EXPERIMENTAL TESTING OF THE PIKOTEK 6" 1500# HP VCS FLANGE GASKET

Prepared for
PIKOTEK
Lakewood, Colorado

December 1997

STRESS ENGINEERING SERVICES, INC.
Houston, Texas

pikotek
engineering solutions today for tomorrow's problems

P.O. Box 260438 • 12980 West Cedar Drive • Lakewood, CO 80226 • (303) 988-1242 • FAX (303) 988-1922

The following test report is a comprehensive analysis of the Pikotek Flowlok flange sealing system in a standard 6 inch ANSI class 1500 raised face flange (ASTM A105 carbon steel flanges, ASTM A193 grade B7 stud bolts and A194 nuts). The testing was conducted at Stress Engineering in Houston, Texas and witnessed by Lloyd's Register Technical Services, Inc.

The ASME B16.5 rated working pressure for this flange joint at ambient temperature is 3,705 psig. Using the Pikotek VCS Flowlok HP gasket, the flange joint was hydrotested with water at 9,900 psig and cycle tested with nitrogen gas at 6,600 psig with an applied bending moment (external load) of 50,000 ft-lbs. all while remaining within ASME Boiler and Pressure Vessel Code Section 8, Division 1 and 2 allowable stresses, and thus complying with ASME B31.3 as an approved unlisted component.

For more information about this new product application, please contact:

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On the internet at www.pikotek.com

Lloyd's Register Technical Services Inc.

Main order or contract reference	Pikotek, Inc.	*Certificate No.*	ISH9700183/1
Purchaser	Pikotek, Inc.	*Office*	Houston
For delivery to	Unknown	*Date*	01 December 1997
This certificate is issued to	Pikotek, Inc.	*Order No.*	Unknown
to certify that the material described has been inspected at	Stress Engineering Services, Inc. Houston, Texas	*Order status*	Complete
Inspection dates	20 November 1997	*Final*	21 November 1997

General Certificate

This is to certify, that at the request of Pikotek, Inc., the undersigned inspector did attend the works of Stress Engineering Services, Houston, TX on the above mentioned date for the purpose of inspecting the undernoted per the listed scope of inspection.

ONE (1) 6" CLASS 1500 HP VCS FLANGE GASKET

Scope of Inspection:

1.0 Witness testing of flange gasket.

Results of these inspection activities were found satisfactory and the equipment is considered to comply with Pikotek Inc's., Test Procedure 9752T2 Rev. B, dated 25 November 1997.

Test data attached?

Inspector to Lloyd's Register Technical Services Inc.

J. E. Robinson

By signing this report of examination neither the Inspector nor his employer makes any warranty, expressed or implied, concerning any inaccuracy in any report issued. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage, or a loss of any kind, arising from or connected with this inspection.

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Lakewood, Colorado

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PN5168

Prepared for
PIKOTEK
Lakewood, Colorado

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December 1997

STRESS ENGINEERING SERVICES, INC.
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SUMMARY

Pikotek of Lakewood, Colorado requested that Stress Engineering Services, Inc. of Houston, Texas test the 6" Class 1500# HP VCS flange gasket considering both pressure and bending loads. Testing involved make-up of the flange assemblies, a hydrotest to 9,900 psi (one and a half times the working pressure), cyclic testing to 6,600 psi using nitrogen gas, and a bending test which involved the application of 50,000 ft-lbs. in conjunction with five pressure cycles to 6,600 psi using nitrogen gas. Testing Procedure 9752T2 provided by Pikotek was used in conducting the work.

The objective in testing was to verify that no leakage would occur under any of the imposed loading conditions. Leakage was determined by pressure-monitoring in addition to a bubble leakage detection system. Two of the twelve studs were fitted with strain gages so that strain could be monitored during make-up (to insure adequate pre-load) and during the testing.

The results of the testing indicate that the Pikotek gasket design satisfied the minimum requirements of the test procedure. During the hydrotest, the pressure dropped from 9,924 psi to 9,834 psi after a 60-minute hold (the test procedure permitted a pressure decrease up to 500 psi during this same time interval). During the nitrogen cycle testing, the maximum pressure drop (of the 10 cycles conducted) was from 6,648 psi to 6,620 psi (the test procedure permitted an internal pressure decrease of 330 psi during this same time interval). When the 50,000 ft-lbs. bending test was conducted, the maximum pressure drop was from 6,628 psi to 6,586 psi (leakage criterion same as for the nitrogen cycle testing). Therefore, the conclusion is that the Pikotek 6" Class 1500# HP VCS flange gasket satisfies the minimum requirements as set forth in the Pikotek Testing Procedure.

INTRODUCTION

Prior to conducting the tests, the testing assembly was fabricated. The components involved in this assembly were,

- 6" Class 1500# ASME 16.5 flanges with a bore diameter of 5.38-5.41 inches
- Studs and nuts for the respective flanges, Grades A193-B7 and A194, respectively
- 6" XXS end caps
- 6" pipe joints to be used in the bending testing (XXS, 0.864 inch wall thickness).

The assembles were constructed by welding the end caps to the flanges. Ports were drilled and tapped in the end caps to accommodate the necessary pressure equipment. Attached to each of the two end caps were pipe segments for the purpose of applying bending to the flanges. Also welded to these pipe joints were Stress Engineering Services, Inc. (SES) end caps that match the load frame for conducting the bending testing. **Figure 1** provides a photograph of the assembly prior to make-up. It should be noted in this figure that a filler bar was placed inside the flanges to minimize the volume required for pressurization. Provided in **Appendix A** are the Mill Test Reports for the various components of the flange assembly. The bore diameters of the flanges were verified to be within the 5.38-5.41 inch range prior to testing.

For the purpose of measuring strain in the bolting, two of the twelve studs were fitted with gages (at 0, 90, and 180° relative to the flange orientation) in order to capture strain in the bolting during make-up and testing. These two studs were machined down to the minor diameter for ease in mounting the strain gages. **Figure 2** provides a photograph of this set-up.

Strain gages were also placed on one of the flanges and on one of the pipe segments. **Figure 3** and **Figure 4** show these strain gage installations, respectively. The purpose of installing gages on the pipe was for monitoring strain during the bending process and to ensure that the correct level of bending was applied. Gages on the pipe were installed at -90, 0, and +90 relative to the neutral axis of the pipe.

Considering a bending moment of 50,000 ft-lbs. and the given pipe geometry, the strain is computed using the following equation,

$$\epsilon = \frac{\sigma}{E} = \frac{Mc}{EI} = \frac{600{,}000\,in\text{-}lbs \cdot 3.3125\,inches}{30X10^6 psi \cdot 66.3\,in^4} = 998\ \mu\epsilon$$

where:	M	Bending moment (in-lbs)
	c	Outer radius (inches)
	E	Young's Modulus (psi)
	I	Moment of Inertia (in^4)
	$\mu\epsilon$	Microstrain (strain multiplied by 10^6).

During the bending testing, this value was the target strain level (tension on top/compression on bottom).

After completion of the flange assemblies and installation of the strain gages, the make-up condition was established by torquing the bolting up to 680 ft-lbs. incrementally at 30, 65, and 100% of the specified torque. A cris-cross pattern was used in the flange make-up. Strain gage readings were taken at each of these torque intervals. **Appendix B** provides a computer listing of the strain readings taken at the specified intervals during the make-up and testing process. For purposes of validating the bolt stresses, consider the following relation which incorporates bolt stress, bolt friction, bolt size, and applied torque.

$$T = KFd$$

where:	T	Applied torque (in-lbs)
	K	Friction factor (assume 0.15)
	F	Bolt force (calculated by multiplying bolt stress by bolt area, lbs.)
	d	Bolt major diameter (inches).

The previous equation is rearranged to determine the bolt force for a given torque and is calculated as follows,

$$F = \frac{T}{Kd} = \frac{(680 ft\text{-}lbs \cdot 12\, in/ft)}{(0.15 \cdot 1.375\, in)} = 39{,}564\, lbs.$$

This value is then used to compute the bolt stress by dividing by the tensile stress area (1.155 in^2). This corresponds to a bolt stress of 34,254 psi. Using this bolt stress, the strain in the bolt is computed to be,

$$\epsilon = \frac{\sigma}{E} = \frac{34{,}254\, psi}{30\ X\ 10^6} = 1{,}141\ \mu\epsilon$$

The axial strain in the Bolt #1 as measured by the strain gages (see Rosette #2 at 680 ft-lbs. torque in **Appendix B**) was 1,151 $\mu\epsilon$ and in Bolt #2 (Rosette #5) the axial strain was 1,144 $\mu\epsilon$. Both of these experimental values show excellent agreement with the theoretical bolt strain.

The torquing of the bolt was accomplished using a hydraulic wrench as shown in **Figure 5**, but calibration of the torque was accomplished using a calibrated torque wrench. The final torque values obtained using these two devices were close.

Once the make-up process was complete, the flange assembly was placed in the SES 2.5 million lb. load frame. This load frame is capable of generating 2.5 million pounds in tension, 1 million in compression, and 100,000 ft-lbs. in bending. **Figure 6** provides a photograph of flange assembly installed in the load frame. For the purposes of this testing, the sample was pressurized (for the hydrostatic and nitrogen cycle testing) and the load frame served only as a cradle; however, in the bending phase of the testing the load frame placed a bending moment of 50,000 ft-lbs. on the sample using a combination of hydraulic cylinders (the top one acting in compression and the bottom one acting in tension).

Before conducting the pressure testing, a rubber boot was placed around the flanges for the purpose of detecting leaks should they occur. **Figure 7** and **Figure 8** show the flange assembly before and after the installation of the rubber boot, respectively. As seen in **Figure 7**, a copper tube is placed on the inside of the boot and runs to an outside bath (via plastic hose) where leak detection is made possible by the detection of bubbles. Several pounds of pressure (less than 5 psi) were blown into the boot after it was attached to the flanges to insure that no leakage was possible. No leakage occurred through the boot set-up. Because of the tight fit-up between the nuts and external flange surface and lubricating grease there was no leakage through the bolting. As stated previously, the primary indicator of leakage was the pressure; however, the boot system served as a secondary indicator.

During the bending test, the amount of bending was controlled using the load provided by the hydraulic cylinders. As a check, the strain gages mounted on the pipe were monitored to ensure that the proper amount of bending was being applied. Prior to the bending test, the strain gages located on the pipe were zeroed to remove the effects of weight.

TESTING PROCEDURE

This section of the report provides a summary of the Pikotek Testing Procedure, 9752T2 Rev. B, dated November 25, 1997. A copy of this test procedure is provided in **Appendix C**. Also provided in this appendix are the calibration sheets for the torque wrench, temperature probe, and pressure transducer as requested by the Testing Procedure. The major components or stages of the testing procedure are as follows,

1. Install strain gages on the studs and flange
2. Torque the bolting using a cris-cross pattern to 680 ft-lbs.
3. Conduct a preliminary hydrostatic test to 3,300 psi to shakedown the strain gages and equipment
4. Conduct a hydrostatic test to 9,900 psi and hold for 60 minutes
5. Conduct a cyclic nitrogen test by cycling between 0 and 6,600 psi for 10 cycles (30 minute holds)
6. Apply 50,000 ft-lbs. and repeat Step #5 for 5 cycles with 10 minutes holds
7. Disassemble the flanges and inspect the gasket.

Strain gage readings were taken at the end of each of the specified torque levels (30, 65 and 100%). During the pressure and bending testing, strains and pressure were monitored continuously.

RESULTS

An extensive amount of strain gage data was taken during the testing process. For this reason, the Results section will be divided into the following sections,

- Make-up Testing
- Hydrotest to 9,900 psi with a 60 minute hold
- Nitrogen cycle tests to 6,600 psi with a 30 minute holds
- Bending Test to 50,000 lbs. with cyclic nitrogen applications to 6,600 psi/10 minute holds.

In each of the following sections, strain and pressure will be presented as appropriate.

Make-up Testing

Strain readings were taken at the end of the torque process at the specified intervals (30, 65, and 100% of the 680 ft-lbs. maximum). Readings were also taken at 0 ft-lbs. after the gages had been zeroed. **Appendix B** provides a listing of all the strains taken during make-up in addition to strain readings taken before the hydrostatic and during the bending test. **Table 1** provides a listing of the strain gage locations as they relate to the Rosette Number and the Channel. Bolt #1 was located at the top position of the flange (when placed in the load frame), and Bolt #2 is located on the bottom of the flange (180° from Bolt #1).

As discussed previously, the strain in the bolting was used to monitor that a sufficient level of pre-load was established in the make-up process. The axial strain in Bolt #1 as measured by the strain gages (see Rosette #5 at 680 ft-lbs. torque in **Appendix B**) was 1,151 $\mu\epsilon$ and in Bolt #2 the axial strain was 1,144 $\mu\epsilon$ (see Rosette #12). Both of these measured strain values show excellent agreement with the theoretical bolt strain of 1,141 $\mu\epsilon$ at 680 ft-lbs. A strain measurement of 1,141 $\mu\epsilon$ equals a stress of approximately 34 ksi.

One issue worth noting is the orientation of the strain gages on the bolting relative to the bending axis of the flanges. The alignment of Bolt #1 aligned perfectly with the orientation of the flange. In other words, the 0° position on the flange (top in this case) aligned with the 0° position on the bolt. This orientation is not easy to achieve because of the tendency the bolt has to rotate in the process of being torqued. The alignment for Bolt #2 was approximately 65° offset from the flange orientation. The information presented in **Table 1** reflects these configurations.

Hydrostatic Testing

After the make-up testing was completed, a preliminary hydrostatic test was conducted to ensure that all of the strain gages, pressure transducers, and data acquisition system were calibrated and working properly. Data will not be reported for this phase of the testing. All indications showed that the measuring devices were working correctly. On the day of testing, the laboratory temperature was approximately 65°F.

The hydrostatic test was conducted by pressurizing the flange assembly to 9,900 psi using water. The pressure was held at this position for 60 minutes. Unlike the bolting make-up where strain gage readings were taken at the end of each torque-up stage (225, 450 and 860 ft-lbs.), readings were taken continuously for all measurement devices during the hydrotest. **Appendix D** provides a plot showing the following variables as functions of time,

- Internal pressure (up to 9,900 psi)
- Axial strain gage readings at 0, 90, and 180° on Bolt #1
- Axial strain gage readings at 65, 155, and 245° on Bolt #2
- Hoop and axial strain gage readings on the flange.

There are several noteworthy observations in relation to the data provided in **Figure D1** of **Appendix D.**

- During the 60-minute pressure hold, there was a drop in pressure from 9,924 psi to 9,834 psi, which was less than the 500 psi drop permitted by the Pikotek Testing Procedure.
- Once the desired internal pressure was established, there was no change in the bolt strain as indicated by the measurements for Bolt #1 and Bolt #2.

Nitrogen Cycle Testing

At the completion of the hydrotesting, water was removed from the flange assembly and the nitrogen gas pressure system was attached. The process for pressurizing with nitrogen gas involved the following steps,

- Pressurize sample to 6,600 psi
- Hold pressure for 30 minutes
- Drop pressure down to zero and repeat process as necessary.

These steps were carried out to provide a total of 10 pressure cycles.

In the course of conducting the testing, several data points were taken and visually observed. These values were internal pressure and temperature on the exterior surface of the flange and are recorded in **Table 3**. The objective in carrying out this task was to monitor the changes in pressure and temperature that occurred before and after the testing. The temperature change is important when considering a compressible gas such as nitrogen. The temperature drop as listed will not directly correspond to the magnitude of the temperature decrease on the inside of the chamber; however, it is apparent from the information presented that a decrease occurred for each of the pressure cycles.

As noted in **Table 2**, the largest drop in pressure was 46 psi (6,648 to 6,602 psi) in Cycle #6 which is well within the permitted pressure drop as specified in the Pikotek Testing Procedure (a permitted pressure drop of 330 psi). Also, no bubbles appeared in the leakage detection system during the course of testing. This indicates that no leaks developed within the confines of the boot region. In addition to monitoring the pressure drop, this method is an additional indicator of leakage.

Appendix E contains the plots showing strain in the bolting and flange as a function of cycle time for the nitrogen cycle testing (**Figure E1** through **E10**). There are two main observations that are made in observing these plots,

- In the course of conducting the nitrogen testing, there is minimal change in the strain readings for the various members when comparing results between the cycles. This is important because it shows the consistent behavior exhibited by the flange and gasket in the presence of cyclic loading.

- The pressure drop during the 30-minute hold was small, certainly within the limits permitted by the Pikotek Testing Procedure.

Bending Test with Nitrogen Cycling

After the nitrogen cycle testing was completed, the bending testing was initiated. The basic steps involved in this testing were,

- Apply a bending moment of 50,000 ft-lbs to the sample (validated using SES load readings and strain gages located on pipe)
- Apply pressure of 6,600 psi to sample using nitrogen gas
- Hold pressure for 10 minutes
- Drop pressure to 0 psi
- Repeat above steps as required.

These steps were carried out to provide a total of 5 pressure cycles. The 50,000 ft-lbs. bending moment was maintained during all pressure cycling.

As mentioned previously, the strain in the piping attached to the flanges was monitored during the testing to ensure that the correct level of bending was being applied. The strain data (listed in **Appendix B**) indicates that the strain in the pipe with the applied bending was 1008 $\mu\epsilon$ on top surface and -996 $\mu\epsilon$ on the bottom of the pipe (channels 20 and 23, respectively).

The experimental strain values compare accurately with the calculated value as shown below,

$$\epsilon_{bending} = \frac{Mc}{EI} = \frac{600{,}000\ in\text{-}lbs. \cdot 3.3125\,in}{30X10^6 psi \cdot 66.3\,in^4} = 998.8\ \mu\epsilon$$

As with any member placed in bending, the exterior surfaces have bending strains (one in compression and one in tension), while there exists a neutral axis along which no bending strain exists. As indicated in the above equation, this occurs when the value for c is zero. Strain gages were placed on the piping attached to the flanges at 0, 90, and 180° for the purpose of detecting this strain pattern.

As with the nitrogen cycle testing, strain and pressure were monitored during the course of the bending test. **Appendix F** provides the plot associated with these data (**Figure F1**). In addition to the internal pressure and bolt/flange strain, readings are also presented for the strain gages placed on the piping. As expected, the top surface strain was in tension, while the strain gages located at 180° (on the bottom) were in compression. Strain data is also provided in **Appendix B** for the bending test (last set of data). Even though no bending strain exists along the neutral axis, it is possible to generate membrane strain at this location in response to internal pressure. The negative axial strain measured on the neutral axis of the pipe (see **Figure F1**) is in response to this phenomenon.

There are several important considerations in studying the **Appendix F** plot and the data in **Appendix B**.

- The strains in the bolting change as a direct result of the bending process, as would be expected. In studying the axial strain readings for the bolts at 0 and 180°, the strain in the top bolt is increased while the strain in the bolt at 180° is decreased. Consider the following changes in strain data between the make-up condition and the flange assembly subjected to 50,000 ft-lbs.,

Axial Strain in Top Bolt (Channel 5)	1151 $\mu\epsilon$ (Makeup)	1285 $\mu\epsilon$ (Bending) Net change of +145 $\mu\epsilon$
Axial Strain in Bottom Bolt (Channel 12)	1144 $\mu\epsilon$ (Makeup)	983 $\mu\epsilon$ (Bending) Net change of -161 $\mu\epsilon$

- The primary objective in subjecting the flange assembly to 50,000 ft-lbs. was to determine if under these conditions the gasket would seal the flanges. During testing, no leakage was detected considering either the bubble leakage system or decreases in internal pressure.

- The maximum drop in pressure measured during the bending test was 42 psi (see **Table 3**, Cycle #4 and #5), which is considerably less than the permitted 330 psi as provided by the Pikotek Testing Procedure.

Post-testing Examination

After the completion of the testing, the flange halves were disassembled and measurements were taken of the gasket. **Figure 9** is a photograph of the flanges and gasket after separation, while in **Figure 10** a close-up photograph of the gasket after its removal is provided. There was no visible damage to the gasket after its removal other than the impression left by the outer diameter of the raised face. **Table 4** provides the dimensions of the gasket taken prior to testing and after the disassembly process.

CONCLUSIONS

The objective of the tests conducted by Stress Engineering Services, Inc. on the Pikotek 6" 1500# HP VCS gasket was to determine if under the selected conditions the gasket would seal the flanges properly. The testing consisted of hydrotesting to 9,900 psi, 10 cycles of nitrogen pressure to 6,600 psi, and a bending test to 50,000 ft-lbs. combined with 5 cycles of nitrogen. Leakage was not detected under any of these conditions. The gasket sealed the flanges and satisfied the requirements as set forth in the Pikotek Testing Procedure.

Table 1 Strain Gage Locations and Orientations

Gage Location	Rosette #	Channel #	Gage Type	Orientation
Bolt #1 (Top Bolt)	1	2	Tri-axial	Hoop at 0° Circumferential Position
	1	3	Tri-axial	45° at 0° Circumferential Position
	1	4	Tri-axial	Axial at 0° Circumferential Position
	2	5	Uni-axial	Axial at 90° Circumferential Position
	3	6	Tri-axial	Hoop at 180° Circumferential Position
	3	7	Tri-axial	45° at 180° Circumferential Position
	3	8	Tri-axial	Axial at 180° Circumferential Position
Bolt #2 (Bottom Bolt)	4	9	Tri-axial	Hoop at 65° Circumferential Position
	4	10	Tri-axial	45° at 65° Circumferential Position
	4	11	Tri-axial	Axial at 65° Circumferential Position
	5	12	Uni-axial	Axial at 155° Circumferential Position
	6	13	Tri-axial	Hoop at 245° Circumferential Position
	6	14	Tri-axial	45° at 245° Circumferential Position
	6	15	Tri-axial	Axial at 245° Circumferential Position
Flange	7	16	Tri-axial	Hoop
	7	17	Tri-axial	45°
	7	18	Tri-axial	Axial
Pipe	8	19	Bi-axial	Hoop on top of pipe (0°)
	8	20	Bi-axial	Axial on top of pipe (0°)
	9	21	Uni-axial	Axial on Neutral Axis of Pipe (90°)
	10	22	Bi-axial	Hoop on bottom of pipe (180°)
	10	23	Bi-axial	Axial on bottom of pipe (180°)

Notes.

1. All Circumferential Position Angles are relative to the top of the Pipe/Flange assembly while in the load frame
2. The bending strains in the bolting are determined by considering the Axial strains at 0° and 180° (tri-axial gages)
3. The membrane strains in the bolting are determined by considering the Axial strains at 90° (uni-axial gages)
4. The orientation of Bolt #1 was perfectly aligned with the flange position. In other words, 0° on the bolt lined up with the top of the flange. From a mechanics standpoint, this means that the bending moment vector of the bolt was aligned with the bending moment vector of the pipe/flange assembly.
5. The orientation of Bolt #2 was 65° offset from the bending axis of the pipe/flange assembly.

Table 2 Pressure and Temperature Values Monitored During the Nitrogen Cycle Test

Cycle Number	Time	Temperature (°F)	Pressure (psi)	Notes
1	10:03	65.2	6614	Start hold for Cycle #1
	10:33	63.8	6584	End hold for Cycle #1
	10:37	62.0	0	Final reading for Cycle #1 (at 0 psi)
2	10:46	67.6	6620	Start hold for Cycle #2
	11:16	63.7	6592	End hold for Cycle #2
	11:20	62.2	0	Final reading for Cycle #2 (at 0 psi)
3	11:26	68.0	6616	Start hold for Cycle #3
	12:00	63.7	6586	End hold for Cycle #3
	12:04	62.6	0	Final reading for Cycle #3 (at 0 psi)
4	12:12	67.8	6638	Start hold for Cycle #4
	12:42	64.0	6602	End hold for Cycle #4
	12:46	62.4	14	Final reading for Cycle #4 (at 0 psi)
5	12:54	68.1	6628	Start hold for Cycle #5
	13:30	64.1	6590	End hold for Cycle #5
	13:35	62.6	8	Final reading for Cycle #5 (at 0 psi)
6	13:42	68.5	6648	Start hold for Cycle #6
	14:12	64.5	6602	End hold for Cycle #6
	14:16	62.9	10	Final reading for Cycle #6 (at 0 psi)
7	14:24	68.6	6648	Start hold for Cycle #7
	14:54	64.7	6600	End hold for Cycle #7
	14:57	63.3	12	Final reading for Cycle #7 (at 0 psi)
8	15:03	68.5	6638	Start hold for Cycle #8
	15:36	65.0	6610	End hold for Cycle #8
	15:43	63.4	2	Final reading for Cycle #8 (at 0 psi)
9	15:51	69.2	6614	Start hold for Cycle #9
	16:22	65.4	6576	End hold for Cycle #9
	16:28	63.8	2	Final reading for Cycle #9 (at 0 psi)
10	16:35	69.5	6646	Start hold for Cycle #10
	17:06	65.7	6612	End hold for Cycle #10
	17:15	64.7	0	Final reading for Cycle #10 (at 0 psi)

Table 3 Pressure and Temperature Values Monitored During the Bending Test

Cycle Number	Time	Temperature (°F)	Pressure (psi)	Notes
1	18:21	70.3	6624	Start hold for Cycle #1
	18:32	67.8	5892	End hold for Cycle #1
	18:35	66.5	4	Final reading for Cycle #1 (at 0 psi)
2	18:43	71.3	6630	Start hold for Cycle #2
	18:53	68.3	6602	End hold for Cycle #2
	18:57	66.9	4	Final reading for Cycle #2 (at 0 psi)
3	19:02	72.4	6620	Start hold for Cycle #3
	19:12	69.1	6582	End hold for Cycle #3
	19:16	67.1	2	Final reading for Cycle #3 (at 0 psi)
4	19:21	73.3	6620	Start hold for Cycle #4
	19:31	69.6	6578	End hold for Cycle #4
	19:35	67.4	4	Final reading for Cycle #4 (at 0 psi)
5	19:41	73.4	6628	Start hold for Cycle #5
	19:51	69.6	6506	End hold for Cycle #5
	19:55	67.6	2	Final reading for Cycle #5 (at 0 psi)

Table 4 Measurements Taken of Gasket Before and After Testing

Location of Measurement	Measurement Before Testing (inches)	Measurement After Testing (inches)
Outer diameter	10.999	10.998
Inner diameter	5.382	5.381
Gasket Thickness	0.310	0.309
O-ring thickness	0.365	0.350
Inner Teflon ring thickness	0.375	0.328

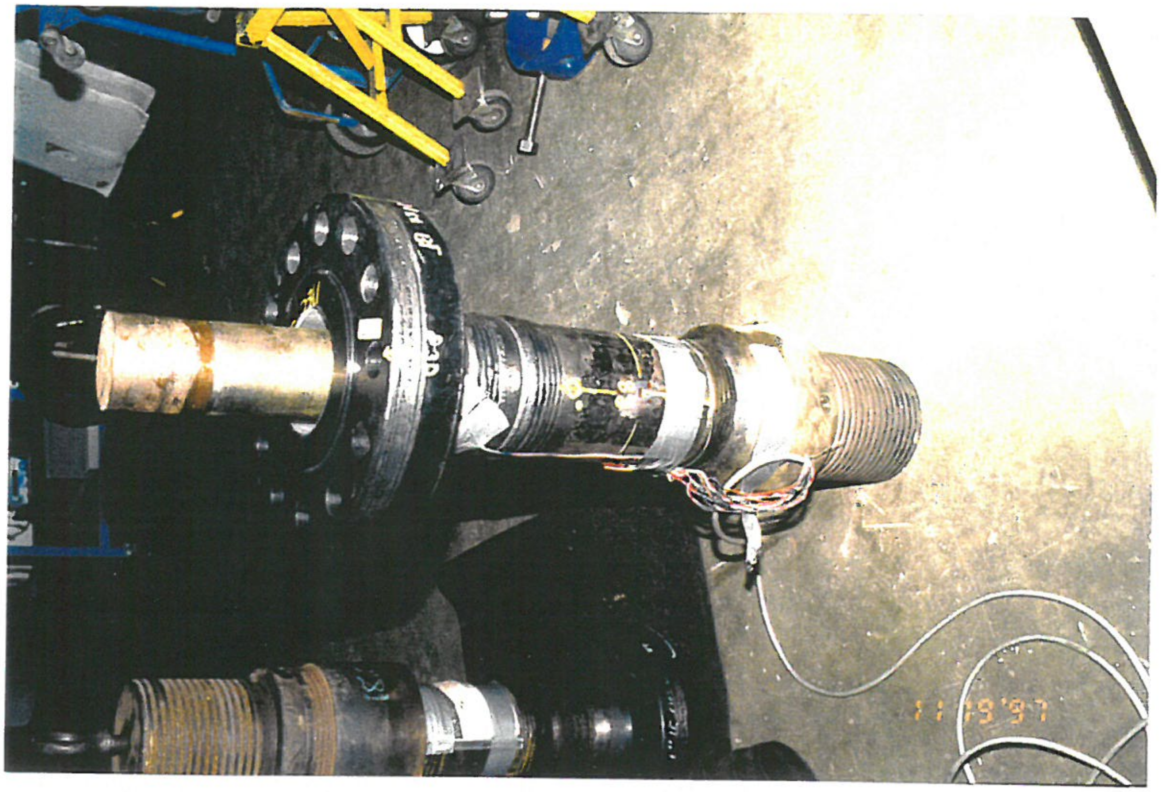


Figure 1 Photograph of flange assembly prior to make-up

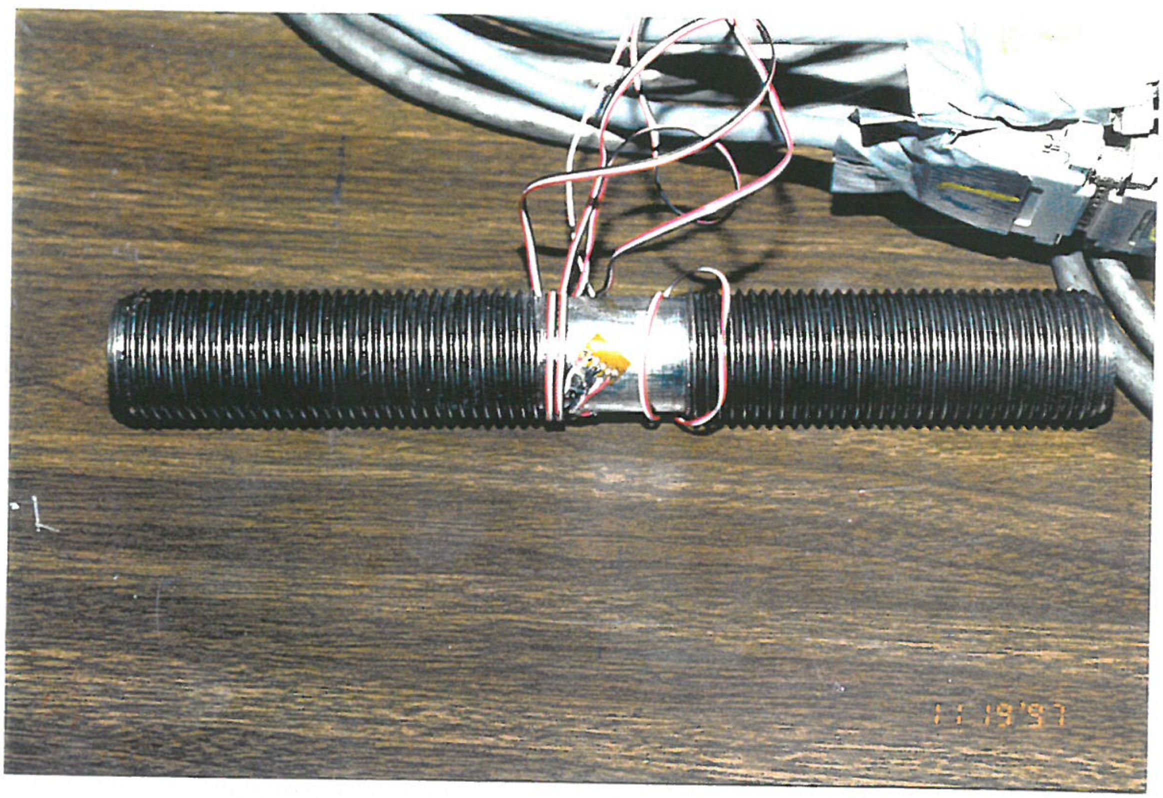


Figure 2 Photograph of strain gage installation on a stud

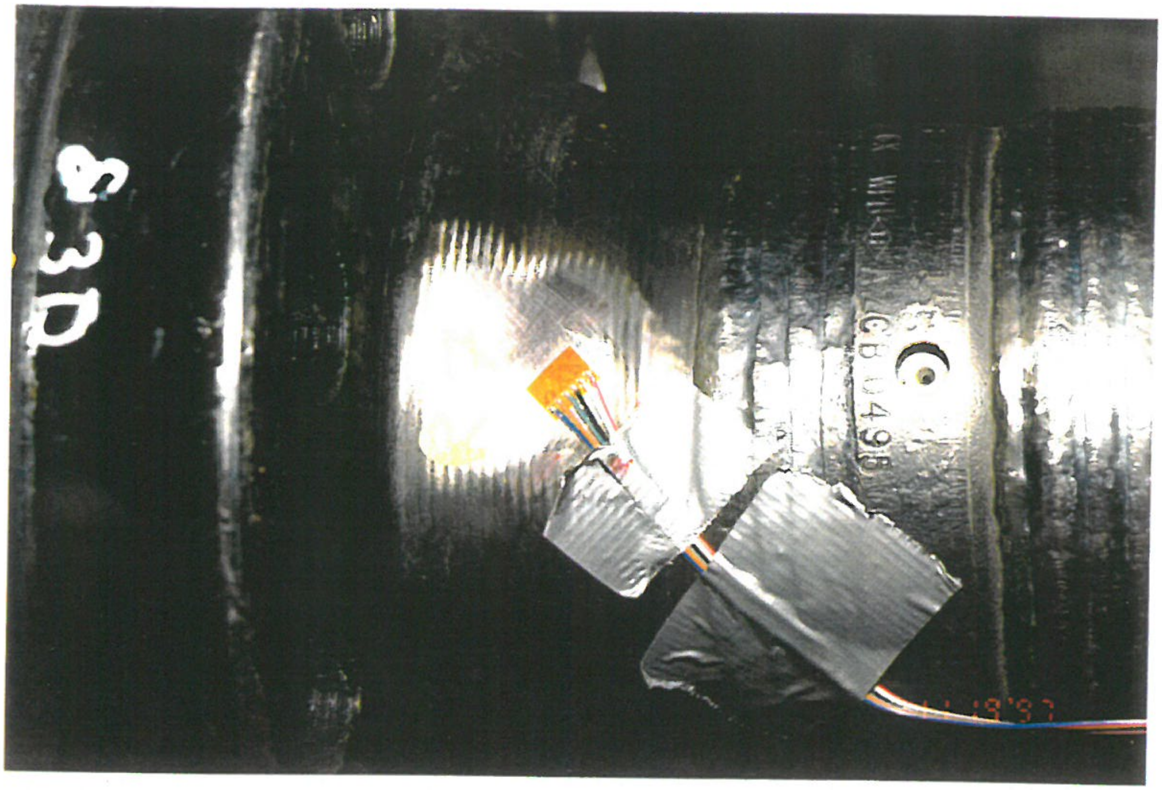


Figure 3 Strain gage installed on one of the two flanges

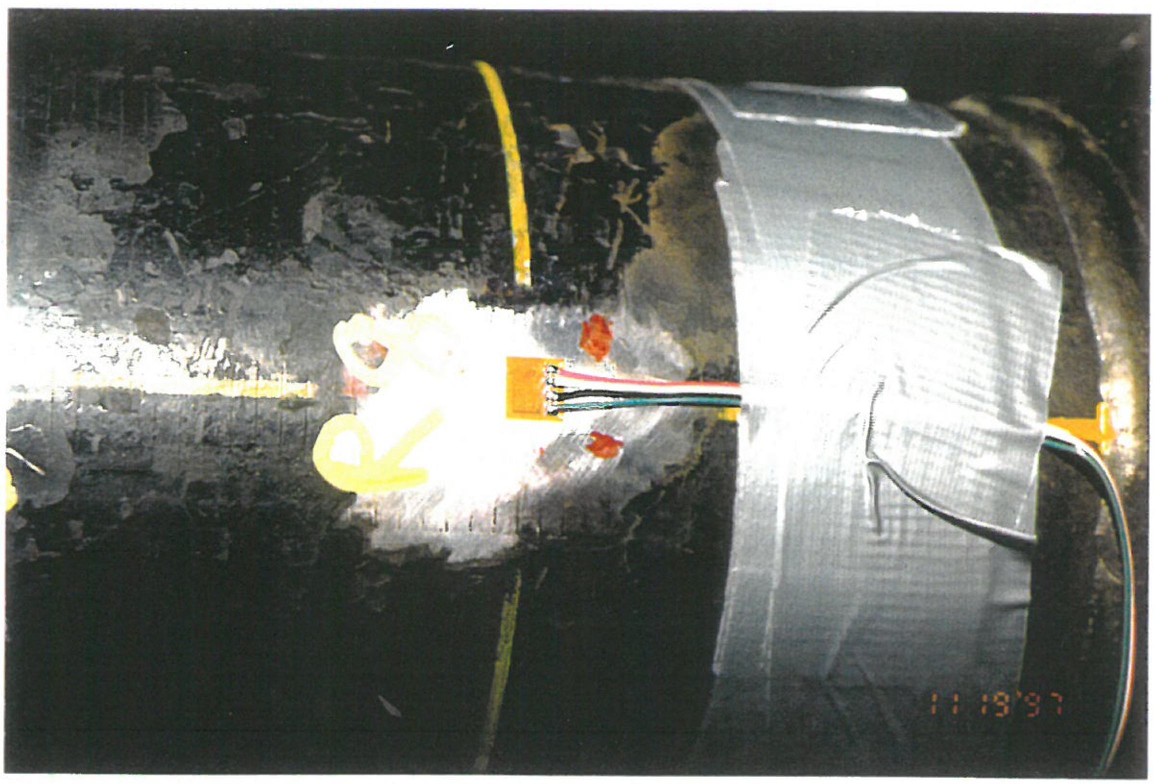


Figure 4 Strain gage installed on one of the attached pipes

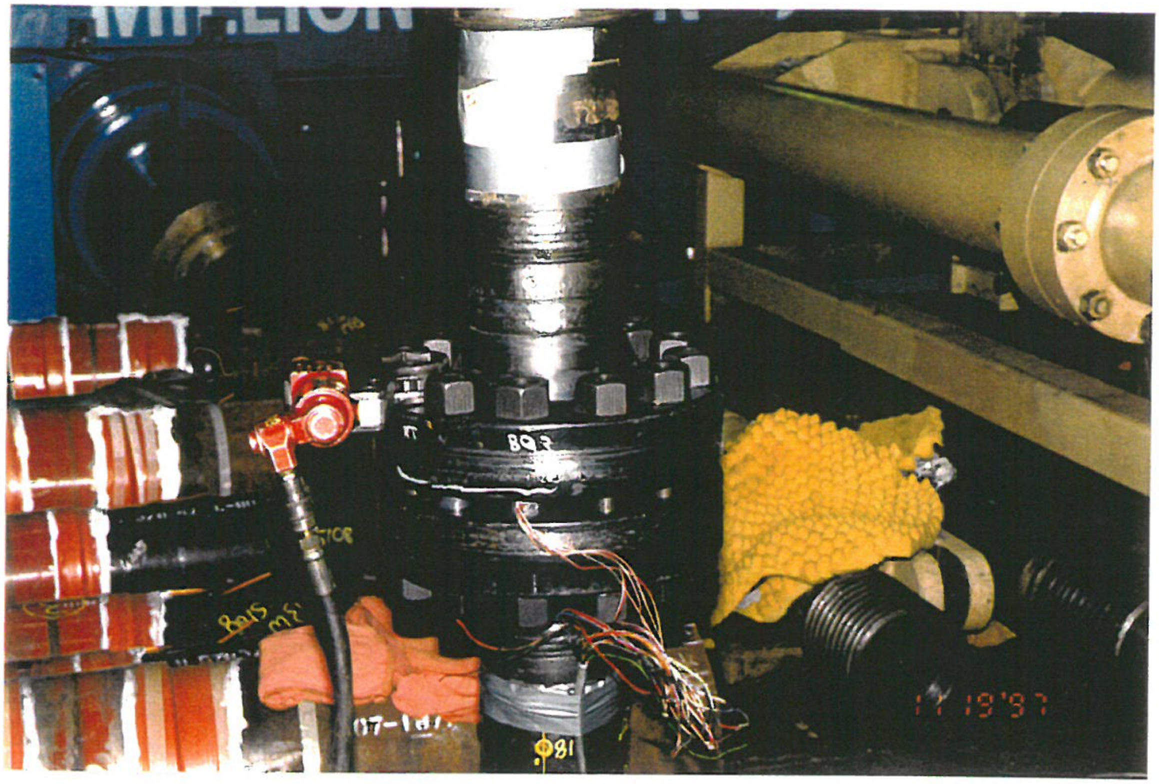


Figure 5 Using a hydraulic wrench to make-up the bolting

Figure 6 Photograph of the flange assembly installed in the load frame

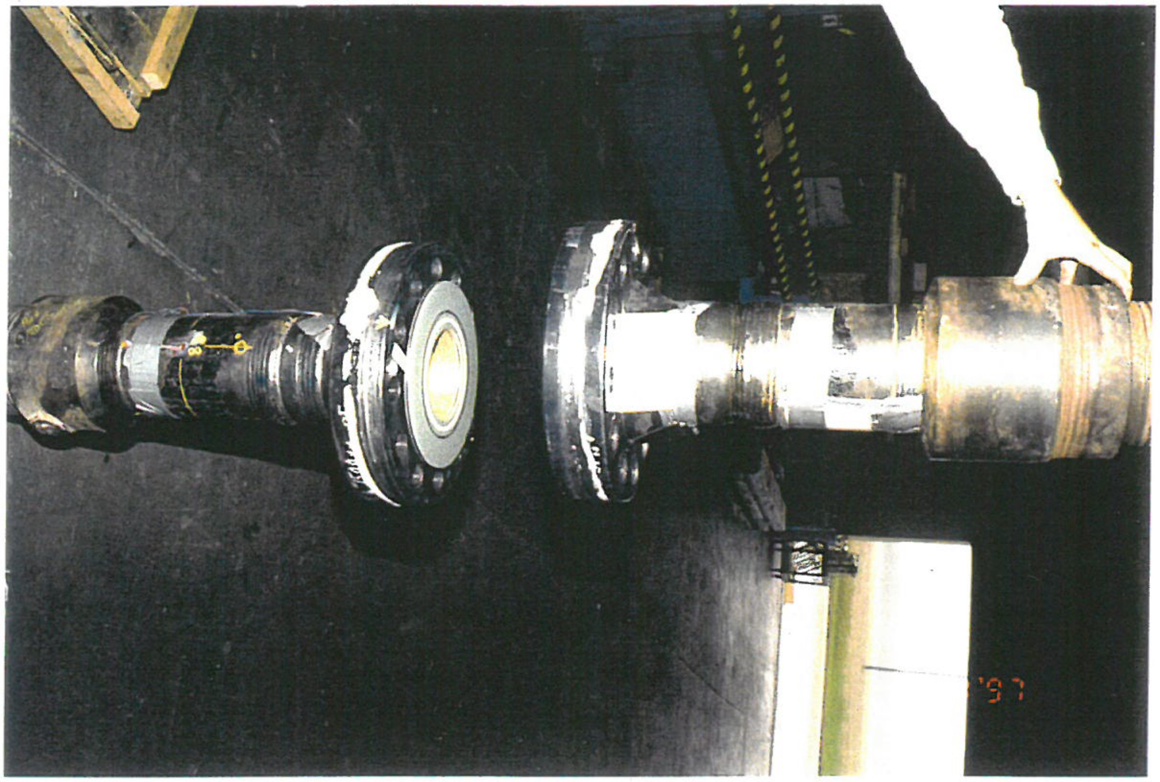


Figure 9 Photograph of flanges and gasket after disassembly

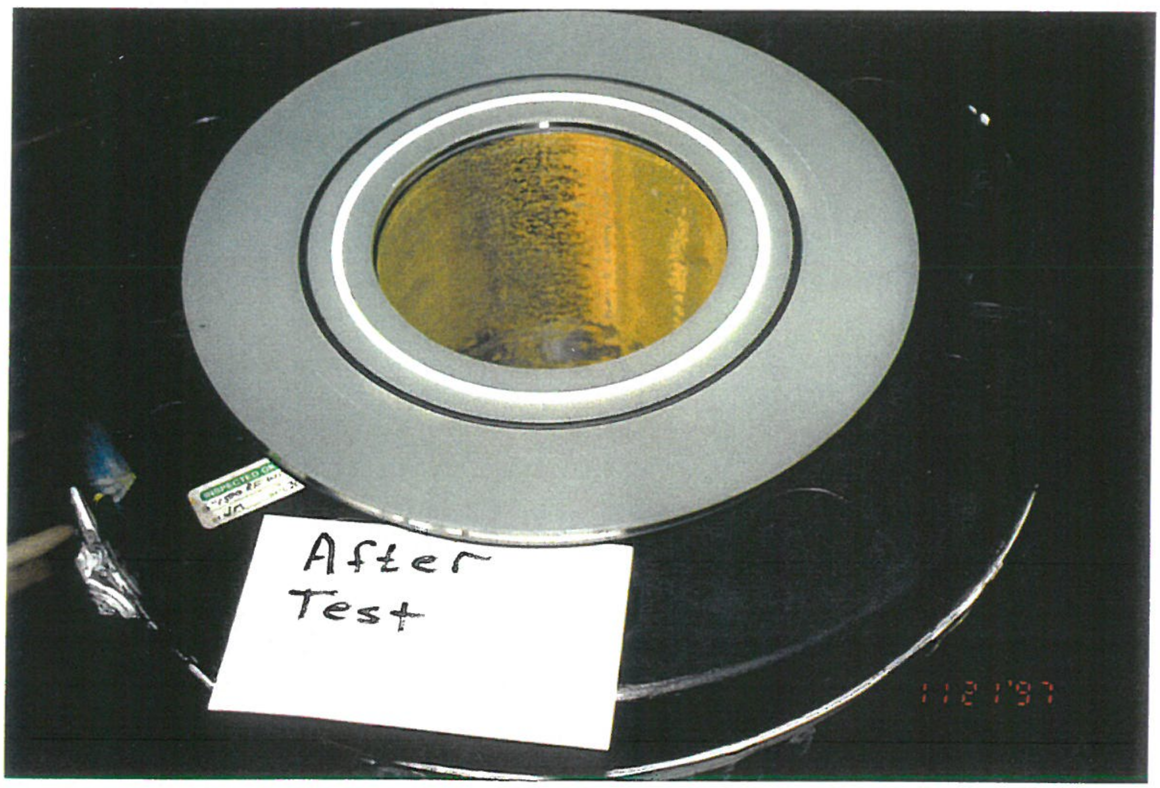


Figure 10 Close-up photograph of the gasket after disassembly

Appendix A Mill Test Report for Flange Assembly Components

Roltex Manufacturing Co., L.P.
4901 Oates Rd
Houston, Tx.77013

Order Number: 0025244
PO Number: 9572
Order Date: 11/03/97

MATERIAL TEST REPORT

S LYNCO FLANGE & FITTING
O 5114 STEADMONT
L HOUSTON TX 77040
D

S LYNCO FLANGE & FITTING
H WILL CALL
I
P

ITEMS

m#	Qty	Description	Matl Spec	Heat Code	Mill Heat Number
01	2	6" 1500 RF WN XX	SA105-N-96	B03	83544

CHEMICAL PROPERTIES

eat Code	C	Si	Mn	P	S	Cr	Al	Cu	Ni	Mo	V	Cb				CE
03	0.170	0.210	1.120	0.010	0.011	0.080	0.020	0.200	0.140	0.030	0.003	0.002	0.000	0.000	0.000	0.407

PHYSICAL PROPERTIES

eat Code	Tensl	Yield	%Elong	%R.A.	BHN	Charpy	Ft-Lbs	Lat Expsn	Shr Fract	Test Temp
03	76995	45385	28.00	60.00	148-154					

NOTES

eat Code	Note
03	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL

e certify that our flanges are capable of passing a hydrostatic est compatible with their rating. We certify that all test esults and process information contained herein are correct and ue as contained in the records of the company.

oltex Manufacturing Co., L.P.

Boltex, Inc.
4901 Oates Rd
Houston Tx 77013

11/04/97

MATERIAL TEST REPORT

S Lynco Flange & Fitting
O 5114 Steadmont
L Houston TX 77040
D

S Lynco Flange & Fitting
H 5114 Steadmont
I Houston TX 77040
P

ITEMS

.n#	Qty	Description	Matl Spec	Heat Code	Mill Heat Number
)01	1	6" 1500 RF WN XX	SA105-N-96	830	64713

CHEMICAL PROPERTIES

eat Code	C	Si	Mn	P	S	Cr	Al	Cu	Ni	Mo	V	Cb			CE
30	0.180	0.210	1.120	0.013	0.010	0.070	0.037	0.270	0.090	0.020	0.004	0.004	0.000	0.000	0.380

PHYSICAL PROPERTIES

at Code	Tensl	Yield	%Elong	%R.A.	BHN	Charpy	Ft-Lbs	Lat Expan	Shr Fract	Test Te
0	73513	42920	32.40	66.80	150-160					

NOTES

at Code	Note
)	NORMALIZED. TEMP/1650F. TIME @ TEMP/1 HR PER INCH. AIR COOL

his Information Has Been Electronically Transmitted *

certify that our flanges are capable of passing a hydrostatic
t compatible with their rating. We certify that all test re-
ts and process information contained herein are correct and
as contained in the records of the company.

CHALLENGE MACHINE

P.O. 13306

STANDARD FASTENER & SUPPLY CO.
ALLSTATE SUPPLY COMPANY INC.
804 MONTANA STREET
SOUTH HOUSTON, TEXAS 77587

11/03/97 **MATERIAL TEST REPORT**

CUSTOMER: LYNCO CUSTOMER PO#:9575
QTY: 24 DESCRIPTION: 1 3/8 2H HEX NUT
LOT NUMBER:7B9013
HEAT CODE: 7B9013 SPECIFICATION: ASTMA/ASME SA194
C: .46 MN: .78 P: .019 S: .019 SI: .18 CR:
NI: MO: CU: TI: V:
B: CB: AL: OTHER:

YIELD x .2% OFFSET: TENSILE: %ELG IN 2":
% R A:
TYPE HARDNESS: HRC28
SMPLE HRDNSS AFTER 24HR:455C HRC 22
CHARPY V-NOTCH TEMP: 1: 2: 3:
PROOF LOAD LBF: 215800
HARDENED AT:
TEMPERED AT: 460C

CUSTOMER: LYNCO CUSTOMER PO#:9575
QTY: 12 DESCRIPTION: 1 3/8 X 10 B7 STUD
LOT NUMBER:L75
HEAT CODE: 680P426 SPECIFICATION: ASTMA/ASME SA193
C: .43 MN: .84 P: .011 S: .023 SI: .24 CR: .88
NI: .06 MO: .16 CU: TI: V:
B: CB: AL: OTHER:

YIELD x .2% OFFSET: 120265 TENSILE: 139847 %ELG IN 2": 18.9
% R A: 58.42
TYPE HARDNESS: HB 285
SMPLE HRDNSS AFTER 24HR:
CHARPY V-NOTCH TEMP: 1: 2: 3:
PROOF LOAD LBF:
HARDENED AT:
TEMPERED AT: 1100F

We hereby certify that the foregoing data is a true copy of the data furnished by the producing mill.

Authorized Signature

U. S. STEEL GROUP
A division of USX Corporation

6" .864

TUBULAR PRODUCTS CERTIFIED TEST REPORT

(TYPE B - IN ACCORDANCE WITH ISO 10474 / EN10204 / DIN50049)

Chamac
·1634391
133010

TIME: 07:04:21 USX™

USS, USX, USX are trademarks of USX Corporation

MORGAN CITY

MILL ORDER / ITEM NO.	SHIPPERS NO.	P.O. NUMBER	VEHICLE I.D.	
[illegible]	Y06791	97-15511	[illegible]	INVOICE NO 0460725

4106

Lynco FLANGE & FITTING, INC.
5114 STEADMONT DRIVE
HOUSTON, TEXAS 77040
(713) 690-0040

Lynco FLANGE & FITTING, INC.
5114 STEADMONT DRIVE
HOUSTON, TEXAS 77040
(713) 690-0040

VENDOR
USS TUBULAR PRODUCTS
USS FAIRFIELD WORKS
P.O. BOX 599
FAIRFIELD ALABAMA 35064

SPECIFICATION AND GRADE

PIPE CARBON SMLS STD PIPE API 5L-*41ST EDITION DTD 4/1/95 GRADE B AND GRADE X42 ASTM A53-*95 ASTM A106-*94A GRADE B QUAD STENCIL ASME SA53-*1995 EDITION 1995 ADDENDUM ASME SA106-*1995 EDITION 1995 ADDENDUM GRADE B BLK REG MILL COAT PE BEV 30 DEG MEETING ALL THE APPLICABLE REQUIREMENTS OF NACE STANDARD MR-01-75

TESTING/INSPECTION INFORMATION

OD GOOD

MATERIAL COND: AS-ROLLED | O.D.: 6.625 (168.275) in (mm) | WALL: 0.864 (21.945) in (mm)

PRODUCT IDENTIFICATION	TEST TYPE / ORIENTATION	TEST COND.	GAUGE WIDTH	YIELD PSI	EXT %	TENSILE UT PSI	Y/T	ELONG % (IN 2")	HARDNESS SCALE: HRB	MIN HYDRO PSI	DWELL (SEC)
			IN	MIN: 42,000 MAX:	.50 MAJOR	MIN 60,000 SIZE MAX:	MAX:	MIN: 29.5	MIN: MAX: 99.5	8220	5
A24611 ✓	STRIP/L/B	AR	1.5	45,700	.50	78,100	0.59	47.1	81.7	8220	5
A42445	STRIP/L/B	AR	1.5	45,500	.50	76,400	0.60	44.6	85.4	8220	5
		**	END OF	DATA	THIS SHEET	**					

LEGEND: L - LONGITUDINAL, U - UPSET; T - TRANSVERSE, N - NORMALIZED; QT - QUENCHED & TEMPERED, SR - STRESS RELIEVED; AR - AS ROLLED, AQ - AS QUENCHED; B - BODY; W - WELD

PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO	C.E.*
A24611	HEAT	25	96	010	008	23	01	01	06	01	023		00					
A24611	PROD	26	93	010	007	23	01	01	06	01	021		00					
A24611	PROD	26	94	010	007	23	01	01	06	01	020		00					
A42445	HEAT	25	92	007	006	21	01	01	05	02	021		00					
A42445	PROD	25	93	007	006	22	01	01	04	02	019		00					
A42445	PROD	26	94	008	006	22	01	01	04	02	019		00					
		**	END	OF	DATA	THIS	SHEET	**										

Mill Test Reports Furnished By
PIPE DISTRIBUTORS, INC.
Apply to Your Order No. ______

9572

*C.E. IS BASED ON THE FOLLOWING EQUATION(S):

A division of USX Corporation

CERTIFIED TEST REPORT

(TYPE B - IN ACCORDANCE WITH ISO 10474 / EN10204 / DIN50049)

USS, USX, USX are trademarks of USX Corporation

MILL ORDER / ITEM NO.	SHIPPERS NO.	P.O. NUMBER	
DR06810 05	Y06791	97-15511	INVOICE NO 0460725

MATERIAL COND: AS-ROLLED

O.D.: 6.625(168.275) in (mm) WALL: 0.864 (21.945) in (mm)

PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	MIN COLLAPSE	CHARPY V-NOTCH IMPACT TESTING: DIR	TEST LOC.	TEMP	SIZE	TEST COND.	FT-LBS 1	2	3	AVG	% SHEAR 1	2	3	AVG
A24611	OK																
A42445	OK																
			** END OF DATA THIS SHEET **														

LEGEND: L - LONGITUDINAL T - TRANSVERSE B - BODY W - WELD HAZ - HEAT AFFECTED ZONE

TESTING / INSPECTION INFORMATION

TEST / INSPECTION	YES	RESULTS / COMMENTS
FULL LENGTH VISUAL	X	
FULL LENGTH EMI	X	OD X OD / ID ___ L X L / T ___
FULL LENGTH MPI		
FULL LENGTH UT	X	OD ___ OD / ID X L X L / T ___
END AREA INSPECTION (PLAIN END)	X	MPI X UT ___
SPECIAL END AREA (SEA) INSP.		MPI ___ UT ___
FULL LENGTH DRIFT		DRIFT MANDREL SIZE:

ADDITIONAL NOTES / COMMENTS

ALL MELTING AND MANUFACTURING TOOK PLACE IN THE USA.
MANUFACTURED IN AN ISO 9001 CETIFIED FACILITY - CERTIFICATE #30727.
NO REPAIRS BY WELDING. NO MERCURY OR MERCURY COMPOUNDS ARE ADDED TO THE STEEL AND ALL MERCURY
BEARING EQUIPMENT IS PROTECTED BY A DOUBLE BOUNDARY OF CONTAINMENT.
01 MILL
SHOW CHEM AND PHYSICALS REPORT HYDROSTATIC TEST PRESSURES SHOW
ALSO MEETS THE REQUIREMENTS OF ASME SA53 1992 EDITION, & SA106 1992 EDITION GRADE B
MATERIAL WAS HOT FINISHED - NO HEAT TREATMENT.
** END OF DATA **

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MANUFACTURED, SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS THE REQUIREMENTS IN SUCH RESPECTS.

PREPARED BY THE OFFICE OF: N. ZGONC

DATE 09/05/97

409071001 K4007B40 6907074018 CBA 3-0-0

Appendix B Strain Gage Readings Taken During the Testing

===================== STRAIN AND STRESS SUMMARY TABLE =====================

CLIENT : PIKOTEK
LOAD = 0.000 ftlbs

TEST SPECIMEN : 6IN 15K FLANGE
SCAN # 33 DATE : 19 Nov 1997 * 11:03:04

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
33	1	0	-2	3	-8	-66	62	66	[Channs 2 , 3 , 4]
33	2	-0	0	0	-9	0	0	0	[Channs 5]
33	3	0	-0	0	-1	-5	4	5	[Channs 6 , 7 , 8]
33	4	-1	-2	2	-61	-74	69	74	[Channs 9 , 10 , 11]
33	5	-2	0	0	-58	0	0	0	[Channs 12]
33	6	1	-1	2	7	-32	37	40	[Channs 13 , 14 , 15]
33	7	-1	-1	1	-32	-42	38	42	[Channs 16 , 17 , 18]
33	8	-0	-1	1	-24	-29	27	29	[Channs 19 , 20]
33	9	-1	0	0	-16	0	0	0	[Channs 21]
33	10	-1	-1	1	-30	-36	33	36	[Channs 22 , 23]

LOAD = 0.000 ftlbs

Strain Measurements
Make-up Loading
(zeroed at 0 ft-lbs.)

===================== STRAIN AND STRESS SUMMARY TABLE =====================

CLIENT : PIKOTEK
LOAD = 517.000 ftlbs

TEST SPECIMEN : 6IN 15K FLANGE
SCAN # 34 DATE : 19 Nov 1997 * 11:19:13

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
34	1	1075	-304	1537	32440	615	32137	32440	[Channs 2 , 3 , 4]
34	2	637	0	0	19104	0	0	0	[Channs 5]
34	3	649	-238	974	19052	-1418	19799	20470	[Channs 6 , 7 , 8]
34	4	1118	-362	1636	33264	-882	33714	34146	[Channs 9 , 10 , 11]
34	5	1212	0	0	36359	0	0	0	[Channs 12]
34	6	403	-97	563	12341	794	11964	12341	[Channs 13 , 14 , 15]
34	7	164	116	179	6560	5453	6083	6560	[Channs 16 , 17 , 18]
34	8	0	-2	2	-4	-49	47	49	[Channs 19 , 20]
34	9	1	0	0	28	0	0	0	[Channs 21]
34	10	0	0	0	9	6	8	9	[Channs 22 , 23]

LOAD = ~~517.00~~0 ftlbs

Strain Measurements
Make-up Loading
(225 ft-lbs.)

===================== STRAIN AND STRESS SUMMARY TABLE =====================

CLIENT : PIKOTEK
LOAD = 450.000 ftlbs

TEST SPECIMEN : 6IN 15K FLANGE
SCAN # 35 DATE : 19 Nov 1997 * 11:38:55

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
35	1	1257	-352	1794	37947	811	37548	37947	[Channs 2 , 3 , 4]
35	2	808	0	0	24244	0	0	0	[Channs 5]
35	3	857	-290	1266	25388	-1092	25951	26480	[Channs 6 , 7 , 8]
35	4	1397	-413	2013	41982	196	41885	41982	[Channs 9 , 10 , 11]
35	5	1055	0	0	31660	0	0	0	[Channs 12]
35	6	979	-340	1453	28915	-1537	29713	30451	[Channs 13 , 14 , 15]
35	7	260	132	276	9869	6912	8772	9869	[Channs 16 , 17 , 18]
35	8	1	-0	2	40	3	38	40	[Channs 19 , 20]
35	9	-0	0	0	-4	0	0	0	[Channs 21]
35	10	1	2	2	60	73	67	73	[Channs 22 , 23]

LOAD = 450.000 ftlbs

Strain Measurements
Make-up Loading
(450 ft-lbs.)

STRAIN AND STRESS SUMMARY TABLE

CLIENT : PIKOTEK   TEST SPECIMEN : 6IN 15K FLANGE
LOAD = 680.000 ftlbs   SCAN # 36 DATE : 19 Nov 1997 * 11:46:08

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
36	1	1708	-479	2439	51568	1102	51026	51568	[Channs 2 , 3 , 4]
36	2	1151	0	0	34525	0	0	0	[Channs 5]
36	3	1355	-456	1998	40164	-1620	40998	41785	[Channs 6 , 7 , 8]
36	4	1638	-473	2350	49306	588	49015	49306	[Channs 9 , 10 , 11]
36	5	1144	0	0	34322	0	0	0	[Channs 12]
36	6	1126	-407	1685	33108	-2288	34310	35396	[Channs 13 , 14 , 15]
36	7	336	181	357	12875	9289	11509	12875	[Channs 16 , 17 , 18]
36	8	1	1	1	48	30	42	48	[Channs 19 , 20]
36	9	-0	0	0	-3	0	0	0	[Channs 21]
36	10	2	2	2	69	75	72	75	[Channs 22 , 23]

LOAD = 680.000 ftlbs

Strain Measurements
Make-up Loading
(680 ft-lbs. - Final Torque)

STRAIN AND STRESS SUMMARY TABLE

CLIENT : PIKOTEK   TEST SPECIMEN : 6IN 15K FLANGE
LOAD = 680.000 ftlbs   SCAN # 37 DATE : 19 Nov 1997 * 14:40:44

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
37	1	1680	-468	2396	50757	1193	50171	50757	[Channs 2 , 3 , 4]
37	2	1121	0	0	33618	0	0	0	[Channs 5]
37	3	1315	-439	1936	38994	-1472	39750	40466	[Channs 6 , 7 , 8]
37	4	1632	-473	2343	49125	539	48857	49125	[Channs 9 , 10 , 11]
37	5	1151	0	0	34542	0	0	0	[Channs 12]
37	6	1109	-393	1652	32679	-1979	33712	34658	[Channs 13 , 14 , 15]
37	7	336	140	358	12465	7939	10929	12465	[Channs 16 , 17 , 18]
37	8	26	-78	115	85	-2324	2367	2408	[Channs 19 , 20]
37	9	1	0	0	18	0	0	0	[Channs 21]
37	10	-20	76	107	98	2310	2262	2310	[Channs 22 , 23]

LOAD = 680.000 ftlbs

Strain Measurements
Loaded in the frame with no support
which indicate the presence of bendi

STRAIN AND STRESS SUMMARY TABLE

CLIENT : PIKOTEK   TEST SPECIMEN : 6IN 15K FLANGE
LOAD = 0.000 ftkips   SCAN # 38 DATE : 20 Nov 1997 * 18:03:31

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
38	1	1681	-475	2403	50704	961	50231	50704	[Channs 2 , 3 , 4]
38	2	1109	0	0	33280	0	0	0	[Channs 5]
38	3	1288	-431	1897	38187	-1487	38952	39674	[Channs 6 , 7 , 8]
38	4	1636	-470	2345	49278	675	48944	49278	[Channs 9 , 10 , 11]
38	5	1186	0	0	35580	0	0	0	[Channs 12]
38	6	1078	-368	1594	31918	-1454	32669	33372	[Channs 13 , 14 , 15]
38	7	376	35	441	12751	4875	11144	12751	[Channs 16 , 17 , 18]
38	8	-0	-0	0	-9	-6	8	9	[Channs 19 , 20]
38	9	0	0	0	4	0	0	0	[Channs 21]
38	10	-0	0	0	-1	3	3	3	[Channs 22 , 23]

LOAD = 0.000 ftkips

Strain Measurements
Immediately preceding Bending Te
(after hydro and nitrogen cycling
had been performed)

==================== STRAIN AND STRESS SUMMARY TABLE ====================

CLIENT : PIKOTEK
LOAD = 50.600 ftkips

TEST SPECIMEN : 6IN 15K FLANGE
SCAN # 39 DATE : 20 Nov 1997 * 18:12:26

SCAN#	ROS #	e1	e2	EPEQ	S1	S2	SIGE	SI	
39	1	1858	-525	2656	56049	1069	55522	56049	[Channs 2 , 3 , 4]
39	2	1285	0	0	38536	0	0	0	[Channs 5]
39	3	1461	-477	2142	43432	-1280	44086	44712	[Channs 6 , 7 , 8]
39	4	1475	-422	2113	44456	680	44120	44456	[Channs 9 , 10 , 11]
39	5	983	0	0	29486	0	0	0	[Channs 12]
39	6	906	-330	1357	26597	-1907	27600	28504	[Channs 13 , 14 , 15]
39	7	571	295	606	21737	15356	19353	21737	[Channs 16 , 17 , 18]
39	8	-287	1008	1443	516	30395	30140	30395	[Channs 19 , 20]
39	9	-151	0	0	-4523	0	0	0	[Channs 21]
39	10	279	-996	1421	-648	-30062	29743	30062	[Channs 22 , 23]

LOAD = 50.600 ftkips

Strain Measurements
Bending Test - 50,000 ft-lbs.

Appendix C Pikotek Testing Procedure and Calibration Sheets

Test Procedure 9752T2
Revision B
November 25, 1997

TEST PROCEDURE 9752T2

for the

6″ CLASS 1500 HP VCS FLANGE GASKET

PIKOTEK INCORPORATED
P.O. Box 260438
12980 West Cedar Drive
Lakewood, Colorado 80226

Prepared by John W. Fowler, PE Date 25 Nov 97

Approved by ______________________ Date ______

1.0 OBJECTIVE

This test program is to verify performance of the PIKOTEK HP VCS Flange Gasket for high-pressure service in 6 inch Class 1500 flanges. This test is intended to qualify the gasket and bolted flange assembly in accordance with industry requirements for higher pressure ratings.

2.0 COMPONENTS AND MATERIAL

The test fixture assembly is shown in Figure 1. Quantities and Drawing or part numbers for the test components are as follows:

Quantity	Component	Drawing/Part Number	Material
2	Flange		ASTM A105
11	Studs		A193-B7
1	Stud, modified		A193-B7
24	Nuts		A194
1	Gasket	PG-1500-T-HP	Pikotek

The test flanges shall be manufactured from material having a minimum specified yield strength of 36,000 psi and tensile of 75,000 psi in accordance with the requirements of ASME 16.5. The flange shall have a 5.38 to 5.41 inch diameter bore and a 8.50 inch raised face with a standard phonograph finish. The hub shall have a 45 degree taper from a 9.00 inch diameter at the flange back-face to a 6.375 inch outside diameter. Studs and nuts shall meet the requirements of ASTM A193 Grade B7 and A194 respectively. Material certifications shall be kept with this file.

INSPECTION

1. Flanges, studs and nuts shall be clean and free from grease, dirt, or other contamination.

2. Measure and record the dimensions of all components to ensure manufacture to the appropriate drawing or purchase order.

ASSEMBLY

1. Install three-element strain gages to one test flange and to the modified stud in accordance with the gage manufacturer's instructions. The strain gage locations are shown in Figure 1.

2. With the bore vertical, place the flange equipped with the strain gage on a flat level surface. Using a new Pikotek HP VCS gasket, assemble the test flanges and lead the strain gage cables as shown.

3. Using a calibrated torque measuring device, apply a maximum of

680 foot-pounds of torque to each stud and nut assembly. Apply torque in a criss-cross pattern to each stud in turn in stages of 30%, 65%, and 100% of the maximum.

4. Install a calibrated pressure indicator capable of measuring and recording fluid pressure within 1/2% accuracy. Attach the strain gages to appropriate strain measuring and recording equipment.

5. Apply hydrostatic pressure not to exceed 3,300 psig (50% of the working pressure) to the test port. Per the manufacturer's instructions, shake down the strain gages and calibrate the instrumentation.

PRESSURE AND LEAKAGE TEST

1. Apply a hydrostatic test pressure of 9,900 psig to the test fixture. Note and record strain and fluid leakage or pressure drop. Hold the pressure for 1 hour. Leak tightness is satisfactory if there is no visible or audible evidence of leakage and the pressure change is less than 500 psi.

2. Drop the pressure to zero. Note and record the strain gage readings.

3. Using nitrogen gas, apply the full rated working pressure of 6,600 psig to the test fixture. Again, note and record strain readings and fluid pressure. Measure and record leakage using appropriate leak detection equipment. Hold the working pressure for 30 minutes. Leak tightness is satisfactory if there is no visible or audible evidence of leakage and the pressure change is less than 330 psi.

4. Drop the nitrogen pressure to zero. Note and record strain gage readings.

5. Repeat steps 3 and 4 for a total of 10 pressure cycles to the full rated working pressure.

6. (Optional) Apply a bending moment of 50,000 foot-pounds to the test flange assembly. Repeat steps 3 and 4 for an additional 5 pressure cycles, while maintaining the bending moment. The hold period for these cycles is 10 minutes, and the leakage criterion is the same as step 3.

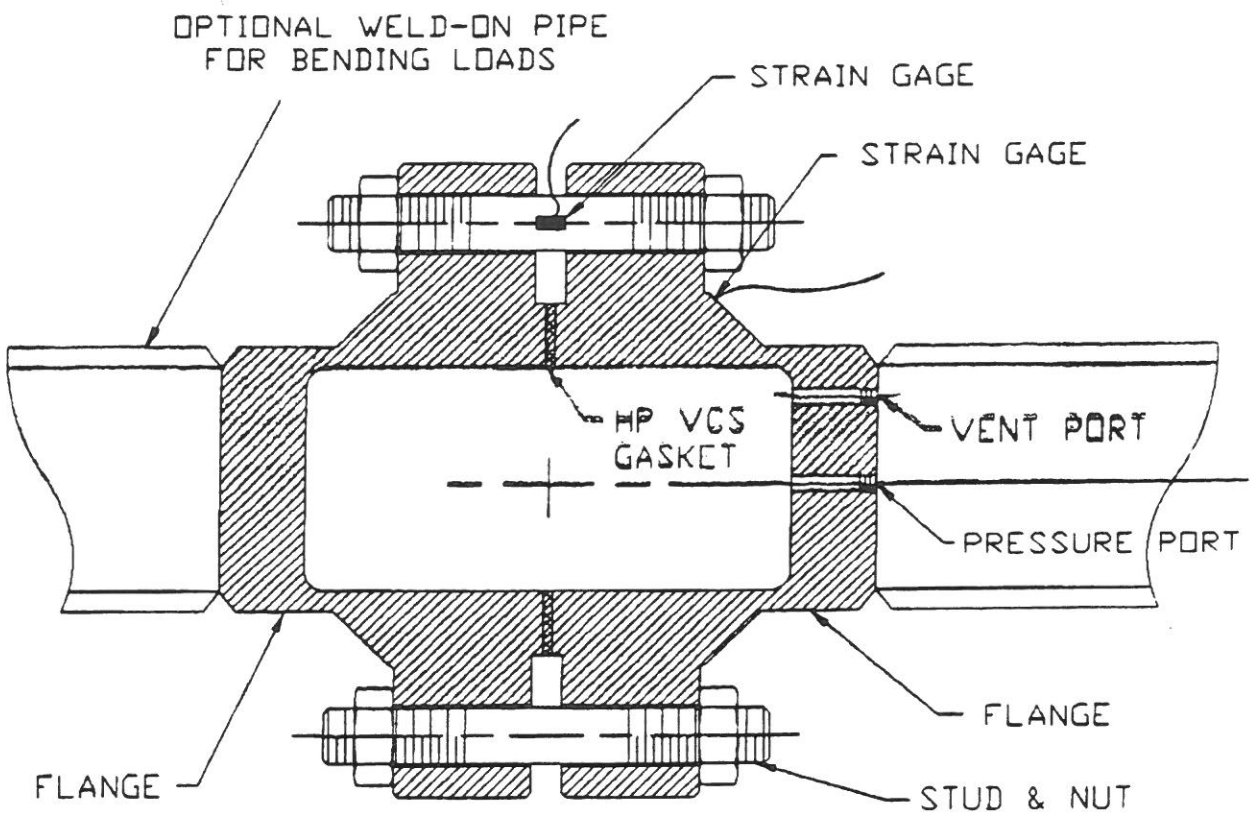
DISASSEMBLY AND INSPECTION

1. With the bore vertical, place the test fixture on a flat level surface. Remove the studs and nuts and remove the upper flange. Inspect the upper flange and gasket. Note and record any wear, deformation, or damage and photograph the components as deemed necessary.

2. Remove the gasket from the lower flange. Inspect, measure and record any dimensional changes, then photograph as deemed necessary.

RESULTS

Prepare a test report, which includes identification of the components, material certifications, the test sequence including pressure and bending loads, and pressure and strain readings. The test report shall be numbered, dated and signed.



TEST FIXTURE
PIKOTEK HP VCS GASKET
ASME B16.5 FLANGES

- FIGURE 1 -

DYNISCO
EASUREMENT/CONTROL

DATA VAL.DATION

Commercial St., Sharon, MA 02067, Tel: 617-784-8400

PENCE:

E: MAR 3 1 1997

NISCO ORDER #:

EL NUMBER: PT130-10M-H57

ESSURE RANGE: 0-10000 PSIG

IAL NUMBER 353218

NSDUCER DATA:

RO LOAD OUTPUT:	-0.006	mv/v
L RANGE SENSITIVITY:	2.995	mv/v
PRESSURE SENSITIVITY:	2.397	mv/v
UNT CALIB. SENSITIVITY:	2.394	mv/v
PUT RESISTANCE:	386	ohms
PUT RESISTANCE:	438	ohms
ULATION RES. @ 50 vdc:	>1000	megohm

MEASUREMENT EQUIPMENT
MAINTAINED CALIBRATED
TRACEABLE TO N.I.S.T.

ELECTRICAL INTERFACE:

CONNECTOR....PT02A-10-6P
MATE.........PT06A-10-6S(SR

A	SIGNAL +
B	SIGNAL -
C	EXCITATION +
D	EXCITATION -
E	SHUNT CALIBRATION
F	SHUNT CALIBRATION

EXCITATION:
6-10 volts 12 volt MAX

TEST EXCITATION=10 vdc

TEST TECH:4496

MANUFACTURED UNDER
ISO 9001 QUALITY
SYSTEM APPROVED BY BSI

MODEL: PT130-10M-H57

RANGE:0-10000 PSIG

SER.#: 353218

TEST INPUT#:4

DATE:31 Mar 1997

CALIBRATION:

INCR	OUT (mv/v)	%ERR BFSL
0%	-0.006	0.00
20%	0.595	-0.10
40%	1.196	-0.03
60%	1.795	-0.03
80%	2.391	-0.10
100%	2.989	
80%	2.394	-0.02
60%	1.800	0.15
40%	1.200	0.11
20%	0.598	0.02
0%	-0.005	0.00

REDUCED DATA:

ZERO BAL:	-0.006	mv/v
F.R. SENS:	2.995	mv/v
ACCURACY (BFSL):	0.15	%
ZERO NON RETURN:	0.02	%

IMPEDANCE:

OUTPUT RES:	386	ohms
INPUT RES:	438	ohms

SHUNT CALIBRATION:

80% SENS:	2.397	mv/v
Rcal SENS:	2.394	mv/v
Rcal ERR:	-0.10	%

FORM X 20530

An OMEGA Technologies Company

Certificate of Calibration

for

STRESS ENGINEERING

Cust PO: TB305
Report No: 709941827

Model: CL23A
Serial No: T103652

CAL-3

Omega Engineering, Inc. certifies that the above instrumentation has been calibrated to meet or exceed the published specifications. This calibration was performed using instrumentation and standards that are traceable to the United States National Institute of Standards and Technology, and is in compliance with ISO-10012-1.

Accuracy of UUT: +/-0.5F <1250, +/-0.9F > 1250

Range	Standard	As Found	As Left
KF	32	31.9	31.9
	2300	2299.6	2299.6
JF	32	31.7	31.7
	1400	1399.7	1399.7
TF	32	31.8	31.8
	750	749.6	749.6

Max Calibration System Uncertainty: 8ppm (DC), +/-0.01% (Ohms), +/-0.2C (Temp)

NIST Traceable Test Nos: 110566

Calibration Standards:		Cal Due:
Fluke 5700A Calibrator	CN# 12-930-06	03/12/98
Ice Point Reference	CN# 13-930-05	04/28/98

Test Conditions: Temp 23C +/-2C RH 35% +/-20%

Accepted and Certified By: ____________________ Date: 9/25/97

John L. Howard, Inst Lab Supervisor

PROTO® BRAND TORQUE WRENCH
CERTIFICATE of ACCURACY

OWNER:

____
Name

____
Street

____
City State Zip Code

CERTIFICATION:

This was tested 4-16-97 for correct
(Date)

calibration and is certified to be within the tolerances allowed per the following specification:

- ☐ Federal Specification GGG-W-686E, Dated 30 May 1994 and Interim Amendment 1, Date 12/10/71
- ☒ ANSI B107.14M
- ☐ ISO 6787
- ☐ Other Specifications:

TEST EQUIPMENT:

- ☒ Proto 6150 Electronic Tester, Serial No. 697
- ☐ Proto Mechanical Torque Tester, Model________, Serial No.________.

The accuracy of the test equipment is certified to be within 1% of the indicated reading of the full range of the test equipment used. The last date of certification was 11-4-96. The weights and arms used are traceable to the National Institute of Standards and Technology through test. Number 12667. Humidity 50 % Temperature 68.

TORQUE WRENCH IDENTIFICATION:

This Certificate of Accuracy applies only to Part No. 6020A Serial No. WXC39499

P.O. No. S0637987

Req. No. STW-161

Tested By Bruce Eaton
(Inspector)

Barry Bowen
Quality Control Manager or Designate

Tests were performed at the following Torque Wrench Calibration and Certification Center:

STANLEY-PROTO INDUSTRIAL TOOLS
14117 Industrial Blvd., N.E.
Covington, GA 30209

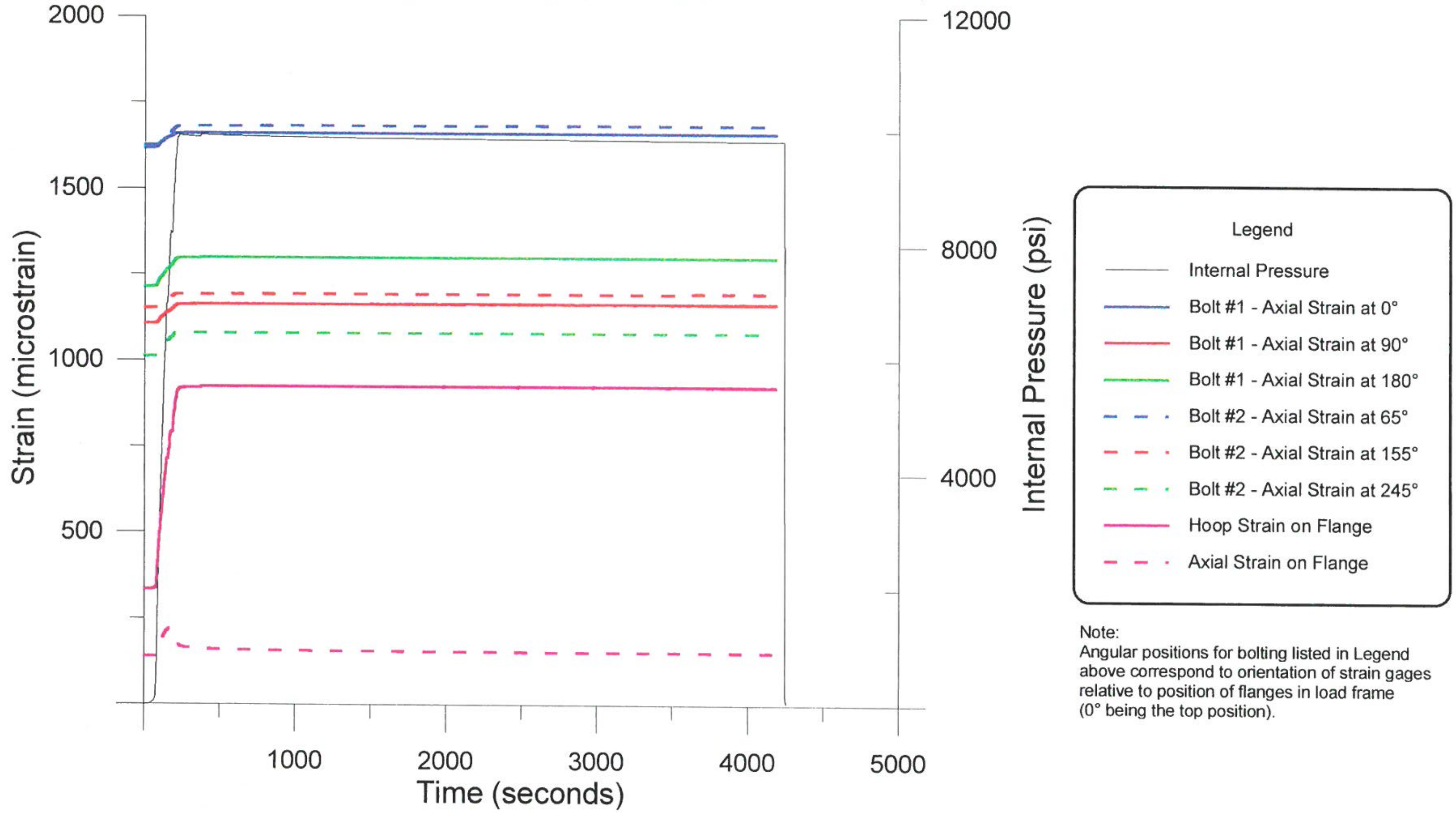
Form # 0024

Printed in U.S.A.

Appendix D Plot of Strain Gage Readings During Hydrostatic Testing

Figure D1
STRAIN AND PRESSURE AS A FUNCTION OF TIME HYDROSTATIC TESTING TO 9,900 psi

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997



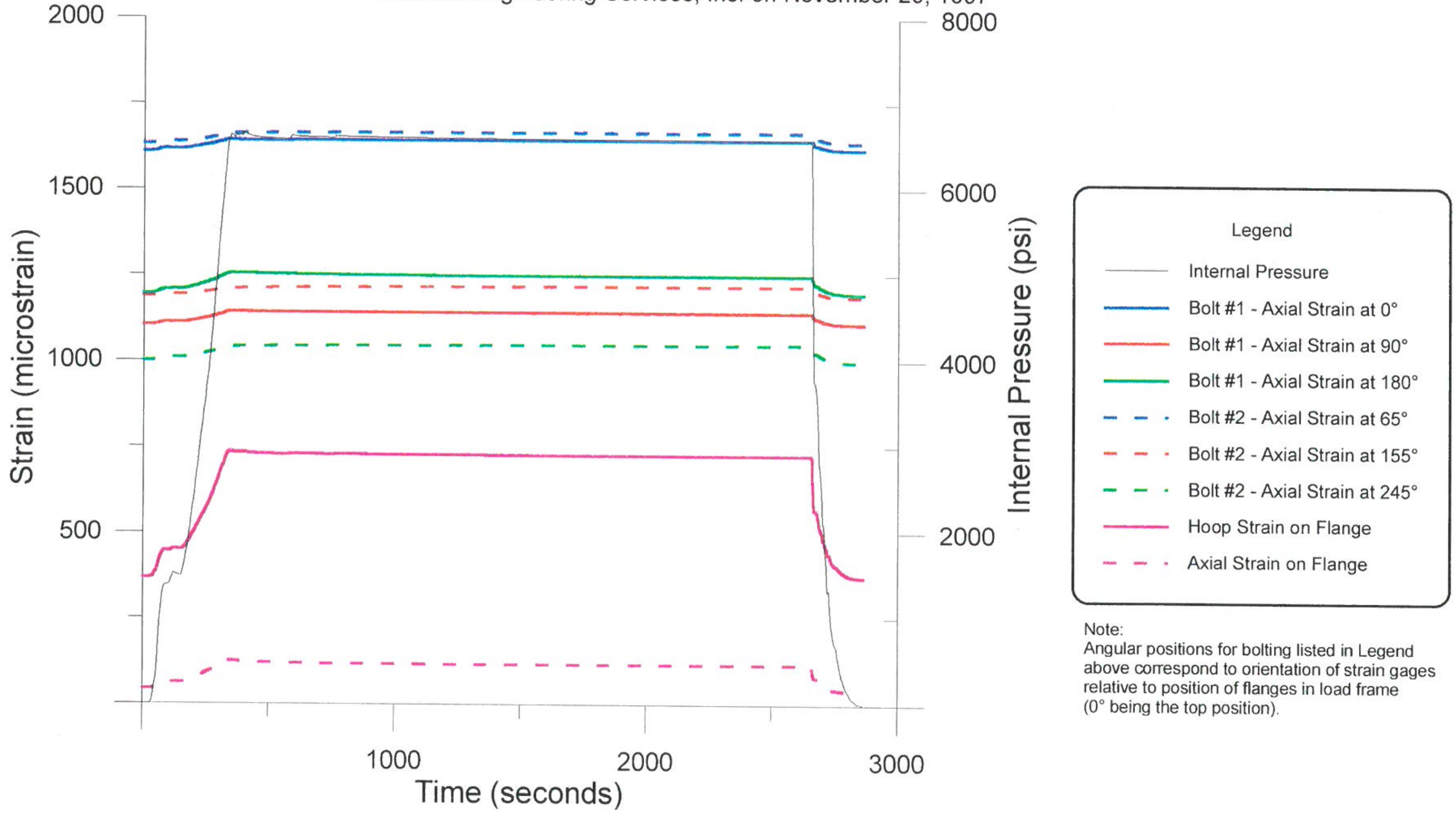
Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_d1.grf

Appendix E Plots of Strain Gage Readings Taken During Nitrogen Cycle Testing

Figure E1
STRAIN AND PRESSURE AS A FUNCTION OF TIME
NITROGEN TESTING TO 6,600 psi (CYCLE #1)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

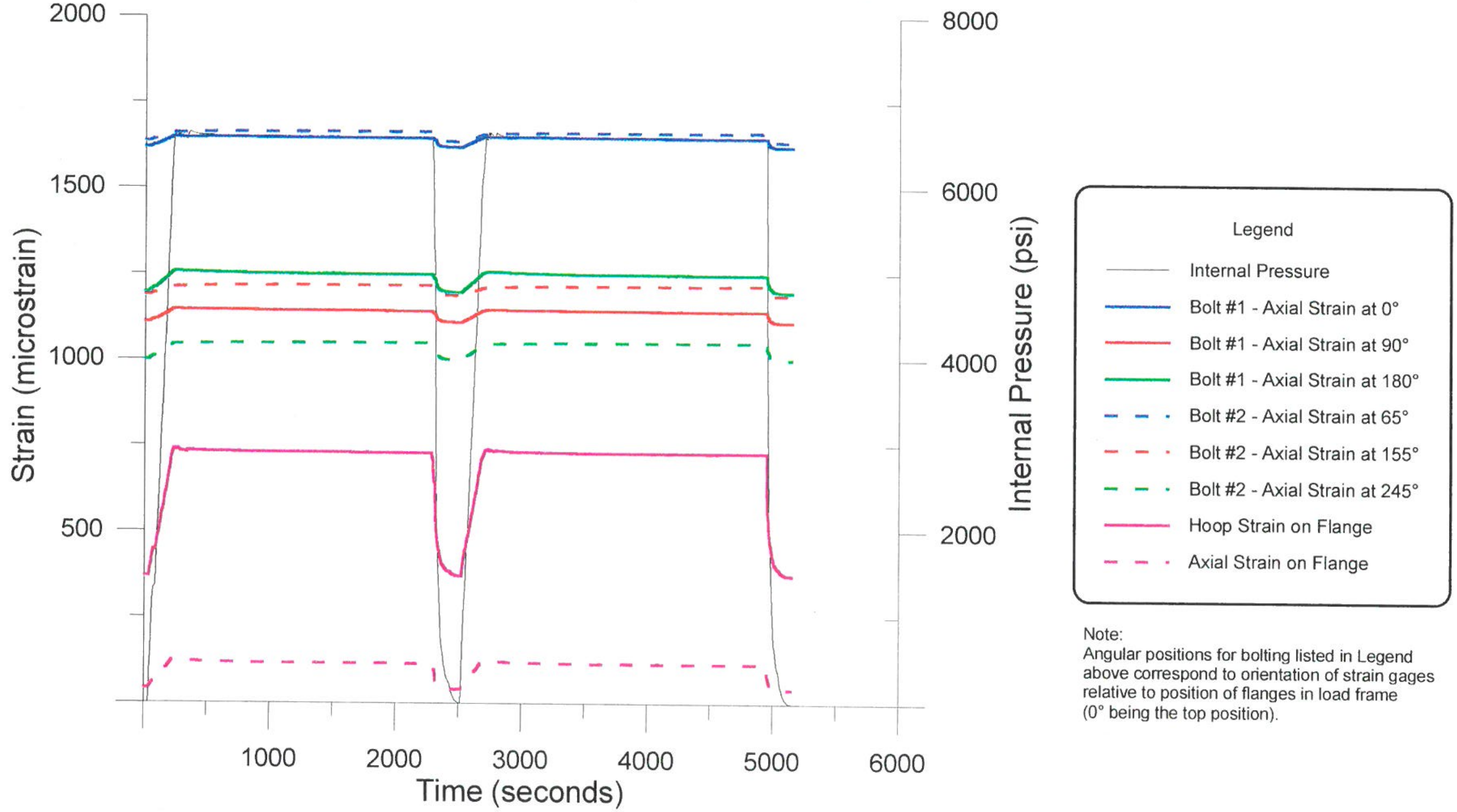


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e1.grf

Figure E2 and Figure E3
STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLES #2 & #3)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

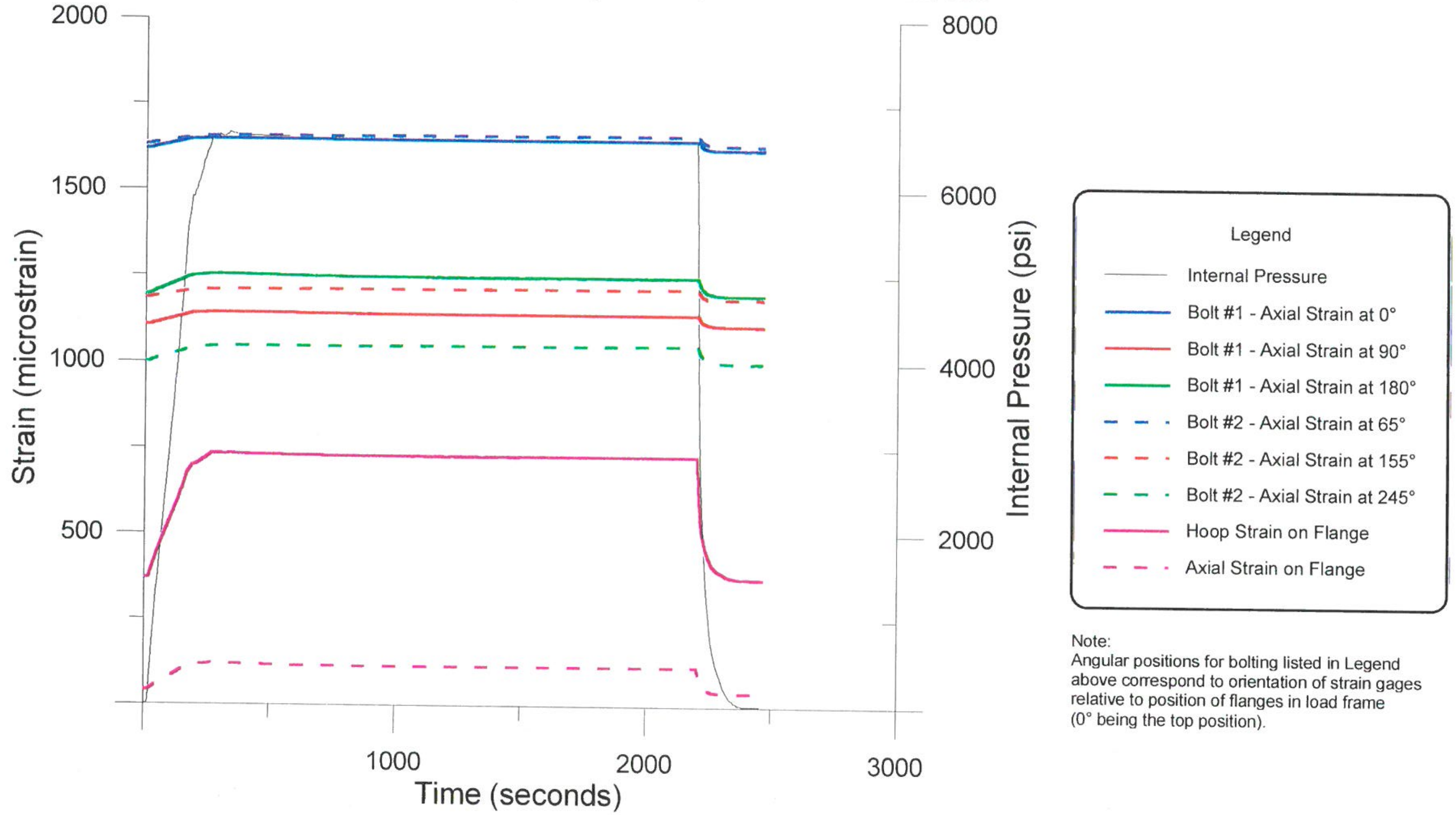


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e2&3.grf

Figure E4
STRAIN AND PRESSURE AS A FUNCTION OF TIME
NITROGEN TESTING TO 6,600 psi (CYCLE #4)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

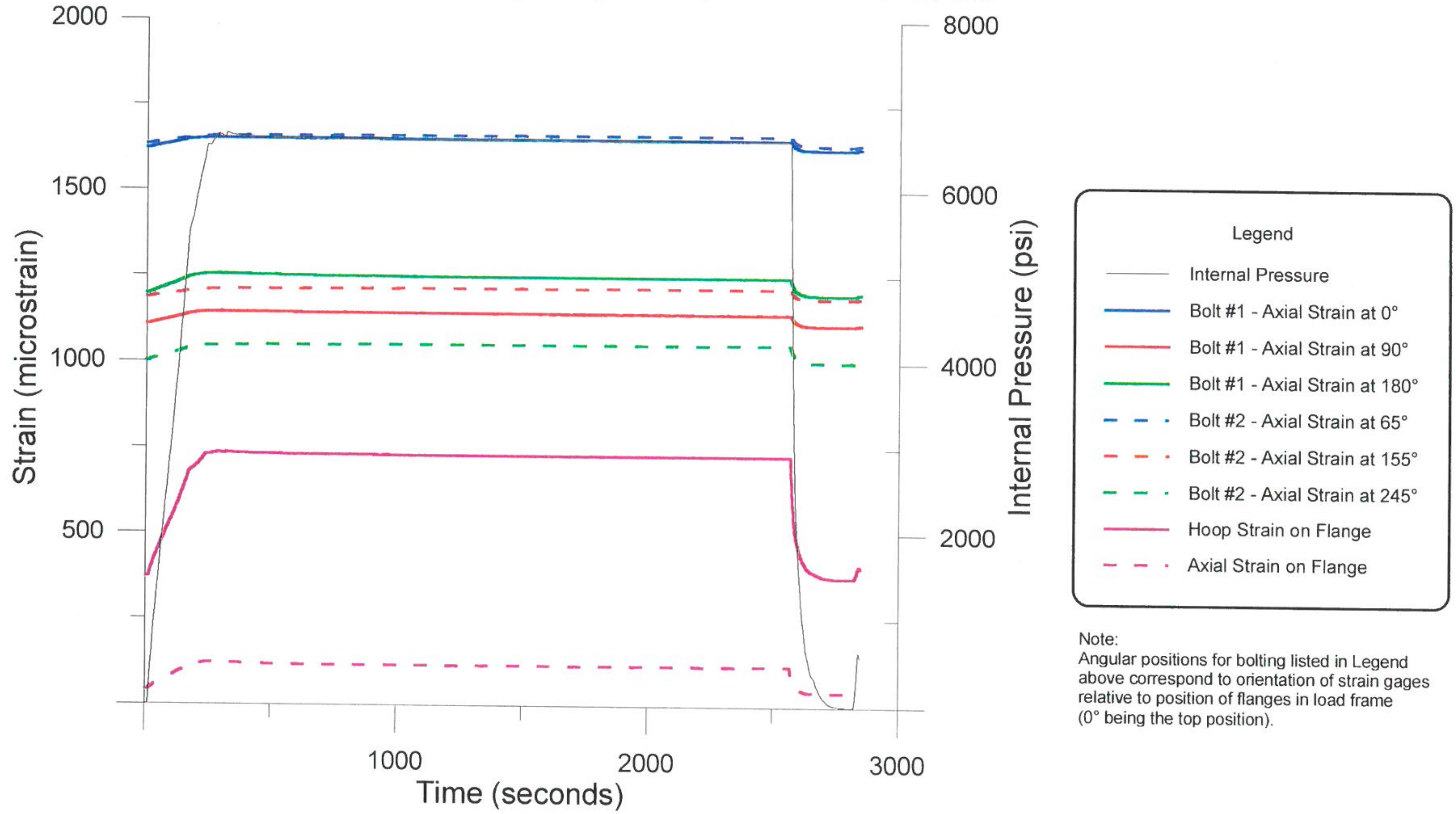


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e4.grf

Figure E5
STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLE #5)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

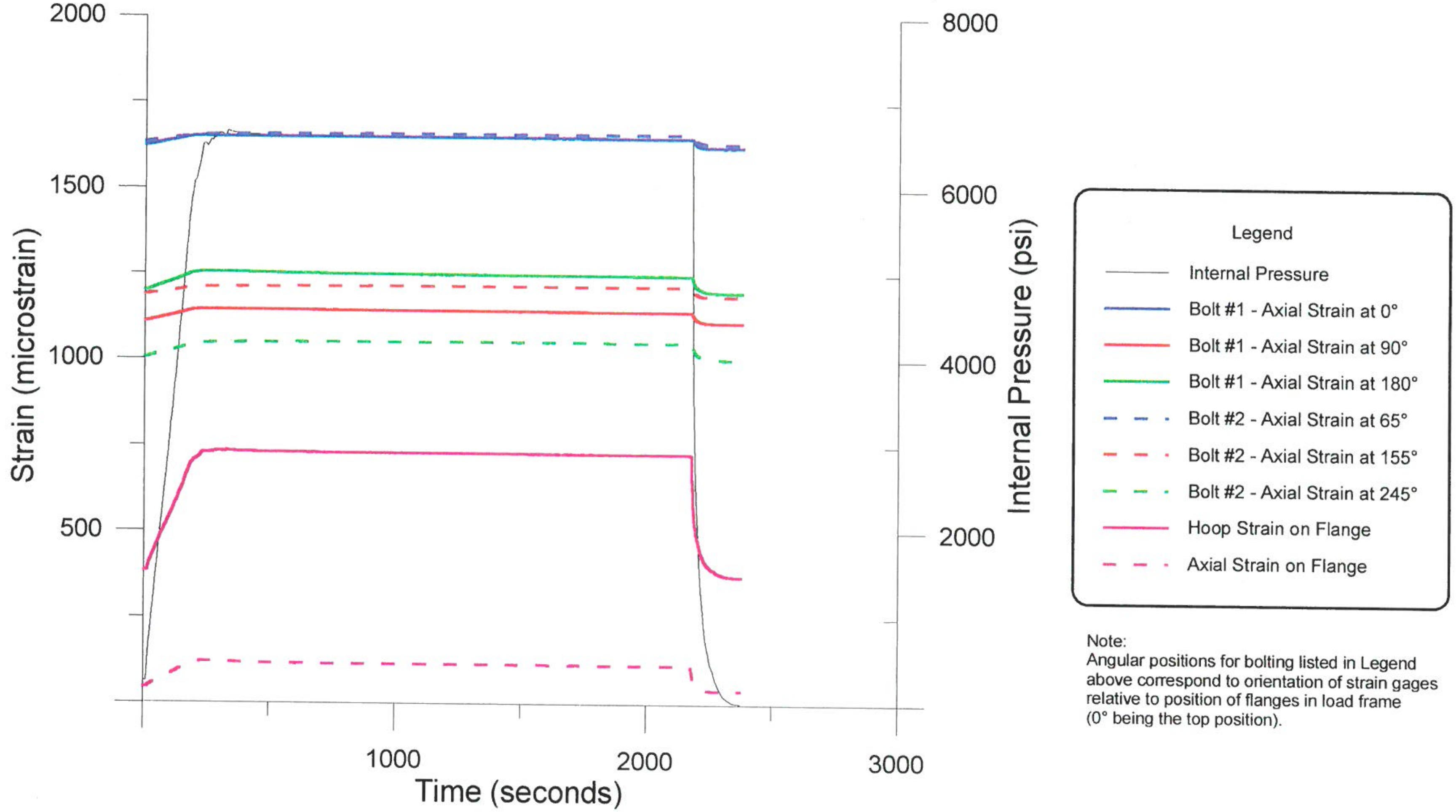


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e5.grf

Figure E6
STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLE #6)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997



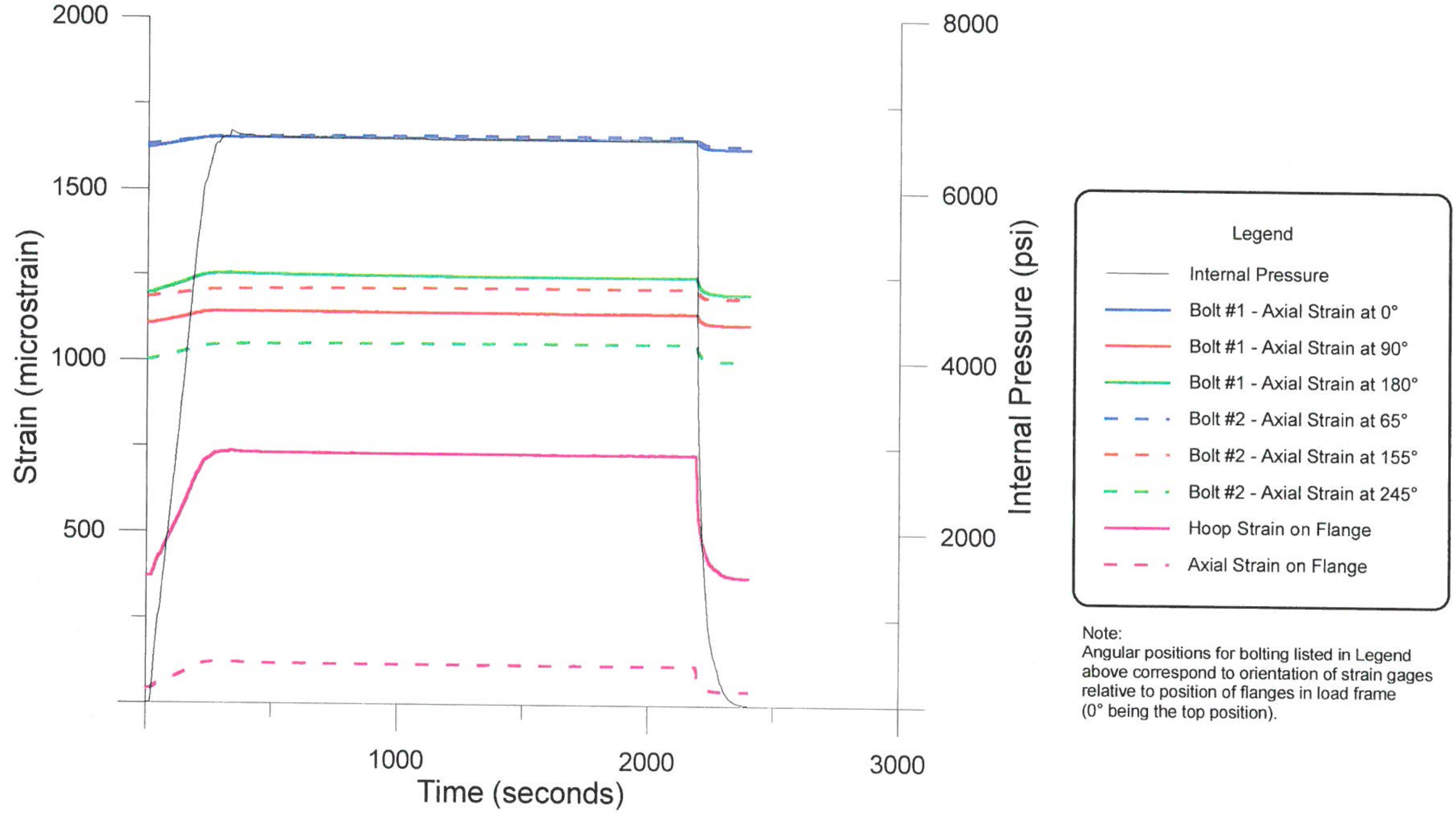
Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e6.grf

Figure E7

STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLE #7)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

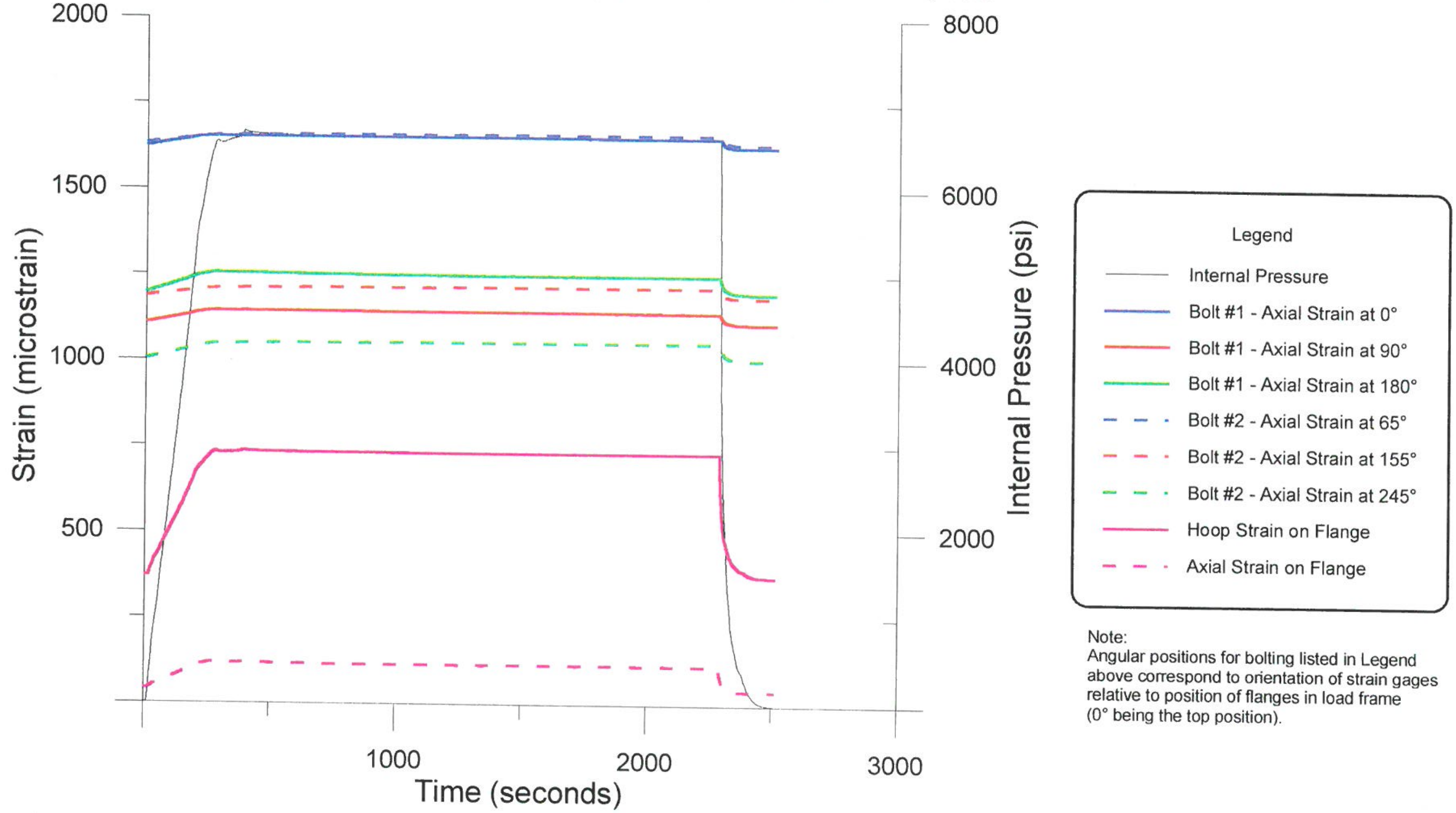


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e7.grf

Figure E8
STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLE #8)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

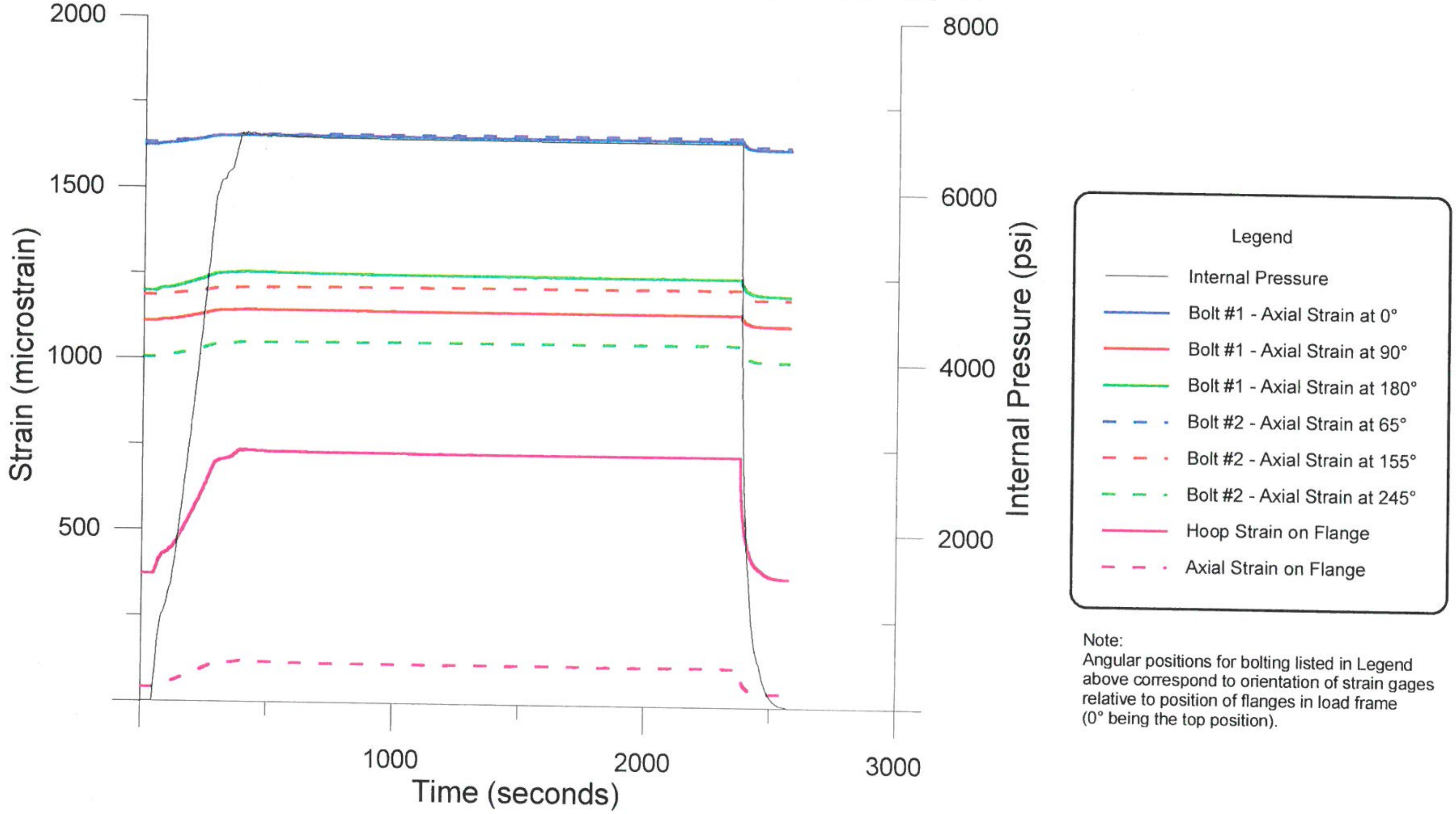


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e8.grf

Figure E9
STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLE #9)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997

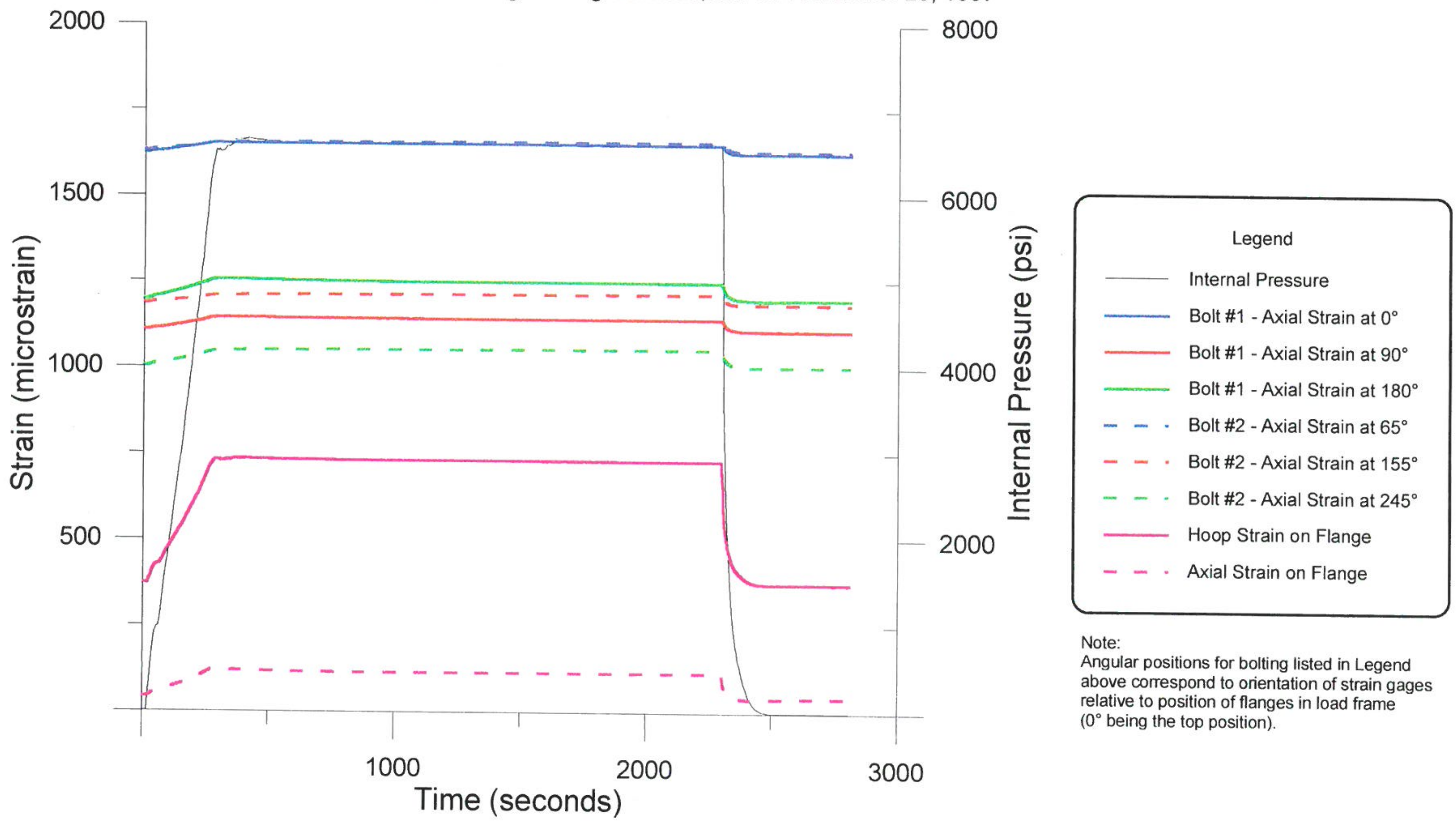


Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e9.grf

Figure E10
STRAIN AND PRESSURE AS A FUNCTION OF TIME NITROGEN TESTING TO 6,600 psi (CYCLES #10)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997



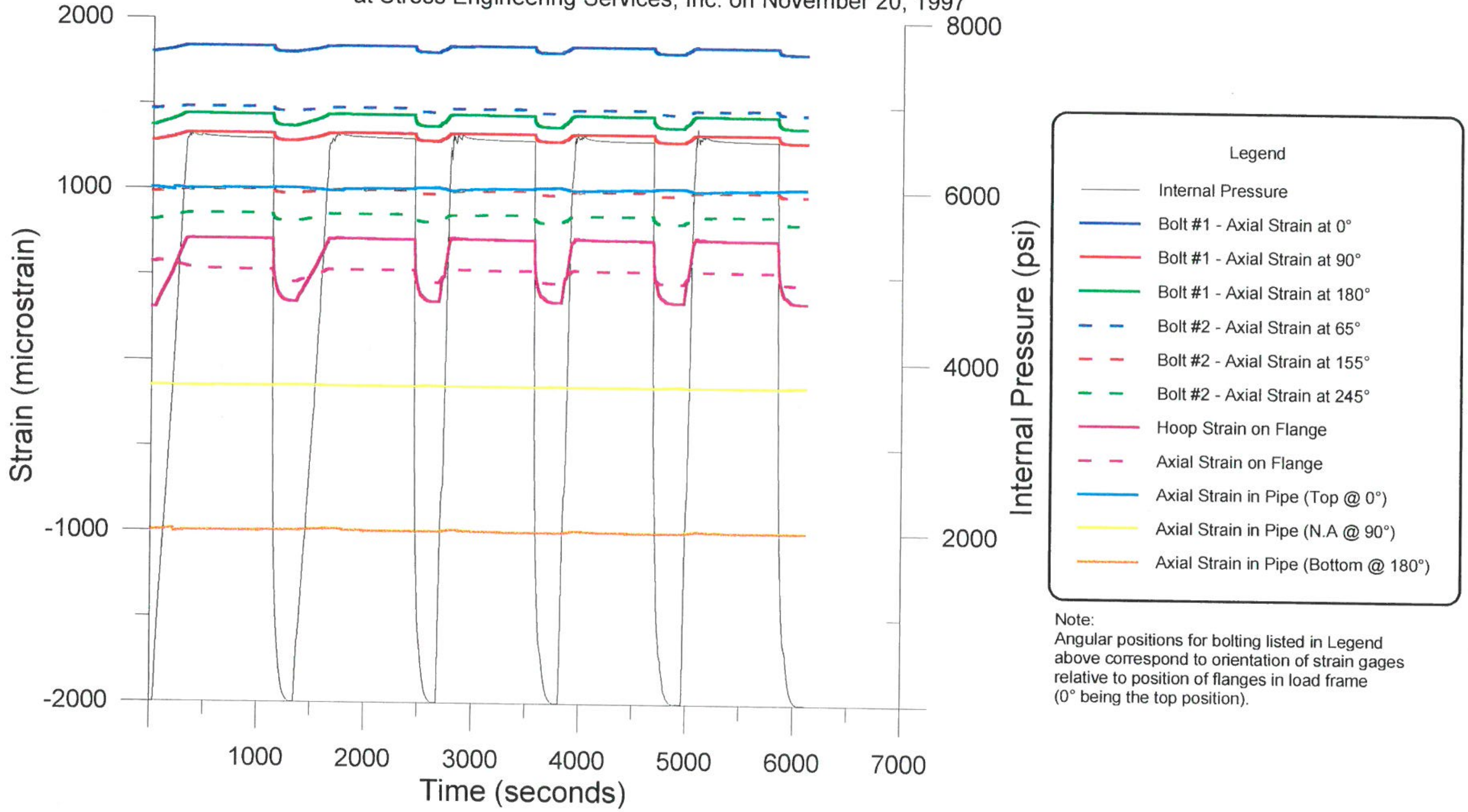
Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_e10.grf

Appendix F Plots of Strain Gage Readings Taken During Bending/Nitrogen Cycle Testing

Figure F1
STRAIN AND PRESSURE AS A FUNCTION OF TIME BENDING TO 50,000 FT-LBS. AND NITROGEN TESTING TO 6,600 psi (CYCLES #1 - #5)

Testing of the Pikotek 6" ANSI Class 1500# HP VCS Gasket
at Stress Engineering Services, Inc. on November 20, 1997



Note:
Angular positions for bolting listed in Legend above correspond to orientation of strain gages relative to position of flanges in load frame (0° being the top position).

c:/ses/pn5168/data/fig_f1.grf