	47.3	60.4	63.1	0.580	TRL (B. Stocking)
B0432004-101-188	33.3%	622-10	70	0.01	strain gage	19.5	36.1	44.2	57.5	64.1	0.765	UDRI (A. Hutson)
B0432004-101-191	34.0%	632-09	70	0.01	extensometer	21.9	38.1	46.6	59.7	67.8	1.071	TRL (B. Stocking)
B0432004-101-195	33.2%	643-04	70	0.01	extensometer	20.0	35.7	45.2	59.4	65.0	0.697	TRL (B. Stocking)
B0432004-101-195	33.6%	643-08	70	0.01	strain gage	21.0	36.2	45.3	59.5	66.3	0.755	UDRI (A. Hutson)
B0432004-101-198	32.9%	653-08	70	0.01	extensometer	19.4	38.6	44.9	58.5	64.3	0.832	TRL (B. Stocking)

Table B2. Transverse Tension Data of SCS-6/Ti6Al-4V (Table 2 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.136 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.402 inches (average)	**TRANSVERSE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)	**TENSION**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating	**$[90]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07	

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.20% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-198	33.1%	653-11	70	0.01	extensometer	22.5	36.6	45.9	59.2	63.4	0.617	TRL (B. Stocking)
B0432004-101-200	32.7%	712-07	70	0.01	extensometer	18.8	38.4	45.2	59.3	63.6	0.628	UDRI (A. Hutson)
B0432004-101-206	33.2%	732-11	70	0.01	extensometer	19.9	35.1	43.8	55.3	61.3	0.693	TRL (B. Stocking)
B0432004-101-209	33.3%	742-04	70	0.01	extensometer	20.4	35.1	43.4	55.8	58.1	0.550	TRL (B. Stocking)
B0432004-101-210	33.3%	743-04	70	0.01	extensometer	20.2	39.2	46.4	61.2	65.4	0.625	UDRI (A. Hutson)
B0432004-101-213	33.2%	753-05	70	0.01	extensometer	20.4	39.3	45.2	58.8	65.3	0.778	TRL (B. Stocking)
B0432004-101-213	33.6%	753-07	70	0.01	extensometer	20.6	37.5	46.2	Note 3	59.3	0.485	TRL (B. Stocking)
B0432004-101-215	34.5%	812-08	70	0.01	extensometer	20.0	36.0	43.4	54.7	56.4	0.531	UDRI (A. Hutson)
B0432004-101-218	34.2%	822-06	70	0.01	extensometer	20.8	36.6	43.7	56.2	59.7	0.583	TRL (B. Stocking)
B0432004-101-222	34.2%	833-06	70	0.01	extensometer	21.3	35.3	42.7	54.0	55.3	0.496	TRL (B. Stocking)
B0432004-101-225	34.2%	843-04	70	0.01	extensometer	19.1	38.7	45.3	58.4	61.7	0.609	UDRI (A. Hutson)
B0432004-101-227	33.8%	852-05	70	0.01	extensometer	21.3	38.9	47.1	60.4	62.2	0.561	TRL (B. Stocking)
B0432004-101-228	33.0%	853-06	70	0.01	extensometer	22.3	38.4	45.5	59.4	63.6	0.606	TRL (B. Stocking)
AVERAGE	**33.5%**					**21.3**	**36.6**	**45.3**	**59.4**	**63.7**	**0.644**	
B0432004-101-143	34.6%	322-05	400	0.01	extensometer	23.2	23.8	33.6	46.2	52.2	1.640	TRL (B. Stocking)
B0432004-101-143	33.1%	322-09	400	0.01	extensometer	21.9	25.3	33.2	45.7	50.5	1.301	TRL (B. Stocking)
B0432004-101-147	32.8%	333-04	400	0.01	extensometer	20.7	21.2	33.3	46.0	50.9	1.575	TRL (B. Stocking)
B0432004-101-150	32.7%	343-02	400	0.01	extensometer	20.6	25.7	33.6	46.0	51.3	1.352	TRL (B. Stocking)
B0432004-101-153	32.8%	353-05	400	0.01	extensometer	20.7	23.1	33.8	47.0	52.6	1.747	TRL (B. Stocking)
B0432004-101-153	33.7%	353-09	400	0.01	extensometer	20.2	25.9	34.6	46.6	51.8	1.577	TRL (B. Stocking)
B0432004-101-206	33.3%	732-09	400	0.01	extensometer	19.2	26.0	32.8	44.9	50.1	1.579	TRL (B. Stocking)
B0432004-101-206	33.1%	732-12	400	0.01	extensometer	19.5	26.7	35.1	47.3	52.4	1.149	TRL (B. Stocking)
B0432004-101-207	32.3%	733-07	400	0.01	extensometer	18.3	25.4	32.4	44.8	49.8	1.797	TRL (B. Stocking)
B0432004-101-210	33.3%	743-08	400	0.01	extensometer	19.5	27.0	34.7	47.5	53.0	1.587	TRL (B. Stocking)
B0432004-101-212	33.2%	752-07	400	0.01	extensometer	19.6	26.4	33.1	45.0	51.3	1.275	TRL (B. Stocking)
B0432004-101-213	33.0%	753-04	400	0.01	extensometer	18.8	26.7	34.2	45.9	51.8	1.404	TRL (B. Stocking)
AVERAGE	**33.2%**					**20.2**	**25.3**	**33.7**	**46.1**	**51.5**	**1.499**	
B0432004-101-117	33.4%	133-05	600	0.01	extensometer	18.7	19.7	27.2	39.1	45.3	1.713	TRL (B. Stocking)
B0432004-101-117	33.1%	133-09	600	0.01	strain gage	21.0	20.3	28.8	40.4	47.5	0.649	UDRI (A. Hutson)
B0432004-101-120	33.4%	143-04	600	0.01	extensometer	18.7	19.7	26.7	39.1	44.9	1.450	TRL (B. Stocking)
B0432004-101-120	33.2%	143-08	600	0.01	extensometer	18.7	17.7	25.9	38.2	43.5	1.142	TRL (B. Stocking)
B0432004-101-123	33.1%	153-02	600	0.01	strain gage	24.7	19.7	30.0	41.7	46.5	0.757	UDRI (A. Hutson)
B0432004-101-123	32.8%	153-07	600	0.01	extensometer	17.4	20.1	27.8	40.2	47.4	1.993	TRL (B. Stocking)
B0432004-101-126	33.4%	213-05	600	0.01	extensometer	16.9	22.1	27.1	38.1	44.1	1.739	TRL (B. Stocking)
B0432004-101-132	33.7%	233-06	600	0.01	strain gage	20.7	20.9	29.6	40.8	44.9	0.973	UDRI (A. Hutson)

Table B2. Transverse Tension Data of SCS-6/Ti6Al-4V (Table 3 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.136 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.402 inches (average)	**TRANSVERSE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)	**TENSION**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating	**$[90]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07	

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.20% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-132	33.6%	233-10	600	0.01	extensometer	16.8	19.6	26.0	37.2	45.0	1.997	TRL (B. Stocking)
B0432004-101-134	33.8%	242-04	600	0.01	extensometer	17.0	22.2	28.8	41.3	48.1	1.982	TRL (B. Stocking)
B0432004-101-136	33.4%	251-04	600	0.01	strain gage	20.8	19.7	28.7	40.8	45.7	0.900	UDRI (A. Hutson)
B0432004-101-136	33.5%	251-10	600	0.01	extensometer	18.0	18.5	26.5	38.0	43.2	1.083	TRL (B. Stocking)
B0432004-101-141	32.8%	313-06	600	0.01	extensometer	20.3	19.3	28.7	40.3	46.1	2.005	TRL (B. Stocking)
B0432004-101-143	33.6%	322-07	600	0.01	strain gage	20.8	20.1	28.8	40.5	47.7	Note 4	UDRI (A. Hutson)
B0432004-101-146	33.2%	332-06	600	0.01	extensometer	19.6	22.1	28.6	39.9	43.5	1.238	TRL (B. Stocking)
B0432004-101-149	32.9%	342-11	600	0.01	extensometer	19.4	17.8	25.1	36.6	42.7	1.966	TRL (B. Stocking)
B0432004-101-150	33.1%	343-05	600	0.01	strain gage	20.4	20.5	28.2	39.4	44.9	0.915	UDRI (A. Hutson)
B0432004-101-153	32.9%	353-07	600	0.01	extensometer	21.7	19.8	29.5	41.7	46.3	1.602	TRL (B. Stocking)
B0432004-101-156	34.0%	413-07	600	0.01	extensometer	19.1	23.3	29.5	40.8	46.1	1.746	TRL (B. Stocking)
B0432004-101-162	33.2%	433-06	600	0.01	extensometer	18.5	20.8	26.4	37.2	44.6	1.887	UDRI (A. Hutson)
B0432004-101-165	33.9%	443-04	600	0.01	extensometer	21.0	23.4	30.5	41.8	45.6	1.081	TRL (B. Stocking)
B0432004-101-165	33.4%	443-08	600	0.01	extensometer	21.0	19.0	27.5	40.1	44.8	1.565	TRL (B. Stocking)
B0432004-101-168	33.9%	453-07	600	0.01	strain gage	13.1	23.5	30.0	Note 4	46.2	Note 4	UDRI (A. Hutson)
B0432004-101-168	33.7%	453-11	600	0.01	extensometer	22.6	18.5	29.4	41.0	45.8	1.673	TRL (B. Stocking)
B0432004-101-170	33.1%	512-10	600	0.01	extensometer	20.1	20.4	30.1	41.6	46.6	1.767	TRL (B. Stocking)
B0432004-101-176	33.7%	532-10	600	0.01	extensometer	17.2	19.8	27.5	38.8	44.7	1.404	UDRI (A. Hutson)
B0432004-101-180	33.1%	543-02	600	0.01	extensometer	18.2	18.6	28.2	39.2	45.4	1.484	TRL (B. Stocking)
B0432004-101-182	33.5%	552-05	600	0.01	extensometer	18.5	22.3	30.7	41.9	48.1	1.574	TRL (B. Stocking)
B0432004-101-183	34.2%	553-04	600	0.01	extensometer	19.2	22.6	29.6	39.8	45.2	1.515	UDRI (A. Hutson)
B0432004-101-183	34.1%	553-08	600	0.01	extensometer	18.6	22.5	29.6	40.8	43.8	0.810	TRL (B. Stocking)
B0432004-101-185	33.1%	612-09	600	0.01	extensometer	17.0	21.4	28.1	37.8	42.2	1.481	TRL (B. Stocking)
B0432004-101-189	34.0%	623-08	600	0.01	extensometer	14.5	17.4	21.9	30.4	44.0	1.844	UDRI (A. Hutson)
B0432004-101-192	33.6%	633-02	600	0.01	extensometer	17.7	22.6	28.0	38.9	44.4	1.710	TRL (B. Stocking)
B0432004-101-195	33.8%	643-05	600	0.01	extensometer	20.0	19.8	28.1	39.9	45.3	2.058	TRL (B. Stocking)
B0432004-101-198	33.6%	653-05	600	0.01	extensometer	18.4	21.8	28.3	38.8	43.5	1.599	UDRI (A. Hutson)
B0432004-101-198	33.3%	653-09	600	0.01	extensometer	18.1	22.1	28.0	38.7	48.5	1.836	TRL (B. Stocking)
B0432004-101-200	33.1%	712-05	600	0.01	extensometer	19.3	18.4	23.0	38.3	44.9	1.701	TRL (B. Stocking)
B0432004-101-204	33.4%	723-08	600	0.01	extensometer	18.0	20.7	27.0	37.3	41.5	1.101	UDRI (A. Hutson)
B0432004-101-206	33.3%	732-10	600	0.01	extensometer	18.2	22.2	27.2	38.3	44.2	1.676	TRL (B. Stocking)
B0432004-101-209	33.6%	742-09	600	0.01	extensometer	16.9	22.1	28.2	39.2	45.6	1.909	TRL (B. Stocking)
B0432004-101-210	33.0%	743-06	600	0.01	extensometer	17.9	17.1	24.8	36.5	42.8	1.567	UDRI (A. Hutson)
B0432004-101-212	33.0%	752-10	600	0.01	extensometer	17.4	20.5	27.0	39.0	44.8	1.422	TRL (B. Stocking)
B0432004-101-218	34.3%	822-07	600	0.01	extensometer	18.6	22.8	28.1	39.0	45.0	1.859	TRL (B. Stocking)

Table B2. Transverse Tension Data of SCS-6/Ti6Al-4V (Table 4 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Dogbone Shape
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.136 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.402 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3553-96 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 06 - Apr 07

SCS-6 / Ti-6Al-4V TRANSVERSE TENSION $[90]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Strain rate (1/s)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.20% (ksi)	UTS (ksi)	ε_f (%)	Test Facility (Engineer)
B0432004-101-219	33.1%	823-07	600	0.01	extensometer	17.2	18.2	25.1	35.8	41.6	1.340	UDRI (A. Hutson)
B0432004-101-222	35.7%	833-08	600	0.01	extensometer	18.1	22.2	27.9	38.3	43.7	1.909	TRL (B. Stocking)
B0432004-101-225	34.3%	843-07	600	0.01	extensometer	17.3	23.1	28.2	39.0	45.6	1.873	TRL (B. Stocking)
B0432004-101-228	33.3%	853-03	600	0.01	extensometer	18.3	20.3	29.3	41.6	46.6	1.364	UDRI (A. Hutson)
B0432004-101-228	33.6%	853-05	600	0.01	extensometer	16.7	21.6	28.8	40.0	46.7	2.268	TRL (B. Stocking)
AVERAGE	**33.5%**					**18.7**	**19.7**	**27.9**	**39.2**	**45.1**	**1.546**	

Compiled By:
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
Apr-08

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value
Note 10: Tabs debonded and specimen slipped prior to fracture

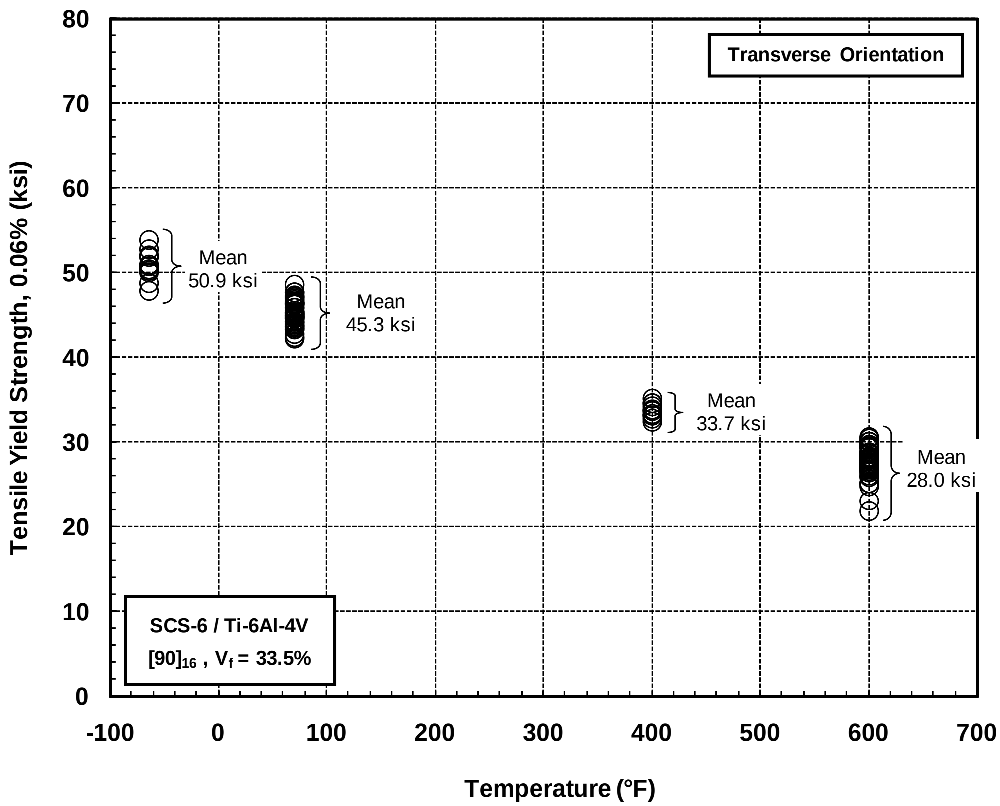

Figure B4. Transverse 0.06%-Offset Tensile Yield Strength of $[90]_{16}$ Laminate

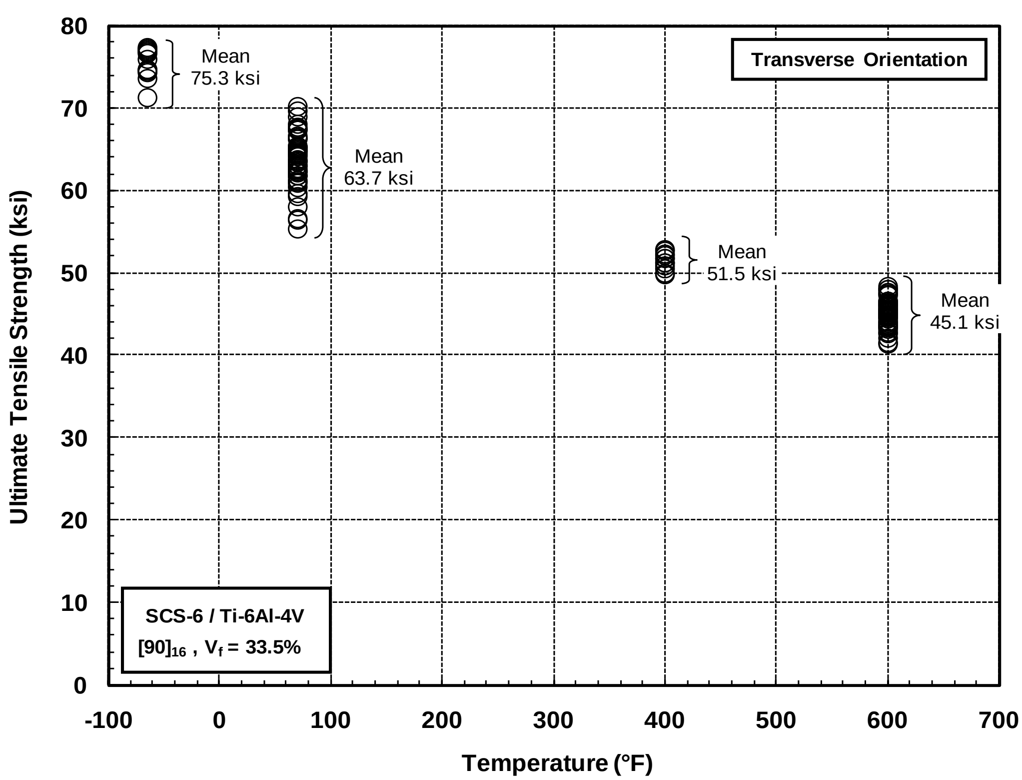

Figure B5. Transverse Ultimate Tensile Strength of $[90]_{16}$ Laminate

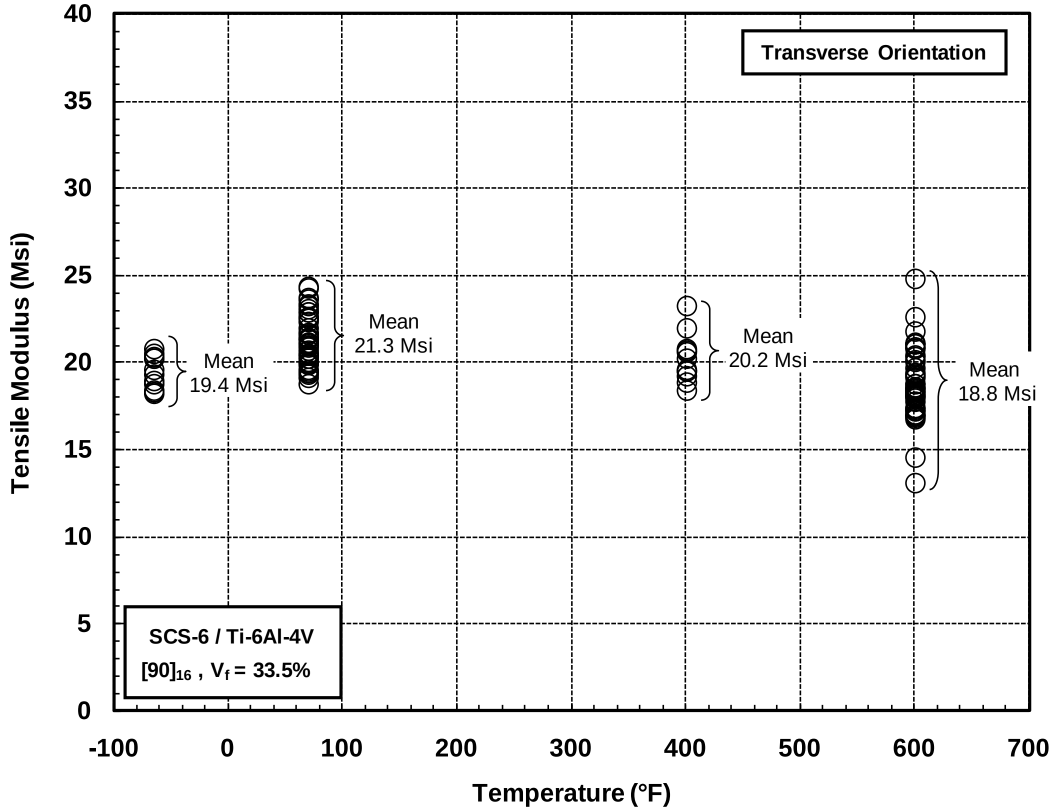

Figure B6. Transverse Tensile Modulus of $[90]_{16}$ Laminate

APPENDIX C
INDIVIDUAL COMPRESSION TEST RESULTS

Table C1. Longitudinal Compression Data of SCS-6/Ti6Al-4V (Table 1 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Straight Sided
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.499 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3410-03 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Mar 08

SCS-6 / Ti-6Al-4V LONGITUDINAL COMPRESSION $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UCS (ksi)	ε_f (%)	Test Facility
B0432004-101-124	34.0%	211-02	-65	0.05	strain gage	31.4	408.7	418.4	500.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-124	34.2%	211-07	-65	0.05	strain gage	30.2	414.3	441.3	Note 4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-135	33.2%	243-03	-65	0.05	strain gage	30.3	447.9	450.4	546.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-135	33.3%	243-08	-65	0.05	strain gage	30.3	419.8	432.9	530.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-130	33.3%	231-09	-65	0.05	strain gage	31.9	480.2	484.1	595.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-199	32.7%	711-06	-65	0.05	strain gage	29.7	477.1	479.8	540.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-199	32.8%	711-10	-65	0.05	strain gage	30.0	454.8	457.3	Note 4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-202	33.2%	721-06	-65	0.05	strain gage	30.4	409.4	425.3	516.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-202	33.1%	721-10	-65	0.05	strain gage	30.6	420.4	432.4	523.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-208	33.6%	741-07	-65	0.05	strain gage	32.1	418.9	427.2	513.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-208	32.9%	741-11	-65	0.05	strain gage	29.7	440.1	442.8	524.5	Note 11	Note 11	TRL (B. Stockings)
AVERAGE	**33.3%**					**30.6**	**435.6**	**444.7**	**532.2**			
B0432004-101-109	33.6%	111-03	70	0.05	strain gage	30.5	360.1	392.0	494.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-109	33.7%	111-07	70	0.05	strain gage	32.2	456.3	457.6	596.8	697.4	2.303	UDRI (A. Hutson)
B0432004-101-112	33.8%	121-08	70	0.05	strain gage	30.6	437.2	442.0	Note 9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-112	33.8%	121-11	70	0.05	strain gage	31.4	424.4	435.1	554.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-115	33.8%	131-09	70	0.05	strain gage	32.8	395.6	420.9	559.9	693.1	2.329	UDRI (A. Hutson)
B0432004-101-115	33.8%	131-13	70	0.05	strain gage	30.4	420.7	423.5	534.1	701.2	2.790	TRL (B. Stockings)
B0432004-101-119	32.7%	142-09	70	0.05	strain gage	30.3	361.3	383.5	482.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-121	33.3%	151-09	70	0.05	strain gage	29.8	360.5	383.2	473.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-124	34.3%	211-08	70	0.05	strain gage	29.7	360.7	373.9	464.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-124	34.3%	211-12	70	0.05	strain gage	30.3	373.8	391.6	492.8	747.6	Note 9	UDRI (A. Hutson)
B0432004-101-135	33.6%	243-09	70	0.05	strain gage	30.3	352.1	381.0	475.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-135	33.6%	243-13	70	0.05	strain gage	31.5	362.9	399.6	504.6	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-130	34.1%	231-01	70	0.05	strain gage	31.7	391.2	426.6	Note 9	685.1	Note 9	UDRI (A. Hutson)
B0432004-101-130	33.0%	231-04	70	0.05	strain gage	32.8	379.5	400.8	503.1	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-130	33.1%	231-05	70	0.05	strain gage	29.1	361.5	374.7	463.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-133	33.6%	241-11	70	0.05	strain gage	28.7	425.7	426.2	529.9	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-139	34.3%	311-02	70	0.05	strain gage	30.8	363.8	393.6	489.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-139	34.1%	311-03	70	0.05	strain gage	31.5	363.0	395.8	497.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-139	33.6%	311-07	70	0.05	strain gage	29.1	472.5	490.3	567.3	734.4	Note 9	UDRI (A. Hutson)
B0432004-101-142	33.8%	321-08	70	0.05	strain gage	31.2	363.0	396.8	496.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-142	33.6%	321-12	70	0.05	strain gage	31.1	422.2	425.1	533.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-148	34.0%	341-08	70	0.05	strain gage	31.9	384.1	398.2	503.1	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-149	34.3%	342-03	70	0.05	strain gage	35.0	367.2	411.0	534.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-154	32.8%	411-03	70	0.05	strain gage	29.8	387.8	390.4	482.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-157	32.3%	421-04	70	0.05	strain gage	30.6	394.6	401.4	Note 9	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-157	32.8%	421-08	70	0.05	strain gage	30.8	363.1	386.8	482.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-160	33.6%	431-05	70	0.05	strain gage	28.9	362.7	373.3	459.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-163	33.8%	441-06	70	0.05	strain gage	31.6	396.5	409.1	519.3	Note 11	Note 11	UDRI (A. Hutson)

Table C1. Longitudinal Compression Data of SCS-6/Ti6Al-4V (Table 2 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Straight Sided
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.499 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3410-03 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Mar 08

SCS-6 / Ti-6Al-4V LONGITUDINAL COMPRESSION $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UCS (ksi)	ε_f (%)	Test Facility
B0432004-101-163	33.6%	441-10	70	0.05	strain gage	30.4	Note 9	Note 9	478.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-166	34.2%	451-01	70	0.05	strain gage	28.0	430.9	461.5	514.1	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-166	33.7%	451-05	70	0.05	strain gage	29.1	364.9	370.9	456.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-166	33.6%	451-09	70	0.05	strain gage	30.3	Note 4	Note 4	Note 4	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-169	33.1%	511-07	70	0.05	strain gage	28.6	363.9	377.1	465.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-169	33.2%	511-11	70	0.05	strain gage	28.1	356.4	380.3	502.0	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-171	33.1%	513-08	70	0.05	strain gage	28.9	366.9	373.4	458.6	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-171	33.3%	513-12	70	0.05	strain gage	33.2	Note 9	Note 9	Note 9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-172	33.3%	521-09	70	0.05	strain gage	27.7	417.0	418.1	507.0	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-175	32.8%	531-11	70	0.05	strain gage	29.3	Note 9	Note 9	Note 9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-178	35.2%	541-02	70	0.05	strain gage	30.3	387.5	391.5	484.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-178	33.5%	541-05	70	0.05	strain gage	29.7	365.3	379.0	472.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-181	34.1%	551-01	70	0.05	strain gage	30.0	338.5	Note 10	Note 3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-181	33.9%	551-03	70	0.05	strain gage	30.9	337.0	368.9	458.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-181	33.6%	551-13	70	0.05	strain gage	29.4	361.5	373.0	460.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-184	32.4%	611-01	70	0.05	strain gage	29.8	313.8	354.1	442.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-184	33.6%	611-13	70	0.05	strain gage	29.1	360.0	371.7	461.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-186	33.2%	613-02	70	0.05	strain gage	27.6	392.1	393.2	484.8	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-187	33.1%	621-03	70	0.05	strain gage	29.0	319.4	349.3	433.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-187	33.3%	621-07	70	0.05	strain gage	29.2	321.7	351.5	437.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-190	32.7%	631-04	70	0.05	strain gage	26.6	370.9	371.9	456.3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-196	33.1%	651-05	70	0.05	strain gage	28.6	356.3	369.6	Note 9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-196	33.7%	651-08	70	0.05	strain gage	28.3	373.9	376.4	466.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-201	33.3%	713-06	70	0.05	strain gage	29.3	328.7	356.7	Note 9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-201	33.3%	713-10	70	0.05	strain gage	28.2	359.2	378.2	470.3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-203	34.3%	722-02	70	0.05	strain gage	28.8	386.0	387.4	457.6	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-203	33.9%	722-09	70	0.05	strain gage	30.7	350.0	372.9	459.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-203	33.1%	722-11	70	0.05	strain gage	29.1	357.3	370.6	Note 9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-205	32.9%	731-06	70	0.05	strain gage	28.3	354.4	375.3	463.9	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-205	33.1%	731-10	70	0.05	strain gage	29.0	381.0	383.7	475.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-209	34.4%	742-01	70	0.05	strain gage	30.5	360.4	383.8	477.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-211	33.8%	751-03	70	0.05	strain gage	29.7	362.3	376.7	467.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-211	32.7%	751-10	70	0.05	strain gage	29.6	330.8	359.4	447.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-212	33.7%	752-01	70	0.05	strain gage	28.9	370.7	382.0	476.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-214	33.3%	811-07	70	0.05	strain gage	30.3	343.4	Note 9	461.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-217	33.5%	821-08	70	0.05	strain gage	28.6	360.9	379.9	476.6	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-217	33.6%	821-12	70	0.05	strain gage	29.9	339.3	367.7	455.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-220	33.3%	831-10	70	0.05	strain gage	28.9	363.4	370.2	458.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-220	33.7%	831-13	70	0.05	strain gage	30.1	344.2	374.1	466.6	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-223	33.7%	841-11	70	0.05	strain gage	28.5	360.2	377.6	469.0	Note 11	Note 11	UDRI (A. Hutson)

Table C1. Longitudinal Compression Data of SCS-6/Ti6Al-4V (Table 3 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Straight Sided
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.499 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3410-03 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Mar 08

SCS-6 / Ti-6Al-4V LONGITUDINAL COMPRESSION $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UCS (ksi)	ε_f (%)	Test Facility
B0432004-101-226	33.1%	851-01	70	0.05	strain gage	29.7	370.3	387.5	Note 9	Note 11	Note 11	TRL (B. Stockings)
AVERAGE	**33.5%**					**29.9**	**372.1**	**390.5**	**484.8**			
B0432004-101-199	33.7%	711-01	400	0.05	strain gage	29.8	202.3	239.4	309.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-199	32.7%	711-05	400	0.05	strain gage	29.1	209.1	236.6	293.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-202	33.4%	721-02	400	0.05	strain gage	27.4	203.1	232.7	285.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-202	33.3%	721-07	400	0.05	strain gage	27.7	204.5	233.3	287.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-208	33.1%	741-05	400	0.05	strain gage	29.5	200.3	236.8	290.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-208	33.1%	741-09	400	0.05	strain gage	28.3	206.3	239.0	296.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-216	33.1%	813-05	400	0.05	strain gage	28.3	212.9	236.9	290.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-216	33.3%	813-10	400	0.05	strain gage	28.7	202.8	237.2	289.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-218	33.6%	822-11	400	0.05	strain gage	28.9	202.9	237.4	293.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-221	34.3%	832-03	400	0.05	strain gage	28.9	181.9	234.5	Note 4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-221	34.3%	832-04	400	0.05	strain gage	28.6	191.1	237.5	Note 4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-223	34.3%	841-06	400	0.05	strain gage	28.9	213.1	243.9	299.0	Note 11	Note 11	TRL (B. Stockings)
AVERAGE	**33.5%**					**28.7**	**202.5**	**237.1**	**293.5**			
B0432004-101-109	33.4%	111-09	600	0.05	strain gage	29.9	206.2	230.0	322.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-109	33.7%	111-13	600	0.05	strain gage	30.3	224.1	287.3	395.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-112	34.2%	121-05	600	0.05	strain gage	32.4	132.0	218.5	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-112	33.8%	121-09	600	0.05	strain gage	31.2	202.5	233.5	308.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-115	33.5%	131-06	600	0.05	strain gage	30.2	202.9	234.7	301.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-115	33.9%	131-10	600	0.05	strain gage	33.0	173.1	241.0	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-124	34.3%	211-10	600	0.05	strain gage	28.0	216.3	257.5	313.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-124	34.1%	211-13	600	0.05	strain gage	28.4	202.2	218.3	278.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-135	33.7%	243-01	600	0.05	strain gage	31.8	158.4	219.3	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-135	33.3%	243-10	600	0.05	strain gage	28.8	201.4	219.9	281.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-130	33.9%	231-02	600	0.05	strain gage	29.9	202.4	225.6	295.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-130	32.9%	231-06	600	0.05	strain gage	31.9	194.2	233.9	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-131	33.6%	232-12	600	0.05	strain gage	32.4	178.8	210.1	285.2	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-133	33.6%	241-13	600	0.05	strain gage	33.2	176.6	224.4	327.7	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-139	33.7%	311-04	600	0.05	strain gage	31.2	202.9	228.8	295.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-139	33.7%	311-08	600	0.05	strain gage	27.9	200.6	214.4	276.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-139	32.7%	311-12	600	0.05	strain gage	31.2	191.4	211.4	302.5	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-140	34.0%	312-10	600	0.05	strain gage	31.6	184.5	227.2	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-142	33.7%	321-02	600	0.05	strain gage	33.3	195.5	228.6	326.6	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-142	33.2%	321-04	600	0.05	strain gage	30.0	201.7	226.9	293.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-142	33.4%	321-05	600	0.05	strain gage	29.5	191.5	222.4	290.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-142	33.6%	321-09	600	0.05	strain gage	29.3	202.2	224.5	286.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-151	34.4%	351-04	600	0.05	strain gage	31.6	167.1	229.0	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-154	32.8%	411-06	600	0.05	strain gage	29.0	203.4	221.2	285.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-157	32.4%	421-05	600	0.05	strain gage	31.0	201.7	227.4	318.8	Note 11	Note 11	TRL (B. Stockings)

Table C1. Longitudinal Compression Data of SCS-6/Ti6Al-4V (Table 4 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Straight Sided
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.499 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3410-03 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Mar 08

SCS-6 / Ti-6Al-4V LONGITUDINAL COMPRESSION $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Stroke rate (in/min)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UCS (ksi)	ε_f (%)	Test Facility
B0432004-101-157	32.8%	421-09	600	0.05	strain gage	30.1	230.1	237.7	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-160	33.1%	431-07	600	0.05	strain gage	29.5	178.5	208.5	265.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-163	33.6%	441-07	600	0.05	strain gage	29.8	202.7	225.0	292.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-163	33.8%	441-11	600	0.05	strain gage	30.6	171.2	220.3	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-166	33.1%	451-06	600	0.05	strain gage	31.6	199.3	210.4	362.9	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-166	33.4%	451-13	600	0.05	strain gage	32.7	182.2	219.7	322.2	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-169	34.0%	511-04	600	0.05	strain gage	29.1	183.4	215.7	276.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-169	33.5%	511-08	600	0.05	strain gage	27.8	188.4	212.0	271.6	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-171	33.3%	513-05	600	0.05	strain gage	29.6	177.7	214.5	302.6	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-171	33.0%	513-09	600	0.05	strain gage	29.4	212.7	214.9	256.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-172	33.3%	521-11	600	0.05	strain gage	30.1	178.3	217.6	277.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-175	33.4%	531-03	600	0.05	strain gage	30.9	190.3	218.9	Note 3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-181	33.2%	551-06	600	0.05	strain gage	Note 4	Note 4	Note 4	Note 4	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-184	33.0%	611-04	600	0.05	strain gage	28.3	179.6	209.6	266.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-186	32.7%	613-06	600	0.05	strain gage	28.2	170.1	201.9	256.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-190	32.8%	631-03	600	0.05	strain gage	28.9	193.0	208.5	277.8	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-190	33.4%	631-07	600	0.05	strain gage	28.7	176.4	196.5	260.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-193	33.5%	641-06	600	0.05	strain gage	27.7	175.1	201.5	258.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-196	33.8%	651-04	600	0.05	strain gage	28.4	200.5	216.7	273.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-196	33.1%	651-09	600	0.05	strain gage	28.8	170.8	202.3	272.5	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-201	33.2%	713-04	600	0.05	strain gage	28.2	182.7	208.8	264.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-201	33.6%	713-08	600	0.05	strain gage	28.3	179.4	208.2	265.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-203	32.9%	722-10	600	0.05	strain gage	29.5	199.8	217.3	291.9	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-205	34.5%	731-01	600	0.05	strain gage	29.3	167.2	206.5	268.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-205	32.5%	731-07	600	0.05	strain gage	27.6	210.2	223.4	305.8	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-211	33.2%	751-06	600	0.05	strain gage	28.8	201.1	215.6	276.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-214	34.5%	811-02	600	0.05	strain gage	30.6	201.6	229.7	300.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-214	33.7%	811-06	600	0.05	strain gage	27.5	245.4	249.3	303.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-217	33.4%	821-03	600	0.05	strain gage	29.9	194.5	219.1	296.7	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-217	33.6%	821-07	600	0.05	strain gage	28.1	210.2	221.9	286.9	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-220	33.1%	831-05	600	0.05	strain gage	28.1	190.2	211.6	268.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-226	33.4%	851-08	600	0.05	strain gage	29.7	189.8	215.0	285.9	Note 11	Note 11	UDRI (A. Hutson)
AVERAGE	**33.5%**					**29.9**	**191.9**	**221.3**	**291.4**			

Compiled By:	Note 1: Stress-strain behavior was linear to termination of test
A. Hutson (University of Dayton Research Institute)	Note 2: Did not reach 0.02 offset before failure
J. Kleek (Air Force Research Laboratory)	Note 3: Did not reach 0.2 offset before failure
Apr-08	Note 4: Value not reported, anomalies in digital stress-strain data
	Note 5: No stress-strain digital data available
	Note 6: Specimen broke outside gage length; value for max strain at failure is measured
TRL = Touchstone Research Laboratory	Note 7: Value not reported, extensometer slipped near end of test
UDRI = University of Dayton Research Institute	Note 8: Proportional limit was manually determined
	Note 9: Insufficient number of data points to calculate value
	Note 10: Did not reach 0.06 offset before failure
	Note 11: Test stopped prior to fracture

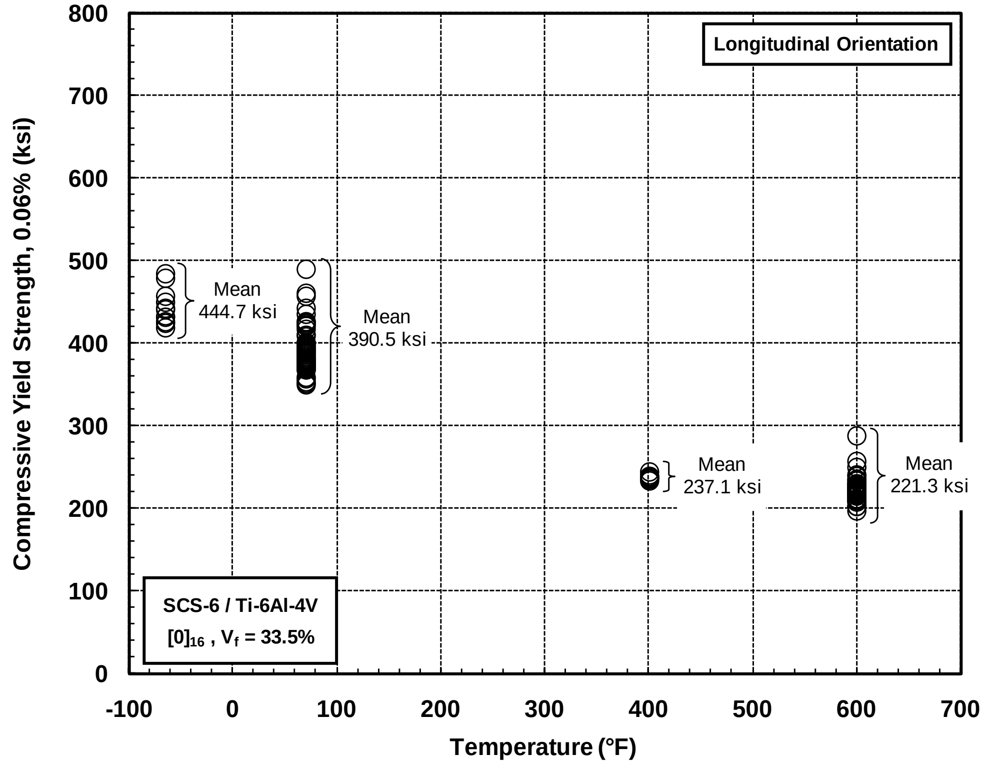

Figure C1. Longitudinal Compressive Yield Strength (0.06%-offset) of $[0]_{16}$ Laminate

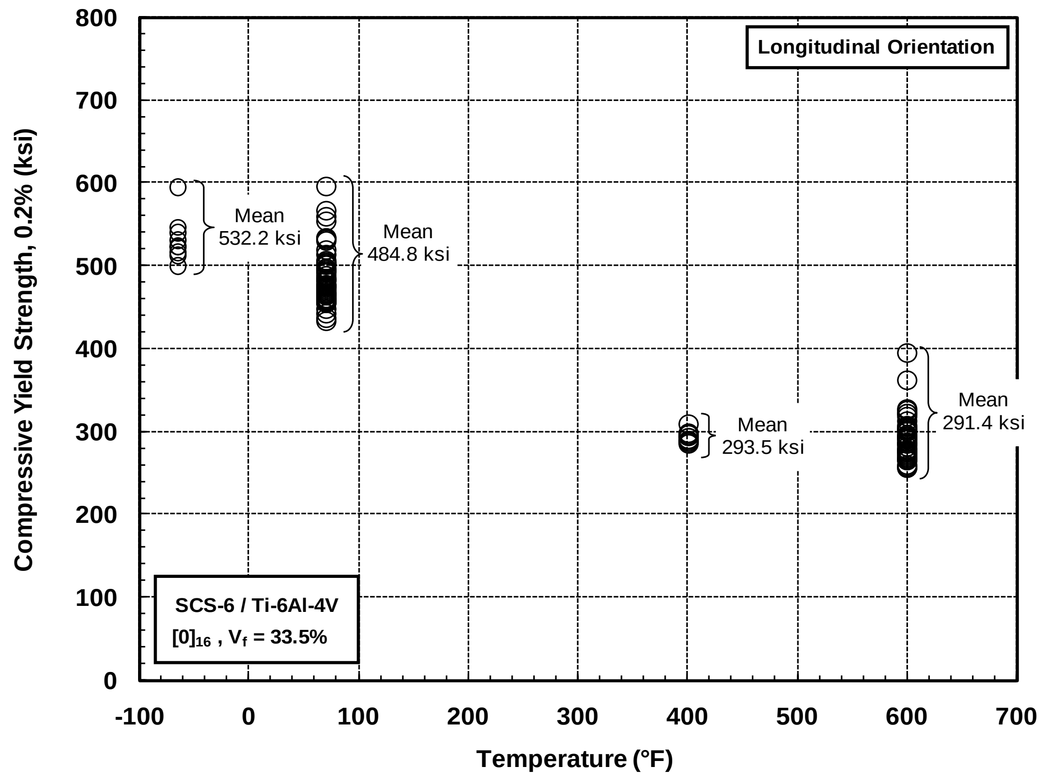

Figure C2. Longitudinal Compressive Yield Strength (0.2%-offset) of $[0]_{16}$ Laminate

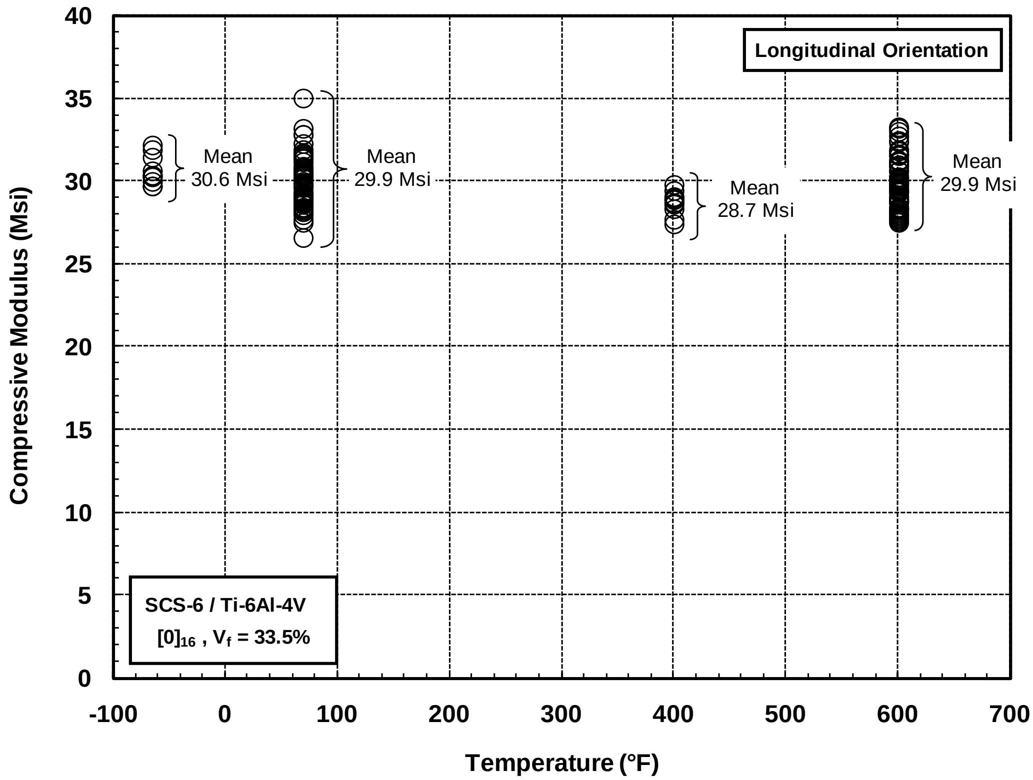

Figure C3. Longitudinal Compressive Modulus of $[0]_{16}$ Laminate

Table C2. Transverse Compression Data of SCS-6/Ti6Al-4V (Table 1 of 2)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Straight Sided
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.500 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3410-03 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Feb 07 - Jan 09

SCS-6 / Ti-6Al-4V TRANSVERSE COMPRESSION $[90]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Stroke rate (in/min)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UCS (ksi)	ε_1 (%)	Test Facility
B0432004-101-111		113-01	-65	0.05	strain gage	21.8	135.7	166.7	194.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-111		113-02	-65	0.05	strain gage	22.0	135.6	166.4	194.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-111		113-03	-65	0.05	strain gage	21.7	145.8	165.5	189.2	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-122		152-04	-65	0.05	strain gage	21.6	135.5	166.7	193.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-122		152-05	-65	0.05	strain gage	21.3	148.4	168.6	193.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-122		152-06	-65	0.05	strain gage	21.3	126.1	158.2	184.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-204		723-04	-65	0.05	strain gage	21.1	133.0	162.1	190.0	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-204		723-05	-65	0.05	strain gage	21.2	149.2	168.8	193.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-207		733-03	-65	0.05	strain gage	21.3	152.8	172.4	197.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-210		743-03	-65	0.05	strain gage	21.5	134.6	163.5	189.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-210		743-07	-65	0.05	strain gage	21.8	135.4	166.3	192.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-213		753-03	-65	0.05	strain gage	21.4	134.5	161.9	188.8	Note 11	Note 11	TRL (B. Stockings)
						21.5	**138.9**	**165.6**	**191.7**			
B0432004-101-126	33.5%	213-06	70	0.05	strain gage	20.1	110.8	141.3	165.2	182.3	2.649	TRL (B. Stockings)
B0432004-101-126	33.2%	213-07	70	0.05	strain gage	20.3	113.3	141.7	164.5	187.4	4.342	UDRI (A. Hutson)
B0432004-101-131	33.4%	232-03	70	0.05	strain gage	20.2	108.1	138.0	158.4	180.8	2.701	TRL (B. Stockings)
B0432004-101-134	33.1%	242-01	70	0.05	strain gage	20.6	112.0	147.1	169.3	192.8	Note 4	TRL (B. Stockings)
B0432004-101-134	33.2%	242-02	70	0.05	strain gage	21.7	120.3	150.1	174.2	199.3	4.704	UDRI (A. Hutson)
B0432004-101-137	33.5%	252-05	70	0.05	strain gage	20.7	108.5	139.1	160.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-141	33.2%	313-03	70	0.05	strain gage	20.4	109.0	139.1	164.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-141	32.8%	313-05	70	0.05	strain gage	20.6	112.2	141.2	164.6	186.1	4.387	UDRI (A. Hutson)
B0432004-101-144	33.3%	323-03	70	0.05	strain gage	20.7	110.1	141.0	164.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-147	33.0%	333-02	70	0.05	strain gage	20.4	122.2	143.4	160.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-147	33.0%	333-03	70	0.05	strain gage	20.9	112.6	141.9	162.7	190.3	5.040	UDRI (A. Hutson)
B0432004-101-152	33.6%	352-05	70	0.05	strain gage	21.3	113.5	144.4	167.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-156	34.2%	413-03	70	0.05	strain gage	23.2	111.3	138.0	157.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-156	34.3%	413-04	70	0.05	strain gage	20.1	135.4	149.7	170.2	192.7	4.774	UDRI (A. Hutson)
B0432004-101-159	33.0%	423-05	70	0.05	strain gage	24.3	108.5	143.3	163.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-159	33.0%	423-07	70	0.05	strain gage	24.1	107.1	142.1	165.6	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-162	33.6%	433-01	70	0.05	strain gage	20.0	97.2	162.7	177.6	194.3	2.593	UDRI (A. Hutson)
B0432004-101-162	33.8%	433-02	70	0.05	strain gage	23.6	130.5	150.8	170.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-185	33.2%	612-04	70	0.05	strain gage	20.5	109.4	137.0	158.5	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-185	33.4%	612-05	70	0.05	strain gage	19.1	127.7	140.5	157.4	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-189	33.8%	623-04	70	0.05	strain gage	23.4	107.1	138.7	158.4	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-192	33.9%	633-05	70	0.05	strain gage	23.9	110.3	143.3	163.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-192	34.8%	633-07	70	0.05	strain gage	20.4	130.0	146.8	167.4	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-197	34.6%	652-01	70	0.05	strain gage	24.2	108.5	139.3	158.7	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-215	34.8%	812-04	70	0.05	strain gage	24.6	131.2	153.0	171.3	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-215	34.4%	812-06	70	0.05	strain gage	19.6	126.1	140.8	160.6	Note 11	Note 11	UDRI (A. Hutson)

Table C2. Transverse Compression Data of SCS-6/Ti6Al-4V (Table 2 of 2)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	Straight Sided
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.500 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 3410-03 (MMC's)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Feb 07 - Jan 09

SCS-6 / Ti-6Al-4V TRANSVERSE COMPRESSION $[90]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	E (Msi)	Prop. Limit (ksi)	YS 0.06% (ksi)	YS 0.2% (ksi)	UCS (ksi)	ε_1 (%)	Test Facility
B0432004-101-219	33.2%	823-04	70	0.05	strain gage	24.7	112.3	145.4	163.1	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-222	34.7%	833-03	70	0.05	strain gage	24.9	110.0	142.7	161.8	Note 11	Note 11	TRL (B. Stockings)
B0432004-101-222	34.8%	833-05	70	0.05	strain gage	19.5	123.8	138.2	157.2	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-227	34.0%	852-02	70	0.05	strain gage	25.4	108.6	139.0	156.2	Note 11	Note 11	TRL (B. Stockings)
	33.7%					**21.8**	**114.9**	**143.3**	**163.8**			
B0432004-101-131	33.7%	232-07	600	0.05	strain gage	21.2	60.1	85.3	103.5	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-137	33.3%	252-06	600	0.05	strain gage	20.0	73.2	89.5	101.6	117.66	1.640	UDRI (A. Hutson)
B0432004-101-144	33.0%	323-07	600	0.05	strain gage	19.5	67.5	83.2	95.7	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-152	32.9%	352-10	600	0.05	strain gage	20.9	59.2	84.7	100.5	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-174	33.4%	523-03	600	0.05	strain gage	21.4	80.9	90.8	103.0	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-182	33.7%	552-03	600	0.05	strain gage	20.4	75.8	90.4	104.3	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-189	33.6%	623-05	600	0.05	strain gage	19.5	64.7	82.1	96.7	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-197	33.7%	652-03	600	0.05	strain gage	22.3	57.3	83.9	99.5	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-219	33.2%	823-05	600	0.05	strain gage	20.1	75.5	90.2	101.2	Note 11	Note 11	UDRI (A. Hutson)
B0432004-101-227	34.1%	852-03	600	0.05	strain gage	22.9	65.4	88.3	103.4	Note 11	Note 11	UDRI (A. Hutson)
AVERAGE	**33.5%**					**20.8**	**68.0**	**86.9**	**100.9**			

Compiled By:
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
Apr-08

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value
Note 10: Did not reach 0.06 offset before failure
Note 11: Test stopped prior to fracture

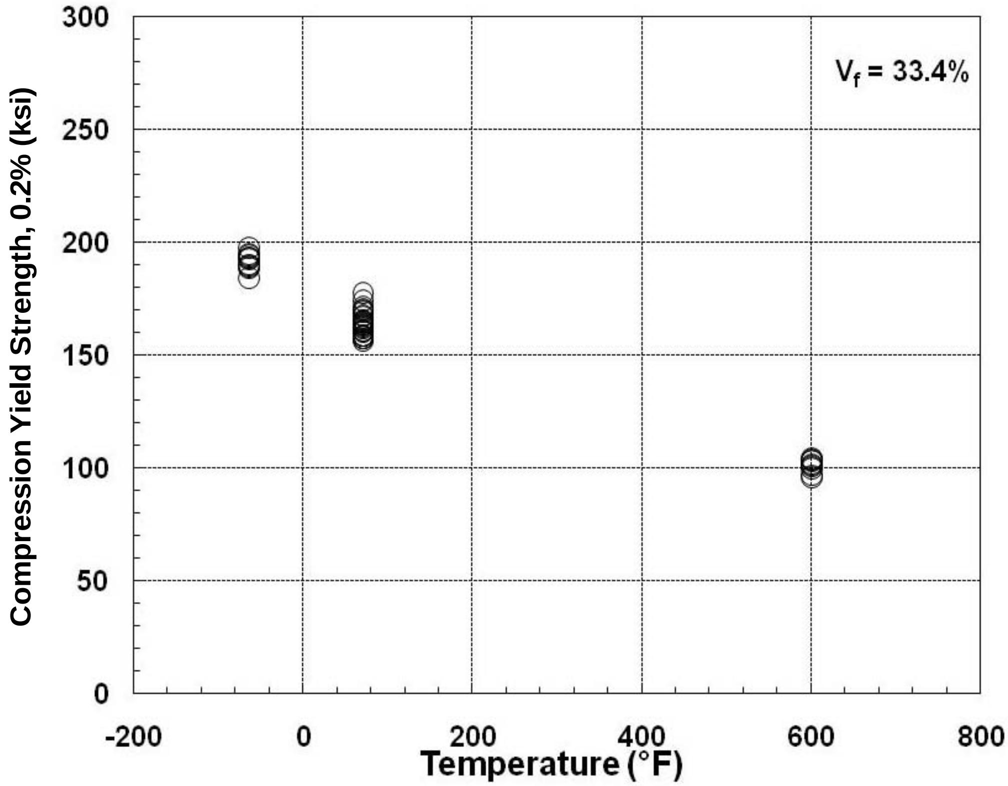

Figure C4. Transverse Compression Yield Strength (0.2%-offset) of $[90]_{16}$ Laminate

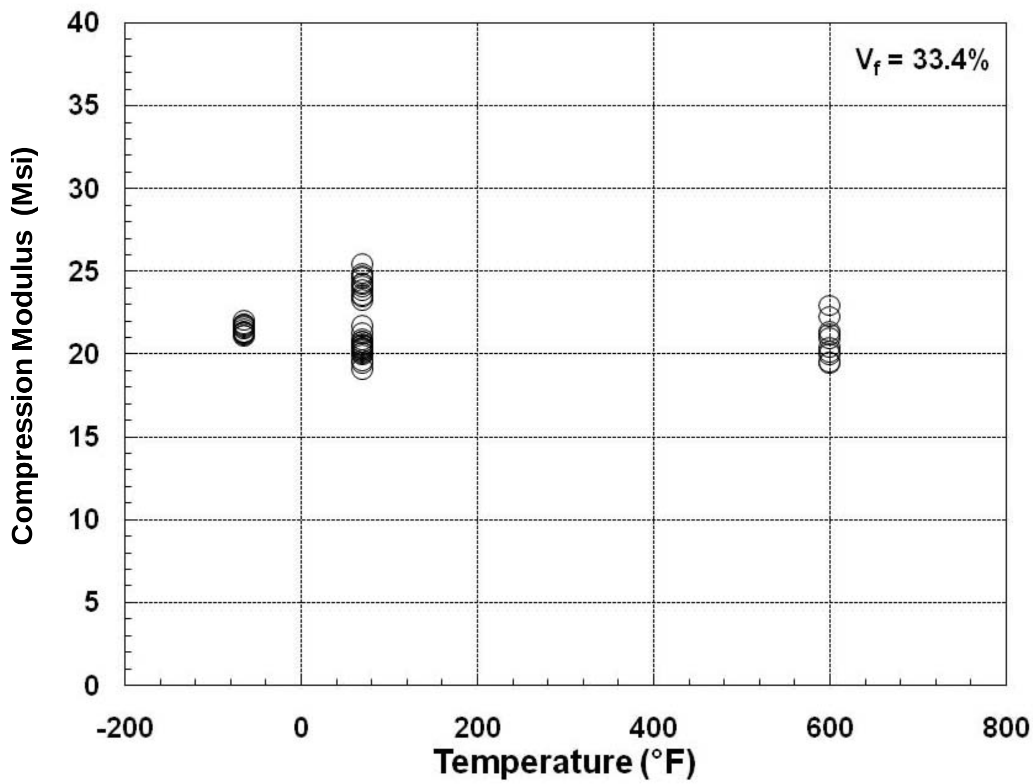

Figure C5. Transverse Compression Modulus of $[90]_{16}$ Laminate

APPENDIX D
INDIVIDUAL IOSEPESCU SHEAR TEST RESULTS

Table D1. Longitudinal Shear Data of SCS-6/Ti6Al-4V (Table 1 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	V-notch Beam
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.443 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 5379-98 (Composites)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heatin
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jan 07 - Feb 09

SCS-6 / Ti-6Al-4V LONGITUDINAL SHEAR $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	G (Msi)	Prop. Limit (ksi)	YS 0.2% (ksi)	Test Facility
B0432004-101-130	34.2%	231-14A	-65	0.01	strain gage	8.1	67.3	72.5	TRL (B. Stockings)
B0432004-101-130	34.1%	231-14B	-65	0.01	strain gage	8.0	62.1	71.6	TRL (B. Stockings)
B0432004-101-132	33.3%	233-03A	-65	0.01	strain gage	7.6	62.6	Note 4	TRL (B. Stockings)
B0432004-101-132	33.0%	233-03B	-65	0.01	strain gage	7.7	61.5	76.8	TRL (B. Stockings)
B0432004-101-134	33.4%	242-12A	-65	0.01	strain gage	7.7	71.8	75.8	TRL (B. Stockings)
B0432004-101-134	33.5%	242-12B	-65	0.01	strain gage	7.4	68.5	75.2	TRL (B. Stockings)
B0432004-101-203	34.2%	722-03A	-65	0.01	strain gage	8.0	67.5	73.3	TRL (B. Stockings)
B0432004-101-203	33.9%	722-03B	-65	0.01	strain gage	7.8	67.0	75.0	TRL (B. Stockings)
B0432004-101-203	#DIV/0!	722-08A	-65	0.01	strain gage				TRL (B. Stockings)
B0432004-101-203	#DIV/0!	722-08B	-65	0.01	strain gage				TRL (B. Stockings)
B0432004-101-210	33.2%	743-09A	-65	0.01	strain gage	8.0	69.2	76.1	TRL (B. Stockings)
B0432004-101-210	33.1%	743-09B	-65	0.01	strain gage	7.9	72.6	76.7	TRL (B. Stockings)
	#DIV/0!					7.8	67.0	74.8	
B0432004-101-110	33.8%	112-06A	70	0.01	strain gage	7.9	51.5	64.2	TRL (B. Stockings)
B0432004-101-110	33.4%	112-06B	70	0.01	strain gage	7.4	39.8	55.2	UDRI (A. Hutson)
B0432004-101-113	33.6%	122-02A	70	0.01	strain gage	7.6	47.9	54.7	UDRI (A. Hutson)
B0432004-101-113	33.4%	122-02B	70	0.01	strain gage	7.6	56.0	62.0	TRL (B. Stockings)
B0432004-101-116	33.0%	132-04A	70	0.01	strain gage				TRL (B. Stockings)
B0432004-101-116	33.0%	132-04B	70	0.01	strain gage	7.9	56.2	64.1	TRL (B. Stockings)
B0432004-101-121	#DIV/0!	151-07A	70	0.01	strain gage				TRL (B. Stockings)
B0432004-101-121	32.8%	151-07B	70	0.01	strain gage	12.2	60.8	66.2	UDRI (A. Hutson)
B0432004-101-126	33.5%	213-02A	70	0.01	strain gage	7.2	62.3	67.9	TRL (B. Stockings)
B0432004-101-126	33.3%	213-02B	70	0.01	strain gage	7.9	54.6	63.2	TRL (B. Stockings)
B0432004-101-133	33.6%	241-14A	70	0.01	strain gage	8.0	51.9	61.3	UDRI (A. Hutson)
B0432004-101-133	34.1%	241-14B	70	0.01	strain gage	7.4	58.5	64.8	TRL (B. Stockings)
B0432004-101-137	33.1%	252-02A	70	0.01	strain gage	7.6	59.5	67.2	TRL (B. Stockings)
B0432004-101-137	33.2%	252-02B	70	0.01	strain gage	7.5	58.7	67.2	TRL (B. Stockings)
B0432004-101-145	34.2%	331-05A	70	0.01	strain gage	8.0	66.8	71.4	TRL (B. Stockings)
B0432004-101-145	34.0%	331-05B	70	0.01	strain gage	8.2	60.7	65.9	UDRI (A. Hutson)
B0432004-101-148	34.0%	341-05A	70	0.01	strain gage	7.5	55.0	62.6	TRL (B. Stockings)
B0432004-101-148	34.2%	341-05B	70	0.01	strain gage	7.8	59.8	66.1	TRL (B. Stockings)
B0432004-101-151	34.0%	351-08A	70	0.01	strain gage	8.0	54.3	62.4	UDRI (A. Hutson)
B0432004-101-151	34.0%	351-08B	70	0.01	strain gage	7.9	61.5	68.2	TRL (B. Stockings)

Table D1. Longitudinal Shear Data of SCS-6/Ti6Al-4V (Table 2 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	V-notch Beam
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.443 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 5379-98 (Composites)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heatin
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jan 07 - Feb 09

SCS-6 / Ti-6Al-4V LONGITUDINAL SHEAR $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	G (Msi)	Prop. Limit (ksi)	YS 0.2% (ksi)	Test Facility
B0432004-101-155	33.6%	412-04A	70	0.01	strain gage	7.7	61.5	67.3	TRL (B. Stockings)
B0432004-101-155	33.1%	412-04B	70	0.01	strain gage	6.0	26.9	45.5	UDRI (A. Hutson)
B0432004-101-161	#DIV/0!	432-11A	70	0.01	strain gage	7.6	58.4	65.0	TRL (B. Stockings)
B0432004-101-161	#DIV/0!	432-11B	70	0.01	strain gage	7.7	60.7	67.8	TRL (B. Stockings)
B0432004-101-164	33.6%	442-09A	70	0.01	strain gage	8.0	51.8	60.3	UDRI (A. Hutson)
B0432004-101-164	33.7%	442-09B	70	0.01	strain gage	7.7	60.5	66.8	TRL (B. Stockings)
B0432004-101-170	35.0%	512-02A	70	0.01	strain gage	7.9	65.1	70.9	TRL (B. Stockings)
B0432004-101-170	34.7%	512-02B	70	0.01	strain gage	8.2	61.5	64.1	UDRI (A. Hutson)
B0432004-101-174	34.9%	523-02A	70	0.01	strain gage	7.8	64.6	69.1	TRL (B. Stockings)
B0432004-101-174	34.9%	523-02B	70	0.01	strain gage	7.8	55.5	65.4	TRL (B. Stockings)
B0432004-101-177	35.0%	533-01A	70	0.01	strain gage	8.1	48.3	58.4	UDRI (A. Hutson)
B0432004-101-177	35.1%	533-01B	70	0.01	strain gage	7.5	55.1	64.3	TRL (B. Stockings)
B0432004-101-185	32.7%	612-02A	70	0.01	strain gage	7.6	62.4	67.8	TRL (B. Stockings)
B0432004-101-185	33.3%	612-02B	70	0.01	strain gage	8.3	56.1	63.7	UDRI (A. Hutson)
B0432004-101-189	35.4%	623-10A	70	0.01	strain gage	7.9	58.1	66.7	TRL (B. Stockings)
B0432004-101-189	35.6%	623-10B	70	0.01	strain gage	7.7	54.3	66.0	TRL (B. Stockings)
B0432004-101-192	33.0%	633-01A	70	0.01	strain gage	8.1	63.0	67.2	UDRI (A. Hutson)
B0432004-101-192	32.6%	633-01B	70	0.01	strain gage	7.7	58.8	70.3	TRL (B. Stockings)
B0432004-101-203	34.0%	722-04A	70	0.01	strain gage	7.6	60.0	Note 4	TRL (B. Stockings)
B0432004-101-203	33.9%	722-04B	70	0.01	strain gage	8.0	58.9	63.6	UDRI (A. Hutson)
B0432004-101-204	34.0%	723-03A	70	0.01	strain gage	7.7	54.7	66.4	TRL (B. Stockings)
B0432004-101-204	33.8%	723-03B	70	0.01	strain gage	7.8	58.1	66.7	TRL (B. Stockings)
B0432004-101-207	34.4%	733-02A	70	0.01	strain gage	8.3	61.5	64.5	UDRI (A. Hutson)
B0432004-101-207	33.9%	733-02B	70	0.01	strain gage	7.8	61.1	68.1	TRL (B. Stockings)
B0432004-101-215	34.3%	812-02A	70	0.01	strain gage	7.8	58.9	67.0	TRL (B. Stockings)
B0432004-101-215	34.3%	812-02B	70	0.01	strain gage	8.0	57.5	63.3	UDRI (A. Hutson)
B0432004-101-219	33.7%	823-02A	70	0.01	strain gage	7.8	64.0	68.7	TRL (B. Stockings)
B0432004-101-219	34.0%	823-02B	70	0.01	strain gage	7.8	62.5	68.7	TRL (B. Stockings)
B0432004-101-225	33.5%	843-11A	70	0.01	strain gage	7.8	55.1	61.5	UDRI (A. Hutson)
B0432004-101-225	33.1%	843-11B	70	0.01	strain gage	7.5	57.7	65.9	TRL (B. Stockings)
	#DIV/0!					7.9	57.3	64.8	
B0432004-101-155	33.4%	412-02A	400	0.01	strain gage	7.4	42.0	48.8	TRL (B. Stockings)
B0432004-101-155	33.5%	412-02B	400	0.01	strain gage	11.3	Note 4	Note 4	TRL (B. Stockings)

Table D1. Longitudinal Shear Data of SCS-6/Ti6Al-4V (Table 3 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	V-notch Beam
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.443 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 5379-98 (Composites)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heatin
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jan 07 - Feb 09

SCS-6 / Ti-6Al-4V LONGITUDINAL SHEAR $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Stroke rate (in/min)	Strain Sensor	G (Msi)	Prop. Limit (ksi)	YS 0.2% (ksi)	Test Facility
B0432004-101-158	33.3%	422-04A	400	0.01	strain gage	7.6	43.9	48.0	TRL (B. Stockings)
B0432004-101-158	33.1%	422-04B	400	0.01	strain gage	7.6	43.6	49.6	TRL (B. Stockings)
B0432004-101-161	34.5%	432-01A	400	0.01	strain gage	7.8	47.1	54.5	TRL (B. Stockings)
B0432004-101-161	34.8%	432-01B	400	0.01	strain gage	7.6	46.2	51.1	TRL (B. Stockings)
B0432004-101-219	33.9%	823-10A	400	0.01	strain gage	7.5	46.0	50.6	TRL (B. Stockings)
B0432004-101-219	33.4%	823-10B	400	0.01	strain gage	7.8	46.1	50.8	TRL (B. Stockings)
B0432004-101-222	34.6%	833-09A	400	0.01	strain gage	7.7	42.3	50.9	TRL (B. Stockings)
B0432004-101-222	34.4%	833-09B	400	0.01	strain gage	7.5	41.2	49.7	TRL (B. Stockings)
B0432004-101-227	33.4%	852-09A	400	0.01	strain gage	7.5	41.2	49.7	TRL (B. Stockings)
B0432004-101-227	33.5%	852-09B	400	0.01	strain gage				TRL (B. Stockings)
	33.8%					7.9	44.0	50.4	
B0432004-101-110	32.9%	112-08A	600	0.01	strain gage	9.3	40.1	Note 4	TRL (B. Stockings)
B0432004-101-110	33.7%	112-08B	600	0.01	strain gage				UDRI (A. Hutson)
B0432004-101-113	33.9%	122-04A	600	0.01	strain gage	4.1	16.2	32.4	UDRI (A. Hutson)
B0432004-101-113	33.8%	122-04B	600	0.01	strain gage	4.4	41.1	Note 4	TRL (B. Stockings)
B0432004-101-116	33.4%	132-06A	600	0.01	strain gage	8.5	41.3	Note 4	TRL (B. Stockings)
B0432004-101-116	33.1%	132-06B	600	0.01	strain gage	8.9	43.4	Note 4	TRL (B. Stockings)
B0432004-101-132	33.5%	233-02A	600	0.01	strain gage	9.4	42.7	Note 4	TRL (B. Stockings)
B0432004-101-132	33.5%	233-02B	600	0.01	strain gage	11.6	41.0	43.8	TRL (B. Stockings)
B0432004-101-134	33.9%	242-13A	600	0.01	strain gage	15.3	45.7	Note 4	TRL (B. Stockings)
B0432004-101-134	33.7%	242-13B	600	0.01	strain gage	6.1	42.5	44.1	UDRI (A. Hutson)
B0432004-101-137	33.0%	252-03A	600	0.01	strain gage	4.7	21.9	39.9	UDRI (A. Hutson)
B0432004-101-137	33.2%	252-03B	600	0.01	strain gage	23.2	36.8	Note 4	TRL (B. Stockings)
B0432004-101-140	33.6%	312-04A	600	0.01	strain gage	8.7	41.9	45.8	TRL (B. Stockings)
B0432004-101-140	33.5%	312-04B	600	0.01	strain gage	5.7	39.9	Note 9	UDRI (A. Hutson)
B0432004-101-148	34.5%	341-01A	600	0.01	strain gage	11.3	17.7	44.2	TRL (B. Stockings)
B0432004-101-148	34.8%	341-01B	600	0.01	strain gage	12.5	42.8	47.1	TRL (B. Stockings)
B0432004-101-151	34.1%	351-10A	600	0.01	strain gage	6.0	38.9	42.8	UDRI (A. Hutson)
B0432004-101-151	33.7%	351-10B	600	0.01	strain gage	29.5	34.7	Note 4	TRL (B. Stockings)
B0432004-101-158	33.4%	422-07A	600	0.01	strain gage	9.9	19.2	46.5	TRL (B. Stockings)
B0432004-101-158	33.1%	422-07B	600	0.01	strain gage	5.2	Note 5	Note 5	UDRI (A. Hutson)
B0432004-101-164	33.4%	442-07A	600	0.01	strain gage	9.0	42.2	45.9	TRL (B. Stockings)
B0432004-101-164	33.8%	442-07B	600	0.01	strain gage	9.0	43.1	45.3	TRL (B. Stockings)

Table D1. Longitudinal Shear Data of SCS-6/Ti6Al-4V (Table 4 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	V-notch Beam
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.134 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.443 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM D 5379-98 (Composites)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heatin
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jan 07 - Feb 09

SCS-6 / Ti-6Al-4V LONGITUDINAL SHEAR $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Stroke rate (in/min)	Strain Sensor	G (Msi)	Prop. Limit (ksi)	YS 0.2% (ksi)	Test Facility
B0432004-101-167	33.1%	452-02A	600	0.01	strain gage	6.1	36.5	40.1	UDRI (A. Hutson)
B0432004-101-167	34.3%	452-02B	600	0.01	strain gage	10.5	29.1	Note 4	TRL (B. Stockings)
B0432004-101-170	34.3%	512-03A	600	0.01	strain gage	12.4	26.4	Note 4	TRL (B. Stockings)
B0432004-101-170	34.4%	512-03B	600	0.01	strain gage	Note 4	Note 4	Note 4	UDRI (A. Hutson)
B0432004-101-174	34.2%	523-10A	600	0.01	strain gage	12.4	26.9	Note 4	TRL (B. Stockings)
B0432004-101-174	34.8%	523-10B	600	0.01	strain gage	12.3	18.7	46.6	TRL (B. Stockings)
B0432004-101-177	33.3%	533-09A	600	0.01	strain gage	7.4	Note 5	Note 5	UDRI (A. Hutson)
B0432004-101-177	33.3%	533-09B	600	0.01	strain gage	8.7	41.8	44.8	TRL (B. Stockings)
B0432004-101-185	32.4%	612-03A	600	0.01	strain gage	7.3	36.9	45.7	TRL (B. Stockings)
B0432004-101-185	33.1%	612-03B	600	0.01	strain gage	4.5	18.4	40.1	UDRI (A. Hutson)
B0432004-101-189	33.2%	623-02A	600	0.01	strain gage	11.6	17.7	44.2	TRL (B. Stockings)
B0432004-101-189	33.2%	623-02B	600	0.01	strain gage	9.2	40.3	44.0	TRL (B. Stockings)
B0432004-101-192	33.2%	633-09A	600	0.01	strain gage	5.7	39.5	46.7	UDRI (A. Hutson)
B0432004-101-192	33.1%	633-09B	600	0.01	strain gage	14.5	41.3	Note 4	TRL (B. Stockings)
B0432004-101-203	33.6%	722-05A	600	0.01	strain gage	7.3	37.7	44.9	TRL (B. Stockings)
B0432004-101-203	33.9%	722-05B	600	0.01	strain gage	6.5	34.7	42.4	UDRI (A. Hutson)
B0432004-101-204	34.6%	723-02A	600	0.01	strain gage	8.7	42.0	46.4	TRL (B. Stockings)
B0432004-101-204	34.4%	723-02B	600	0.01	strain gage	8.0	41.4	45.8	TRL (B. Stockings)
B0432004-101-210	34.3%	743-01A	600	0.01	strain gage	5.9	36.6	42.4	UDRI (A. Hutson)
B0432004-101-210	34.2%	743-01B	600	0.01	strain gage	7.8	42.5	47.4	TRL (B. Stockings)
B0432004-101-215	33.9%	812-03A	600	0.01	strain gage	10.1	35.4	46.2	TRL (B. Stockings)
B0432004-101-215	34.2%	812-03B	600	0.01	strain gage	4.3	16.8	36.3	UDRI (A. Hutson)
B0432004-101-222	35.0%	833-01A	600	0.01	strain gage	9.8	18.5	Note 4	TRL (B. Stockings)
B0432004-101-222	34.9%	833-01B	600	0.01	strain gage	11.9	Note 4	Note 4	TRL (B. Stockings)
B0432004-101-225	33.7%	843-12A	600	0.01	strain gage	7.3	31.2	42.4	UDRI (A. Hutson)
B0432004-101-225	33.7%	843-12B	600	0.01	strain gage	11.2	Note 4	45.8	TRL (B. Stockings)
AVERAGE	**33.7%**					**9.4**	**34.4**	**43.8**	

Compiled By:
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
May-09

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measure
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value
Note 10: Did not reach 0.06 offset before failure

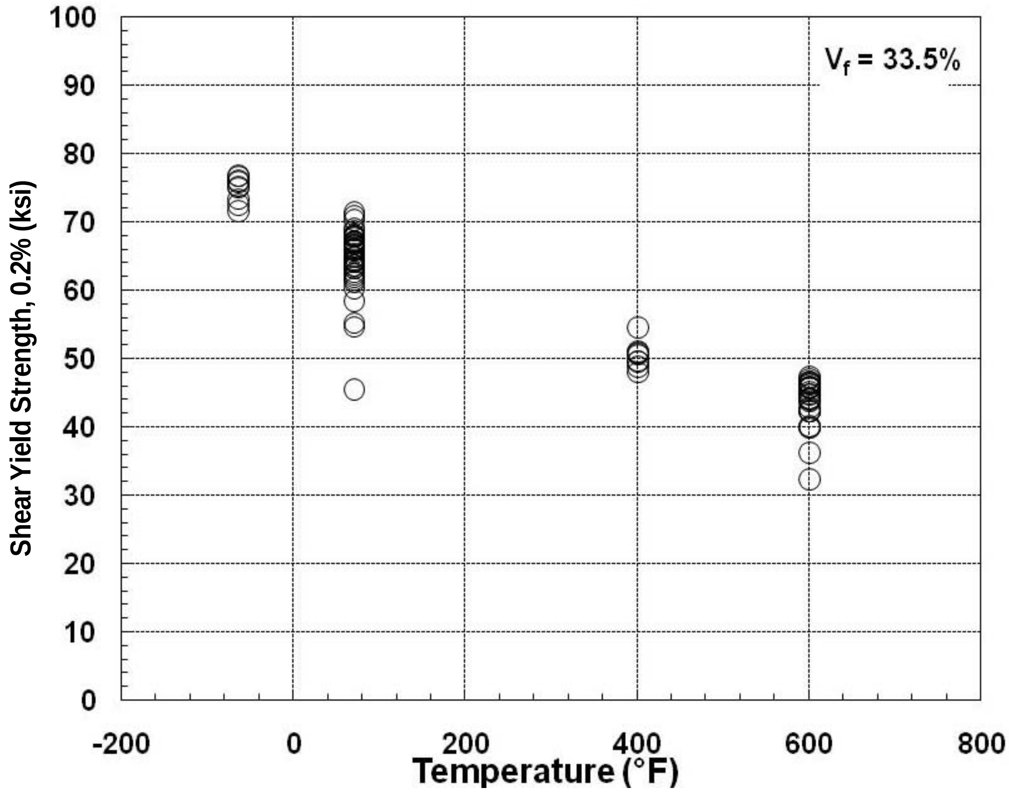

Figure D1. Shear Yield Strength (0.2%-offset) of $[0]_{16}$ Laminate

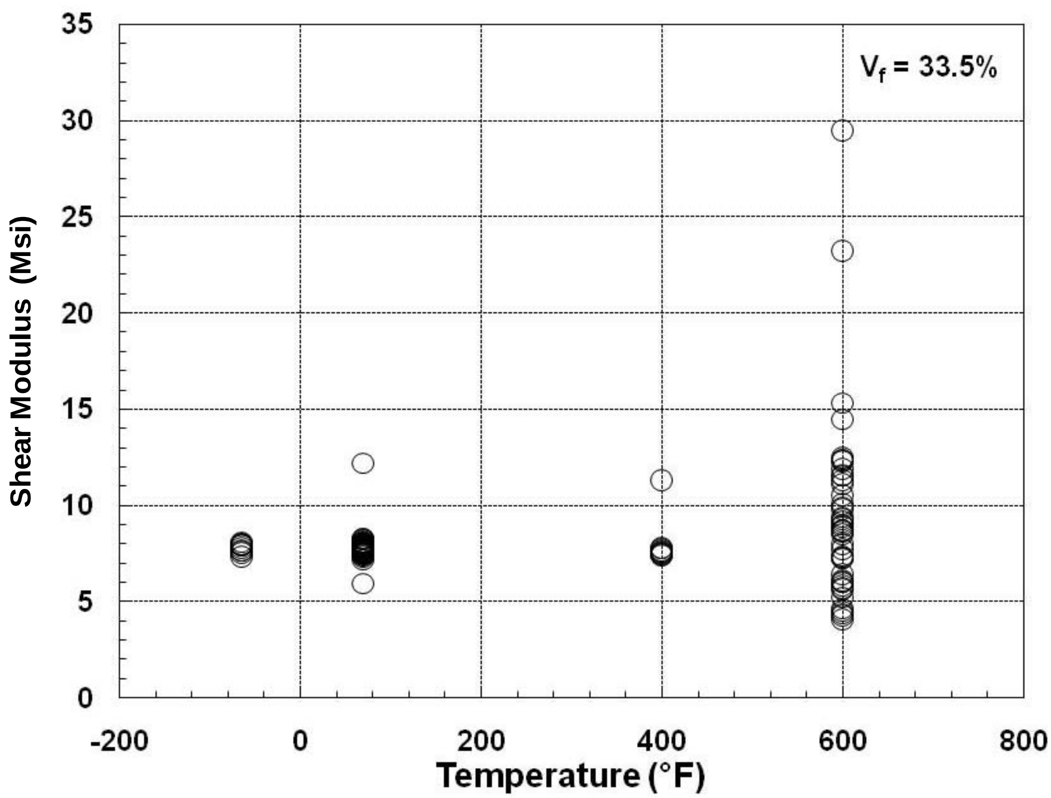

Figure D2. Shear Modulus of $[0]_{16}$ Laminate

APPENDIX E
INDIVIDUAL FATIGUE TEST RESULTS

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 1 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (^oF)	Frequency Hz	Strain Sensor	E_1^t at N=1 (Msi)	E_1^t at N=Nf/2 (Msi)	σ_{max} (ksi)	σ_{min} (ksi)	Nf	Test Facility
B0432004-101-214	34.2%	811-01	-65	1,5	extensometer	30.1	30.4	170	17	16,530	TRL (B. Stockings)
B0432004-101-214	33.7%	811-04	-65	1,5	extensometer	28.7	29.5	150	15	40,745	TRL (B. Stockings)
B0432004-101-214	33.7%	811-09	-65	1,10	extensometer	28.3	no data	130	13	121,572	TRL (B. Stockings)
B0432004-101-214	33.4%	811-13	-65	15-20	extensometer	30.1	no data	110	11	363,531	TRL (B. Stockings)
B0432004-101-216	34.7%	813-01	-65	1,10	extensometer	28.4	no data	90	9	531,222	TRL (B. Stockings)
B0432004-101-216	33.6%	813-03	-65	1	extensometer	28.7	28.6	170	17	13,527	TRL (B. Stockings)
B0432004-101-216	32.9%	813-06	-65	1,10	extensometer	29.0	no data	130	13	56,471	TRL (B. Stockings)
B0432004-101-216	33.2%	813-11	-65	1,10	extensometer	27.9	no data	130	13	84,619	TRL (B. Stockings)
B0432004-101-217	33.8%	821-02	-65	1,10	extensometer	29.0	27.6	110	11	78,925	TRL (B. Stockings)
B0432004-101-217	33.2%	821-04	-65	1,10	extensometer	29.0	no data	90	9	610,189	TRL (B. Stockings)
B0432004-101-217	33.3%	821-06	-65	1	extensometer	28.6	28.5	170	17	15,529	TRL (B. Stockings)
B0432004-101-217	33.2%	821-09	-65	1,5	extensometer	28.7	29.0	150	15	24,591	TRL (B. Stockings)
B0432004-101-220	33.9%	831-02	-65	1,10	extensometer	29.8	no data	130	13	76,190	TRL (B. Stockings)
B0432004-101-220	33.2%	831-04	-65	1,10	extensometer	26.8	no data	110	11	249,806	TRL (B. Stockings)
B0432004-101-220	32.8%	831-06	-65	1,10	extensometer			90	9		TRL (B. Stockings)
B0432004-101-220	32.8%	831-08	-65	1	extensometer	28.2	28.3	170	17	7,773	TRL (B. Stockings)
B0432004-101-223	33.9%	841-03	-65	1,5	extensometer	27.4	27.5	150	15	36,822	TRL (B. Stockings)
B0432004-101-223	33.9%	841-05	-65	1,10	extensometer	30.1	no data	130	13	108,634	TRL (B. Stockings)
B0432004-101-223	33.2%	841-07	-65	1,10	extensometer	27.4	29.2	110	11	215,622	TRL (B. Stockings)
B0432004-101-223	33.1%	841-09	-65	1,10	extensometer	30.6	no data	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-224	34.4%	842-02	-65	1	extensometer	28.4	28.0	170	17	12,268	TRL (B. Stockings)
B0432004-101-226	33.5%	851-05	-65		extensometer	29.0	28.1	150	15	39,900	TRL (B. Stockings)
B0432004-101-226	33.6%	851-07	-65	1,10	extensometer	29.4	no data	130	13	99,901	TRL (B. Stockings)
B0432004-101-226	33.8%	851-09	-65	1,5,10	extensometer	28.7	28.2	110	11	173,797	TRL (B. Stockings)
B0432004-101-226	33.9%	851-11	-65	1,10	extensometer	30.4	no data	90	9	590,567	TRL (B. Stockings)
	33.6%					**28.9**					
B0432004-101-109	33.7%	111-04	70	20	extensometer	30.6	31.2	110	11	294,833	TRL (B. Stockings)
B0432004-101-109	33.5%	111-08	70	20	Strain Gage	33.6	32.8	150	15	62,130	UDRI (A. Hutson)
B0432004-101-109	33.6%	111-12	70	20	extensometer	no data	no data	130	13	129,984	TRL (B. Stockings)

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 2 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09
LOAD RATIO:	0.1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-110	33.8%	112-01	70	20	extensometer	29.2	28.1	110	11	254,971	TRL (B. Stockings)
B0432004-101-112	34.2%	121-06	70	20	extensometer	30.6	29.3	110	11	1,000,000	TRL (B. Stockings)
B0432004-101-112	33.8%	121-10	70	20	Strain Gage	33.9	33.5	90	9	1,000,000	UDRI (A. Hutson)
B0432004-101-112	34.4%	121-13	70	1-10	extensometer	39.5	37.2	130	13	425,482	TRL (B. Stockings)
B0432004-101-113	33.4%	122-10	70	1-20	extensometer	no data	no data	170	17	21,104	TRL (B. Stockings)
B0432004-101-115	33.6%	131-02	70	5-20	extensometer	no data	no data	130	13	171,087	TRL (B. Stockings)
B0432004-101-115	34.3%	131-07	70	20	Strain Gage	33.7	33.5	150	15	36,387	UDRI (A. Hutson)
B0432004-101-115	34.2%	131-11	70	1-10	extensometer	38.6	39.1	170	17	20,198	TRL (B. Stockings)
B0432004-101-116	33.2%	132-01	70	20	Strain Gage	29.6	no data	90	9	1,000,000	UDRI (A. Hutson)
B0432004-101-116	34.1%	141-01	70	1-10	extensometer	37.2	35.5	100	11	1,000,000	TRL (B. Stockings)
B0432004-101-116	33.3%	141-03	70	1-20	extensometer	no data	no data	170	17	28,641	TRL (B. Stockings)
B0432004-101-118	33.3%	141-07	70	5-20	extensometer	no data	no data	130	13	202,776	TRL (B. Stockings)
B0432004-101-118	33.5%	141-09	70	20	extensometer	no data	no data	60	6	1,000,000	UDRI (A. Hutson)
B0432004-101-118	33.6%	141-11	70	1-10	extensometer	38.7	39.3	110	11	555,198	TRL (B. Stockings)
B0432004-101-118	33.2%	142-02	70	1-10	extensometer	37.5	37.2	170	17	22,817	TRL (B. Stockings)
B0432004-101-118	33.2%	142-06	70	20	Strain Gage	31.7	32.0	90	9	1,000,000	UDRI (A. Hutson)
B0432004-101-119	33.9%	151-01	70	1-20	extensometer	no data	no data	170	17	18,537	TRL (B. Stockings)
B0432004-101-119	33.2%	151-04	70	20	Strain Gage	30.0	30.6	150	15	28,155	UDRI (A. Hutson)
B0432004-101-121	33.3%	151-05	70	1-10	extensometer	38.6	39.7	130	13	62,385	TRL (B. Stockings)
B0432004-101-169	32.7%	411-04	70	1-10	extensometer	35.6	35.9	170	17	20,811	TRL (B. Stockings)
B0432004-101-169	33.2%	411-07	70	1-10	extensometer	36.7	38.1	150	15	36,002	TRL (B. Stockings)
B0432004-101-169	32.8%	411-12	70	1-20	extensometer	29.9	29.5	130	13	120,552	TRL (B. Stockings)
B0432004-101-171	32.7%	412-07	70	1-20	extensometer	29.0	28.9	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-171	32.6%	412-10	70	20	extensometer	28.7	28.0	110	11	257,745	UDRI (A. Hutson)
B0432004-101-171	32.7%	421-01	70	1-10	extensometer	37.8	37.8	170	17	18,557	TRL (B. Stockings)
B0432004-101-172	32.5%	421-06	70	1-10	extensometer	37.0	37.2	150	15	36,838	TRL (B. Stockings)
B0432004-101-172	33.1%	421-10	70	1-10	extensometer	37.1	37.7	130	13	73,223	TRL (B. Stockings)
B0432004-101-172	34.3%	422-02	70	1-20	extensometer	29.7	29.2	90	9	599,082	TRL (B. Stockings)
B0432004-101-172	32.7%	422-09	70	20	extensometer	28.8	28.6	110	11	155,638	UDRI (A. Hutson)

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 3 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(^oF)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-173	33.9%	431-01	70	1-10	extensometer	35.0	34.3	170	17	14,010	TRL (B. Stockings)
B0432004-101-173	33.1%	431-08	70	1-10	extensometer	34.9	35.0	150	15	24,356	TRL (B. Stockings)
B0432004-101-175	33.6%	431-12	70	1-10	extensometer	35.5	34.8	130	13	80,623	TRL (B. Stockings)
B0432004-101-175	33.6%	432-02	70	1-20	extensometer	28.5	28.3	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-175	32.8%	432-10	70	20	extensometer	29.1	29.1	110	11	250,724	UDRI (A. Hutson)
B0432004-101-175	33.9%	441-03	70	1-10	extensometer	36.6	36.4	170	17	25,220	TRL (B. Stockings)
B0432004-101-176	33.1%	441-08	70	1-10	extensometer	37.4	37.2	150	15	46,632	TRL (B. Stockings)
B0432004-101-178	34.7%	441-13	70	1-10	extensometer	36.7	33.7	130	13	147,083	TRL (B. Stockings)
B0432004-101-178	34.8%	442-01	70	1-20	extensometer	29.4	29.2	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-178	33.8%	442-04	70	20	extensometer	29.3	28.6	110	11	246,258	UDRI (A. Hutson)
B0432004-101-178	33.9%	451-03	70	1-10	extensometer	36.6	37.1	170	17	19,297	TRL (B. Stockings)
B0432004-101-179	34.0%	451-07	70	1-10	extensometer	36.0	35.7	150	15	37,847	TRL (B. Stockings)
B0432004-101-179	34.2%	451-11	70	1-10	extensometer	35.5	33.4	130	13	85,696	TRL (B. Stockings)
B0432004-101-181	33.5%	452-07	70	1-20	extensometer	27.3	27.9	90	9	788,072	TRL (B. Stockings)
B0432004-101-181	33.4%	452-10	70	20	extensometer	29.7	29.9	110	11	81,310	UDRI (A. Hutson)
B0432004-101-199	33.1%	611-02	70	20	extensometer	29.2	29.5	170	17	11,274	UDRI (A. Hutson)
B0432004-101-199	32.9%	611-05	70	1-10	extensometer	36.2	36.1	150	15	14,790	TRL (B. Stockings)
B0432004-101-199	32.8%	611-08	70	1-10	extensometer	35.2	34.2	110	11	88,063	TRL (B. Stockings)
B0432004-101-200	33.0%	611-11	70	20	extensometer	29.7	30.0	130	13	37,824	UDRI (A. Hutson)
B0432004-101-200	32.5%	613-05	70	1-10	extensometer	34.9	32.4	90	9	298,170	TRL (B. Stockings)
B0432004-101-200	33.0%	613-09	70	1-10	extensometer	36.3	36.1	150	15	20,022	TRL (B. Stockings)
B0432004-101-201	33.5%	613-13	70	20	extensometer	29.0	28.1	170	17	11,845	UDRI (A. Hutson)
B0432004-101-201	32.4%	621-01	70	1-10	extensometer	35.2	34.1	110	11	116,063	TRL (B. Stockings)
B0432004-101-201	32.9%	621-04	70	1-10	extensometer	35.7	36.4	90	9	331,427	TRL (B. Stockings)
B0432004-101-201	33.6%	621-08	70	20	extensometer	29.7	29.7	130	13	37,125	UDRI (A. Hutson)
B0432004-101-202	33.6%	621-13	70	1-10	extensometer	34.7	34.0	150	15	20,045	TRL (B. Stockings)
B0432004-101-202	32.2%	622-01	70	1-10	extensometer	36.0	34.9	110	11	75,640	TRL (B. Stockings)
B0432004-101-202	33.1%	622-02	70	20	extensometer	29.0	29.3	170	17	7,471	UDRI (A. Hutson)
B0432004-101-205	32.6%	622-04	70	1-10	extensometer	36.0	36.1	150	15	21,844	TRL (B. Stockings)

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 4 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-205	33.2%	631-02	70	1-10	extensometer	35.6	35.4	110	11	53,782	TRL (B. Stockings)
B0432004-101-205	33.2%	631-06	70	20	extensometer	28.9	27.6	130	13	41,201	UDRI (A. Hutson)
B0432004-101-205	34.3%	631-10	70	1-10	extensometer	37.8	38.1	90	9	258,558	TRL (B. Stockings)
B0432004-101-208	33.7%	641-02	70	1-10	extensometer	36.8	36.6	90	9	383,564	TRL (B. Stockings)
B0432004-101-208	33.2%	641-05	70	20	extensometer	29.1	28.4	170	17	12,139	UDRI (A. Hutson)
B0432004-101-208	32.6%	641-08	70	1-10	extensometer	33.8	33.5	150	15	25,849	TRL (B. Stockings)
B0432004-101-208	33.9%	642-02	70	20	extensometer	29.0	27.0	130	13	29,823	UDRI (A. Hutson)
B0432004-101-211	34.9%	642-12	70	20	extensometer	30.3	30.8	170	17	12,980	UDRI (A. Hutson)
B0432004-101-211	34.1%	651-02	70	1-10	extensometer	36.8	35.7	110	11	140,951	TRL (B. Stockings)
B0432004-101-211	33.5%	651-06	70	1-10	extensometer	35.4	34.7	90	9	399,582	TRL (B. Stockings)
B0432004-101-211	33.3%	651-10	70	20	extensometer	30.0	30.0	130	13	44,386	UDRI (A. Hutson)
	33.4%					**33.4**	**33.1**				
B0432004-101-139	33.4%	311-01	600	20	Strain gage	31.9	31.7	140	14	95,650	UDRI (A. Hutson)
B0432004-101-139	33.9%	311-05	600	3	extensometer	27.3	26.9	160	16	44,495	TRL (B. Stockings)
B0432004-101-139	33.5%	311-11	600	3, 10	extensometer	26.3	25.9	120	12	263,481	TRL (B. Stockings)
B0432004-101-139	33.5%	311-13	600	1	extensometer			100	10	913,058	TRL (B. Stockings)
B0432004-101-140	33.9%	312-07	600	20	extensometer	no data	no data	80	8	1,000,000	UDRI (A. Hutson)
B0432004-101-140	33.9%	312-09	600	1	extensometer	no data	no data	100	10	322,075	TRL (B. Stockings)
B0432004-101-140	34.0%	312-11	600	20	extensometer	26.6	26.1	140	14	112,877	UDRI (A. Hutson)
B0432004-101-142	34.1%	321-01	600	3, 20	extensometer			100	10	1,000,000	TRL (B. Stockings)
B0432004-101-142	33.6%	321-03	600	20	extensometer	26.9	26.6	80	8	1,000,000	UDRI (A. Hutson)
B0432004-101-142	33.2%	321-06	600	3	extensometer	28.7	28.3	160	16	37,659	TRL (B. Stockings)
B0432004-101-142	33.4%	321-13	600	3	extensometer	28.0	27.9	120	12	360,609	TRL (B. Stockings)
B0432004-101-143	35.0%	322-02	600	20	extensometer	29.0	28.3	140	14	55,298	UDRI (A. Hutson)
B0432004-101-143	33.4%	322-11	600	3, 20	extensometer	no data	no data	100	10		TRL (B. Stockings)
B0432004-101-143	34.2%	322-12	600	3	extensometer	28.9	29.1	160	16	66,598	TRL (B. Stockings)
B0432004-101-145	34.5%	331-02	600	20	extensometer	no data	no data	80	8	1,000,000	UDRI (A. Hutson)
B0432004-101-145	33.8%	331-11	600	20	extensometer	29.3	28.6	120	12	472,884	TRL (B. Stockings)
B0432004-101-146	33.6%	332-09	600	3, 10	extensometer	25.8	25.9	100	10	924,285	TRL (B. Stockings)

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 5 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09
LOAD RATIO:	0.1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(^oF)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-146	33.9%	332-11	600	20	extensometer	no data	no data	140	14	17,659	UDRI (A. Hutson)
B0432004-101-146	34.3%	332-12	600	1	extensometer	26.4	no data	160	16	37,884	TRL (B. Stockings)
B0432004-101-148	34.4%	341-02	600	20	extensometer	28.0	no data	120	12	415,420	TRL (B. Stockings)
B0432004-101-148	34.1%	341-04	600	20	extensometer	no data	no data	80	8	1,000,000	UDRI (A. Hutson)
B0432004-101-148	33.6%	341-10	600	3, 20	extensometer	28.2	28.1	100	10	1,000,000	TRL (B. Stockings)
B0432004-101-149	34.8%	342-01	600	20	extensometer	27.1	no data	160	16	92,716	TRL (B. Stockings)
B0432004-101-149	34.1%	342-04	600	20	extensometer	29.5	28.8	140	14	98,211	UDRI (A. Hutson)
B0432004-101-151	34.7%	351-01	600	20	extensometer	27.2	no data	120	12	318,645	TRL (B. Stockings)
B0432004-101-151	34.5%	351-03	600	3, 20	extensometer	25.8	25.4	100	10	928,011	TRL (B. Stockings)
B0432004-101-151	34.9%	351-05	600	20	extensometer	no data	no data	80	8	1,000,000	UDRI (A. Hutson)
B0432004-101-169	34.8%	511-02	600	1,3	extensometer	27.8	no data	160	16	41,508	TRL (B. Stockings)
B0432004-101-169	33.7%	511-05	600	1,3	extensometer	32.7	no data	140	14	96,681	TRL (B. Stockings)
B0432004-101-169	33.5%	511-09	600	20	extensometer	no data	no data	100	10	476,688	UDRI (A. Hutson)
B0432004-101-171	33.7%	513-03	600	1,3	extensometer	31.3	no data	120	12	143,848	TRL (B. Stockings)
B0432004-101-171	33.4%	513-06	600	1,20	extensometer	30.9	30.4	90	9	913,292	TRL (B. Stockings)
B0432004-101-171	33.3%	513-10	600	20	extensometer	no data	no data	100	10	376,677	UDRI (A. Hutson)
B0432004-101-172	34.3%	521-02	600	1,3	extensometer	25.8	25.7	160	16	38,361	TRL (B. Stockings)
B0432004-101-172	33.1%	521-04	600	1,3	extensometer	23.8	no data	140	14	66,759	TRL (B. Stockings)
B0432004-101-172	33.2%	521-06	600	1,3,20	extensometer	31.8	no data	120	12	187,379	TRL (B. Stockings)
B0432004-101-172	33.3%	521-10	600	1,3,20	extensometer	25.9	26.0	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-173	34.5%	522-01	600	1,3	extensometer	26.5	27.0	160	16	36,712	TRL (B. Stockings)
B0432004-101-175	33.4%	531-01	600	20	extensometer	25.9	26.1	100	10	103,086	UDRI (A. Hutson)
B0432004-101-175	33.2%	531-04	600	1,3	extensometer	26.2	25.7	140	14	75,977	TRL (B. Stockings)
B0432004-101-175	33.2%	531-08	600	1,3	extensometer	26.4	26.0	120	12	116,448	TRL (B. Stockings)
B0432004-101-175	33.5%	531-12	600	1,3,20	extensometer	27.2	27.4	90	9	887,007	TRL (B. Stockings)
B0432004-101-176	34.5%	532-01	600	1	extensometer	24.9	no data	160	16	15,937	TRL (B. Stockings)
B0432004-101-176	34.3%	532-11	600	1,3	extensometer	26.7	26.7	140	14	75,031	TRL (B. Stockings)
B0432004-101-178	33.9%	541-03	600	20	extensometer	26.9	no data	100	10		UDRI (A. Hutson)
B0432004-101-178	34.2%	541-06	600	1,3,20	extensometer	26.2	26.1	120	12	256,682	TRL (B. Stockings)

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 6 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-178	33.9%	541-10	600	1,3,20	extensometer	27.4	no data	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-178	34.2%	541-13	600	20	extensometer	no data	no data	100	10	469,526	UDRI (A. Hutson)
B0432004-101-179	34.2%	542-09	600	1,3	extensometer	27.0	no data	160	16	32,415	TRL (B. Stockings)
B0432004-101-181	33.3%	551-04	600	1,3	extensometer	26.7	no data	140	14	46,977	TRL (B. Stockings)
B0432004-101-181	33.4%	551-07	600	1,3,20	extensometer	25.3	no data	120	12	215,974	TRL (B. Stockings)
B0432004-101-181	33.5%	551-10	600	1,20	extensometer	23.6	no data	90	9	1,000,000	TRL (B. Stockings)
B0432004-101-199	32.7%	711-07	600	1, 3	extensometer	29.8	no data	140	14	57,116	TRL (B. Stockings)
B0432004-101-199	32.6%	711-09	600	20	extensometer	24.5	24.2	160	16	16,383	UDRI (A. Hutson)
B0432004-101-199	32.6%	711-11	600	1,3,20	extensometer	27.6	no data	100	10	489,156	TRL (B. Stockings)
B0432004-101-201	34.2%	713-01	600	1, 20	extensometer	27.1	no data	80	8	1,000,000	TRL (B. Stockings)
B0432004-101-201	33.4%	713-05	600	20	extensometer	no data	no data	120	12	83,573	UDRI (A. Hutson)
B0432004-101-201	33.7%	713-09	600	1, 3	extensometer	27.1	no data	140	14	77,147	TRL (B. Stockings)
B0432004-101-201	32.9%	713-12	600	1,3,20	extensometer	28.5	no data	100	10	456,313	TRL (B. Stockings)
B0432004-101-202	32.8%	721-03	600	20	extensometer	no data	no data	160	16	18,002	UDRI (A. Hutson)
B0432004-101-202	33.3%	721-08	600	1,3,20	extensometer	28.1	28.4	90	9	916,973	TRL (B. Stockings)
B0432004-101-202	33.5%	721-12	600	1, 3	extensometer	26.7	25.2	140	14	65,442	TRL (B. Stockings)
B0432004-101-205	33.5%	731-02	600	20	extensometer	no data	no data	120	12	226,093	UDRI (A. Hutson)
B0432004-101-205	32.8%	731-04	600	1,3,20	extensometer	26.2	25.4	100	10	583,953	TRL (B. Stockings)
B0432004-101-205	32.8%	731-08	600	20	extensometer	no data	no data	160	16	27,500	UDRI (A. Hutson)
B0432004-101-205	33.0%	731-11	600	20	extensometer	26.0	25.3	120	12	131,772	UDRI (A. Hutson)
B0432004-101-206	33.5%	732-02	600	1,3,20	extensometer	27.0	27.0	90	9	723,680	TRL (B. Stockings)
B0432004-101-208	34.0%	741-01	600	1, 3	extensometer	27.3	26.4	140	14	70,676	TRL (B. Stockings)
B0432004-101-208	33.2%	741-03	600	20	extensometer	no data	no data	160	16	59,874	UDRI (A. Hutson)
B0432004-101-208	33.1%	741-08	600	1,3,20	extensometer	25.3	29.8	100	10	494,899	TRL (B. Stockings)
B0432004-101-208	32.9%	741-10	600	1,3,20	extensometer	26.3	25.6	101	10	655,290	TRL (B. Stockings)
B0432004-101-209	34.7%	742-02	600	20	extensometer	no data	no data	120	12	336,640	UDRI (A. Hutson)
B0432004-101-209	33.6%	742-11	600	1, 20	extensometer	28.4	no data	140	14	53,916	TRL (B. Stockings)
B0432004-101-211	34.5%	751-01	600	1, 3	extensometer	28.7	no data	100	10	626,019	TRL (B. Stockings)
B0432004-101-211	33.3%	751-04	600	20	extensometer	27.7	27.4	160	16	23,970	UDRI (A. Hutson)

Table E1 – Longitudinal R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 7 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Aug 06 - Mar 09
LOAD RATIO:	0.1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-211	33.3%	751-08	600	1	extensometer	24.7	no data	90	9		TRL (B. Stockings)
B0432004-101-211	33.2%	751-11	600	20	extensometer	no data	no data	120	12	215,171	UDRI (A. Hutson)
AVERAGE	**33.7%**					**27.3**	**27.1**				

<u>Compiled By:</u>
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
May-09

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 1 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09
LOAD RATIO:	-1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	(Hz)		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-214	34.1%	811-03	-65	1, 5	extensometer	28.7	28.4	120	-120	31,817	TRL (B. Stockings)
B0432004-101-214	33.8%	811-05	-65	1, 5	extensometer	28.4	27.0	100	-100	61,552	TRL (B. Stockings)
B0432004-101-214	33.8%	811-10	-65	5	extensometer	26.5	no data	80	-80	157,546	TRL (B. Stockings)
B0432004-101-214	34.2%	811-12	-65	1, 5	extensometer	28.6	no data	70	-70	212,719	TRL (B. Stockings)
B0432004-101-216	33.5%	813-07	-65	1, 5	extensometer	26.9	no data	60	-60	587,922	TRL (B. Stockings)
B0432004-101-216	33.4%	813-08	-65	1, 3	extensometer	28.5	27.3	120	-120	31,172	TRL (B. Stockings)
B0432004-101-216	33.0%	813-12	-65	1, 3, 5	extensometer	27.4	26.3	100	-100	63,548	TRL (B. Stockings)
B0432004-101-216	33.4%	813-13	-65	1, 5	extensometer	28.4	no data	80	-80	111,680	TRL (B. Stockings)
B0432004-101-217	33.6%	821-01	-65	1, 5	extensometer	31.0	no data	70	-70	227,045	TRL (B. Stockings)
B0432004-101-217	33.1%	821-05	-65	1, 5	extensometer	26.4	no data	60	-60	361,436	TRL (B. Stockings)
B0432004-101-217	33.1%	821-11	-65	1	extensometer	28.7	28.7	120	-120	35,509	TRL (B. Stockings)
B0432004-101-217	33.5%	821-13	-65	1, 5	extensometer	27.4	27.4	100	-100	68,268	TRL (B. Stockings)
B0432004-101-218	34.6%	822-12	-65	5	extensometer			60	-60	341,963	TRL (B. Stockings)
B0432004-101-220	33.3%	831-01	-65	1, 5	extensometer	28.8	no data	80	-80	118,775	TRL (B. Stockings)
B0432004-101-220	33.3%	831-03	-65	1, 5	extensometer	28.3	no data	70	-70	244,206	TRL (B. Stockings)
B0432004-101-220	32.7%	831-07	-65	1, 5	extensometer	26.1	no data	60	-60		TRL (B. Stockings)
B0432004-101-220	32.8%	831-09	-65	1	extensometer	27.5	27.7	120	-120	30,681	TRL (B. Stockings)
B0432004-101-223	34.3%	841-01	-65	1, 5	extensometer	28.3	28.1	100	-100	56,376	TRL (B. Stockings)
B0432004-101-223	33.5%	841-04	-65	1, 5	extensometer	26.9	no data	80	-80	153,681	TRL (B. Stockings)
B0432004-101-223	33.4%	841-08	-65	5	extensometer	no data	no data	70	-70	875,842	TRL (B. Stockings)
B0432004-101-223	33.6%	841-10	-65	5	extensometer	29.3	no data	60	-60	629,255	TRL (B. Stockings)
B0432004-101-224	34.6%	842-12	-65	1, 5	extensometer	28.1	27.9	120	-120	41,743	TRL (B. Stockings)
B0432004-101-226	34.0%	851-02	-65	1, 5	extensometer	28.7	27.8	100	-100	61,529	TRL (B. Stockings)
B0432004-101-226	33.3%	851-04	-65	5	extensometer	28.5	no data	80	-80	135,818	TRL (B. Stockings)
B0432004-101-226	33.7%	851-06	-65	1, 5	extensometer	no data	no data	70	-70	218,330	TRL (B. Stockings)
B0432004-101-226	34.0%	851-10	-65	1, 5	extensometer	28.0	no data	60	-60	479,395	TRL (B. Stockings)
	33.6%										
B0432004-101-109	33.7%	111-05	70	3-5	extensometer	no data	no data	90	-90	167,753	TRL (B. Stockings)
B0432004-101-109	33.4%	111-10	70	5	strain gage	32.3	no data	110	-110	34,850	UDRI (A. Hutson)

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 2 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09
LOAD RATIO:	-1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	(Hz)		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-109	33.4%	111-11	70	1-3	extensometer	no data	no data	120	-120	20,743	TRL (B. Stockings)
B0432004-101-110	33.6%	112-02	70	1,5	extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-110	33.3%	112-03	70	2	extensometer	31.6	31.3	120	-120	21,153	UDRI (A. Hutson)
B0432004-101-110	33.5%	112-11	70	5	extensometer	28.6	28.3	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-111	34.0%	113-09	70	5	extensometer	no data	no data	100	-100	33,990	UDRI (A. Hutson)
B0432004-101-112	33.2%	121-01	70	1-3	extensometer	no data	no data	100	-100	99,391	TRL (B. Stockings)
B0432004-101-112	34.1%	121-04	70	1,5	extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-113	33.9%	122-06	70	2	extensometer	28.4	25.6	80	-80	299,968	UDRI (A. Hutson)
B0432004-101-113	33.1%	122-08	70	2	extensometer	27.5	27.0	120	-120	19,443	UDRI (A. Hutson)
B0432004-101-113	33.2%	122-09	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-113	33.3%	122-11	70	1-5	extensometer	no data	no data	90	-90	51,848	TRL (B. Stockings)
B0432004-101-115	33.6%	131-05	70	1,5	extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-115	33.9%	131-12	70	1-3	extensometer	no data	no data	120	-120	23,021	TRL (B. Stockings)
B0432004-101-116	33.2%	132-02	70	5	strain gage	31.0	no data	110	-110	33,256	UDRI (A. Hutson)
B0432004-101-116	33.2%	132-03	70	5	extensometer	no data	no data	80	-80	303,334	UDRI (A. Hutson)
B0432004-101-116	33.2%	132-09	70	1-3	extensometer	no data	no data	100	-100	60,983	TRL (B. Stockings)
B0432004-101-116	33.6%	132-11	70	1,5	extensometer	no data	no data	70	-70	449,750	TRL (B. Stockings)
B0432004-101-118	33.4%	141-02	70	5	strain gage	32.2	no data	110	-110	45,510	UDRI (A. Hutson)
B0432004-101-118	33.2%	141-05	70	2	extensometer	31.2	32.7	120	-120	20,506	UDRI (A. Hutson)
B0432004-101-118	33.5%	141-06	70	1-5	extensometer	no data	no data	90	-90	279,084	TRL (B. Stockings)
B0432004-101-118	33.2%	141-08	70	5	extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-118	33.5%	141-09	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-118		141-10	70	5	extensometer			80	-80	87,672	UDRI (A. Hutson)
B0432004-101-118	33.7%	141-12	70	1-3	extensometer	no data	no data	120	-120	30,906	TRL (B. Stockings)
B0432004-101-118	33.7%	141-13	70	5	extensometer	27.9	27.6	70	-70	1,000,000	UDRI (A. Hutson)
B0432004-101-119	33.1%	142-10	70	1-3	extensometer	no data	no data	100	-100	51,498	TRL (B. Stockings)
B0432004-101-119	33.3%	142-11	70	5	extensometer	28.9	28.0	80	-80	294,366	UDRI (A. Hutson)
B0432004-101-121	33.5%	151-02	70	5	extensometer	no data	no data	100	-100	597,835	TRL (B. Stockings)
B0432004-101-121	33.4%	151-10	70	5	extensometer	31.9	32.6	80	-80	110,439	UDRI (A. Hutson)

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 3 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone	**SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$**
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09	
LOAD RATIO:	-1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(^oF)	(Hz)		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-123	33.3%	153-12	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-169	34.3%	511-01	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-169	33.6%	511-10	70	1	extensometer	28.7	28.3	120	-120	25,631	TRL (B. Stockings)
B0432004-101-169	33.3%	511-13	70	10	extensometer	no data	no data	70	-70	625,438	TRL (B. Stockings)
B0432004-101-171	34.3%	513-01	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-171	33.3%	513-04	70	1, 3	extensometer	31.8	32.3	100	-100	58,038	TRL (B. Stockings)
B0432004-101-171	33.3%	513-11	70	1, 3	extensometer	no data	no data	80	-80	278,185	TRL (B. Stockings)
B0432004-101-172	33.6%	521-03	70	1	extensometer	28.9	no data	120	-120	13,798	TRL (B. Stockings)
B0432004-101-172	33.2%	521-05	70	1,10	extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-172	33.3%	521-07	70	1	extensometer	29.7	29.0	100	-100	79,576	TRL (B. Stockings)
B0432004-101-172	33.5%	521-13	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-173	34.2%	522-02	70	1, 3	extensometer	27.3	27.6	80	-80	148,094	TRL (B. Stockings)
B0432004-101-173	34.6%	522-12	70	1	extensometer	30.2	30.7	120	-120	23,488	TRL (B. Stockings)
B0432004-101-175	34.5%	531-02	70	1,10	extensometer	no data	no data	70	-70	647,194	TRL (B. Stockings)
B0432004-101-175	33.4%	531-05	70	1	extensometer	29.4	29.2	100	-100	36,918	TRL (B. Stockings)
B0432004-101-175	33.1%	531-09	70	1, 3	extensometer	33.0	no data	80	-80	296,243	TRL (B. Stockings)
B0432004-101-175	33.5%	531-13	70	2	extensometer	28.7	28.7	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-176	34.7%	532-12	70	1	extensometer	30.2	no data	120	-120	19,641	TRL (B. Stockings)
B0432004-101-178	35.2%	541-01	70	1,10	extensometer	no data	no data	70	-70		TRL (B. Stockings)
B0432004-101-178	33.6%	541-04	70	1, 3	extensometer	30.8	no data	100	-100	67,113	TRL (B. Stockings)
B0432004-101-178	34.0%	541-09	70	1, 3	extensometer	29.2	no data	80	-80	371,395	TRL (B. Stockings)
B0432004-101-178	33.5%	541-12	70	1	extensometer	30.2	no data	120	-120	23,091	TRL (B. Stockings)
B0432004-101-179	34.2%	542-10	70	1,10	extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-179	34.6%	542-12	70	1, 3	extensometer	30.1	no data	100	-100	46,816	TRL (B. Stockings)
B0432004-101-181	34.3%	551-02	70	1, 3	extensometer	29.8	29.1	80	-80	285,590	TRL (B. Stockings)
B0432004-101-181	33.6%	551-05	70	5	extensometer	no data	no data	60	-60	1,000,000	UDRI (A. Hutson)
B0432004-101-199	33.8%	711-02	70	5	extensometer	no data	no data	120	-120	17,132	UDRI (A. Hutson)
B0432004-101-199	32.7%	711-08	70	1,10	extensometer	no data	no data	70	-70	202,783	TRL (B. Stockings)
B0432004-101-199	32.7%	711-13	70	2	extensometer			100	-100	22,172	UDRI (A. Hutson)

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 4 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**LONGITUDINAL**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09	
LOAD RATIO:	-1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	(Hz)		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-200	33.4%	712-09	70	1, 3, 5	extensometer	28.4	no data	60	-60	1,000,000	TRL (B. Stockings)
B0432004-101-200	33.2%	712-10	70	1, 3	extensometer	28.6	30.5	80	-80	121,487	TRL (B. Stockings)
B0432004-101-200	33.1%	712-11	70	5	extensometer	no data	no data	120	-120	18,241	UDRI (A. Hutson)
B0432004-101-201	34.2%	713-02	70	1,10	extensometer	no data	no data	70	-70	301,355	TRL (B. Stockings)
B0432004-101-201	33.5%	713-07	70	1, 3	extensometer	no data	no data	60	-60	1,000,000	TRL (B. Stockings)
B0432004-101-201	33.0%	713-11	70	5	extensometer	no data	no data	100	-100	40,587	UDRI (A. Hutson)
B0432004-101-201	33.0%	713-13	70	1, 3	extensometer	no data	no data	80	-80	54,280	TRL (B. Stockings)
B0432004-101-202	32.9%	721-01	70	1,10	extensometer	no data	no data	70	-70	637,658	TRL (B. Stockings)
B0432004-101-202	33.2%	721-11	70	5	extensometer	no data	no data	120	-120	20,691	UDRI (A. Hutson)
B0432004-101-202	33.1%	721-13	70	1, 3	extensometer	no data	no data	60	-60	859,305	TRL (B. Stockings)
B0432004-101-205	33.2%	731-03	70	1	extensometer	no data	no data	80	-80	229,679	TRL (B. Stockings)
B0432004-101-205	32.7%	731-05	70	5	extensometer	no data	no data	100	-100	43,362	UDRI (A. Hutson)
B0432004-101-205	32.7%	731-09	70	1,10	extensometer	no data	no data	70	-70	346,823	TRL (B. Stockings)
B0432004-101-205	33.0%	731-12	70	1, 3, 5	extensometer	31.8	31.7	60	-60	838,766	TRL (B. Stockings)
B0432004-101-208	33.8%	741-02	70	2	extensometer			120	-120	24,423	UDRI (A. Hutson)
B0432004-101-208	33.1%	741-04	70	1, 3	extensometer	28.9	27.7	80	-80	376,587	TRL (B. Stockings)
B0432004-101-208	32.9%	741-12	70	1,10	extensometer	no data	no data	70	-70	596,011	TRL (B. Stockings)
B0432004-101-208	33.1%	741-13	70	5	extensometer	no data	no data	100	-100	50,460	UDRI (A. Hutson)
B0432004-101-211	34.9%	751-02	70	5	extensometer	no data	no data	120	-120	21,188	UDRI (A. Hutson)
B0432004-101-211	33.4%	751-05	70	1, 3	extensometer	33.1	33.7	60	-60	950,562	TRL (B. Stockings)
B0432004-101-211	33.4%	751-09	70	5	extensometer	no data	no data	100	-100	32,447	UDRI (A. Hutson)
B0432004-101-211	33.4%	751-12	70	1, 3	extensometer	26.2	25.9	80	-80	300,232	TRL (B. Stockings)
	33.5%					**29.9**	**29.4**				
B0432004-101-124	34.2%	211-09	600		extensometer	no data	no data	110	-110	107,738	TRL (B. Stockings)
B0432004-101-124	34.2%	211-11	600	5	extensometer	no data	no data	100	-100	470,327	UDRI (A. Hutson)
B0432004-101-125	33.3%	212-10	600		extensometer	no data	no data	90	-90	306,774	TRL (B. Stockings)
B0432004-101-125	33.8%	212-11	600		extensometer	no data	no data	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-125	33.7%	212-12	600	5	extensometer	27.2	26.9	80	-80	495,131	UDRI (A. Hutson)
B0432004-101-135	33.4%	243-07	600		extensometer	no data	no data	110	-110	92,253	TRL (B. Stockings)

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 5 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone	**SCS-6 / Ti-6Al-4V**
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**LONGITUDINAL**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**FATIGUE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**$[0]_{16}$**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09	
LOAD RATIO:	-1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	(Hz)		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-135	33.5%	243-12	600	5	extensometer	25.6	25.8	100	-100	118,839	UDRI (A. Hutson)
B0432004-101-138	33.8%	253-02	600	5	extensometer	no data	no data	80	-80	424,310	UDRI (A. Hutson)
B0432004-101-138	33.2%	253-03	600		extensometer	no data	no data	90	-90	250,760	TRL (B. Stockings)
B0432004-101-138	33.5%	253-04	600		extensometer	no data	no data	70	-70	784,650	TRL (B. Stockings)
B0432004-101-130	32.9%	231-03	600	5	extensometer	no data	no data	100	-100	150,158	UDRI (A. Hutson)
B0432004-101-130	32.9%	231-08	600		extensometer	no data	no data	110	-110	107,405	TRL (B. Stockings)
B0432004-101-130	33.2%	231-10	600		extensometer	no data	no data	90	-90	274,267	TRL (B. Stockings)
B0432004-101-130	32.9%	231-11	600	5	extensometer	no data	no data	80	-80	348,944	UDRI (A. Hutson)
B0432004-101-130	33.0%	231-12	600		extensometer	no data	no data	70	-70	614,439	TRL (B. Stockings)
B0432004-101-130	33.1%	231-13	600	5	extensometer	no data	no data	100	-100	156,709	UDRI (A. Hutson)
B0432004-101-133	33.1%	241-01	600	5	extensometer	no data	no data	80	-80	361,633	UDRI (A. Hutson)
B0432004-101-133	33.3%	241-02	600		extensometer	23.7	23.0	110	-110	90,691	TRL (B. Stockings)
B0432004-101-133	33.1%	241-04	600		extensometer	27.8	26.7	90	-90	305,367	TRL (B. Stockings)
B0432004-101-133	33.4%	241-07	600	5	extensometer	no data	no data	100	-100	155,603	UDRI (A. Hutson)
B0432004-101-133	33.4%	241-10	600		extensometer	25.1	25.8	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-133	33.3%	241-12	600		extensometer	26.2	24.7	110	-110	88,894	TRL (B. Stockings)
B0432004-101-136	33.0%	251-02	600	5	extensometer	no data	no data	80	-80	443,608	UDRI (A. Hutson)
B0432004-101-136	33.4%	251-11	600		extensometer	27.1	25.8	90	-90	258,241	TRL (B. Stockings)
B0432004-101-136	33.5%	251-12	600		extensometer	27.4	26.5	70	-70	1,000,000	TRL (B. Stockings)
B0432004-101-154	33.3%	411-08	600	5	extensometer	no data	no data	110	-110	79,162	TRL (B. Stockings)
B0432004-101-154	33.5%	411-09	600	5	extensometer	no data	no data	100	-100	139,864	TRL (B. Stockings)
B0432004-101-154	32.9%	411-13	600	5	extensometer	no data	no data	90	-90	225,165	TRL (B. Stockings)
B0432004-101-155	32.8%	412-08	600	5	extensometer	no data	no data	70	-70	647,321	TRL (B. Stockings)
B0432004-101-155	32.8%	412-11	600	5	extensometer	no data	no data	80	-80	373,420	UDRI (A. Hutson)
B0432004-101-157	32.8%	421-07	600	5	extensometer	no data	no data	100	-100	94,743	TRL (B. Stockings)
B0432004-101-157	32.8%	421-11	600	5	extensometer	no data	no data	100	-100	115,737	TRL (B. Stockings)
B0432004-101-157	33.2%	421-13	600	5	extensometer	no data	no data	90	-90	157,958	TRL (B. Stockings)
B0432004-101-158	34.2%	422-01	600	5	extensometer	no data	no data	70	-70	760,863	TRL (B. Stockings)
B0432004-101-158	33.0%	422-10	600	5	extensometer	no data	no data	80	-80	383,713	UDRI (A. Hutson)

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 6 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09
LOAD RATIO:	-1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp. (°F)	Frequency (Hz)	Strain Sensor	E_1^t at N=1 (Msi)	E_1^t at N=Nf/2 (Msi)	σ_{max} (ksi)	σ_{min} (ksi)	Nf	Test Facility
B0432004-101-160	33.6%	431-02	600	5	extensometer	no data	no data	110	-110	74,268	TRL (B. Stockings)
B0432004-101-160	33.2%	431-09	600	5	extensometer	no data	no data	100	-100	120,419	TRL (B. Stockings)
B0432004-101-160	34.3%	431-11	600	5	extensometer	no data	no data	90	-90	230,611	TRL (B. Stockings)
B0432004-101-161	33.3%	432-04	600	5	extensometer	no data	no data	70	-70	517,295	TRL (B. Stockings)
B0432004-101-161	32.8%	432-06	600	5	extensometer	no data	no data	80	-80	250,594	UDRI (A. Hutson)
B0432004-101-163	34.3%	441-02	600	5	extensometer	no data	no data	110	-110	87,745	TRL (B. Stockings)
B0432004-101-163	33.1%	441-09	600	5	extensometer	26.1	25.2	100	-100	134,875	TRL (B. Stockings)
B0432004-101-163	33.5%	441-12	600	5	extensometer	25.1	24.5	90	-90	217,108	TRL (B. Stockings)
B0432004-101-164	34.8%	442-02	600	5	extensometer	25.4	25.6	70	-70	706,221	TRL (B. Stockings)
B0432004-101-164	33.4%	442-05	600	5	extensometer	no data	no data	80	-80	357,972	UDRI (A. Hutson)
B0432004-101-166	33.7%	451-04	600	5	extensometer	24.6	23.8	110	-110	73,713	TRL (B. Stockings)
B0432004-101-166	34.1%	451-08	600	5	extensometer	24.8	21.7	100	-100	89,511	TRL (B. Stockings)
B0432004-101-166	34.4%	451-12	600	5	extensometer	25.3	24.3	90	-90	183,727	TRL (B. Stockings)
B0432004-101-167	33.5%	452-08	600	5	extensometer	24.2	23.9	70	-70	476,175	TRL (B. Stockings)
B0432004-101-167	33.4%	452-11	600	5	extensometer	25.2	24.1	80	-80	275,411	UDRI (A. Hutson)
B0432004-101-184	33.1%	611-03	600	5	extensometer	no data	no data	110	-110	33,911	UDRI (A. Hutson)
B0432004-101-184	33.1%	611-06	600	5	extensometer	no data	no data	100	-100	49,268	TRL (B. Stockings)
B0432004-101-184	33.2%	611-12	600	5	extensometer	no data	no data	90	-90	67,906	UDRI (A. Hutson)
B0432004-101-186	33.2%	613-01	600	5	extensometer	no data	no data	80	-80	172,745	TRL (B. Stockings)
B0432004-101-186	32.0%	613-03	600	5	extensometer	no data	no data	70	-70	264,383	TRL (B. Stockings)
B0432004-101-186	32.6%	613-07	600	5	extensometer	no data	no data	110	-110	39,606	UDRI (A. Hutson)
B0432004-101-186	33.2%	613-12	600	5	extensometer	no data	no data	108	-108	30,978	TRL (B. Stockings)
B0432004-101-187	33.0%	621-05	600	5	extensometer	no data	no data	80	-80	237,937	TRL (B. Stockings)
B0432004-101-187	33.4%	621-06	600	5	extensometer	no data	no data	90	-90	125,452	UDRI (A. Hutson)
B0432004-101-187	33.6%	621-09	600	5	extensometer	no data	no data	70	-70	468,676	TRL (B. Stockings)
B0432004-101-190	32.5%	631-01	600	5	extensometer	no data	no data	100	-100	43,695	TRL (B. Stockings)
B0432004-101-190	33.5%	631-05	600	5	extensometer	no data	no data	110	-110	19,939	UDRI (A. Hutson)
B0432004-101-190	33.6%	631-08	600	5	extensometer	no data	no data	80	-80	151,590	TRL (B. Stockings)
B0432004-101-190	33.7%	631-13	600	5	extensometer	no data	no data	70	-70	283,217	TRL (B. Stockings)

Table E2 – Longitudinal R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 7 of 7)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Oct 06 - Apr 09
LOAD RATIO:	-1		

SCS-6 / Ti-6Al-4V LONGITUDINAL FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	(Hz)		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-191	33.0%	632-01	600	5	extensometer	26.7	26.8	90	-90	124,015	UDRI (A. Hutson)
B0432004-101-191	33.0%	632-02	600	5	extensometer	24.6	24.4	100	-100	35,014	TRL (B. Stockings)
B0432004-101-191	34.1%	632-12	600	5	extensometer	24.8	24.5	80	-80	107,249	TRL (B. Stockings)
B0432004-101-193	33.1%	641-04	600	5	extensometer	26.7	26.6	110	-110	31,589	UDRI (A. Hutson)
B0432004-101-193	33.5%	641-07	600	5	extensometer	25.6	25.8	70	-70	190,637	TRL (B. Stockings)
B0432004-101-193	33.8%	641-09	600	5	extensometer	no data	no data	90	-90	112,743	UDRI (A. Hutson)
B0432004-101-193	32.5%	641-11	600	5	extensometer	no data	no data	110	-110	35,907	UDRI (A. Hutson)
B0432004-101-194	33.5%	642-01	600	5	extensometer	24.6	25.2	100	-100	42,772	TRL (B. Stockings)
B0432004-101-196	33.4%	651-03	600	5	extensometer	25.3	25.3	80	-80	186,901	TRL (B. Stockings)
B0432004-101-196	33.5%	651-07	600	5	extensometer	no data	no data	90	-90	112,075	UDRI (A. Hutson)
B0432004-101-196	32.7%	651-11	600	5	extensometer	26.4	25.8	70	-70	288,986	TRL (B. Stockings)
AVERAGE	**33.3%**					**25.7**	**no data**				

Compiled By:
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
May-09

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value

Table E3 – Transverse R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 1 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Sep 06 - Apr 09
LOAD RATIO:	0.1		

SCS-6 / Ti-6Al-4V TRANSVERSE FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-185	33.6%	612-08	-65	1, 3	extensometer	20.2	19.9	38.0	3.8	96,418	TRL (B. Stockings)
B0432004-101-185	33.7%	612-10	-65	1, 3, 15	extensometer	20.7	21.1	35.0	3.5	789,988	TRL (B. Stockings)
B0432004-101-188	33.9%	622-12	-65	1, 3, 15	extensometer	21.0	20.9	32.0	3.2	1,000,000	TRL (B. Stockings)
B0432004-101-189	33.9%	623-07	-65	1, 3, 15	extensometer	20.9	21.0	29.0	2.9	1,000,000	TRL (B. Stockings)
B0432004-101-189	33.9%	623-09	-65	1, 3, 15	extensometer	20.4	20.7	26.0	2.6	1,000,000	TRL (B. Stockings)
B0432004-101-191	33.0%	632-03	-65	1, 3	extensometer	19.7	18.3	38.0	3.8	102,209	TRL (B. Stockings)
B0432004-101-192	33.7%	633-06	-65	1, 3, 15	extensometer	19.8	19.4	35.0	3.5	234,612	TRL (B. Stockings)
B0432004-101-192	33.8%	633-08	-65	1, 3, 15	extensometer	19.5	19.7	32.0	3.2	1,000,000	TRL (B. Stockings)
B0432004-101-194	34.0%	642-03	-65	1, 3, 15	extensometer	19.7	19.8	29.0	2.9	1,000,000	TRL (B. Stockings)
B0432004-101-194	34.2%	642-05	-65	1, 3	extensometer	22.7	no data	26.0	2.6		TRL (B. Stockings)
B0432004-101-195	33.1%	643-01	-65	1, 3	extensometer	18.8	18.2	38.0	3.8	42,202	TRL (B. Stockings)
B0432004-101-195	33.6%	643-03	-65	1, 3, 15	extensometer	20.9	20.7	35.0	3.5	1,000,000	TRL (B. Stockings)
B0432004-101-195	33.9%	643-06	-65	1, 3, 15	extensometer	20.1	20.0	32.0	3.2	1,000,000	TRL (B. Stockings)
B0432004-101-195	33.5%	643-09	-65	1, 3, 10	extensometer	20.0	22.2	26.0	2.6	751,006	TRL (B. Stockings)
B0432004-101-197	34.2%	652-04	-65	1, 3, 5	extensometer	22.9	21.6	29.0	2.9	1,000,000	TRL (B. Stockings)
B0432004-101-197	34.3%	652-06	-65	1, 3, 5	extensometer	19.9	20.9	26.0	2.6	1,000,000	TRL (B. Stockings)
	33.8%										
B0432004-101-111	33.6%	113-04	70	1-20	extensometer	20.8	21.4	28	2.8	699,244	TRL (B. Stockings)
B0432004-101-111	34.0%	113-06	70	20	extensometer	22.5	21.2	34	3.4	91,240	UDRI (A. Hutson)
B0432004-101-114	33.4%	123-02	70	1-20	extensometer	22.9	22.8	28	2.8	316,860	TRL (B. Stockings)
B0432004-101-114	33.5%	123-04	70	20	extensometer	20.2	20.2	25	2.5	1,000,000	UDRI (A. Hutson)
B0432004-101-114	33.5%	123-06	70	20	extensometer	no data	no data	31	3.1	163,752	TRL (B. Stockings)
B0432004-101-117	33.3%	133-06	70	1-20	extensometer	22.6	22.4	28	2.8	157,706	TRL (B. Stockings)
B0432004-101-117	33.1%	133-10	70	20	extensometer	20.0	19.7	34	3.4	171,377	UDRI (A. Hutson)
B0432004-101-120	33.3%	143-02	70	1-20	extensometer	23.4	23.0	37	3.7	30,359	TRL (B. Stockings)
B0432004-101-120	34.0%	143-05	70	20	extensometer	22.5	22.1	25	2.5	1,000,000	UDRI (A. Hutson)
B0432004-101-120	33.5%	143-09	70	20	extensometer	no data	no data	31	3.1	1,000,000	TRL (B. Stockings)
B0432004-101-122	34.4%	152-08	70	1-20	extensometer	23.3	23.3	37	3.7	32,682	TRL (B. Stockings)
B0432004-101-122	34.2%	152-10	70	20	extensometer	20.0	20.1	34	3.4	1,000,000	UDRI (A. Hutson)
B0432004-101-123	33.1%	153-03	70	20	extensometer	no data	no data	31	3.1	72,376	TRL (B. Stockings)

Table E3 – Transverse R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 2 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Sep 06 - Apr 09
LOAD RATIO:	0.1		

SCS-6 / Ti-6Al-4V TRANSVERSE FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(^oF)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-123	32.7%	153-05	70	20	extensometer	19.8	19.8	25	2.5	1,000,000	UDRI (A. Hutson)
B0432004-101-123	32.8%	153-08	70	1-20	extensometer	22.7	21.8	37	3.7	11,793	TRL (B. Stockings)
B0432004-101-125	34.1%	212-06	70	1-20	extensometer	no data	no data	34	3.4	89,546	TRL (B. Stockings)
B0432004-101-125	33.8%	212-08	70	1-20	extensometer	no data	no data	28	2.8	1,000,000	TRL (B. Stockings)
B0432004-101-126	33.2%	213-09	70	20	extensometer	20.2	19.2	37	3.7	17,190	UDRI (A. Hutson)
B0432004-101-126	33.0%	213-11	70	1-20	extensometer	no data	no data	25	2.5	1,000,000	TRL (B. Stockings)
B0432004-101-138	33.3%	253-08	70	1-20	extensometer	no data	no data	34	3.4	67,693	TRL (B. Stockings)
B0432004-101-138	33.6%	253-11	70	20	extensometer			31	3.1	709,192	UDRI (A. Hutson)
B0432004-101-131	33.9%	232-09	70	1-20	extensometer	no data	no data	28	2.8	635,121	TRL (B. Stockings)
B0432004-101-131	33.6%	232-04	70	20	extensometer	19.9	20.0	37	3.7	41,094	UDRI (A. Hutson)
B0432004-101-132	33.6%	233-07	70	20	extensometer	20.1	20.0	31	3.1	864,579	UDRI (A. Hutson)
B0432004-101-132	33.4%	233-11	70	1-20	extensometer	no data	no data	25	2.5	1,000,000	TRL (B. Stockings)
B0432004-101-134	33.3%	242-08	70	1-20	extensometer	no data	no data	34	3.4	146,155	TRL (B. Stockings)
B0432004-101-134	33.6%	242-06	70	20	extensometer	20.4	19.9	37	3.7	41,911	UDRI (A. Hutson)
B0432004-101-136	33.2%	251-03	70	1-20	extensometer	no data	no data	28	2.8	161,134	TRL (B. Stockings)
B0432004-101-137	33.2%	252-07	70	1-20	extensometer	no data	no data	25	2.5	1,000,000	TRL (B. Stockings)
B0432004-101-137	33.2%	252-09	70	20	extensometer	20.9	20.5	31	3.1	1,000,000	UDRI (A. Hutson)
B0432004-101-170	33.7%	512-07	70	1-20	extensometer	no data	no data	37	3.7	12,393	TRL (B. Stockings)
B0432004-101-173	33.1%	522-03	70	1-20	extensometer	no data	no data	34	3.4	58,465	TRL (B. Stockings)
B0432004-101-173	34.6%	522-09	70	20	extensometer	20.9	21.7	28	2.8	1,000,000	UDRI (A. Hutson)
B0432004-101-173	33.9%	522-10	70	1-20	extensometer	no data	no data	23	2.3	1,000,000	TRL (B. Stockings)
B0432004-101-174	33.6%	523-08	70	1-20	extensometer	no data	no data	25	2.5	1,000,000	TRL (B. Stockings)
B0432004-101-176	34.1%	532-05	70	1-20	extensometer	no data	no data	37	3.7	6,057	TRL (B. Stockings)
B0432004-101-176	34.2%	532-09	70	1-20	extensometer	no data	no data	34	3.4	26,157	TRL (B. Stockings)
B0432004-101-177	33.9%	533-02	70	1-20	extensometer	no data	no data	31	3.1	58,513	TRL (B. Stockings)
B0432004-101-177	34.0%	533-06	70	20	extensometer	22.2	no data	28	2.8	1,000,000	UDRI (A. Hutson)
B0432004-101-179	34.8%	542-05	70	1-20	extensometer	no data	no data	25	2.5	561,403	TRL (B. Stockings)
B0432004-101-179	34.4%	542-07	70	1-20	extensometer	no data	no data	37	3.7	88,392	TRL (B. Stockings)
B0432004-101-179	33.2%	542-08	70	20	extensometer			31	3.1	43,524	TRL (B. Stockings)
B0432004-101-180	33.5%	543-03	70	20	extensometer	21.0	20.4	28	2.8	1,000,000	UDRI (A. Hutson)

Table E3 – Transverse R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 3 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	**SCS-6 / Ti-6Al-4V TRANSVERSE FATIGUE $[0]_{16}$**
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Sep 06 - Apr 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-180	33.8%	543-06	70	1-20	extensometer	no data	no data	34	3.4	230,489	TRL (B. Stockings)
B0432004-101-183	33.7%	553-02	70	1-20	extensometer	no data	no data	31	3.1	218,954	TRL (B. Stockings)
B0432004-101-183	34.4%	553-06	70	1-10	extensometer	no data	no data	25	2.5	1,000,000	TRL (B. Stockings)
	33.6%					**21.3**	**21.0**				
B0432004-101-141	32.7%	313-07	600	1,3,20	extensometer	18.7	17.7	24.0	2.4	1,000,000	TRL (B. Stockings)
B0432004-101-143	33.9%	322-03	600	5, 20	extensometer	17.4	17.2	21.0	2.1	114,628	UDRI (A. Hutson)
B0432004-101-144	32.8%	323-02	600	5, 20	extensometer	17.6	17.2	12.0	1.2	1,000,000	UDRI (A. Hutson)
B0432004-101-144	33.1%	323-06	600	1	extensometer	17.1	15.5	30.0	3.0	12,337	TRL (B. Stockings)
B0432004-101-146	33.4%	332-04	600	20	extensometer			21.0	2.1	1,000,000	UDRI (A. Hutson)
B0432004-101-146	33.5%	332-07	600	1	extensometer	21.5	20.3	27.0	2.7	41,732	TRL (B. Stockings)
B0432004-101-147	33.2%	333-05	600	1,3,20	extensometer	19.6	19.6	24.0	2.4	1,000,000	TRL (B. Stockings)
B0432004-101-147	33.1%	333-07	600	20	extensometer			12.0	1.2	1,000,000	UDRI (A. Hutson)
B0432004-101-149	33.3%	342-08	600	1	extensometer	20.3	19.3	30.0	3.0	12,369	TRL (B. Stockings)
B0432004-101-149	33.4%	342-10	600	1	extensometer	22.2	21.7	27.0	2.7	39,232	TRL (B. Stockings)
B0432004-101-150	33.1%	343-03	600	20	extensometer	no data	no data	21.0	2.1	no data	UDRI (A. Hutson)
B0432004-101-150	33.0%	343-07	600	1,3,20	extensometer	19.5	no data	24.0	2.4	no data	TRL (B. Stockings)
B0432004-101-152	33.2%	352-09	600	1	extensometer	18.0	17.6	30.0	3.0	11,903	TRL (B. Stockings)
B0432004-101-153	33.6%	353-02	600	20	extensometer			12.0	1.2	1,000,000	UDRI (A. Hutson)
B0432004-101-153	33.2%	353-04	600	1	extensometer	19.5	no data	27.0	2.7	204,988	TRL (B. Stockings)
B0432004-101-200	33.0%	712-04	600	1,3,20	extensometer	21.3	no data	24.0	2.4	1,000,000	TRL (B. Stockings)
B0432004-101-200	33.0%	712-06	600	1,3	extensometer	17.8	17.3	27.0	2.7	50,895	TRL (B. Stockings)
B0432004-101-200	32.6%	712-08	600	1	extensometer	21.7	17.2	30.0	3.0	11,032	TRL (B. Stockings)
B0432004-101-204	33.6%	723-07	600	1,20	extensometer	19.0	18.4	21.0	2.1	1,000,000	TRL (B. Stockings)
B0432004-101-204	33.6%	723-09	600	1,3,20	extensometer	19.2	17.8	24.0	2.4	1,000,000	TRL (B. Stockings)
B0432004-101-204	33.8%	723-10	600	1	extensometer	17.1	17.1	27.0	2.7	23,758	TRL (B. Stockings)
B0432004-101-206	33.2%	732-08	600	1	extensometer	17.7	16.7	30.0	3.0	12,324	TRL (B. Stockings)
B0432004-101-207	33.0%	733-06	600	20	extensometer	no data	no data	18.0	1.8	1,000,000	UDRI (A. Hutson)
B0432004-101-207	32.6%	733-08	600	1,3,20	extensometer	24.7	no data	21.0	2.1	1,000,000	TRL (B. Stockings)
B0432004-101-207	32.5%	733-09	600	1,3	extensometer	19.7	19.5	24.0	2.4	93,377	TRL (B. Stockings)
B0432004-101-209	33.7%	742-03	600	5,20	extensometer	17.0	16.9	15.0	1.5	1,000,000	UDRI (A. Hutson)

Table E3 – Transverse R=0.1 Fatigue Data of SCS-6/Ti6Al-4V (Table 4 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**TRANSVERSE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Sep 06 - Apr 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-209	33.8%	742-05	600	1	extensometer	21.3	no data	27.0	2.7	20,219	TRL (B. Stockings)
B0432004-101-209	33.1%	742-10	600	1,20	extensometer	16.2	no data	30.0	3.0	9,467	TRL (B. Stockings)
B0432004-101-212	33.2%	752-05	600	20	extensometer			15.0	1.5	1,000,000	UDRI (A. Hutson)
B0432004-101-212	33.1%	752-09	600	1,3,20	extensometer	19.5	19.1	21.0	2.1	1,000,000	TRL (B. Stockings)
B0432004-101-215	34.9%	812-10	600	5	extensometer	16.1	15.5	24.0	2.4	21,327	UDRI (A. Hutson)
B0432004-101-218	34.8%	822-04	600	20	extensometer	no data	no data	18.0	1.8	1,000,000	UDRI (A. Hutson)
B0432004-101-218	33.5%	822-08	600	1,3,20	extensometer	18.0	17.7	21.0	2.1	1,000,000	TRL (B. Stockings)
B0432004-101-219	33.6%	823-06	600	1,3	extensometer	20.0	19.6	27.0	2.7	105,368	TRL (B. Stockings)
B0432004-101-219	33.7%	823-08	600	20	extensometer	no data	no data	24.0	2.4	76,754	UDRI (A. Hutson)
B0432004-101-221	33.7%	832-08	600	1	extensometer	18.9	18.1	30.0	3.0	7,519	TRL (B. Stockings)
B0432004-101-221	34.1%	832-10	600	1,3,20	extensometer	18.4	18.5	21.0	2.1	1,000,000	TRL (B. Stockings)
B0432004-101-222	34.9%	833-02	600	5,20	extensometer	18.3	18.7	18.0	1.8	1,000,000	UDRI (A. Hutson)
B0432004-101-224	33.0%	842-03	600	1,3	extensometer	18.7	18.6	27.0	2.7	91,357	TRL (B. Stockings)
B0432004-101-224	33.4%	842-09	600	1	extensometer	18.5	17.6	30.0	3.0	23,016	TRL (B. Stockings)
B0432004-101-225	33.8%	843-02	600	5,20	extensometer			24.0	2.4	1,000,000	UDRI (A. Hutson)
B0432004-101-225	33.9%	843-05	600	1,20	extensometer	16.0	no data	21.0	2.1	1,000,000	TRL (B. Stockings)
B0432004-101-227	32.9%	852-07	600	1,20	extensometer	19.4	no data	27.0	2.7	47,442	TRL (B. Stockings)
B0432004-101-228	33.2%	853-04	600	5	extensometer	17.0	17.1	18.0	1.8	100,000	UDRI (A. Hutson)
B0432004-101-228	33.1%	853-07	600	1,20	extensometer	21.4	no data	30.0	3.0	18,537	TRL (B. Stockings)
AVERAGE	**33.4%**					**19.0**	**18.0**				

Compiled By:
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
May-09

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value

Table E4 – Transverse R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 1 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**TRANSVERSE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Nov 06 - Apr 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-156	34.2%	413-06	-65	1, 3	extensometer	22.4	21.7	35.0	-35	44,102	TRL (B. Stockings)
B0432004-101-156	34.8%	413-08	-65	1	extensometer	23.7	22.7	32.0	-32	47,214	TRL (B. Stockings)
B0432004-101-159	33.1%	423-04	-65	1, 5	extensometer	22.6	24.0	29.0	-29	230,630	TRL (B. Stockings)
B0432004-101-159	33.1%	423-06	-65	1, 5	extensometer	19.9	20.4	26.0	-26	678,678	TRL (B. Stockings)
B0432004-101-159	33.0%	423-08	-65	1, 3, 5	extensometer	20.0	20.4	23.0	-23	1,000,000	TRL (B. Stockings)
B0432004-101-162	33.1%	433-04	-65	1, 3	extensometer	21.4	21.5	35.0	-35	37,785	TRL (B. Stockings)
B0432004-101-162	33.0%	433-05	-65	1, 3	extensometer	23.1	25.9	32.0	-32	113,903	TRL (B. Stockings)
B0432004-101-162	33.1%	433-07	-65	1, 5	extensometer	20.1	20.3	29.0	-29	96,263	TRL (B. Stockings)
B0432004-101-165	34.0%	443-01	-65	1, 5	extensometer	21.4	21.5	26.0	-26	121,654	TRL (B. Stockings)
B0432004-101-165	34.2%	443-02	-65	1, 3, 5	extensometer	18.6	18.6	23.0	-23	1,000,000	TRL (B. Stockings)
B0432004-101-165	33.6%	443-05	-65	1, 3	extensometer	21.2	no data	35.0	-35	42,955	TRL (B. Stockings)
B0432004-101-165	33.4%	443-06	-65	1, 3	extensometer	no data	no data	32.0	-32	102,924	TRL (B. Stockings)
B0432004-101-168	34.2%	453-04	-65	1, 5	extensometer	21.3	21.1	29.0	-29	169,658	TRL (B. Stockings)
B0432004-101-168	33.7%	453-08	-65	1, 3, 5	extensometer	18.1	20.4	26.0	-26	873,808	TRL (B. Stockings)
B0432004-101-168	33.9%	453-12	-65	1, 3, 5	extensometer	18.0	19.1	23.0	-23	1,000,000	TRL (B. Stockings)
	33.6%										
B0432004-101-111	33.9%	113-05	70	5	strain gage	no data	no data	29	-29	31,893	UDRI (A. Hutson)
B0432004-101-111	33.8%	113-07	70	1-5	extensometer	no data	no data	23	-23	156,758	TRL (B. Stockings)
B0432004-101-114	33.3%	123-03	70	1-5	extensometer	no data	no data	26	-26	70,870	TRL (B. Stockings)
B0432004-101-114		123-07	70	5	extensometer	no data	no data	20	-20	122,964	UDRI (A. Hutson)
B0432004-101-117	33.1%	133-07	70	1-5	extensometer	no data	no data	32	-32	12,984	TRL (B. Stockings)
B0432004-101-117	33.0%	133-11	70	1-5	extensometer	no data	no data	23	-23	253,585	TRL (B. Stockings)
B0432004-101-117	33.1%	133-12	70	5	strain gage	21.1	18.1	29	-29	41,728	UDRI (A. Hutson)
B0432004-101-120	33.5%	143-06	70	1-5	extensometer	no data	no data	26	-26	110,133	TRL (B. Stockings)
B0432004-101-120	33.5%	143-07	70	1-5	extensometer	no data	no data	32	-32	12,664	TRL (B. Stockings)
B0432004-101-120		143-10	70	5	extensometer	no data	no data	29	-29	27,112	UDRI (A. Hutson)
B0432004-101-122	33.7%	152-07	70	5	extensometer	20.9	20.6	20	-20	1,000,000	UDRI (A. Hutson)
B0432004-101-122	34.2%	152-09	70	1-5	extensometer	no data	no data	23	-23	328,834	TRL (B. Stockings)
B0432004-101-123		153-04	70	5	extensometer	no data	no data	20	-20	1,000,000	UDRI (A. Hutson)

Table E4 – Transverse R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 2 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**TRANSVERSE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Nov 06 - Apr 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-123	33.1%	153-06	70	1-5	extensometer	no data	no data	26	-26	172,894	TRL (B. Stockings)
B0432004-101-123	33.0%	153-10	70	1-5	extensometer	no data	no data	32	-32	36,211	TRL (B. Stockings)
B0432004-101-125	34.6%	212-04	70	1-3	extensometer	no data	no data	32	-32	26,923	TRL (B. Stockings)
B0432004-101-125	34.0%	212-07	70	1-3	extensometer	20.2	20.5	29	-29	107,821	TRL (B. Stockings)
B0432004-101-126	33.3%	213-10	70	1, 3, 5	extensometer	20.9	21.5	26	-26	182,763	TRL (B. Stockings)
B0432004-101-126	33.0%	213-12	70	1, 3, 5	extensometer	20.5	19.7	20	-20	1,000,000	TRL (B. Stockings)
B0432004-101-131	33.8%	232-11	70	1-3	extensometer	19.3	19.0	29	-29	24,729	TRL (B. Stockings)
B0432004-101-131	34.0%	232-06	70	5	extensometer			23	-23	1,000,000	UDRI (A. Hutson)
B0432004-101-131	34.1%	232-08	70	1-3	extensometer	no data	no data	**32**	**-32**	**31,875**	TRL (B. Stockings)
B0432004-101-132	33.7%	233-09	70	1, 3, 5	extensometer	19.3	no data	26	-26	66,444	TRL (B. Stockings)
B0432004-101-132	33.2%	233-12	70	1, 3, 5	extensometer	19.6	19.3	20	-20	1,000,000	TRL (B. Stockings)
B0432004-101-134	33.2%	242-10	70	1-5	extensometer	20.9	no data	29	-29	41,154	TRL (B. Stockings)
B0432004-101-134	33.6%	242-05	70	2, 5	extensometer			23	-23	1,000,000	UDRI (A. Hutson)
B0432004-101-134	33.8%	242-07	70	1-3	extensometer	no data	no data	**32**	**-32**	**16,801**	TRL (B. Stockings)
B0432004-101-136	33.4%	251-05	70	1	extensometer	22.4	23.1	26	-26	43,706	TRL (B. Stockings)
B0432004-101-137	33.0%	252-08	70	1-5	extensometer	19.4	no data	20	-20	1,000,000	TRL (B. Stockings)
B0432004-101-170	34.2%	512-09	70	5	extensometer	no data	no data	**32**	**-32**	**36,040**	UDRI (A. Hutson)
B0432004-101-173	34.2%	522-05	70	1, 3	extensometer	18.9	18.3	29	-29	66,336	TRL (B. Stockings)
B0432004-101-174	33.1%	523-07	70	5	extensometer	no data	no data	26	-26	63,011	UDRI (A. Hutson)
B0432004-101-174	34.1%	523-09	70	1, 3, 5	extensometer	19.4	19.5	20	-20	590,927	TRL (B. Stockings)
B0432004-101-176	33.9%	532-03	70	1, 3	extensometer	22.0	23.0	29	-29	21,940	TRL (B. Stockings)
B0432004-101-176	34.3%	532-07	70	2	extensometer	no data	no data	**32**	**-32**	**18,398**	UDRI (A. Hutson)
B0432004-101-177	34.0%	533-04	70	1, 3, 5	extensometer	23.7	20.3	23	-23	501,458	TRL (B. Stockings)
B0432004-101-177	33.8%	533-08	70	1, 3, 5	extensometer	20.0	20.4	20	-20	1,000,000	TRL (B. Stockings)
B0432004-101-179	34.3%	542-04	70	5	extensometer	no data	no data	26	-26	90,672	UDRI (A. Hutson)
B0432004-101-179	34.4%	542-06	70	1, 5	extensometer	22.7	no data	29	-29	46,796	TRL (B. Stockings)
B0432004-101-180	33.4%	543-04	70	1, 3, 5	extensometer	19.2	17.8	23	-23	258,314	TRL (B. Stockings)
B0432004-101-180	33.5%	543-07	70	2	extensometer	no data	no data	**32**	**-32**	**36,049**	UDRI (A. Hutson)
B0432004-101-183	33.8%	553-03	70	1, 5	extensometer	20.3	no data	20	-20	1,000,000	TRL (B. Stockings)

Table E4 – Transverse R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 3 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone	
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)	**SCS-6 / Ti-6Al-4V**
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)	**TRANSVERSE**
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)	**FATIGUE**
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating	**$[0]_{16}$**
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Nov 06 - Apr 09	
LOAD RATIO:	0.1			

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-183	34.3%	553-05	70	2, 5	extensometer	no data	no data	26	-26	372,568	UDRI (A. Hutson)
	33.7%					**20.6**	**20.1**				
B0432004-101-141	33.0%	313-08	600	1,3,5	extensometer	19.0	19.7	20.0	-20.0	22,982	TRL (B. Stockings)
B0432004-101-143	34.3%	322-10	600	5	extensometer	no data	no data	17.5	-17.5	161,229	UDRI (A. Hutson)
B0432004-101-144	32.7%	323-04	600	5	extensometer	17.6	17.8	10.0	-10.0	1,000,000	UDRI (A. Hutson)
B0432004-101-144	32.9%	323-08	600	1,3,5	extensometer	17.2	no data	15.0	-15.0	1,000,000	TRL (B. Stockings)
B0432004-101-146	33.5%	332-05	600	5	extensometer	no data	no data	17.5	-17.5	1,000,000	UDRI (A. Hutson)
B0432004-101-146	33.8%	332-08	600	1,3,5	extensometer	18.2	17.4	12.5	-12.5	1,000,000	TRL (B. Stockings)
B0432004-101-147	32.7%	333-06	600	1,3,5	extensometer	17.1	17.8	20.0	-20.0	123,029	TRL (B. Stockings)
B0432004-101-149	33.6%	342-09	600	5	extensometer	no data	no data	10.0	-10.0	1,000,000	UDRI (A. Hutson)
B0432004-101-149	33.5%	342-12	600	1,3,5	extensometer	15.7	16.6	15.0	-15.0	1,000,000	TRL (B. Stockings)
B0432004-101-150	33.2%	343-06	600	1,3,5	extensometer	17.8	no data	12.5	-12.5	1,000,000	TRL (B. Stockings)
B0432004-101-150	33.4%	343-09	600	5	extensometer			17.5	-17.5	1,000,000	UDRI (A. Hutson)
B0432004-101-152	33.2%	352-04	600	1,3	extensometer	15.5	no data	20.0	-20.0	1,000,000	TRL (B. Stockings)
B0432004-101-152	33.2%	352-09	600	1,3,5	extensometer	18.3	17.9	15.0	-15.0	11,903	TRL (B. Stockings)
B0432004-101-153	33.7%	353-03	600	5	extensometer	no data	no data	10.0	-10.0	1,000,000	UDRI (A. Hutson)
B0432004-101-153	34.6%	353-08	600	1,3,5	extensometer	18.0	18.3	12.5	-12.5	1,000,000	TRL (B. Stockings)
B0432004-101-188	33.9%	622-08	600	1,3,5	extensometer	18.6	no data	20.0	-20.0	137,855	TRL (B. Stockings)
B0432004-101-188	33.9%	622-09	600	5	extensometer	no data	no data	12.5	-12.5	1,000,000	UDRI (A. Hutson)
B0432004-101-188	33.9%	622-11	600	1,3,5	extensometer	19.1	no data	17.5	-17.5	1,000,000	TRL (B. Stockings)
B0432004-101-191	33.6%	632-04	600	1,3,5	extensometer	19.0	no data	15.0	-15.0	1,000,000	TRL (B. Stockings)
B0432004-101-191	34.3%	632-05	600	1,3,5	extensometer	17.5	no data	10.0	-10.0	1,000,000	UDRI (A. Hutson)
B0432004-101-191	33.1%	632-10	600	1,3,5	extensometer	17.1	16.9	20.0	-20.0	28,856	TRL (B. Stockings)
B0432004-101-194	34.2%	642-07	600	1,3,5	extensometer	17.5	17.2	17.5	-17.5	33,721	TRL (B. Stockings)
B0432004-101-194	34.0%	642-10	600	5	extensometer	18.1	21.3	12.5	-12.5	1,000,000	UDRI (A. Hutson)
B0432004-101-195	33.3%	643-02	600	1,3,5	extensometer	17.2	17.2	15.0	-15.0	1,000,000	TRL (B. Stockings)
B0432004-101-195	33.9%	643-07	600	1,3,5	extensometer	16.7	16.2	10.0	-10.0	1,000,000	TRL (B. Stockings)
B0432004-101-197	34.2%	652-05	600	1,3,5	extensometer	15.5	14.9	20.0	-20.0	16,977	TRL (B. Stockings)
B0432004-101-197	34.0%	652-07	600	1,3,5	extensometer	14.8	15.3	17.5	-17.5	14,036	TRL (B. Stockings)

Table E4 – Transverse R=-1 Fatigue Data of SCS-6/Ti6Al-4V (Table 4 of 4)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.401 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 466-96 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	LN2 / Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Nov 06 - Apr 09
LOAD RATIO:	0.1		

SCS-6 / Ti-6Al-4V TRANSVERSE FATIGUE $[0]_{16}$

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	Strain Sensor	E_1^t at N=1	E_1^t at N=Nf/2	σ_{max}	σ_{min}	Nf	Test Facility
			(°F)	Hz		(Msi)	(Msi)	(ksi)	(ksi)		
B0432004-101-198	32.8%	653-04	600	1,3,5	extensometer	15.2	14.5	15.0	-15.0	92,959	TRL (B. Stockings)
B0432004-101-198	33.5%	653-06	600	5	extensometer	no data	no data	12.5	-12.5	1,000,000	UDRI (A. Hutson)
B0432004-101-198	33.5%	653-10	600	1,3,5	extensometer	15.6	15.4	10.0	-10.0	1,000,000	TRL (B. Stockings)
B0432004-101-215	34.6%	812-07	600	1,3,5	extensometer	19.1	18.8	17.5	-17.5	21,887	TRL (B. Stockings)
B0432004-101-215	34.8%	812-09	600	2	extensometer			20.0	-20.0	75,734	UDRI (A. Hutson)
B0432004-101-218	34.1%	822-05	600	1,3,5	extensometer	17.4	17.5	12.5	-12.5	1,000,000	TRL (B. Stockings)
B0432004-101-219	33.2%	823-09	600	1,3,5	extensometer	18.3	18.0	10.0	-10.0	1,000,000	TRL (B. Stockings)
B0432004-101-221	34.3%	832-09	600	5	extensometer	no data	no data	15.0	-15.0	1,000,000	UDRI (A. Hutson)
B0432004-101-221	34.2%	832-11	600	1,3,5	extensometer	18.6	no data	17.5	-17.5	145,385	TRL (B. Stockings)
B0432004-101-222	35.0%	833-04	600	1,3,5	extensometer	16.2	no data	12.5	-12.5	1,000,000	TRL (B. Stockings)
B0432004-101-224	33.3%	842-04	600	5	extensometer	no data	no data	20.0	-20.0	1,000,000	UDRI (A. Hutson)
B0432004-101-224	33.3%	842-10	600	1,3,5	extensometer	16.1	no data	10.0	-10.0	1,000,000	TRL (B. Stockings)
B0432004-101-225	34.2%	843-03	600	1,3,5	extensometer	16.8	17.6	17.5	-17.5	58,755	TRL (B. Stockings)
B0432004-101-225	33.9%	843-06	600	5	extensometer	no data	no data	15.0	-15.0	1,000,000	UDRI (A. Hutson)
B0432004-101-225	34.2%	843-08	600	5	extensometer	no data	no data	20.0	-20.0	76,562	UDRI (A. Hutson)
B0432004-101-227	34.7%	852-04	600	1,3,5	extensometer	17.3	17.9	12.5	-12.5	1,000,000	TRL (B. Stockings)
B0432004-101-227	33.0%	852-06	600	5	extensometer	18.3	18.3	15.0	-15.0	1,000,000	UDRI (A. Hutson)
B0432004-101-228	33.2%	853-02	600	1,3,5	extensometer	16.8	16.8	10.0	-10.0	1,000,000	TRL (B. Stockings)
AVERAGE	**33.7%**					**17.3**	**17.4**				

Compiled By:
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
May-09

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measure
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value

APPENDIX F
INDIVIDUAL FATIGUE CRACK GROWTH TEST RESULTS

Table F1 – Longitudinal Crack Growth Data of SCS-6/Ti6Al-4V (Table 1 of 3)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.750 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 647-00 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 07 - Apr 09

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	R	σ_{max}	Notch Length	Crack Bridging	N_f	Test Facility
			(^oF)	Hz		(ksi)	(in)	(full, partial, none)		
B0432004-101-111	33.5%	113-10	70	5	0.1	80	0.0772	partial	9,099	UDRI (A. Hutson)
B0432004-101-113	33.4%	122-05	70	5	0.1	55	0.0735	full	1,993,139	UDRI (A. Hutson)
B0432004-101-114	34.4%	123-12	70	5	0.1	100	0.0778	none	3,071	UDRI (A. Hutson)
B0432004-101-116	33.4%	132-08	70	5	0.1	80	0.0775	partial	8,610	UDRI (A. Hutson)
B0432004-101-117	33.8%	133-03	70	5	0.1	55	0.0730	full	3,365,134	UDRI (A. Hutson)
B0432004-101-119	33.6%	142-01	70	5	0.1	100	0.0745	none	3,314	UDRI (A. Hutson)
B0432004-101-120	33.5%	143-11	70	5	0.1	100	0.0778	none	2,761	UDRI (A. Hutson)
B0432004-101-120	33.3%	143-12	70	1	0.1	95	0.0812	none	2,006	UDRI (A. Hutson)
B0432004-101-121	33.2%	151-08	70	5	0.1	55	0.0735	full	938,888	UDRI (A. Hutson)
B0432004-101-122	33.2%	152-03	70	5	0.1	80	0.0778	none	4,095	UDRI (A. Hutson)
B0432004-101-141	33.1%	313-10	70	5	0.1	100	0.0768	none	4,982	UDRI (A. Hutson)
B0432004-101-144	34.3%	323-01	70	5	0.1	55	0.0730	full	1,993,139	UDRI (A. Hutson)
B0432004-101-145	34.3%	331-03	70	5	0.1	70	0.0778	partial	402,198	UDRI (A. Hutson)
B0432004-101-145	33.7%	331-08	70	5	0.1	80	0.0769	partial	15,683	UDRI (A. Hutson)
B0432004-101-147	33.0%	333-09	70	5	0.1	100	0.0774	none	2,552	UDRI (A. Hutson)
B0432004-101-148	33.0%	341-07	70	5	0.1	80	0.0770	partial	29,977	UDRI (A. Hutson)
B0432004-101-148	34.0%	341-11	70	5	0.1	55	0.0771	full	965,766	UDRI (A. Hutson)
B0432004-101-150	33.2%	343-11	70	5	0.1	95	0.0774	none	5,707	UDRI (A. Hutson)
B0432004-101-151	33.9%	351-07	70	5	0.1	80	0.0765	partial	16,710	UDRI (A. Hutson)
B0432004-101-152	33.5%	352-03	70	5	0.1	55	0.0772	full	1,710,493	UDRI (A. Hutson)
B0432004-101-153	33.6%	353-12	70	5	0.1	100	0.0767	none	3,415	UDRI (A. Hutson)
	33.7%						**0.0765**			
B0432004-101-140	33.7%	312-01	600	10	0.1	65	0.0771	full	357,868	UDRI (A. Hutson)
B0432004-101-140	33.6%	312-03	600	1	0.1	95	0.0774	partial	18,020	UDRI (A. Hutson)
B0432004-101-141	34.1%	313-02	600	10	0.1	55	0.0773	full	512,895	UDRI (A. Hutson)
B0432004-101-144	32.5%	323-09	600	1	0.1	110		none	30	UDRI (A. Hutson)
B0432004-101-145	34.3%	331-04	600	10	0.1	85	0.0777	partial	95,100	UDRI (A. Hutson)
B0432004-101-145	33.9%	331-07	600	1	0.1	105	0.0772	partial	9,891	UDRI (A. Hutson)
B0432004-101-147	33.8%	333-10	600	10	0.1	85	0.0774	partial	20,945	UDRI (A. Hutson)
B0432004-101-148	34.0%	341-03	600	5	0.1	65	0.0775	full	466,692	UDRI (A. Hutson)
B0432004-101-148	33.4%	341-09	600	1	0.1	115		none	1	UDRI (A. Hutson)
B0432004-101-150	33.4%	343-12	600	5	0.1	55	0.0776	full	71,091	UDRI (A. Hutson)
B0432004-101-151	34.6%	351-06	600	1	0.1	105		none		UDRI (A. Hutson)
B0432004-101-151	33.8%	351-09	600	10	0.1	85	0.0773	partial	97,303	UDRI (A. Hutson)

Table F1 – Longitudinal Crack Growth Data of SCS-6/Ti6Al-4V (Table 2 of 3)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.750 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 647-00 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 07 - Apr 09

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	R	σ_{max}	Notch Length	Crack Bridging	N_f	Test Facility
			(°F)	Hz		(ksi)	(in)	(full, partial, none)		
B0432004-101-152	33.9%	352-02	600	1	0.1	115		none	1	UDRI (A. Hutson)
B0432004-101-153	34.0%	353-01	600	10	0.1	65	0.0790	full	380,394	UDRI (A. Hutson)
B0432004-101-155	33.8%	412-01	600	1	0.1	95	0.0772	partial	16,710	UDRI (A. Hutson)
B0432004-101-155	33.5%	412-05	600	2	0.1	85	0.0773	partial	23,000	UDRI (A. Hutson)
B0432004-101-156	34.4%	413-02	600	10	0.1	65	0.0779	full	304,012	UDRI (A. Hutson)
B0432004-101-158	33.2%	422-03	600		0.1	75		partial		UDRI (A. Hutson)
B0432004-101-158	33.1%	422-05	600	10	0.1	65	0.0778	full	415,736	UDRI (A. Hutson)
B0432004-101-159	34.5%	423-01	600	1	0.1	105	0.0776	none	183	UDRI (A. Hutson)
B0432004-101-161	33.4%	432-03	600	2	0.1	85	0.0781	partial	21,456	UDRI (A. Hutson)
B0432004-101-161	33.2%	432-09	600	10	0.1	75	0.0778	partial		UDRI (A. Hutson)
B0432004-101-162	33.3%	433-09	600	1	0.1	105		none	320	UDRI (A. Hutson)
B0432004-101-164	33.3%	442-06	600	5	0.1	55	0.0776	full	352,452	UDRI (A. Hutson)
B0432004-101-164	33.3%	442-10	600	2	0.1	85	0.0773	partial	12,652	UDRI (A. Hutson)
B0432004-101-167	33.9%	452-01	600	5	0.1	65	0.0779	full	137,233	UDRI (A. Hutson)
B0432004-101-167	33.5%	452-04	600	1	0.1	105				UDRI (A. Hutson)
B0432004-101-168	34.6%	453-02	600	5	0.1	55	0.0776	full	35,454	UDRI (A. Hutson)
	33.7%						**0.0776**			
B0432004-101-113	33.6%	122-03	600	1	0.5	110	0.0774	none	1,113	UDRI (A. Hutson)
B0432004-101-114	33.9%	123-11	600	10	0.5	95	0.0776	partial	49,941	UDRI (A. Hutson)
B0432004-101-119	33.2%	142-03	600	1	0.5	110	0.0774	partial	5,692	UDRI (A. Hutson)
B0432004-101-119	33.0%	142-07	600	1	0.5	95		partial		UDRI (A. Hutson)
B0432004-101-121	33.0%	151-06	600	1	0.5	110	0.0768	partial	3,117	UDRI (A. Hutson)
B0432004-101-122	34.0%	152-02	600	1	0.5	95	0.0767	partial	77,071	UDRI (A. Hutson)
B0432004-101-155	33.7%	412-06	600	1	0.5	95	0.0772	partial	56,546	UDRI (A. Hutson)
B0432004-101-156	32.7%	413-10	600	1	0.5	110	0.0825	partial	12,833	UDRI (A. Hutson)
B0432004-101-158	33.1%	422-06	600	5	0.5	65	0.0777	full	763,069	UDRI (A. Hutson)
B0432004-101-158	32.6%	422-08	600	1	0.5	110	0.0775	none	1,282	UDRI (A. Hutson)
B0432004-101-159	32.9%	423-09	600	1	0.5	115		none		UDRI (A. Hutson)
B0432004-101-161	33.3%	432-07	600	5	0.5	75	0.0776	partial	393,761	UDRI (A. Hutson)
B0432004-101-162	33.3%	433-10	600	1	0.5	95	0.0765	partial	29,950	UDRI (A. Hutson)
B0432004-101-164	33.2%	442-08	600	5	0.5	65	0.0775	full	428,388	UDRI (A. Hutson)
B0432004-101-165	33.5%	443-12	600	1	0.5	95	0.0767	partial	66,930	UDRI (A. Hutson)
B0432004-101-167	33.9%	452-03	600	1	0.5	115		none		UDRI (A. Hutson)
B0432004-101-167	33.6%	452-06	600	5	0.5	75	0.0776	partial	45,630	UDRI (A. Hutson)

Table F1 – Longitudinal Crack Growth Data of SCS-6/Ti6Al-4V (Table 3 of 3)

MATERIAL:	Titanium Matrix Composite Panels	SPECIMEN GEOMETRY:	dogbone
FIBER:	SCS-6 (Silicon Carbide)	SPEC THICKNESS:	0.135 inches (average)
MATRIX:	Ti-6Al-4V	SPEC WIDTH:	0.750 inches (average)
PRODUCT FORM:	HIP'd Panels (6X9 inches)	TEST METHOD:	ASTM E 647-00 (Metals)
LAY-UP:	$[0]_{16}$ (Unidirectional)	TEST ENVIRONMENT:	Lab Air / Resistance Heating
MANUFACTURE:	FMW Composite Systems	TEST DATES:	Jun 07 - Apr 09

Lot I.D. (Panel)	Fiber v/o	Specimen No.	Test Temp.	Frequency	R	σ_{max}	Notch Length	Crack Bridging	N_f	Test Facility
			(^oF)	Hz		(ksi)	(in)	(full, partial, none)		
B0432004-101-168	34.1%	453-03	600	1	0.5	110				UDRI (A. Hutson)
AVERAGE	**33.4%**						**0.0776**			

<u>Compiled By:</u>
A. Hutson (University of Dayton Research Institute)
J. Kleek (Air Force Research Laboratory)
May-09

TRL = Touchstone Research Laboratory
UDRI = University of Dayton Research Institute

Note 1: Stress-strain behavior was linear to termination of test
Note 2: Did not reach 0.02 offset before failure
Note 3: Did not reach 0.2 offset before failure
Note 4: Value not reported, anomalies in digital stress-strain data
Note 5: No stress-strain digital data available
Note 6: Specimen broke outside gage length; value for max strain at failure is measured
Note 7: Value not reported, extensometer slipped near end of test
Note 8: Proportional limit was manually determined
Note 9: Insufficient number of data points to calculate value

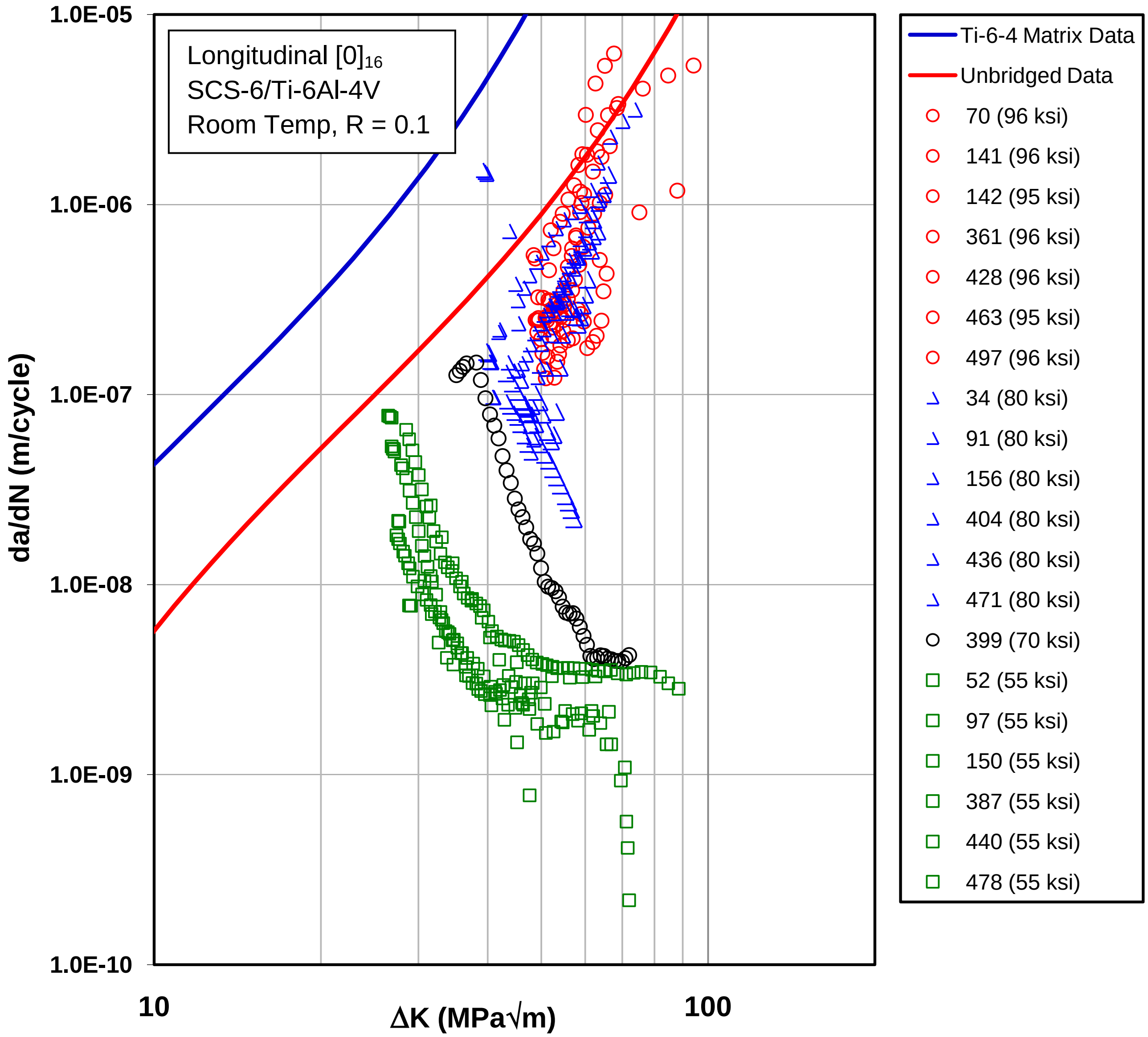

Figure F1. Crack Growth Results at RT and R=0.1 for "All" Stresses including Unreinforced Matrix Data and Stiffness Corrected Unreinforced or "Unbridged" Behavior

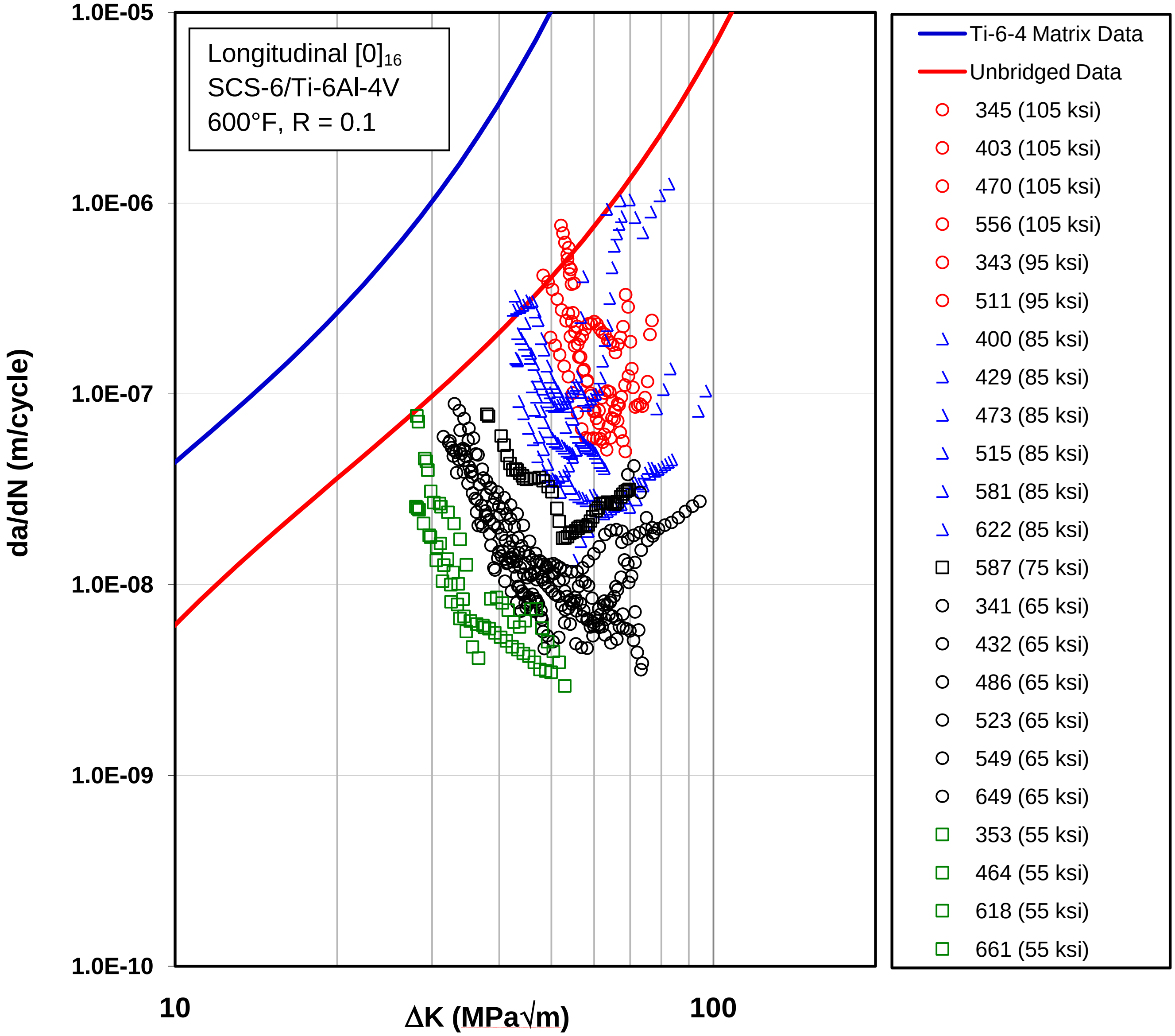

Figure F2. Crack Growth Results at 600°F and R=0.1 for "All" Stresses including Unreinforced Matrix Data and Stiffness Corrected Unreinforced or "Unbridged" Behavior

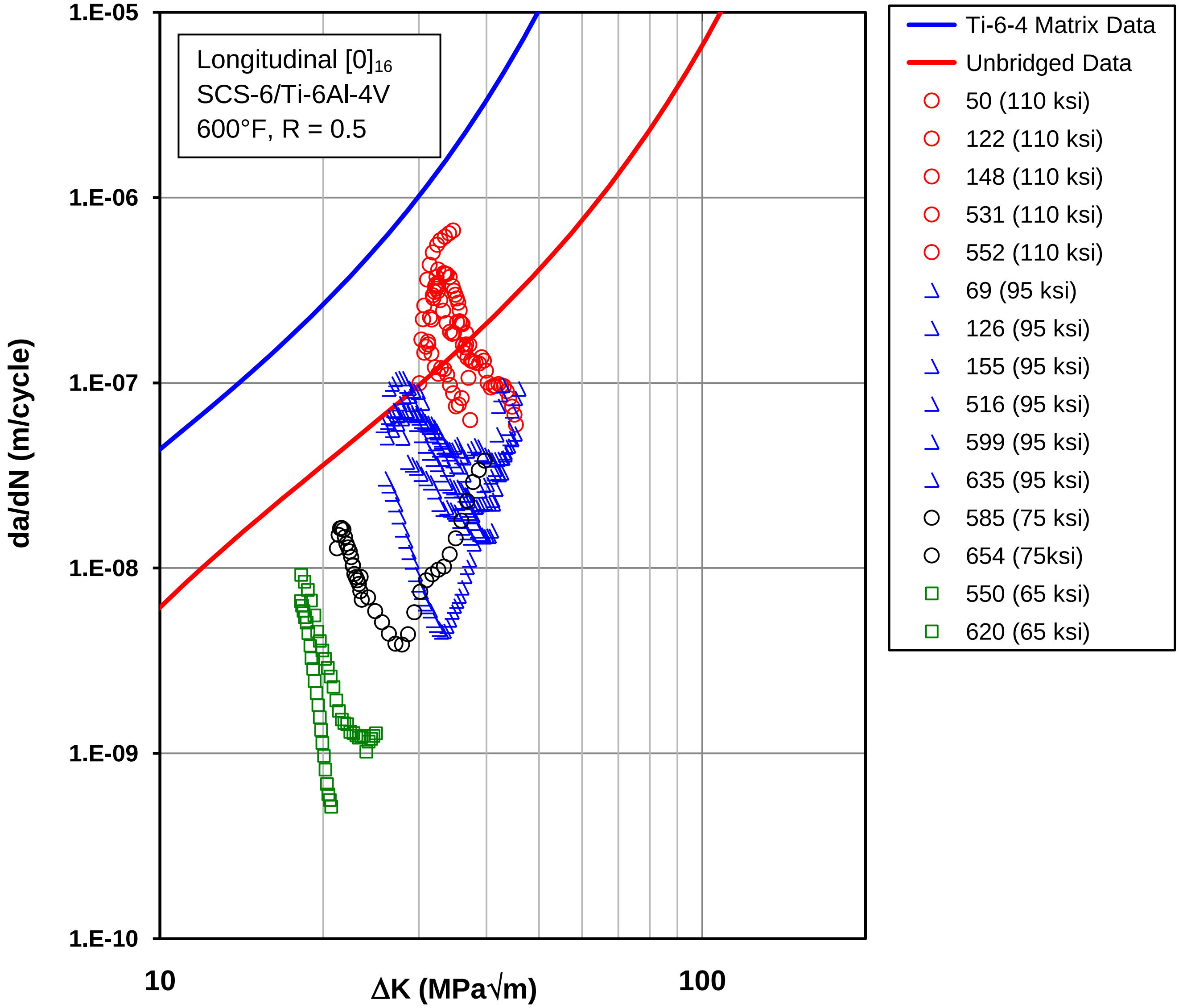

Figure F3. Crack Growth Results at 600°F and R=0.1 for "All" Stresses including Unreinforced Matrix Data and Stiffness Corrected Unreinforced or "Unbridged" Behavior