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Large Gate Valve Soft Closure Notes

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This is an internal working note
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The "soft closure" allows LIGO to bake the large GNB gate valves in the closed position but with minimum force applied to the O-ring. This will prevent the gate O-rings from pullout due to sticking.

The attached notes are PSI's results from a test performed in the Hanford X-arm End Station in September 1998. WGV20 was used as the test valve.

The test was performed as follows:

Three vacuum volumes were involved in the process. They were the 80K pump, (high pressure side), the gate annulus, and the BSC volume or the low pressure side. Each volume had a turbo pump and pressure gauges. The high pressure side also had a variable leak valve to allow raising the pressure in a controlled fashion.

Prior to heating, the valve was first closed, then opened by 1.75 inches as measured at the lead screw. Two of four motor mounts were removed to reduce the drive belt tension. The drive belt was then removed. The gate was allowed to settle to its natural resting position and this was measured as the "freefall" position. The drive pulley was rotated by hand back and forth to confirm this natural resting position.

At this time gas was admitted to the high pressure side (through the leak valve) in order to confirm that the gate was in a sealed position. Three pressures were monitored: PT524 (high pressure), P Aux-annulus (gate seal annulus pressure) and PT 510 (low pressure). The "freefall" position was determined to be "leak tight" as measured by these pressure gauges. The bakeout was then started.

Once 150C was reached the pressure gradient was again established and maintained for approximately 8 hours with no measurable leakage. At the end of this period further tests were performed to determine sensitivity to drive pulley position. It was found that no leakage was observed until the pulley was rotated open by about 1/3 of a turn. The test was terminated at this point. If this method is used in future then the "freefall" position will have to be determined experimentally and tested prior to bake since each valve may behave somewhat differently.

LIGO-C982159-00-V

Soft Closure Test Notes

All pressures are in Torr

9/17/98

1340 Start Aux. Carts, main turbo running

Close WGV20

Adjust variable leak valve

Setpoint	Pressure PT524
20	<2E-5
30	8.5E-2
25	9.5E-3
20	<2E-5

Record position of WGV20

1. Valve Closed 10-13/16"
2. Open ~ 1 ¾" 8-9/16"
3. Freefall Closure 9-5/16"
4. Final Position 9-5/16"

Increase pressure in the high (cryopump) side. No leakage observed. Open WGV20 1/8→1/4 turn until gate annulus pressure increased. Reset to original position to verify finding the minimum compression setting, which happens to be the freefall position. This freefall position was controlled by manually braking the pulley as the valve closed.

1510 PT524 = 7.0E-2

PT510 = 8.0E-9

P_{Aux_cryo} = 1.4E-2

$P_{Aux\_annulus}$ = 7.0E-7

$P_{main\ turbo}$ = 4.6E-9

Variable leak valve setting = 27

1515 Close variable leak valve and start heating.

9/18/98

750 PT524 = 1.8E-7

PT510 = 3.9E-8

P_{Aux_cryo} = 1.7E-7

$P_{Aux\_annulus}$ = 5.8E-7

$P_{main\ turbo}$ = 1.5E-8

Variable leak valve setting = 18

Open variable leak valve to 22, let stabilize, lower to 20. Pulley position has not moved.

815 PT524 = 8E-4

P_{Aux_cryo} = 1.4E-5

1200 Notes from J. Worden and R. Weiss

V1	Annulus	V2
5.5E-3	1E-6	1.9E-8
1E-2	2.1E-6	7.5E-7 Rai up top
2.2E-2	1E-6	2.5E-8 Closed (Variable leak valve)

9/19/98

700 PT524 < 1E-3 (pirani only)
PT510 = 2.5E-7
P_{Aux_cryo} = 4.5E-7
$P_{Aux\_annulus}$ = 5.7E-6
$P_{main\ turbo}$ = 5.0E-8
Variable leak valve setting = 0

1200 Temp = 115°C
PT524 = 1.0E-5
PT510 = 3.0E-7

9/20/98

950 Temp = 150°C
PT524 = 2.0E-5
PT510 = 1.0E-6

1850 Temp = 150°C
PT524 = 2.4E-5
PT510 = 1.1E-6
P_{Aux_cryo} = 1.6E-6
$P_{Aux\_annulus}$ = 7.3E-6
$P_{main\ turbo}$ = 2.8E-7
Variable leak valve setting = 0

9/21/98

720 Temp = 150°C
PT524 = 2.3E-5
PT510 = 1.1E-6
P_{Aux_cryo} = 1.6E-6
$P_{Aux\_annulus}$ = 7.0E-6
$P_{main\ turbo}$ = 3.1E-7
Variable leak valve setting = 0

820 Open variable leak valve to achieve $10^{-2} \rightarrow 10^{-1}$ pressure in cryo. Variable leak valve setting is 28. No change in any other pressures.

850 Temp = 150°C
PT524 = 2.3E-1
PT510 = 1.1E-6
P_{Aux_cryo} = 1.4E-1 (above turbo)/ 4.7 (foreline)
$P_{Aux\_annulus}$ = 7.0E-6
$P_{main\ turbo}$ = 3.1E-7
Variable leak valve setting = 27.5

1600 Temp = 150°C
PT524 = 1.7E-1
PT510 = 1.1E-6
P_{Aux_cryo} = 7.8E-2 (above turbo)/ 4.1 (foreline)
$P_{Aux\_annulus}$ = 6.8E-6
$P_{main\ turbo}$ = 3.2E-7
Variable leak valve setting = 27.5

Adjusting gate compression at temperature (150C) to check for leakage:

Close drive pulley:	1/4 turn	1/8 turn	0 turn
PT524 =	1.7E-01	1.7E-01	1.7E-01
PT510 =	1.0E-06	1.0E-06	1.0E-06
PAux_cryo =	7.8E-02	7.8E-02	7.8E-02
PAux_annulus =	7.3E-06	7.3E-06	6.9E-06
Pmain turbo =	2.8E-07	2.8E-07	2.9E-07

Open drive pulley by number of teeth (60 teeth on entire pulley):

	2	4	6	8*	12	16	20	24
PT524 =	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.4E-01	1.7E-01
PT510 =	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.1E-06	1.1E-06	1.8E-06	4.5E-06
PAux_cryo =	7.8E-02	7.8E-02	7.8E-02	7.8E-02	7.8E-02	7.8E-02	7.8E-02	7.6E-02
PAux_annulus =	6.8E-06	6.7E-06	6.7E-06	6.7E-06	6.7E-06	6.7E-06	7.0E-06	7.7E-06
Pmain turbo =	3.0E-07	3.1E-07	3.0E-07	3.0E-07	3.1E-07	3.1E-07	5.0E-07	9.6E-07

* At this point the valve will not stay open by itself

Return to the zero point.
PT524 = 1.7E-1
PT510 = 1.2E-6
P_{Aux_cryo} = 7.8E-2
$P_{Aux\_annulus}$ = 6.7E-6
$P_{main\ turbo}$ = 2.9E-7
Variable leak valve setting = 27.5

1630 Start temperature rampdown

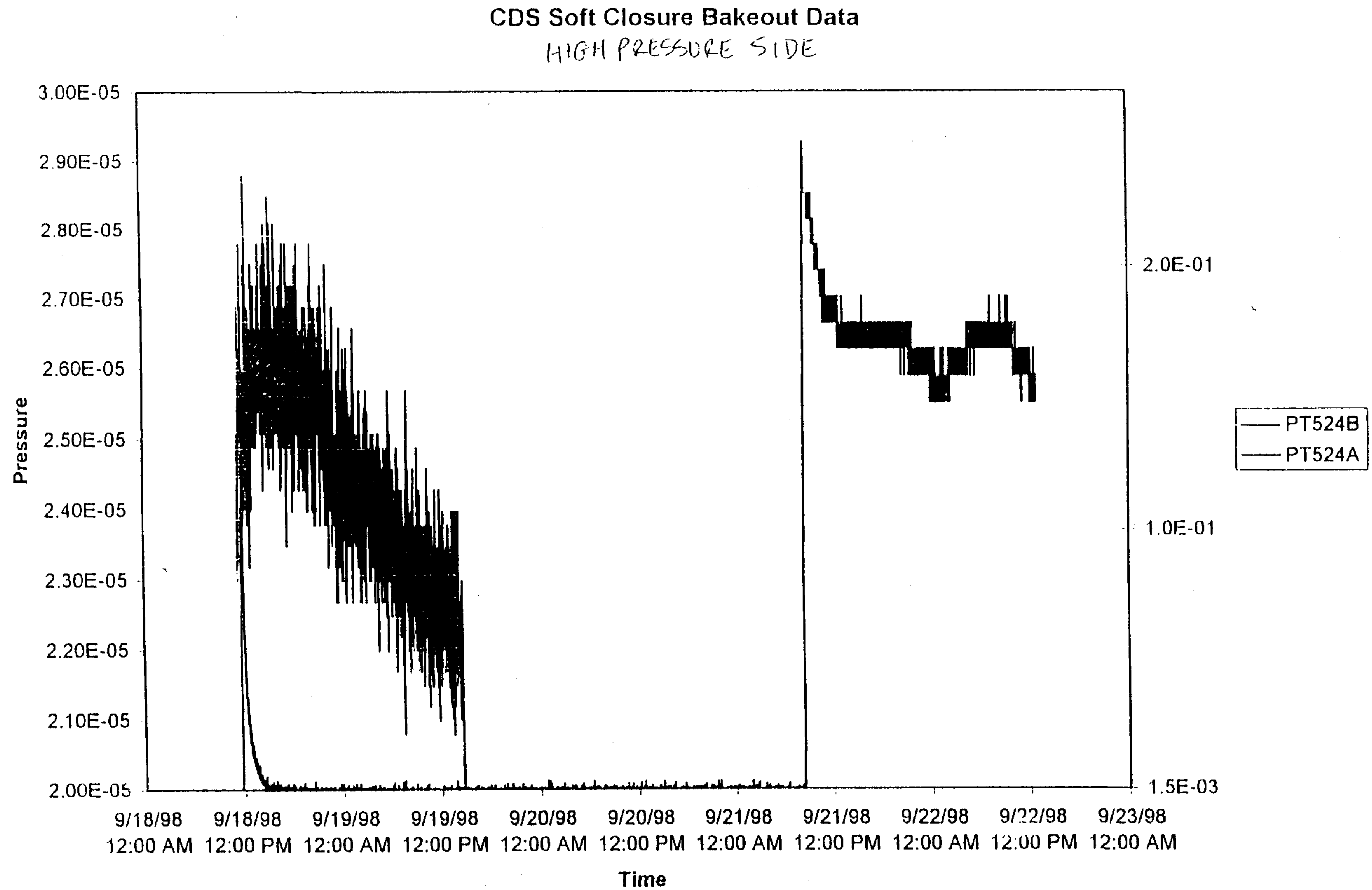
9/22/98
815 Temp = 119°C
PT524 = 1.8E-1
PT510 = 4.5E-7
P_{Aux_cryo} = 7.9E-2
$P_{Aux\_annulus}$ = 4.2E-6
$P_{main\ turbo}$ = 1.3E-7
Variable leak valve setting = 27.5
1640 Temp = 102°C
PT524 = 1.6E-1
PT510 = 2.5E-7
P_{Aux_cryo} = 6.2E-2
$P_{Aux\_annulus}$ = 2.8E-6

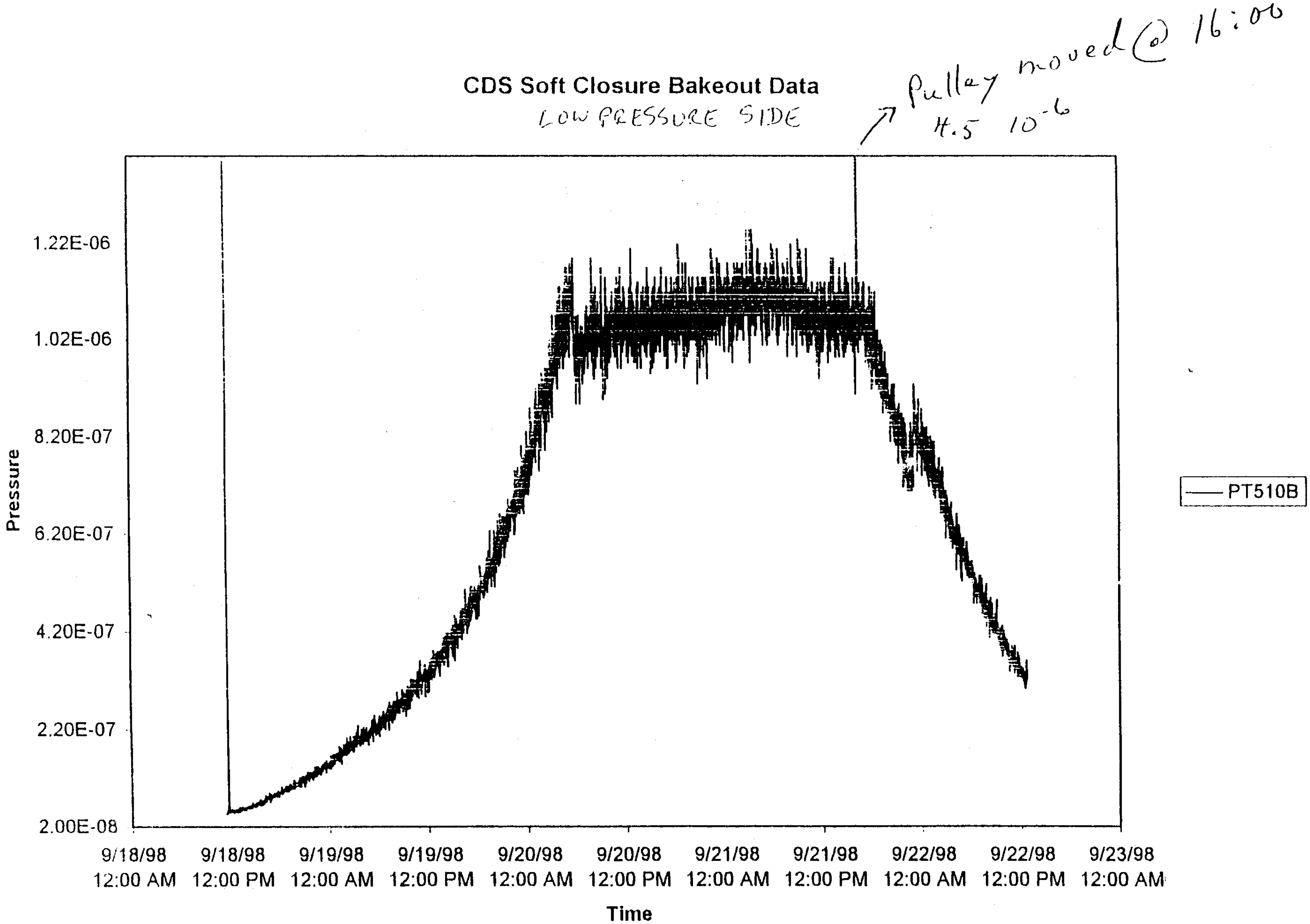
$P_{main\ turbo}$ = 6.7E-8
Variable leak valve setting = 27.5

9/23/98

810 Temp = 71°C
PT524 = 1.6E-1
PT510 = 7.0E-8
P_{Aux_cryo} = 6.6E-2
$P_{Aux\_annulus}$ = 1.1E-6
$P_{main\ turbo}$ = 4.4E-8
Variable leak valve setting = 27.5

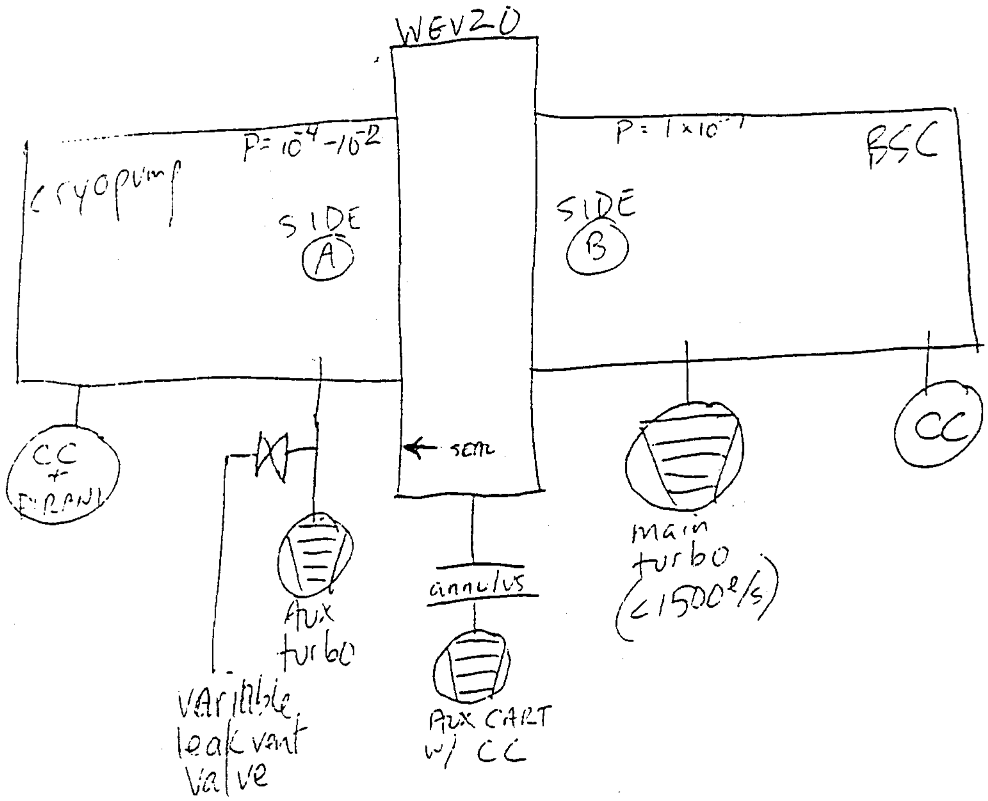
930 End of soft closure test by LIGO's account. Continue cooldown, return annulus to ion pumping, close variable leak valve.


CDS Soft Closure Bakeout Data
HIGH PRESSURE SIDE
3.00E-05
2.90E-05
2.80E-05
2.70E-05
2.60E-05
2.50E-05
2.40E-05
2.30E-05
2.20E-05
2.10E-05
2.00E-05
Pressure
2.0E-01
1.0E-01
1.5E-03
PT524B
PT524A
9/18/98 12:00 AM
9/18/98 12:00 PM
9/19/98 12:00 AM
9/19/98 12:00 PM
9/20/98 12:00 AM
9/20/98 12:00 PM
9/21/98 12:00 AM
9/21/98 12:00 PM
9/22/98 12:00 AM
9/22/98 12:00 PM
9/23/98 12:00 AM
Time


CDS Soft Closure Bakeout Data
LOW PRESSURE SIDE
Pulley moved @ 16:00
4.5 10-6
1.22E-06
1.02E-06
8.20E-07
6.20E-07
4.20E-07
2.20E-07
2.00E-08
Pressure
9/18/98 12:00 AM
9/18/98 12:00 PM
9/19/98 12:00 AM
9/19/98 12:00 PM
9/20/98 12:00 AM
9/20/98 12:00 PM
9/21/98 12:00 AM
9/21/98 12:00 PM
9/22/98 12:00 AM
9/22/98 12:00 PM
9/23/98 12:00 AM
Time
PT510B

SOFT CLOSURE BAKEOUT TEST

WGV20 - 44'E
RIGHT END STATION



PROCEDURE

1. WITH WEV20 CLOSED, OPEN ELECTRICALLY, STROKING STEM 1¾". THE ORINGS SHOULD BE OFF THE SEALING SURFACE.
2. REMOVE DRIVE BELT (NOT LIMIT SWITCH BELT!). LET THE VALVE SETTLE INTO THE CLOSED POSITION. REMEASURE STEM LENGTH.
3. OPEN WEV20 ANNULUS SPACE TO AUX. CART. CHECK PRESSURE AT ANNULUS AUX CART. PRESSURE SHOULD INCREASE SLIGHTLY ABOVE MAIN VOLUME PRESSURES (SIDE (B)) IF ORINGS SEAL. RECORD PRESSURES.
4. WITH AUX TURBO PUMPING ON SIDE (A) + MAIN TURBO PUMPING ON SIDE (B)), SLOWLY ADMIT AIR INTO SIDE (A) UNTIL $P_{ANNULUS} = 10^{-2}$
5. If $P_{ANNULUS}$ INCREASES, SNUG THE VALVE CLOSED BY ¼ TURN, WATCHING THE ANNULUS PRESSURE. AS SOON AS IT STARTS TO DROP, LEAVE VALVE, RECORD STEM LENGTH + WATCH PRESSURE. IF $P_{ANNULUS} < 10^{-5}$ THE SEAL IS GOOD.

6. IF $P_{ANNULUS}$ DECREASES OR MAINTAINS, THEN THE ORING MAY NOT BE AT THE "MINIMUM COMPRESSION TO ACHIEVE 10^{-3} T-ℓ/s LEAK RATE" SETTING. WE WILL BACK THE VALVE OPEN UNTIL THE PRESSURE DOES INCREASE, THEN REPEAT STEP #5. (3 times)

7. WHEN SEAL IS GOOD, REDUCE PRESSURE IN SIDE (A) TO $10^{-4} \rightarrow 10^{-1}$ AND START BAKEOUT OF VALVE. RECORD ALL PRESSURES AND TEMPERATURES. BAKE AT 150°C FOR 24 HOURS.

8. WHEN VALVE IS AT AMBIENT TEMPERATURE, CLOSE VALVE COMPLETEL

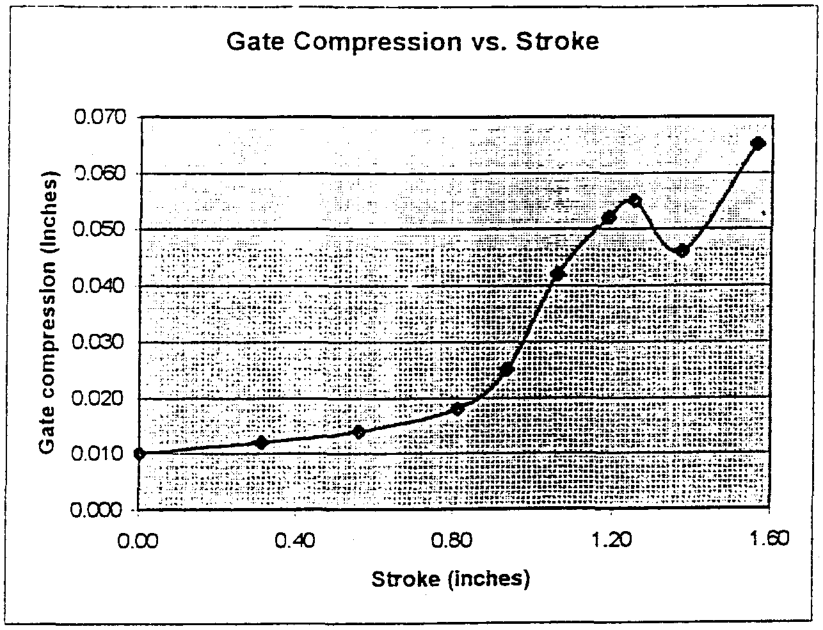
9. BACKFILL ANNULUS TO VERIFY LEAK TIGHTNESS OF GATE SEAL.

10. REPUMP ANNULUS + GET BACK TO ION PUMPING.

Gate Compression to Stroke Ratio for the Soft Closure Bakeout Test

Data taken from the measurement of WGV15 with the spool removed. Refer to the table and graph below.

Depth	Stroke	Gate compress
10.0625	0.0000	0.010
9.7500	0.3125	0.012
9.5000	0.5625	0.014
9.2500	0.8125	0.018
9.1250	0.9375	0.025
9.0000	1.0625	0.042
8.8750	1.1875	0.052
8.8125	1.2500	0.055
8.6875	1.3750	0.046
8.5000	1.5625	0.065



The depth is measured from the top of the drive nut to the top of the drive shaft. The stroke is the change in depth from the lockover position to the measured position. The gate compression is the distance from the gate face to the sealing surface on the valve body, measure in four places.

The stroke starts from the Closed position and behaves linearly only for the first ½" of travel. The stroke-to-gate-compression relationship then enters into a nonlinear region. This is explained by the design of the pocket guides and the path that the carriage and gate take to unlock/lock.

This data would allow for the measurement of oring compression knowing the following information: Oring diameter = 0.270±0.004", Groove depth = 0.202±0.003", and gate to body distance in the closed position, in this case 0.010". As you can see, the stacking of tolerances alone lead to and error of over 100% when trying to achieve 0.005" compression. All parameters would have to be accurately measured.

Applying the above data from WGV15 to another valve would again lead to large errors. The pocket guides are custom ground for each valve to minimize shock and vibration. This is a manufacturing absolute due to the stacking of tolerances throughout the valve. Completely standard items are installed into the valves with the pocket guides being installed last. This is the best way to "tune" the valves travel into the pockets and therefore the travel as the gate compresses against the valve body.

The area of minimum oring compression occurs in the nonlinear region, making that prediction difficult. The nonlinearity is dictated by the curvature of the pocket guide and its interaction with the linking mechanism.

The only way to know the exact compression on the oring is by a direct measurement after measuring all involved components. This will not be done on WGV20 for the soft closure test, so trial and error will be used to find the point of minimum compression for optimal sealing.