ASTM F1387 Testing of Mechanically Attached Fittings
Evans Presslok® Fittings

Final REPORT
SwRI® Project 18057.15.520

Prepared for

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EVANS
COMPONENTS, INC®

TABLE OF CONTENTS

1.0 OBJECTIVE 1
2.0 EXPERIMENTAL APPROACH 1
2.1 Pneumatic Proof 2
2.2 Hydrostatic Proof 3
2.3 Impulse 3
2.4 Flexure Fatigue 4
2.5 Tensile 5
2.6 Hydrostatic Burst 5
3.0 RESULTS AND DISCUSSION 6
3.1 Pneumatic and Hydrostatic Proof Tests 6
3.2 Impulse Test 9
3.3 Flexure Fatigue Test 10
3.4 Tensile Test 10
3.5 Hydrostatic Burst Test 13
4.0 SUMMARY OF THE RESULTS 16
APPENDIX A

APPENDIX B

APPENDIX C 19

LIST OF FIGURES

Page

Figure 1: Schematic of the Evans Presslok® system.. 1
Figure 2: Picture of selected 2.0 in diameter specimens prior to the hydrostatic testing................. 2
Figure 3: Picture of the setup used for the pneumatic proof test... 3
Figure 4: Picture of the setup used for the impulse test 4
Figure 5: Picture of the setup used for the flexure fatigue test... 5
Figure 6: Results of the pneumatic proof tests of the 0.5-in diameter specimens............................ 6
Figure 7: Results of the pneumatic proof tests of the 1.0-in diameter specimens............................ 7
Figure 8: Results of the pneumatic proof tests of the 2.0-in diameter specimens............................ 7
Figure 9: Results of the hydrostatic proof tests of the 0.5-in diameter specimens........................... 8
Figure 10: Results of the hydrostatic proof tests of the 1.0-in diameter specimens 8
Figure 11: Results of the hydrostatic proof tests of the 2.0-in diameter specimens 9
Figure 12: Picture of the tensile test showing slippage at the joint (indicated by red arrows) 11
Figure 13: Typical result of the tensile test conducted on the 2.0-in diameter specimen (ID: 28797-6).. 11
Figure 14: Typical result of the tensile test conducted on the 1.0-in diameter specimen (ID: 28796-5).. 12
Figure 15: Typical result of the tensile test conducted on the 0.5-in diameter specimen (ID: 28795-4).. 12
Figure 16: Results of the hydrostatic burst tests conducted on the 0.5-in diameter specimens..... 14
Figure 17: Results of the hydrostatic burst tests conducted on the 1.0-in diameter specimens..... 14
Figure 18: Results of the hydrostatic burst tests conducted on the 2.0-in diameter specimens..... 15

LIST OF TABLES

Page
Table 1: Summary of the pneumatic and hydrostatic proof tests 9
Table 2: Summary of the pressure readings for the impulse test.. 10
Table 3: Summary of the Flexure Fatigue Test 10
Table 3: Summary of the tensile test results...13
Table 5: Summary of the results of for the 2.0 in diameter specimens 16
Table 6: Summary of the results of for the 1.0 in diameter specimens 17
Table 7: Summary of the results of for the 0.5 in diameter specimens 18

1.0 OBJECTIVE

This study was conducted to test the performance of the Evans PL Series Presslok® system made of 316/304 stainless steel permanent tube fittings, following most guidelines of ASTM F1387 (2012) standard. The Evans Presslok® stainless steel fittings are designed specifically to join plain end stainless steel tube systems weld free.

2.0 EXPERIMENTAL APPROACH

A schematic of the Evans Presslok® system is schematically shown in
Figure **1**. The system consists of a pre-lubricated O-ring seal that compresses against the tube outer diameter and the 316/304 stainless steel inner housing. The housing incorporates the gasket and a tube stop; the latter helps position the tube. The entire system is assembled with the Evans PLT tool jaws.

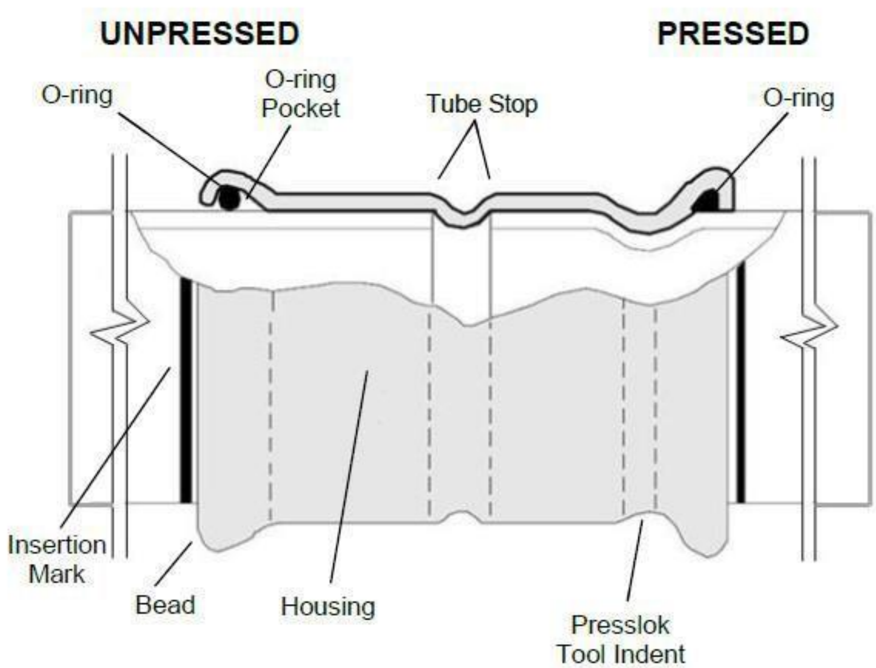

Figure 1: Schematic of the Evans Presslok® system

Permanently attached Presslok® fittings were tested using specimens of the same type, grade, and class (316/304 stainless steel). The fully assembled specimens were provided by Evans. The Presslok® fittings and tubing diameters were 0.50 in, 1.0 in, and 2.0 in. The nominal cross sections of the tubes were 0.049 in for the 0.5 in tube diameter and 0.065 in for the 1.0 and 2.0 in tube diameters. Each specimen was assigned a characteristic letter and a number for traceability.

The specimens used for the tensile test consisted of two 10 inch stainless steel tubes joined by a Presslok® coupling located in the center of the specimen. At each tube end, a NPT threaded fitting was attached which allowed connecting the specimen to the tensile frame. The overall specimen length was 25 in. For the rest of the tests, each specimen consisted of two 10-12 in stainless steel tubes separated by a centrally positioned stainless steel Presslok® coupling. One end of these specimens had a Presslok® cap, whereas the other end had a stainless steel concentric reducer coupled to a 0.25 in female NPT fitting. The length of these specimens was 26 in (see Figure 2).

Figure 2: Picture of selected 2.0 in diameter specimens prior to the hydrostatic testing

Unless otherwise specified, ambient conditions were maintained at 75±5 ºF and test pressure maintained at ±2% of the target value, unless otherwise noted. Allowable test temperature applied to test specimen during testing was ±2 ºF, unless otherwise noted. Test fluids used to pressurize the specimens was water unless otherwise noted. The rated pressures of the Presslok® coupling are 300 psi for the 0.50 in and 1.0 in diameters and 200 psi for the 2.0 in diameter.

The test program included the following standard tests according to ASTM F1387 standard test (2012): pneumatic proof, hydrostatic proof, impulse, flexure fatigue, tensile, and hydrostatic burst. The tests described were conducted per ASTM F1387 standard procedure (Standard Specification for Performance of Piping and Tubing Mechanically Attached Fittings). Hydrostatic burst pressure testing was done at 3X maximum working pressure for ½” – 1”, and 2.5X maximum for the 2”

2.1 Pneumatic Proof

Figure **3** shows a typical picture of the test setup used for the pneumatic test of each specimen size. The specimens of the same size were arranged in a manifold type configuration, each containing 6 specimens. A high-pressure nitrogen storage tank provided the required pressure within the test specimens.

The nitrogen flow was directed to the specimen by way of 0.25-in. high pressure tubing. The tank and tubing were provided with a series of pressure regulators, transducers, and valves to control and monitor the pressure in the specimens. The specimens were pressurized to 100 psig for 5 min, using HIP high pressure equipment (model: 37-5.75-60) rated to 41,000 psi. If a detectable leakage occurred, the faulty specimen/s was identified, retightened, and the test resumed. Then, the pressure was gradually increased to reach 360±18 psi (for the 0.50 in and 1 in fittings) and 235±12 psi (2.0 in fitting), and maintained at those pressures for 5 min. The pressure, measured by a calibrated pressure transducer (serial number: 13348930) connected to a data logger, was continually monitored throughout the test. The specimens pass the pneumatic test if there are no detectable leaks or drop in pressure throughout the test.


Figure 3: Picture of the setup used for the pneumatic proof test

2.2 Hydrostatic Proof

After passing the pneumatic proof test, the specimens were subjected to the hydrostatic proof test using the same manifold configurations. The specimens were filled with tap water and pressurized to 100 psig for 5 min, using HIP high pressure equipment (model: 37-5.75-60) rated to 41,000 psi. If no leakage was noted, the pressure was gradually increased to 150% of the rated pressure (0.50 in and 1.0 in = 430±22 psi, and 2.0 in = 278±14 psi). The pressurized fittings were then continually observed for signs of leakage including, spray, mist, or water droplets. The pressure, measured by a calibrated pressure transducer (serial number: 13348930) connected to a data logger, was continually monitored throughout the test. A clean, dry, collection bucket was placed below the fitting to measure any leakage that may occur. The specimens pass the hydrostatic test if there are no detectable leaks or drop in pressure throughout the test.

2.3 Impulse

After passing the pneumatic and hydrostatic proof tests, the impulse test was conducted on 6 specimens of each size attached to a manifold (see Figure **4**). A high pressure pump controlled with pneumatic solenoid valves allowed cyclic pressurization of the specimens at a rate of one every 3-6 seconds. The cyclic pressure was recorded by a pressure transducer connected at one of the end of the manifold. A custom software program was used to monitor and control the pressure in each manifold system. In addition, one 3-liter capacity autoclave was used to control the low pressure and act as solution reservoir during each pressurization/depressurization cycle.

Initially, all the specimens were filled with tap water. Later, the internal solution was replaced by oil for the 1.0 in diameter specimens. The specimens were pressurized to 133±5% of the rated pressure, followed by a depressurization to a pressure not greater than 20±5% of the rated pressure. The impulse test was conducted for at least 1,000,000 pressure cycles. After the completion of the impulse test, the hydrostatic proof test was conducted on each specimen. The pressurized fittings were then continually observed for signs of leakage including, spray, mist, or water droplets. The static pressure, indicated by a pressure gauge, was continually monitored for pressure drop. A clean, dry, collection bucket was placed below the fitting to measure any leakage that may occur. The specimens pass the impulse test if there are no detectable leaks observed after the subsequent hydrostatic proof test.

Figure 4: Picture of the setup used for the impulse test

2.4 Flexure Fatigue

Six (6) specimens of each tube size were subjected to the flex fatigue test. The test consists of applying a bidirectional flexure in addition to an internal hydrostatic pressure (Figure 5). The specimens were filled with water and pressurized to the corresponding rated pressures. Calibrated strain gages on the high stress sides of each specimen, located at 180 degrees and 0.125 in. away from the middle joint, were used to measure the stress levels set to 2%. After the application of the bending stress, the internal pressure was applied to each tube. Pressure and strain were monitored during the entire flex test. The flex fatigue tests were conducted for 30,000 cycles at a rate of two cycles per second. Each cycle consisted of a side to side motion passing through zero stress at midpoint of deflection. The flex fatigue test was conducted at room temperature.

At the end of the flexure fatigue test, the specimens were subjected to the hydrostatic proof test. The pressurized fittings were then continually observed for signs of leakage including, spray, mist, or water droplets. The static pressure, indicated by a pressure gauge, was continually monitored for pressure drop. A clean, dry, collection bucket was placed below the fitting to measure any leakage that may occur. The specimens pass the flexure fatigue if there are no detectable leaks during the test and after the subsequent hydrostatic proof test.

2.5 Tensile

Six (6) specimens of each size, that passed the pneumatic and hydrostatic proof tests, were tested. The specimens were placed in a constant strain rate tensile machine. Prior to testing, the test frame, load cell, caliper and micrometer were calibrated. Temperature and relative humidity of the laboratory environment were recorded during the test. A MTS Insight electromechanical test frame equipped with a 100 kN calibrated load cell (serial number: 262379) was used to load the specimens in displacement control at a rate of 0.05 in/min. Both the load and crosshead displacement were recorded using the MTS TestWorks software. Each specimen was gripped into the test frame using wedge grips. The maximum applied load, maximum shear stress, and the type of joint failure were assessed.

2.6 HydrostaticBurst

This test demonstrates the reliability of the specimens when exposed to hydrostatic overpressure. This test was conducted on four (4) specimens of each size that passed the hydrostatic and pneumatic proof tests. The specimens were filled with water and placed inside a chamber with one end free to move. The pressure was gradually increased to three (3) times the rated pressure to attain 900 psi (for the 0.5 and 1 in diameter) and 500 psi (for the 2 in diameter) at a rate not exceeding 25,000 psi/min and held for about 1 min. The specimens pass the hydrostatic burst test when three (3) times ½” – 1” and (2.5) times 2” rated pressure had been attained without leaks or burst.

3.0 RESULTS AND DISCUSSION

The results reported next are of representative specimens. The results of the multiple specimens tested, reported in Appendix A, are comparable to those described below unless otherwise noted.

3.1 Pneumatic and Hydrostatic Proof Tests

The results of the pneumatic and hydrostatic proof tests are shown in
Figure **6** to
Figure **11**. The internal pressure was maintained at a minimum of 365 psi for the 0.5 in and 1.0 in diameter specimens. For the 2.0 in diameter specimens, the internal pressure attained a minimum of 235 psi. The pneumatic proof tests did not reveal failure for all the specimens tested. The remaining specimens did not exhibit water leaks or other abnormalities, attaining a minimum pressure of 430 psi for the 0.5 in and 1.0 in diameter specimens and 278 psi for the 2.0 in diameter specimens. In several cases, there was an apparent decrease in pressure. This pressure decrease was due to a pipe expansion during the test.

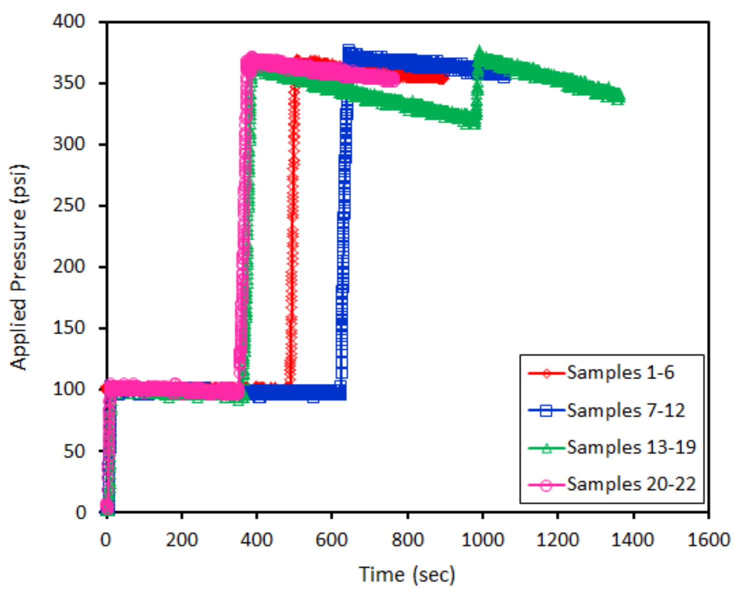

Figure 6: Results of the pneumatic proof tests of the 0.5-in diameter specimens

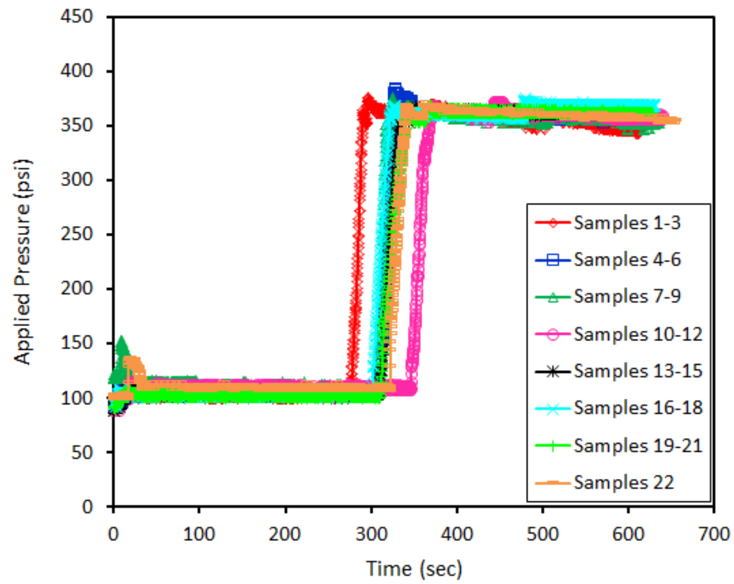

Figure 7: Results of the pneumatic proof tests of the 1.0-in diameter specimens

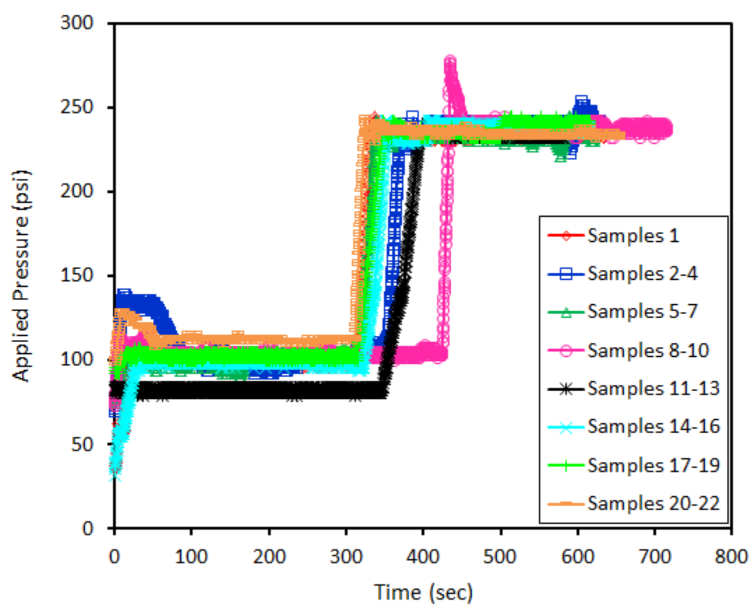

Figure 8: Results of the pneumatic proof tests of the 2.0-in diameter specimens

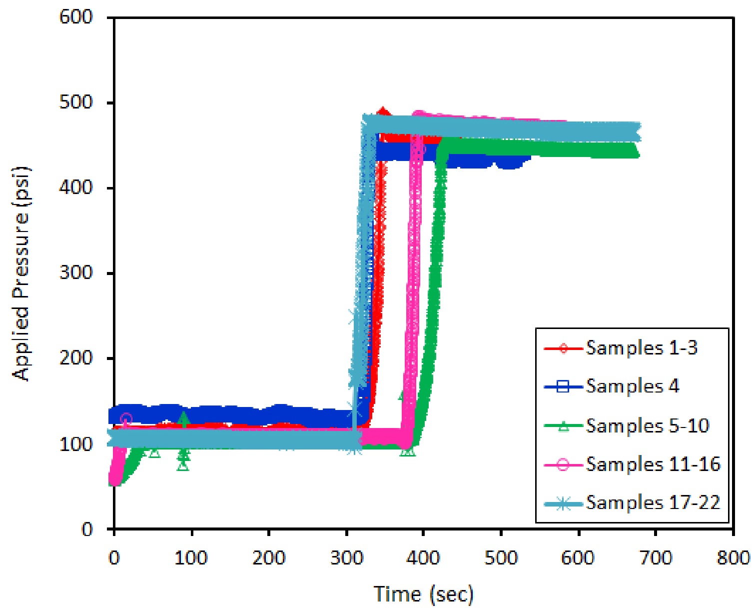

Figure 9: Results of the hydrostatic proof tests of the 0.5-in diameter specimens

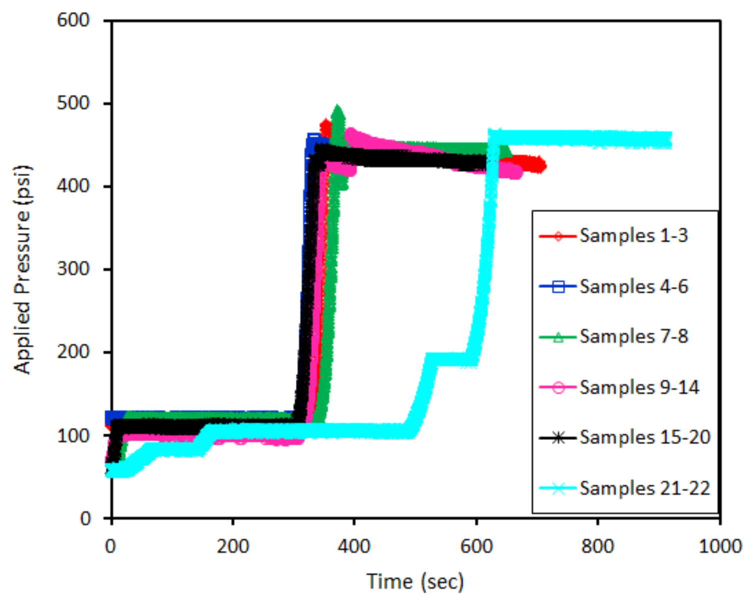

Figure 10: Results of the hydrostatic proof tests of the 1.0-in diameter specimens

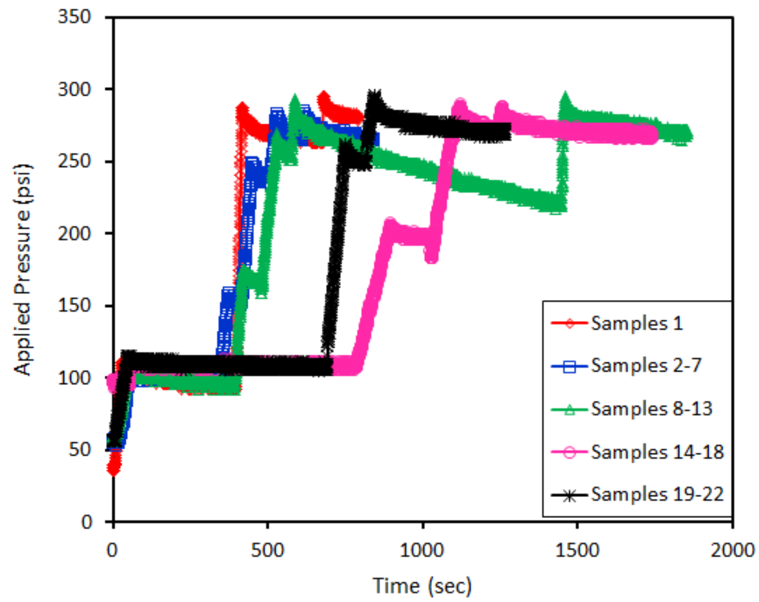

Figure 11: Results of the hydrostatic proof tests of the 2.0-in diameter specimens

Table 1: Summary of the pneumatic and hydrostatic proof tests

Specimen Diameter (in)	Target Hydrostatic Pressure (psi)	Target Pneumatic Pressure (psi)	Hydrostatic Proof Test	Pneumatic Proof Test
0.5	430±22	360±18	Pass	Pass
1.0	430±22	360±18	Pass	Pass
2.0	278±14	235±12	Pass	Pass

3.2 Impulse Test

For the impulse test, the high/low pressure was cycled approximately every 4-6 sec.

Table 2 shows the average and standard deviation of the high and low pressures for each specimen size. During the impulse tests, no leaks or other abnormalities were recorded. After the completion of the impulse tests, the specimens passed the hydrostatic proof tests, showing no leaks.

Table 2: Summary of the pressure readings for the impulse test

Specimen Diameter (in)	Number of Cycles	Average of Maximum Applied Pressure (psig)	Average of Minimum Applied Pressure (psig)	Impulse Test	Hydrostatic Proof Test
0.5	1,001,120	421.8±25.1	62.3±15.2	Pass	Pass
1.0	1,000,095	415.9±16.7	64.7±12.4	Pass	Pass
2.0	1,000,015	271±23.1	38.9±19.7	Pass	Pass

3.3 Flexure Fatigue Test

The results of the flexure fatigue tests (see Table 3), conducted on six (6) specimens of each size for 30,000 cycles, did not show leaks or other abnormalities. At the conclusion of the flexure fatigue test, the hydrostatic tests showed no leaks or anomalies.

Table 3: Summary of the Flexure Fatigue Test

Specimen Diameter (in)	Pressure Rating (psig)	Specimen Deflection (in)	Cycles	Flexure Fatigue Test	Hydrostatic Proof Test
0.5	300	0.362	30,000	Pass	Pass
1.0	300	0.179	30,000	Pass	Pass
2.0	200	0.088	30,000	Pass	Pass

3.4 Tensile Test

Figure 12 shows a typical picture of the tensile test specimen and

Table 4 summarizes the tensile test results.

Figure **15** shows typical tensile test results for each specimen diameter. The results showed similar average tensile values for the 2.0 in and 1.0 in diameter specimens (2,158 lbf and 2,467 lbf, respectively). The average tensile result for the 0.5 in diameter specimens was 1,519 lbf. The remaining tensile test results are presented in Appendix A.

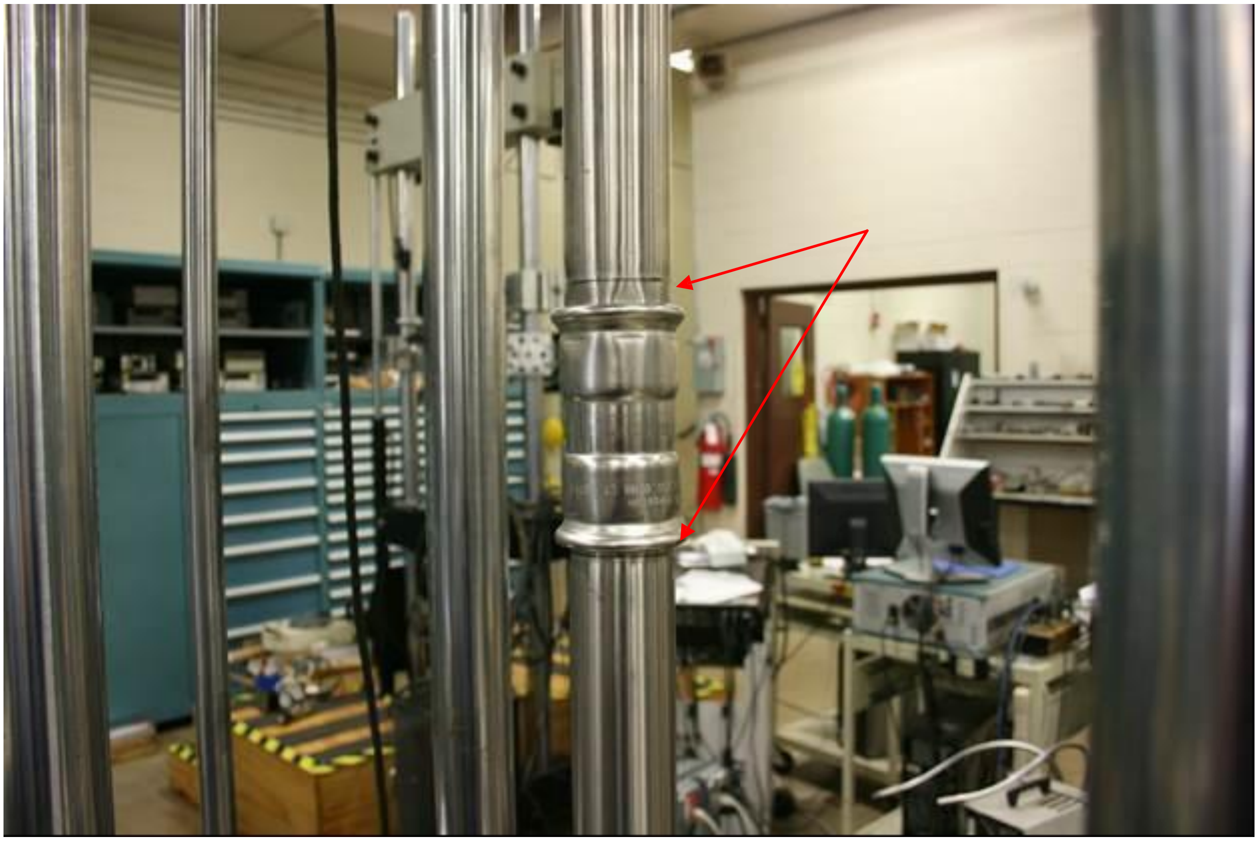

Figure 12: Picture of the tensile test showing slippage at the joint (indicated by red arrows)

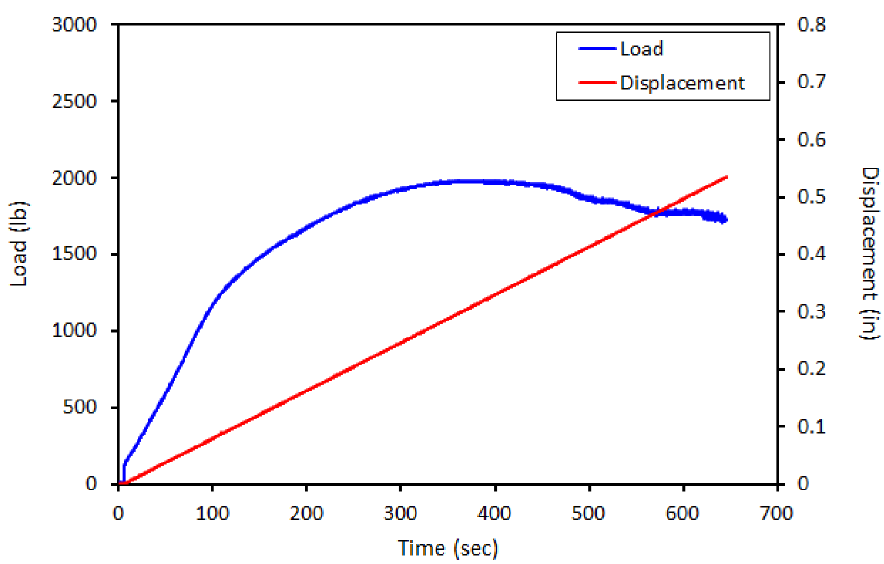

Figure 13: Typical result of the tensile test conducted on the 2.0-in diameter specimen (ID: 28797-6)

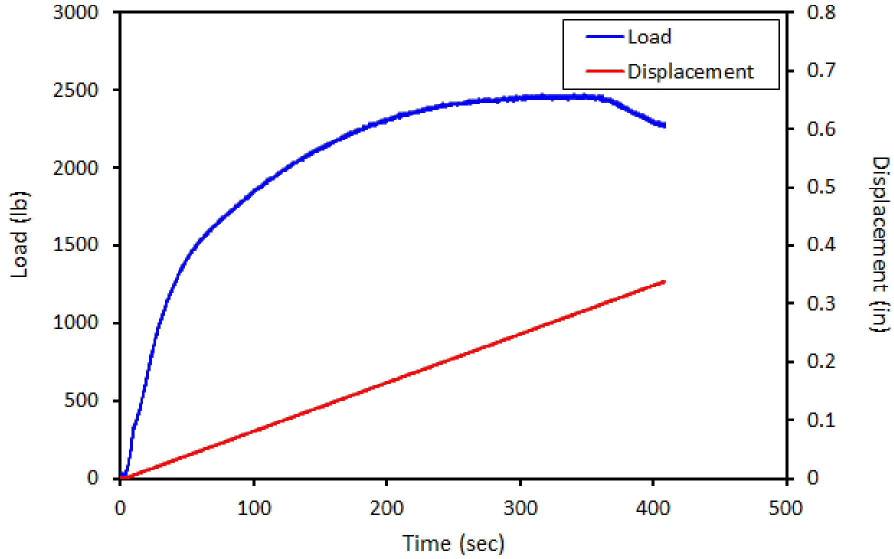

Figure 14: Typical result of the tensile test conducted on the 1.0-in diameter specimen (ID: 28796-5)

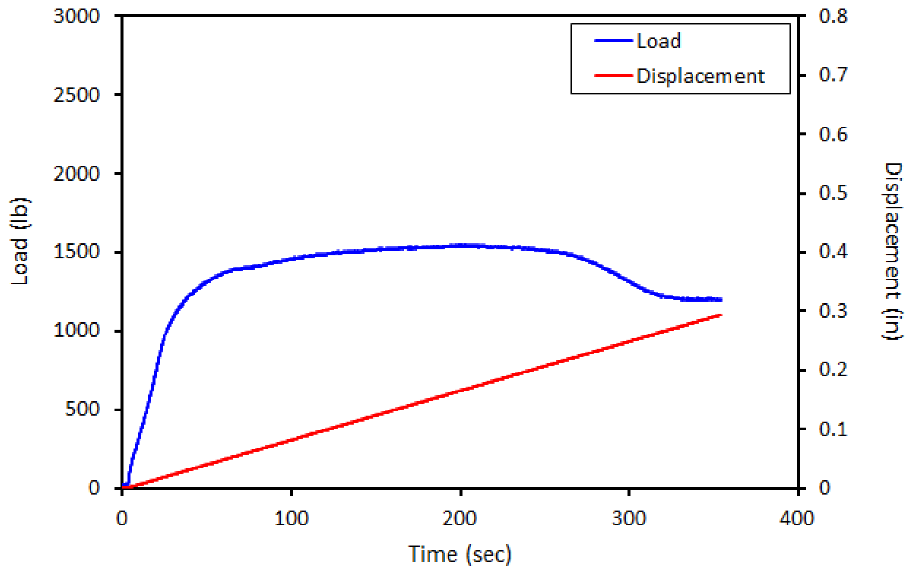

Figure 15: Typical result of the tensile test conducted on the 0.5-in diameter specimen (ID: 28795-4)

Table 4: Summary of the tensile test results

Specimen ID	Diameter (in)	Maximum Load (lbf)	Average (lbf)	Standard Deviation (lbf)
28797-6	2.0	1,986.7	2,157.7	257.8
28797-5		2,061.8		
28797-4		2,165.2		
28797-3		1,926.3		
28797-2		2,647.9		
28797-1		2,158.3		
28796-6	1.0	2,518.5	2,467.0	69.6
28796-5		2,474.4		
28796-4		2,423.4		
28796-3		2,517.5		
28796-2		2,520.4		
28796-1		2,347.8		
28795-6	0.5	1,577.9	1,519.1	56.5
28795-5		1,478.2		
28795-4		1,549.6		
28795-3		1,579.1		
28795-2		1,478.7		
28795-1		1,450.7		

3.5 Hydrostatic Burst Test

The hydrostatic burst tests were conducted on up to five (5) specimens for each diameter size, previously hydrostatically proof tested. The burst test results (see Figure 16 to Figure 18) show that both the 0.5 in and 1.0 in diameter specimens reached the target 3X minimum burst pressure (900 psi) the 2.0 in diameter specimens reached target 2.5X minimum burst pressure (500 psi).

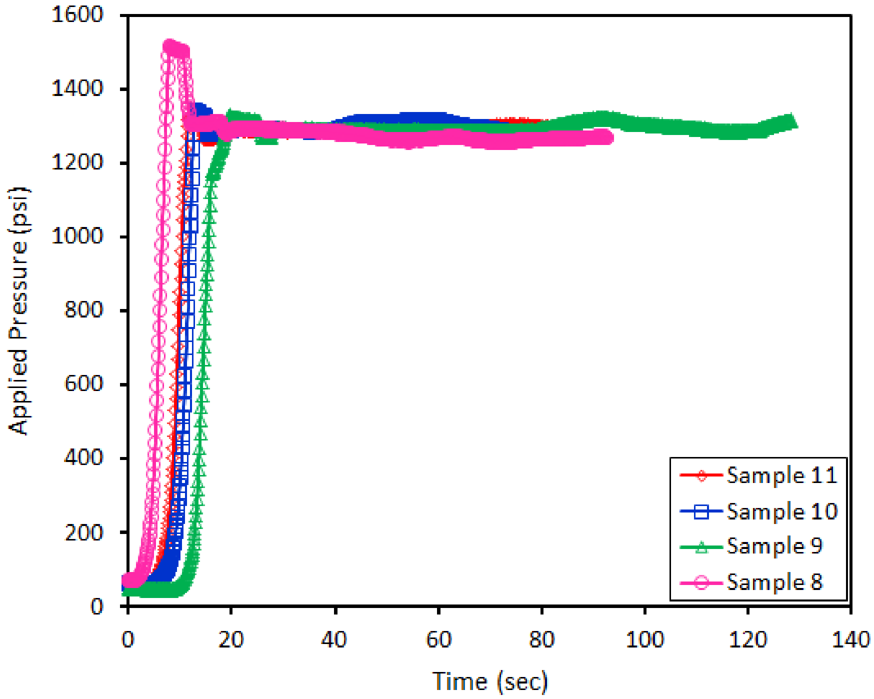

Figure 16: Results of the hydrostatic burst tests conducted on the 0.5-in diameter specimens

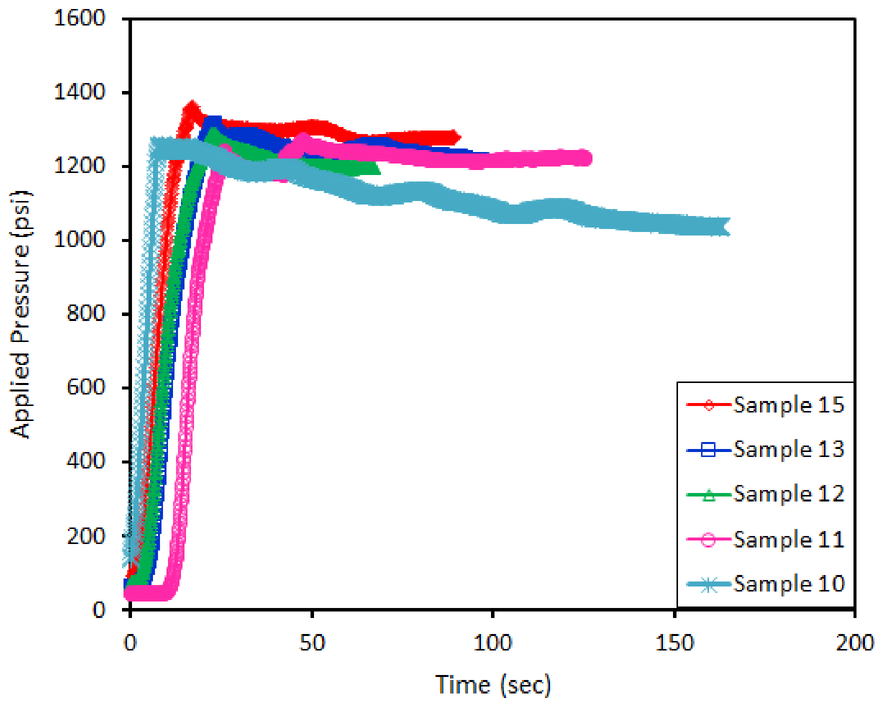

Figure 17: Results of the hydrostatic burst tests conducted on the 1.0-in diameter specimens

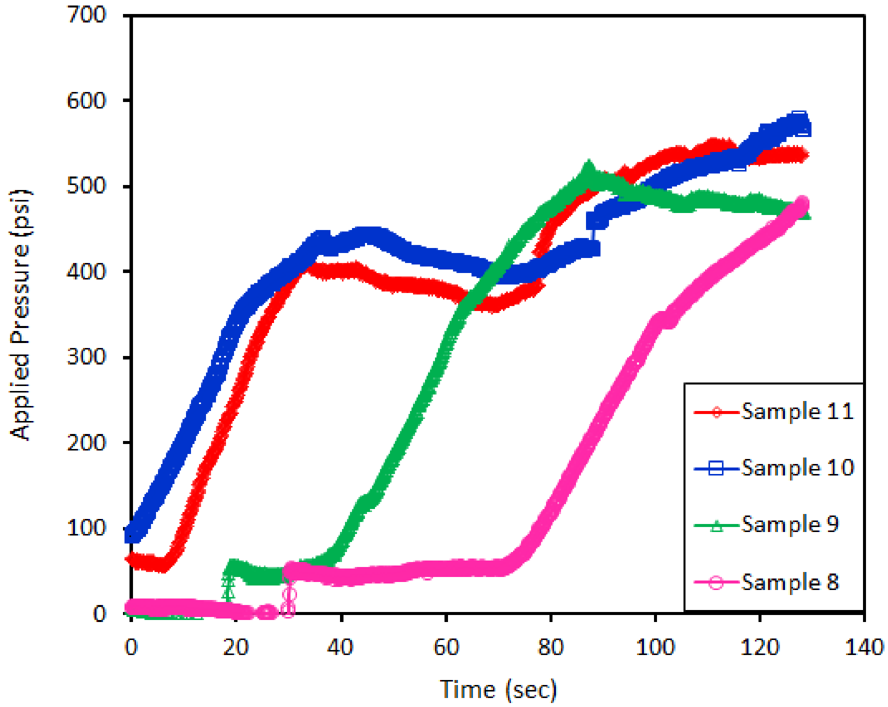

Figure 18: Results of the hydrostatic burst tests conducted on the 2.0-in diameter specimens

4.0 SUMMARY OF THE RESULTS

Table 5: Summary of the results of for the 2.0 in diameter specimens

Specimen ID	Hydrostatic Proof Test	Pneumatic Proof Test	Impulse Test	Flexure Fatigue Test	Hydrostatic Burst Test	Tensile Test	Comments
28794-1	Pass/278 psi	Pass/235 psi					
28794-2	Pass/278 psi	Pass/235 psi	Pass				
28794-3	Pass/278 psi	Pass/235 psi	Pass				
28794-4	Pass/278 psi	Pass/235 psi	Pass				
28794-5	Pass/278 psi	Pass/235 psi	Pass				
28794-6	Pass/278 psi	Pass/235 psi	Pass				
28794-7	Pass/278 psi	Pass/235 psi	Pass				
28794-8	Pass/278 psi	Pass/235 psi			Pass		
28794-9	Pass/278 psi	Pass/235 psi			Pass		
28794-10	Pass/278 psi	Pass/235 psi			Pass		
28794-11	Pass/278 psi	Pass/235 psi			Pass		
28794-12	Pass/278 psi	Pass/235 psi			Pass		
28794-13	Pass/278 psi	Pass/235 psi		Pass			
28794-14	Pass/278 psi	Pass/235 psi		Pass			
28794-15	Pass/278 psi	Pass/235 psi		Pass			
28794-16	Pass/278 psi	Pass/235 psi		Pass			
28794-17	Pass/278 psi	Pass/235 psi		Pass			
28794-18	Pass/278 psi	Pass/235 psi		Pass			
28794-19	Pass/278 psi	Pass/235 psi					
28794-20	Pass/278 psi	Pass/235 psi					
28794-21	Pass/278 psi	Pass/235 psi					
28794-22	Pass/278 psi	Pass/235 psi					
28797-1	Pass/278 psi	Pass/235 psi				2,158.3	
28797-2	Pass/278 psi	Pass/235 psi				2,647.9	
28797-3	Pass/278 psi	Pass/235 psi				1,926.3	
28797-4	Pass/278 psi	Pass/235 psi				2,165.2	
28797-5	Pass/278 psi	Pass/235 psi				2,061.8	
28797-6	Pass/278 psi	Pass/235 psi				1,986.7	

Table 6: Summary of the results of for the 1.0 in diameter specimens

Specimen ID	Hydrostatic Proof Test	Pneumatic Proof Test	Impulse Test	Flexure Fatigue Test	Hydrostatic Burst Test	Tensile Test	Comments
28793-2	Pass/430 psi	Pass/365 psi	Pass				
28793-4	Pass/430 psi	Pass/365 psi	Pass				
28793-8	Pass/430 psi	Pass/365 psi	Pass				
28793-9	Pass/430 psi	Pass/365 psi	Pass				
28793-10	Pass/430 psi	Pass/365 psi	Pass				
28793-11	Pass/430 psi	Pass/365 psi			Pass		
28793-12	Pass/430 psi	Pass/365 psi			Pass		`
28793-13	Pass/430 psi	Pass/365 psi			Pass		
28793-14	Pass/430 psi	Pass/365 psi			Pass		
28793-15	Pass/430 psi	Pass/365 psi			Pass		
28793-16	Pass/430 psi	Pass/365 psi					
28793-17	Pass/430 psi	Pass/365 psi					
28793-18	Pass/430 psi	Pass/365 psi		Pass			
28793-19	Pass/430 psi	Pass/365 psi		Pass			
28793-20	Pass/430 psi	Pass/365 psi		Pass			
28793-21	Pass/430 psi	Pass/365 psi		Pass			
28793-22	Pass/430 psi	Pass/365 psi		Pass			
28796-1	Pass/430 psi	Pass/365 psi				2,347.8	
28796-2	Pass/430 psi	Pass/365 psi				2,520.4	
28796-3	Pass/430 psi	Pass/365 psi				2,517.5	
28796-4	Pass/430 psi	Pass/365 psi				2,423.4	
28796-5	Pass/430 psi	Pass/365 psi				2,474.4	
28796-6	Pass/430 psi	Pass/365 psi				2,518.5	

Table 7: Summary of the results of for the 0.5 in diameter specimens

Specimen ID	Hydrostatic Proof Test	Pneumatic Proof Test	Impulse Test	Flexure Fatigue Test	Hydrostatic Burst Test	Tensile Test	Comments
28792-1	Pass/430 psi	Pass/365 psi	Pass				
28792-2	Pass/430 psi	Pass/365 psi	Pass				
28792-3	Pass/430 psi	Pass/365 psi	Pass				
28792-4	Pass/430 psi	Pass/365 psi	Pass				
28792-6	Pass/430 psi	Pass/365 psi	Pass				
28792-7	Pass/430 psi	Pass/365 psi	Pass				
28792-8	Pass/430 psi	Pass/365 psi			Pass		
28792-9	Pass/430 psi	Pass/365 psi			Pass		
28792-10	Pass/430 psi	Pass/365 psi			Pass		
28792-11	Pass/430 psi	Pass/365 psi			Pass		
28792-12	Pass/430 psi	Pass/365 psi		Pass			
28792-13	Pass/430 psi	Pass/365 psi		Pass			
28792-14	Pass/430 psi	Pass/365 psi		Pass			
28792-15	Pass/430 psi	Pass/365 psi		Pass			
28792-16	Pass/430 psi	Pass/365 psi		Pass			
28792-17	Pass/430 psi	Pass/365 psi		Pass			
28792-18	Pass/430 psi	Pass/365 psi					
28792-19	Pass/430 psi	Pass/365 psi					
28792-20	Pass/430 psi	Pass/365 psi					
28792-21	Pass/430 psi	Pass/365 psi					
28792-22	Pass/430 psi	Pass/365 psi					
28795-1	Pass/430 psi	Pass/365 psi				1,450.7	
28795-2	Pass/430 psi	Pass/365 psi				1,478.7	
28795-3	Pass/430 psi	Pass/365 psi				1,579.1	
28795-4	Pass/430 psi	Pass/365 psi				1,549.6	
28795-5	Pass/430 psi	Pass/365 psi				1,478.2	
28795-6	Pass/430 psi	Pass/365 psi				1,577.9	

Appendix A
Tensile Test Results

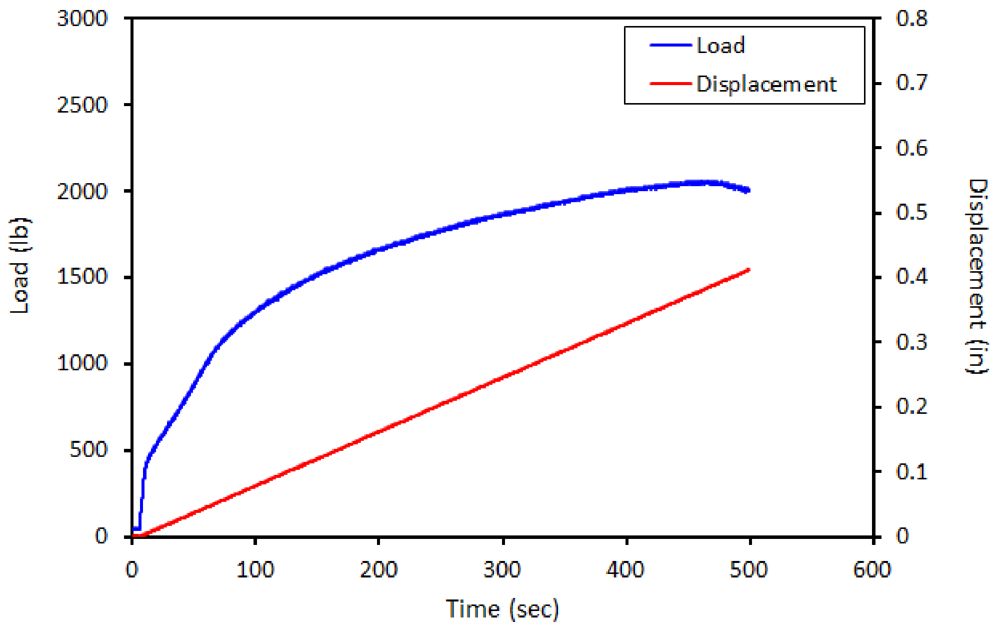

Figure C-1: Tensile test result of the 2 in diameter specimen (28797-5)

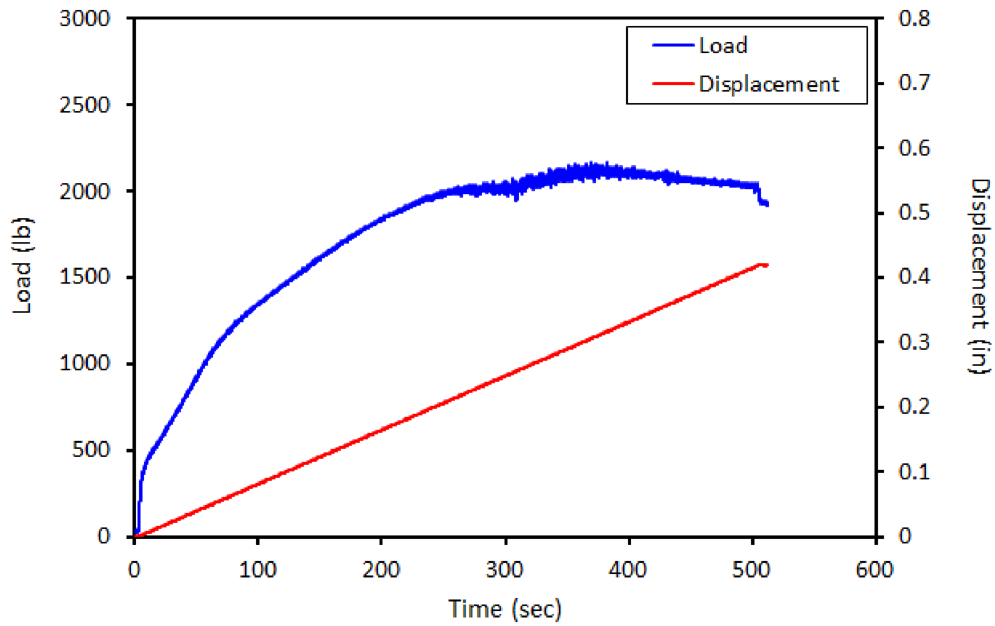

Figure C-2: Tensile test result of the 2 in diameter specimen (28797-4)

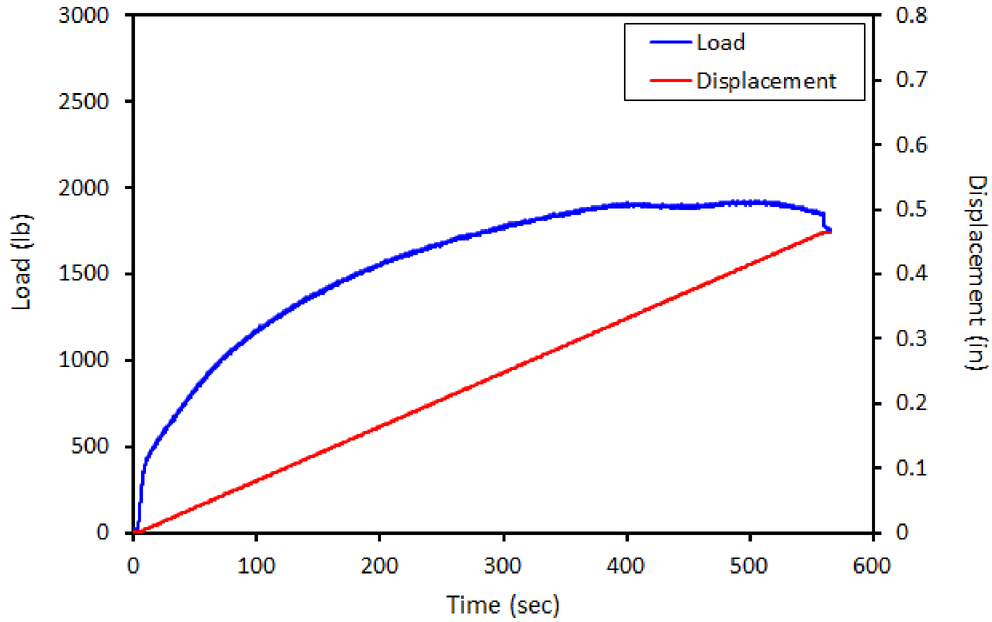

Figure C-3: Tensile test result of the 2 in diameter specimen (28797-3)

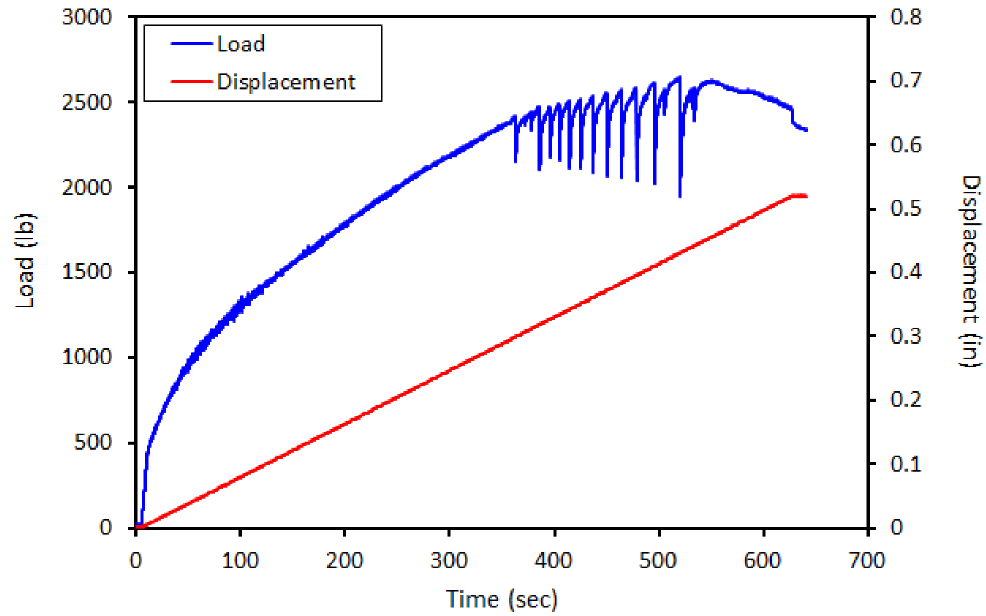

Figure C-4: Tensile test result of the 2 in diameter specimen (28797-2)

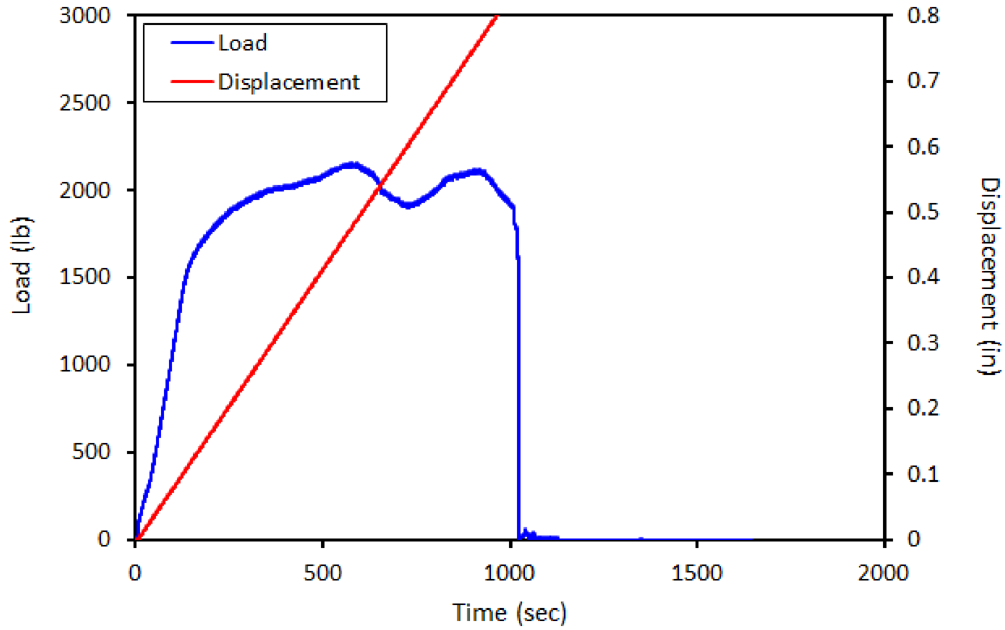

Figure C-5: Tensile test result of the 2 in diameter specimen (28797-1)

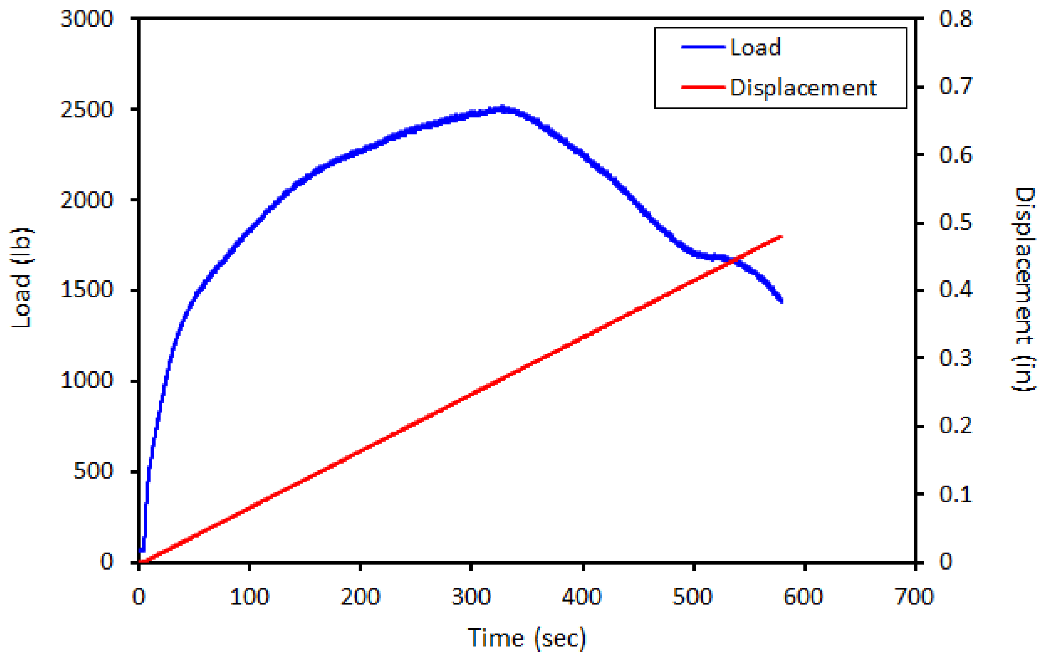

Figure C-6: Tensile test result of the 1 in diameter specimen (28796-6)

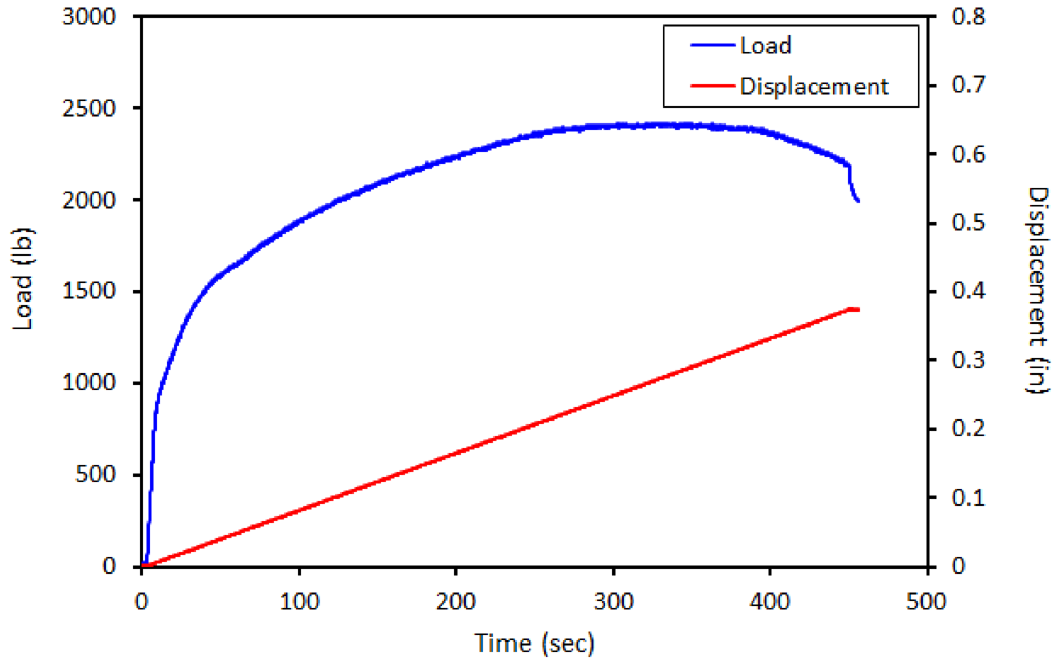

Figure C-7: Tensile test result of the 1 in diameter specimen (28796-4)

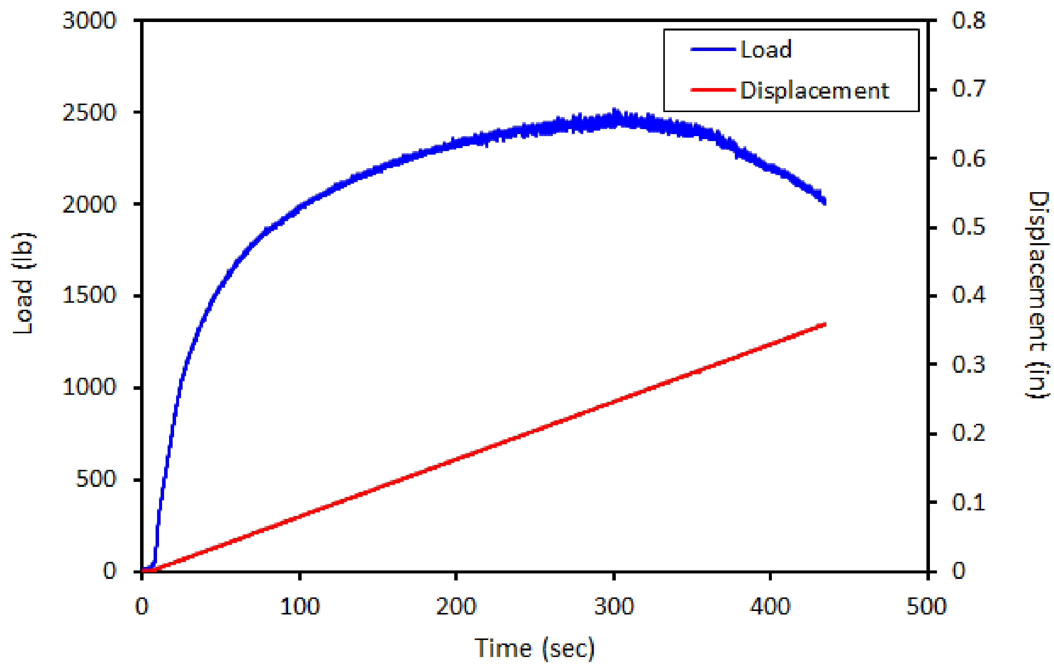

Figure C-8: Tensile test result of the 1 in diameter specimen (28796-3)

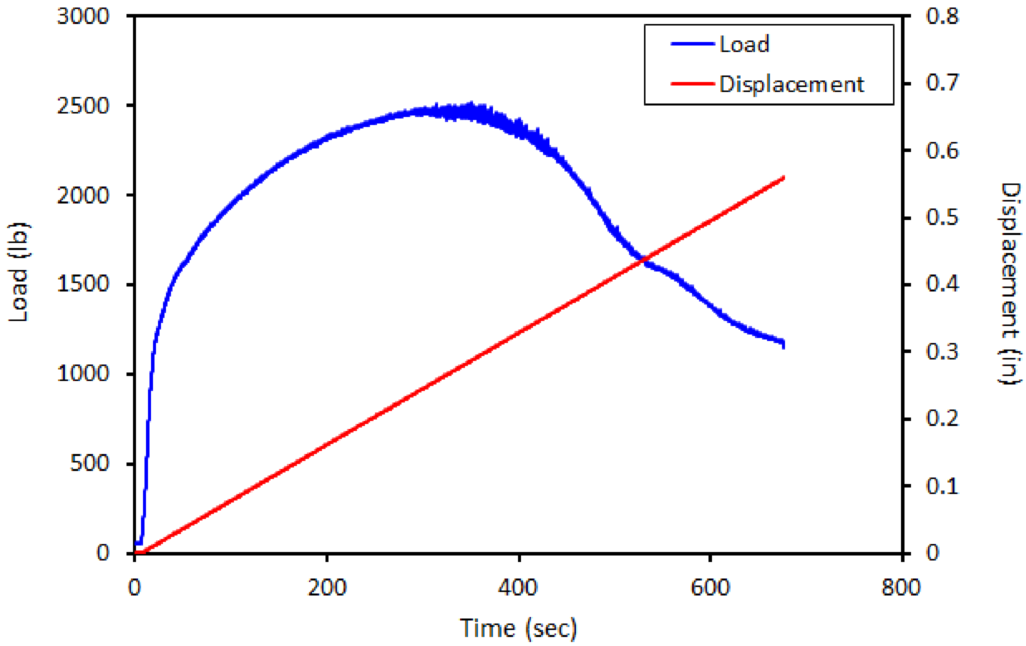

Figure C-9: Tensile test result of the 1 in diameter specimen (28796-2)

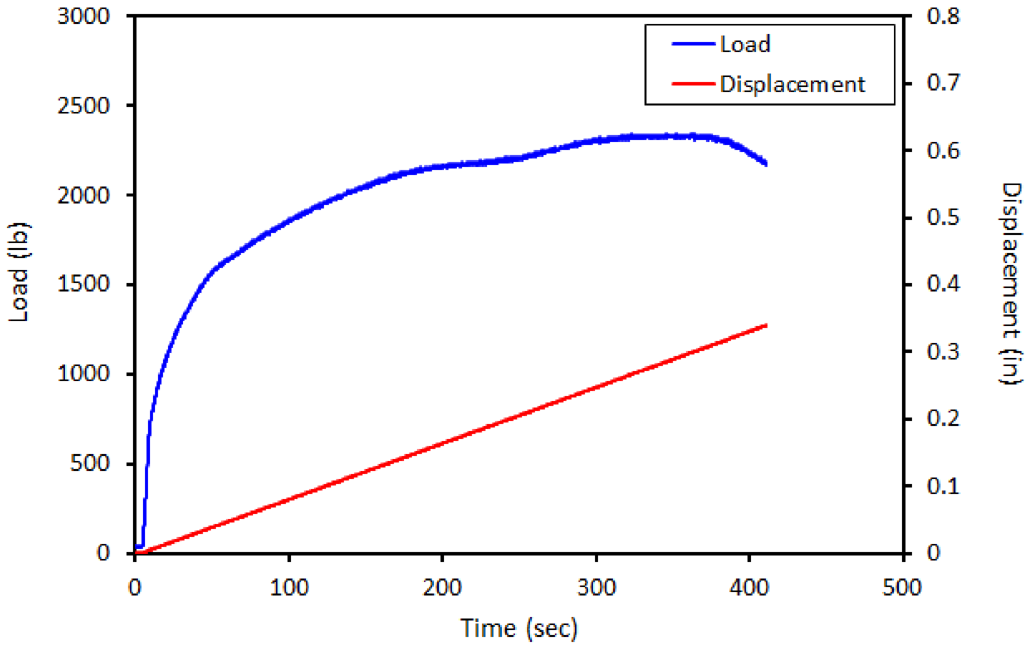

Figure C-10: Tensile test result of the 1 in diameter specimen (28796-1)

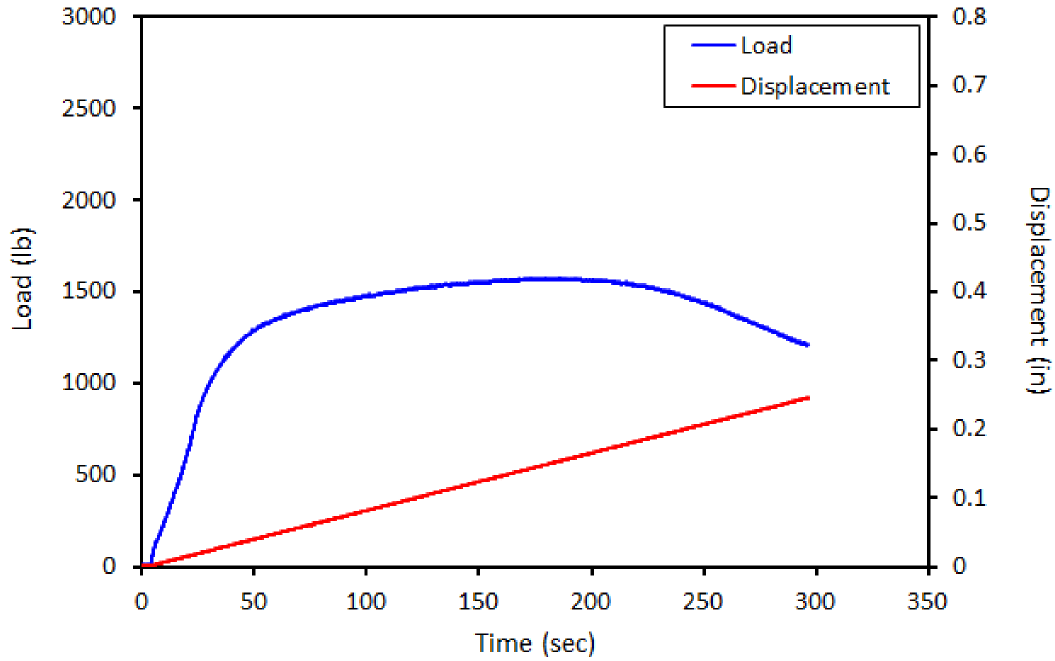

Figure C-11: Tensile test result of the 0.5 in diameter specimen (28795-6)

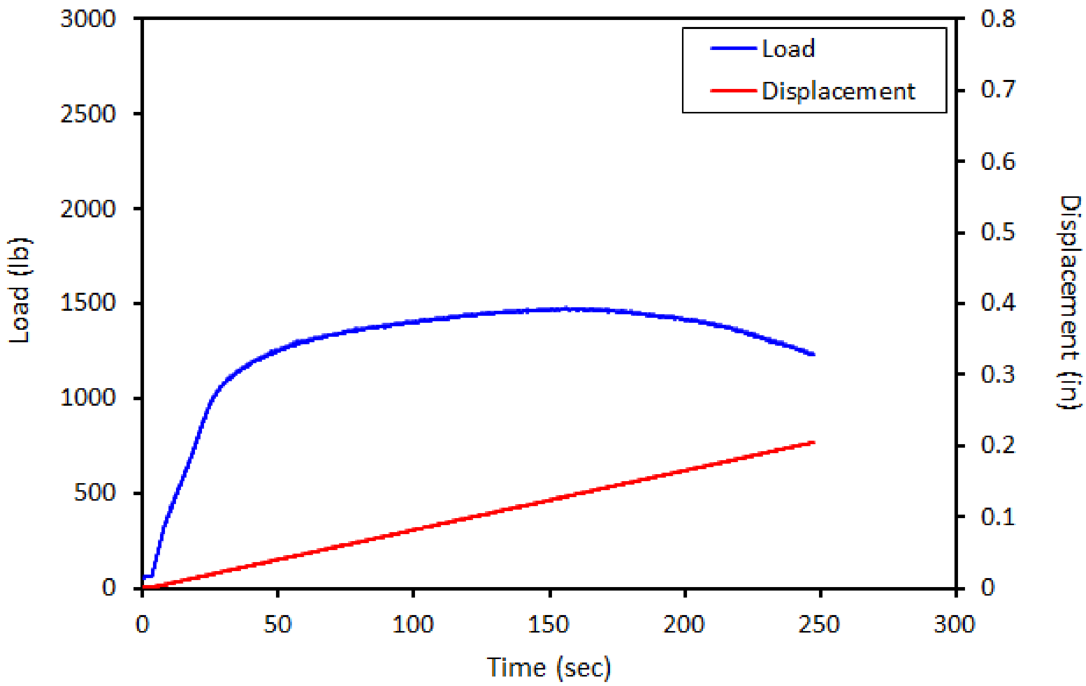

Figure C-12: Tensile test result of the 0.5 in diameter specimen (28795-5)

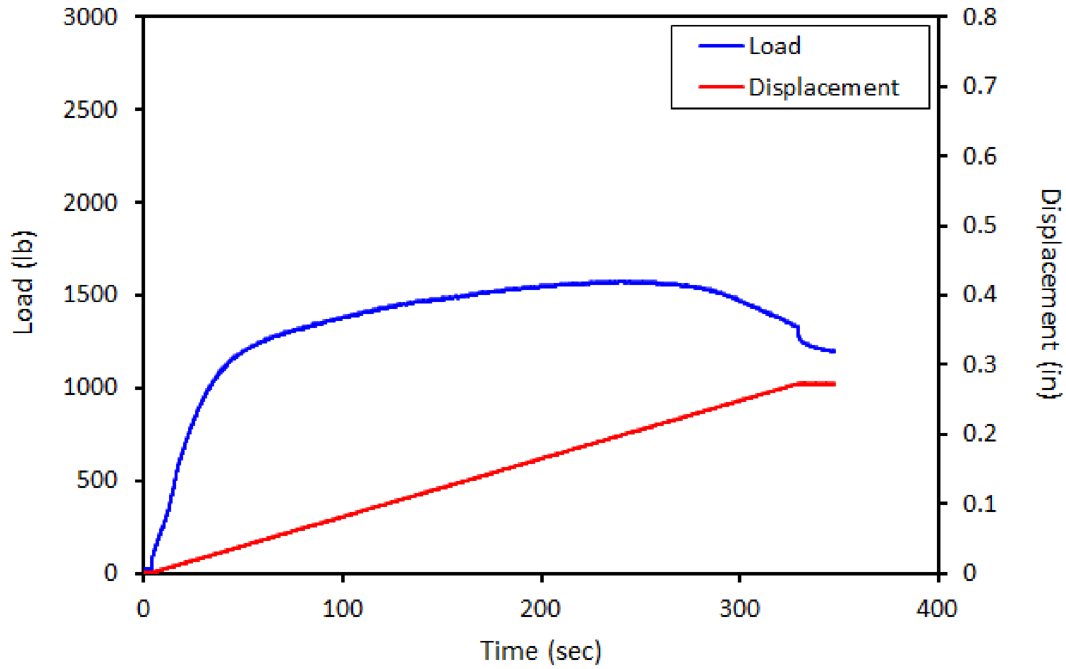

Figure C-13: Tensile test result of the 0.5 in diameter specimen (28795-3)

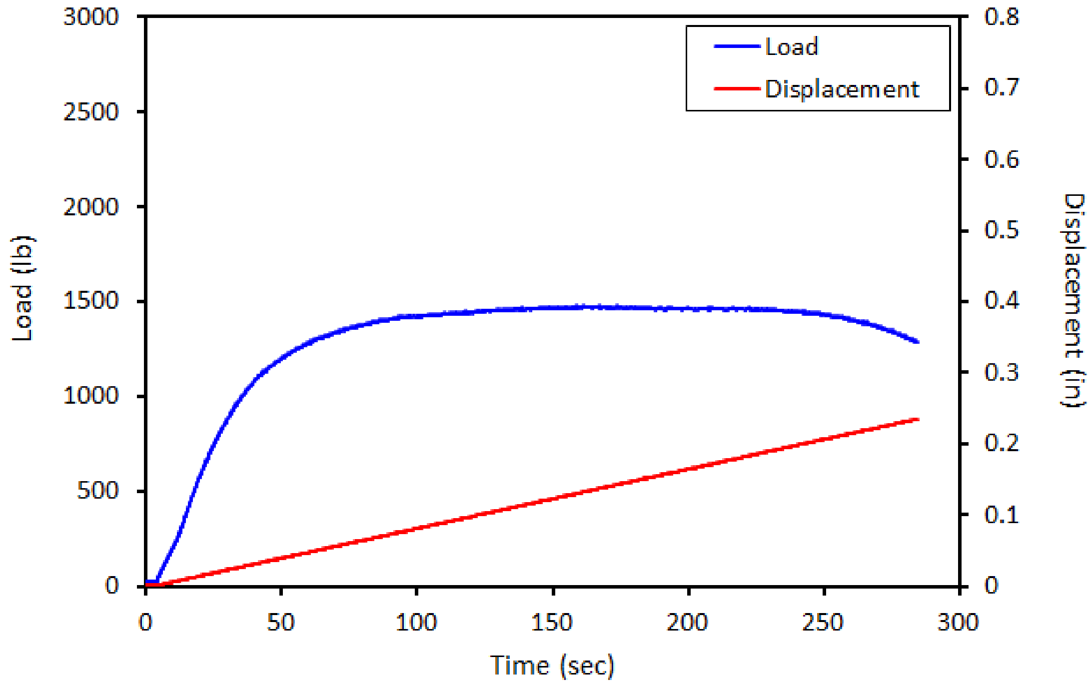

Figure C-14: Tensile test result of the 0.5 in diameter specimen (28795-2)

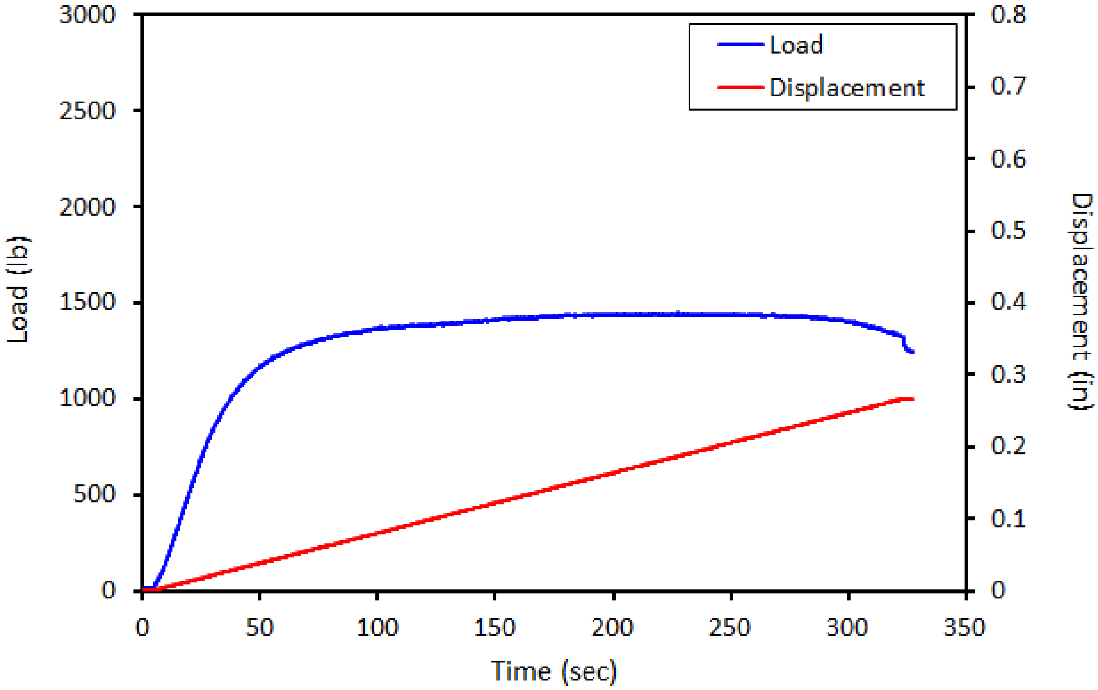

Figure C-15: Tensile test result of the 0.5 in diameter specimen (28795-1)