ASTM F1387 Testing of Mechanically Attached Fittings Evans Presslok™ Fittings

Final REPORT
SwRI® Project 18057.15.520

Prepared for

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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.

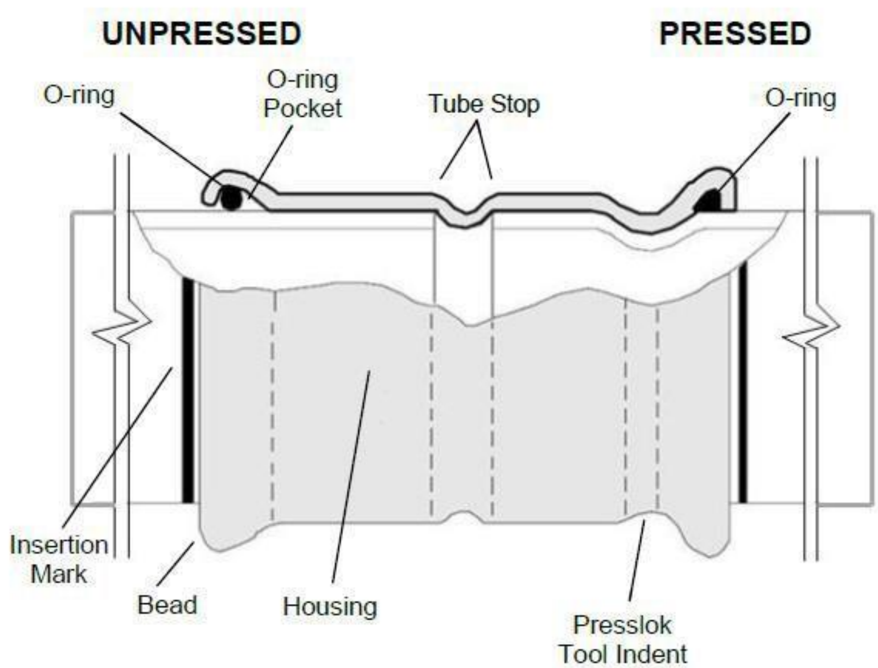


Figure 1: Schematic of the Evans Presslok™ system

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 Hydrostatic Burst

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.

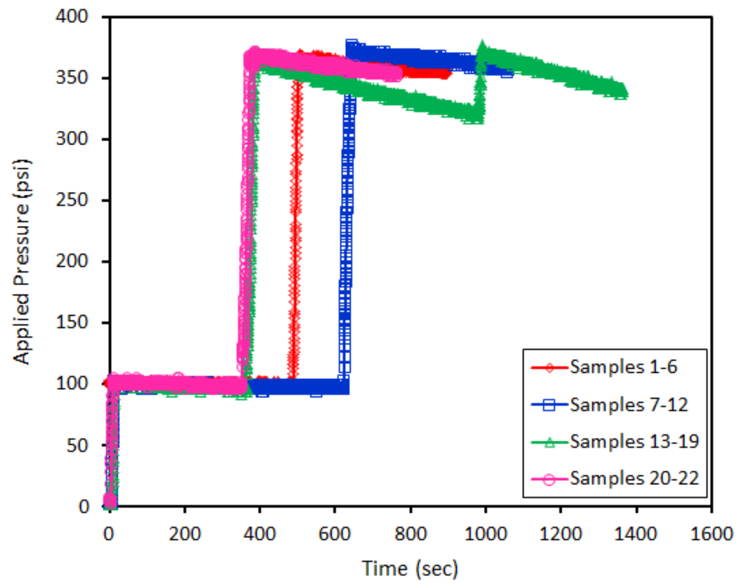


Figure 6: Results of the pneumatic proof tests of the 0.5-in diameter specimens

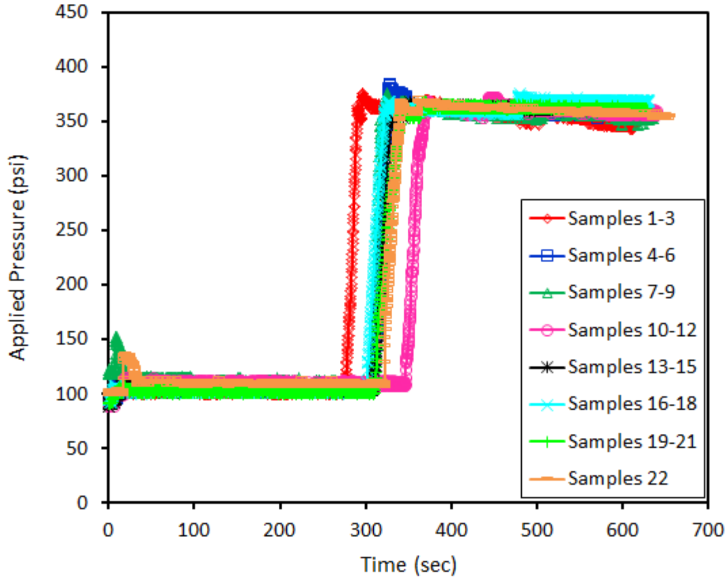


Figure 7: Results of the pneumatic proof tests of the 1.0-in diameter specimens

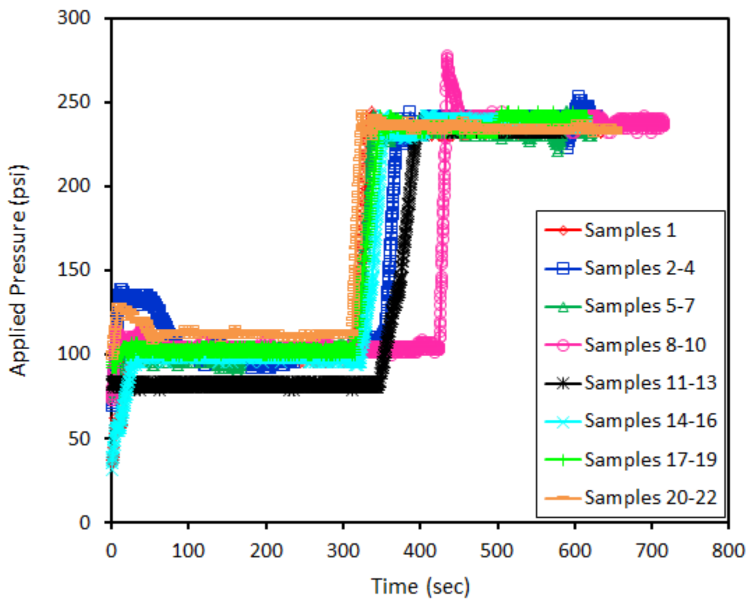


Figure 8: Results of the pneumatic proof tests of the 2.0-in diameter specimens

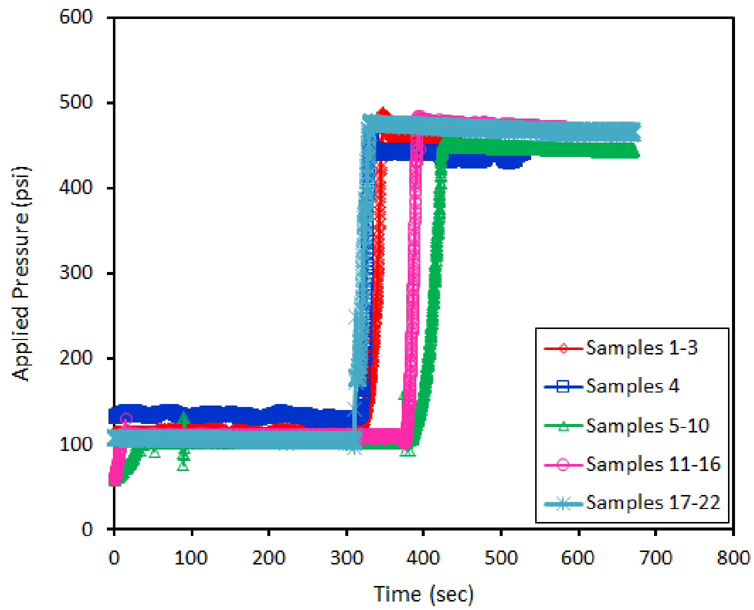


Figure 9: Results of the hydrostatic proof tests of the 0.5-in diameter specimens

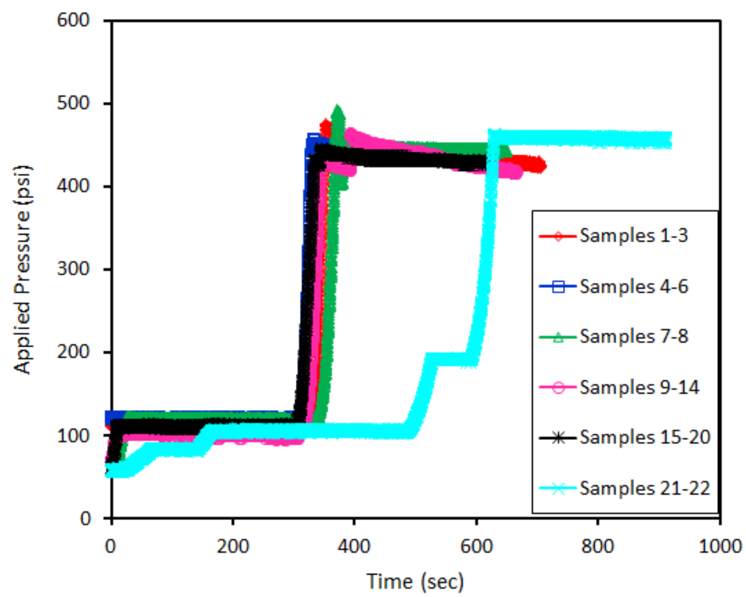


Figure 10: Results of the hydrostatic proof tests of the 1.0-in diameter specimens

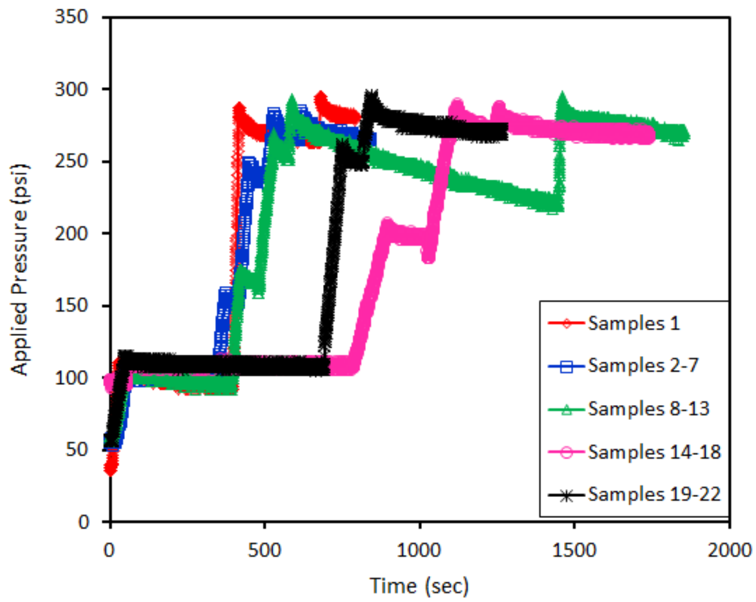


Figure 11: Results of the hydrostatic proof tests of the 2.0-in diameter specimens

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.

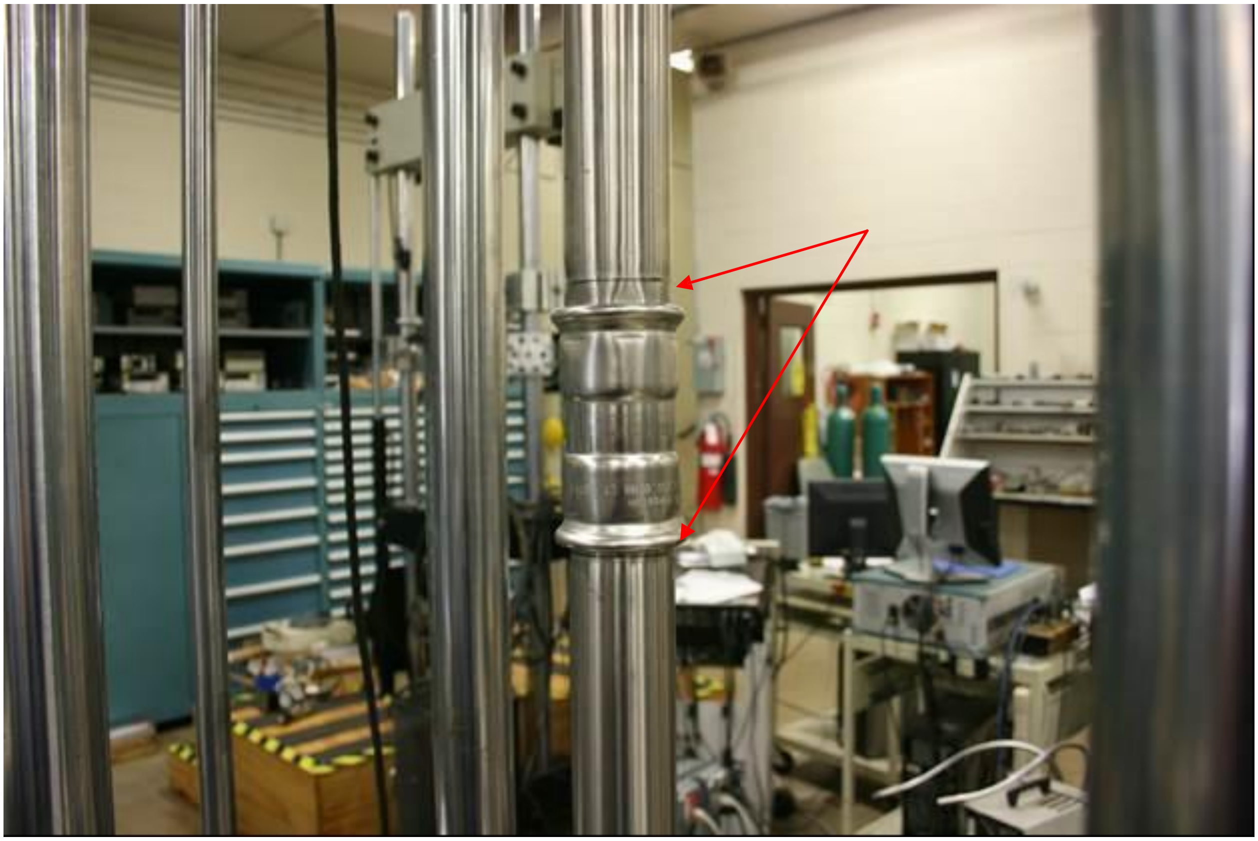


Figure 12: Picture of the tensile test showing slippage at the joint (indicated by red arrows)

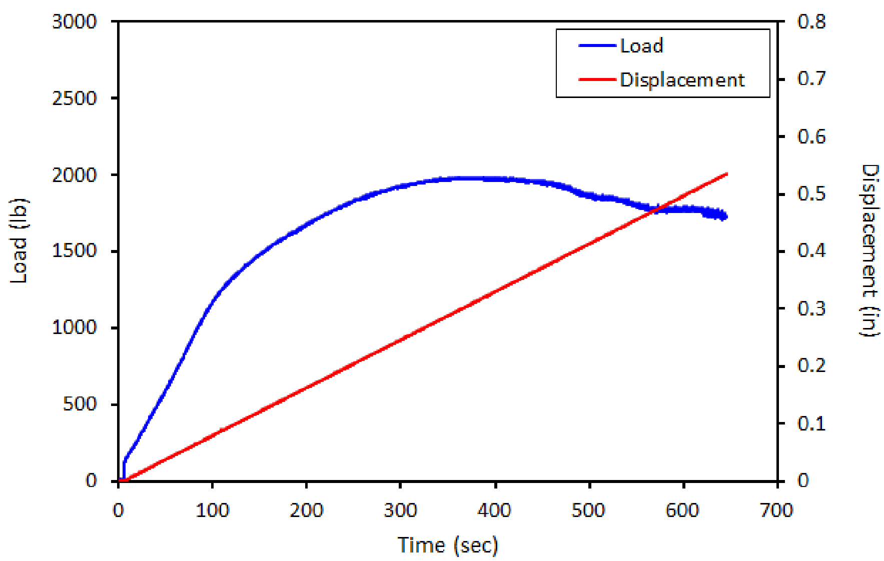


Figure 13: Typical result of the tensile test conducted on the 2.0-in diameter specimen (ID: 28797-6)

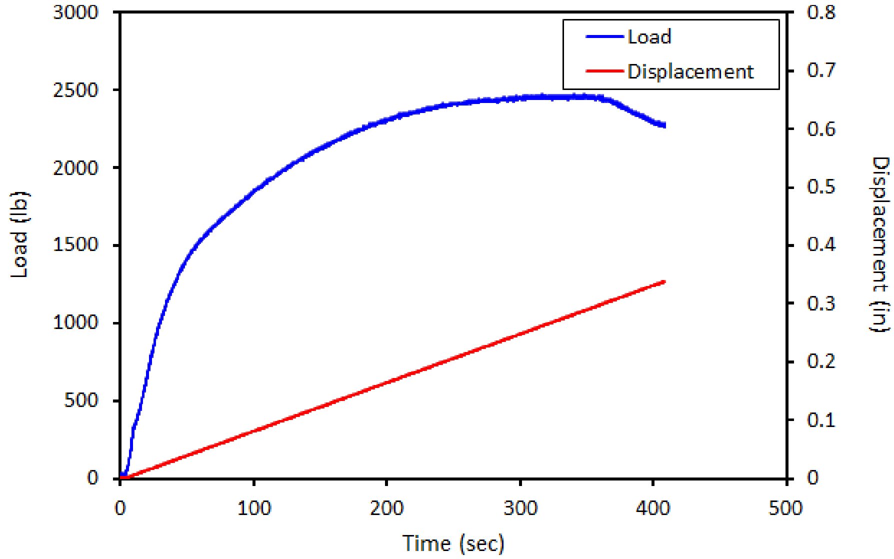


Figure 14: Typical result of the tensile test conducted on the 1.0-in diameter specimen (ID: 28796-5)

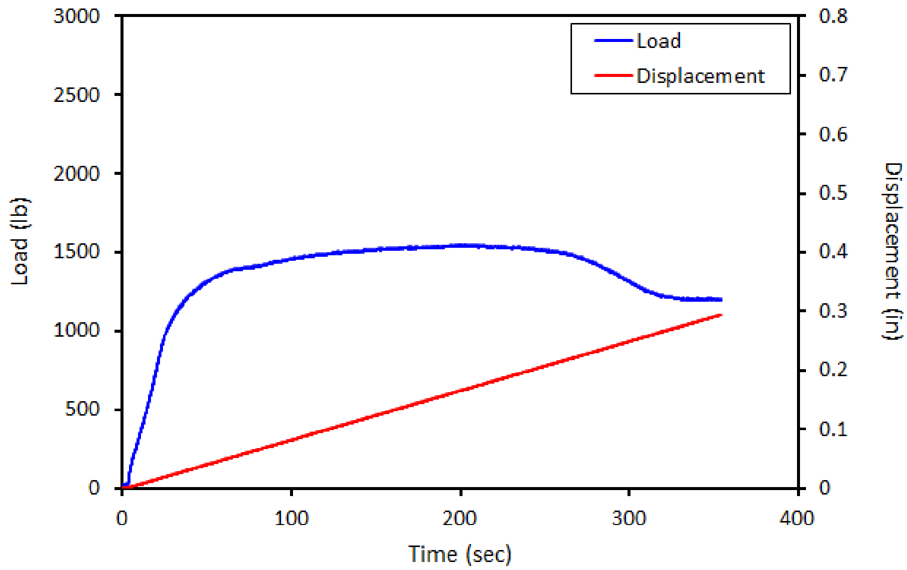


Figure 15: Typical result of the tensile test conducted on the 0.5-in diameter specimen (ID: 28795-4)

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).

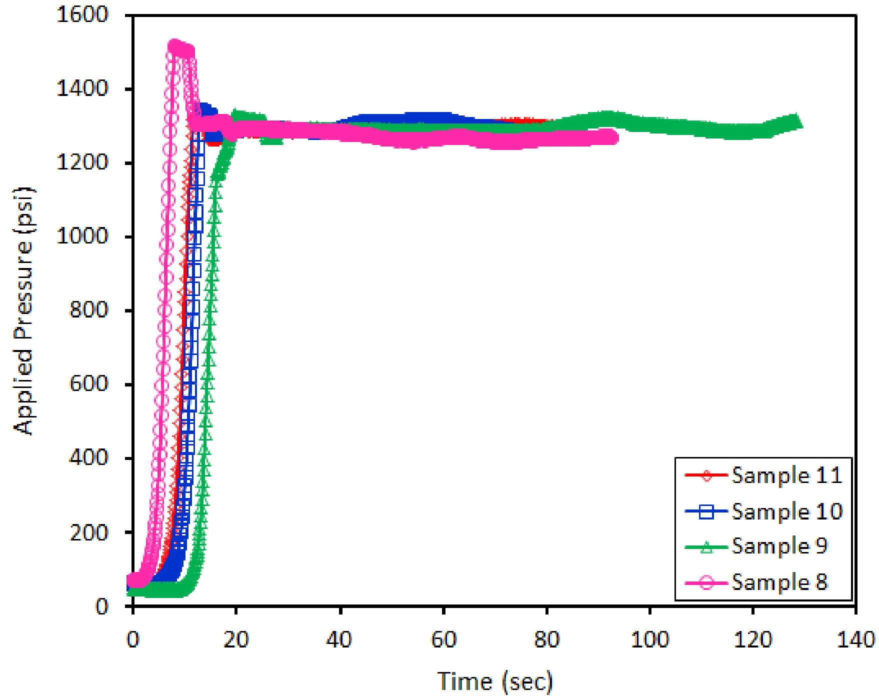


Figure 16: Results of the hydrostatic burst tests conducted on the 0.5-in diameter specimens

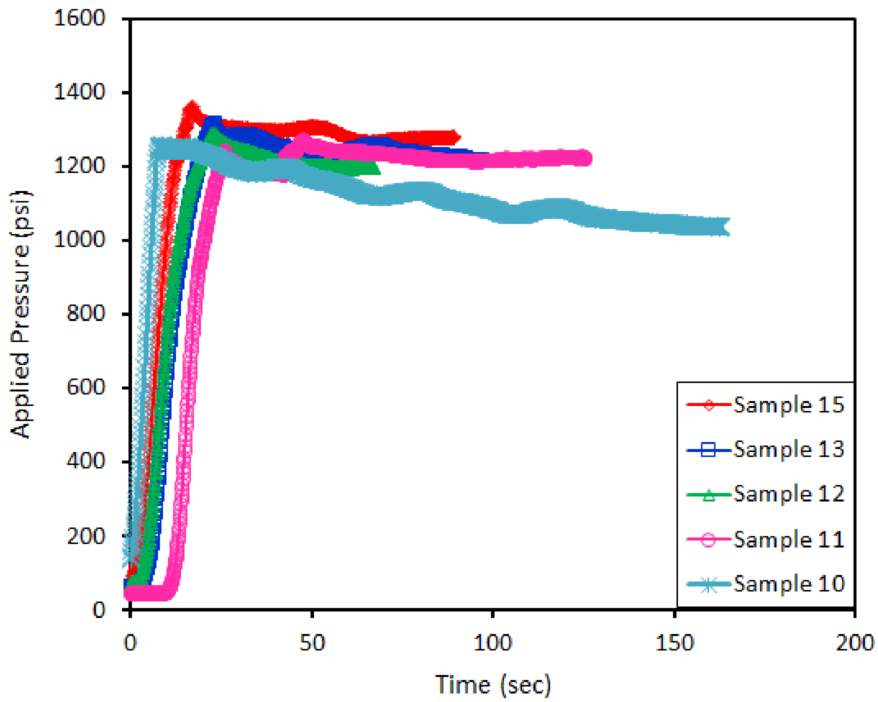


Figure 17: Results of the hydrostatic burst tests conducted on the 1.0-in diameter specimens

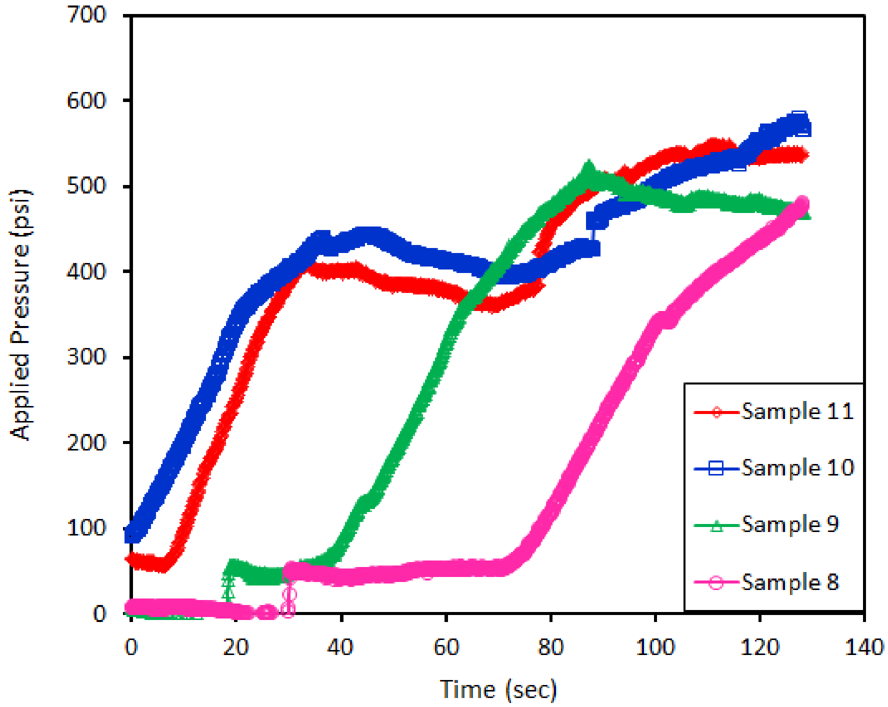


Figure 18: Results of the hydrostatic burst tests conducted on the 2.0-in diameter specimens

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

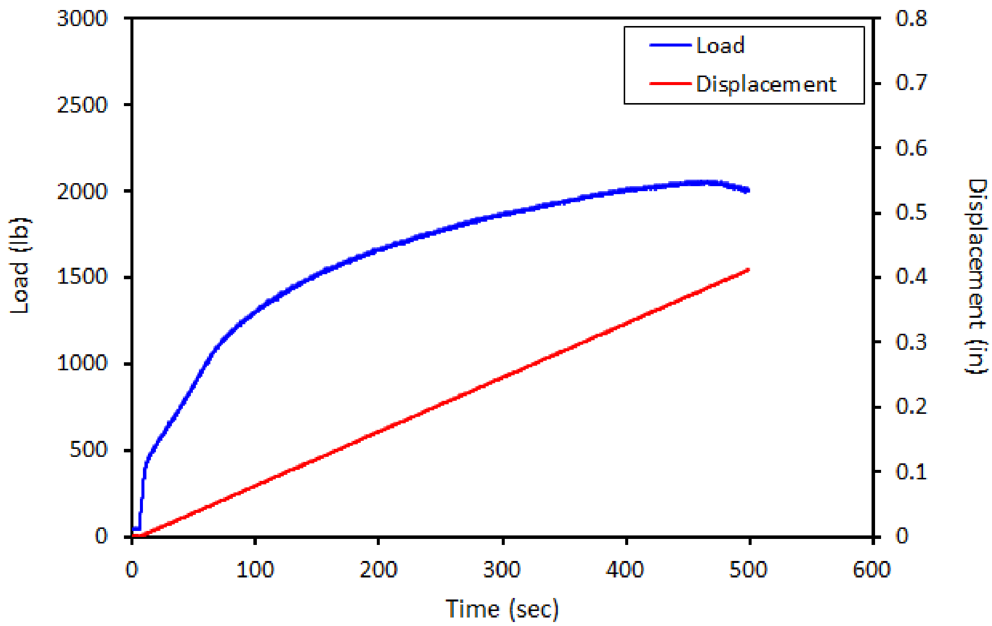


Figure C-1: Tensile test result of the 2 in diameter specimen (28797-5)

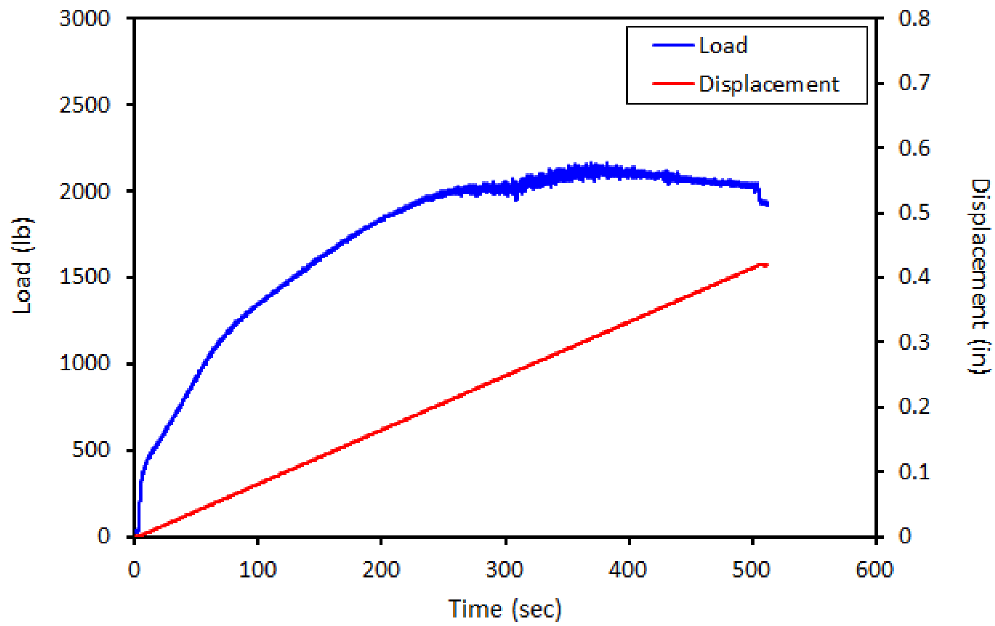


Figure C-2: Tensile test result of the 2 in diameter specimen (28797-4)

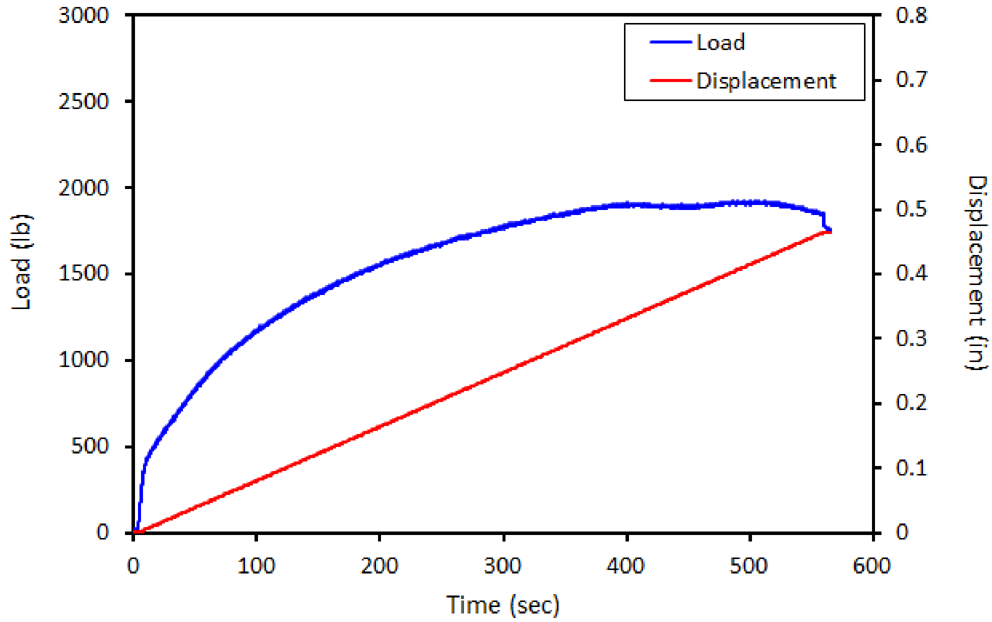


Figure C-3: Tensile test result of the 2 in diameter specimen (28797-3)

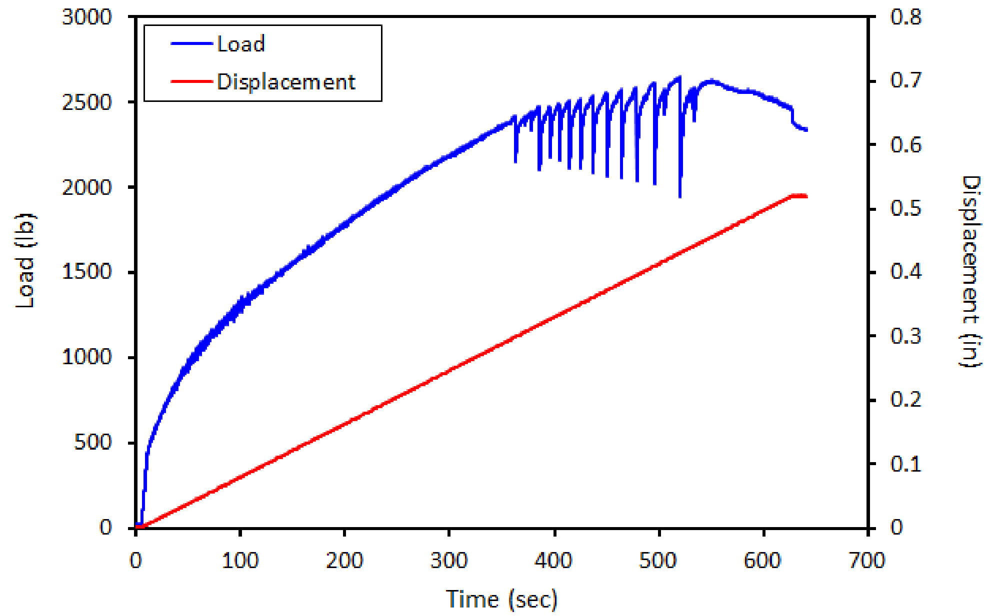


Figure C-4: Tensile test result of the 2 in diameter specimen (28797-2)

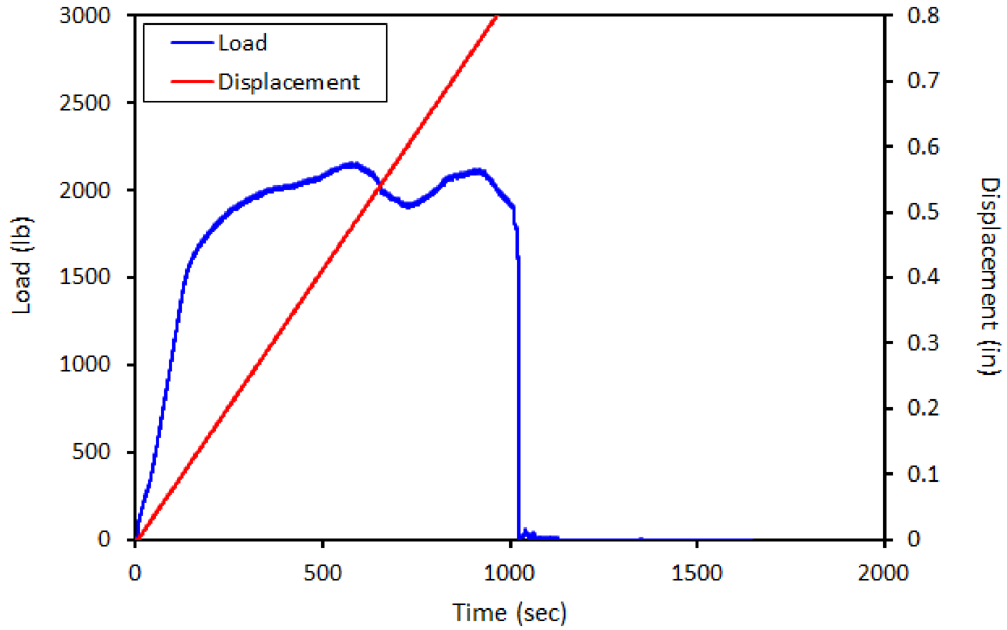


Figure C-5: Tensile test result of the 2 in diameter specimen (28797-1)

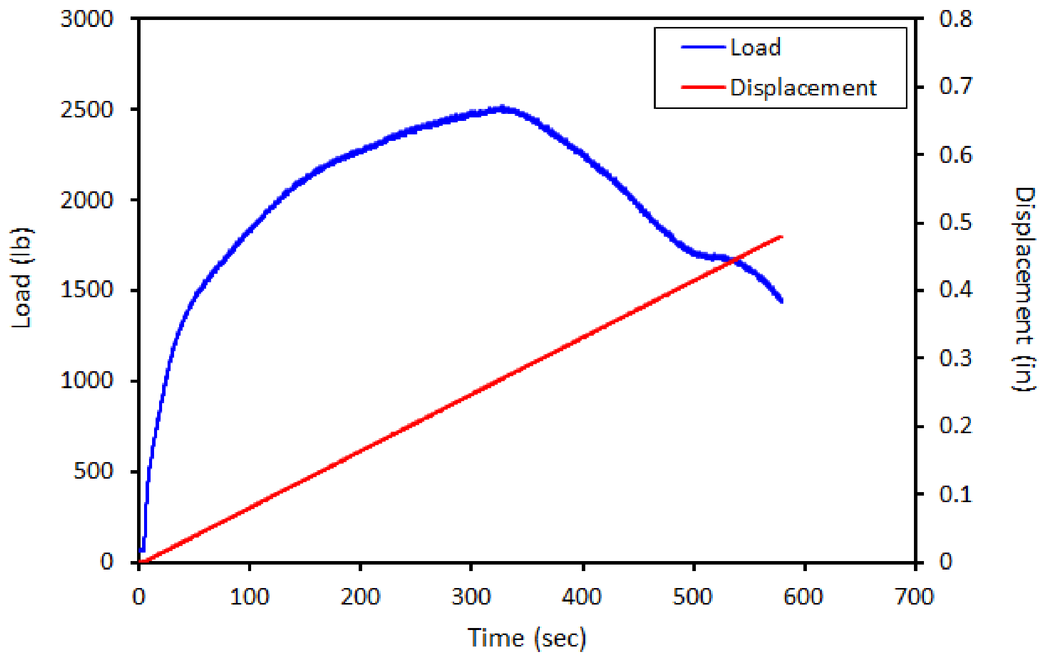


Figure C-6: Tensile test result of the 1 in diameter specimen (28796-6)

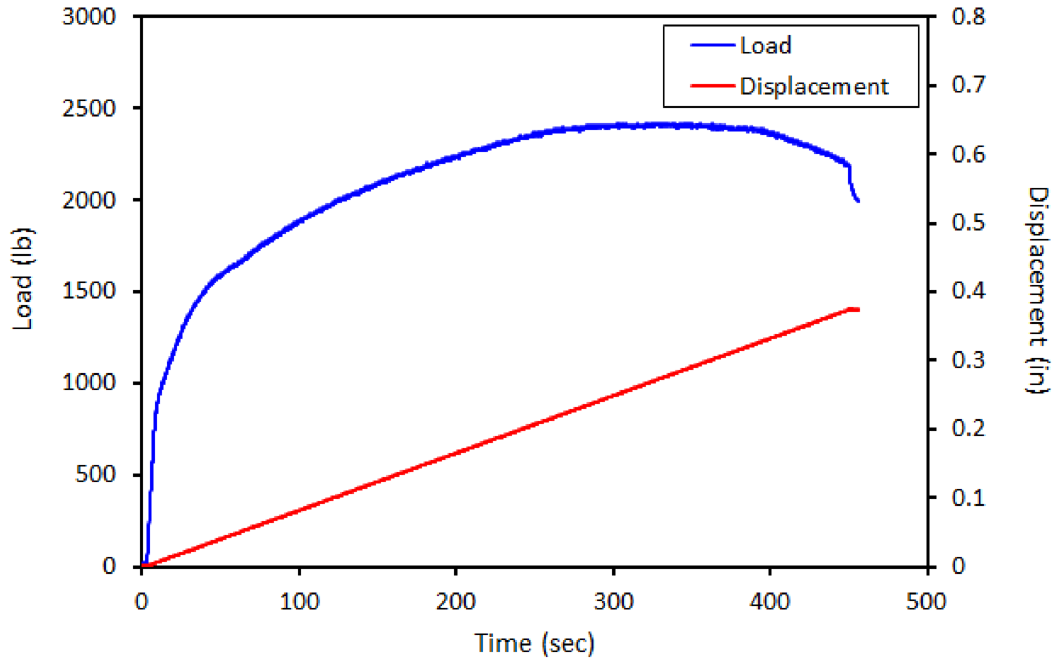


Figure C-7: Tensile test result of the 1 in diameter specimen (28796-4)

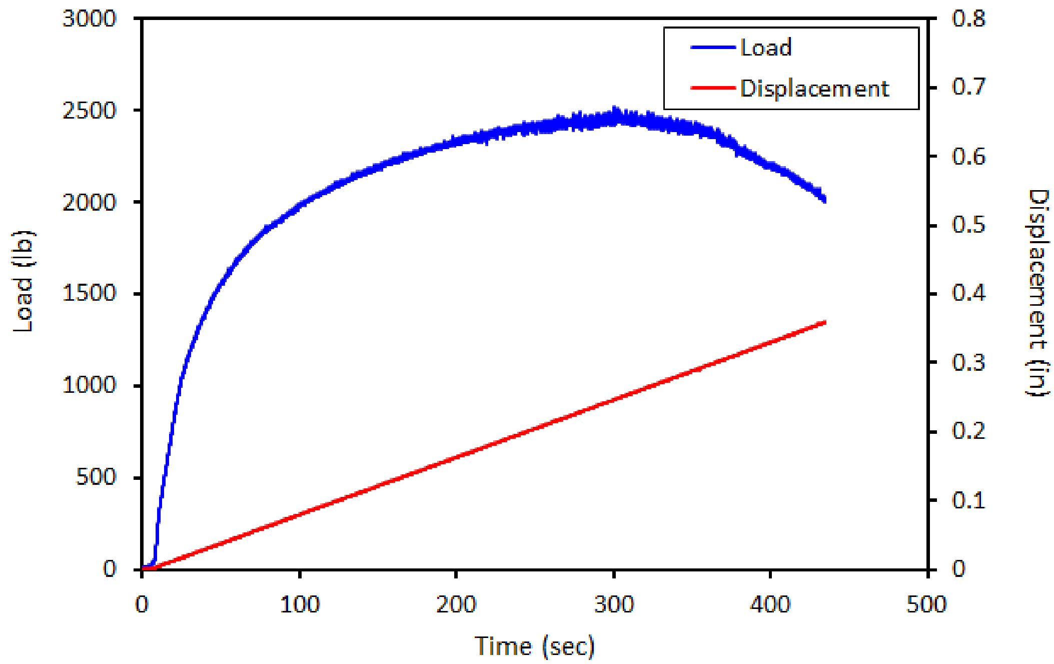


Figure C-8: Tensile test result of the 1 in diameter specimen (28796-3)

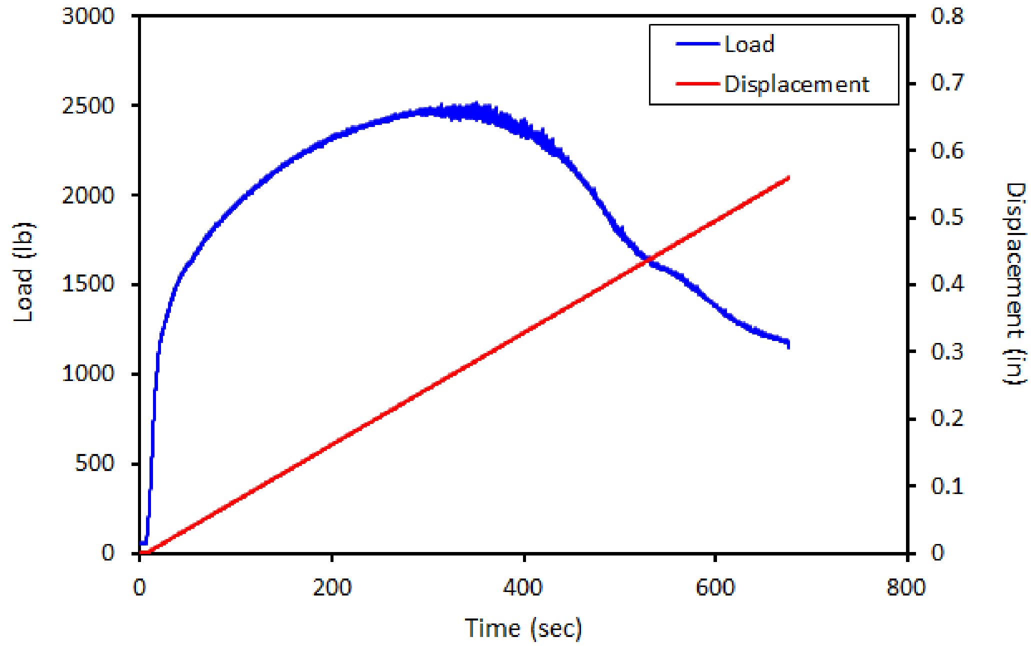


Figure C-9: Tensile test result of the 1 in diameter specimen (28796-2)

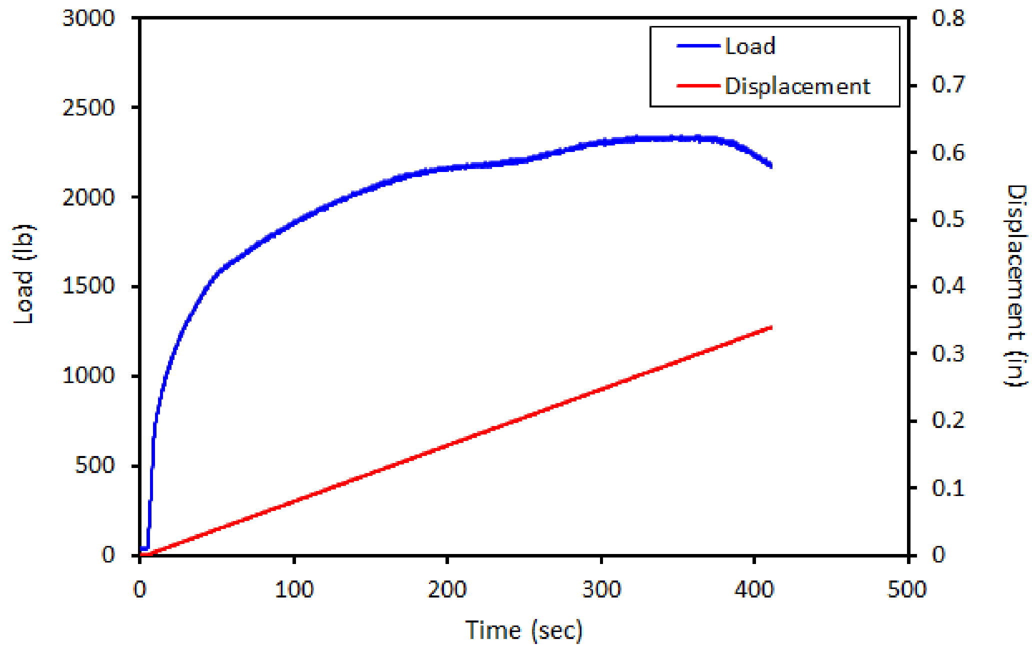


Figure C-10: Tensile test result of the 1 in diameter specimen (28796-1)

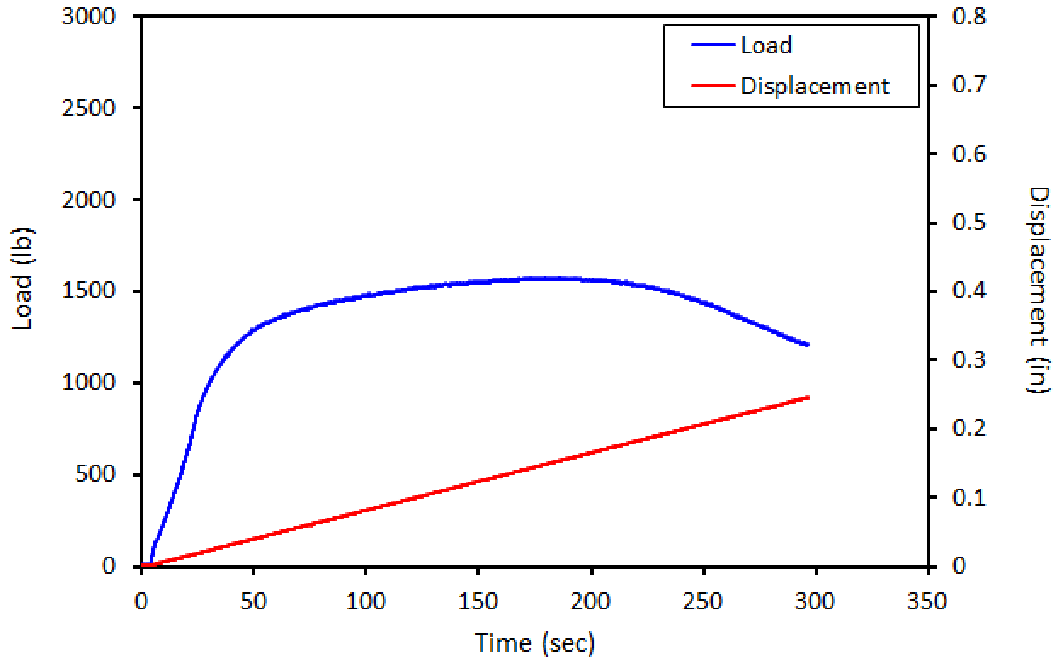


Figure C-11: Tensile test result of the 0.5 in diameter specimen (28795-6)

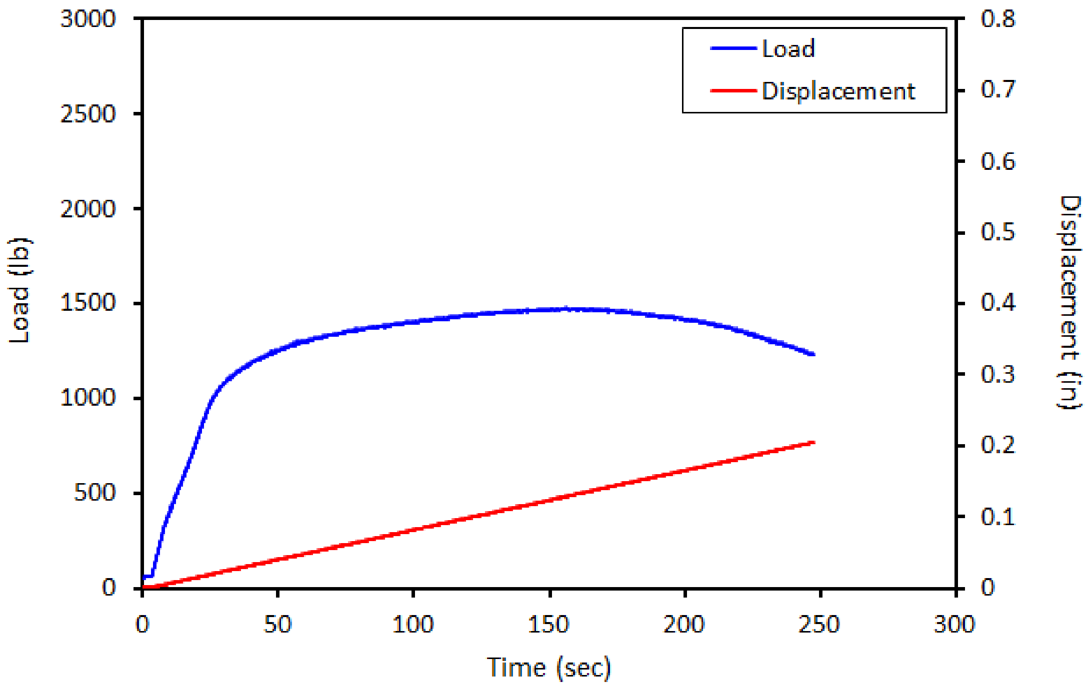


Figure C-12: Tensile test result of the 0.5 in diameter specimen (28795-5)

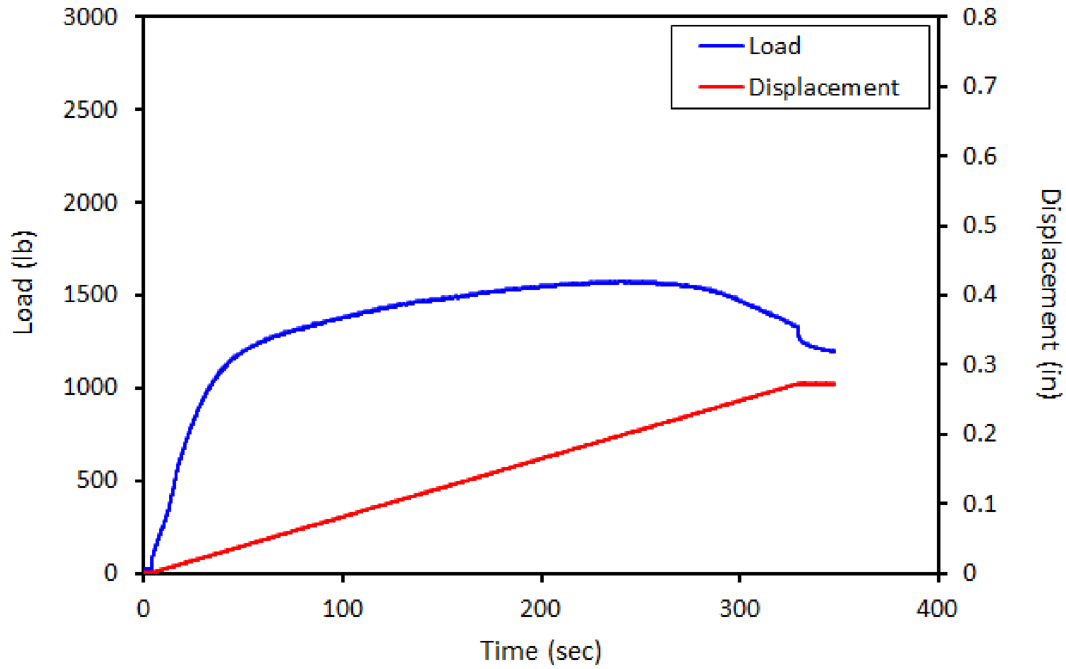


Figure C-13: Tensile test result of the 0.5 in diameter specimen (28795-3)

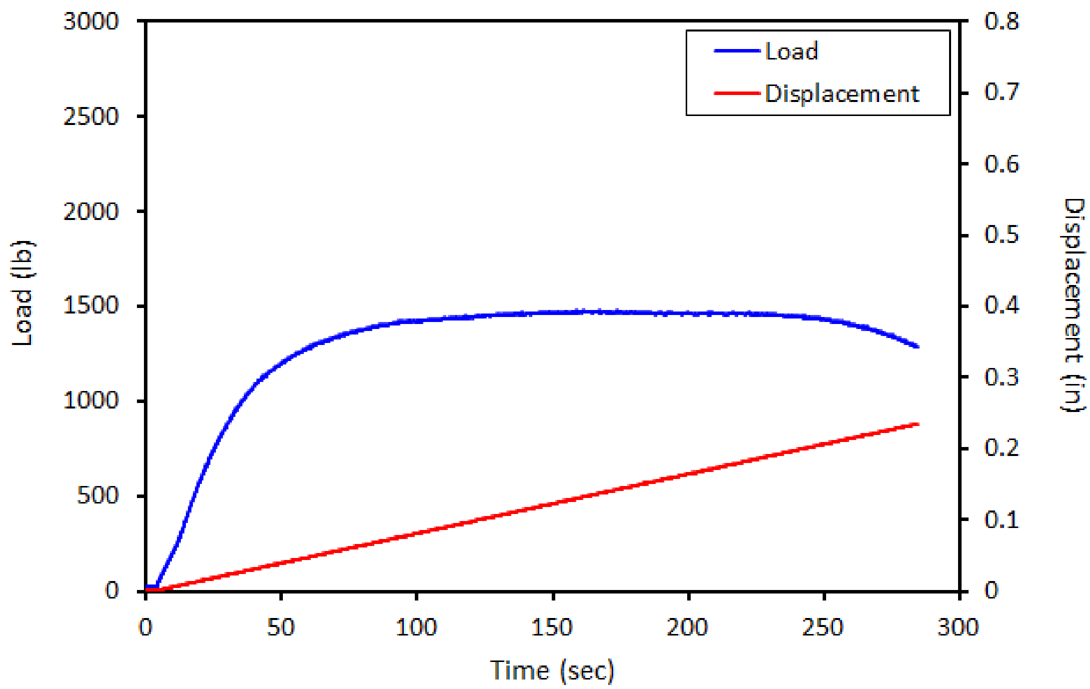


Figure C-14: Tensile test result of the 0.5 in diameter specimen (28795-2)

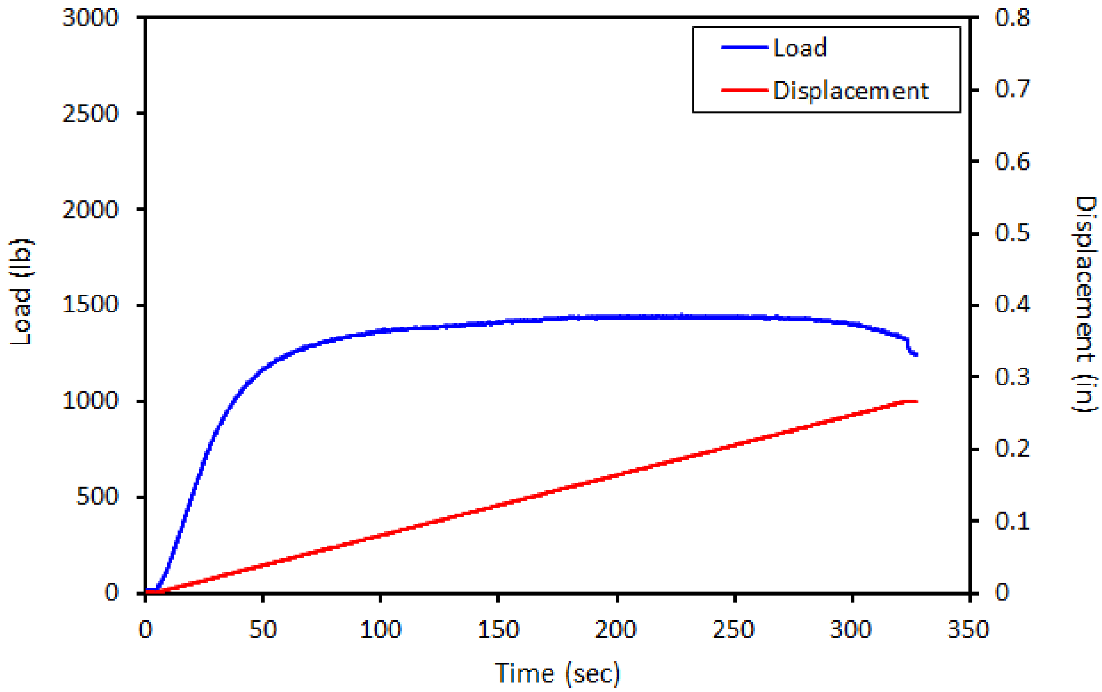
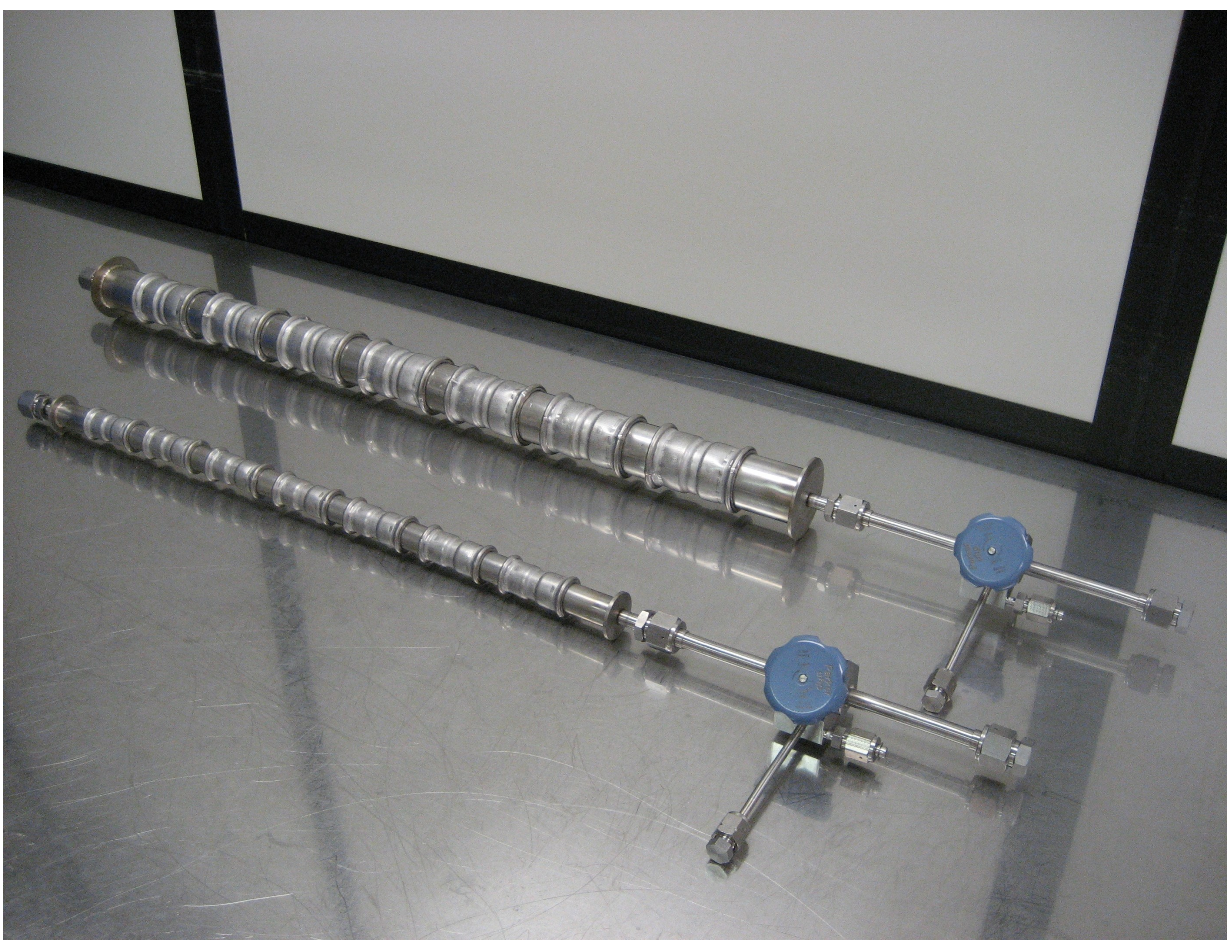


Figure C-15: Tensile test result of the 0.5 in diameter specimen (28795-1)

Evans PLHT Series Presslok Cleanliness & Leak Tests

316L CFOS Stainless Tube Presslok System



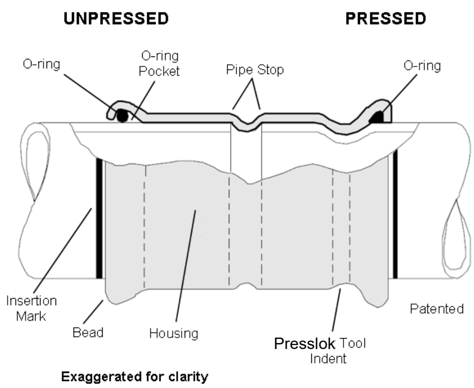
304 Stainless CFOS
Evans Presslok System

Evans PLHT/PL Series Presslok Qualification Tests

The Evans PLHT Series Presslok System with cleaned for O2 Service (PLHT Series) stainless fittings is designed specifically to join plain end stainless steel tube systems “weld free”.

The system incorporates 316L tube from 1/2” through 4” with a system of Presslok couplings, elbows, tees, reducers, and integrated valve assemblies. A portable, hand-held electric tool assembles the fitting on the tube with a permanent mechanical attachment. The system is guaranteed to perform to a helium leak rate of 1 X 10-7 scc/sec. O-ring seal is guaranteed for lifetime of installation”.

1. PRESSLOK COMPONENT



O-ring: The precisely molded synthetic rubber o-ring compresses against the pipe O.D. and inner housing for a lifelong, leak-tight seal. Grade “E” is rated for -30°F to +230°F (-34°C to -110°C) for water, Vacuum Exhaust, CDA, Nitrogen, Argon and other medium purity inert gases;. Grade “V” (Viton) is recommended for higher temperature , more aggressive chemicals/gas applications +20°F to + 300°F (+6C° to +149C°). Grade K Perfluoroelastomer is recommended for solvent, vacuum, high temrperature and more aggressive chemistries

Housing: Precision formed Type 316 Stainless steel, the housing incorporates the gasket and a tube stop. The unique design assures permanent engagement onto the tube when pressed with the Evans Presslok Tool. Using available adapters, the Presslok System allows easy field make-up of fitting combinations for reductions and adaptation to threaded components.

Tube Stop: To assure a uniform takeout from overall center-to-end or end-to-end dimensions, an integral tube stop locates tube position.

O-ring Pocket: Sized to contain the Pre-lubricated (Evans 111 high purity lube) o-ring before assembly, the pocket is formed around the o-ring during the pressing operation to fully surround and compress it for a complete leak-free seal.

Helium, Particle, Moisture, Out-gassing Tests

Description: FST TecLab performed an inbound and outbound Helium leak test on 1”, 1-1/2” and 2” pipe sizes, and with pipe size Presslok fittings. Leak rate not to exceed 1.0 x 10-7 std. cc per sec.

1. **Helium Leak Test**

Inboard Helium Leak Test: Each Presslok fitting on test specimens were enclosed on a 3-4 mil plastic bag and sealed with clean room tape. A Leybold MOD UL200 leak detector with dry scroll pump was turned on and calibrated. Test specimen was then connected to the leak detector, where a vacuum was pulled on its internal volume. The leak rate was allowed to stabilize and recorded as the starting leak rate. At this time Helium was injected into the plastic bag covering the Presslok fitting. Helium was allowed to sit in the bag for 5 minutes, at this time the leak rate was recorded as final leak rate.

Outboard Helium Leak Test: The Leybold MOD UL200 Helium leak detector was connected to FST SS bell jar. Test specimen was placed inside the bell jar with a sealed outside connection for Helium. The bell jar lid was closed and the internal volume pumped down to a stable leak rate (recorded as starting leak rate). The internal volume of the test specimen was pressurized to 110 PSIG with Helium and left for 15 minutes. At that time the final leak rate was recorded

Equipment: Leybold MOD UL200, FST SS Bell Jar

Conclusions:
Leak rates indicate that all test specimens are well within customer specified parameters. Therefore all test specimens passed both Helium leak tests.

Leak Detector:	**Serial Number**	**Calibrated Leak**	**Sensitivity**
FST 585	20600066309	9.1 x 10-7 std. cc/sec Helium	1.0 x 10-11 std. cc/sec Helium
Last Calibrated	**Calibration Due**		
3/26/02	3/26/03		

I.D.	**Inboard Test**		**Outboard Test**	
Tube Size	Starting Leak Rate	Final Leak Rate	Starting Leak Rate	Final Leak Rate
1”	1.2 x 10-10	5.4 x 10-11	3.6 x 10-9	1.4 x 10-8
1-1/2”	3.6 x 10-10	1.8 x 10-10	5.1 x 10-9	3.6 x 10-9
2”	1.6 x 10-10	4.0 x10-8	1.7 x 10-7	2.0 x 10-8

Note: all leak rates are expressed in std. cc/per sec Helium

2. Particle Count Test

Description:

Determine particle analysis during crimping of Vic-Evans fittings on 1-1/2" and 2" sizes.

Test Procedures:

A filtered nitrogen purge was used. All flow levels were set at 20 ft / sec. for turbulent distribution of particles. A base line particle count was established before crimping on each size pipe. After base line, the fittings were crimped one side at a time with the particle counter running to record particle activity. The 2" had fittings (4) crimps. The 1-1/2" had one fitting (2) crimps. Below are the findings of the test.

Equipment: Climate Ultimate 100 laser particle counter, FST # 596, CAL due date 6/23/04

Particle range: 0.10u to 1.0u. Welded end caps with 1/2" Swagelok fitting.

Base line 2" tube assembly

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
2	2	3	4	6	6

1st Crimp

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
3	4	6	12	25	40

2nd Crimp

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
5	14	43	74	107	152

Tap down after 1st & 2nd crimping

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
8	17	47	79	113	161

Counts are cumulative from base line to tap down

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
0	0	0	0	0	0

After tapping the test piece down, we saw some particles released. The particle counter was restarted and run for a 1cfm sample with no particles. Then, the particle counter was restarted for 3rd and 4th crimping.

3rd Crimp

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
0	6	12	22	33	50

4th Crimp

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
0	8	36	102	1098	256

Tap Down After 3rd & 4th Crimping

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
8	11	17	19	22	30

Particle count after 3rd and 4th crimping was restarted and can be added together

10 min run after tap down (clean up)

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
0	0	0	0	0	0

Base line 1-1/2" tube assembly

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
0	0	7	27	89	129

1st Crimp

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
1	3	9	14	30	41

2nd Crimp

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
2	7	18	30	53	69

Tap down after 1st & 2nd crimping

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
12	23	37	47	54	75

10 min run after tap down (clean up)

1.0u	0.50u	0.30u	0.20u	0.15u	0.10u
0	0	0	0	0	0

After tapping the test piece down, we saw some particles released. The particle counter was restarted and run for 1cfm sample with no particles.

Conclusion:

Final particle counts indicate that all tests performed within customers specified parameters.

EVANS COMPONENTS

Out-gassing, Moisture Testing:

Executive Summary: *Ralph M. Cohen Consultancy*

Two spool pieces (one each of 2 inch and 1 inch diameter) assembled from short lengths of 304 SS tubing and 7 Presslok couplings (two 0-rings per coupling), each, were tested to quantify the level on contaminants that might be imparted on a gas stream using this joining technique. The tests were conducted by passing purified gas through the spools at both ambient and elevated temperature. The gas exited the spools and was directed to getters (contaminant traps) supplied by SAES Puregas (San Luis Obisbo, CA). At the conclusion of the sampling period, the getters were sent to SAES for determination of the contaminant levels using a GC-MS (gas chromatograph-mass spectrometer).

The principal contaminants were organic and due to one compound, alphamethylstyrene, a chemical intermediated in the manufacture of plasticizers, resins and polymers. Additional compounds observed were volatile aromatics such as ethylbenzene and xylene along with some oxygen containing organic compounds - the most prominent of which was acetophenone. The most common use of acetophenone is its combination with other compounds to produce polymeric resins. Concentrations in the 2 inch sample were 2.2 ppb at elevated temperature and 0.7 ppb at ambient (toluene equivalent). In a process application, the normally higher flows would result in significant dilution. The concentrations measured in the 1 inch sample were significantly lower at 74 ppt and 14 ppt (elevated and ambient temperature, respectively, toluene equivalent). No acidic or basic contaminants were found in either sample.

Photovoltaic industry bulk gas specs are currently being negotiated amongst industry experts. Allowable total hydrocarbon concentration has not yet been agreed but values in the 100 - 1000 ppb range (methane equivalent) for N2 and Argon streams are being considered. The results of these tests indicate that this “weld-free” method of connecting tubing will likely be satisfactory for these applications, especially if the couplers are used primarily to join 20 feet long prefabricated manifolds into laterals, thus minimizing the number of connectors in each lateral.

Moisture dry down testing showed that a short spool (2 inch diameter) containing 7 Presslok couplings dried down from 1.5 ppm to < 100 ppb in approximately 2 hours, 20 minutes at a flow rate of 6 liters per minute. A spike of only 54 ppb occurred when the sample was heated to 40 ^{O}C.

Similarly, the 1 inch diameter spool showed dry down from 194 ppb to <100 ppb in approximately 8 minutes which is < 25% of the time for the 2 inch spool to make the same reduction. This would be expected given the ratio of internal area and volume.

Comparing ambient temperature dry down time for a 2 inch diameter spool with 7 Presslok couplings to a piece of tubing with no couplers, the tube with no couplers dried from 2 ppm to 35 ppb in 15 hours while the spool with couplers dried from 1.5 ppm to 78 ppb in 22 hours, 50 ppb in 23.5 hours and 34 ppb in 49 hours.

Procedure for Evans PLHT Presslok fitting Out-gassing Test

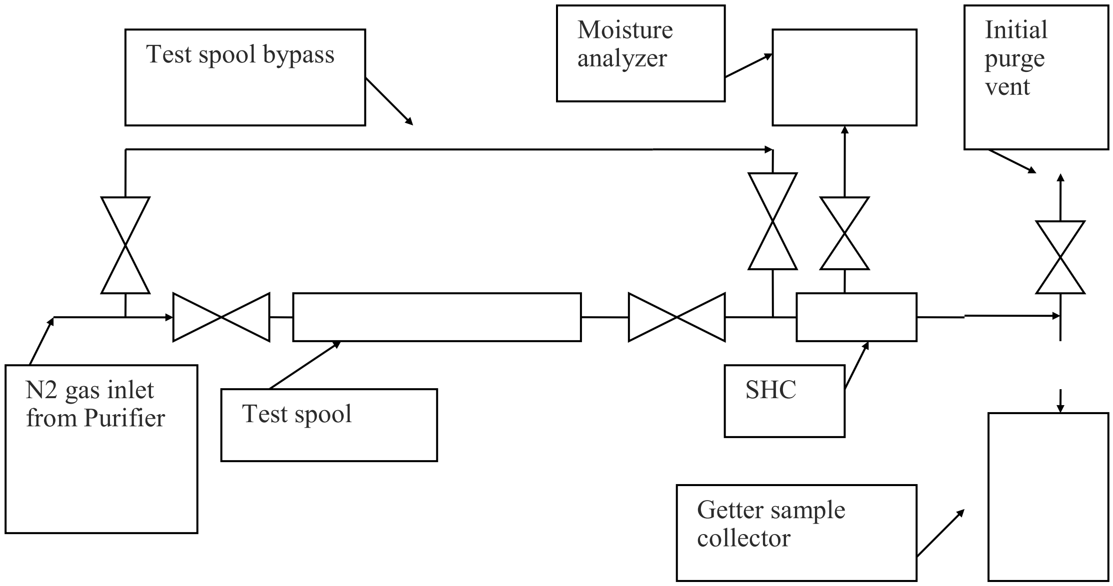
Description:

To determine the impact on gas purity in a tubing system that uses o-rings in tubing couplers that are lightly coated with Evans 111 high purity lubricant (perfluoropolyether based, low vapor pressure) as a required aid for assembly. Using ASTM-2595, the supplier determined that the evaporation rate at 400 ^{O}F is 1.7% in 22 hours. Realizing this test is not useful in predicting performance in an actual piping system, the supplier worked with the Ralph M Cohen Consultancy and SAES Pure Gas to develop suitable tests.

Test spools configuration consisted of the following:

- One spool 2 inch diameter x 40 inch length consisting of Dockweiler 304 SS x .065 wall tubing with 14 Presslok coupling connections
- One spool 1 inch diameter x 30 inch length consisting of Dockweiler 304 SS x .065 wall tubing with 14 Presslok coupling connections.
- One 2 inch diameter x 40 inch length of Dockweiler 304 SS x .065 wall tubing.
- Each spool has a 1/2 inch male face seal connector on inlet and outlet.

Test Configuration:



Tests

Setup: A source of High Purity N2 with certification and a downstream purifier was provided; gas pressure could be set between 30-50 psig with a downstream bleed valve and flow meter capable of flowing 5-20 LPM. The moisture analyzer was connected to the valve at the outlet of the sample manifold.

Purge Test: Bypass valves were opened and spool isolation valves remained closed. N2 flowed through bypass line. Moisture analyzer readings recorded periodically until bypass line reaches a level of <60 ppb. Flow rate through analyzer was 100 sccm.
Then bleed valve was opened and flow was set to 10 LPM until the moisture counter to stabilize at <60ppb. Closed bleed valve.

Moisture Test: Opened isolation valves on test spool and closed valves on bypass.
Dried down entire test spool until the moisture analyzer indicates <50 ppb. After a period of time at 100 sccm flow rate, purge flow was increased to 6 lpm as recommended by SAES lab.
Recorded time and readings, (as moisture readings stabilized, frequency of the readings decreased).

After completing the moisture dry-down test on the 2 inch spool, it was connected to one of the supplied SAES Getter (Collect Torr) units. **Instructions provided by SAES for running the test were followed**. Recorded date and time started. Flow rate maintained by using supplied flow meters (Port 1, 2, & 3 flowed at 2.0 LPM, Port 4 to flow at 0.10 LPM). Tests were run for **6 hours.** Verified flow rates were within spec after 2 hours. At test completion, recorded the time and flow rates. Capped the Collect Torr and closed isolation valve and plugged it ensuring unit was pressurized. The process was repeated at elevated temperature for the 2 inch spool; then again after dry-down of the 1 inch spool at both ambient and elevated temperature.

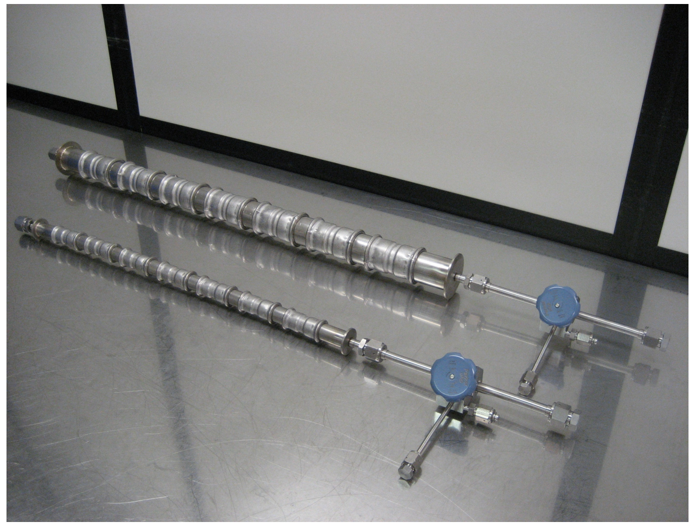
Getter Test 1: *(Collect Torr **Serial #209506**)* 2 inch spool with 14 Presslok connections. This test conducted at ambient temperature (~ 20 ^{O}C).
Getter Test 2: *(Collect Torr **Serial #209512**)* 2 inch spool with 14 Presslok connections, spool heated to 40 ^{O}C (placed test spool into oven and set temperature control to 40 ^{O}C.
Getter Test 3: *(Collect Torr **Serial #209098**)* 1 inch spool with 14 Presslok connections, test conducted at ambient temperature (~ 20 ^{O}C).
Getter Test 4: *(Collect Torr **Serial #209095**)* 1 inch spool with 14 Presslok connections, spool heated to 40 ^{O}C (placed test spool into oven and set temperature to 40 ^{O}C

Tubing Test for Moisture: Finally install a 2 inch x 40 inch LG tube into test fixture and test for moisture dry-down characteristics.

EQUIPMENT:

Moisture Analyzer: Meeco Tracer S/N 12226-25-2
Purifier: ARM Model OKC FP; P/N OIKC-V04-I-FP

TEST SETUP: Purge gas and purifier, Meeco moisture analyzer connected to testing manifold, and test sample located in environmental chamber for elevated temperature test.



TEST SAMPLES: 1 inch and 2 inch diameter with 14 Presslok connectors each

Evans 111 High Purity Lubrication:

Evans PLHT (Pre-Lubricated O-Ring) Presslok fittings are supplied with Evans 111 High Purity Lubricant applied to the o-ring. All fitting are individually labeled as so and are packaged and sealed in nylon bags.

This is written to confirm the absence of Hydrocarbons (oil) and Silicone in Evans 111 High Purity Lubricant. Evans 111 is oxygen compatible and is commonly used in the Semiconductor, Solar, TFT/LCD Flat Panel industries for oil free air, nitrogen, vacuum exhaust and other high purity inert gas and water applications.

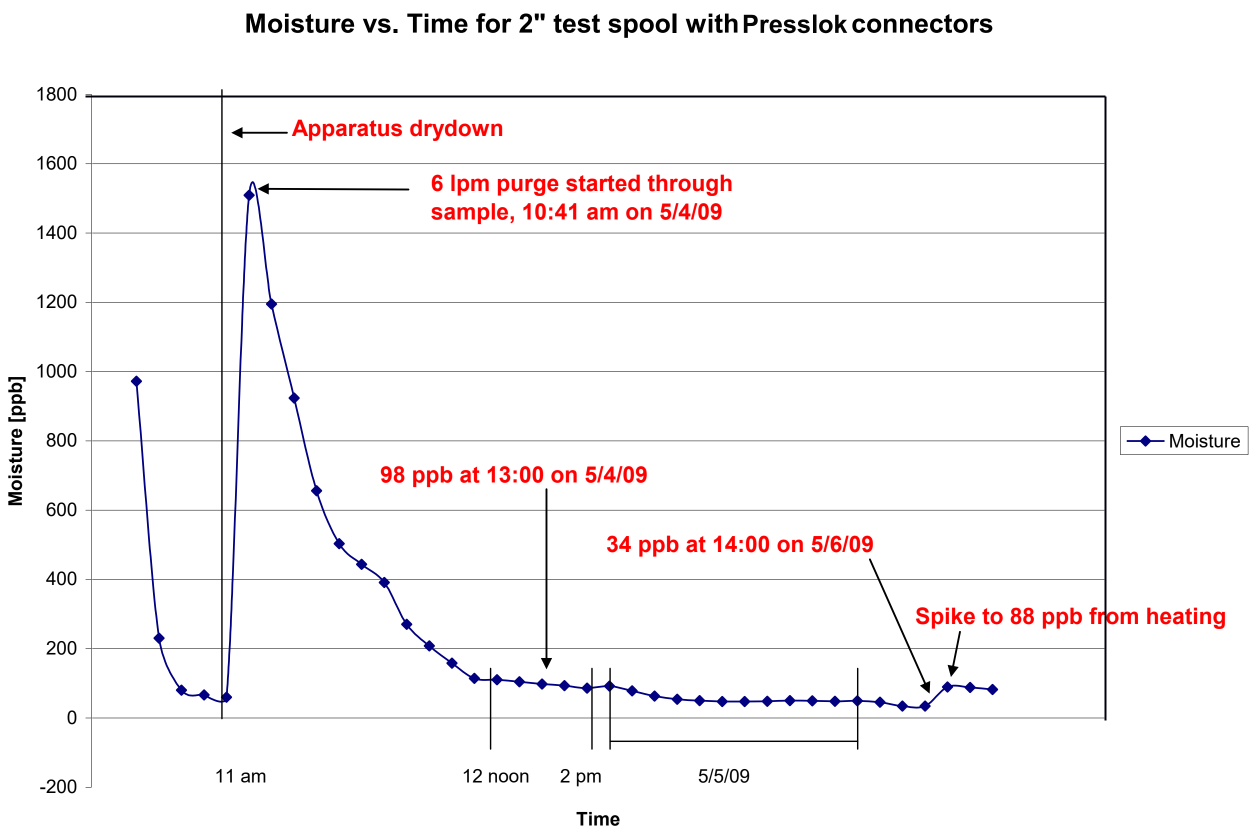
Evans 111 Lubricant does not have a flash point and will not support burning. This product is both chemically and biologically inert. Evans 111 Lubricant is a perfluoropolyether (Teflon) lube; it meets the specification requirements and has been qualified under Military Specification MIL-PRF-27617F, Types I, II, and III.
This lubricant is rated for temperatures of -100°F to 450°F . Vapor Pressure rated @ 68°F 10-10 Torr. Vacuum Thermal Stability, NASA SP-R-0022A 24 hrs. @ 6x10-6, weight loss 0.07% water vapor recovery 0.01%.

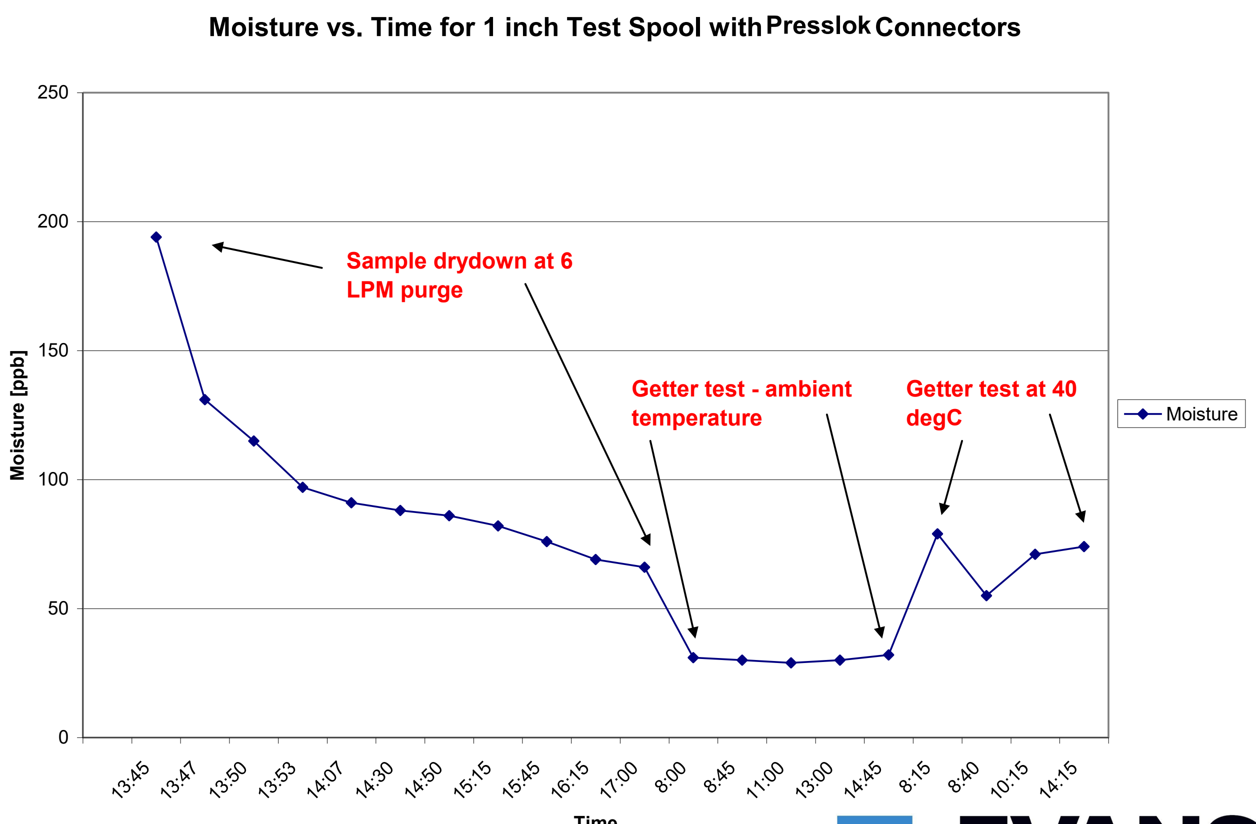
PERFORMANCE TEST	TEST METHOD	CONDITION	TYPICAL VALUE
Temperature Range			-100°F to 450°F
NLGINo.			1-2
Worked Penetration	ASTM D-1403	60 strokes	*265-325*
Evaporation	ASTM D-2595	22 hrs, 400°F, max	1.70%
Oil Separation	FED-STD-791, Method 321	30 bra, 400°F, max	12.75%
Four-Ball Wear Test	ASTM D-2266	1200 rpm, 40 kg, 167°F, 52 100 steel, 1 hour 2 hours	1.00 mm 1.50 mm
Low Temperature Torque	ASTM D-1478	@-65°F, Starting, max 60 mm Running, max	*576 g-cm* *300 g-cm*
Copper Corrosion	ASTM D-130	24 hrs, 2 12°F	1b
LOX Impact Sensitivity	ASTM D-25 12	20 Impacts From 1100 mm	No Reaction
Oxidation Stability	ASTM D-492	250°F, 100 his	0 psi Drop

EVANS COMPONENTS

Results

Moisture dry down: test results from data collected by Evans Components:





EVANS COMPONENTS

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Compressed Dry Air or Inert Gas Microcontamination Analysis
Evans CFOS Grade PLHT Series Presslok

Summary

Four CollectTorr manifolds were utilized to test two types of tubing spool assemblies at two different temperatures (ambient and 40 °C). Two spool sizes were tested (1 and 2 inch diameter) that both contain 14 Presslok connections. Sampling was performed by Evans Components Inc. personnel.

The samples were tested for acidic, basic, and organic contaminants. No acidic or basic outgassing was observed in any of the four samples. Organic outgassing was observed in all four samples. The highest organic outgassing was observed in the 2” spool heated test and was observed at a level about four times greater than the next highest levels seen in 2” spool ambient temperature test (676 pptV and 2192 pptV as toluene, respectively). Much lower levels were observed in the 1” spool ambient and 1” spool heated tests (14 pptV and 74 pptV as toluene, respectively) with about five times higher levels seen in the 1” spool heated test. A majority of the organic outgassing is due to one compound, alpha-methylstyrene. Alpha-methylstyrene is most often used as a chemical intermediate in the manufacture of plasticizers, resins and polymers. Additional compounds observed are volatile aromatics such as ethylbenzene and xylene along with some oxygen containing organic compounds the most prominent of which is acetophenone. The most common use of acetophenone is its combination with other compounds to produce polymeric resins.

Sampling Location and Description

Four CollectTorr manifolds were used to analyze the outgassing of a two types of tubing spool assemblies at two different temperatures (room temp and 40 °C). All samples were collected for a period of six hours. A table with the sampling details is given below. Both spools were sampled identically. Sampling volumes for acids and bases was 720 liters based on 2 lpm sampling flow rate whereas sampling volumes for organic and refractory compounds was 36 liters based on 0.1 lpm sampling flow rate.

		2” spool ambient	2” spool heated	1” spool ambient	1” spool heated
Acids	Flow Rate (Lpm)	2.0	2.0	2.0	2.0
	Sampling Time (min)	360	360	360	360
	Sampling Volume (L)	720	720	720	720
Bases	Flow Rate (Lpm)	2.0	2.0	2.0	2.0
	Sampling Time (min)	360	360	360	360
	Sampling Volume (L)	720	720	720	720
Organic & Refractory Com-pounds	Flow Rate (Lpm)	0.10	0.10	0.10	0.10
	Sampling Time (min)	360	360	360	360
	Sampling Volume (L)	36	36	36	36

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Sample Analysis Techniques:

Analysis of Acidic and Basic Contaminants

Acidic and basic contaminants are collected onto solid-state traps and extracted into an aqueous solution. Sample analysis is performed with a dual ion chromatography system Dionex ICS-3000. Samples are eluted through both the anion (for analysis of acids) and the cation (for analysis of bases) columns at a rate of 1 mL/min which is held at a temperature of 30 °C throughout the analysis. Analyte signals are measure with a conductivity detector and quantification is based on the response factor of authentic standards. In the following analytical results table, LOQ (limit of quantification) is defined as the quantity of a given compound that gives a peak 3 times higher than the trap background.

Organic and Refractories Compound Analysis

Organic and Refractory contaminants are collected onto a solid-state trap and are quantified using thermal desorption gas chromatography mass spectrometry (TD-GC-MS) TD-650 Clarus-600 GC-MS. An internal standard (toluene-d8) is added onto each adsorbent tube immediately prior to desorption into the gas chromatograph. Once a sample tube has been desorbed into the gas chromatograph it is eluted through the column with helium as the carrier gas at a flow rate of 1 ml/min. The GC is equipped with a 0.32 mm non-polar 5% phenyl/95% poly(dimethylsiloxane) column. The column is held at an initial temperature of 35°C for 8 minutes then is ramped at a rate of 10 degrees a minute to a final temperature of 300C and is held there for a period of 10 minutes. Analyte identification is performed by comparing both the retention and mass spectrum to those of authentic standards. Unknown identification is performed with library searches of the NIST mass spectral database and comparisons of relative retention times to those of known compounds. Quantification of analytes is based on the response factor from a 5-point calibration curve of a toluene authentic standard. In the following analytical results table, LOQ (limit of quantification) is defined as the quantity of a given compound that gives a peak with a signal to noise ration of 15:1

Note: Refractory contaminants are all the hydrocarbons containing one or more ethero-atom (S, P, B, Si, Cl, I, Br) detected in the entire chromatogram scan.

Analytical Results: Acids and Bases

	LOQ	**LOQ**	**2" spool ambient**		**2" spool heated**	
Acids	(Units: ng/L)	(Units: pptv)	(Units: ng/L)	(Units: pptv)	(Units: ng/L)	(Units: pptv)
Fluoride (F^-)	0.022	27	*	*	*	*
Chloride (Cl^-)	0.029	19	*	*	*	*
Bromide (Br^-)	0.028	9	*	*	*	*
Nitrite (NO_2^-)	0.028	14	*	*	*	*
Nitrate (NO_3^-)	0.056	22	*	*	*	*
Sulfite (SO_3^{2-})	0.022	8	*	*	*	*
Sulfate (SO_4^{2-})	0.018	7	*	*	*	*
Phosphate (PO_4^{3-})	0.057	14	*	*	*	*
Acetate ($C_2H_4O_2^-$)	0.057	23	*	*	*	*
Formate (CHO_2^-)	0.028	15	*	*	*	*
	LOQ	**LOQ**	**2" spool ambient**		**2" spool heated**	
Bases	(Units: ng/L)	(Units: pptv)	(Units: ng/L)	(Units: pptv)	(Units: ng/L)	(Units: pptv)
Ammonium (NH_4^+) **	0.025	34	*	*	*	*
* Species not detected at or above the limit of quantification. ** Other amines or other organic bases (such as amides) are reported, if present, in the Organic and refractory report.						

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Acids	LOQ (Units: ng/L)	LOQ (Units: pptv)	1" spool ambient (Units: ng/L)	1" spool ambient (Units: pptv)	1" spool heated (Units: ng/L)	1" spool heated (Units: pptv)
Fluoride (F^-)	0.022	27	*	*	*	*
Chloride (Cl^-)	0.029	19	*	*	*	*
Bromide (Br^-)	0.028	9	*	*	*	*
Nitrite (NO_2^-)	0.028	14	*	*	*	*
Nitrate (NO_3^-)	0.056	22	*	*	*	*
Sulfite (SO_3^{2-})	0.022	8	*	*	*	*
Sulfate (SO_4^{2-})	0.018	7	*	*	*	*
Phosphate (PO_4^{3-})	0.057	14	*	*	*	*
Acetate ($C_2H_4O_2^-$)	0.057	23	*	*	*	*
Formate (CHO_2^-)	0.028	15	*	*	*	*
Bases	**LOQ** (Units: ng/L)	**LOQ** (Units: pptv)	**1" spool ambient** (Units: ng/L)	**1" spool ambient** (Units: pptv)	**1" spool heated** (Units: ng/L)	**1" spool heated** (Units: pptv)
Ammonium (NH_4^+) **	0.025	34	*	*	*	*
* Species not detected at or above the limit of quantification. ** Other amines or other organic bases (such as amides) are reported, if present, in the Organic and refractory report.						

Organics and Refractories

Total Organics by Volatility (Units: pptV as toluene)	LOQ (Units: ng/L)	LOQ (Units: pptv)	2" spool ambient (Units: ng/L)	2" spool ambient (Units: pptv)	2" spool heated (Units: ng/L)	2" spool heated (Units: pptv)
Non-Condensable Organics (MW<120, Bp<150)	0.028	7	2.447	657	6.464	1737
Condensable Organics (MW>120, Bp>150)	0.028	7	0.069	19	1.694	455
Refractory Compounds	0.028	7	*	*	*	*
Total			2.516	676	8.158	2192
* Species not detected at or above the limit of quantification						

EVANS COMPONENTS

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Total Organics by Volatility	**LOQ**	**LOQ**	**1" spool ambient**		**1" spool heated**	
(Units: pptV as toluene)	(Units: ng/L)	(Units: pptv)	(Units: ng/L)	(Units: pptv)	(Units: ng/L)	(Units: pptv)
Non-Condensable Organics (MW<120, Bp<150)	0.028	7	0.054	14	0.213	57
Condensable Organics (MW>120, Bp>150)	0.028	7	*	*	0.063	17
Refractory Compounds	0.028	7	*	*	*	*
Total			0.054	14	0.276	74
* Species not detected at or above the limit of quantification						

Semiquantitated Individual Organics by Sampling Point

Note: Peaks identified as hydrocarbon have fragmentation patterns similar to most straight and branched chain alkanes thus an exact identification is not possible. Peaks identified as oxygenated organics have fragmentation patterns similar to oxygen containing hydrocarbons however a strong match to one individual compound was not observed. The match fit number indicates how close a NIST library identification is to an authentic standard. The closer this value is to 1000 the more reliable the match. The reported concentrations are given as a toluene equivalent.

2" spool ambient 05-06-09

Retention Time (min)	Library ID	match fit	(Units: ng/L)	(Units: pptv)
				as toluene
3.33	oxygenated hydrocarbon		0.045	12
3.82	oxygenated hydrocarbon		0.043	11
5.14	oxygenated hydrocarbon		0.028	7
10.56	toluene-d8 internal standard			
10.87	hydrocarbon		0.059	16
13.37	ethylbenzene	989	0.046	12
13.59	xylene isomer	974	0.030	8
16.36	alpha-methylstyrene	963	2.196	590
18.28	acetophenone	984	0.069	19

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2" spool heated 05-07-09

Retention Time (min)	Library ID	match fit	(Units: ng/L)	(Units: pptv)
				as toluene
3.34	oxygenated hydrocarbon		0.820	220
4.24	oxygenated hydrocarbon		0.053	14
10.56	toluene-d8 internal standard			
10.69	toluene	967	0.101	27
13.36	ethylbenzene	989	0.100	27
13.59	xylene isomer	976	0.067	18
14.21	xylene isomer	961	0.037	10
15.94	oxygenated hydrocarbon		0.055	15
16.37	alpha-methylstyrene	950	5.232	1406
18.29	acetophenone	985	1.041	280
18.74	benzene, (1-methoxy-1-methylethyl)-	938	0.047	13
22.33	benzene, 1,3-bis(1-methylethenyl)-	917	0.606	163

1" spool ambient 05-08-09

Retention Time (min)	Library ID	match fit	(Units: ng/L)	(Units: pptv)
				as toluene
10.56	toluene-d8 internal standard			
16.35	alpha-methylstyrene	966	0.054	14

1" spool heated 05-11-09

Retention Time (min)	Library ID	match fit	(Units: ng/L)	(Units: pptv)
				as toluene
3.87	oxygenated hydrocarbon		0.030	8
10.56	toluene-d8 internal standard			
10.85	toluene	914	0.050	13
16.35	alpha-methylstyrene	962	0.133	36
22.33	benzene, 1,3-bis(1-methylethenyl)-	902	0.063	17

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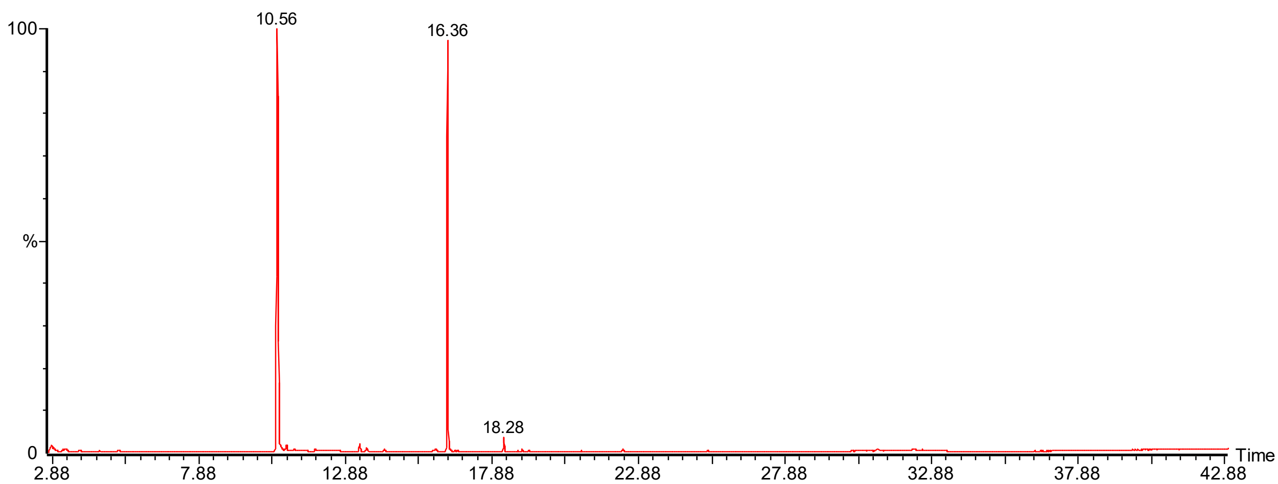
5. Organic Analysis TD-GC-MS Chromatograms

Note: The large peak present in the chromatogram (RT ≈ 10.5 min) corresponds to the deuterated internal standard (toluene-d8). The small peak present at a retention time of 31.04 minutes is due to the instrument background.

2" spool ambient 05-06-09

, 15-MAY-2009 + 15:21:25



2" spool heated 05-07-09

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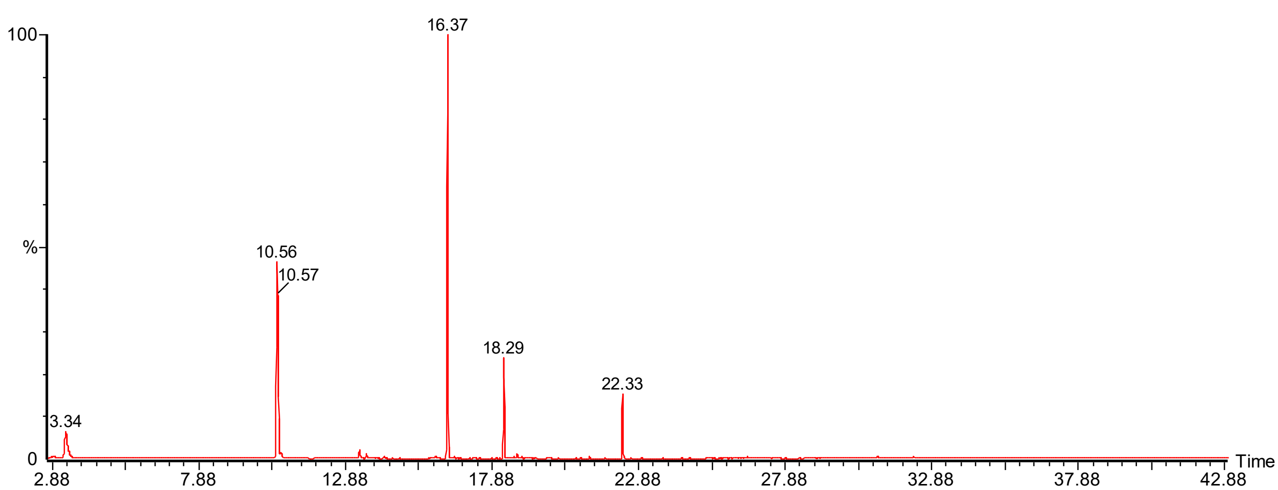

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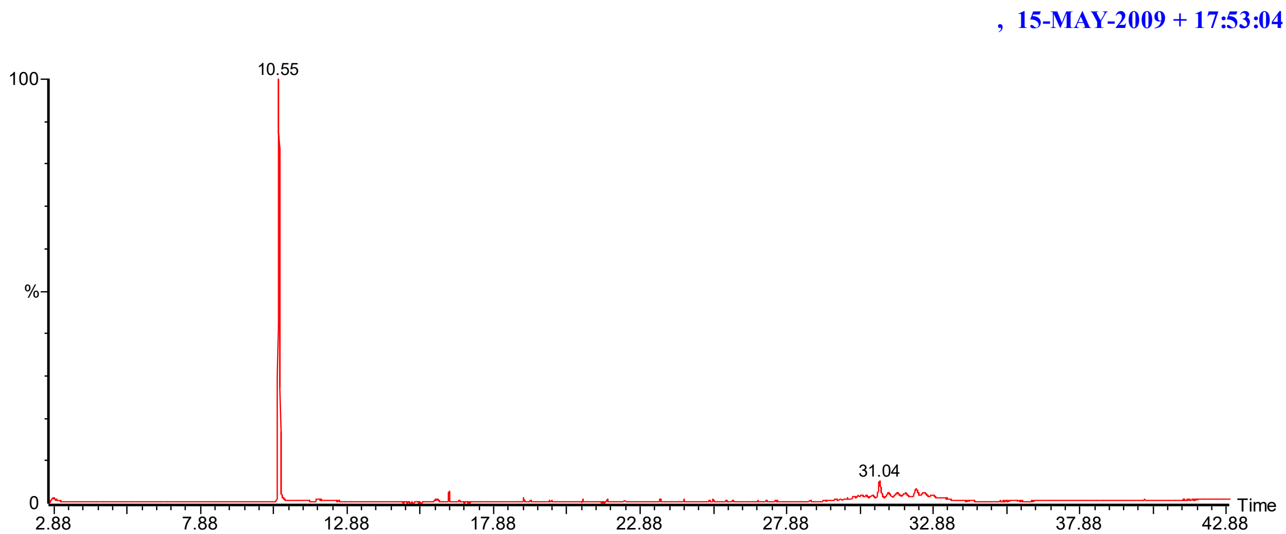
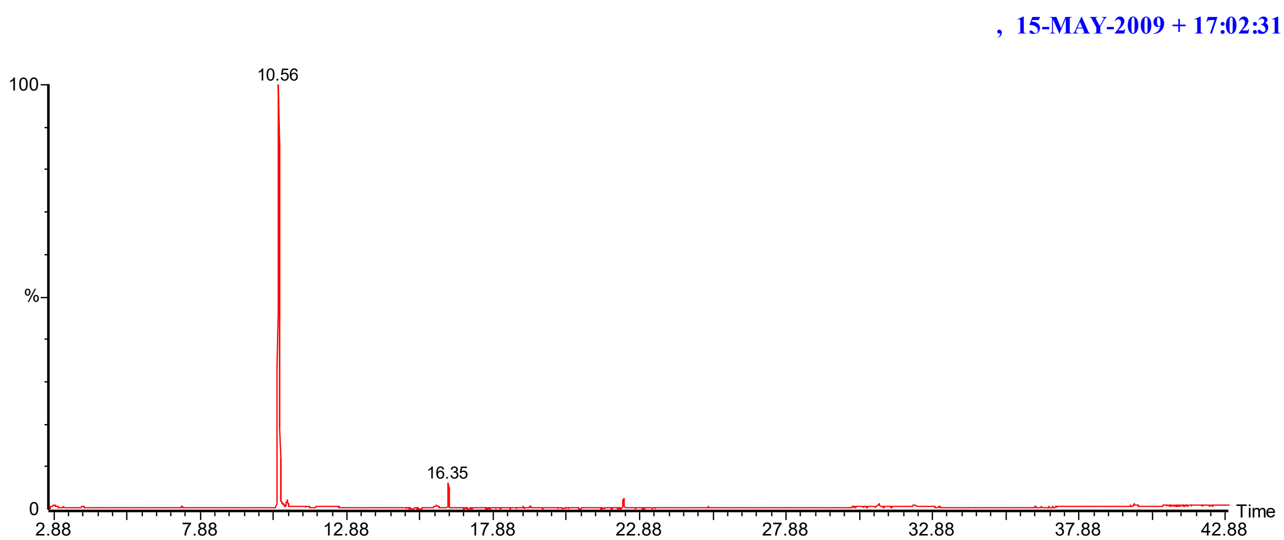
1” spool ambient 05-08-09



1” spool heated 05-11-09



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NOTE: Product availability and specifications contained herein are subject to change without notice. Consult local distributor or factory for potential revisions.