Attachment 4

Calculation ME-0498

Pressure Locking and Stem Effect Thermal Binding Analysis
For Generic Letter 95-07

VIRGINIA POWER		CALC ADDENDUM COVER SHEET
Calc Number: ME-0498	Rev. 0	Add: 00A
Station(s): NAPS AND SPS	Units 00	Sheet 1 of 15

Addendum Title (Subject): Pressure Locking and Stem Effect and Thermal Binding Analysis for Generic Letter 95-07.

Changes Calc Status? [ ] Yes [x] No New Status: ____

Reference Numbers: IR No.:____ Job No.____
Initiating Document: (DCP, IEER, REA, etc.):____

Attachments? [x] Yes [ ] No Labeled 1 through 1

Originator: [x] Virginia Power Discipline: Mechanical Engineering
[ ] A/E Firm Name:____

EDS Mark Number References? (not listed in the calc or previous addenda)

Station	Unit	System	Prefix	Sequence	Comp. Code	Suffix
[38]	[01]	[SI]	[MOV]	[1842]	[VALVE]	[ ]
[38]	[01]	[SI]	[MOV]	[1842]	[VALVOP]	[ ]
[38]	[01]	[SI]	[MOV]	[1869A]	[VALVE]	[ ]
[38]	[01]	[SI]	[MOV]	[1869A]	[VALVOP]	[ ]
[38]	[01]	[SI]	[MOV]	[1869B]	[VALVE]	[ ]
[38]	[01]	[SI]	[MOV]	[1869B]	[VALVOP]	[ ]
[38]	[~~01~~ 02 PDJ 6/28/96]	[SI]	[MOV]	[2842]	[VALVE]	[ ]

[x] Additional Mark Numbers? (Check if "yes"). See ____.

Objective:

The purpose of this addendum is to include several new MOVs into the original pressure locking calculation for SPS and NAPS. These additional MOVs were determined to be potentially susceptible to pressure locking while reviewing pressure locking effects in segregated/non-segregated parallel flow paths on MOVs during a LOCA.

Conclusions:

This addendum concludes that based upon the Virginia Power methodology for calculating pressure locking effects, all of the newly identified MOVs have positive margin in the event of a pressure locked condition.

	Signature	Date
Prepared By (Print Name) Paul D. Jones	Paul D. Jones	6-25-96
Reviewed By (Print Name) John J. Wolak	John J. Wolak	6-25-96
Other (If Applicable Print Name) Bruce F. DeMars	B F DeMars	6-25-96

(May 95)

ASSOCIATED INFORMATION

CALCULATION NUMBER:	REV.NO.	SHEET
ME-0498	0	2 OF 15

Additional Mark Nos:

Station	Unit	System	Prefix/ID		Component/ID	
38	02	SI	MOV	2842	VALVOP	
38	02	SI	MOV	2869A	VALVE	
38	02	SI	MOV	2869A	VALVOP	
38	02	SI	MOV	2869B	VALVE	
38	02	SI	MOV	2869B	VALVOP	
59	01	SI	MOV	1836	VALVE	
59	01	SI	MOV	1836	VALVOP	
59	01	SI	MOV	1869A	VALVE	
59	01	SI	MOV	1869A	VALVOP	
59	01	SI	MOV	1869B	VALVE	
59	01	SI	MOV	1869B	VALVOP	
59	02	SI	MOV	2836	VALVE	
59	02	SI	MOV	2836	VALVOP	
59	02	SI	MOV	2869A	VALVE	
59	02	SI	MOV	2869A	VALVOP	
59	02	SI	MOV	2869B	VALVE	
59	02	SI	MOV	2869B	VALVOP	

TABLE OF CONTENTS

Prepared By: Paul D. Jones Date: 6-25-96
Reviewed By: Ed Walsh Date: 6-25-96
Reviewed By: [signature] Date: 6-25-96

OBJECTIVE

The purpose of this addendum is to determine the effect on valve pullout forces due to pressure locking. NAPS valves X-SI-MOV-X836 and X-SI-MOV-X869A,B and SPS valves X-SI-MOV-X842 and X-SI-MOV-X869A,B are potentially susceptible to pressure locking during a large break loss of coolant accident (LBLOCA).

The method used to evaluate the pressure locking effects are the same as those used in the original issue of this calculation. Since the original issue of this calculation found that the VP pressure locking methodology is more conservative than the method developed by the Westinghouse Owner's Group (WOG), only the VP method will be used in this addendum.

Prepared By:	[signature]	Date:	6-25-96
Reviewed By:	[signature]	Date:	6-25-96
Reviewed By:	[signature]	Date:	6-25-96

METHOD OF ANALYSIS

This analysis calculates the expected maximum pullout thrust on the valves discussed in the Objective. The pressure locking thrusts are determined with a method developed by Virginia Power.

Virginia Power Pressure Locking Methodology

Since pressure locking occurs when the valve bonnet is pressurized to a higher pressure than the flow side of the discs, the resultant force on the valve disk can be calculated based upon this force imbalance. The pullout thrust in a pressure locking situation has five components: 1) the pullout force from static seating which resists valve opening (this thrust comes from the VOTES tests for the particular valve and includes the packing load); 2) the bonnet pressure acting on the disk to keep the valve closed; 3) the upstream system pressure acting on the upstream disk which counters the closing force of the bonnet pressure; 4) the downstream system pressure acting on the downstream disk which counters the closing force of the bonnet pressure; and 5) the bonnet pressure acting on the stem which tends to eject the stem from the valve and counters the closing force.

The static pullout force is provided by the stations from diagnostic test results. The packing drag thrust is inherent in the pullout thrust value. Consequently, these calculations do not include a specific packing thrust.

The pressure forces are calculated based upon the disk surface area that the pressure acts upon. The flowstream pressure is distributed over an area the size of the seat inner diameter or the valve port area. The bonnet pressure acts on a surface area equal to the outer diameter of the seat sealing area. The resulting pressure force equation is:

$$F_{pres} = [2*P_{bonnet}*(\pi/4*Seat_{OD}^2)-(P_{up}+P_{dn})*(\pi/4*Seat_{ID}^2)]*VF$$

where: F_{pres}=pressure force, lbs

P_{bonnet}=pressure trapped in bonnet, psi

P_{up}=upstream pressure, psi

P_{dn}=downstream pressure, psi

$Seat_{OD}$=seat outer diameter, in.

$Seat_{ID}$=Seat inner diameter, in.

VF=Valve factor, 0.3 for wedge valves

Often, the seat ID and OD are virtually the same. Consequently, in this analysis, the OD and ID are taken to be the same.

The last component in the pressure locking pullout thrust calculation is the stem rejection force. The bonnet pressure tries to eject the stem from the valve. This force reduces the amount of thrust required to open the valve. The stem rejection force equation is:

Prepared By: Paul D[illegible] Date: 6-25-96
Reviewed By: [illegible] Walsh Date: 6-25-96
Reviewed By: [illegible] Date: 6-25-96

$$F_{stem\ rej} = P_{bonnet} * (\pi/4 * Stem_{OD}^2)$$

where: $F_{stem\ rej}$=stem rejection load, lbs

$Stem_{OD}$=stem outer dimension, in.

Prepared By:	Paul Jones	Date:	6-25-96
Reviewed By:	J. A. Wolak	Date:	6-25-96
Reviewed By:	B. J.	Date:	6-25-96

ASSUMPTIONS

1. All dimensions and diagnostic test results are nominal values. No effort has been made to quantify manufacturing tolerances or include equipment inaccuracies.

2. As mentioned in the methods section, the seat OD and ID are taken to be equivalent. This is due to the fact that typical wedge to seat contact is uneven and only a thin line. This makes expected seat dimensions difficult to quantify.

Prepared By:	Paul D Jones	Date:	6-25-96
Reviewed By:	[signature]	Date:	6-25-96
Reviewed By:	[signature]	Date:	6-25-96

DESIGN INPUTS

1. The bonnet, upstream and downstream pressures are provided in reference 3, page 17 case 4 and page 49 (NAPS) and reference 4, Table A-7 on page 16 and A2 on pages 1-6 (SPS).

2. The pullout forces, where available, are taken from the attached references 5 (NAPS) and 9 (SPS) . The pullout thrust for NAPS 2-SI-MOV-2869A is unavailable. It is assumed that the pullout thrust for this valve is equal to the highest pullout thrust of the unit 1 and 2 valves. The highest pullout is 6395 lbs. Consequently, the pullout thrust for 2-SI-MOV-2869A is rounded up to 6500 lbs.

3. Motor torques, ~~stem factors~~, operator data, valve stem data and valve port diameters are taken from reference 8 (NAPS) and 6 (SPS).

4. The coefficient of friction (COF) used to determine the operator thrust capability, is based upon recent testing (reference 10). For NAPS the COF is 0.20 and for SPS it is 0.11. Stem factors are calculated in Table 2 & are based upon the Limitorque stem factor equation. (reference 11).

Prepared By:	Paul D Jones	Date:	6-25-96
Reviewed By:	J. J. Wolski	Date:	6-25-96
Reviewed By:	BT [signature]	Date:	6-25-96

COMPUTER CODES

QuattroPro version 5 (reference 7) is used to assist in the mathematical calculations presented in the Methods of Analysis section. This simple calculation is independently checked by the reviewer and consequently a sample calculation is not required.

Prepared By: P. Flores Date: 6-25-96
Reviewed By: A.A. Walsh Date: 6-25-96
Reviewed By: [signature] Date: 6-25-96

REFERENCES

1. NRC Generic Letter, 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves," 8/17/95.
2. not used.
3. SWEC Calculation, 11715-341N, Rev. 0, "LHSI and HHSI System Curves."
4. Calculation ME-0408, Rev. 0, "Minimum and Maximum SI System Flow Analysis for Input to Surry Core Uprating Containment Analysis."
5. Tabulation of valve pullout forces at NAPS (attached).
6. ME-0211, Rev. 2, Addendum 02A, "Supplemental Thrust Band Evaluations," 3/15/96.
7. QuattroPro for Windows, Version 5.
8. ME-0492, "Thrust Band Calculation for North Anna Safety-Related Motor Operated Valves", R.E. Brightup, 1/96.
9. Tabulation of valve pullout forces at SPS (attached).
10. Technical Report ME-0092, Rev. 0, "Motor Operated Valve Coefficient of Friction Evaluation Surry and North Anna Power Stations," 10/95.
11. Limitorque User's Manual.

Prepared By:	Paul Dfonzo	Date:	6-25-96
Reviewed By:	J.J. Wolek	Date:	6-25-96
Reviewed By:	BTOzl	Date:	6-25-96

CALCULATIONS

All the calculations for the pressure locking evaluation are provided in Table 1. The results show that all MOVs have at least 20.7% margin between the expected maximum pressure locking pullout force and the operator capability at the time of expected valve operation (which includes a degraded voltage condition).

Prepared By:	Paul D. Jones	Date:	6-25-96
Reviewed By:	[illegible signature]	Date:	6-25-96
Reviewed By:	[illegible signature]	Date:	6-25-96

Table 1 -

Pressure Locking Table for Surry Power Station MOVs

Mark No.	Bonnet Pressure	Upstream System Pressure	Downst. System Pressure	Disc OD	Port OD	Disc Force	Valve Factor	Pressure Force	Stem Diameter	Stem Rejection Load	Pullout Force	Pullout Force (pres force -rej ld+po)	Motor Torque
SI-1842	2510	1448	0	3.445	3.445	33278	0.55	18303.0	1.25	3078.7	3553	18777	13
SI-1869A	2510	1448	0	2.875	2.875	23177	0.2	4635.4	1.25	3078.7	2293*	3850	13.4
SI-1869B	2510	1448	0	2.62	2.62	19248	0.45	8661.6	1.25	3078.7	3100	8683	12.2
SI-2842	2510	1448	0	3.813	3.813	40768	0.2	8153.5	1.625	5203.0	1156	4107	12.6
SI-2869A	2510	1448	0	2.25	2.25	14195	0.3	4258.6	1.125	2493.7	6725	8490	12.1
SI-2869B	2510	1448	0	2.62	2.62	19248	0.55	10586.4	1.125	2493.7	3744	11837	11.7

App Factor	OGR	Pullout Efficiency	Operator Capability	Plant Avg COF	Stem Factor COF=.11	Operator Thrust Capability	Capability -Pullout (margin)	Capability Margin (%)
0.9	69.56	0.4	326	0.11	0.0097	33710	14933	44.3
0.9	28.2	0.4	136	0.11	0.0097	14087	10237	72.7
0.9	38.6	0.45	191	0.11	0.0097	19750	11067	56.0
0.9	78.81	0.4	357	0.11	0.0160	22328	18221	81.6
0.9	72	0.4	314	0.11	0.0137	22853	14363	62.8
0.9	41	0.4	173	0.11	0.0116	14920	3083	20.7

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JGW 6-25-96
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* The attached VOTES test for this valve list two pullout thrusts, 2293 and 2361 lbs. This makes an insignificant difference of approximately 0.5% to the capability margin.

Table 1 - Con't

Pressure Locking Table for North Anna Power Station MOVs

Mark No.	Bonnet Pressure	Upstream System Pressure	Downst. System Pressure	Disc OD	Port OD	Disc Force	Valve Factor	Pressure Force	Stem Diameter	Stem Rejection Load	Pullout Force	Pullout Force (pres force -rej ld+po)	Motor Torque	App Factor
SI-1836	2600	2208	0	2.25	2.25	11890	0.3	3567.1	1.125	2583.1	4979	5963	13.5	0.9
SI-1869A	2600	2208	0	2.25	2.25	11890	0.3	3567.1	1.125	2583.1	6395	7379	13.4	0.9
SI-1869B	2600	2208	0	2.25	2.25	11890	0.3	3567.1	1.125	2583.1	4307	5291	13.6	0.9
SI-2836	2600	2208	0	2.25	2.25	11890	0.3	3567.1	1.125	2583.1	3984	4968	13.8	0.9
SI-2869A	2600	2208	0	2.25	2.25	11890	0.3	3567.1	1.125	2583.1	6500	7484	13.8	0.9
SI-2869B	2600	2208	0	2.25	2.25	11890	0.3	3567.1	1.125	2583.1	4449	5433	13.9	0.9

OGR	Pullout Efficiency	Operator Capability	MOV/plan Avg COF	Stem Factor	Operator Thrust Capability	Capability -Pullout (margin)	Capability Margin (%)
63	0.4	306	0.2	0.0179	17095	11132	65.1
63	0.4	304	0.2	0.0179	16969	9590	56.5
63	0.4	308	0.2	0.0179	17222	11931	69.3
63	0.4	313	0.2	0.0179	17475	12507	71.6
63	0.4	313	0.2	0.0179	17475	9991	57.2
63	0.4	315	0.2	0.0179	17602	12169	69.1

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Add. 0A
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Table 2 - Stem Factor Calculations

SURRY

VALV	STEM INFO							
Mark Number	Stem Diam.	TPI	Pitch	Lead	St	Fs	COF	Fs
						mu=.15		
RC-1535	1.125	5	0.200	0.200	1	0.0094	0.11	0.0076
RC-1536	1.125	5	0.200	0.200	1	0.0094	0.11	0.0076
SI-1842	1.250	3	0.333	0.333	1	0.0116	0.11	0.0097
SI-1869A	1.250	3	0.333	0.333	1	0.0116	0.11	0.0097
SI-1869B	1.250	3	0.333	0.333	1	0.0116	0.11	0.0097
SI-1890A	2.125	3	0.333	0.667	2	0.0219	0.11	0.0183
SI-1890B	2.125	3	0.333	0.667	2	0.0219	0.11	0.0183
RC-2535	1.125	5	0.200	0.200	1	0.0094	0.11	0.0076
RC-2536	1.125	5	0.200	0.200	1	0.0094	0.11	0.0076
SI-2842	1.625	3	0.333	0.667	2	0.0187	0.11	0.0160
SI-2869A	1.125	3	0.333	0.667	2	0.0156	0.11	0.0137
SI-2869B	1.125	4	0.250	0.500	2	0.0134	0.11	0.0116
SI-2890A	2.125	3	0.333	0.667	2	0.0219	0.11	0.0183
SI-2890B	2.125	3	0.333	0.667	2	0.0219	0.11	0.0183

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14a/b

Table 2 - con't.

naps

VALV	STEM INFO							
Mark Number	Stem Diam.	TPI	Pitch	Lead	St	Fs	COF	Fs
						mu=.15		
RC-1535	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
RC-1536	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-1867A	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-1867B	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-1867C	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-1867D	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179

SI-1836, SI-1869A and SI-1869B are all 3" Velans w/1.125" 2st and 3tpi

SI-2836, SI-2869A & SI-2869B are also 3" Velans w/1.125", 2start, 3tpi

Mark Number	Stem Diam.	TPI	Pitch	Lead	St	Fs	COF	Fs
RC-2535	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
RC-2536	1.250	3	0.333	0.333	1	0.0116	0.20	0.0140
SI-2867A	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-2867B	1.125	4	0.250	0.500	2	0.0134	0.20	0.0158
SI-2867C	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-2867D	1.125	3	0.333	0.667	2	0.0156	0.20	0.0179
SI-2867D	1.250	5	0.200	0.200	1	0.0102	0.30	0.0178

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BTD 6-25-96
JJW 6-25-96

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Add. 0A
P. 14b/b

CONCLUSION

The results of this evaluation show that the valves analyzed for a pressure locked condition will perform as required even if the expected worst case condition exists. The pressure locking margins range from approximately 20% to 82%.

Prepared By:	[signature]	Date:	6-25-96
Reviewed By:	[signature]	Date:	6-25-96
Reviewed By:	[signature]	Date:	6-25-96

ATTACHMENT 1 - CALCULATION REVIEW CHECKLIST AND ATTACHED REFERENCES

CALCULATION REVIEW CHECKLIST

CALCULATION NO. ME-0498	REV. NO. 0	ATTACHMENT 1	PAGE 1 OF 26

CALCULATION TITLE: Pressure Locking/Thermal Binding Analysis for GL 89-10

A "NO" answer to any questions requires that an explanation be provided.
NOTE: Reference may be made to explanations contained in the calculation.

QUESTIONS	YES	NO	N/A
1. Is the calculation number and revision identified on each page of the calculation and attachments?	[x]	[ ]	[ ]
2. Does the objective statement identify the reason for performing the calculation and give sufficient background information?	[x]	[ ]	[ ]
3. Have the sources of design inputs been correctly selected and referenced in the calculation?	[x]	[ ]	[ ]
4. Are the sources of design inputs up-to-date and retrievable (and/or a copy attached to the calc.)?	[x]	[ ]	[ ]
5. Where appropriate, have the other disciplines reviewed or provided the design inputs for which they are responsible?	[ ]	[ ]	[x]
6. Have design inputs been confirmed by analysis, test, measurement, field walkdown, or other pertinent means as appropriate for the configuration analyzed?	[x]	[ ]	[ ]
7. Are assumptions adequately described and bounded by the Station Design Basis?	[x]	[ ]	[ ]
8. Have the bases for engineering judgements been adequately and clearly presented?	[x]	[ ]	[ ]
9. Were appropriate calculation/analytic methods used and are outputs reasonable when compared to inputs?	[x]	[ ]	[ ]
10. Are computations technically accurate and has the calculation made appropriate allowances for instrument errors and calibration equipment errors? (Reference STD-EEN-0304)	[x]	[ ]	[ ]
11. Have those computer codes used in the calculation been listed in the "references" or has a statement been placed in the "methods of analysis" section which states - "No computer code used.", if no computer codes were used?	[x]	[ ]	[ ]
12. Have all exceptions to station design basis criteria and regulatory requirements been identified and justified in accordance with ANSI N45.2.11-1974?	[x]	[ ]	[ ]

Comments: (N/A if none) NA

[ ] Additional comment pages added.

Prepared By: P. D. Jones (signature)	Date: 6-25-96	Reviewed By: J. J. Wolak (signature)	Date: 6-25-96

JUN 25 '96 11:18

ME-0498 ADD. 001

ATTACHMENT 1

REF. 5

P.1/5

317271-01

Evaluator: [signature]

Date: 4/30/95

RESULTS

Tag Number: 2-SI-2869B
Test Number: 9
Test Date: 4/30/95

• AS LEFT AFTER COF TESTING

• COF = 0.11

• LIMIT- CLOSE MOV

• CYCLIC LOADING IN CLOSE DIRECTION; NOT ADVERSELY AFFECTING OPERATION

Close			Open		
Stroke Time	9.961	seconds	Stroke Time	9.918	seconds
Bypass Time	8.953	seconds	Bypass Time	2.268	seconds
Max Running Force	-3469	lbs	Max Running Force	2798	lbs
Avg Running Force	-2540	lbs	Avg Running Force	2022	lbs
Thrust at CST	-3394	lbs ✓	Disc Pullout Force	4449	lbs ✓
Maximum Thrust	-8295	lbs ✓			
Available Thrust Margin	-830	lbs	Torque Sw. Setting O/C	3.000/3.000	
Spring Pack Preload		lbs			

Torque Switch Setting Open/Close................: 3.000/3.000
Limit Switch Rotor Adjustment (Y/N).............: Y
Flow (gpm) Start/Finish.........................: 0/ 0
Upstream Pressure (psi) Start/Finish............: 0/ 0
Downstream Pressure (psi) Start/Finish..........: 0/ 0
General Comments:
vtc no. 658 sens.
c-clamp 672,Votes 513,Amp probe 532

Valve Information

Plant: NASI
Unit.: TWO
Tag Number.......: 2-SI-2869B
Type.............: GATE
Size.............: 3"
Target Thrust....: 0 lbs
Orientation......: VERT
Location.........: AB 244 PEN
Stem Material....: 17-4PH
Stem Diameter....: 1.125 inches
Threads per Inch: 3.00
Threads per Rev.: 2
E/Poisson Ratio.: 106.0 x 10E6 psi
VOTES Serial #..:
SFSL Sensitivity 1.376E-0002 fv/v/lb
Votes Force Offset: -2300 lbs

Valve Actuator

Actuator Type..: LIMITORQ
Size...........: SMB-00
Max Thrust Rate: 14000 lbs
Serial #.......: 115917
Order #........: 345804J
Worm Gear Teeth:
Gear Ratio.....: 70
Spring Pack # 22

Actuator Motor

Voltage Type: AC
Volts.......: 460
Amp rating..: 2.60 amps
Nom. Speed..: 1750.00 rpm
Start torque: 15.00 ft-lb
Run Torque..: 3.00 ft-lb
Horse Power.: 0.00 h.p.

Signal Conditioner Calibration Due Date 06/20/95

ME-0498 ADD. 001
ATTACHMENT 1 REF. 5
AS-LEFT AFTER
COF TESTING

COF = 0.15

Evaluator: [signature]
Date: 5/2/95

Tag Number: 2-SI-2836
Test Number: 9
Test Date: 5/2/95

TEST RESULTS

Close			Open		
Stroke Time	10.319	seconds	Stroke Time	10.001	seconds
Bypass Time	1.348	seconds	Bypass Time	2.166	seconds
Max Running Force	-670	lbs	Max Running Force	1060	lbs
Avg Running Force	-513	lbs	Avg Running Force	740	lbs
Thrust at CST	-1574	lbs ✓	Disc Pullout Force	3984	lbs ✓
Maximum Thrust	-6803	lbs ✓			
Available Thrust Margin	-968	lbs	Torque Sw. Setting O/C	2.000/2.000	✓
Spring Pack Preload		lbs			

Calibration Range: 191 to -7731 lbs. ✓

Torque Switch Setting Open/Close................: 2.000/2.000
Limit Switch Rotor Adjustment (Y/N).............: N
Flow (gpm) Start/Finish.........................: 0/ 0
Upstream Pressure (psi) Start/Finish............: 0/ 0
Downstream Pressure (psi) Start/Finish..........: 0/ 0
General Comments:
W.O.#317310-01 THIS IS THE AS LEFT TEST VALUE AFTER VTC. ENG HAS THE DATA FOR TEST 7 AND 8. ESK-6DP-1 REV 4 5/2/95 @ 0545

Valve Information
Plant: NASI
Unit.: TWO
Tag Number.......: 2-SI-2836
Type.............: GATE
Size.............: 3"
Target Thrust...: 0 lbs
Orientation.....: VERT
Location........: AB 244 U2 PEN
Stem Material...: 17-4PH
Stem Diameter...: 1.125 inches
Threads per Inch: 3.00
Threads per Rev.: 2
E/Poisson Ratio.: 106.0 x 10E6 psi
VOTES Serial #..:
FSL Sensitivity 3.163E-0002 fv/v/lb

Valve Actuator
Actuator Type..: LIMITORQ
Size...........: SMB-00
Max Thrust Rate: 14000 lbs
Serial #.......: 115926
Order #........: 345804J
Worm Gear Teeth:
Gear Ratio.....: 70
Spring Pack # 22

Actuator Motor
Voltage Type: AC
Volts.......: 460
Amp rating..: 2.60 amps
Nom. Speed..: 1700.00 rpm
Start torque: 15.00 ft-lb
Run Torque..: 3.00 ft-lb
Horse Power.: 1.00 h.p.

Signal Conditioner Calibration Due Date 06/20/95

As-left and COF
ME-0498 ADD. 001
ATTACHMENT 1
REF. 5

Evaluator: TBuell
Date: / / 22 Feb 96

Tag Number: 1-SI-1869B-1
Test Number: 5 12
Test Date: 2/22/96

TEST RESULTS

Close			Open		
Stroke Time	9.885	seconds	Stroke Time	9.796	seconds
Bypass Time	1.137	seconds	Bypass Time	2.213	seconds
Max Running Force	-18	lbs	Max Running Force	20	lbs
Avg Running Force	-15	lbs	Avg Running Force	17	lbs
Thrust at CST	~~29~~ 3775	lbs	Disc Pullout Force	~~33~~ 4307	lbs
Maximum Thrust	~~58~~ 7444	lbs			
Available Thrust Margin	-12	lbs	Torque Sw. Setting	O/C ~~1.500/1.500~~	
Spring Pack Preload		lbs			

COF = 0.104

thrust band:
limit to 12 122
max allowable: 12 122
accuracy 9.4 %

torque switch set to
5.0 and 5.0 after
completion of testing

C-clamp used as VOTES sensor. All force readings are in uV/V.
Divide by cal device force sens. of 0.00774 to find true thrust readings in lbf.

Torque Switch Setting Open/Close................: ~~1.500/1.500~~ 5.0 / 5.0
Limit Switch Rotor Adjustment (Y/N)............: N
Flow (gpm) Start/Finish........................: 0/ 0
Upstream Pressure (psi) Start/Finish...........: 0/ 0
Downstream Pressure (psi) Start/Finish.........: 0/ 0
General Comments:
VTC A1063 SEN=-.6776 LVDT 10290 SEN=20.279 SYSTEM 1034 MINI-C 20104 SEN=.6982
CFDS=.00774 TCF=1 LIMIT CLOSE W/ NON-LOCKING STEM/STEM NUT.

Valve Information
Plant: NASI
Unit.: ONE
Tag Number......: 1-SI-1869B-1
Type............: GATE
Size............: 3"
Target Thrust...: 0 lbs
Orientation.....:
Location........:
Stem Material...: 17-4 PH
Stem Diameter...: 1.125 inches
Threads per Inch: 3.00
Threads per Rev.: 2
/Poisson Ratio.: 106.0 x 10E6 psi
TES Serial #..:
BFSL Sensitivity 0.000E+0000 µv/v/lb
Votes Force Offset: 1.44 µv/v

Valve Actuator
Actuator Type..:
Size...........: SMB-00
Max Thrust Rate: 14000 lbs
Serial #.......:
Order #........:
Worm Gear Teeth: 40
Gear Ratio.....: 72
Spring Pack # ~~22~~ acts like N1 sp

Actuator Motor
Voltage Type: AC
Volts.......: 460
Amp rating..: ~~00.00~~ amps 2.8
Nom. Speed..: ~~00.00~~ rpm 1700
Start torque: ~~10.00~~ ft-lb 15
Run Torque..: ~~3.00~~ ft-lb 3
Horse Power.: ~~1.00~~ h.p. 1

Signal Conditioner Calibration Due Date 08/05/96

RD 3-5-96
IV MJ 3/1/96

Calibrator mounted in solid transition zone 3/4" below threads.

ME-0498 ADD. 00A
ATTACHMENT 1
REF. 5

Test Results Summary

PLANT: NASI

Unit: ONE

Evaluator: W. Thomas 2/19/96

Valve Tag Number: 1-SI-1836-1
Test Number: 11
Test Date: 2/18/96

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	460.00 Volts AC	

Switch Settings

Open Torque Switch Setting 1.250
Close Torque Switch Setting 1.250

Durations (seconds)

Closing	
Stroke Time	2.064
Seating Time	0.205
Contactor Dropout Time	0.010
Opening	

Motor Currents (amps rms)

Closing	
Inrush Current	12.0
Current at Contactor Dropout	2.5
Opening	
Inrush Current	12.3

General Comments:

Thrust verification test - C clamp-20104 sens .6982 cdfs .00774 votes 513
ALTMAN AND RIORDAN
C-clamp mounted .75" from threads - PARTIAL STROKE

AS LEFT AFTER COF TESTING (COF = 0.148)

C14 6438 LBS ✓ (LIMIT-CLOSE)

C16 9131 LBS ✓

09 4979 LBS ✓

SEE TEST #3 FOR CURRENT & SWITCHES, FULL STROKE

RD
3-4-96

As-left and COF

ME-6498 ADD. 001
ATTACHMENT 1
REF. 5

Evaluator: [signature]
Date: / / 16 Feb 96
Tag Number: 1-SI-1869A
Test Number: 1
Test Date: 2/15/96

TEST RESULTS

Close			Open		
Stroke Time	8.857	seconds	Stroke Time	8.718	seconds
Bypass Time	1.019	seconds	Bypass Time	1.951	seconds
Max Running Force	-1486	lbs	Max Running Force	1547	lbs
Avg Running Force	-1133	lbs	Avg Running Force	1125	lbs
Thrust at CST	-3935	lbs	Disc Pullout Force	6395	lbs
Maximum Thrust	-7569	lbs			
Available Thrust Margin	-2188	lbs	Torque Sw. Setting O/C	~~1.000/1.000~~	
Spring Pack Preload		lbs			

COF Ø.118

Limit closed valve. T.S to be set at 5.0 / 5.0

Calibration Range: 663 to -7258 lbs.

Torque Switch Setting Open/Close...............: ~~1.000/1.000~~
Limit Switch Rotor Adjustment (Y/N)............: N
Flow (gpm) Start/Finish........................: 0/ 0
Upstream Pressure (psi) Start/Finish...........: 0/ 0
Downstream Pressure (psi) Start/Finish.........: 0/ 0
General Comments:
SYSTEM A1076 VTC A1038 SEN=-.6745 LVDT 9712 SEN= 20.408 MINI-C 20086 SEN=.6717 CFDS=.00801 UNTHRD CAL 7/16" BELOW RUNOUT DeFF=1.007" LIMIT CLOSE VALVE WITH NON LOCKING STEM/STEM NUT. HI DISC PULLOUT NOTED. CYCLIC LOADS CORRESPOND TO DRV SLV RPM. TORQUE SWITCH SET TO 5 & 5 POST THIS TEST COLEMAN/ WARREN R.E.ANGLE

Valve Information		Valve Actuator		Actuator Motor	
Plant:	NASI	Actuator Type..:	LIMITORQ	Voltage Type:	AC
Unit.:	ONE	Size...........:	SMB-00	Volts.......:	460
Tag Number......:	1-SI-1869A	Max Thrust Rate:	14000 lbs	Amp rating..:	2.80 amps
Type............:	GATE	Serial #........:	115921	Nom. Speed..:	1700.00 rpm
Size............:	3"	Order #.........:	345804J	Start torque:	15.00 ft-lb
Target Thrust...:	0 lbs	Worm Gear Teeth:	38	Run Torque..:	3.00 ft-lb
Orientation.....:	VERT	Gear Ratio.....:	63	Horse Power.:	1.00 h.p.
Location........:	AB 244 PEN	Spring Pack #	22		
Stem Material...:	17-4PH				
Stem Diameter...:	1.125 inches				
Threads per Inch:	3.00				
Threads per Rev.:	2				
E/Poisson Ratio.:	106.0 x 10E6 psi				
VOTES Serial #..:	A6114				
BFSL Sensitivity	2.845E-0002 µv/v/lb				

Signal Conditioner Calibration Due Date 05/29/96

RD 3-4-96

IV 3/1/96

ME-0498, Rev. 0
Add. 0A
Attachment 1
Ref. 9

Test Results Summary

SURRY | Unit: ONE

Actuator: ______________________

Valve Tag Number: SI-1842
Test Number: 15
Test Date: 9/15/95

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	460.00 Volts AC	

Switch Settings

Open Torque Switch Setting	5.000
Close Torque Switch Setting	5.000

Durations (seconds)

Closing				
Stroke Time		15.234		
To Close Indicator Light On	seconds	15.234	% stroke	100.00
Close Torque Bypass Switch Opens	seconds	12.217	% stroke	80.20
To Open Indicator Light Off	seconds	15.234	% stroke	100.00
Seating Time		0.517		
Contactor Dropout Time		0.022		
Opening				
Stroke Time		14.932		
To Open Indicator Light On	seconds	14.932	% stroke	100.00
Open Torque Bypass Switch Opens	seconds	12.233	% stroke	81.92
To Close Indicator Light Off	seconds	14.932	% stroke	100.00
ntactor Dropout Time		0.014		

Forces (lbs) Calibration Range: 315 to -16518 lbs.

Closing	
Max Running Force	-946
Avg Running Force	-698
Thrust at Start of Wedging	-1002
Spring Pack Preload	-3191
Thrust at CST	-7857
Thrust at Contactor Dropout	-8381
Inertial Thrust	-1950
Maximum Thrust	-10331
Available Thrust Margin	-6855
Opening	
Initial Thrust (At Motor Start)	-10181
Disc Pullout Force	3553 ⇐
Max Running Force	607
Avg Running Force	607

Motor Currents (amps rms)

Closing	
Inrush Current	27.1
Average Running Current	2.8
Current at Contactor Dropout	3.6
Opening	
Inrush Current	26.1
Current at Maximum Pullout Force	3.1
Average Running Current	2.9

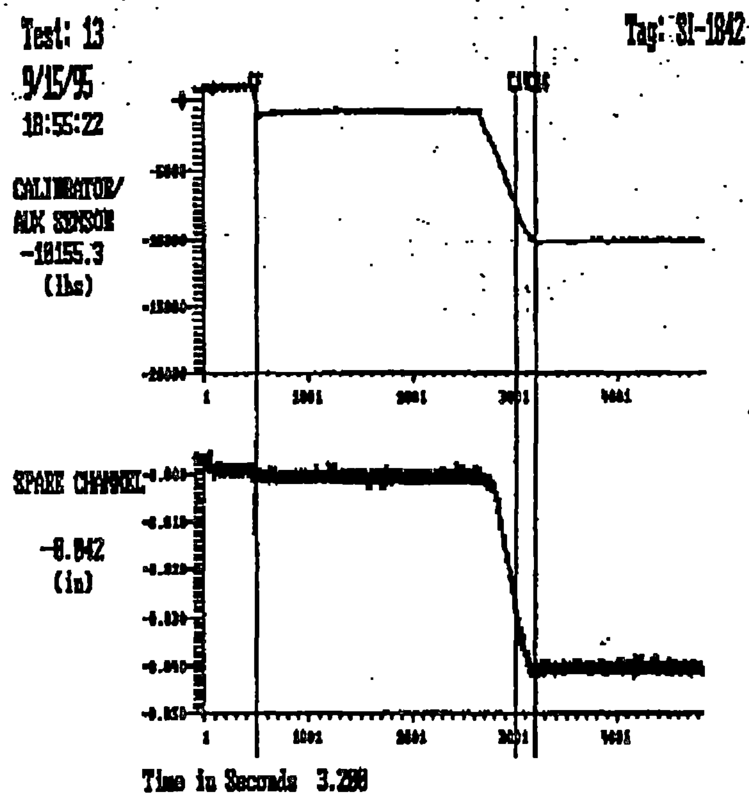
General Comments:

DW290898-03 ENGR TRANSMITTAL USED FOR THRUST RANDS ⇐
LIMITED CLOSED VALVE LST#7000-12000 MAX ALL.#21000 BYPASS 80-90%
VOTES SYS#2 /CLAMP USED:10041 SENS.5259 AS USED.00505 DEFF USED:1.25
TESTED ON U CLAMP AMP USED:6120
TESTED BY:TCAMILLO/RHUNDLEY/McKINLEY

ME-0498, Rev. 0
Add. 0A
Attachment 1
Ref 9

	Time (msecs)	Force (lbs) (Uncorrected)	Current (amps rms)	Description
O0	224	-10181	19.7	Motor Start
O1	231	-10245	26.1	Inrush Current Peak
O2	284	-10203	2.3	Lost Motion Region (Near Middle)
O3	644	-10128	2.8	Hammerblow/Start of Stem Decompression
O5	1198	739	3.1	Stem Takes up Disc Clearance
O9	1238	3553	3.1	Maximum Force at Disc Pullout
O13	1358	607	2.9	Opening Running Condition (Near Begin'g)
O12	12457	684	3.0	Open Torque Bypass Switch Opens
O15	15156	684	3.2	Close Indicator Light Off (Green)
O11	15156	684	3.2	Open Indicator Light On (Red)
O16	15156	684	3.2	Open Limit Switch Opens
O17	15170	717	2.8	Motor Current Cutoff
C0	17799	519	18.5	Motor Start
C1	17806	574	27.1	Inrush Current Peak
C2	17861	486	2.5	Lost Motion Region (Near Middle)
CF	18222	0	3.1	Zeroing Point for CF Calibration
C4	18293	-802	2.7	Closing Running Condition (Near Begin'g)
C7	30016	-769	2.5	Close Torque Bypass Switch Opens
C5	32650	-846	2.7	Closing Running Condition (Near End)
C11	32690	-1002	2.6	Disc Motion Stops / Start of Wedging
C13	32810	-3191	2.9	Spring Pack Starts to Compress
C6	33033	-7857	3.0	Close Indicator Light On (Green)
C8	33033	-7857	3.0	Open Indicator Light Off (Red)
C14	33033	-7857	3.0	Close Torque Switch Opens (or CST)
C15	33055	-8381	3.6	Motor Current Cutoff
C16	33207	-10331	0.0	Maximum Thrust Value
C17	33250	-10267	0.0	Final Thrust Value

ME-0498
Rev. 0, Add. 0A
Attachment 1
Reference 9



Analysis By: T. Carrillo 9.15.95
As Left TV / TMD
LST ≈ # 7750 ≈ .028
TOT = # 10284. ≈ .042
RL ≈ # 794
PRELOAD ≈ 3242

Force Sensor
LST ≈ # 7747
TOT = # 10395
RL = # 868

Torque Switch Setting Open/Close................: 5.000/5.000
Limit Switch Rotor Adjustment (Y/N)............: N
Flow (gpm) Start/Finish.........................: 0/ 0
Upstream Pressure (psi) Start/Finish............: 0/ 0
Downstream Pressure (psi) Start/Finish..........: 0/ 0
General Comments:
WO#290898-03 ENGR TRANSMITTAL USED FOR THRUST BANDS
LIMITED CLOSED VALVE LST#7000-12000 MAX ALL.#21000 BYPASS 80-90%
VOTES SYS#2 /CLAMP USED:10041 SENS.5259 AB USED.00505 DEFF USED:1.25
TESTED ON U CLAMP AMP USED:6120

Valve Information	Valve Actuator	Actuator Motor
Plant: SURRY	Actuator Type..: SMB/GRN	Voltage Type: AC
Unit.: ONE	Size...........: SMB-00	Volts........: 460
Tag Number......: SI-1842	Max Thrust Rate: 14000 lbs	Amp rating..: 3.50 amps
Type............: GATE	Serial #........: 260351	Nom. Speed..: 3400.00 rpm
Size............: 4 INCH	Order #.........: 3A29560	Start torque: 15.00 ft-lb
Target Thrust...: 12834 lbs	Worm Gear Teeth: 40	Run Torque..: 3.00 ft-lb
Orientation.....: HORIZ.	Gear Ratio.....: 28.2	Horse Power.: 1.90 h.p.
Location........: AB 2'LEVEL	Spring Pack # 112	
Stem Material...: 17-4PH		
Stem Diameter...: 1.250 inches		
Threads per Inch: 3.00		
Threads per Rev.: 1		
E/Poisson Ratio.: 106.0 x 10E6 psi		
VOTES Serial #..: A4692	Signal Conditioner Calibration Due Date 12/08/95	
DFSL Sensitivity 3.741E-0002 mv/v/lb		
Aux. Sensor Offset: -139.55 lbs		
Spare Channel Offset: 0.35 in		

UNIT ONE HASKINS 9/13/95 HH2P **ORIGINAL**

ME-0498, Rev. 0, Add 0A

Attachment 1 Ref. 9

TANYA WHITE DATE 8-24-95

VA POWER NCMWB036 SURRY W/O TASK : 00308182 01

ORIGINAL PRINTED 08/22/1995 PAGE 01 OF 05 WR TAG: PROG-M007-5 WR TAG LOC: NOT HUNG

85

MARK NUMBER: 38-01-SI-MOV-1869A-VALVOP- QUAL CLASS: SR
MN DESC: HHSI TO HOT LEGS UTC NUMBER: *
BOM ITEM NO: * MFR: L553 MODEL NO.: SMB-00,345804I SERIAL NO : * ITEM QCL: *
TASK TITLE : * RE-SET TORQUE SWITCH TYPE: PLANNED MAINTENANCE SR TASK: Y

LOC GRID X/Y : 7.3 J ELEV: 2 VIMS FR: *
LOCATION CODE: AB - AUXILIARY BUILDING
LOCATION DESC: 24 FT SOUTH OF GATE 1, 15 FT EAST OF CONTAINMENT WALL, 5 FT OFF FLOOR

Safety Related

TASK PROBLEM DESCRIPTION: TORQUE SWITCH NOT SET IAW REVISED DRP INSTRUCTIONS,1-DRP-007 PL/PL TASK PRIORITY: 4

RETAIN FAILED EQUIPMENT FOR CAUSE DETERMINATION EVALUATION

EQ

EQ HOST : Y	EQ RELATED : Y	HUMAN FACTORS: *		ENVIRONMENTAL ZONE: AB-2B	
REG 1.97 : Y	APPEND R : N	APPEND R AREA: 17		MRSSC: Y	
ISI REQD : *	TECH SPECS : *	SEISMIC : Y			
NPRDS ITEM : Y	INSUL COMP : *	TECH SPEC EXPIRATION DATE/TIME: *		*	

TASK INFORMATION

TAGOUT REQD : Y	WELD/FL REQD : N	ASME PRGM : Y	DEV RPT IND : Y
PMT REQD : Y	SCAF REQD : N	INS REM REQD : N	DEV RPT #'S : S-1674 * *
RWP REQD : Y	CONF ENTRY : N	IND SR : N	ENG REVIEW : Y
	SECURE REL : N	COATING REQD : N	ENG DES DOC : DRP-007

RWP NUMBERS : 95-3025 *______ *______ *______

PLANNER: GENNFBO BOOZE N UCR: 5 LMD: E TASK TYPE: PL
W/R SUBMITTED BY: * * * DEPT: * TROUBLE/BREAKDOWN: N
W/R APPROVED BY : * * * DATE: *

TASK SIGNATURES

OPERATIONS : [signature] DATE/TIME: 9-13-95 0200
LCO : N

QC NOTIFIED : POD DATE/TIME: 9-13-95 / 10:00

TAGGING VERIFIED BY: [signature] DATE/TIME: 9/14/95 / 19:19

TAGGING REPORT NBRS: S1-95-S1-20 S1-95-~~S1~~ CH-54

SPECIAL NOTES : WORK SAFE!!
** NOTE ** CONTACT SYSTEM ENGINEER A.WRIGHT AT EXT. 2747 OR JIM STAUFFER EXT. 2558 FOR ANY QUESTIONS
*** NOTE *** DENATURED ALCOHOL TO BE CARRIED INTO THE RCA ON SATURATED RAGS,IN PLASTIC BAGS ONLY.!!

TASK JOB STEPS

STEP NO	STEP DESCRIPTION	CRAFT	REQUIRED	HOURS	TOT HOURS
01	SURVEY,SET-UP AND RECLAMATION	HP	2	4.0	8.0
02	REVIEW WORK PACKAGE,(PMT) REQUIRMENTS AND (RWP)	ELEC	2	0.3	0.6
03	CONTACT (MOV) COORDINATOR PRIOR TO STARTING WORK	ELEC	1	0.1	0.1
04	VERIFY PROPER MARK #	ELEC	1	0.1	0.1
05	SET UP WORK AREA	ELEC	2	0.5	1.0

AUG 24 1995

ME-0498, Rev. 0, Add 0A
Attachment 1
Ref-9

Test Results Summary

Unit: ONE

Valve Tag Number: SI-1869A
Test Number: 27
Test Date: 9/14/95

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	440.00 Volts AC	

Switch Settings

Open Torque Switch Setting	5.000
Close Torque Switch Setting	5.000

Durations (seconds)

Closing				
Stroke Time		9.810		
To Close Indicator Light On	seconds	9.810	% stroke	100.00
Close Torque Bypass Switch Opens	seconds	2.524	% stroke	25.73
To Open Indicator Light Off	seconds	9.810	% stroke	100.00
Seating Time		0.104		
Contactor Dropout Time		0.013		
Opening				
Stroke Time		9.743		
To Open Indicator Light On	seconds	9.743	% stroke	100.00
Open Torque Bypass Switch Opens	seconds	2.454	% stroke	25.19
To Close Indicator Light Off	seconds	9.743	% stroke	100.00
Contactor Dropout Time		0.021		

Forces (lbs) Calibration Range: 1674 to -16176 lbs.

Closing	
Max Running Force	-2368
Avg Running Force	-2037
Thrust at Start of Wedging	-2368
Thrust at CST	-4912
Thrust at Contactor Dropout	-5979
Inertial Thrust	-2843
Maximum Thrust	-8822
Available Thrust Margin	-2543
Opening	
Initial Thrust (At Motor Start)	-9083
Disc Pullout Force	2293
Max Running Force	2293
Avg Running Force	1976

Motor Currents (amps rms)

Closing	
Inrush Current	15.3
Average Running Current	4.0
Current at Contactor Dropout	3.0
Opening	
Inrush Current	16.8
Current at Maximum Pullout Force	4.0
Average Running Current	4.0

General Comments:

.# 308182-01 RESET TQ SWITCH. NO ADJUSTMENTS MADE. TEST 25 TV WITH JUMPER
T 26 WITHOUT JUMPER AND TEST 27 FULL STROKES AS LEFT.
C-CLAMP USED 10041. SENS OF .5259 AND A.S. OF .00505 : SYSTEM 2 USED
TMD #124. TESTED BY L.D., J.B. , AND D.N. NIGHTSHIFT 9/15/95

	Time (msecs)	Force (lbs) (Uncorrected)	Current (amps rms)	Description
	81	-9015	9.6	Motor Start
	86	-9102	16.8	Inrush Current Peak
	231	-9367	3.9	Lost Motion Region (Near Middle)
03	451	-9190	4.2	Hammerblow/Start of Stem Decompression
04	685	-376	4.3	Stem Compression Fully Relieved
09	742	2361	4.0	Maximum Force at Disc Pullout
013	1031	2288	3.8	Opening Running Condition (Near Begin'g)
012	2535	1998	4.4	Open Torque Bypass Switch Opens
014	9308	1926	4.4	Opening Running Condition (Near End)
011	9824	2071	4.3	Open Indicator Light On (Red)
015	9824	2071	4.3	Close Indicator Light Off (Green)
016	9824	2071	4.3	Open Limit Switch Opens
017	9845	2071	0.9	Motor Current Cutoff
C0	13785	1926	6.9	Motor Start
C1	13790	1998	15.3	Inrush Current Peak
C2	13982	2071	4.2	Lost Motion Region (Near Middle)
C3	14218	68	3.8	Tension to Compression Transition
CF	14219	-0	4.0	Zeroing Point for CF Calibration
C4	14789	-2074	4.2	Closing Running Condition (Near Begin'g)
C7	16309	-2074	3.7	Close Torque Bypass Switch Opens
C5	23011	-1848	4.2	Closing Running Condition (Near End)
C11	23558	-2300	4.0	Disc Motion Stops / Start of Wedging
C14	23595	-4844	4.3	Close Torque Switch Opens (or CST)
C8	23595	-4844	4.3	Open Indicator Light Off (Red)
C6	23595	-4844	4.3	Close Indicator Light On (Green)
C15	23608	-5911	3.0	Motor Current Cutoff
C16	23662	-8754	0.0	Maximum Thrust Value
C17	23822	-8582	0.0	Final Thrust Value

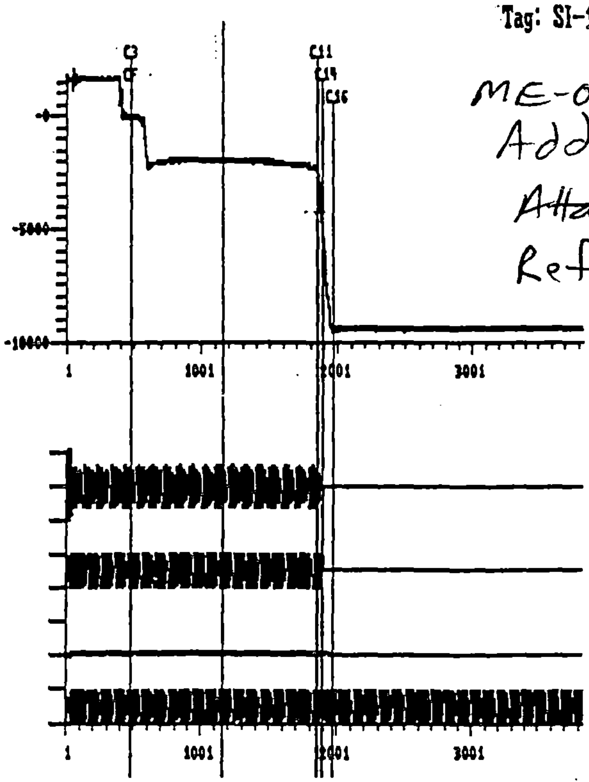
ME 0498, Rev. 0, Add 0A
Attachment 1
Ref. 9

Work Order Copy

Tag: SI-1869A

/26
/14/95
23:38:11

CALIBRATOR/
AUX SENSOR
-1889.4
(lbs)



Time in Seconds 1.168

ME-0498, Rev. 0, Add 0A
Attachment 1
Ref. 9

T.V. without Jumper

	C14	C16
VOTES Sensor	4895	9533
Aux Sensor	5024	9533

Running Load ± 2150

[signature]

Torque Switch Setting Open/Close................: 0.000/0.000
Limit Switch Rotor Adjustment (Y/N).............: N
Flow (gpm) Start/Finish.........................: 0/ 0
Upstream Pressure (psi) Start/Finish............: 0/ 0
Downstream Pressure (psi) Start/Finish..........: 0/ 0
General Comments:

Valve Information
Plant: SURRY
Unit.: ONE
Tag Number.......: SI-1869A
Type.............: GATE
Size.............: 3 INCH
Target Thrust...: 9075 lbs
Orientation......: HORIZ.
Location.........: AB BASE.
Stem Material...: 17-4PH
Stem Diameter...: 1.250 inches
Threads per Inch: 3.00
Threads per Rev.: 1
E/Poisson Ratio.: 106.0 x 10E6 psi
VOTES Serial #..: A4536
SL Sensitivity 1.250E-0002 µv/v/lb
x. Sensor Offset: -1309.73 lbs
Spare Channel Offset: -0.00 in

Valve Actuator
Actuator Type..: 9BN/6BX
Size...........: SMB-00
Max Thrust Rate: 14000 lbs
Serial #........:
Order #.........: 3458041
Worm Gear Teeth: 25
Gear Ratio.....: 28.2
Spring Pack # 022

Actuator Motor
Voltage Type: AC
Volts.......: 440
Amp rating..: 2.70 amps
Nom. Speed..: 1750.00 rpm
Start torque: 15.00 ft-lb
Run Torque..: 0.00 ft-lb
Horse Power.: 1.00 h.p.

Signal Conditioner Calibration Due Date 12/08/95

UNIT ONE Attachment HASKINS 9/15/95 Ref-9 ORIGINAL

NE-0498 Rev-0 Add. 04 W/O TASK : 00815684 01

ENTERED TANYA WHITE DATE 8-24-95

PRINTED 08/22/1995 PAGE 01 OF 05 WR TAG: PROG-M005-5 WR TAG LOC: NOT HUNG

MARK NUMBER: 38-01-SI-MOV-1869B-VALVOP- QUAL CLASS: SR
MN DESC: CHARGING PUMP DISCHARGE TO LOOP UTC NUMBER: *
BOM ITEM NO: * MFR: L553 MODEL NO.: SB-00,3A5149C SERIAL NO : * ITEM QCL: *
TASK TITLE : * PERFORM VOTES VTC AND RETURN TO SERV. TYPE: PLANNED MAINTENANCE SR TASK: Y

LOC GRID X/Y : 7.3 J ELEV: 2 VIMS FR: *
LOCATION CODE: AB - AUXILIARY BUILDING
LOCATION DESC: 20 FT SOUTH OF GATE 1, 15 FT EAST OF CONTAINMENT WALL, 3 FT OFF FLOOR

Safety Related

TASK PROBLEM DESCRIPTION: PERFORM VOTES VTC AND A VOTES RETURN TO SERVICE TESTING PL/SV

RETAIN FAILED EQUIPMENT FOR CAUSE DETERMINATION EVALUATION

EQ HOST : Y EQ RELATED : Y HUMAN FACTORS: * ENVIRONMENTAL ZONE: AB-2B
REG 1.97 : Y APPEND R : N APPEND R AREA: 17 MRSSC: Y
ISI REQD : * TECH SPECS : * SEISMIC : Y
NPRDS ITEM : Y INSUL COMP : * TECH SPEC EXPIRATION DATE/TIME: * *

EQ

T A S K I N F O R M A T I O N

TAGOUT REQD : N WELD/FL REQD : N ASME PRGM : Y DEV RPT IND : N
PMT REQD : Y SCAF REQD : N INS REM REQD : N DEV RPT #'S : * * *
RWP REQD : Y CONF ENTRY : N IND SR : N ENG REVIEW : Y
SECURE REL : N COATING REQD : N ENG DES DOC : *
RWP NUMBERS : 95-3025 *________ *________ *________

PLANNER: GENNFBO BOOZE N UCR: 5 LMD: E TASK TYPE: SV
W/R SUBMITTED BY: * * * DEPT: * TROUBLE/BREAKDOWN: N
W/R APPROVED BY : * * * DATE: *

T A S K S I G N A T U R E S

OPERATIONS : [signature] DATE/TIME: 9/16/95 / 0350
LCO : NO

QC NOTIFIED : POD item 170 DATE/TIME: 9/16/95 0700

TAGGING VERIFIED BY: NA DATE/TIME: NA / NA

TAGGING REPORT NBRS: N/A

SPECIAL NOTES : WORK SAFE"
** NOTE ** DENATURED ALCOHOL TO BE CARRIED INTO THE (RCA) ON SATURATED RAGS,IN PLASTIC BAGS ONLY.!!!!

T A S K J O B S T E P S

STEP NO	STEP DESCRIPTION	CRAFT	REQUIRED	HOURS	TOT HOURS
01	SURVEY,SET-UP AND RECLAMATION	HP	2	4.0	8.0
02	REVIEW WORK PACKAGE,(PMT) REQUIRMENTS AND (RWP)	ELEC	2	0.3	0.6
03	CONTACT(MOV)COORDINATOR PRIOR TO STARTING WORK	ELEC	1	0.1	0.1
04	VERIFY PROPER MARK #	ELEC	1	0.1	0.1
05	SET UP WORK AREA	ELEC	1	0.5	0.[illegible]
06	FME,IAW VPAP-1302	ELEC	1	0.1	0.[illegible]
07	PERFORM VTC VOTES TEST	ELEC	2	5.0	10
08	PERFORM RETURN TO SERVICE VOTES TEST	ELEC	2	5.0	1[illegible]

RECEIVED
AUG 24 1995

Test Results Summary

SURRY

Unit: ONE

ME-0498, Rev. 0, Add 04
Attachment 1
Ref. 9

tor:____________________

Valve Tag Number: SI-1869B
Test Number: 13
Test Date: 9/16/95

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	460.00 Volts AC	

Switch Settings

Open Torque Switch Setting	5.000
Close Torque Switch Setting	5.000

Durations (seconds)

Closing				
Stroke Time		8.525		
To Close Indicator Light On	seconds	8.525	% stroke	100.00
Close Torque Bypass Switch Opens	seconds	2.731	% stroke	32.04
To Open Indicator Light Off	seconds	8.525	% stroke	100.00
Seating Time		0.293		
Contactor Dropout Time		0.017		
Opening				
Stroke Time		8.261		
To Open Indicater Light On	seconds	8.261	% stroke	100.00
Open Torque Bypass Switch Opens	seconds	2.069	% stroke	25.05
To Close Indicator Light Off	seconds	8.261	% stroke	100.00
Contactor Dropout Time		0.011		

Forces (lbs) Calibration Range: 224 to -16626 lbs.

Closing	
Max Running Force	-525
Avg Running Force	-184
Thrust at Start of Wedging	-525
Thrust at CST	-1531
Thrust at Contactor Dropout	-2012
Inertial Thrust	-2586
Maximum Thrust	-4598
Available Thrust Margin	-1006
Opening	
Initial Thrust (At Motor Start)	-4727
Disc Pullout Force	3100
Max Running Force	930
Avg Running Force	272

Motor Currents (amps rms)

Closing	
Inrush Current	26.3
Average Running Current	3.2
Current at Contactor Dropout	3.5
Opening	
Inrush Current	27.0
Current at Maximum Pullout Force	3.1
Average Running Current	3.0

General Comments:

#315684-01
LIMITED CLOSED VALVE >C11 MAX ALL.#14000 BYPASS 25-35% BOTH DIR.
VOTES SYS#2 /CLAMP USED:10041 SENS.5259 AS USED.00505 DEFF USED:1.25
TESTED ON U/ CLAMP AMP USED:6120 TYPE STEM: GP
TESTED BY:TCAMILLO/TCOYNE

ME-0499, Rev. 0
Add 0A
Attachment 1
Ref. 9

	Time (msecs)	Force (lbs) (Uncorrected)	Current (amps rms)	Description
	215	-4727	19.6	Motor Start
	221	-4598	27.0	Inrush Current Peak
[illegible]	282	-4468	2.4	Lost Motion Region (Near Middle)
o3	486	-4336	3.2	Hammerblow/Start of Stem Decompression
o5	849	-0	3.0	Stem Takes up Disc Clearance
o9	890	3100	3.1	Maximum Force at Disc Pullout
o13	1050	310	2.9	Opening Running Condition (Near Begin'g)
o12	2284	155	2.7	Open Torque Bypass Switch Opens
o14	8409	310	2.7	Opening Running Condition (Near End)
o11	8476	155	2.8	Open Indicator Light On (Red)
o15	8476	155	2.8	Close Indicator Light Off (Green)
o16	8476	155	2.8	Open Limit Switch Opens
o17	8487	310	3.0	Motor Current Cutoff
C0	12954	310	12.7	Motor Start
C1	12964	155	26.3	Inrush Current Peak
C2	13017	310	2.4	Lost Motion Region (Near Middle)
CF	13298	-0	3.2	Zeroing Point for CF Calibration
C4	13718	-177	3.2	Closing Running Condition (Near Begin'g)
C7	15685	-177	3.2	Close Torque Bypass Switch Opens
C5	21369	-177	3.1	Closing Running Condition (Near End)
C11	21409	-525	3.2	Disc Motion Stops / Start of Wedging
C14	21479	-1531	3.6	Close Torque Switch Opens (or CST)
C6	21479	-1531	3.6	Close Indicator Light On (Green)
C8	21479	-1531	3.6	Open Indicator Light Off (Red)
C15	21496	-2012	3.5	Motor Current Cutoff
C16	21702	-4598	0.0	Maximum Thrust Value
C17	21742	-4598	0.0	Final Thrust Value

-45-01

3/14

Attachment 1

ME-0498, Rev. 0, Add 0A

Ref. 9

UNIT TWO

ORIGINAL

VA POWER NCMWB036 POW 26 06 SURRY W/O TASK : 00314132 01

ORIGINAL PRINTED 03/14/1995 PAGE 01 OF 05 WR TAG: 058121 WR TAG LOC: NOT HUNG

MARK NUMBER: 38-02-SI-MOV-2842-VALVOP- QUAL CLASS: SR

MN DESC: ALT HHSI TO COLD LEGS UTC NUMBER: *

BOM ITEM NO: * MFR: L553 MODEL NO.: SMB-0,345629C8 SERIAL NO : * ITEM QUAL CL: *

TASK TITLE : ADJUST VALVE STROKE TYPE: CORRECTIVE MAINTENANCE SR TASK: Y

LOC GRID X/Y : 10.5 J ELEV: 2 VIMS FR: *

LOCATION CODE: AB - AUXILIARY BUILDING

LOCATION DESC: 15 FT NORTH OF SOUTH WALL 20 FT WEST OF EAST WALL 4 FT OFF FLOOR

Safety Related

TASK PROBLEM DESCRIPTION: VALVE FAILS 100 LBS.AIR TEST FOR BACK LEAKAGE,NEED TO ADJUST STROKE VALVE SEAT WHEN HAND TORQUED CO/CM

TASK PRIORITY: 1

EQ HOST	: Y	EQ RELATED	: Y	HUMAN FACTORS: *		ENVIRONMENTAL ZONE: AB-2A	
REG 1.97	: N	APPEND R	: Y	APPEND R AREA: 17		MRSSC: Y	
ISI REQD	: *	TECH SPECS	: *	SEISMIC	: Y		
NPRDS ITEM	: Y	INSUL COMP	: *	TECH SPEC EXPIRATION DATE/TIME: *			

TASK INFORMATION

TAGOUT REQD	: Y	WELD/FL REQD	: N	ASME PRGM	: Y	DEV RPT IND	: N
PMT REQD	: Y	SCAF REQD	: N	INS REM REQD	: N	DEV RPT #'S	: *
RWP REQD	: Y	CONF ENTRY	: N	IND SR	: N	ENG REVIEW	: N
		SECURE REL	: N	COATING REQD	: N	ENG DES DOC	: *

RWP NUMBERS : *_______ *_______ *_______ *_______

EQ

PLANNER: GENNFBO BOOZE N UCR: 5 LMD: E TASK TYPE: CM

W/R SUBMITTED BY: HERRY W * DEPT: OPS TROUBLE/BREAKDOWN: N

W/R APPROVED BY : BOOZE N DATE: 03/14/1995

TASK SIGNATURES

OPERATIONS : [signature] DATE/TIME: 3/14/95 1821

LCO : ______

QC NOTIFIED : POD DATE/TIME: ______ / ______

TAGGING VERIFIED BY: ______ DATE/TIME: ______ / ______

TAGGING REPORT NBRS: 2-95-SI-68

SPECIAL NOTES : ** NOTE ** DENATURED ALCOHOL TO BE CARRIED INTO THE (RCA) ON SATURATED RAGS,IN PLASTIC BAGS ONLY.!!!! WORK SAFE!!

TASK JOB STEPS

STEP NO	STEP DESCRIPTION	CRAFT	REQUIRED	HOURS	TOT HOURS
01	SURVEY,SET-UP AND RECLAMATION	HP	2	4.0	8.0
02	REVIEW WORK PACKAGE,(PMT) REQUIRMENTS AND (RWP)	ELEC	2	0.3	0.6
03	CONTACT(MOV)COORDINATOR PRIOR TO STARTING WORK	ELEC	1	0.1	0.1
04	VERIFY PROPER MARK #	ELEC	1	0.1	0.1
05	SET UP WORK AREA	ELEC	1	0.5	0.5
06	VERIFY CONPONENT IS PROPERLY TAGGED	ELEC	1	0.1	0.1
07	FME,IAW VPAP-1302	ELEC	1	0.1	0.1
08	ADJUST VALVE STROKE	ELEC	2	4.0	8.0
09	CLEAN WORK AREA,RELEASE TAGS AND CLOSE OUT(PMT)	ELEC	1	1.0	1.0
10	DOCUMENT WORK PERFORMED AND MATERIALS USED	ELEC	1	1.0	1.0
11	COMPLETE ALL PAPER WORK AND REVIEW WORK PACKAGE	ELEC	1	1.0	1.0
				TOTAL EST HOURS:	20.5

ME-0498, Rev. 0, Add 07
Attachment 1
Reference 9

Test Results Summary

RY

Unit: TWO

...tor: [signature]

Verify: Jeff Bridger

Valve Tag Number: SI-2842
Test Number: 18
Test Date: 3/15/95

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	460.00 Volts AC	

Switch Settings

Open Torque Switch Setting 5.000
Close Torque Switch Setting 5.000

	AUX SEN.	VOTES SEN.
TST =	3789	3822
MAX =	22,041	20,937
TOTAL:	21,987	20,748

Durations (seconds)

Closing				
Stroke Time		9.323		
To Close Indicator Light On	seconds	9.323	% stroke	100.00
Close Torque Bypass Switch Opens	seconds	8.565	% stroke	91.87
To Open Indicator Light Off	seconds	9.323	% stroke	100.00
Seating Time		0.152		
Contactor Dropout Time		0.012		
Opening				
Stroke Time		9.030		
To Open Indicator Light On	seconds	9.030	% stroke	100.00
Open Torque Bypass Switch Opens	seconds	8.489	% stroke	94.01
To Close Indicator Light Off	seconds	9.030	% stroke	100.00
Contactor Dropout Time		0.016		

Forces (lbs) Calibration Range: 1517 to -20973 lbs.

Closing	
Max Running Force	-6137
Avg Running Force	-2276
Thrust at Start of Wedging	-153
Thrust at CST	-1523
Thrust at Contactor Dropout	-3186
Inertial Thrust	-15507
Maximum Thrust	-18693
Available Thrust Margin	-1371
Opening	
Initial Thrust (At Motor Start)	-18344
Disc Pullout Force	1156
Max Running Force	763
Avg Running Force	467

Motor Currents (amps rms)

Closing	
Inrush Current	25.4
Average Running Current	2.4
Current at Contactor Dropout	2.5
Opening	
Inrush Current	25.5
Current at Maximum Pullout Force	2.2
Average Running Current	2.3

General Comments:

WO# 3149322-01 BYPASSES SET AT 90 TO 95 % BOTH WAYS. SYSTEM #2 USED
S USED A1176 , SENS. 5494 ; TV DEV SENS. .00406 TESTED ON SOLID
GR TRANSMITTAL USED TO SET THRUST BAND. (A.WRIGHT) ATTACHED.
LIMIT RESET TO SUPPORT 16.4 GROUP TO REDUCE LEAKAGE.
PREVIOUS CAL ENTERED FOR FORCE SENSOR. NON-LINEAR TESTED BY:CAMILLO/HUNDLEY

ME-0498, Rev. 0, AddA
Attachment 1
Ref. 9

	Time (msecs)	Force (lbs) (Uncorrected)	Current (amps rms)	Description
	41	-18344	22.3	Motor Start
	45	-18344	25.5	Inrush Current Peak
O3	92	-20950	4.9	Hammerblow/Start of Stem Decompression
O2	101	-15877	2.1	Lost Motion Region (Near Middle)
O5	561	200	2.4	Stem Takes up Disc Clearance
O9	650	1156	2.2	Maximum Force at Disc Pullout
O13	981	478	2.4	Opening Running Condition (Near Begin'g)
O12	8530	374	2.2	Open Torque Bypass Switch Opens
O14	8911	263	2.4	Opening Running Condition (Near End)
O16	9071	226	2.3	Open Limit Switch Opens
O11	9071	226	2.3	Open Indicator Light On (Red)
O15	9071	226	2.3	Close Indicator Light Off (Green)
O17	9087	200	2.3	Motor Current Cutoff
C0	12833	469	8.9	Motor Start
C1	12845	410	25.4	Inrush Current Peak
C2	12897	427	1.9	Lost Motion Region (Near Middle)
CF	13317	0	2.3	Zeroing Point for CF Calibration
C4	13356	-5484	2.4	Closing Running Condition (Near Begin'g)
C7	21398	-2734	2.4	Close Torque Bypass Switch Opens
C5	22092	-153	2.5	Closing Running Condition (Near End)
C11	22132	-153	2.5	Disc Motion Stops / Start of Wedging
C14	22156	-1523	2.6	Close Torque Switch Opens (or CST)
C6	22156	-1523	2.6	Close Indicator Light On (Green)
C8	22156	-1523	2.6	Open Indicator Light Off (Red)
C15	22168	-3186	2.5	Motor Current Cutoff
C16	22284	-18693	0.0	Maximum Thrust Value
C17	22324	-18970	0.0	Final Thrust Value

UNIT TWO Attachment 1 CH 2-6-95 0150-02 (70150185) ME-0498 Rev. 0, Add 0A **ORIGINAL**

VA POWER NCHWB036 POW 20 06 SURRY W/O TASK : 00285789 01 Ref. 9
ORIGINAL PRINTED 01/12/1995 PAGE 01 OF 05 WR TAG: PROG 3 WR TAG LOC: PROG 3

MARK NUMBER: 3B-02-SI-MOV-2869A-VALVOP- QUAL CLASS: SR
MN DESC: HHSI TO HOT LEGS UTC NUMBER: *
BOM ITEM NO: * MFR: L553 MODEL NO.: SMB-00,345804I SERIAL NO : * ITEM QUAL CL: *
TASK TITLE : * PERFORM VOTES TEST OF MOV. TYPE: PLANNED MAINTENANCE SR TASK: Y

LOC GRID X/Y : 10.5 J ELEV: 2 VIMS FR: *
LOCATION CODE: AB - AUXILIARY BUILDING
LOCATION DESC: 20 FT NORTH OF SOUTH WALL 20 FT WEST OF EAST WALL 4 FT OFF FLOOR

Safety Related

TASK PROBLEM VOTES TEST TASK PRIORITY: 3
DESCRIPTION: PERFORM VOTES TESTING TO RESET WITHIN BAND DR# S-93-0741
CTS-2178
CTS-1674,GL-89-10

EQ HOST	: Y	EQ RELATED	: Y	HUMAN FACTORS: *		ENVIRONMENTAL ZONE: AB-2A	
REG 1.97	: *	APPEND R	: Y	APPEND R AREA: 17		MRSSC: Y	
ISI REQD	: *	TECH SPECS	: *	SEISMIC	: Y		
NPRDS ITEM	: Y	INSUL COMP	: *	TECH SPEC EXPIRATION DATE/TIME: *		*	

EQ

TASK INFORMATION

TAGOUT REQD	: N	WELD/FL REQD	: N	ASME PRGM	: Y	DEV RPT IND	: Y
PMT REQD	: Y	SCAF REQD	: N	INS REM REQD	: N	DEV RPT #'S	: S-93-0741 * *
RWP REQD	: Y	CONF ENTRY	: N	IND SR	: N	ENG REVIEW	: N
		SECURE REL	: N	COATING REQD	: N	ENG DES DOC	: *

RWP NUMBERS : *2025 *________ *________ *________

PLANNER: GENNFBO BOOZE N UCR: 5 LMD: E TASK TYPE: RG
W/R SUBMITTED BY: HUGHES D L DEPT: SENG TROUBLE/BREAKDOWN: N
W/R APPROVED BY : MONE F P DATE: 08/09/1993

TASK SIGNATURES

OPERATIONS : B. Juneerez DATE/TIME: 2-6-95 / 1630
LCO :

QC NOTIFIED : POD DATE/TIME: 2/7/95 / 16:00

TAGGING VERIFIED BY: N/A DATE/TIME: ________ /________

TAGGING REPORT NBRS: N/A ________ ________

SPECIAL NOTES : WORK SAFE" WHT

TASK JOB STEPS

STEP NO	STEP DESCRIPTION	CRAFT	REQUIRED	HOURS	TOT HOURS
01	SURVEY,SET-UP AND RECLAMATION	HP	2	2.0	4.0
02	REVIEW WORK PACKAGE,(PMT) REQUIREMENTS AND (RWP)	ELEC	2	0.5	1.0
03	CONTACT (MOV) COORDINATOR,J. STAUFFER,EXT.2558	ELEC	1	0.1	0.1
04	PRIOR TO STARTING WORK	ELEC	1	0.1	0.1
05	VERIFY PROPER MARK #	ELEC	1	0.1	0.1
06	SET UP WORK AREA	ELEC	1	0.1	0.1
07	PERFORM VOTES DIAGNOSTIC TEST IAW PROCEDURE	ELEC	2	5.0	10.0
08	CLEAN WORK AREA AND CLOSE OUT (PMT)	ELEC	1	0.5	0.5
09	CONTACT (MOV) COORDINATOR WITH TEST RESULTS	ELEC	1	0.1	0.1
10	DOCUMENT WORK PERFORMED	ELEC	1	1.0	1.0
11	COMPLETE ALL PAPER WORK AND REVIEW WORK PACKAGE	ELEC	1	1.0	1.0
				TOTAL EST HOURS:	18.0

PENETRATION RELATED

ME-0498, Rev. 0, Add. 0A
Attachment 1
Ref. 9

Test Results Summary

: SURRY   Unit: TWO

Evaluator: D. Gills

Valve Tag Number: SI-2869A
Test Number: 28
Test Date: 2/7/95

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	440.00 Volts AC	

Switch Settings

Open Torque Switch Setting	5.000
Close Torque Switch Setting	5.000

Durations (seconds)

Closing				
Stroke Time		10.303		
Close Torque Bypass Switch Opens	seconds	2.888	% stroke	28.03
To Open Indicator Light Off	seconds	10.304	% stroke	100.01
Seating Time		0.256		
Contactor Dropout Time		0.013		
Opening				
Stroke Time		9.362		
Open Torque Bypass Switch Opens	seconds	2.259	% stroke	24.13
To Close Indicator Light Off	seconds	9.362	% stroke	100.00
Contactor Dropout Time		0.016		

Forces (lbs)   Calibration Range: 641 to -15176 lbs.

Closing	
Max Running Force	-564
Avg Running Force	-104
Thrust at Start of Wedging	-564
Spring Pack Preload	-5272
Thrust at CST	-871
Thrust at Contactor Dropout	-1287
Inertial Thrust	-7497
Maximum Thrust	-8784
Available Thrust Margin	-307
Opening	
Initial Thrust (At Motor Start)	-5584
Disc Pullout Force	6725
Max Running Force	822
Avg Running Force	364

Motor Currents (amps rms)

Closing	
Inrush Current	16.0
Average Running Current	2.5
Current at Contactor Dropout	2.5
Opening	
Inrush Current	16.0
Current at Maximum Pullout Force	2.5
Average Running Current	2.5

General Comments:

WO# 00285789-01 VALVE CHANGED TO LIMIT CLOSE USING WO# 00299578-01 RESET CLOSE LIMIT AS PER DRP-007 NOTE 2 CST= 847.1# TOTAL= 8642# FINAL= 8557#

TESTED By SLAYTON & Bridges.

ME-0498, Rev. 0, Add. 0A
Attachment 1
Ref. 9
Test 27

Thrust Verification using Force Sensor

CST = 847.1# @ .001
TOTAL = 8642# @ .042
FINAL = 8557# @ .043

2-8-95

Verified By
Randy Hundley 2-8-95

Test: 27
2/7/95
20:25:56

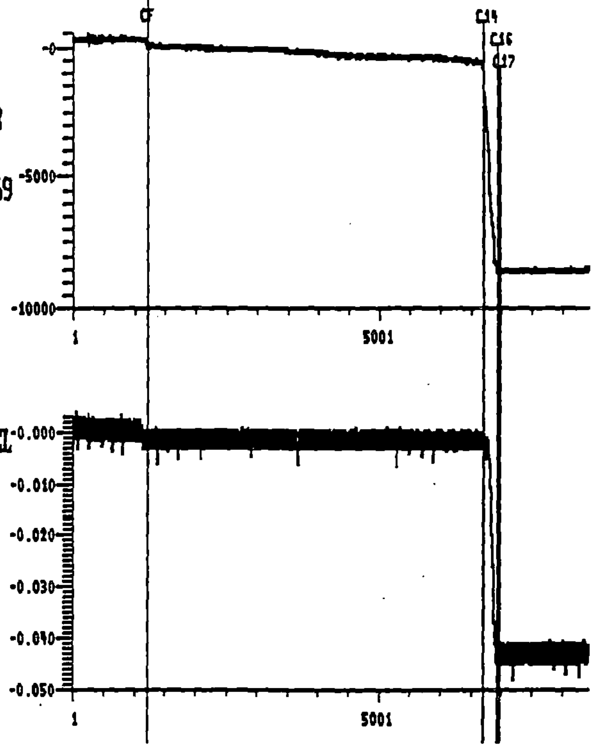
Tag: SI-2869A

VOTES SENSOR

Force = -52.69
(lbs)

SPARE CHANNEL

-0.003
(in)



Time in Seconds 1.217
Calibration Range: 641 to -15176 lbs.

Torque Switch Setting Open/Close...............: 5.000/5.000
Limit Switch Rotor Adjustment (Y/N)............: Y
Flow (gpm) Start/Finish........................: 0/ 0
Upstream Pressure (psi) Start/Finish...........: 0/ 0
Downstream Pressure (psi) Start/Finish.........: 0/ 0
General Comments:
WO# 00285789-01 VALVE CHANGED TO LIMIT CLOSE USING WO# 00299578-01 RESET CLOSE LIMIT AS PER DRP-007 NOTE 2 CST= 847.1# TOTAL= 8642# FINAL= 8557#
TESTED BY SLAYTON & BRIDGES

Valve Information

Plant: SURRY
Unit.: TWO
Tag Number......: SI-2869A
Type............: GATE
Size............: 3INCH
Target Thrust...: 8517 lbs
Orientation.....: HORIZ
Location........: AUX-BAS
Stem Material...: 17-4PH
Stem Diameter...: 1.125 inches
Threads per Inch: 3.00
Threads per Rev.: 2
E/Poisson Ratio.: 106.0 x 10E6 psi
VOTES Serial #..: A5452
BFSL Sensitivity -1.280E-0002 µv/v/lb
Spare Channel Offset: -0.13 in

Valve Actuator

Actuator Type..: 9BN/6BX
Size...........: SMB/00
Max Thrust Rate: 12500 lbs
Serial #.......: 114534
Order #........: 345804I
Worm Gear Teeth: 25
Gear Ratio.....: 72
Spring Pack # 022

Actuator Motor

Voltage Type: AC
Volts.......: 440
Amp rating..: 2.70 amps
Nom. Speed..: 1750.00 rpm
Start torque: 15.00 ft-lb
Run Torque..: 0.00 ft-lb
Horse Power.: 1.00 h.p.

Signal Conditioner Calibration Due Date 07/04/95

ME-0498, Attachment 1
Rev. 0
Add 04
Ref. 9

	Time (msecs)	Force (lbs) (Uncorrected)	Current (amps rms)	Description
[illegible]	124	-5584	3.2	Motor Start
[illegible]	131	-5732	16.0	Inrush Current Peak
O2	157	-5000	7.9	Lost Motion Region (Near Middle)
O9	1991	6725	2.5	Maximum Force at Disc Pullout
O12	2383	6282	2.5	Open Torque Bypass Switch Opens
O13	2769	306	2.6	Opening Running Condition (Near Begin'g)
O14	9459	295	2.5	Opening Running Condition (Near End)
O16	9486	271	2.6	Open Limit Switch Opens
O15	9486	271	2.6	Close Indicator Light Off (Green)
O17	9502	351	1.8	Motor Current Cutoff
C0	14826	1037	4.1	Motor Start
C0-	14826	1037	4.1	
C1	14835	1394	16.0	Inrush Current Peak
C2	14860	329	6.6	Lost Motion Region (Near Middle)
CF	15799	-0	2.4	Zeroing Point for CF Calibration
C4	15866	30	2.5	Closing Running Condition (Near Begin'g)
C7	17714	-15	2.4	Close Torque Bypass Switch Opens
C5	25075	-458	2.4	Closing Running Condition (Near End)
C11	25107	-564	2.3	Disc Motion Stops / Start of Wedging
C14	25129	-871	2.5	Close Torque Switch Opens (or CST)
C8	25130	-908	2.5	Open Indicator Light Off (Red)
C15	25142	-1287	2.5	Motor Current Cutoff
C13	25225	-5272	0.0	Spring Pack Starts to Compress
C16	25363	-8784	0.0	Maximum Thrust Value
C17	25565	-8689	0.0	Final Thrust Value
VC1	25565	-8689	0.0	

Attachment ... ME-0498 Rev. 0 Add. 0A

Safety Related 5/13

VA POWER NCMWB036 SURRY Ref. 9 W/O TASK : 00341652 02
ORIGINAL PRINTED 05/13/1996 PAGE 01 OF 05 WR TAG: * WR TAG LOC: *

MARK NUMBER: 38-02-SI-MOV-2869B-VALVOP- QUAL CLASS: SR
MN DESC: HHSI TO HOT LEGS UTC NUMBER: *
BOM ITEM NO: * MFR: L553 MODEL NO.: SMB-00,152299-01 SERIAL NO : * ITEM QCL: *
TASK TITLE : ELECTRICAL DISCONNECT AND RECONNECT TYPE: CORRECTIVE MAINTENANCE SR TASK: Y

LOC GRID X/Y : 10.7 J ELEV: 2 VIMS FR: *
LOCATION CODE: AB - AUXILIARY BUILDING
LOCATION DESC: 20 FT NORTH OF SOUTH WALL 20 FT WEST OF EAST WALL 3 FT OFF FLOOR

EQ

TASK PROBLEM DESCRIPTION: ELECTRICAL DISCONNECT AND RECONNECT TO SUPPORT MECH.TASK 1 TASK PRIORITY: 1

RETAIN FAILED EQUIPMENT FOR CAUSE DETERMINATION EVALUATION

EQ REL	: N	EQML	: Y	HUMAN FACTORS: *		ENVIRONMENTAL ZONE: AB-2B	
REG 1.97	: N	APPEND R	: N	APPEND R AREA: 17		MRSUS: Y	
SEISMIC	: Y	NPRDS ITEM	: Y	INSUL COMP	: *		

TASK INFORMATION

TAGOUT REQD	: Y	WELD/FL REQD	: N	ASME PRGM	: N	DEV RPT IND	: Y
PMT REQD	: Y	SCAF REQD	: N	INS REM REQD	: N	DEV RPT #'S	: S-96-1019 * *
RWP REQD	: Y	CONF ENTRY	: N	IND SR	: N	ENG REVIEW	: N
		SECURE REL	: N	COATING REQD	: N	ENG DES DOC	: *

RWP NUMBERS : *________ *________ *________ *________

PLANNER: GENWTYN TYNES JR W H UCR: 6 LMD: E TASK TYPE: DE
W/R SUBMITTED BY: * * * DEPT: * TROUBLE/BREAKDOWN: N
W/R APPROVED BY : * * * DATE: * WINDOW: ________ FEG: ________

TASK SIGNATURES

OPERATIONS : [signature] DATE/TIME: 5-14-96 / 0530
LCO ________

QC NOTIFIED : P.O.P. DATE/TIME: ________ / ________

TAGGING VERIFIED BY: Marlow B. Sloz DATE/TIME: 5-14-96 / 0910

TAGGING REPORT NBRS: 2-96-SI-0043 ________ ________

SPECIAL NOTES : WORK SAFE!! WHT
** NOTE ** DENATURED ALCOHOL TO BE CARRIED INTO THE (RCA) ON SATURATED RAGS, IN PLASTIC BAGS ONLY.
******************** NOTE ********************
THIS OPERATOR MUST BE CHECKED FOR PROPER GREASE LEVEL BY THE MECHANICS BEFORE THIS OPERATOR IS ENERGIZED.

TASK JOB STEPS

STEP NO	STEP DESCRIPTION	CRAFT	REQUIRED	HOURS	TOT HOURS
01	SURVEY/SETUP/RECLAMATION.	HP	2	2.0	4.0
02	REVIEW WORK PACKAGE, (PMT) REQUIRMENTS AND (RWP)	ELEC	2	0.2	0.4
03	VERIFY PROPER MARK #	ELEC	1	0.1	0.1
04	SET UP WORK AREA	ELEC	2	1.0	2.0
05	VERIFY WITH OPS SHIFT SUPERVISOR THAT CLEAR PLASTIC CAP IS OVER MOV SWITCH IN MCR	ELEC	1	0.2	0.2

ME-0498, Rev-0, Add.0A

Attachment 1

Ref. 9

Test Results Summary

SURRY

Unit: TWO

uator: ______________________

Valve Tag Number: SI-2869B
Test Number: 10
Test Date: 5/17/96

Test Conditions

	Full Open	Full Closed
Flow (GPM)	0	0
Upstream Pressure (PSI)	0	0
Downstream Pressure (PSI)	0	0
Motor Voltage	460.00 Volts AC	

Switch Settings

Open Torque Switch Setting	5.000
Close Torque Switch Setting	5.000

Durations (seconds)

Closing				
Stroke Time		9.639		
Close Torque Bypass Switch Opens	seconds	2.806	% stroke	29.11
To Open Indicator Light Off	seconds	9.639	% stroke	100.00
Seating Time		0.145		
Contactor Dropout Time		0.014		
Opening				
Stroke Time		9.575		
Open Torque Bypass Switch Opens	seconds	3.044	% stroke	31.79
To Close Indicator Light Off	seconds	9.575	% stroke	100.00
Contactor Dropout Time		0.012		

Forces (lbs) Calibration Range: 1273 to -8198 lbs.

Closing	
Running Force	-2113
Avg Running Force	-1931
Thrust at Start of Wedging	-2060
Spring Pack Preload	-2311
Thrust at CST	-3004
Thrust at Contactor Dropout	-3612
Inertial Thrust	-3371
Maximum Thrust	-6983
Available Thrust Margin	-944
Opening	
Initial Thrust (At Motor Start)	-6962
Disc Pullout Force	3744
Max Running Force	1223
Avg Running Force	1043

Motor Currents (amps rms)

Closing	
Inrush Current	18.2
Average Running Current	3.0
Current at Contactor Dropout	2.1
Opening	
Inrush Current	16.6
Current at Maximum Pullout Force	3.3
Average Running Current	3.0

General Comments:

W.O.#341652-02 THRUST VERICIATION PERFORMED WITH CST ONLY, C-CLAMP USED
069 SEN..5432 AUX.SEN..00695 TCF.SEN..00575 THRUST BANDS AS PRE.
G.TRANSMITTAL MIN. HSC BUT LEAST THAN 2XRL MAX. 12478 BYPASS 25%-35%
BOTH DIR. SYSTEM #1 USED TESTED BY SLAYTON,JODRY,FULLER

ME-0498, Rev. 9 Add on Attachment 1 Ref. 9

	Time (msecs)	Force (lbs) (Uncorrected)	Current (amps rms)	Description
	73	-6962	4.6	Motor Start
	82	-6962	16.6	Inrush Current Peak
	361	-6862	2.9	Lost Motion Region (Near Middle)
O3	622	-6674	3.0	Hammerblow/Start of Stem Decompression
O4	725	-695	3.1	Stem Compression Fully Relieved
O5	841	962	3.1	
O9	913	3744	3.3	Maximum Force at Disc Pullout
O13	1481	1049	3.0	Opening Running Condition (Near Begin'g)
O12	3117	1020	3.1	Open Torque Bypass Switch Opens
O14	8793	1078	3.1	Opening Running Condition (Near End)
O16	9648	1136	2.9	Open Limit Switch Opens
O15	9648	1136	2.9	Close Indicator Light Off (Green)
O17	9660	1049	2.1	Motor Current Cutoff
C0	11965	1049	11.7	Motor Start
C1	11970	1049	18.2	Inrush Current Peak
C3	12510	0	2.9	Tension to Compression Transition
CF	12510	0	2.9	Zeroing Point for CF Calibration
C4	13618	-1775	3.0	Closing Running Condition (Near Begin'g)
C7	14771	-1892	3.0	Close Torque Bypass Switch Opens
C5	20983	-1863	3.2	Closing Running Condition (Near End)
C11	21572	-2060	2.9	Disc Motion Stops / Start of Wedging
C13	21582	-2311	3.1	Spring Pack Starts to Compress
C8	21604	-3004	3.0	Open Indicator Light Off (Red)
C14	21604	-3004	3.0	Close Torque Switch Opens (or CST)
C15	21618	-3612	2.1	Motor Current Cutoff
C16	21717	-6983	0.0	Maximum Thrust Value
C17	21758	-6952	0.0	Final Thrust Value

VIRGINIA POWER — CALCULATION COVER/INPUT SHEET

Type	Sub	Station	Unit	Status	System	Total pages:
[CALC]	[MEC]	[99]	[00]	[AC]	[ ]	16

Doc. No.	Rev.	QA Class	Aprvd Date	Attachments:
[ME-0498]	[0]	[SR]	[ ]	1 thru 3

CALC. Title/Subject: (Plus any Key Words for Retrieval purposes) Pressure Locking and Stem Effect Thermal Binding Analysis for Generic Letter 95-07

REFERENCE NUMBERS: IR NO.: -- JOB No: ______
Initiating Document (DCP,EWR, etc.): ______

ORIGINATOR: VP [X] Discipline Mechanical Engineering
A/E [_] Firm Name ______ Vendor Code: ______
A/E Calc. No.: ______

Mark Number References: (Sample on first line)

Station	Unit	System	Prefix/ID		Component/ID	
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Use Associated Information Sheet to continue.

OBJECTIVE:

The objective of this calculation is to determine the expected pullout thrust loads on the NAPS and SPS valves that are susceptible to pressure locking and thermal binding. The valves evaluated here were identified as being the most susceptible to these phenomena in reference 2.

SUMMARY OF RESULTS/CONCLUSIONS:

The results of this pressure locking and thermal binding analysis show that the minimum margin for pressure locking is 52% and the minimum margin for thermal binding is 66%.

Is Associated Information Form Attached? (X)YES ( )NO

PREPARED BY:	DATE:	REVIEWED BY:	DATE:	INDEP. REVIEW	DATE:
Paul D. Jones (signature) P. D. JONES	2-20-96	J. J. Wolak (signature) J. J. WOLAK	2-21-96	BFDemars (signature) B. F. Demars	2-21-96

ASSOCIATED INFORMATION

CALCULATION NUMBER:	REV. NO.	SHEET
ME-0498	0	2 OF 16

In addition to the Engineering Data System (EDS)/Mark Numbers identified on the Calculation Cover Sheet, the following Systems, Components, Structures, and/or Programs are associated with this calculation:
(SEE STD-GN-0008 FOR CODES)

Affected Structures:	CODE	DESCRIPTION
	[ ]	[ ]
Use additional	[ ]	[ ]
Sheets as needed	[ ]	[ ]
( ) see attached	[ ]	[ ]

Affected Structures:	CODE	DESCRIPTION
	[ ]	[ ]
Use additional	[ ]	[ ]
Sheets as needed	[ ]	[ ]
( ) see attached	[ ]	[ ]

Additional Mark Nos.:

Station	Unit	System	Prefix/ID		Component/ID	
[38]	[01]	[RC]	[MOV]	[1535]	[VALVE]	[ ]
[38]	[01]	[RC]	[MOV]	[1535]	[VALVOP]	[ ]
[38]	[01]	[RC]	[MOV]	[1536]	[VALVE]	[ ]
[38]	[01]	[RC]	[MOV]	[1536]	[VALVOP]	[ ]
[38]	[02]	[RC]	[MOV]	[2535]	[VALVE]	[ ]
[38]	[02]	[RC]	[MOV]	[2535]	[VALVOP]	[ ]
[38]	[02]	[RC]	[MOV]	[2536]	[VALVE]	[ ]

OTHER ITEMS: (Non-EDS Equipment ID's)
(Pipe Seg.
line number,
equip., etc.

[_] Additional (enter on next page)

PROGRAMS:

- [_] ALARA
- [_] APPENDIX R (APP R)
- [_] EQUIPMENT QUALIFICATION (EQ)
- [_] HEALTH PHYSICS (HP)
- [_] HEAVY LOADS (HVY LD)
- [_] HIGH ENERGY LINE BREAK (HELB)
- [_] HUMAN FACTORS (HF)
- [_] IE 79-14
- [_] IN-SERVICE INSP/NDE (ISI/NDE)
- [_] PERFORMANCE TESTING (PT)
- [_] PROBALISTIC RISK ASSESSMENT
- [_] REG. GUIDE 1.97 (RG 1.97)
- [_] SURVEILLANCE (SURVL)
- [_] WELDING (WELD)
- [x] OTHER (Specify) GL 89-10 and GL 95-07

Comments:

ASSOCIATED INFORMATION

CALCULATION NUMBER:	REV.NO.	SHEET
ME-0498	0	3 OF 16

Additional Mark Nos:

Station	Unit	System	Prefix/ID		Component/ID	
38	02	RC	MOV	2536	VALVOP	
59	01	RC	MOV	1535	VALVE	
59	01	RC	MOV	1535	VALVOP	
59	01	RC	MOV	1536	VALVE	
59	01	RC	MOV	1536	VALVOP	
59	02	RC	MOV	2535	VALVE	
59	02	RC	MOV	2535	VALVOP	
59	02	RC	MOV	2536	VALVE	
59	02	RC	MOV	2536	VALVOP	

TABLE OF CONTENTS

Prepared By: P D Jones Date: 2-20-96

Reviewed By: J. J. Wolak Date: 2-21-96

Reviewed By: B. DeMar Date: 2-21-96

OBJECTIVE

The purpose of this calculation is to determine the effect on valve pullout forces due to pressure locking and stem effect thermal binding. Only the MOVs identified in the reference 2 Type 1 report as being susceptible to pressure locking or stem effect thermal binding are evaluated. The Type 1 report is in response to the Nuclear Regulatory Commission Generic Letter 95-07 (Reference 1) on pressure locking and stem effect thermal binding.

The reference 2 report identifies the North Anna (NAPS) block valves, X-RC-MOV-X535,-1536 and the block valves at Surry SPS as being susceptible to stem effect thermal binding and the block valves at NAPS as being susceptible to pressure locking. Pressure locking is not a concern at SPS because the piping to the block valves is drained. Consequently, there is no way to pressure lock the valves (reference 2).

NAPS 2-RC-MOV-2536 is not susceptible to stem effect thermal binding since this MOV has a SB style operator. This operator has a compensating springpack which cushions the inertial thrust delivered to the valve and as a side benefit, it allows stem thermal stresses to be relieved by spring deflection.

Prepared By: P D Jones Date: 2-20-96
Reviewed By: J. G. Walsh Date: 2-21-96
Reviewed By: B 7 DeMars Date: 2-21-96

METHOD OF ANALYSIS

This analysis calculates the expected maximum pullout thrust on valves identified in Reference 2. The pressure locking thrusts are determined with a method developed by Virginia Power and also by a method developed by the Westinghouse Owner's Group (WOG) and Commonwealth Edison (Reference 3). The stem effect thermal binding evaluation is performed using the WOG methodology.

Virginia Power Pressure Locking Methodology

Since pressure locking occurs when the valve bonnet is pressurized more than the flow side of the discs, the resultant force on the valve disk can be calculated based upon this force imbalance. The pullout thrust in a pressure locking situation has five components: 1) the pullout force from static seating which resists valve opening; 2) the bonnet pressure acting on the disk to keep the valve closed; 3) the upstream system pressure acting on the upstream disk which counters the closing force of the bonnet pressure; 4) the downstream system pressure acting on the downstream disk which counters the closing force of the bonnet pressure; and 5) the bonnet pressure acting on the stem which tends to eject the stem from the valve and counters the closing force.

The static pullout force is provided by the stations.

Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	J. J. Walak	Date:	2-21-96
Reviewed By:	B F DeMars	Date:	2-21-96

The pressure forces are calculated based upon the disk surface area that the pressure acts upon. The flowstream pressure is distributed over an area the size of the seat inner diameter or the valve port area. The bonnet pressure acts on a surface area equal to the outer diameter of the seat sealing area. The resulting pressure force equation is:

$$F_{pres} = [2*P_{bonnet}*(\pi/4*Seat_{OD}^2)-(P_{up}+P_{dn})*(\pi/4*Seat_{ID}^2)]*VF$$

where: F_{pres}=pressure force, lbs

P_{bonnet}=pressure trapped in bonnet, psi

P_{up}=upstream pressure, psi

P_{dn}=downstream pressure, psi

$Seat_{OD}$=seat outer diameter, in.

$Seat_{ID}$=Seat inner diameter, in.

VF=Valve factor, 0.3 for wedge valves

Often, the seat ID and OD are virtually the same. Consequently, in this analysis, the OD and ID are taken to be the same. This may be slightly non-conservative. However, this is more than offset by assuming that bonnet pressure acts across the whole wedge surface area. The wedge hub on these flex wedge valves does not allow bonnet pressure to act over a significant percentage of the wedge (see assumption 3).

The last component in the pressure locking pullout thrust calculation is the stem rejection force. The bonnet pressure tries to eject the stem from the valve. This force reduces the amount of thrust required to open the valve. The stem rejection force equation is:

$$F_{stem\ rej} = P_{bonnet} * (\pi/4 * Stem_{OD}^2)$$

where: $F_{stem\ rej}$=stem rejection load, lbs

$Stem_{OD}$=stem outer dimension, in.

WOG Methodology

The WOG pressure locking and thermal binding (stem growth) methodologies are fully discussed in reference 9 and will not be repeated.

Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	J. J. Wolak	Date:	2-21-96
Reviewed By:	DB7 DeWan	Date:	2-21-96

ASSUMPTIONS

1. All dimensions are nominal. No effort has been made to quantify manufacturing tolerances.
2. As mentioned in the methods section, the seat OD and ID are taken to be equivalent. This is due to the fact that typical wedge to seat contact is uneven and only a thin line. This makes expected seat dimensions difficult to quantify.
3. A flex wedge is a one piece design. In a pressure locking situation, system pressure uniformly acts across the disk outside face. Bonnet pressure acts across the entire interior wedge face except at the hub which joins the two wedge halves. The cross sectional area of the hub reduces bonnet pressure effects approximately 9-10%

Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	F. F. Walake	Date:	2-21-96
Reviewed By:	B F Earl	Date:	2-21-96

DESIGN INPUTS

1. The valve wedge dimensional data was supplied by Westinghouse (reference 8) and Velan (reference 7) for their valves.
2. The bonnet, upstream and downstream pressures are provided in reference 3.
3. The valve port diameters and stem and wedge configurations are taken from the applicable valve drawing or the mentioned references.
4. The pullout forces, where available, are taken from the attached reference 5. Pullout thrusts for SPS 1-RC-MOV-1535, -1536 are unavailable. It is assumed that the pullout thrust for these two valves is equal to the greatest pullout thrust to maximum thrust ratio for all the valves of interest. NAPS 2-RC-MOV-2536 has a pullout thrust of 4556 lbs and a maximum thrust of 7297 lbs. This pullout ratio is 62.4%. The pullout thrusts for the two SPS valves then becomes 6992 for 1-RC-MOV-1535 (total thrust is 11,205 lbs) and 7291 lbs for 1-RC-MOV-1536 (total thrust is 11,685 lbs).
5. Motor torques, stem factors, operator data and coefficient of friction are taken from reference 13.

Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	J. J. Walsh	Date:	2-21-96
Reviewed By:	B. Oldman	Date:	2-21-96

COMPUTER CODES

Two pieces of software are used in this calculation. QuattroPro version 5 (reference 11) is used to assist in the mathematical calculations presented in the Methods of Analysis section. This simple calculation is independently checked by the reviewer and consequently a sample calculation is not required.

The WOG analysis for pressure locking and stem effect thermal binding are performed with MathCad version 5 (reference 10). The analysis is presented in the attached reference 9. Reference 12 provides verification of the accuracy of the stem growth analysis (stem effect thermal binding) and will not be repeated here. The pressure locking analysis is presented in this calculation to compare with the VP methodology. No safety related or design basis input is developed with the WOG pressure locking analysis and therefore no independent verification is required.

Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	[illegible signature]	Date:	2-21-96
Reviewed By:	[illegible signature]	Date:	2-21-96

REFERENCES

1. NRC Generic Letter, 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves," 8/17/95.
2. Type 1 Report, NP-3068, "Pressure Locking and Thermal Binding of Safety-Related Power Operated Gate Valves, NRC Generic Letter 95-07" B.F. DeMars, 1/31/96.
3. Memo, B.F. DeMars to P.D. Jones, "Design Inputs for Calculation ME-0498, Rev. 0, 2/8/96.
4. Velan Valve drawing 88405-2, "3-inch, 1500#, Bolted Bonnet Gate Valve."
5. Tabulation of Block Valve Pullout Forces at NAPS and SPS, (attached).
6. Westinghouse Valve Drawing, 8373D77, (NAPS 2-RC-MOV-2536).
7. DC-147, Rev.0, Add. 3, Velan Weak Link Analysis, 12/94.
8. Fax from Westinghouse to B.F. DeMars, "8373D77 Valve Wedge Data," 1/31/96, attached.
9. STEMGROW and PRESSURE LOCKING User's Manuals, (attached).
10. MathCad Version 5.
11. QuattroPro for Windows, Version 5.
12. ME-0499, "Verification of Computer Calculation "STEMGROW" Westinghouse Owner's Group Computer Program," B.F. DeMars, 2/96.
13. ME-0492, "Thrust Band Calculation for North Anna Safety-Related Motor Operated Valves", R.E. Brightup,1/96.

Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	[signature]	Date:	2-21-96
Reviewed By:	[signature]	Date:	2-21-96

CALCULATIONS

All the calculations for the pressure locking evaluation are provided in Table 3. The results show that all four MOVs have at least 52% margin between the expected maximum pressure locking pullout force and the operator capability at the time of expected valve operation (which includes a degraded voltage condition).

The WOG pressure locking analysis is provided in Attachment 2.

The VP method provides more conservative pressure locking pullout thrusts than the WOG method. This appears to be a result of the more exacting evaluation developed by Commonwealth Edison/WOG which was benchmarked against test data. A comparison between the two methods is shown in table 1 below for the NAPS valves.

Table 1 - Pressure Locking Results and Comparison Between VP and WOG Methods

Mark Number	VP Pressure Locking Results	WOG Pressure Locking Results
RC-1535	5392	3896
RC-1536	5102	3606
RC-2535	5873	4377
RC-2536	7337	5014

Prepared By: P D Jones Date: 2-20-96
Reviewed By: J. J. Walak Date: 2-21-96
Reviewed By: B F Davl Date: 2-21-96

The stem effect thermal binding evaluations are summarized in Table 2 (the actual calculation is in Attachment 1). The results show that stem effect thermal binding increases the pullout thrust for the analyzed valves. However, the increase is small and does not encroach upon any MOV limits.

Table 2 - Stem effect thermal binding Results Based Upon WOG Methods

Mark Number/Station	Pullout thrust w/thermal binding (lbs)	Operator Capability (lbs)	Capability Margin (%)
1-RC-MOV-1535/NAPS	4286	12786	66.48
1-RC-MOV-1536/NAPS	3814	14183	73.11
2-RC-MOV-2535/NAPS	4665	14310	67.40
1-RC-MOV-1535/SPS	7491	27370	72.63
1-RC-MOV-1536/SPS	8016	27893	71.26
2-RC-MOV-2535/SPS	6730	27109	75.17
2-RC-MOV-2536/SPS	5811	27293	78.71

Prepared By: PD Jones Date: 2-20-96
Reviewed By: [signature] Date: 2-21-96
Reviewed By: [signature] Date: 2-21-96

Pressure Locking Table for North Anna Power Station MOVs

Mark No.	Bonnet Pressure	Upstream System Pressure	Downst. System Pressure	Disc OD	Port OD	Disc Force	Valve Factor	Pressure Force	Stem Diameter	Stem Rejection Load	Pullout Force	Pullout Force (pres force -rej ld+po)	Motor Torque	App Factor	OGR	Pullout Efficiency	Operator Capability	MOV/plan Avg COF	Stem Factor	Operator Thrust Capability	Capability -Pullout (margin)	Capability Margin (%)
RC-1535	2235	1500	3	2.25	2.25	11791	0.3	3537.3	1.125	2220.5	4075	5392	11.4	0.9	55.8	0.4	229	0.2	0.0179	12786	7394	57.8
RC-1536	2235	1500	3	2.25	2.25	11791	0.3	3537.3	1.125	2220.5	3785	5102	11.2	0.9	63	0.4	254	0.2	0.0179	14183	9081	64.0
RC-2535	2235	1500	3	2.25	2.25	11791	0.3	3537.3	1.125	2220.5	4556	5873	11.3	0.9	63	0.4	256	0.2	0.0179	14310	8437	59.0
RC-2536	2235	1500	3	2.62	2.62	15988	0.55	8793.3	1.25	2741.4	1285	7337	10.2	0.9	52.2	0.45	216	0.2	0.0140	15370	8033	52.3

2-16-96
2-19-96
2-19-96

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CONCLUSION

The results of this evaluation show that all the valves identified in reference 2 as susceptible to pressure locking and/or stem effect thermal binding should perform as required even if the expected worst case condition exists. The pressure locking margins range from approximately 52% to 64%. The margins from the stem effect thermal binding calculation range from approximately 66% to 79%.

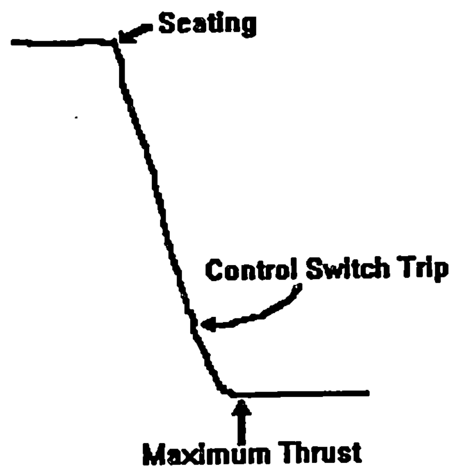
Prepared By:	P D Jones	Date:	2-20-96
Reviewed By:	J. J. Walsh	Date:	2-21-96
Reviewed By:	BJ Dent	Date:	2-21-96

ATTACHMENT 1 - STEM GROWTH (THERMAL BINDING) ANALYSIS

ME-0478 Rev. 0

Program STEMGROW for NAPS
1-RC-MOV-1535

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 9304 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 4075 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 3573 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 8.644 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 498 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 8.564 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 55.8$
Stem Lead (in)	$Lead = 0.667 \cdot in$

Program STEMGROW

Calculations:

$$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$$ $$Stem_{speed} = 0.339 \cdot \frac{in}{sec}$$

$$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$$ $$Static_{rate} = 38437 \cdot \frac{lbf}{sec}$$

$$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$$ $$Stiffness = 113492 \cdot \frac{lbf}{in}$$

$$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$$ $$UnseatingRatio = 0.438$$

$$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$$ $$StemElongation = 0.0043 \cdot in$$

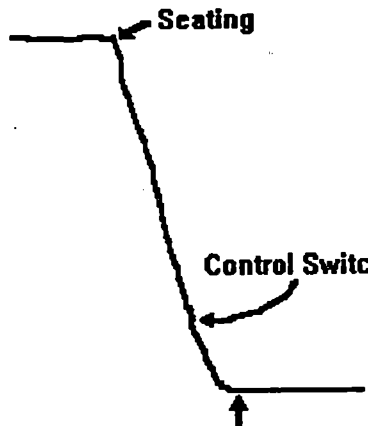
$$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$$ $$Final_{thrust} = 9787 \cdot lbf$$

$$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$$ $$Final_{unseating} = 4286 \cdot lbf$$

ME-0498, Rev. 0

Program STEMGROW for NAPS
1-RC-MOV-1536

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 7355 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 3785 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 2033 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 8.722 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 1109 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 8.488 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 63$
Stem Lead (in)	$Lead = 0.667 \cdot in$

Program STEMGROW

Calculations:

$$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$$

$$Stem_{speed} = 0.3 \cdot \frac{in}{sec}$$

$$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$$

$$Static_{rate} = 3949 \cdot \frac{lbf}{sec}$$

38,137.5

$$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$$

$$Stiffness = 13164 \cdot \frac{lbf}{in}$$

$$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$$

$$UnseatingRatio = 0.5146$$

$$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$$

$$StemElongation = 0.0043 \cdot in$$

$$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$$

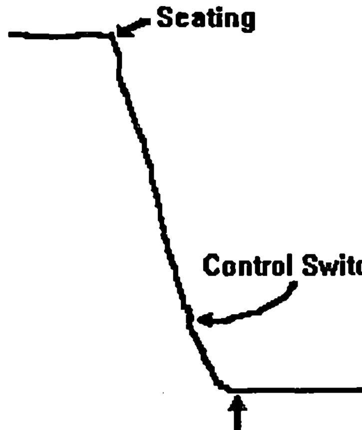
$$Final_{thrust} = 7411 \cdot lbf$$

$$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$$

$$Final_{unseating} = 3814 \cdot lbf$$

Program STEMGROW for NAPS
2-RC-MOV-2535

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 7297 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 4556 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 2529 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 10.383 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 1412 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 10.292 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 63$
Stem Lead (in)	$Lead = 0.667 \cdot in$

Program STEMGROW

Calculations:

$$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$$ $$Stem_{speed} = 0.3 \cdot \frac{in}{sec}$$

$$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$$ $$Static_{rate} = 12275 \cdot \frac{lbf}{sec}$$

$$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$$ $$Stiffness = 40919 \cdot \frac{lbf}{in}$$

$$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$$ $$UnseatingRatio = 0.6244$$

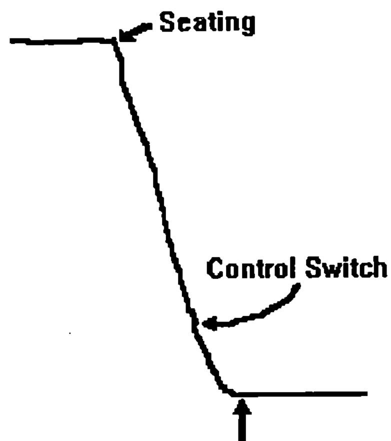
$$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$$ $$StemElongation = 0.0043 \cdot in$$

$$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$$ $$Final_{thrust} = 7471 \cdot lbf$$

$$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$$ $$Final_{unseating} = 4665 \cdot lbf$$

Program STEMGROW for SPS
1-RC-MOV-1535

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 11205 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 6992 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 9996 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 50.139 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 1478 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 49.33 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 101.3$
Stem Lead (in)	$Lead = 0.2 \cdot in$

Program STEMGROW

Calculations:

$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$ $Stem_{speed} = 0.056 \cdot \frac{in}{sec}$

$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$ $Static_{rate} = 10529 \cdot \frac{lbf}{sec}$

$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$ $Stiffness = 188222 \cdot \frac{lbf}{in}$

$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$ $UnseatingRatio = 0.624$

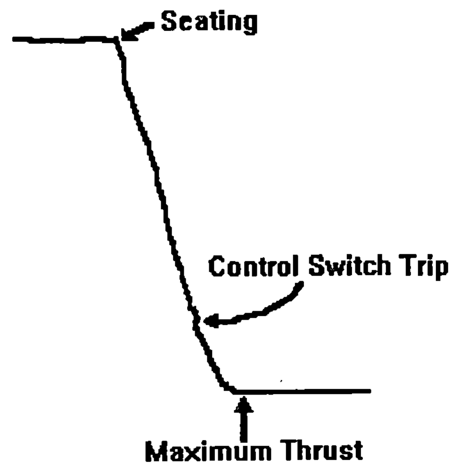
$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$ $StemElongation = 0.0043 \cdot in$

$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$ $Final_{thrust} = 12005 \cdot lbf$

$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$ $Final_{unseating} = 7491 \cdot lbf$

Program STEMGROW for SPS
1-RC-MOV-1536

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 11685 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 7291 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 10530 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 47.971 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 2564 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 47.45 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 101.3$
Stem Lead (in)	$Lead = 0.2 \cdot in$

Program STEMGROW

Calculations:

$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$ $\qquad Stem_{speed} = 0.056 \cdot \frac{in}{sec}$

$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$ $\qquad Static_{rate} = 15290 \cdot \frac{lbf}{sec}$

$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$ $\qquad Stiffness = 273328 \cdot \frac{lbf}{in}$

$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$ $\qquad UnseatingRatio = 0.624$

$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$ $\qquad StemElongation = 0.0043 \cdot in$

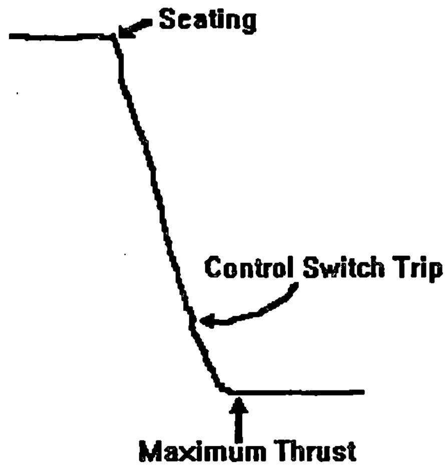
$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$ $\qquad Final_{thrust} = 12847 \cdot lbf$

$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$ $\qquad Final_{unseating} = 8016 \cdot lbf$

ME-0498, Rev. 0

Program STEMGROW for SPS
2-RC-MOV-2535

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 11883 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 6298 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 10531 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 46.261 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 2626 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 45.523 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 101.3$
Stem Lead (in)	$Lead = 0.2 \cdot in$

ME-0498, Rev. 0

Program STEMGROW

Calculations:

$$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$$ $$Stem_{speed} = 0.056 \cdot \frac{in}{sec}$$

$$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$$ $$Static_{rate} = 10711 \cdot \frac{lbf}{sec}$$

$$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$$ $$Stiffness = 191482 \cdot \frac{lbf}{in}$$

$$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$$ $$UnseatingRatio = 0.53$$

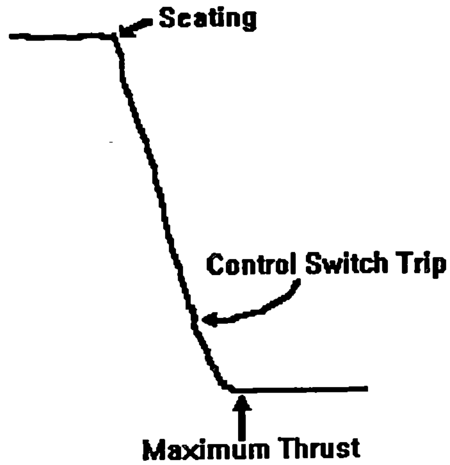
$$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$$ $$StemElongation = 0.0043 \cdot in$$

$$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$$ $$Final_{thrust} = 12697 \cdot lbf$$

$$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$$ $$Final_{unseating} = 6730 \cdot lbf$$

Program STEMGROW for SPS
2-RC-MOV-2536

Typical Thrust Trace



Inputs:

Stem Travel (in)	$Travel = 2.25 \cdot in$
Change in Temperature (F)	$DeltaTemp = 300 \cdot F$
Mod. of Therm. Exp. (in/in F)	$TempCoef = 0.000006 \cdot \frac{in}{in \cdot F}$
Max. Static Closing Force (lbf)	$Max_{close} = 13757 \cdot lbf$
Max. Static Unseating Force (lbf)	$Max_{open} = 5365 \cdot lbf$
Control Switch Trip Thrust (lbf)	$CST_{thrust} = 11995 \cdot lbf$
Control Switch Trip Time (sec)	$CST_{time} = 45.517 \cdot sec$
Thrust at Seating (lbf)	$Seat_{thrust} = 1077 \cdot lbf$
Time of Seating (sec)	$Seat_{time} = 44.792 \cdot sec$
Motor Speed (rpm)	$MotorSpeed = 1700 \cdot \frac{1}{min}$
Actuator Overall Ratio	$OAR = 101.3$
Stem Lead (in)	$Lead = 0.2 \cdot in$

Program STEMGROW

Calculations:

$$Stem_{speed} := MotorSpeed \cdot \frac{min}{60 \cdot sec} \cdot \frac{Lead}{OAR}$$ $$Stem_{speed} = 0.056 \cdot \frac{in}{sec}$$

$$Static_{rate} := \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$$ $$Static_{rate} = 15059 \cdot \frac{lbf}{sec}$$

$$Stiffness := \frac{Static_{rate}}{Stem_{speed}}$$ $$Stiffness = 269207 \cdot \frac{lbf}{in}$$

$$UnseatingRatio := \frac{Max_{open}}{Max_{close}}$$ $$UnseatingRatio = 0.39$$

$$StemElongation := Travel \cdot DeltaTemp \cdot TempCoef$$ $$StemElongation = 0.0043 \cdot in$$

$$Final_{thrust} := Max_{close} + StemElongation \cdot Stiffness$$ $$Final_{thrust} = 14902 \cdot lbf$$

$$Final_{unseating} := UnseatingRatio \cdot Final_{thrust}$$ $$Final_{unseating} = 5811 \cdot lbf$$

ATTACHMENT 2 - PRESSURE LOCKING ANALYSIS USING WOG METHODS

Program PRESLOK, Version 1 - NAPS 1-RC-MOV-1535

INPUTS:

Bonnet Pressure	$P_{bonnet} = 2235 \cdot psi$
Upstream Pressure	$P_{up} = 1500 \cdot psi$
Downstream Pressure	$P_{down} = 3 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 0.761 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 1.125 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 0.63 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.85 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 4075 \cdot lbf$
Close Valve Factor	$VF = 0.3$
Stem Diameter	$D_{stem} = 1.125 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.25 \cdot in$

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)}$$ $\mu = 0.291$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$ $DPavg = 1483.5 \cdot psi$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot \left(1 - \nu^2\right)}$$ $D = 1.15 \cdot 10^6 \cdot lbf \cdot in$

$$G := \frac{E}{2 \cdot (1 + \nu)}$$ $G = 1.096 \cdot 10^7 \cdot psi$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right]$$ $C_2 = 0.0807$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$ $C_3 = 0.0105$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right]$$ $C_8 = 0.7598$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$ $C_9 = 0.2783$

$$L_3 := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^2 - 1\right]$$ $L_3 = 0$

$$L_9 := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^2\right]\right]$$ $L_9 = 0$

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0012$$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.0731$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot\left(a^2 - b^2\right) - L_{17}\right] \qquad M_{rb} = -241\cdot lbf$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot\left(a^2 - b^2\right) \qquad Q_b = 1022.8\cdot\frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -1.0636\cdot 10^{-5}\cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.142$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -3.1955\cdot 10^{-5}\cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot\left(a^2 - b^2\right)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 1.4241\cdot 10^{-5}\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -5.6832\cdot 10^{-5}\cdot in$$

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -9.384\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -4.205\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -2.486\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -1.607\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 2499.1\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}{}^2\cdot P_{bonnet} \qquad F_{piston} = 2221.6\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 1028.2\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 1014.5\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 4075\cdot lbf$$

$$F_{total} = 3896.1\cdot lbf$$

Program PRESLOK, Version 1 - NAPS 1-RC-MOV-1536

INPUTS:

Bonnet Pressure	$P_{bonnet} = 2235 \cdot psi$
Upstream Pressure	$P_{up} = 1500 \cdot psi$
Downstream Pressure	$P_{down} = 3 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 0.761 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 1.125 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 0.63 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.85 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 3785 \cdot lbf$
Close Valve Factor	$VF = 0.3$
Stem Diameter	$D_{stem} = 1.125 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.25 \cdot in$

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)}$$ $\mu = 0.291$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$ $DPavg = 1483.5 \cdot psi$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot \left(1 - \nu^2\right)}$$ $D = 1.15 \cdot 10^6 \cdot lbf \cdot in$

$$G := \frac{E}{2 \cdot (1 + \nu)}$$ $G = 1.096 \cdot 10^7 \cdot psi$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right]$$ $C_2 = 0.0807$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$ $C_3 = 0.0105$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right]$$ $C_8 = 0.7598$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$ $C_9 = 0.2783$

$$L_3 := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^2 - 1\right]$$ $L_3 = 0$

$$L_9 := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^2\right]\right]$$ $L_9 = 0$

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right]$$ $L_{11} = 0.0012$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right]$$ $L_{17} = 0.0731$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot\left(a^2 - b^2\right) - L_{17}\right]$$ $M_{rb} = -241\cdot lbf$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot\left(a^2 - b^2\right)$$ $Q_b = 1022.8\cdot\frac{lbf}{in}$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11}$$ $y_{bq} = -1.0636\cdot 10^{-5}\cdot in$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right]$$ $K_{sa} = -0.142$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G}$$ $y_{sq} = -3.1955\cdot 10^{-5}\cdot in$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot\left(a^2 - b^2\right)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)}$$ $y_{stretch} = 1.4241\cdot 10^{-5}\cdot in$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch}$$ $y_q = -5.6832\cdot 10^{-5}\cdot in$

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -9.384\cdot 10^{-8} \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -4.205\cdot 10^{-8} \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -2.486\cdot 10^{-8} \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -1.607\cdot 10^{-7} \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 2499.1\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}^{\ 2}\cdot P_{bonnet} \qquad F_{piston} = 2221.6\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 1028.2\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 1014.5\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 3785\cdot lbf$$

$$F_{total} = 3606.1\cdot lbf$$

Program PRESLOK, Version 1 - NAPS 2-RC-MOV-2535

INPUTS:

Bonnet Pressure	$P_{bonnet} = 2235 \cdot psi$
Upstream Pressure	$P_{up} = 1500 \cdot psi$
Downstream Pressure	$P_{down} = 3 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 0.761 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 1.125 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 0.63 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.85 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 4556 \cdot lbf$
Close Valve Factor	$VF = 0.3$
Stem Diameter	$D_{stem} = 1.125 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.25 \cdot in$

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)}$$ $\mu = 0.291$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$ $DPavg = 1483.5 \cdot psi$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot \left(1 - \nu^2\right)}$$ $D = 1.15 \cdot 10^6 \cdot lbf \cdot in$

$$G := \frac{E}{2 \cdot (1 + \nu)}$$ $G = 1.096 \cdot 10^7 \cdot psi$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right]$$ $C_2 = 0.0807$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$ $C_3 = 0.0105$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right]$$ $C_8 = 0.7598$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$ $C_9 = 0.2783$

$$L_3 := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^2 - 1\right]$$ $L_3 = 0$

$$L_9 := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^2\right]\right]$$ $L_9 = 0$

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right]$$

$L_{11} = 0.0012$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right]$$

$L_{17} = 0.0731$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot\left(a^2 - b^2\right) - L_{17}\right]$$

$M_{rb} = -241\cdot lbf$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot\left(a^2 - b^2\right)$$

$Q_b = 1022.8\cdot\frac{lbf}{in}$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11}$$

$y_{bq} = -1.0636\cdot 10^{-5}\cdot in$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right]$$

$K_{sa} = -0.142$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G}$$

$y_{sq} = -3.1955\cdot 10^{-5}\cdot in$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot\left(a^2 - b^2\right)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)}$$

$y_{stretch} = 1.4241\cdot 10^{-5}\cdot in$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch}$$

$y_q = -5.6832\cdot 10^{-5}\cdot in$

ME-0498, Rev. 0

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -9.384\cdot 10^{-8}\ \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -4.205\cdot 10^{-8}\ \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -2.486\cdot 10^{-8}\ \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -1.607\cdot 10^{-7}\ \cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 2499.1\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}^{\ 2}\cdot P_{bonnet} \qquad F_{piston} = 2221.6\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 1028.2\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 1014.5\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 4556\cdot lbf$$

$$F_{total} = 4377.1\cdot lbf$$

Program PRESLOK, Version 1 - NAPS 2-RC-MOV-2536

INPUTS:

Bonnet Pressure	$P_{bonnet} = 2235 \cdot psi$
Upstream Pressure	$P_{up} = 1500 \cdot psi$
Downstream Pressure	$P_{down} = 3 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 1.01 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 1.62 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.056 \cdot in$
Seat Angle	$\theta = 7 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.85 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 1285 \cdot lbf$
Close Valve Factor	$VF = 0.55$
Stem Diameter	$D_{stem} = 1.25 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.61 \cdot in$

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)} \qquad \mu = 0.512$$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2} \qquad DPavg = 1483.5 \cdot psi$$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot \left(1 - \nu^2\right)} \qquad D = 2.689 \cdot 10^6 \cdot lbf \cdot in$$

$$G := \frac{E}{2 \cdot (1 + \nu)} \qquad G = 1.096 \cdot 10^7 \cdot psi$$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right] \qquad C_2 = 0.0529$$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right] \qquad C_3 = 0.0057$$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right] \qquad C_8 = 0.7987$$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right] \qquad C_9 = 0.2469$$

$$L_3 := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^2 - 1\right] \qquad L_3 = 0$$

$$L_9 := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^2\right]\right] \qquad L_9 = 0$$

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 5.1809\cdot10^{-4}$$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.0488$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot\left(a^2 - b^2\right) - L_{17}\right] \qquad M_{rb} = -292.9\cdot lbf$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot\left(a^2 - b^2\right) \qquad Q_b = 1060.1\cdot\frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -7.6059\cdot10^{-6}\cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.0842$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -2.9623\cdot10^{-5}\cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot\left(a^2 - b^2\right)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 2.1487\cdot10^{-5}\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -5.8716\cdot10^{-5}\cdot in$$

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -7.514\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -2.592\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -3.109\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -1.322\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 4522.2\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}{}^2\cdot P_{bonnet} \qquad F_{piston} = 2742.8\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 2981.2\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 3490.5\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 1285\cdot lbf$$

$$F_{total} = 5013.9\cdot lbf$$

ATTACHMENT 3 - CALCULATION REVIEW CHECKLIST AND ATTACHED REFERENCES

CALCULATION REVIEW CHECKLIST

CALCULATION NO. ME-0498	REV. NO. 0	ATTACHMENT 3	PAGE 1 OF 1

CALCULATION TITLE: Pressure Locking/Thermal Binding Analysis for GL 89-10

A "NO" answer to any questions requires that an explanation be provided.
NOTE: Reference may be made to explanations contained in the calculation.

QUESTIONS	YES	NO	N/A
1. Is the calculation number and revision identified on each page of the calculation and attachments?	[x]	[ ]	[ ]
2. Does the objective statement identify the reason for performing the calculation and give sufficient background information?	[x]	[ ]	[ ]
3. Have the sources of design inputs been correctly selected and referenced in the calculation?	[x]	[ ]	[ ]
4. Are the sources of design inputs up-to-date and retrievable (and/or a copy attached to the calc.)?	[x]	[ ]	[ ]
5. Where appropriate, have the other disciplines reviewed or provided the design inputs for which they are responsible?	[ ]	[ ]	[x]
6. Have design inputs been confirmed by analysis, test, measurement, field walkdown, or other pertinent means as appropriate for the configuration analyzed?	[x]	[ ]	[ ]
7. Are assumptions adequately described and bounded by the Station Design Basis?	[x]	[ ]	[ ]
8. Have the bases for engineering judgements been adequately and clearly presented?	[x]	[ ]	[ ]
9. Were appropriate calculation/analytic methods used and are outputs reasonable when compared to inputs?	[x]	[ ]	[ ]
10. Are computations technically accurate and has the calculation made appropriate allowances for instrument errors and calibration equipment errors? (Reference STD-EEN-0304)	[x]	[ ]	[ ]
11. Have those computer codes used in the calculation been listed in the "references" or has a statement been placed in the "methods of analysis" section which states - "No computer code used.", if no computer codes were used?	[x]	[ ]	[ ]
12. Have all exceptions to station design basis criteria and regulatory requirements been identified and justified in accordance with ANSI N45.2.11-1974?	[x]	[ ]	[ ]

Comments: (N/A if none) NA

[ ] Additional comment pages added.

Prepared By:	Date:	Reviewed By:	Date:
Paul Jones	2-20-96	John Walak	2-21-96

VIRGINIA POWER
NORTH CAROLINA POWER

Memorandum

ME-0498, Rev. 0
Reference 3

To Mr. P. D. Jones - IN1NW

Innsbrook Technical Center

From B. DeMars - IN1NW

February 8, 1996

DESIGN INPUTS FOR CALCULATION ME-0498 REV. 0

The following pressures should be used in the determination of the opening requirements for the following North Anna valves:

1-RC-MOV-1535/1536	Bonnet pressure - 2235 psig
2-RC-MOV-2535/2536	Upstream pressure - 1500 psig
	Downstream pressure - 3 psig

The bonnet pressure is the operating pressure of the pressurizer. It is postulated that steam condensate is trapped in the bonnet at this pressure during a SGTR event. Ref. NCRODP - 38 Reactor Coolant System

The upstream pressure was estimated to be the minimum pressure at which the PORV block valves would be called upon to open to depressurize the RCS in the event of a SGTR. This pressure was based on using the Surry SGTR analysis for minimum case safeguards. Ref. SPS UFSAR Figure 14.3-3

The downstream pressure was based on the operating pressure of the primary relief tank. Ref. NCRODP - 38 Reactor Coolant System

B. DeMars

cc: E. W. May - IN1NW
J. J. Wolak - IN1NW

ME-0498, Rev. 0
Reference 5

MARK NO.	TEST DATE	O9	C11	C11 TIME	C14	C14 TIME	C16
1-RC-1535	9-16-94	4075#	498#	8.564s	3573#	8.644s	9304#
1-RC-1536	9-16-94	3785#	1109#	8.488s	2033#	8.722s	7355#
2-RC-2535	4-18-95	4556#	1412#	10.292s	2529#	10.383s	7297#
2-RC-2536	5-18-95	1285#	813#	11.276s	2575#	11.380s	5262#

- PORT DIA 2.25 in
- 17-4 PH STEM COEFF THERMAL EXPANSION 6.3×10^{-6} in/in °F

ME-0498, Rev. 0
Reference 5

BRUCE DEMARS
X 2188 (FAX)

SPS VOTES TEST DATA					
	MOV NO	RC-1535	RC-1536	RC-2535	RC-2536
	TEST DATE	9/18/95	9/18/95	2/28/95	2/28/95
SEAT THRUST	HSC #	1478	2564	2626	1077
CST	TST # LBS	9996	10530	10531	11995
MAX CLOSING THRUST	TOT #	11205	11685	11883	13757
	ULR	N/A	N/A	53%	39%
CST	TIME CST	50.139	47.971	46.261	45.517
TIME OF SEAT	TIME HSC TO TST	0.805	0.520	0.738	0.725

UNREVIEWED DATA PROVIDED BY

[signature] 11/6/95

Reference 8

EC-577 East, Mail Stop 32

WESTINGHOUSE ELECTRIC CORPORATION
SYSTEMS & MAJOR PROJECTS DIVISION / MSE

COVER SHEET FOR TELECOPY NO. (412) 374-6639
WIN: 284-6639

ATTENTION: B. Demars

LOCATION:

TELECOPY NO.: 804-273-2188

CONFIRMATION NO.:

NOTES: Valve Data for 3" valve built to drawing
8373D77.
Seat Angle 7°
Disc thickness - 1.01"
Seat Radius - 1.620
Hub Radius - 1.056
Hub Length - 0.61

FROM: T J Matty **PHONE:** 6401

DATE: 1/31/96 **TELECOPY NO.:** (412) 374-6639
WIN: 284-6639
or: 284-6647

NUMBER OF PAGES INCLUDING COVER SHEET 1

Ref V-EC-1600

ME-0498 Rev. 0
Reference 9

USER'S GUIDE FOR PRESLOK, A GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

REVISION 0

January 2, 1996

ME-0498, Rev. 0
Ref. 9

USER'S GUIDE FOR PRESLOK
GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM
USING THE COMMONWEALTH EDISON MODEL

RECORD OF REVISION PAGE

Rev. 0	Original Issue	January 2, 1996

USER'S GUIDE FOR PRESLOK
GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM
USING THE COMMONWEALTH EDISON MODEL

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INTRODUCTION

Pressure locking is a phenomenon which can cause the unseating thrust for a gate valve to increase dramatically from its typical static unseating thrust. This can possibly result in the valve failing to open due to the actuator having insufficient thrust capability. Pressure locking can also result in valve damage in cases where the actuator thrust capability exceeds the valve structural capacity. For these reasons, a proper understanding of the conditions which may cause pressure locking, as well as a methodology for predicting the increase in unseating thrust for a pressure locked valve, are necessary.

A method of analyzing gate valves to predict the increase in unseating thrust for a pressure locked valve has been developed by Commonwealth Edison, and has been presented by Mr. Brian Bunte (Ref. 1). The Westinghouse Owner's Group, in the Pressure Locking/Thermal Binding Task Team meeting on November 13 and 14 , 1995, authorized the preparation of a MATHCAD program and accompanying user's manual to allow the uniform use of the Commonwealth Edison pressure locking analysis methodology. This manual is the result of that authorization.

This manual and the program file for performing the analysis are available from the Westinghouse Owner's Group and may be obtained by contacting L. I. Ezekoye at (412) 374-6643 or W. E. Moore at (412) 374-6351. Please indicate whether the program is to be supplied on 3.5 inch diskettes or 5.25 inch diskettes.

HARDWARE/SOFTWARE REQUIREMENTS

The program has been written using the MATHCAD 5.0 for Windows program. This program is available from

MathSoft, Inc.
101 Main Street
Cambridge, MA 02142
1-800-628-4223 or
617-577-1017
Fax: 617-577-8829

The program is also widely available from software vendors.

The following hardware and software requirements for running the MATHCAD 5.0 for Windows program are extracted from the User's Guide which is supplied with the MATHCAD program:

- An 80386 or higher IBM® or compatible computer. A math coprocessor is not required, but its presence will significantly improve performance.
- Microsoft® Windows™ Version 3.1 or later or Windows NT.
- At least 4MB of RAM. All memory above 640K should be configured as extended memory.
- At least 14MB of free hard disk space for MATHCAD files.
- An additional 1MB on the hard disk where MATHCAD is installed.
- At least 8MB of virtual memory. See the Windows user manual for how to specify virtual memory.
- A monitor and graphics card compatible with Windows.
- A mouse supported by Windows.
- Any printer supported by Windows.

The User's Guide supplied with the MATHCAD program should be followed for installation of the MATHCAD program onto your computer. The scope of this manual is to explain the usage of the PRESLOK analysis using the MATHCAD program.

GETTING STARTED

The PRESLOK files are supplied to you on either a 3.5 inch or a 5.25 inch diskette, per your request. It is recommended that the first step to use the files is to copy a "working version" of the files to your hard disk so that the diskette can be retained as a record copy. The files which are included are as follows:

preslok1.mcd	MATHCAD program using the closing valve factor as an input.
preslok2.mcd	MATHCAD program using the coefficient of friction between disk and seat as an input.
plinput1.dat	ASCII file of input data required by version 1 of the PRESLOK program.
plinput2.dat	ASCII file of input data required by version 2 of the PRESLOK program.

The next step to use the program is to create a data file to transfer the input values for the variables to the PRESLOK analysis program. The PRESLOK program is expecting these variables to appear in text file in plain ASCII format with the name "plinput1.dat" for use with version 1 or "plinput2.dat" for use with version 2. The various numbers in the "plinput1.dat" or "plinput2.dat" file can be separated by spaces, commas, or carriage returns, and may appear as integers, floating point numbers, or as E-format numbers such as 2.35E-2 . An ASCII text file can be created using the Windows utility Notepad, or by numerous other methods. This file should be located in the same directory as the PRESLOK file, since when the PRESLOK file is loaded, that directory will become the MATHCAD default directory. The user is also referred to the chapter on "Data Files" in the MATHCAD User's Guide if further explanation of the use of the ".dat" file is needed.

Sample data files are included in the program diskette which can be used simply by changing the input values to the proper values for your analysis. Alternately, other file names can be used for the input data by changing the input file name on the page 1 of the PRESLOK program to the file name desired.

RUNNING THE PRESLOK ANALYSIS

At this point it is assumed that the user has the MATHCAD 5.0 program loaded onto his computer, and that the PRESLOK Version 1 or PRESLOK Version 2 file and the "plinput1.dat" or "plinput2.dat" file are available to the computer in the same directory. To run the PRESLOK analysis, the user should perform the following steps:

1. Double click on the MATHCAD 5.0 icon to start the MATHCAD program.

2. Go to the File pulldown menu and click on Open (or click on the Open File icon on the Tool Bar.)

3. In the Open dialogue box, select the directory containing the preslok1.mcd or preslok2.mcd file and select the desired version of the program. Then click on OK.

4. The PRESLOK program will pick up the input values from the plinput1.dat or plinput2.dat file and perform the analysis if the program is in the automatic mode (Automatic Mode has a check mark next to it in the Math pulldown menu.) If the MATHCAD program is not in the automatic mode, it can be forced to perform the calculation by clicking on the Calculate Document function in the Math pulldown menu. Results may be inspected by using the scroll bar on the right hand side of the display to scroll through the display as desired.

5. To change the inputs, open the Windows utility Notepad and open the plinput1.dat or plinput2.dat file. Make the desired changes to the file and then save it. To have MATHCAD re-perform the analysis with the new input values, open the Math pulldown menu and click on Calculate Document. This alternate use of Notepad and the MATHCAD function Calculate Document should be repeated until the analysis is correct.

6 The output may be printed using the Print command in the pulldown menu under File or using the print icon in the Tool Bar. The user is referred to the MATHCAD User's Guide if any changes are desired to the Page Setup or the Printer Setup.

   Note that valve identifiers or other identifying titles may be added to the output by using the MATHCAD text entry methods given in the MATHCAD User's Guide. If the user desires to add the identifier/title to each page, the use of a header is recommended. The header can be defined through the Headers/Footers command in the Edit pulldown menu or through the Header command in the Page Setup dialogue box. See the Documents and Windows

RUNNING THE PRESLOK ANALYSIS (continued)

section of the MATHCAD User's Guide for further information about Headers.

7. The program may be exited using the Exit command in the File pulldown menu.

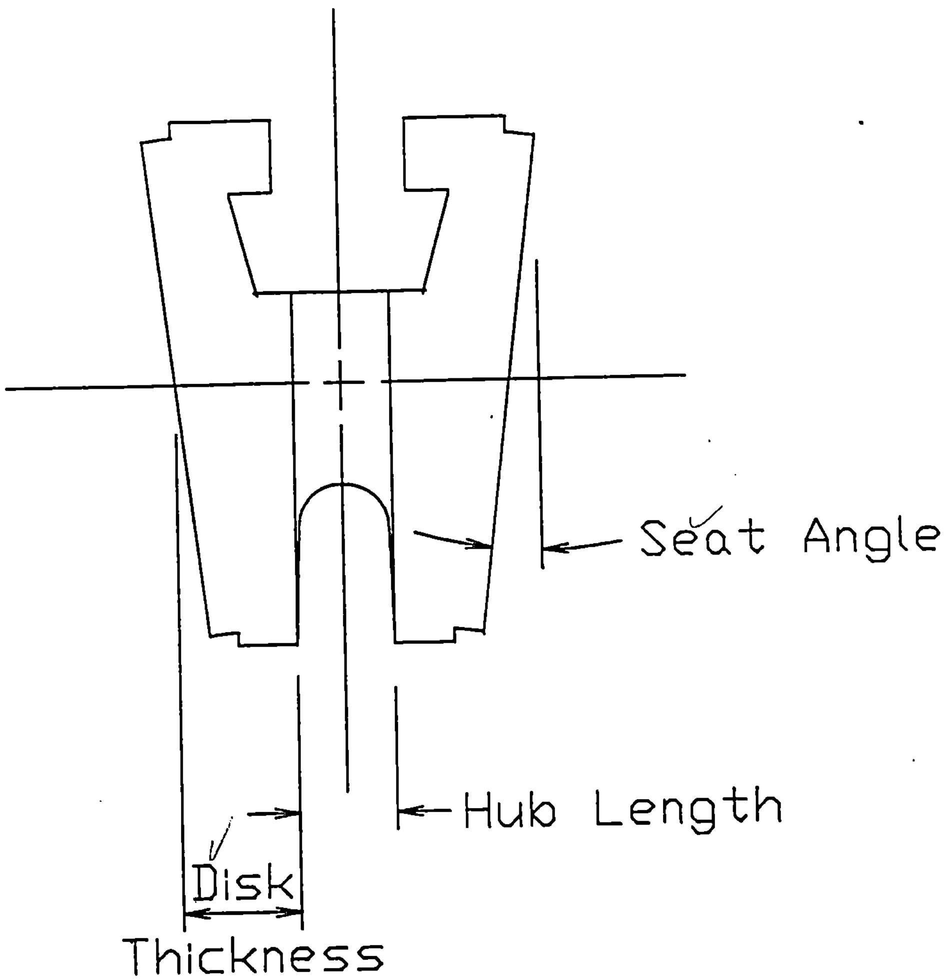


FIGURE 1 Disk Geometry

INPUT PREPARATION

The following inputs are required for the use of the PRESLOK analysis using version 1 of the program:

- Pressure Conditions at the time of the pressure locking event. This includes the upstream, downstream, and bonnet pressure.

Bonnet Pressure:	P_{bonnet}	psi
Upstream Pressure:	P_{up}	psi
Downstream Pressure:	P_{down}	psi

- Valve Disk Geometry. This includes the hub radius, hub length, mean seat radius, average disk thickness, and seat angle.

Disk Thickness:	t	inches
Seat Radius:	a	inches
Hub Radius:	b	inches
Hub Length:	Hub_{length}	inches
Seat Angle:	θ	degrees

The disk thickness recommended for use in these calculations is the thickness at the centerline of the disk vertically. See Figure 1. This will normally be a value which is intermediate between the minimum and maximum thickness of the disk, and this is the thickness which has been used in the comparisons of test measurements which Commonwealth Edison is making with the analytical results. It is noted that the magnitude of the pressure locking force increases with the thickness of the disk, so that use of the maximum disk thickness would yield conservative results. The pressure locking forces predicted by using the maximum value of disk thickness are likely to be unreasonably high though.

The seat radius used in these calculations is the mean seat radius which corresponds to the radius at which one half of the seat area would be outside the mean seat radius and one half of the seat area would be inside the mean radius. Thus, given the inner and outer seat diameters, the mean seat radius is

$$a = \sqrt{\frac{OD_{seat}^2 + ID_{seat}^2}{8}}$$

When the hub cross-section is not reasonably circular (e.g. many Westinghouse gate valve designs), then an effective hub radius is used which corresponds to a circle of equal area to the hub cross-sectional area.

$$b = \sqrt{\frac{Hub\ Area}{\pi}}$$

The hub length is the distance from the inside face of the hub to the inside face of the hub at the hub radius, as shown on Figure 1. The seat angle is as shown on Figure 1.

- Valve Disk Material Properties. This includes the modulus of elasticity and the Poisson's ratio for the disk base material, at the temperature being considered.

Poisson's Ratio:	ν	dimensionless
Modulus of Elasticity:	**E**	psi

- Valve Stem Diameter

Stem Diameter:	D_{stem}	inches

This is the stem diameter in the region of the stem which is inside the packing.

- Static Unseating Thrust

Static Pullout Force:	F_{po}	pounds

This is the static pullout force obtained from testing of the valve for which the calculation is being performed.

- Closing Valve Factor

Valve Factor:	**VF**	dimensionless

It is suggested that this valve factor be the factor obtained from test measurements of closing the valve being considered in a DP test, if possible.

To use version 2 of the program instead of version 1, the closing valve factor VF is replaced by the co-efficient of friction to be considered between the disk and the seat, and the input data file is named plinput2.dat. All other inputs remain the same as for version 1. The different input value is

- Coefficient of Friction between Disk and Seat

Seat to Disk Coefficient of Friction:	μ	dimensionless

THEORY

ASSUMPTIONS

1. The valve disk is assumed to act as two ideal disks connected by a hub. That is, the disks are assumed to be round, of uniform thickness, and perpendicular to a cylindrical, concentric hub. A line perpendicular to the hub centerline and at the middle of the hub length is an axis of symmetry for the wedge. The equations in reference 2 for this idealized structure are assumed to conservatively model the actual load due to pressure forces. This assumption is considered conservative since inspection of the disk drawings show large fillets between the disk hub and seats which should make the valve disk stiffer than assumed in the reference 2 equations.

2. The coefficient of friction between the valve seat and disk is assumed to be the same under pressure locking conditions as it is under DP conditions. This assumption is considered to be justified based on bench marking of the calculations against ComEd and EPRI pressure locking test data for similar flex-wedge gate valves.

3. The upstream, downstream, and bonnet pressure values are considered to be known.

DESIGN INPUTS

The following design inputs are used in calculating the force required to unseat a pressure locked MOV:

- Pressure Conditions at the time of the pressure locking event. This includes the upstream, downstream, and bonnet pressure.

Bonnet Pressure:	P_{bonnet}	psi
Upstream Pressure:	P_{up}	psi
Downstream Pressure:	P_{down}	psi

- Valve Disk Geometry. This includes the hub radius, hub length, mean seat radius, and average disk thickness.

Disk Thickness:	**t**	inches
Seat Radius:	**a**	inches
Hub Radius:	**b**	inches

Hub Length:	$\mathbf{Hub_{length}}$	inches
Seat Angle:	θ	degrees

The disk thickness recommended for use in these calculations is the thickness at the centerline of the disk vertically. See Figure 1. This will normally be a value which is intermediate between the minimum and maximum thickness of the disk, and this is the thickness which has been used in the comparisons of test measurements which Commonwealth Edison is making with the analytical results. It is noted that the magnitude of the pressure locking force increases with the thickness of the disk, so that use of the maximum disk thickness would yield conservative results. The pressure locking forces predicted by using the maximum value of disk thickness are likely to be unreasonably high though.

The seat radius used in these calculations is the mean seat radius which corresponds to the radius at which one half of the seat area would be outside the mean seat radius and one half of the seat area would be inside the mean radius. Thus, given the inner and outer seat diameters, the mean seat radius is

$$a = \sqrt{\frac{OD_{seat}^2 + ID_{seat}^2}{8}}$$

When the hub cross-section is not reasonably circular (e.g. many Westinghouse gate valve designs), then an effective hub radius is used which corresponds to a circle of equal area to the hub cross-sectional area..

$$b = \sqrt{\frac{Hub\ Area}{\pi}}$$

The hub length is the distance from the inside face of the hub to the inside face of the hub at the hub radius, as shown on Figure 1. The seat angle is as shown on Figure 1.

- Valve Disk Material Properties. This includes the modulus of elasticity and the Poisson's ratio for the disk base material.

Poisson's Ratio:	ν	dimensionless
Modulus of Elasticity:	**E**	psi

- Valve Stem Diameter

Stem Diameter:	$\mathbf{D_{stem}}$	inches

This is the stem diameter in the region of the stem which is inside the packing.

- Static Unseating Thrust

  Static Pullout Force: F_{po} pounds

  This is the static pullout force obtained from testing of the valve for which the calculation is being performed.

- Coefficient of Friction between Disk and Seat

  Seat to Disk Coefficient of Friction: μ dimensionless

The analysis program is presented in two versions, one of which requires that the coefficient of friction to be used between the disk and the seat be input directly, and the other which allows the input of the closing valve factor instead. For the version which allows the input of the closing valve factor, the coefficient of friction is calculated as follows:

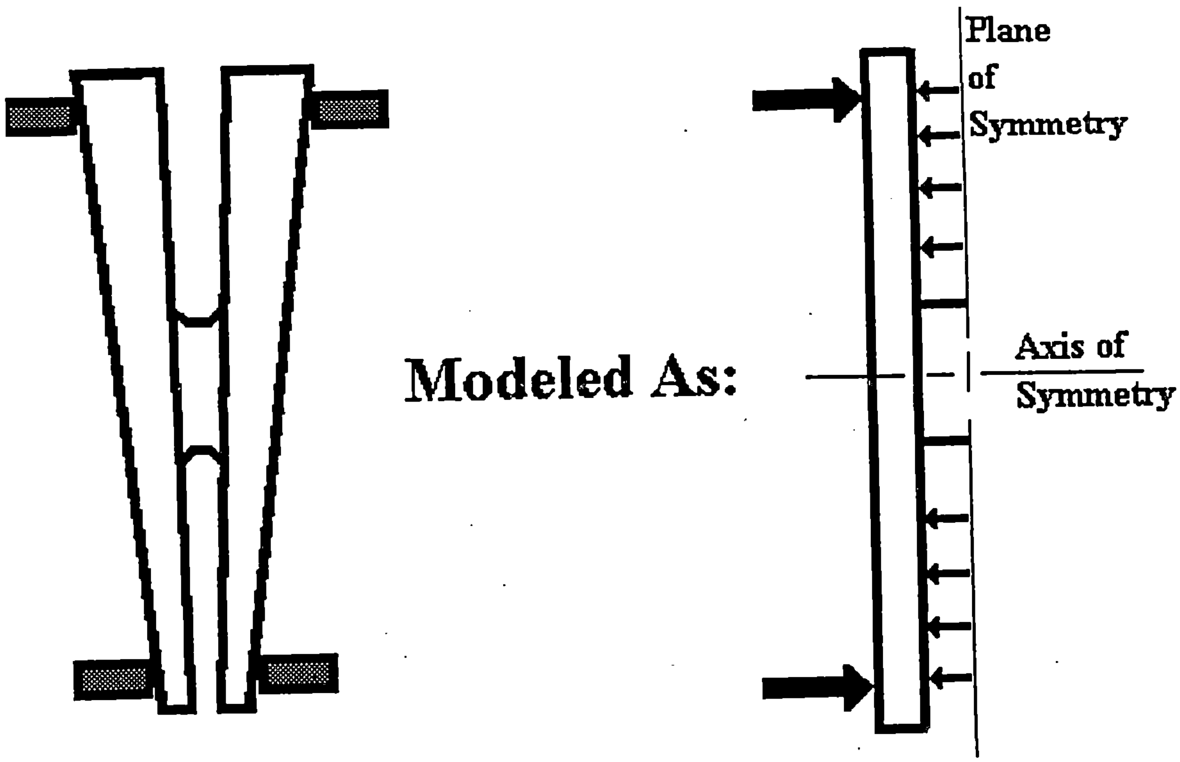
$$\mu = VF \cdot \frac{\cos\theta}{1 + VF \cdot \sin\theta}$$

CALCULATIONS

The methodology for calculating the thrust required to open the MOVs under the pressure locking scenario is based on the Reference 2 (Roark's) engineering handbook. The methodology determines the total force required to open the valve under a pressure locking scenario by solving for the four components to this force. The four components of the force are the pressure locking component, the static unseating component, the piston effect component, and the "reverse piston effect" component. These magnitudes of these components are determined using the following steps:

Pressure Locking Component of Force Required to Open the Valve

The valve disk is modeled as two plates attached at the center by a hub which is concentric with the valve disk. A plane of symmetry is assumed between the valve disks. This plane of symmetry is considered fixed in the analysis.



Based on this geometry, the following constants are calculated using the reference 2 equations:

Average DP Across Disk

$$DP_{avg} = P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$

Disk Stiffness Constants

$$D = \frac{E \cdot t^3}{12 \cdot (1 - \nu^2)}$$

$$G = \frac{E}{2 \cdot (1+\nu)}$$

Geometry Factors

$$C_2 = \frac{1}{4}\cdot\left[1-\left(\frac{b}{a}\right)^2\left(1+2\cdot\ln\left(\frac{a}{b}\right)\right)\right]$$

$$C_3 = \frac{b}{4a}\left\{\left[\left(\frac{b}{a}\right)^2+1\right]\ln\left(\frac{a}{b}\right)+\left(\frac{b}{a}\right)^2-1\right\}$$

$$C_8 = \frac{1}{2}\left[1+\nu+(1-\nu)\left(\frac{b}{a}\right)^2\right]$$

$$C_9 = \frac{b}{a}\left\{\frac{1+\nu}{2}\ln\left(\frac{a}{b}\right) + \frac{1-\nu}{4}\left[1-\left(\frac{b}{a}\right)^2\right]\right\}$$

Deflection Due To Pressure Force

The pressure force is assumed to act uniformly upon the inner surface of the disk between the hub diameter and the outer disk diameter. The outer edge of the disk is assumed to be unimpeded and allowed to deflect away from the pressure force. In addition, the disk hub is allowed to stretch. The total displacement at the outer edge of the valve disk due to shear and bending and due to hub stretch are calculated using the reference 2 equations.

Corresponding Equations

Additional Geometry Factors (r_0 = b for Case 2L)

$$L_{11} = \frac{1}{64}\left\{1+4\cdot\left(\frac{r_0}{a}\right)^2-5\cdot\left(\frac{r_0}{a}\right)^4-4\cdot\left(\frac{r_0}{a}\right)^2\left[2+\left(\frac{r_0}{a}\right)^2\right]\ln\left(\frac{a}{r_0}\right)\right\}$$

$$L_{17} = \frac{1}{4}\left\{1-\frac{1-\nu}{4}\left[1-\left(\frac{r_0}{a}\right)^4\right]-\left(\frac{r_0}{a}\right)^2\left[1+(1+\nu)\ln\left(\frac{a}{r_0}\right)\right]\right\}$$

Moment Factors (r_0 = b for Case 2L)

$$M_{rb} = \frac{-DP_{avg} \cdot a^2}{C_8}\left[\frac{C_9}{2 \cdot a \cdot b}\left(a^2 - r_0^2\right) - L_{17}\right]$$

$$Q_b = \frac{-DP_{avg}}{2 \cdot b}\left(a^2 - r_0^2\right)$$

Bending Deflection due to Pressure

$$y_{bq} = M_{rb}\frac{a^2}{D}C_2 + Q_b\frac{a^3}{D}C_3 - \frac{DP_{avg} \cdot a^4}{D}L_{11}$$

Shear Deflection due to Pressure (r_0 = b for Case 2L)

$$K_{sa} = -0.3 \cdot \left[2 \cdot \ln\left(\frac{a}{b}\right) - 1 + \left(\frac{r_0}{a}\right)^2\left(1 - 2 \cdot \ln\left(\frac{r_0}{b}\right)\right)\right]$$

ROARK 4th & 5th ED DIFFERENCE GO TO ADD NOTE

$$y_{sq} = \frac{K_{sa} \cdot DP_{avg} \cdot a^2}{t \cdot G}$$

Deflection from Hub Stretch due to Pressure

$$P_{force} = \pi\left(a^2 - b^2\right) \cdot DP_{avg}$$

$$y_{stretch} = -\frac{P_{force}}{\pi \cdot b^2}\frac{Hub_{length}}{2E}$$

Total Deflection due to Pressure

$$y_q = y_{bq} + y_{sq} + y_{stretch}$$

An evenly distributed force is assumed to act between the valve seat and the outer edge of the valve disk. This force acts to deflect the outer diameter of the valve disk inward and to compress the disk hub. The pressure force is reacted to by an increase in this contact force between the valve disk and seats. The valve body seats are conservatively assumed to be fixed. Therefore, the deflection due to the known pressure load must be balanced by the deflection due to the unknown seat load. The deflection due to the pressure force was previously calculated. Now, the reference 2 equations are used to determine the contact force between the seat and disk which results in a deflection which is equal and opposite to the deflection due to the pressure force. This is done by first calculating the amount deflection created by a unit load of seat contact force (w = 1 lb/in). The equilibrium contact load is then determined by dividing the deflection caused by the unit contact load into the previously calculated deflection due to the pressure force. The equations are provided below:

Additional Geometry Factors (For Case 1L, $r_0 = a$, $\therefore L_3 = L_9 = 0$

$$L_3 = \frac{r_0}{4a}\left\{\left[\left(\frac{r_0}{a}\right)^2 + 1\right]\cdot\ln\left(\frac{a}{r_0}\right) + \left(\frac{r_0}{a}\right)^2 - 1\right\}$$

$$L_9 = \frac{r_0}{a}\left\{\frac{1+\nu}{2}\cdot\ln\left(\frac{a}{r_0}\right) + \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{r_0}{a}\right)^2\right]\right\}$$

Bending Deflection due to Seat Load ($r_0 = a$)

$$y_{bw} = -\frac{a^3}{D}\cdot\left[\frac{C_2}{C_8}\cdot\left(\frac{r_0\cdot C_9}{b} - L_9\right) - \frac{r_0\cdot C_3}{b} + L_3\right]$$

Shear Deflection due to Seat Load ($r_0 = a$)

$$K_{sa} = -1.2\frac{r_0}{a}\ln\left(\frac{r_0}{b}\right)$$

$$y_{bw} = K_{sa}\frac{a}{t\cdot G}$$

Deflection from Hub Compression Due to Seat Load
(w = 1, ∴Compressive force = 2 π a)

$$y_{compr} = -\frac{2\pi a}{\pi b^2}\left(\frac{Hub_{length}}{2E}\right)$$

Total Deflection from Unit Seat Load (w = 1)

$$y_w = y_{bw} + y_{sw} + y_{compr}$$

Therefore, the equilibrium contact load distribution (lb/in) and the corresponding load applied to each seat is calculated using the relationship below:

$$w_{equilibrium} = \frac{y_q}{y_w}, \textit{ where } y_w \textit{ is calculated for } w = 1$$

$$\textit{Load per seat} = 2\pi a\left(\frac{y_q}{y_w}\right)$$

Determining The Disk To Seat Friction Coefficient

Several methods can be used to determine an appropriate seat to disk friction coefficient. The coefficient of friction between the seat and disk is perhaps best determined based on the open valve factor from a DP test. However, due to the difficulty sometimes encountered in obtaining a good, consistent valve of the opening valve factor from testing, the PRESLOK program is written to accept a closing valve factor or a co-efficient of friction directly. The equation used to calculate the coefficient of friction from the closing valve factor is given in the Design Inputs section of this User's Manual.

The stem force required to overcome the contact load between the seat and disk which opposes the pressure force is equal to:

(seat load) × [μ cos θ - sin θ] × 2 (for two disk faces).

Static Unseating Force

The static unseating force represents the opening packing load and the pullout force due to wedging of the valve disk during closure. These loads are superimposed on the loads due to the pressure forces which occur during pressure locking. The value for this force is based on static test data for the MOVs.

Piston Effect

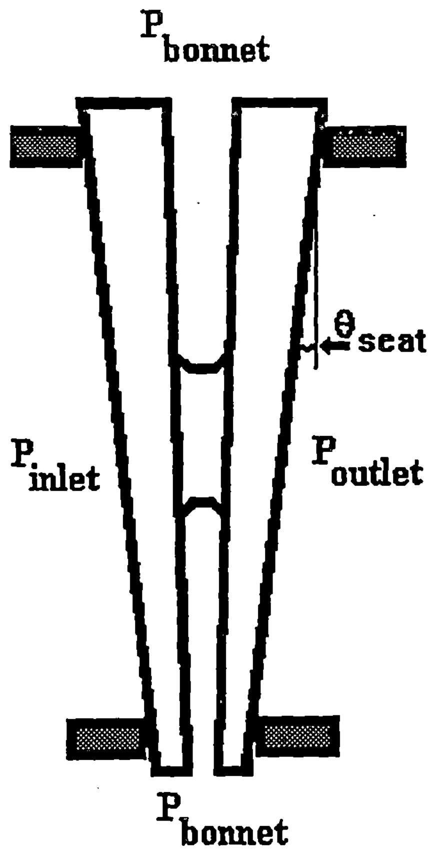
The piston effect due to valve internal pressure exceeding outside pressure is calculated using the standard industry equation. This force assists movement of the valve stem in the open direction.

$$F_{piston\ effect} = \frac{\pi}{4} D_{stem}^2 \left(P_{bonnet} - P_{atm}\right)$$

Reverse Piston Effect (F_{vert})

The reverse piston effect is the term used in this calculation to refer to the pressure force acting downward against the valve disk. This force is equal to the differential pressure across the valve disk times the area of the valve disk times the sine of the seat angle times 2 (for two disk faces).

$$F_{vert} = \pi \cdot a^2 \cdot \sin\theta \cdot \left(2 \cdot P_{bonnet} - P_{up} - P_{down}\right)$$



Total Force Required to Overcome Pressure Locking

As mentioned previously, the total stem force (tension) required to overcome pressure locking is the sum of the four components discussed above. All of the terms are positive with the exception of the piston effect component.

The acceptance criteria recommended for use in this calculation is that the available motor operator thrust capability be at least 120% of that required to unseat the MOV under pressure locking conditions. The 20% margin is provided to allow for uncertainty in the measurement of stem factor, open valve factor, static unseating thrust as well as other effects such as stem factor variation and motor-to-motor torque capability variations. All of these effects are random in nature.

ME-0498, Rev. 0
Ref. 9

EXAMPLE OF AN ANALYSIS PERFORMED WITH PRESLOK, VERSION 1

The following is an image of the input file plinput1.dat used to run an example problem on version 1 of the PRESLOK analysis program:

```
1005    380      350     2       4.36    1.25    0.5    5
0.3     27.6E6   1.875   15409   0.52
```

The input file corresponds to input values as shown:

Bonnet Pressure:	P_{bonnet} = 1005 psi	
Upstream Pressure:	P_{up} = 380 psi	
Downstream Pressure:	P_{down} = 350 psi	
Disk Thickness:	**t** = 2.00 inches	
Seat Radius:	**a** = 4.36 inches	
Hub Radius:	**b** = 1.25 inches	
Hub Length:	**L** = 0.50 inches	
Seat Angle:	θ = 5 degrees	
Poisson's Ratio:	ν = 0.3	(dimensionless)
Modulus of Elasticity:	**E** = 27,600,000 psi	
Stem Diameter:	D_{stem} = 1.875 inches	
Static Pullout Force:	F_{po} = 15,409 pounds	
Valve Factor:	**VF** = 0.52	(dimensionless)

The next five pages contain the output of the PRESLOK program, Version 1, using the above input.

USER'S GUIDE TO PRESLOK
Program PRESLOK, Version 1
Revision 0
December 22, 1995

This Mathcad Program is designed to calculate the estimated opening force under pressure locking scenarios for flex-wedge gate valves using a calculational methodology that accounts for wedge stiffness resisting pressure locking forces. This program was prepared by the Westinghouse Owner's Group based upon the calculational methods developed by Commonwealth Edison.

While this information is presented in good faith and believed to be accurate, the Westinghouse Owner's Group does not guarantee satisfactory results from reliance upon such information. Nothing contained herein is to be construed as a warranty, express or implied, regarding the performance, merchantability, fitness or any other matter with respect to the product, nor as a recommendation to use any product or process in conflict with any patent. The Westinghouse Owner's Group reserves the right, without notice, to alter or improve the methods described herein.

This section of the program reads the thirteen items of input data from the plinput1.dat file.

$i := 0..12$

$input_i := READ(plinput1)$

$P_{bonnet} := input_0 \cdot psi$

$P_{up} := input_1 \cdot psi$

$P_{down} := input_2 \cdot psi$

$t := input_3 \cdot in$

$a := input_4 \cdot in$

$b := input_5 \cdot in$

$Hub_{length} := input_6 \cdot in$

$\theta := input_7 \cdot deg$

$v := input_8$

$E := input_9 \cdot psi$

$D_{stem} := input_{10} \cdot in$

$F_{po} := input_{11} \cdot lbf$

$VF := input_{12}$

Program PRESLOK, Version 1

INPUTS:

Bonnet Pressure	$P_{bonnet} = 1005 \cdot psi$
Upstream Pressure	$P_{up} = 380 \cdot psi$
Downstream Pressure	$P_{down} = 350 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 2 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 4.36 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.25 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.76 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 15409 \cdot lbf$
Close Valve Factor	$VF = 0.52$
Stem Diameter	$D_{stem} = 1.875 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.5 \cdot in$

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)}$$ $\mu = 0.496$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$ $DPavg = 640 \cdot psi$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot \left(1 - \nu^2\right)}$$ $D = 2.022 \cdot 10^7 \cdot lbf \cdot in$

$$G := \frac{E}{2 \cdot (1 + \nu)}$$ $G = 1.062 \cdot 10^7 \cdot psi$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right]$$ $C_2 = 0.1781$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$ $C_3 = 0.0311$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right]$$ $C_8 = 0.6788$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$ $C_9 = 0.2789$

$$L_3 := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^2 - 1\right]$$ $L_3 = 0$

$$L_9 := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^2\right]\right]$$ $L_9 = 0$

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0069$$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.1526$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot\left(a^2 - b^2\right) - L_{17}\right] \qquad M_{rb} = -5265\cdot lbf$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot\left(a^2 - b^2\right) \qquad Q_b = 4466.5\cdot\frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -3.9041\cdot 10^{-4}\cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.4743$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -2.7177\cdot 10^{-4}\cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot\left(a^2 - b^2\right)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 6.4731\cdot 10^{-5}\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -7.2691\cdot 10^{-4}\cdot in$$

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -3.079\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -6.012\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -5.055\cdot 10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -9.597\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 20750.5\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}{}^2\cdot P_{bonnet} \qquad F_{piston} = 2775\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 6662.4\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 16871\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad y_{sw} = -13.079\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

$$F_{total} = 36167.4\cdot lbf$$

EXAMPLE OF AN ANALYSIS PERFORMED WITH PRESLOK, VERSION 2

The following is an image of the input file plinput2.dat used to run an example problem on version 2 of the PRESLOK analysis program:

1005	380	350	2	4.36	1.25	0.5	5
0.3	27.6E6	1.875	15409	0.496			

The input file corresponds to input values as shown:

Bonnet Pressure:	P_{bonnet} = 1005 psi	
Upstream Pressure:	P_{up} = 380 psi	
Downstream Pressure:	P_{down} = 350 psi	
Disk Thickness:	t = 2.00 inches	
Seat Radius:	a = 4.36 inches	
Hub Radius:	b = 1.25 inches	
Hub Length:	L = 0.50 inches	
Seat Angle:	θ = 5 degrees	
Poisson's Ratio:	ν = 0.3	(dimensionless)
Modulus of Elasticity:	E = 27,600,000 psi	
Stem Diameter:	D_{stem} = 1.875 inches	
Static Pullout Force:	F_{po} = 15,409 pounds	
Seat to Disk Coefficient of Friction:	μ = 0.496	(dimensionless)

The next five pages contain the output of the PRESLOK program, Version 2, using the above input.

Program PRESLOK, Version 2
Revision 0
December 22, 1995

This Mathcad Program is designed to calculate the estimated opening force under pressure locking scenarios for flex-wedge gate valves using a calculational methodology that accounts for wedge stiffness resisting pressure locking forces. This program was prepared by the Westinghouse Owner's Group based upon the calculational methods developed by Commonwealth Edison.

While this information is presented in good faith and believed to be accurate, the Westinghouse Owner's Group does not guarantee satisfactory results from reliance upon such information. Nothing contained herein is to be construed as a warranty, express or implied, regarding the performance, merchantability, fitness or any other matter with respect to the product, nor as a recommendation to use any product or process in conflict with any patent. The Westinghouse Owner's Group reserves the right, without notice, to alter or improve the methods described herein.

This section of the program reads the thirteen items of input data from the plinput2.dat file.

$i := 0..12$

$input_i := READ(plinput2)$

$P_{bonnet} := input_0 \cdot psi$

$P_{up} := input_1 \cdot psi$

$P_{down} := input_2 \cdot psi$

$t := input_3 \cdot in$

$a := input_4 \cdot in$

$b := input_5 \cdot in$

$Hub_{length} := input_6 \cdot in$

$\theta := input_7 \cdot deg$

$\nu := input_8$

$E := input_9 \cdot psi$

$D_{stem} := input_{10} \cdot in$

$F_{po} := input_{11} \cdot lbf$

$\mu := input_{12}$

Program PRESLOK, Version 2

INPUTS:

Bonnet Pressure	$P_{bonnet} = 1005 \cdot psi$
Upstream Pressure	$P_{up} = 380 \cdot psi$
Downstream Pressure	$P_{down} = 350 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 2 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 4.36 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.25 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$v = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.76 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 15409 \cdot lbf$
Coefficient of Friction between disk and seat:	$\mu = 0.496$
Stem Diameter	$D_{stem} = 1.875 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.5 \cdot in$

Program PRESLOK, Version 2

PRESSURE FORCE CALCULATIONS

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$ $$DPavg = 640 \cdot psi$$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot \left(1 - \nu^2\right)}$$ $$D = 2.022 \cdot 10^7 \cdot lbf \cdot in$$

$$G := \frac{E}{2 \cdot (1 + \nu)}$$ $$G = 1.062 \cdot 10^7 \cdot psi$$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right]$$ $$C_2 = 0.1781$$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$ $$C_3 = 0.0311$$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right]$$ $$C_8 = 0.6788$$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$ $$C_9 = 0.2789$$

$$L_3 := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^2 - 1\right]$$ $$L_3 = 0$$

$$L_9 := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^2\right]\right]$$ $$L_9 = 0$$

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1+4\cdot\left(\frac{b}{a}\right)^2-5\cdot\left(\frac{b}{a}\right)^4-4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2+\left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0069$$

$$L_{17} := \frac{1}{4}\cdot\left[1-\frac{1-\nu}{4}\cdot\left[1-\left(\frac{b}{a}\right)^4\right]-\left(\frac{b}{a}\right)^2\cdot\left[1+(1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.1526$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot\left(a^2-b^2\right)-L_{17}\right] \qquad M_{rb} = -5265\cdot lbf$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot\left(a^2-b^2\right) \qquad Q_b = 4466.5\cdot\frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -3.9041\cdot 10^{-4}\cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right)-1+\left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.4743$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -2.7177\cdot 10^{-4}\cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot\left(a^2-b^2\right)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 6.4731\cdot 10^{-5}\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -7.2691\cdot 10^{-4}\cdot in$$

Program PRESLOK, Version 2

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -3.079\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -6.012\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -5.055\cdot 10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -9.597\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 20750.5\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}^{\ 2}\cdot P_{bonnet} \qquad F_{piston} = 2775\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 6662.4\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 16889.1\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 15409\cdot lbf$$

$$F_{total} = 36185.5\cdot lbf$$

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Ref. 9

REFERENCES

1. Bunte, Brian, "ComEd Pressure Locking Methodology and Test Program," presented at the NRC Region 3 Workshop on Pressure Locking and Thermal Binding, November 7, 1995.

2. Roark, Raymond J., and Young, Warren C., *Formulas for Stress and Strain, Fifth Edition,* McGraw-Hill Book Company, 1975.

3. Liberal use has also been made of a draft of a report being prepared by Mr. Brian Bunte of Commonwealth Edison Company, tentatively titled "Pressure Locking /Thermal Binding Report."

ME-0498, Rev. 0
Ref. 9

USER'S GUIDE FOR STEMGROW, A GATE VALVE THERMAL BINDING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

REVISION 0

December 29, 1995

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USER'S GUIDE FOR STEMGROW GATE VALVE THERMAL BINDING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

RECORD OF REVISION PAGE

Rev. 0	Original Issue	December 29, 1995

USER'S GUIDE FOR STEMGROW
GATE VALVE THERMAL BINDING ANALYSIS PROGRAM
USING THE COMMONWEALTH EDISON MODEL

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INTRODUCTION

Thermal binding is a phenomenon which can cause the unseating thrust for a gate valve to increase, sometimes dramatically, from its typical static unseating thrust. This can possibly result in the valve failing to open due to the actuator having insufficient thrust capability. Thermal binding can also result in valve damage in cases where the actuator thrust capability exceeds the valve structural capacity. For these reasons, a proper understanding of the conditions which may cause thermal binding, as well as a methodology for predicting the increase in unseating thrust for a thermally bound valve, are necessary. The analysis technique described herein allows the calculation of the increased unseating load for a valve undergoing one type of thermal binding, that due to thermal growth of the valve stem.

A method of analyzing gate valves to predict the increased unseating thrust for a valve which is experiencing thermal binding due to thermal growth of the stem has been developed by Commonwealth Edison, and has been obtained from Mr. Brian Bunte. The Westinghouse Owner's Group, in the Pressure Locking/Thermal Binding Task Team meeting on November 13 and 14 , 1995, authorized the preparation of a MATHCAD program and accompanying user's manual to allow the uniform use of the Commonwealth Edison thermal binding analysis methodology. This manual is the result of that authorization.

This manual and the program file for performing the analysis are available from the Westinghouse Owner's Group and may be obtained by contacting L. I. Ezekoye at (412) 374-6643 or W. E. Moore at (412) 374-6351. Please indicate whether the program is to be supplied on 3.5 inch diskettes or 5.25 inch diskettes.

HARDWARE/SOFTWARE REQUIREMENTS

The program has been written using the MATHCAD 5.0 for Windows program. This program is available from

MathSoft, Inc.
101 Main Street
Cambridge, MA 02142
1-800-628-4223 or
617-577-1017
Fax: 617-577-8829

The program is also widely available from software vendors.

The following hardware and software requirements for running the MATHCAD 5.0 for Windows program are extracted from the User's Guide which is supplied with the MATHCAD program:

- An 80386 or higher IBM® or compatible computer. A math coprocessor is not required, but its presence will significantly improve performance.
- Microsoft® Windows™ Version 3.1 or later or Windows NT.
- At least 4MB of RAM. All memory above 640K should be configured as extended memory.
- At least 14MB of free hard disk space for MATHCAD files.
- An additional 1MB on the hard disk where MATHCAD is installed.
- At least 8MB of virtual memory. See the Windows user manual for how to specify virtual memory.
- A monitor and graphics card compatible with Windows.
- A mouse supported by Windows.
- Any printer supported by Windows.

The User's Guide supplied with the MATHCAD program should be followed for installation of the MATHCAD program onto your computer. The scope of this manual is to explain the usage of the STEMGROW analysis using the MATHCAD program.

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GETTING STARTED

The STEMGROW files are supplied to you on either a 3.5 inch or a 5.25 inch diskette, per your request. It is recommended that the first step to use the files is to copy a "working version" of the files to your hard disk so that the diskette can be retained as a record copy. The files which are included are as follows:

stemgrow.mcd	MATHCAD program for calculating the unseating thrust required for a valve undergoing thermal binding due to stem thermal growth..
sginput.dat	ASCII file of input data required by the STEMGROW program.

The next step to use the program is to create a data file to transfer the input values for the variables to the STEMGROW analysis program. The STEMGROW program is expecting these variables to appear in text file in plain ASCII format with the name "sginput.dat". The various numbers in the "sginput.dat" file can be separated by spaces, commas, or carriage returns, and may appear as integers, floating point numbers, or as E-format numbers such as 2.35E-2 . An ASCII text file can be created using the Windows utility Notepad, or by numerous other methods. This file should be located in the same directory as the STEMGROW file, since when the STEMGROW file is loaded, that directory will become the MATHCAD default directory. The user is also referred to the chapter on "Data Files" in the MATHCAD User's Guide if further explanation of the use of the ".dat" file is needed.

Sample data files are included in the program diskette which can be used simply by changing the input values to the proper values for your analysis. Alternately, other file names can be used for the input data by changing the input file name on the page 1 of the STEMGROW program to the file name desired.

RUNNING THE STEMGROW ANALYSIS

At this point it is assumed that the user has the MATHCAD 5.0 program loaded onto his computer, and that the STEMGROW file and the "sginput.dat" file are available to the computer in the same directory. To run the STEMGROW analysis, the user should perform the following steps:

1. Double click on the MATHCAD 5.0 icon to start the MATHCAD program.

2. Go to the File pulldown menu and click on Open (or click on the Open File icon on the Tool Bar.)

3. In the Open dialogue box, select the directory containing the stemgrow.mcd file and select the stemgrow.mcd file. Then click on OK.

4. The STEMGROW program will pick up the input values from the sginput.dat file and perform the analysis if the program is in the automatic mode (Automatic Mode has a check mark next to it in the Math pulldown menu.) If the MATHCAD program is not in the automatic mode, it can be forced to perform the calculation by clicking on the Calculate Document function in the Math pulldown menu. Results may be inspected by using the scroll bar on the right hand side of the display to scroll through the display as desired.

5. To change the inputs, open the Windows utility Notepad and open the sginput.dat file. Make the desired changes to the file and then save it. To have MATHCAD re-perform the analysis with the new input values, open the Math pulldown menu and click on Calculate Document. This alternate use of Notepad and the MATHCAD function Calculate Document should be repeated until the analysis is correct.

6 The output may be printed using the Print command in the pulldown menu under File or using the print icon in the Tool Bar. The user is referred to the MATHCAD User's Guide if any changes are desired to the Page Setup or the Printer Setup.

   Note that valve identifiers or other identifying titles may be added to the output by using the MATHCAD text entry methods given in the MATHCAD User's Guide. If the user desires to add the identifier/title to each page, the use of a header is recommended. The header can be defined through the Headers/Footers command in the Edit pulldown menu or through the Header command in the Page Setup dialogue box. See the Documents and Windows section of the MATHCAD User's Guide for further information about Headers.

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7. The program may be exited using "Exit" in the File pulldown menu.

INPUT PREPARATION

The following inputs are required for the use of the STEMGROW analysis program:

- Change in temperature to which the portion of the valve stem being inserted into the valve body/bonnet is subject.

Change in Temperature:	**DeltaTemp**	°F

- Valve/Actuator Parameters. These includes the amount of stem travel in going from open to closed, the stem thread lead in inches, the actuator motor speed and the actuator overall gear ratio.

Stem Travel:	**Travel**	inches
Stem Thread Lead:	**Lead**	inches
Actuator Motor Speed:	**MotorSpeed**	RPM
Actuator Overall Gear Ratio:	**OAR**	dimensionless

- Valve Stem Material Properties. The only material property required is the coefficient of linear thermal expansion for the stem material, for the temperature range being considered.

  Coefficient of Thermal Expansion: **TempCoef**

  inches/inch/°F

- Measured forces and times from testing of the subject valve. A sample of a typical thrust versus time curve is given in Figure 1, which illustrates most of the required values. These include the following:

Maximum Static Closing Thrust: (VOTES Event Number C16)	$\mathbf{Max}_{close}$	pounds
Maximum Static Unseating Thrust: (VOTES Event Number 09)	$\mathbf{Max}_{open}$	pounds
Thrust at Control Switch Trip: (VOTES Event Number C14)	$\mathbf{CST}_{thrust}$	pounds
Time at Control Switch Trip: (VOTES Event Number C14)	$\mathbf{CST}_{time}$	seconds
Thrust at Seating: (VOTES Event Number C11)	$\mathbf{Seat}_{thrust}$	pounds
Time at Seating:	$\mathbf{Seat}_{time}$	seconds

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(VOTES Event Number C11)

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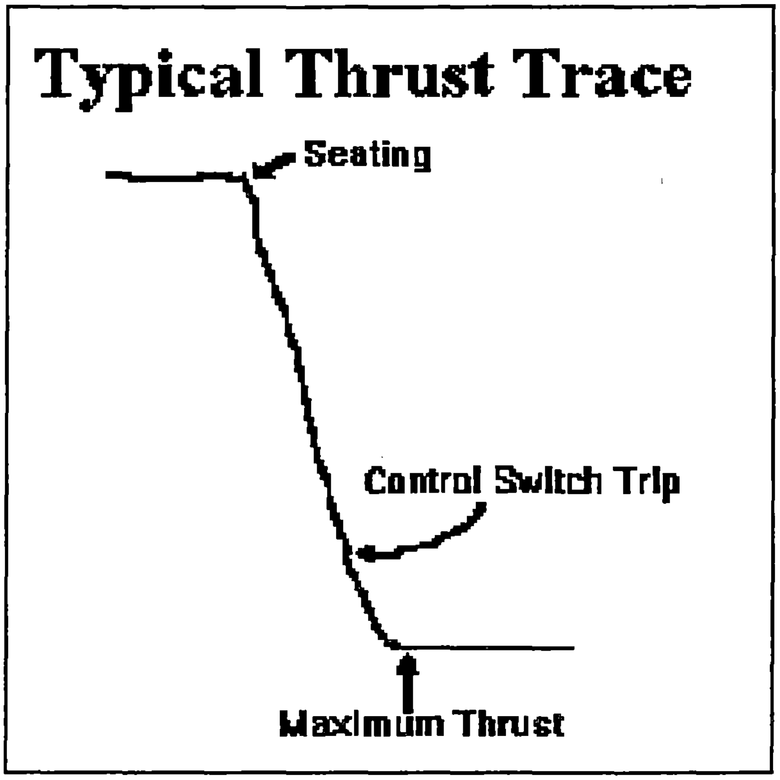

FIGURE 1

THEORY

ASSUMPTIONS

1. This analysis assumes that the stiffness of the entire valve and actuator assembly can be found from measurements taken during the testing of the valve. Specifically, the stiffness of the entire assembly is calculated from the difference in thrusts at seating and at control switch trip divided by the inches of stem travel between seating and control switch trip. The inches of travel between seating and control switch trip are calculated from the time between these events and the stem travel speed, which is found from the motor speed, the overall gear ratio of the actuator, and the lead of the stem threads.

2. Inherent in the first assumption is the assumption that the motor speed remains at a known, constant value for the period between seating and control switch trip, and that this constant travel speed results in a constant rate of increase in thrust as the stem moves.

3. The only portion of the stem which undergoes significant thermal growth is the portion which is moved inside the body or bonnet of the valve in moving from the open to closed position, i.e., a length of the stem equal to the stem travel.

DESIGN INPUTS

The following design inputs are used in calculating the force required to unseat an MOV subject to thermal binding due to stem thermal growth:

- Change in temperature to which the portion of the valve stem being inserted into the valve body/bonnet is subject.

Change in Temperature:	**DeltaTemp**	°F

- Valve/Actuator Parameters. These includes the amount of stem travel in going from open to closed, the stem thread lead in inches, the actuator motor speed and the actuator overall gear ratio.

Stem Travel:	**Travel**	inches
Stem Thread Lead:	**Lead**	inches
Actuator Motor Speed:	**MotorSpeed**	RPM
Actuator Overall Gear Ratio:	**OAR**	dimensionless

- Valve Stem Material Properties. The only material property required is the coefficient of linear thermal expansion for the stem material, for the temperature range being considered.

  Coefficient of Thermal Expansion: **TempCoef**

  inches/inch/°F

- Measured forces and times from testing of the subject valve. A sample of a typical thrust versus time curve is given in Figure 1, which illustrates most of the required values. These include the following:

Maximum Static Closing Thrust: (VOTES Event Number C16)	$\mathbf{Max_{close}}$	pounds
Maximum Static Unseating Thrust: (VOTES Event Number 09)	$\mathbf{Max_{open}}$	pounds
Thrust at Control Switch Trip: (VOTES Event Number C14)	$\mathbf{CST_{thrust}}$	pounds
Time at Control Switch Trip: (VOTES Event Number C14)	$\mathbf{CST_{time}}$	seconds
Thrust at Seating: (VOTES Event Number C11)	$\mathbf{Seat_{thrust}}$	pounds

Time at Seating: (VOTES Event Number C11)	**$Seat_{time}$**	seconds

CALCULATIONS

The methodology for calculating the thrust required to open an MOV subject to thermal binding due to stem growth is based upon calculating the increase in seating thrust due to thermal elongation of the stem. This is done by calculating the free thermal growth of the stem, and then using the stiffness of the valve/actuator assembly to convert the change in length to a change in seating thrust. The unseating thrust under the thermal binding load is then calculated by multiplying the thermally bound seating thrust by the ratio of the normal unseating thrust to the normal seating thrust. The calculations are done using the design inputs as follows:

Valve/Actuator Assembly Stiffness Under Thrust Loading

The stem is assumed to move at a constant rate of speed with a constant rate of increase in thrust during the period between seating and control switch trip during valve testing. The motor speed during this period is assumed to be known. Then, the stem speed can be calculated from

$$Stem\ Speed = Motor\ Speed \cdot \frac{1\ minute}{60\ seconds} \cdot \frac{Lead}{OAR}$$

The motor speed is assumed to be given in revolutions per minute.

The rate of load increase is calculated directly from the measured values of thrust and time.

$$Load\ Rate = \frac{CST_{thrust} - Seat_{thrust}}{CST_{time} - Seat_{time}}$$

The stiffness of the valve/actuator assembly under thrust loading is then obtained from

$$Stiffness = \frac{Load\ Rate}{Stem\ Speed}$$

Ratio of Unseating Force to Seating Force

The ratio of unseating force to seating force is assumed to be the same for the thermally bound condition as it is for normal valve operation. Using values from an opening test performed following a closing test at operating conditions, this ratio is simply

$$Unseating\ Ratio = \frac{Max_{open}}{Max_{close}}$$

Stem Elongation due to Thermal Expansion

The amount of stem elongation due to thermal expansion is calculated by the familiar $L \cdot \alpha \cdot \Delta T$ equation.

$$Stem\ Elongation = Travel \cdot DeltaTemp \cdot TempCoef$$

Total Force Required to Overcome Thermal Binding due to Stem Growth

The total thrust which is holding the valve closed is now calculated as the sum of the thrust due to normal closing plus the additional thrust due to stem thermal growth.

$$Final\ Thrust = Max_{close} + Stem\ Elongation \cdot Stiffness$$

The final value for unseating thrust is just the ration of the normal unseating thrust to the normal closing thrust times the thermally bound closing thrust.

$$Final\ Unseating\ Thrust = Unseating\ Ratio \cdot Final\ Thrust$$

The acceptance criteria recommended for use in this calculation is that the available motor operator thrust capability be at least 120% of that required to unseat the MOV under thermal binding conditions. The 20% margin is provided to allow for uncertainty in the measurements of used to calculate the stiffness and the unseating ration as well as other effects such as valve-to-valve and motor actuator-to-motor actuator variations. All of these effects are random in nature.

EXAMPLE OF AN ANALYSIS PERFORMED WITH STEMGROW

The following is an image of the input file sginput.dat used to run an example problem the STEMGROW analysis program:

```
10       300     0.00001  15000   9000   12000   17.874   1000
16.994   3600    62.5     0.25
```

The input file corresponds to input values as shown:

Stem Travel:	**Travel**	10 inches
Change in Temperature:	**DeltaTemp**	300 °F
Coefficient of Thermal Expansion:	**TempCoef**	0.00001 inches/inch/°F
Maximum Static Closing Thrust:	$\mathbf{Max_{close}}$	15000 pounds
Maximum Static Unseating Thrust:	$\mathbf{Max_{open}}$	9000 pounds
Thrust at Control Switch Trip:	$\mathbf{CST_{thrust}}$	12000 pounds
Time at Control Switch Trip:	$\mathbf{CST_{time}}$	17.874 seconds
Thrust at Seating:	$\mathbf{Seat_{thrust}}$	1000 pounds
Time at Seating:	$\mathbf{Seat_{time}}$	16.994 seconds
Actuator Motor Speed:	**MotorSpeed**	3600 RPM
Actuator Overall Gear Ratio:	**OAR**	62.5 (dimensionless)
Stem Thread Lead:	**Lead**	0.25 inches

The next three pages contain the output of the STEMGROW program, Revision 0, using the above input.