TESTING AND EVALUATION OF FLANGE GASKETS FOR ANSI B16.5 FLANGES

Prepared by

John A. Bradley

FINAL REPORT
SwRI Project No. 06-5227-550

Prepared for

Pikotek, Inc.
P.O. Box 260818
Lakewood, CO 80226

October 1993

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO HOUSTON
DETROIT WASHINGTON, DC

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Reviewed:

for George K. Wolfe, P.E., Manager
Structural Development and
Fabrication Section

Approved:

for Hal Burnside, Director
Structural Engineering Department

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LIST OF FIGURES

INTRODUCTION

Laminated flange gaskets are used to seal ANSI B16.5 bolted flanges. They are widely used by the refinery and chemical industry as flange seals for internal pipe line pressures up to 6,000 psi. This report describes the results of comparative pressure testing of standard gaskets with spiral wound graphite/steel construction (Figure 1) and Pikotek Flowlok VCS gasket design (Figure 2). Similar gas and hydrostatic pressure tests were performed on both types of gaskets. Special test fixtures using 2-inch, 600, ANSI B16.5 test flanges were utilized for these tests. The test flanges presented in Figure 3 were used to perform all pressure tests on the spiral wound gaskets. The test flanges presented in Figure 4 were used to perform all pressure tests and a fire test on Pikotek gaskets. The test procedure for the tests performed appear in Appendix A of this report.

EXECUTIVE SUMMARY

Comparative pressure tests were conducted between standard spiral wound gaskets and Pikotek Flowlok VCS gaskets. The tests consisted of nitrogen leak tests using laboratory grade nitrogen and hydrostatic pressure tests. The gaskets tested were designed to be used in 2-inch, 600, ANSI B16.5 flat face flanges.

Test fixtures were fabricated for each type of gasket using specially prepared ANSI flanges. The flanges provided a means to capture any leak across the gasket and route it through a monitor port on the backside of the flange. A pressure line was installed from the monitor port to a leak detector. The leak detector measured any leakage that passed the test gasket.

The bolts of the test fixture flanges were made up to produce three levels of seal seating stress. Flange bolt makeup torques were calculated to provide equivalent seal seating stress for the standard spiral wound and Pikotek gaskets. The seating stress levels ranged from approximately 7,500 psi to

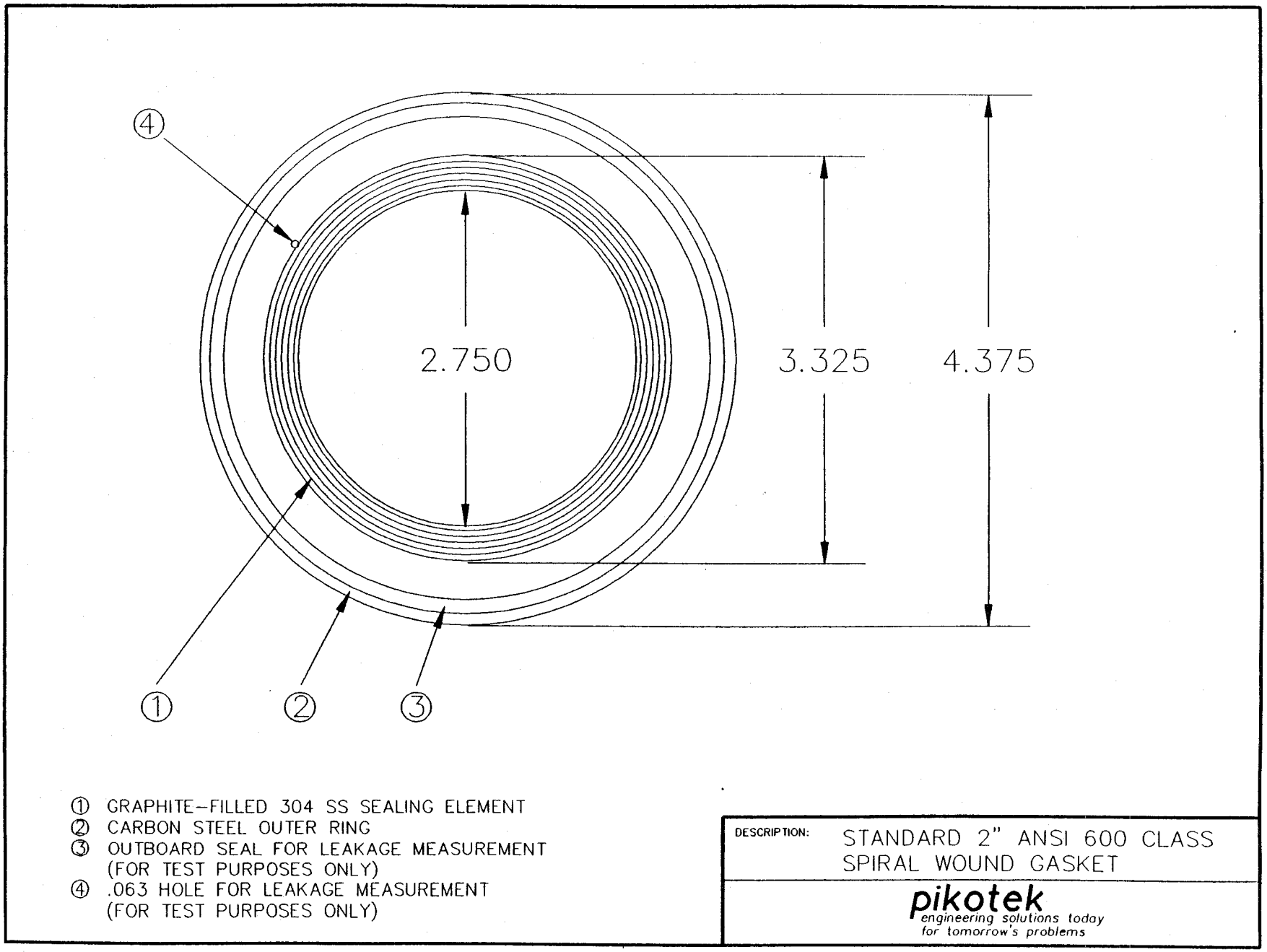
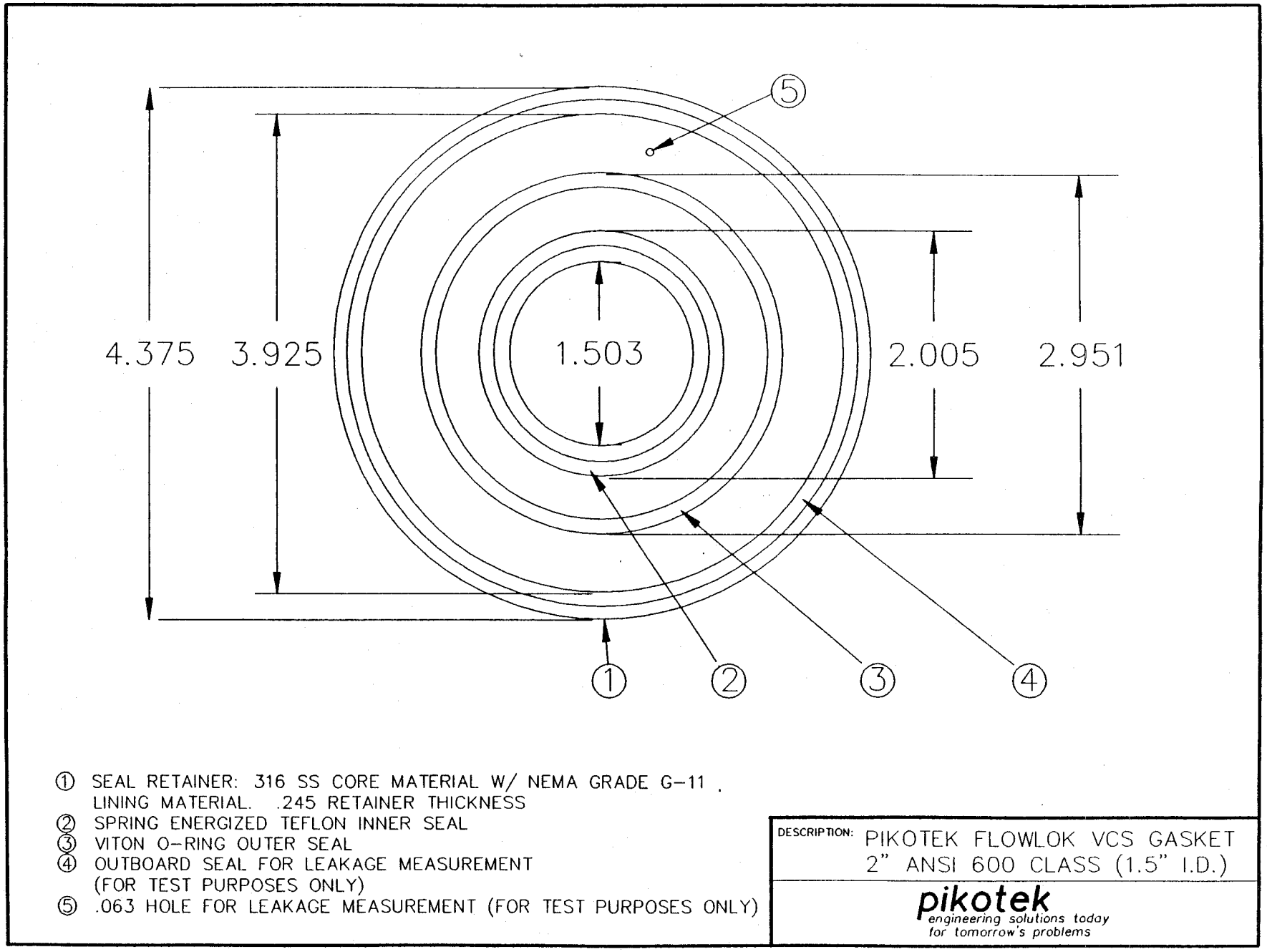


FIGURE 1
STANDARD SPIRAL WOUND GASKET



① SEAL RETAINER: 316 SS CORE MATERIAL W/ NEMA GRADE G-11 LINING MATERIAL. .245 RETAINER THICKNESS
② SPRING ENERGIZED TEFLON INNER SEAL
③ VITON O-RING OUTER SEAL
④ OUTBOARD SEAL FOR LEAKAGE MEASUREMENT (FOR TEST PURPOSES ONLY)
⑤ .063 HOLE FOR LEAKAGE MEASUREMENT (FOR TEST PURPOSES ONLY)

DESCRIPTION: PIKOTEK FLOWLOK VCS GASKET
2" ANSI 600 CLASS (1.5" I.D.)

pikotek
engineering solutions today
for tomorrow's problems

FIGURE 2
PIKOTEK FLOWLOK VCS GASKET

approximately 12,500 psi. The ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Table 2-5.1 recommends a minimum seal seating stress of 10,000 psi for spiral wound gaskets.

A nitrogen leak test was conducted at 4,000 psi. The test indicated the spiral wound gasket leaked at the lower seal seating stress levels and continued to leak until a seal seating stress of 14,744 psi (50 ft-lbs bolt torque) was applied. The Pikotek seal exhibited no detectable leakage at any seal seating stress level.

The hydrostatic pressure test was conducted to determine the internal test pressure where leakage past the flange gaskets was detected. The test flanges for the spiral wound gaskets were made up to apply a seal seating stress of 14,744 psi (50 ft-lbs bolt torque). The spiral wound gasket leaked at 6,600 psi. The Pikotek gasket used for the nitrogen leak test was re-installed and the test flanges made up to produce a seal seating stress of 12,379 psi (150 ft-lbs bolt torque). The Pikotek gasket was pressurized to 14,000 psi with no detectable leakage.

A Pikotek Firelok VCS seal underwent a fire test in compliance with API Specification 6FB, Second Edition, Part I, Non-Bending. The same test fixture used for the nitrogen leak test and the hydrostatic pressure test was used for the fire test. Results of the fire test appear in a separate report.

DESCRIPTION OF TEST SET-UP

Test fixtures were fabricated using specially prepared flanges welded to ASTM A106 double extra heavy pipe. Two sets of test flanges were prepared, one set for testing the standard seal (Figure 3) and one for testing the Pikotek seal (Figure 4). Test fixtures were fabricated for each type of gasket using specially prepared ANSI flanges. A groove and cross-drilled hole were machined into the flange face (Figure 5). This provided a means to capture any leak across the gasket and route it through a 1/8 NPT monitor port (Figure 6) on the backside of the flange. A pressure line was connected from the monitor port to a leak detector. The leak detector measured any leakage that passed the test gasket. The leak detectors were monitored visually during the tests.

Laboratory grade nitrogen, with a moisture content of less than 10 ppm, was used as the pressurization media for the nitrogen leak tests. Tap water was used as the pressurization media for the hydrostatic pressure tests.

The bolting used for the testing was in accordance with ASTM A193, Grade B7. The nuts used for the testing were in accordance with ASTM A194, Grade 2H.

Torques for flange bolt make-up were applied with a calibrated torque wrench. The calibration sheet for the torque wrench appears in Appendix B of this report.

"Never-Seez", Catalog No. NSBT-16, Anti-Seize and Lubricating Compound manufactured by Bostik Corporation, Middleton, MA 01949, was applied to all bolt threads and nut bearing faces prior to torque make-up.

The instrumentation used to measure applied test pressure was calibrated prior to the tests. The calibration sheets for the instrumentation appears in Appendix B of this report.

Test pressures were recorded in real-time on a strip chart recorder. Copies of the strip charts are included in Appendix B of this report.

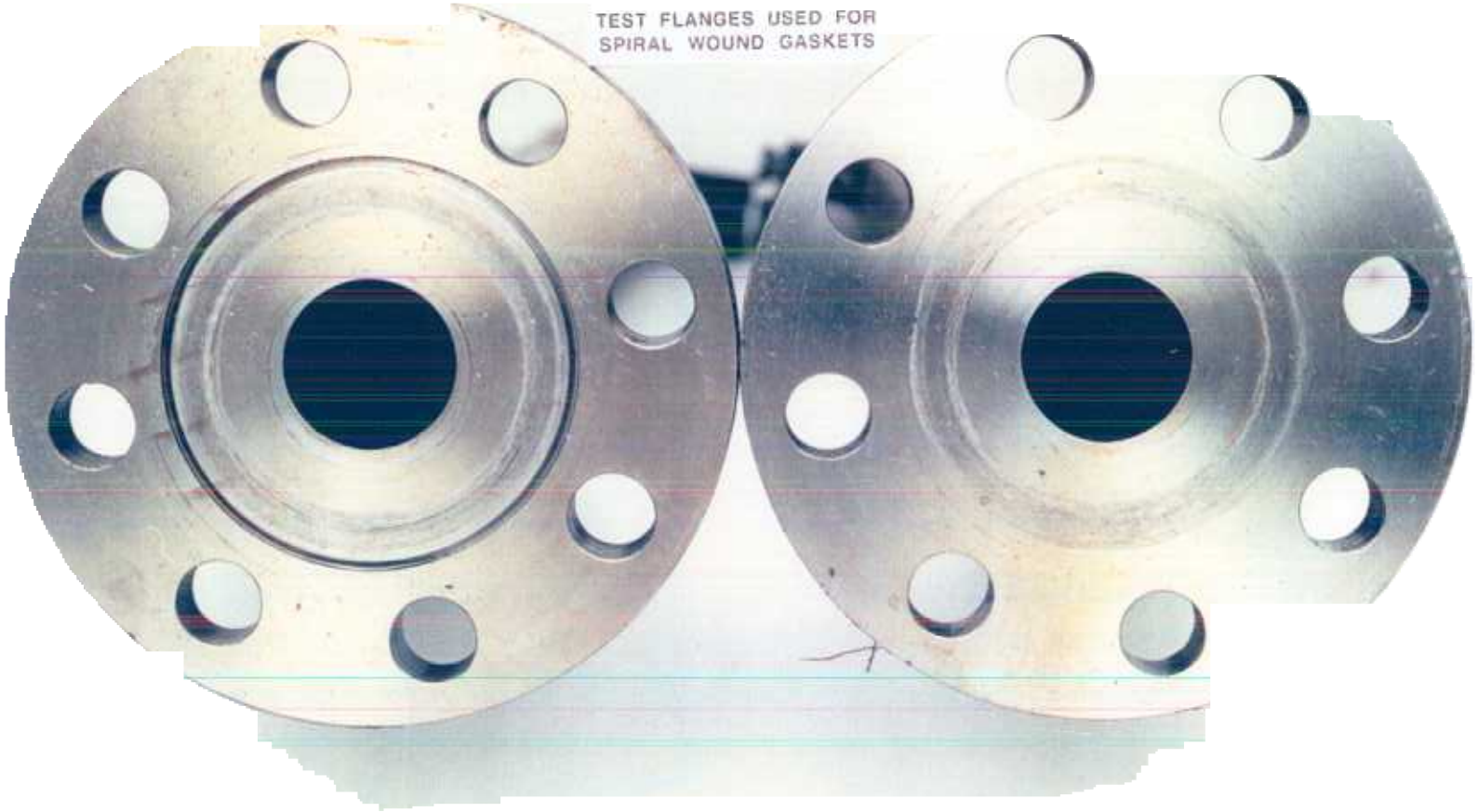


FIGURE 3
~~TEST FIXTURE FOR SPIRAL WOUND GASKETS~~

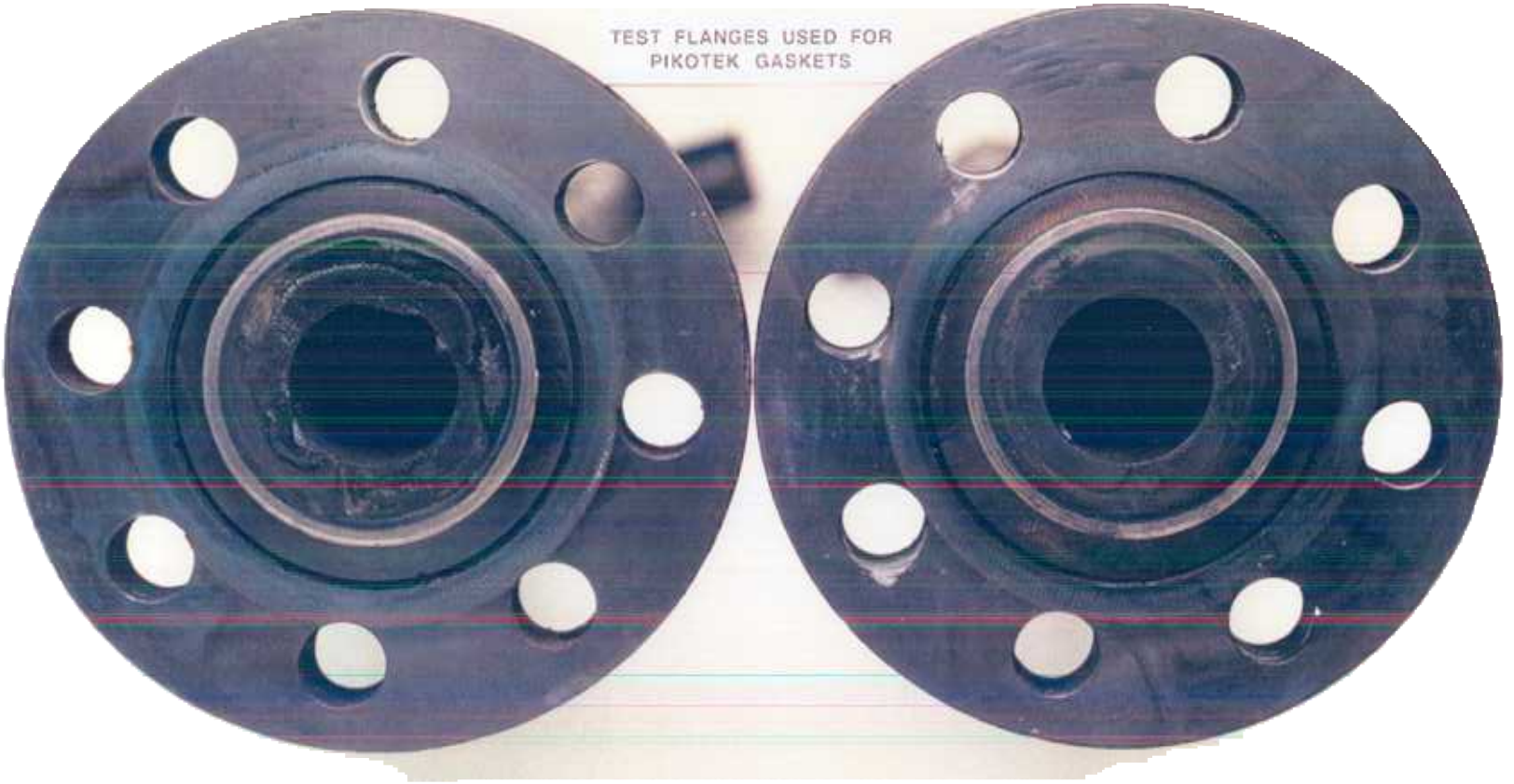


FIGURE 4
TEST FIXTURE FOR PIKOTEK GASKETS

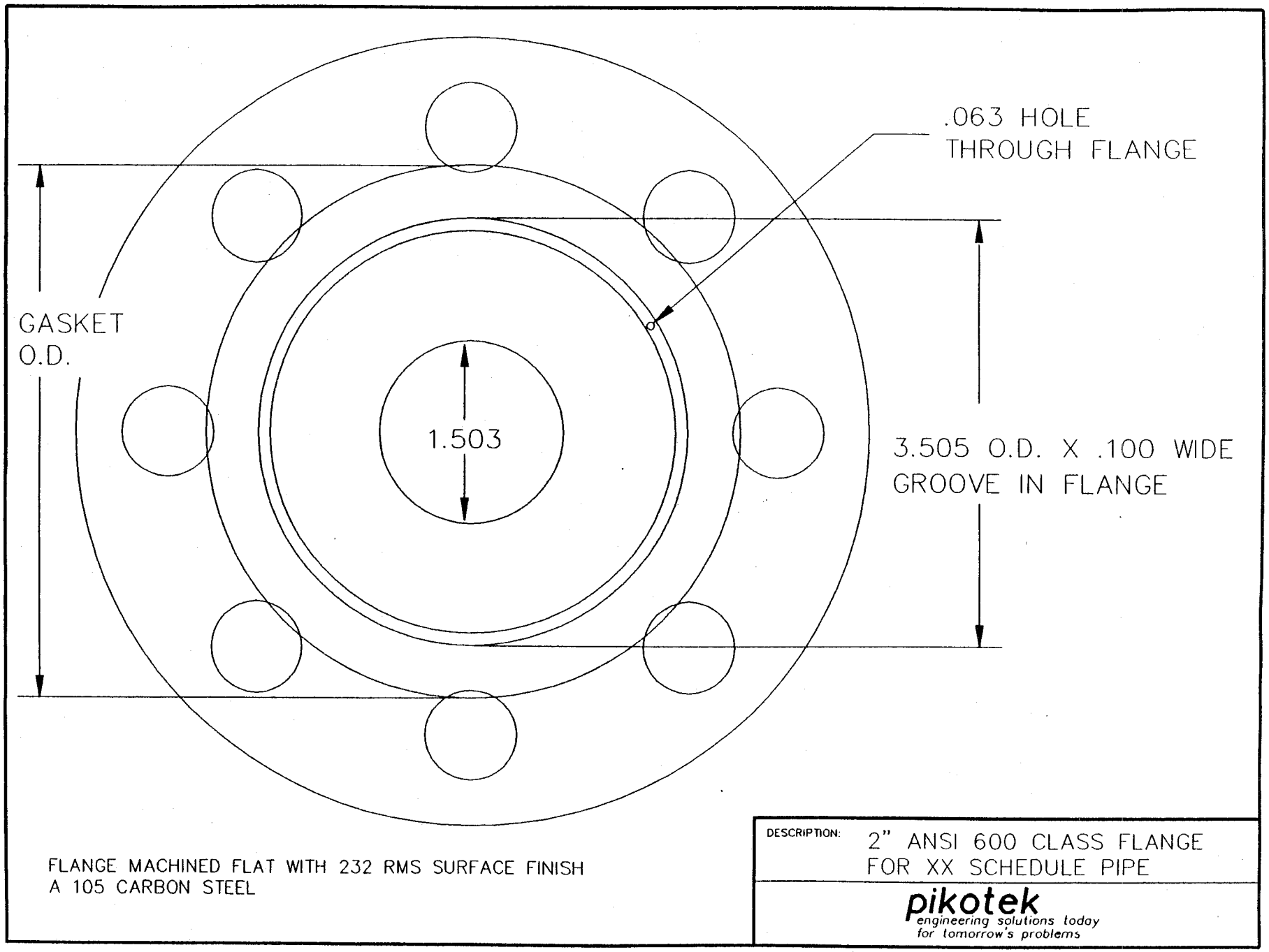


FIGURE 5
FLANGE FACE GROOVE

GUR
ONTOR PORT

GASKET SEATING PRESSURE CALCULATIONS

The gasket seating stress and bolt torque calculations appearing in Appendix C were submitted by Pikotek for incorporation into this report. The calculations were checked using the information submitted for gasket and bolt dimensions and found to be technically correct. The bolt make-up torques taken from Pikotek's calculations were used for flange make-up prior to the pressure tests.

TEST RESULTS

Nitrogen Leak Test

The test procedure appearing in Appendix A was followed for the Nitrogen Leak Test. Each test fixture was pressurized to 4,000 psi with laboratory grade nitrogen with a moisture content of less than 10 ppm. The monitor line was connected to a leak detector. The leak rate was noted at the start of the test and held for 15 minutes. The leak rate was noted at the end of the hold period.

Standard Spiral Wound Gasket

The results of the nitrogen leak test on the standard spiral wound gasket is tabulated in the following table:

BOLT TORQUE, ft-lbs	GASKET SEATING STRESS, psi	LEAK RATE, cc/min	
		INITIAL	FINAL
26	7,667	192 NOTE 1	192
34	10,026	17.66 NOTE 2	17
43	12,680	1.86	1.86
50	14,744	0	0

NOTE 1. The measured leak rate was 32 cc's in 10 seconds. The leak rate per minute was calculated.

NOTE 2. The measured leak rate was 102 cc's in 6 minutes. The leak rate per minute was calculated.

Some damage to the spiral wound gasket was noted after the Nitrogen Leak Test. Photographs of the standard spiral wound gasket after the Nitrogen Leak Test appear in Figures 7 and 8. A plot of the seating stress, bolt torque, and measured leak rates for the nitrogen leak test of the spiral wound gasket appear in Figure 9.

Pikotek Flowlok VCS Gasket

The results of the nitrogen leak test on the Pikotek gasket are tabulated in the following table:

BOLT TORQUE, ft-lbs	GASKET SEATING STRESS, psi	LEAK RATE, cc/min	
		INITIAL	FINAL
90	7,427	0	0
120	9,903	0	0
150	12,379	0	0

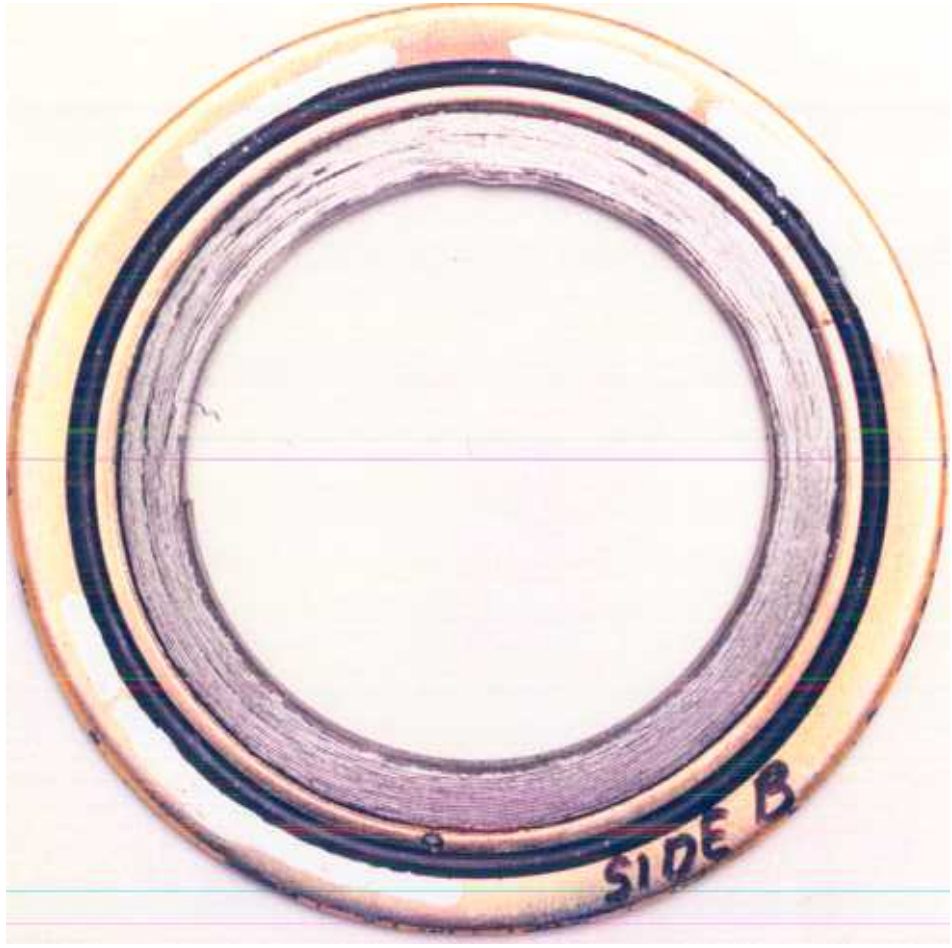
No visible damage to the Pikotek seal was noted after the Nitrogen Leak Test. Photographs of the Pikotek gasket after the Nitrogen Leak Test appear in Figures 10 and 11.

Hydrostatic Pressure Test

The test procedure appearing in Appendix A was followed for the Hydrostatic Pressure Test. The test fixture was pressurized to 4,000 psi with clear tap water and then increased in 500 psi increments. The test was terminated when a leak was detected visually at the monitor line.

SPIRAL WOUND GASKET
AFTER NITROGEN PRESSURE TEST
SIDE A

FIGURE 7



SPIRAL WOUND GASKET
AFTER NITROGEN PRESSURE TEST
SIDE B

FIGURE 8

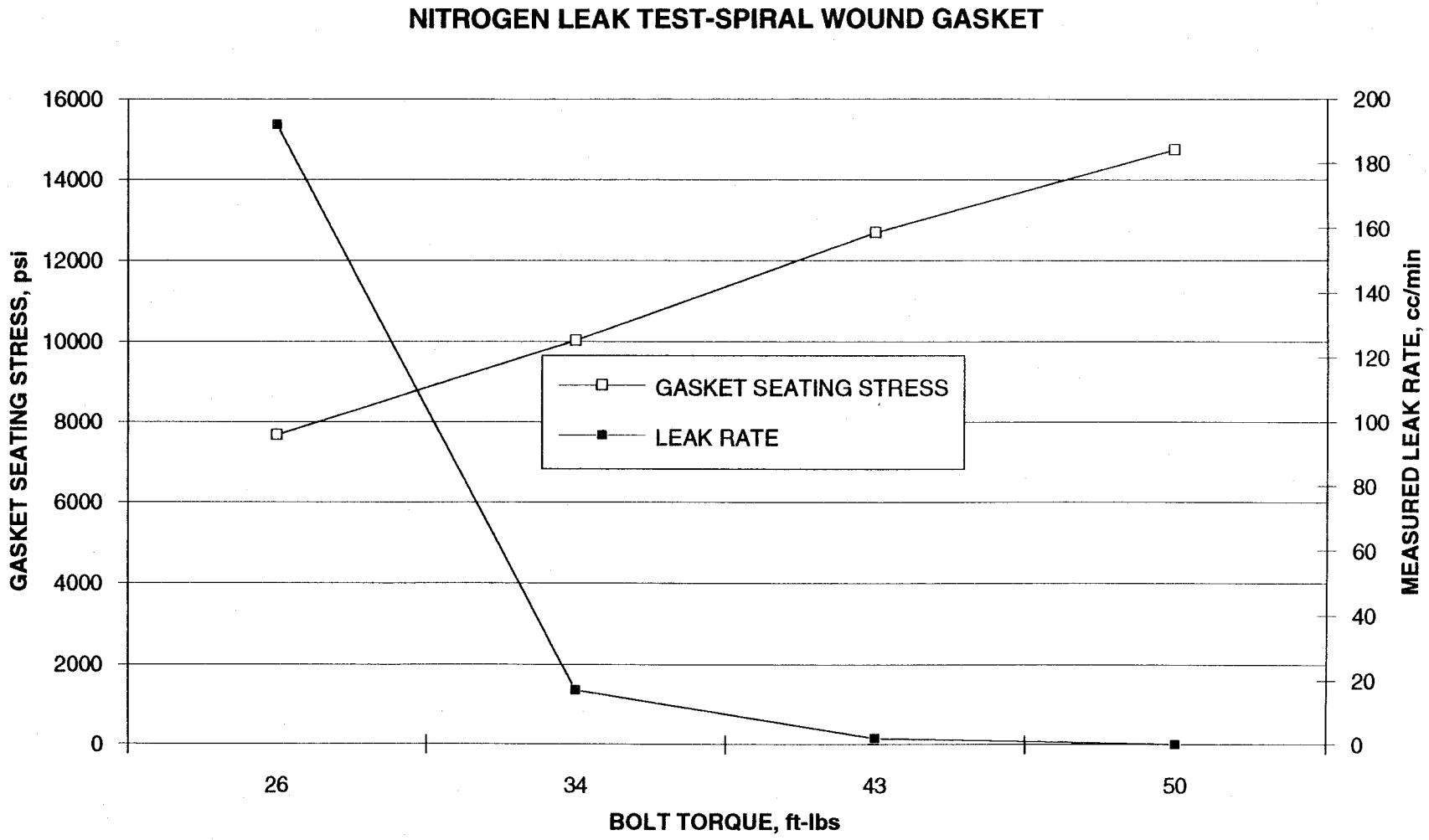


FIGURE 9
NITROGEN LEAK TEST-SPIRAL WOUND GASKET

Standard Spiral Wound Gasket

The test fixture flanges were made up to produce a seal seating stress of 14,744 psi (50 ft-lbs bolt torque). A leak was detected at 6,600 psi. Photographs of the spiral wound gasket after the hydrostatic pressure test appear in Figures 12 and 13.

Pikotek Flowlok VCS Gasket

The same gasket that underwent the Nitrogen Leak Test was re-assembled in the test fixture. The test fixture flanges were made up to produce a seal seating stress of 12,379 psi (150 ft-lbs bolt torque). The gasket was pressurized to 8,500 psi with no leaks detected. The hydrostatic test pump developed a leak and would not exceed 8,500 psi. A higher rated pressure test pump and a pressure transducer were installed. The test fixture was re-pressurized to 8,000 psi. The hydrostatic pressure was increased in 500 psi increments to 14,000 psi with no leaks detected.

Photographs of the the Pikotek gasket after the hydrostatic pressure test and nitrogen leak test, appear in Figures 10 and 11.

Fire Test

Results of the fire test appear in a separate report.

CONCLUSIONS

Nitrogen Leak Test

Standard Spiral Wound Gasket

A Nitrogen Leak Test of a new standard spiral wound gasket was conducted at an internal test pressure of 4,000 psi. The Standard Spiral Wound Gasket leaked until a seal seating stress of between 12,680 psi (43 ft-lbs bolt torque) and 14,744 psi (50 ft-lbs bolt torque) was applied. The leak rate decreased approximately by a factor of ten between 7,667 psi (26 ft-lbs bolt torque) and 10,026 psi seal seating stress (34 ft-lbs bolt torque). The leak rate and decreased again by a factor of ten between a

seating stress of 10,026 psi and 12,680 (43 ft-lbs bolt torque). A plot of the seating stress, bolt torque, and measured leak rates for the nitrogen leak test of the spiral wound gasket appear in Figure 9. Some damage to the sealing element occurred as a result of the test. Photos of the spiral wound gasket appear in Figures 7 and 8.

Pikotek Flowlok VCS Gasket

A Nitrogen Leak Test of a new Pikotek Flowlok VCS gasket was conducted at an internal test pressure of 4,000 psi. Three levels of seal seating stress were applied ranging from 7,427 psi (90 ft-lbs bolt torque) to 12,379 psi (150 ft-lbs bolt torque). No leaks were detected at any level of seal seating stress. No damage to the sealing element was noted after the test. Photos of the Pikotek gasket appear in Figures 10 and 11.

Hydrostatic Pressure Test

Standard Spiral Wound Gasket

A hydrostatic pressure test of a new standard spiral wound gasket was conducted. The internal pressure was increased incrementally from 4,000 psi. A leak was detected at 6,600 psi. Significant damage to the sealing element occurred as a result of the test. Photos of the spiral wound gasket appear in Figures 12 and 13.

Pikotek Flowlok VCS Gasket

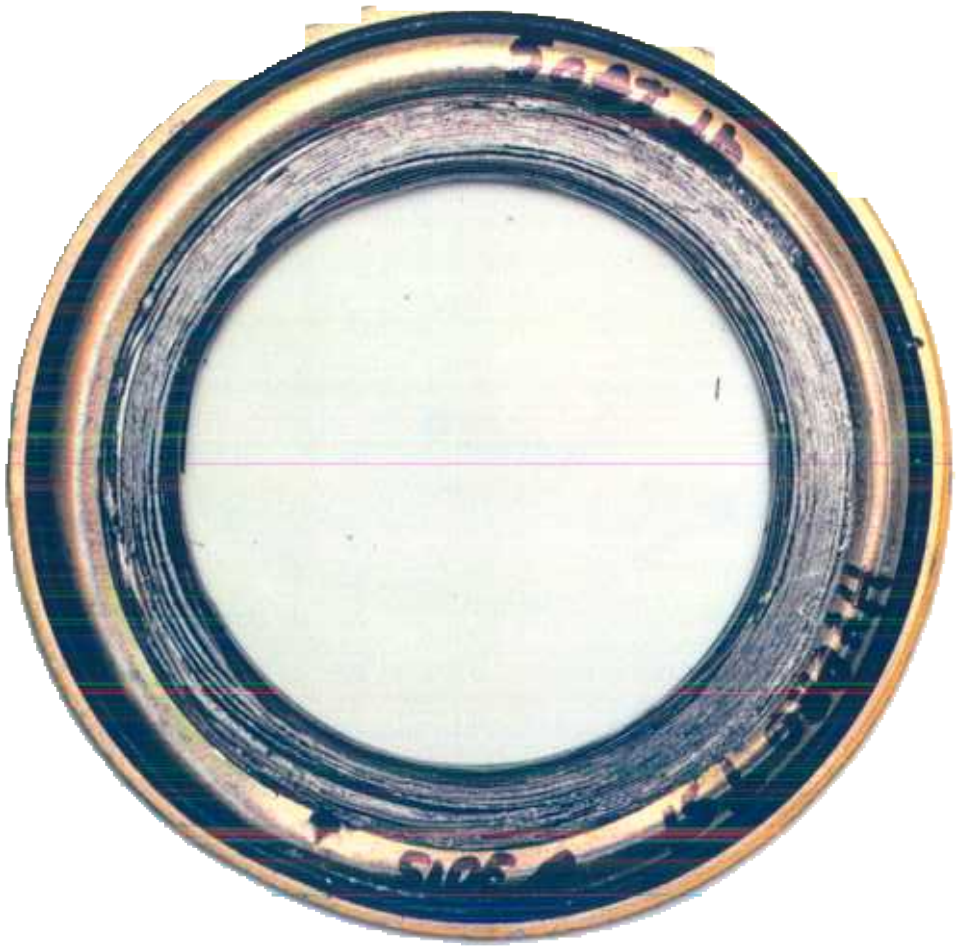
A hydrostatic pressure test was conducted on the same gasket that underwent the nitrogen leak test. The internal pressure was increased incrementally from 4,000 psi to 14,000 psi. No leaks were detected. No damage to the sealing element was noted as a result of the test. Photos of the Pikotek gasket appear in Figures 10 and 11.

PIKOTEK FLOWLOK VCS GASKET
AFTER NITROGEN & HYDROSTATIC PRESSURE TESTS
SIDE A

FIGURE 10

PIKOTEK FLOWLOK VCS GASKET
AFTER NITROGEN & HYDROSTATIC PRESSURE TESTS
SIDE B

FIGURE 11



SPIRAL WOUND GASKET
AFTER HYDROSTATIC PRESSURE TEST
SIDE A

FIGURE 12

SPIRAL WOUND GASKET
AFTER HYDROSTATIC PRESSURE TEST
SIDE B

FIGURE 13

APPENDIX A

TEST PROCEDURE

TEST PROCEDURE
FOR
TESTING OF FLANGE GASKETS
FOR ANSI B16.5 FLANGES

SETUP AND CHECKOUT

1. Calibrate a 10,000 psi transducer and strip chart. Fill out a calibration sheet for all equipment calibrated.

2. Install a new standard spiral wound gasket in test fixture.

3. Connect the test flanges to the nitrogen pressure source.

4. Connect the monitor port to the leak detectors.

5. Pressurize the test fixture to 4,000 psi nitrogen pressure.

6. Perform a bubble leak check on all valves and fittings. Correct any leaks as necessary.

NITROGEN LEAK TEST

STANDARD SPIRAL WOUND GASKET

1. Assemble test fixture with a standard spiral wound gasket. Make up bolts hand tight making sure the gasket is seated against the flange faces evenly.

2. Torque the bolts evenly to 26 ft-lbs. Install the sample in the blast chamber. Pressurize the sample to 4,000 psi nitrogen pressure. Record the initial leak rate. Hold the pressure for 15 minutes. Note the leak rate. Bleed the pressure to zero.

3 Remove the sample from the blast chamber. Increase the bolt torque to 34 ft-lbs. Re-install the sample in the blast chamber. Re-pressurize the sample to 4,000 psi. Record the initial leak rate. Hold the pressure for 15 minutes. Note the leak rate. Bleed the pressure to zero.

4. Repeat step 3 for bolt torques of 43 and 50 ft-lbs.

PIKOTEK GASKET

1. Assemble test fixture using a Pikotek gasket. Make up bolts hand tight making sure the gasket is seated against the flange faces evenly.

2. Torque the bolts evenly to 90 ft-lbs. Install the sample in the blast chamber. Pressurize the sample to 4,000 psi nitrogen pressure. Record the initial leak rate. Hold the pressure for 15 minutes. Note the leak rate. Bleed the pressure to zero.

3 Remove the sample from the blast chamber. Increase the bolt torque to 120 ft-lbs. Re-install the sample in the blast chamber. Re-pressurize the sample to 4,000 psi. Record the initial leak rate. Hold the pressure for 15 minutes. Note the leak rate. Bleed the pressure to zero.

4. Repeat step 4 for a bolt torque of 150 ft-lbs.

HYDROSTATIC PRESSURE TEST

STANDARD SPIRAL WOUND GASKET

1. Install a new standard spiral wound gasket in test fixture for spiral wound gaskets. Torque the bolts evenly to 50 ft-lbs.

2. Fill test fixture and monitor line with water. Connect the pressure and monitor line to the test flanges and install the sample in the blast chamber.

3. Pressurize the sample to 4,000 psi.

4. Monitor the leak port line continuously.

5. Increase the pressure in 500 psi increments to 12,000 psi while checking the monitor line at each increment. Discontinue the test if a leak is detected at the monitor line.

6. Complete "Hydrostatic Test Report", SwRI Form 06QC5HR.

PIKOTEK GASKET

1. Install the Pikotek gasket used for the nitrogen leak test in test fixture for Pikotek gaskets. Torque the bolts evenly to 150 ft-lbs.

2. Fill test fixture and monitor line with water. Connect the pressure and monitor line to the test flanges and install the sample in the blast chamber.

3. Pressurize the sample to 4,000 psi.

4. Monitor the leak port line continuously.

5. Increase the pressure in 500 psi increments to 14,000 psi while checking the monitor line at each increment. Discontinue the test if a leak is detected at the monitor line.

6. Complete "Hydrostatic Test Report", SwRI Form 06QC5HR.

APPENDIX B

CALIBRATION SHEETS

HYDROSTATIC TEST REPORTS

STRIP CHARTS

S O U T H W E S T R E S E A R C H I N S T I T U T E

Department of Quality Assurance
Calibration Laboratory

CERTIFICATE OF CALIBRATION

Issued to: DIV06 B81 MARK MERCER Device No: 1807

Manufacturer: SNAP-ON Model: TE 250-FU

Nomenclature: TORQUE WRENCH

Serial Number: 9522 SwRI No: NONE Cal interval 6 Mo.

Remarks

Accuracy: +/-4% F.S. Procedure: MFGR

ENVIRONMENT

Temperature: 75 Humidity: 35 Location: ROOM A11 B68 SWRI

CONCLUSION

Tolerance/Remarks: Received in tolerance, no adjustments made

"LIMITED CALIBRATION"
CLOCKWISE ONLY (0 - 150ft.LB.)

STANDARD READING:	UNIT UNDER TEST:
150 ft.lbs.	150.9 ft.lbs.
120 ft.lbs.	120.4 ft.lbs.
90 ft.lbs.	90.7 ft.lbs.
60 ft.lbs.	60.3 ft.lbs.
30 ft.lbs.	29.3 ft.lbs.

Calibration was in accord with requirements of MIL-STD-45662A. Measurements are traceable to the National Institute of Standards and Technology. Inspection and test data are on file and available for inspection.

Signed Jerry L. Laybourn

Calibration Date: 03/08/93

Cal interval: 6 Months

Record Number: 00010864 Next Calibration Due: 09/08/93

S O U T H W E S T R E S E A R C H I N S T I T U T E

Department of Quality Assurance
Calibration Laboratory

Device Serial No: 9522 Calibration Date: 03/08/93

STANDARDS

Standard No: 1825 Manufacturer: STURTEVANT/RICHM Model: DIGITAL SYS 2
Nomenclature: TORQUE WRENCH ANALYZER
Serial No: 5003 Cal.Due: 10/06/93 Cal.Rec.No: 00009711

PRESSURE GAGE CERTIFICATION

Southwest Research Institute

Structural Research and Ocean Engineering Division

Model # G831-300-30m
Gage No. S/N 404756 Date 8-17-93

Dead Weight Tester Serial No. S/N 837 1009 / ASHCROFT

GAGE READING	DEAD WEIGHT	GAGE READING	DEAD WEIGHT
0	0		
2004	2000		
4001	4000		
6002	6000		
7998	8000		
10,004	10,000		

REMARKS:

Hardy Instrument Indicator
Model # 0582-5340-42
S/N # 75090-00

Certification Performed By Jane A. Williams

PRESSURE GAGE CERTIFICATION

Southwest Research Institute

Structural Research and Ocean Engineering Division

Gage No. PT/GM Cooke Date 9/13/93

Dead Weight Tester Serial No. 93

GAGE READING	DEAD WEIGHT	GAGE READING	DEAD WEIGHT
0	0		
10003	10000		
0	0		
1002	1000		
2001	2000		
3001	3000		
4002	4000		
5001	5000		
6000	6000		

REMARKS:

SENSOTEC Mod.# 60-3147-02 SER.# 87658

"Dynisco" SER.# 472100 0-10K X-ducer

Mod.# G-831-300-10M

Certification Performed By [signature]

HYDROSTATIC TEST REPORT

PROJECT NO. 06-5227-550 SPONSOR PIKOTEK

CONTRACT No. N/A

ITEM PIKOTEK FLO LOC VCS

DATE OF TEST 8/13/93 OPERATOR Joe P. Canelli

TEST PARAMETERS

DESIGN PRESSURE 2150 TEST PRESSURE 4000

TEST DURATION 15 MIN TIME AT TEST PRESSURE 15 MIN

INSTRUMENTATION CALIBRATION RECORD

PRESSURE TRANSDUCER No 983-300-10M DATE OF CALIBRATION 8/13/93

PRESSURE INDICATOR No 60-3147-02 DATE OF CALIBRATION 8/13/93

OTHER INSTRUMENTATION TE 250 FU TORQUE WRENCH DATE OF CALIBRATION 3/8/93

OTHER INSTRUMENTATION _____ DATE OF CALIBRATION _____

TEST DESCRIPTION

PRESSURE TO 4000 W/ N_2, HOLD FOR 15 min AT 90, 120, 150 FT-LB BOLT TORQUE, MONITOR LEAK AT START & END OF HOLD PERIOD

TEST RESULTS

90 FT-LB NO LEAK

120 FT-LB "

150 FT-LB "

COMMENTS _____

QC SUPERVISOR J. A. Bradley DATE 8/13/93

AUTHORIZED INSPECTOR _____ DATE _____

FORM NO SwRI 06QC5HR REV 6/3/91

HYDROSTATIC TEST REPORT

PROJECT NO. 06-5227-550 SPONSOR PIKOTEK

CONTRACT No. N/A

ITEM STD ϕ SPIRAL WOUND FLANGE GASKET

DATE OF TEST 8/13/93 OPERATOR Joe P. Cavellis

TEST PARAMETERS

DESIGN PRESSURE 2150 TEST PRESSURE ~~N/A~~ 4000

TEST DURATION 15 MIN TIME AT TEST PRESSURE 15 MIN

INSTRUMENTATION CALIBRATION RECORD

PRESSURE TRANSDUCER No G-831-300-10 MS DATE OF CALIBRATION 8/13/93

PRESSURE INDICATOR No 60-3147-02 DATE OF CALIBRATION 8/13/93

OTHER INSTRUMENTATION TORQUE WRENCH TE-250-FH DATE OF CALIBRATION 3/8/93

OTHER INSTRUMENTATION _____ DATE OF CALIBRATION _____

TEST DESCRIPTION

PRESSURE TO 4000 W/ N_2, HOLD FOR 15 MIN AT 26, 34, 43 FT-Lb BOLT TORQUE, MONITOR LEAK RATE AT START & END OF HOLD PERIOD

TEST RESULTS

26 FT-Lb – 32cc in 10SEC

34 FT-Lb – 102cc in 6 min

43 FT-Lb – 28 cc in 15 min

50 FT-Lb – ϕ LEAK

COMMENTS _____

QC SUPERVISOR Ja Bradley DATE 8/13/93

AUTHORIZED INSPECTOR _____ DATE _____

FORM NO SwRI 06QC5HR REV 6/3/91

HYDROSTATIC TEST REPORT

PROJECT NO. 06-5227-550 SPONSOR PIKOTEK

CONTRACT No. N/A

ITEM PIKOTEK PROLOK VCS FLANGE GASKET

DATE OF TEST 8/16/93 OPERATOR Joe P. Canelli

TEST PARAMETERS

DESIGN PRESSURE 2150 TEST PRESSURE ULTIMATE

TEST DURATION N/A TIME AT TEST PRESSURE N/A

INSTRUMENTATION CALIBRATION RECORD

PRESSURE TRANSDUCER No G-831-300-10M DATE OF CALIBRATION 8/13/93

PRESSURE INDICATOR No 60-3147-02 DATE OF CALIBRATION 8/13/93

OTHER INSTRUMENTATION TE 250-FU TORQUE WRENCH DATE OF CALIBRATION 3/8/93

OTHER INSTRUMENTATION _____ DATE OF CALIBRATION _____

TEST DESCRIPTION

PRESSURE TO 4000. INCREASE BY 500 PSI TO LEAK DETECTED

TEST RESULTS

PRESSURED TO 8,500 PSI PUMP LEAKING NEW PUMP & TRANSDUCER REQ'D

COMMENTS _____

QC SUPERVISOR Ja Bradley DATE 8/16/93

AUTHORIZED INSPECTOR _____ DATE _____

FORM NO SwRI O6QC5HR REV 6/3/91

HYDROSTATIC TEST REPORT

PROJECT NO. 06-5227-550 SPONSOR PIKOTEK

CONTRACT No. N/A

ITEM PIKOTEK FLOLOK UCS FLANGE GASKET

DATE OF TEST 8-17-93 OPERATOR Joe P. Canelles

TEST PARAMETERS

DESIGN PRESSURE 2150 TEST PRESSURE ULTIMATE

TEST DURATION N/A TIME AT TEST PRESSURE N/A

INSTRUMENTATION CALIBRATION RECORD

PRESSURE TRANSDUCER No G831-300-30M DATE OF CALIBRATION 8/17/93

PRESSURE INDICATOR No 0582-5340-42 DATE OF CALIBRATION 8/17/93

OTHER INSTRUMENTATION TE 250 FU TORQUE WRENCH DATE OF CALIBRATION 3/8/93

OTHER INSTRUMENTATION _____ DATE OF CALIBRATION _____

TEST DESCRIPTION

PRESSURE TO 8000 INCREASE BY 500 PSI TO LEAK DETECTED

TEST RESULTS

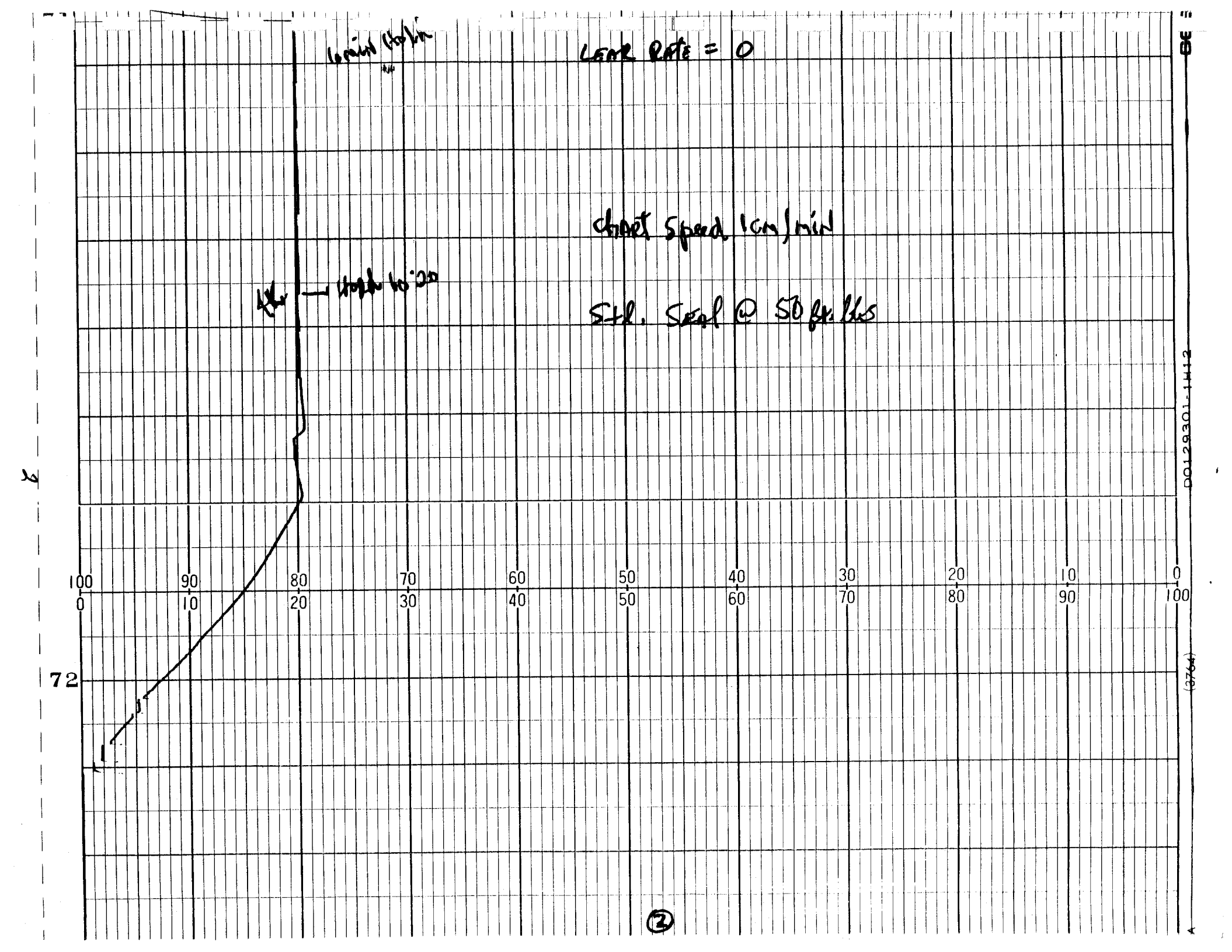
PRESSURED TO 14,000, NO LEAK DETECTED

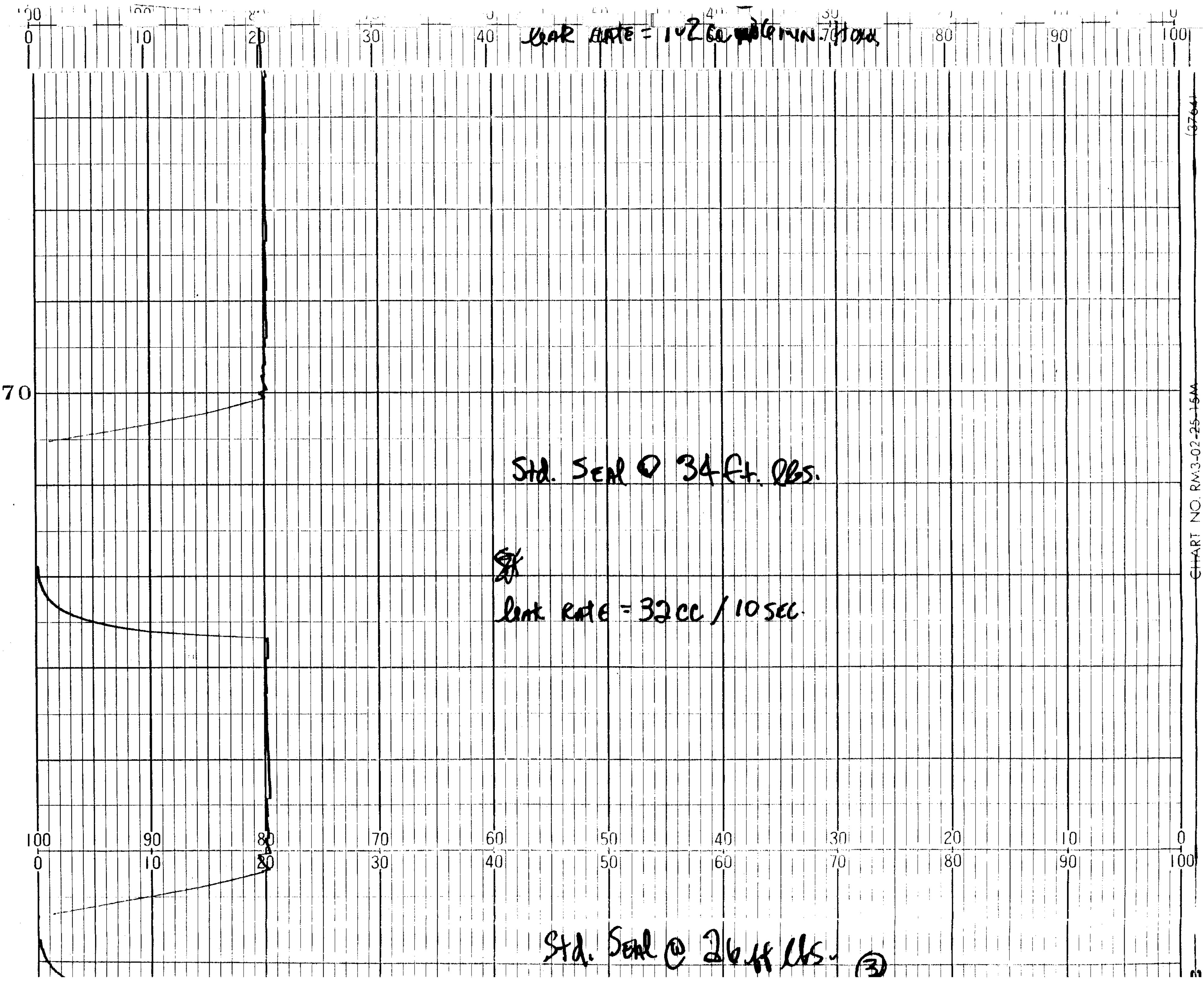
COMMENTS _____

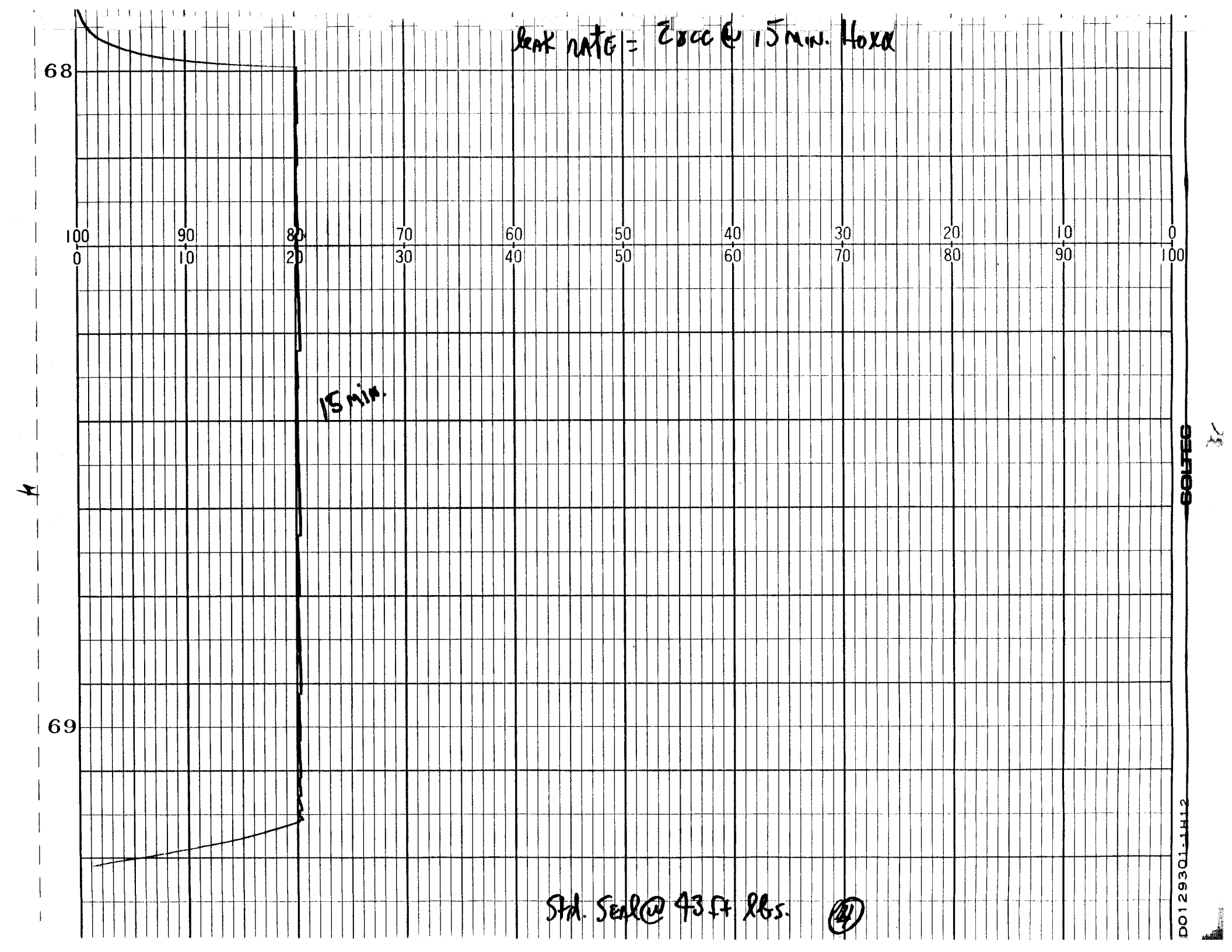
QC SUPERVISOR J.A. Bradley DATE 8/17/93

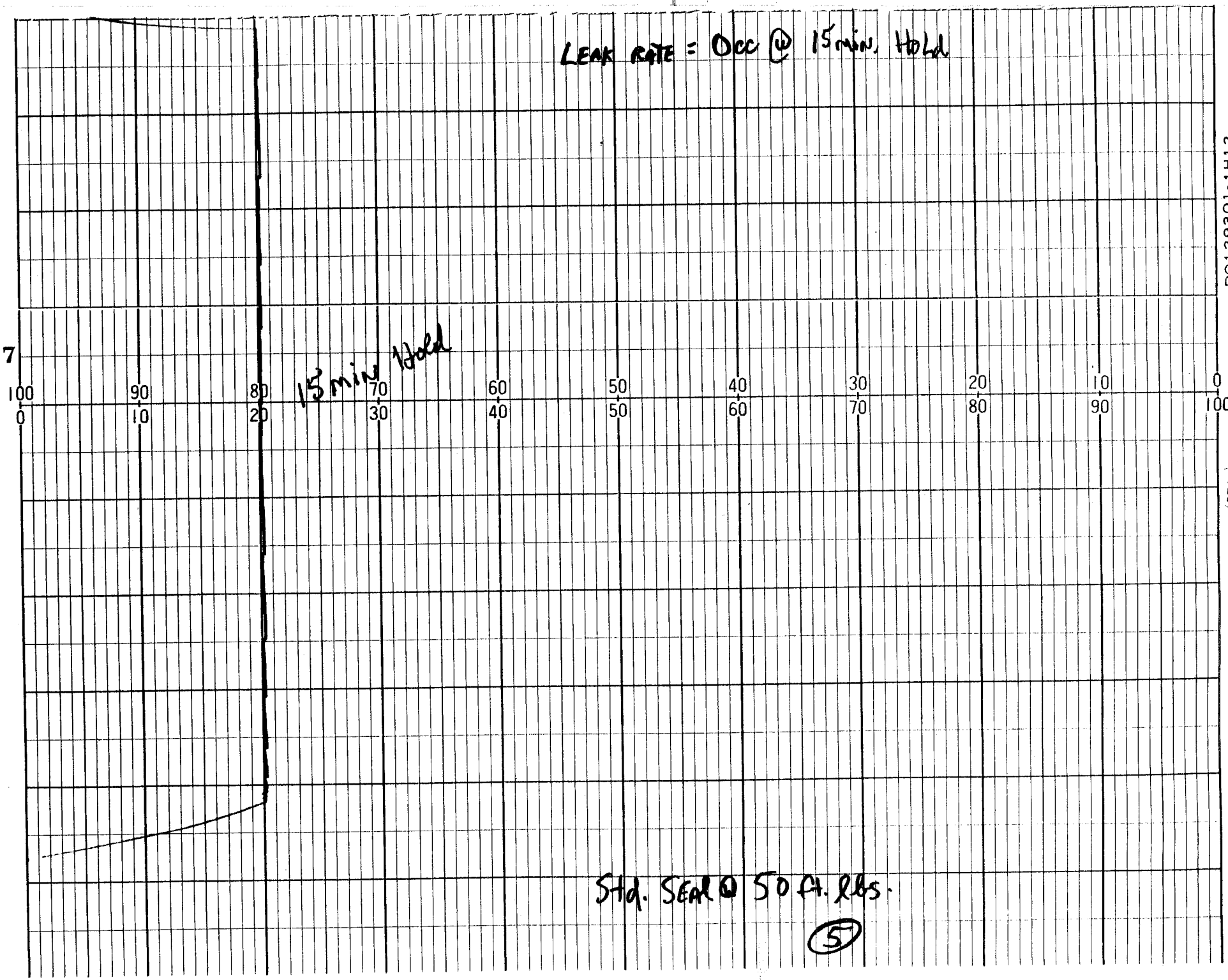
AUTHORIZED INSPECTOR _____ DATE _____

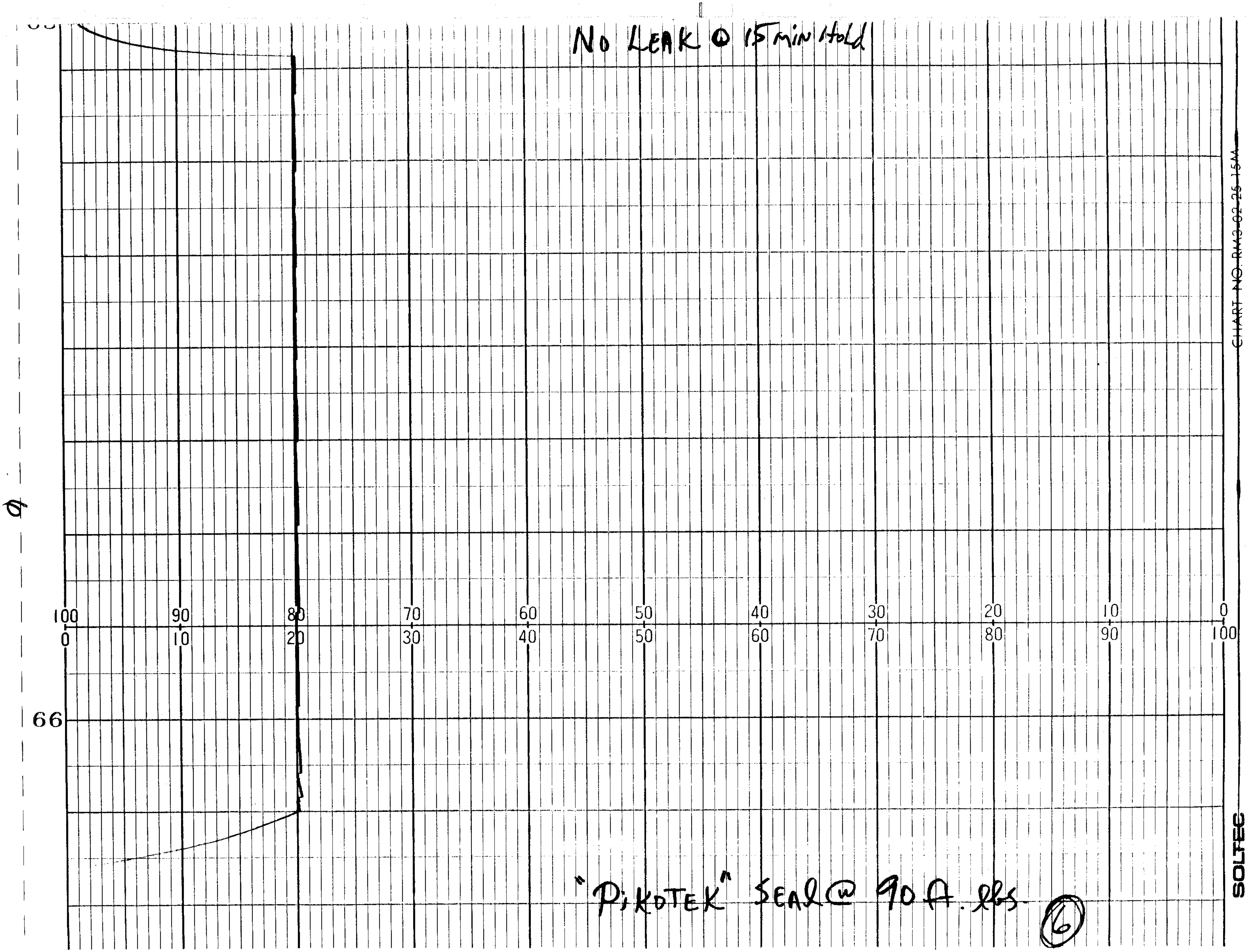
FORM NO SwRI 06QC5HR REV 6/3/91

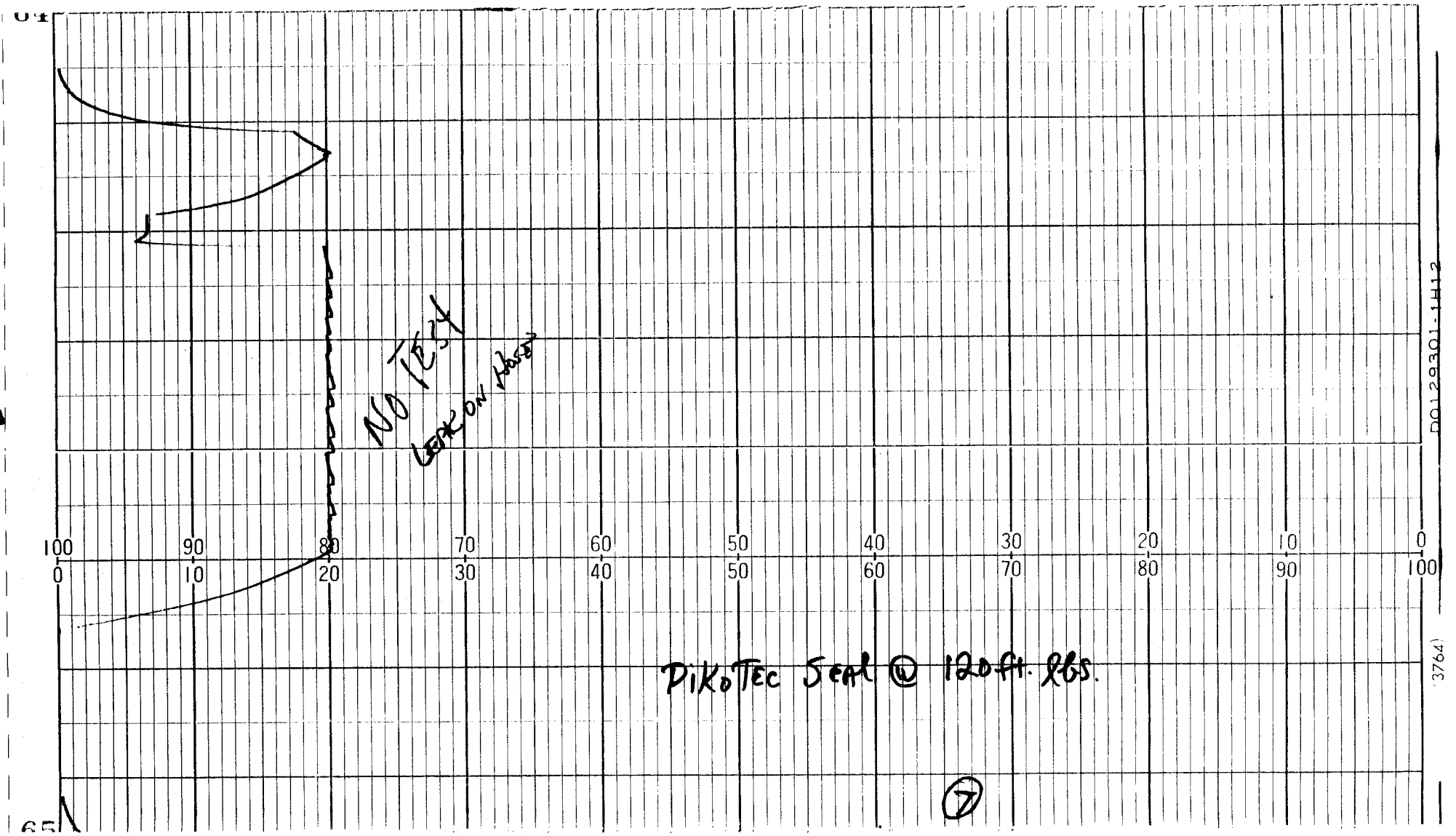

LEAK RATE = 0
Chart Speed 1cm/min
Stl. Seal @ 50 ft. lbs
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
72
DO129301-1H12
(3764)

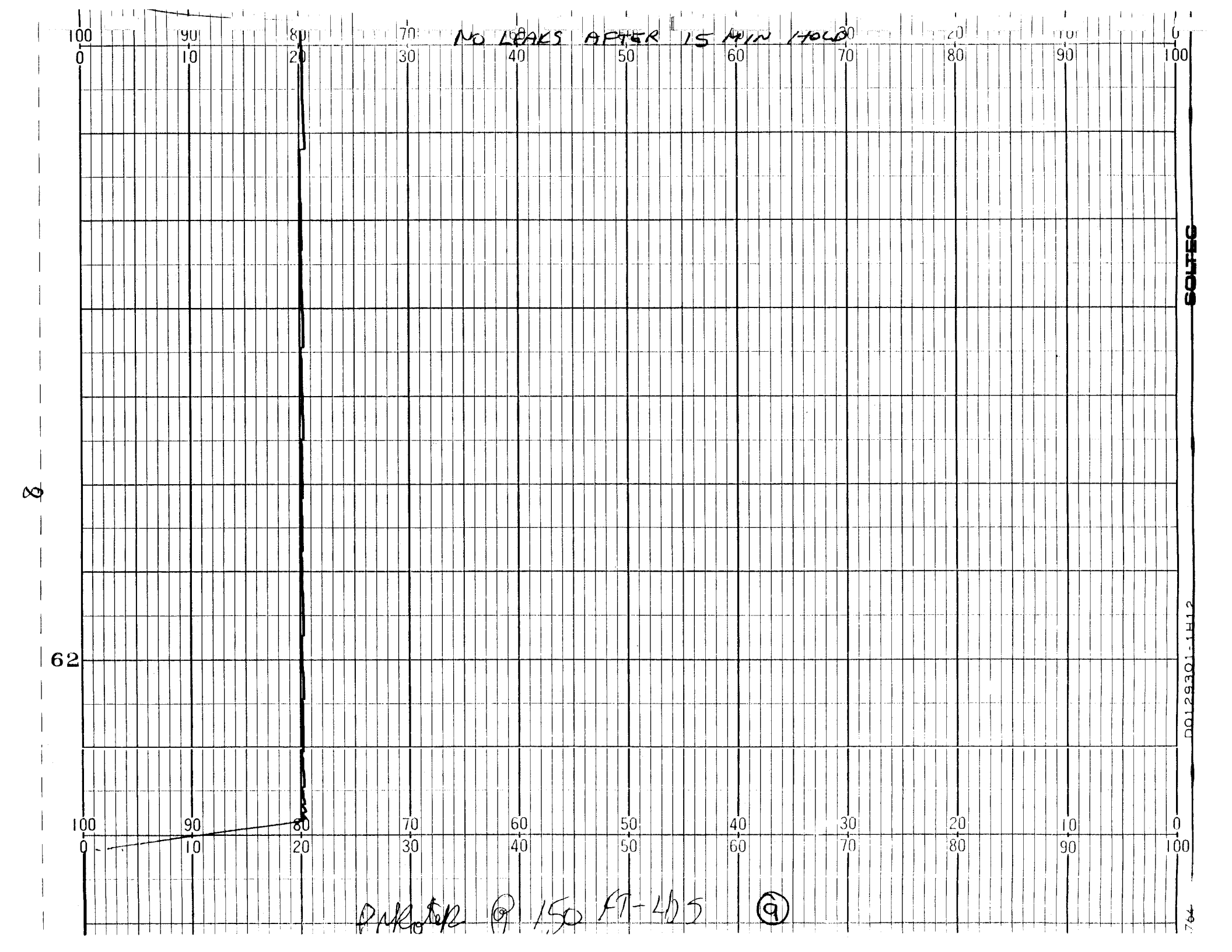

Std. Seal @ 34 ft. lbs.
Leak Rate = 32 cc / 10 sec.
Std. Seal @ 26 ft lbs.
CHART NO. RM3-02-25-15M
(3764)
70

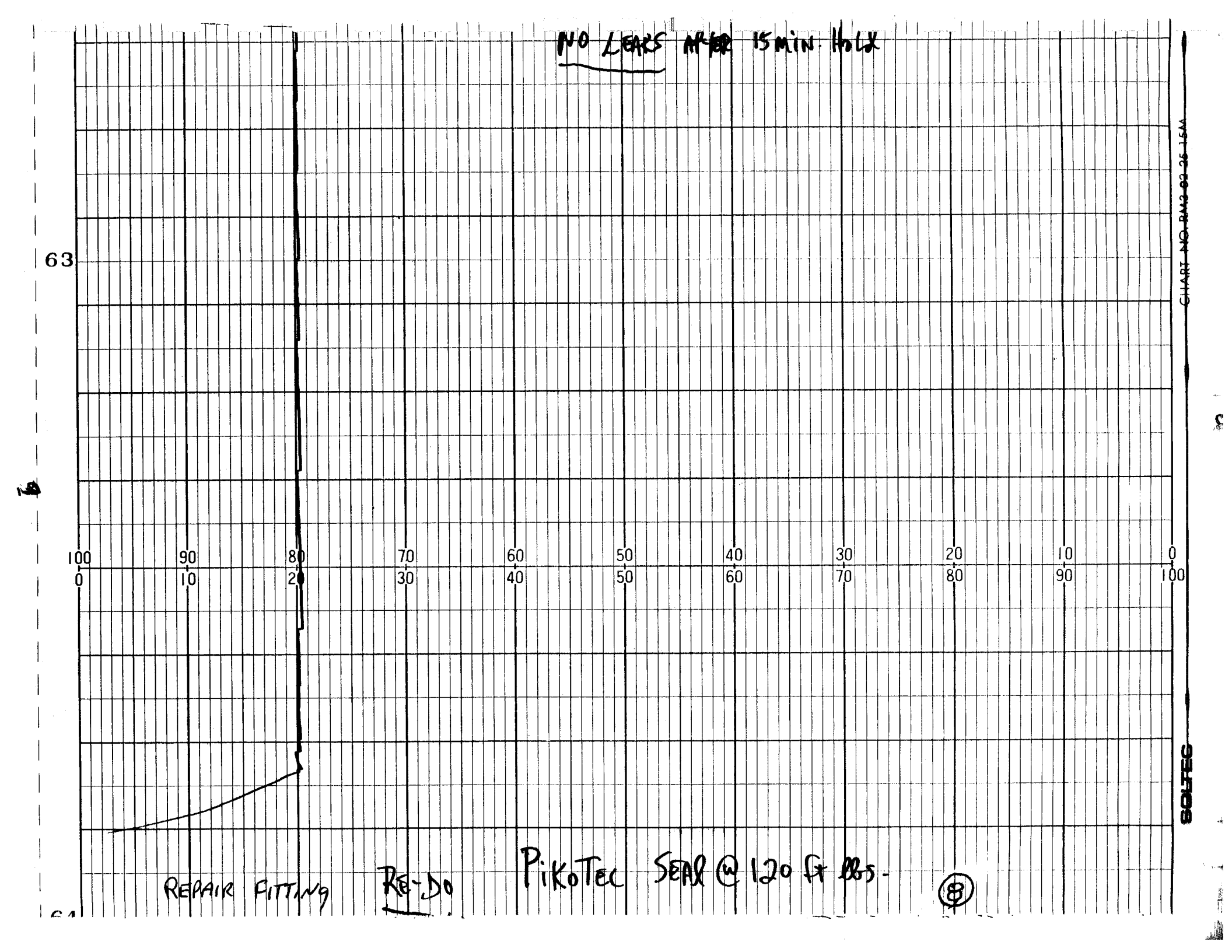

leak rate = 2 scc @ 15 min. Hoxa
68
100 0
90 10
80 20
70 30
60 40
50 50
40 60
30 70
20 80
10 90
0 100
15 min.
69
Std. Seal @ 43 ft lbs.
(4)
SERIES
D0129301-1H12

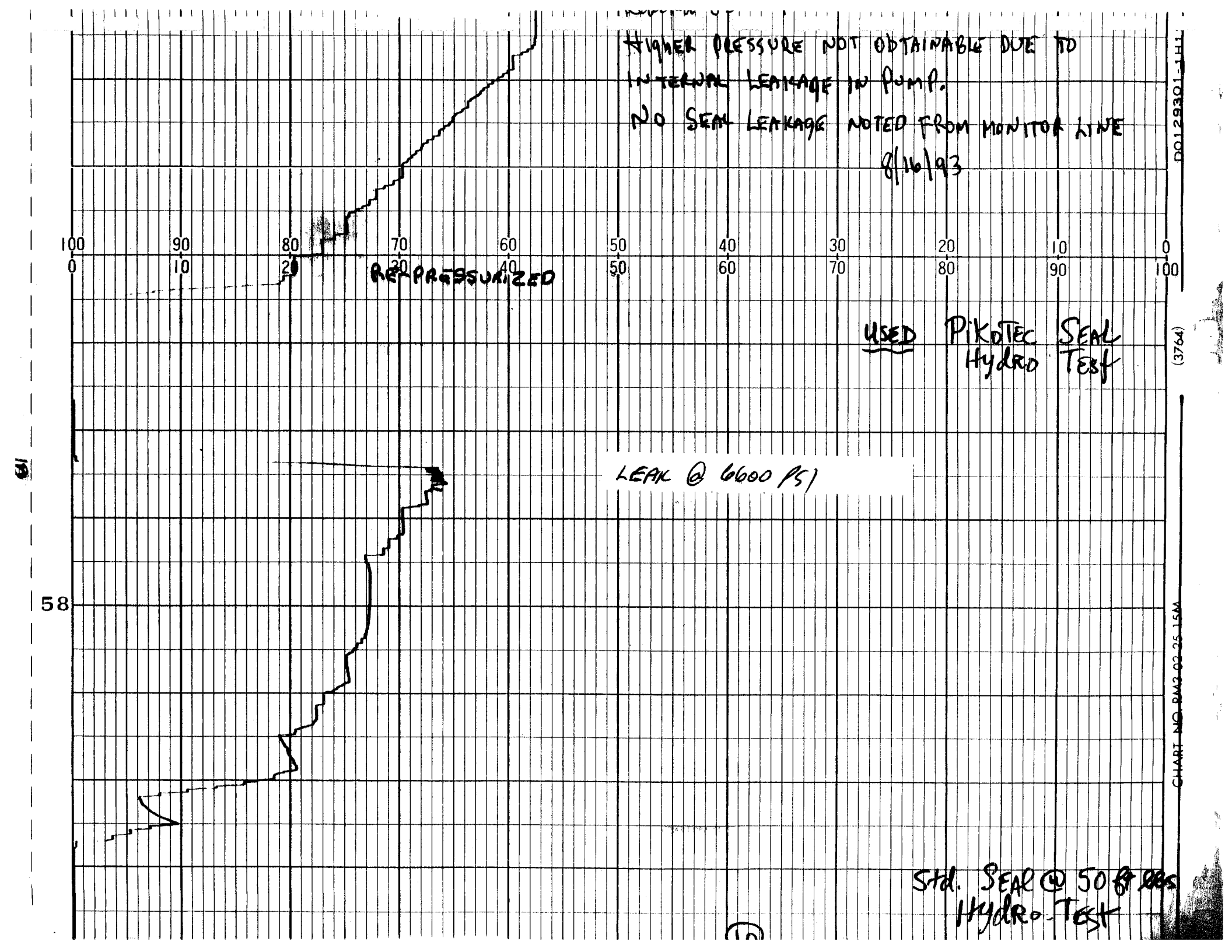

LEAK RATE = 0cc @ 15min. Hold
67
15 min Hold
100 0
90 10
80 20
70 30
60 40
50 50
40 60
30 70
20 80
10 90
0 100
Std. SEAL @ 50 ft. lbs.
(5)
CHART NO. RM3-02-25-15M
(3764)
PD129301-1H12

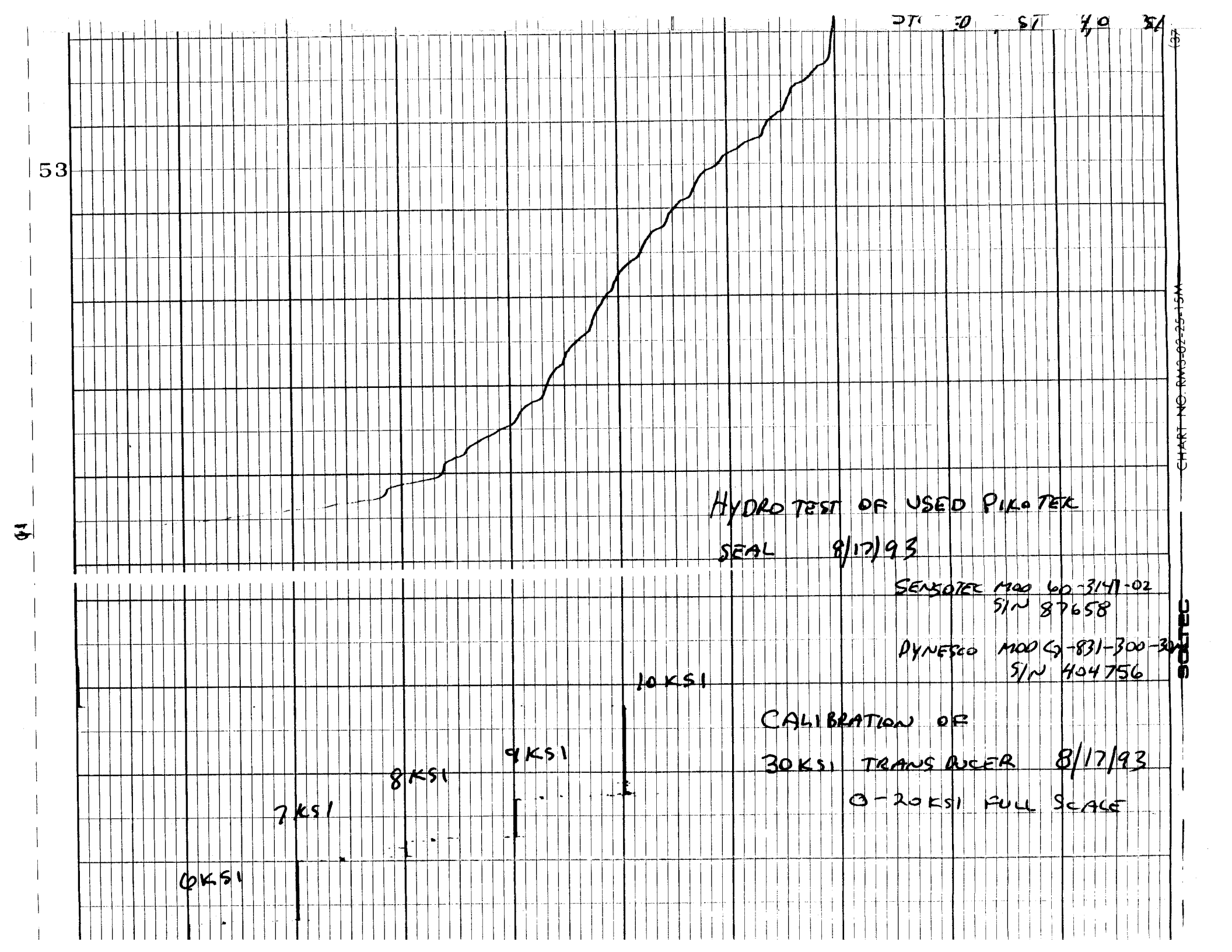

No LEAK @ 15 min Hold
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
66
"PIKOTEK" SEAL @ 90 ft. lbs.
6
CHART NO. RM3-02-25-15M
SOLTEC


NO TEST
LEAK ON HOSE
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
PIKOTEC SEAL @ 120 Ft. LBS.
7
DQ129301-1H12
(3764)


NO LEAKS AFTER 15 MIN HOLD
8
62
SOLTEC
DQ129301-1H12
PARKER @ 150 FT-LBS
9


NO LEAKS AFTER 15 MIN. HOLD
63
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
CHART NO. RM2-2M-25-1500
SOLTEC
REPAIR FITTING
RE-DO
PIKOTEC SEAL @ 120 Ft lbs.
8


HIGHER PRESSURE NOT OBTAINABLE DUE TO
INTERNAL LEAKAGE IN PUMP.
NO SEAL LEAKAGE NOTED FROM MONITOR LINE
8/16/93
RE-PRESSURIZED
USED PIKOTEC SEAL
HYDRO TEST
LEAK @ 6600 PSI
Std. SEAL @ 50 PSIG
HYDRO-TEST
58
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
DO129301-1H1
(3764)
CHART NO. RM3-02-25-15M


53
HYDRO TEST OF USED PIKOTEK
SEAL 8/17/93
SENSOTEC MOD 60-3141-02
S/N 87658
DYNESCO MOD CA-831-300-30
S/N 404756
CALIBRATION OF
30KSI TRANSDUCER 8/17/93
0-20KSI FULL SCALE
0KSI
7KSI
8KSI
9KSI
10KSI
CHART NO. RM3-02-25-15M
SOLTEC

APPENDIX C

GASKET SEATING PRESSURE CALCULATIONS

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API Fire Test:

Pikotek Firelok brand VCS gasket made up of the following component materials:

Seal Retainer - 316 stainless steel core material bonded to NEMA grade G-11 lining material. Standard .152 inch retainer thickness.

Secondary Sealing Elements - Spring-energized Teflon inboard seals with graphite-filled 316 stainless steel spiral wound outboard seals (Firelok tandem seal design).

Gasket Seating Stress Calculations

The comparative tests conducted on the standard spiral wound gasket and the Pikotek Flowlok brand VCS were all conducted in accordance with accepted industry parameters for gasket seating stress (ASME guidelines were used for the spiral wound type gaskets and information submitted by the manufacturer was used for the Pikotek brand gaskets). Bolt stress and torque values were derived from surface area calculations of the surface sealing area for the respective test gasket specimens as supplied by the manufacturer of each respective test gasket. Since the minimum required seating stress for each respective test gasket (the gasket Y factor) was the same for both types (10,000 PSI of compressive gasket seating stress for both), then that was the midpoint in the range of seating stresses used during the Nitrogen leak test. The low and high target stress values were 7,500 PSI and 12,500 PSI.

Bolt torque calculations were based on ASTM guidelines (ASTM standard designations: A193/A193M-92 and A453/A453M-92a) for 5/8 inch stud bolts (2 inch ANSI 600 class flanges having 8 stud bolts per end-connection). A193 grade B7 (high strength carbon steel) stud bolts were used for the Nitrogen leak test and the hydrostatic pressure test and A453 grade 660 (high temperature alloy) stud bolts were used for the API fire test.

	A193 grade B7	A453 grade 660
Tensile Strength	125 KSI	130 KSI
Yield Strength	105 KSI	85 KSI
Elongation	16%	15%

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(cont.)	A193 grade B7	A453 grade 660
High Temperature Characteristics	Fair	Good
Total Compression per Foot Pound of Torque[1]	101 lbs.	101 lbs.

[1]Using a graphite-based thread lubricant which yields a friction coefficient of 0.16

Bolt torque values were calculated using Cobb's formula:

$$T = F_m(D_n f_n + C_a D_p)/2$$

where:

T = Torque Value
F_m = Intended Bolt Stress
D_n = Bolt Diameter x Nut Diameter (0.625 x 1.250)
f_n = Friction Coefficient (0.16)
C_a = Thread Angle Factor (0.2)
D_p = Pitch Diameter (0.566)

To calculate actual foot pounds, then divide by 12

Intended bolt stress is calculated as follows:

$$F_m = (S_m \times A_g)/8$$

where:

S_m = Target Seating Stress
A_g = Impacted Surface Area of the Sealing Element

The surface area of the sealing element of a standard 2 inch nominal ANSI class 600 spiral wound gasket is calculated based on the following formula:

$$\text{Area} = (ODr)^2 \times 3.1416 - (IDr)^2 \times 3.1416$$

where:

ODr = the radius of the outer seal dimension

IDr = the radius of the inner seal dimension

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Therefore, the area of the sealing element of the spiral wound gasket is calculated as follows:

$$(3.325/2)^2 \times 3.1416 - (2.750/2)^2 \times 3.1416 = \mathbf{2.74}\ \text{in}^2$$

The surface area of the complete sealing element of a 2 inch ANSI class 600 Pikotek Flowlok brand VCS gasket (made for XX wall thickness piping with 1.5 inch bore) is calculated based on the following formula:

$$\text{Area} = [(ODr)^2 \times 3.1416 - (IDr)^2 \times 3.1416] - .5[(ODgr)^2 \times 3.1416 - (IDgr)^2 \times 3.1416]$$

where:

ODr = the radius of the outer seal dimension defined as the area measurement located inside of the outermost O-ring groove (used for media leak measurement) or in other words the true gasket outside diameter divided by two

IDr = the radius of the inner seal dimension or in other words the true gasket inside diameter divided by two

$ODgr$ = the radius of the outer dimension of the leak measurement groove machined into one of the flanges

$IDgr$ = the radius of the inner dimension of the leak measurement groove machined into one of the flanges

Therefore, the area of the sealing element of the Pikotek gasket is calculated as follows:

$$[(3.925/2)^2 \times 3.1416 - (1.503/2)^2 \times 3.1416] - .5[(3.505/2)^2 \times 3.1416 - (3.305/2)^2 \times 3.1416] = \mathbf{9.79}\ \text{in}^2$$

Based on the sealing surface area of each gasket that is actually impacted by flange compression, the following torque values were assigned which then yielded the desired gasket seating stress.

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	Pikotek Flowlok VCS	Standard Spiral Wound
Gasket Surface Area of Sealing Element Impacted by Flange Compression	9.79 in^2	2.74 in^2
Minimum Gasket Seating Stress (Gasket Y Factor)[1]	10,000 PSI	10,000 PSI
Total Gasket Compression per Foot Pound of Bolt Torque[2]	82.53 PSI	294.89 PSI

[1]Based on ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 for spiral wound gasket and information provided by the manufacturer for Pikotek gasket

[2]Using calibrated torque wrench and graphite-based lubricant and torquing the stud bolts in a star pattern sequence; also see section on stud bolts

Therefore, the following torque values were used during the Nitrogen leak test in order to generate the three target seating stress values:

	Gasket Compressive Stress Values 7,500	10,000	12,500
Pikotek Flowlok VCS	90 ft.lbs.	120 ft.lbs.	150 ft.lbs.
Spiral Wound Gasket	26 ft.lbs.	34 ft.lbs.	43 ft.lbs.

Actual Gasket Compression Yielded (in PSI):

	Pikotek Flowlok VCS	Standard Spiral Wound
Low Value (7,500)	7,427.7	7,667.1
Midpoint (10,000)	9,903.6	10,026.3
High Value (12,500)	12,379.5	12,680.3

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During the hydrostatic pressure test, the torque values used were 50 ft.lbs. of bolt torque on the spiral wound gasket (resulting in 14,744.5 PSI of seating stress and well above the ASME 10,000 PSI gasket Y factor) and 150 ft.lbs. of bolt torque on the Pikotek gasket (resulting in 12,379.5 PSI of seating stress and also above the 10,000 PSI gasket Y factor submitted by the manufacturer). Therefore, these bolt torque parameters were both sufficient to insure that the respective test gasket specimens were adequately seated during the hydrostatic pressure test.

During the API 6FB fire test (see specification also attached as an exhibit) which was only conducted on the Pikotek Firelok brand VCS flange gasket, the bolt torque used was 180 ft.lbs. This particular torque parameter was used in order to offset any potential effects from stud bolt relaxation resulting from the significantly elevated temperatures. This resulted in a bolt stress of approximately 18,136 PSI which was well within the yield limits of the respective grade 660 stud bolts.

Flanges were 2 inch ANSI 600 class weld neck with 1.5 inch bore for XX 2 inch pipe (double heavy wall thickness). All welding was performed in accordance with Southwest Research Institute standard practices and procedures. Flanges were constructed from A105 carbon steel.

Standard zinc plated carbon steel grade 1050 washers were used during the Nitrogen leak test and the hydrostatic pressure test. No washers were used during the API fire test.

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	Pikotek Flowlok VCS	Standard Spiral Wound
Gasket Surface Area of Sealing Element Impacted by Flange Compression	9.79 in^2	2.74 in^2
Minimum Gasket Seating Stress (Gasket Y Factor)[1]	10,000 PSI	10,000 PSI
Total Gasket Compression per Foot Pound of Bolt Torque[2]	82.53 PSI	294.89 PSI

[1]Based on ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 for spiral wound gasket and information provided by the manufacturer for Pikotek gasket

[2]Using calibrated torque wrench and graphite-based lubricant and torquing the stud bolts in a star pattern sequence; also see section on stud bolts

Therefore, the following torque values were used during the Nitrogen leak test in order to generate the three target seating stress values:

	Gasket Compressive Stress Values 7,500	10,000	12,500
Pikotek Flowlok VCS	90 ft.lbs.	120 ft.lbs.	150 ft.lbs.
Spiral Wound Gasket	26 ft.lbs.	34 ft.lbs.	43 ft.lbs.

Actual Gasket Compression Yielded (in PSI):

	Pikotek Flowlok VCS	Standard Spiral Wound
Low Value (7,500)	7,427.7	7,667.1
Midpoint (10,000)	9,903.6	10,026.3
High Value (12,500)	12,379.5	12,680.3

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