Attachment 4

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Calculation ME-0498

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

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 Analyzis for Generic Letter 95-07.	VIRGINIA POWER	CALC ADDE	NDUM COVER SHEET
Station(s): NAPS AND SPS Units 00 Sheet 1 of 15	Calc Number: ME-0498	Rev. 0	Add: 00A
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.: Initiating Document: (DCP, IEER, REA, etc.): Attachments? [X] Yes [] No Labeled _1 through [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 [.38] [01] [SI] [MOV] [1842 [.38] [01] [SI] [MOV] [1842 [.38] [01] [SI] [MOV] [1869A [.38] [01] [SI] [MOV] [1869A [.38] [01] [SI] [MOV] [1869B [.484] [01] [SI] [MOV] [1869B [.486] [01] [SI] [MOV] [1869B [.486] [01] [SI] [MOV] [1869B [.486] [01] [SI] [MOV] [2842 [.486] [01] [SI] [MOV] [2842 [.486] [01] [SI] [MOV] [2842 [.486] [01] [SI] [MOV	Station(s): NAPS AND SPS	Units 00	Sheet 1 of <u>15</u>
Changes Calc Status? [] Yes [X] No New Status: Reference Numbers: IR No.: Job No. Initiating Document: (DCP, IEER, REA, etc.):	Addendum Title (Subject): <u>Pressure Lock</u> Binding Analysis for Generic Letter 95-	ing and Stem Ef 07.	fect and Thermal
Reference Numbers: IR No.: Job No. Initiating Document: (DCP, IEER, REA, etc.):	Changes Calc Status? [] Yes [x] No	New Status:	
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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. Prepared By (Print Name) Paul D. Jones Signature 6-25-96 Reviewed By (Print Name) John J. Wolak Signature 6-25-96	Station Unit System Prefix Sequ [<u>38</u>] [01] [SI] [MOV] [1842 [<u>38</u>] [01] [SI] [MOV] [1842 [<u>38</u>] [01] [SI] [MOV] [1869A [<u>38</u>] [01] [SI] [MOV] [1869B [<u>38</u>] [01] [SI] [MOV] [1869B [<u>38</u>] [01] [SI] [MOV] [1869B [<u>38</u>] [01] [SI] [MOV] [2842 $C^2 \rho \rho (\rho g \rho g$ [x] Additional Mark Numbers? (Check if Objective: The purpose of this addendum is to the original pressure locking calc additional MOVs were determined to pressure locking while reviewing p segregated/non-segregated parallel LOCA.	ence Comp. [VALVE] [VALVO] [VALVO] [VALVE] [VALVO] [VALVE] [VALVO] [VALVE] [VALVE] "yes"). See "yes"). See include several ulation for SPS be potentially ressure locking flow paths on D	Code Suffix Suffix P_] P_] Suffix P_] Suffix P_] Suffix P_] Suffix Suffix Suffix Suffix Suffix Suffix Suffix Suffix Suffix Susceptible to effects in MOVs during a
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6-25-96 Date: 6-25-96 Date: 6-25-86 Date:

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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.

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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

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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:

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

where: F_{nres}=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_{DD}=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:

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

where: $F_{stem rej}$ =stem rejection load, lbs Stem_{oD}=stem outer dimension, in.

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Date: 6-25-98 6-25-96 Date: 6-25-86 Date:

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ASSUMPTIONS

- 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.

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Date: 6-25-96 6.25.96 Date: 6-25-26 Date:

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DESIGN INPUTS

- 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.
- 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 9 are based upon the Limitorpue stem factor equation. (reference 11).

Prepared By: Reviewed By: Reviewed By: MOV Evaluation/ME-0498

Date: 6-75-96 6-25-912 Date: 6-25-96 Date:

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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.

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6-25-96 Date: 6-25-96 Date: 6-25-25 Date:

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REFERENCES

- 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).
- 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).
- 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: Reviewed By: Reviewed By:

6.25-96 Date: 6.25.96 Date: 6-25-16 Date:

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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).

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Date: Date: 6-25-86 Date:

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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	Motor Torque
SI-1842	2510	1448	0	3.445	3.445	33278	0.55	18303.0	1.25	3078.7	3553	-rej ld+po) 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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* The attached VOTES test for this value list two pullent thrusts, 2293 and 2361 163. This makes an insignificant difference of approximately 0.5% to the capability margin. <u>Table 1</u> - Con 7: 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 -rei 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

Pullout Efficiency	Operator Capability	MOV/plan Avg COF	Stem Factor	Operator Thrust Capability	Capability -Pullout (margin)	Capability Margin (%)
0.4	306	0.2	0.0179	17095	11132	65.1
0.4	304	0.2	0.0179	16969	959 <u>0</u>	56.5
0.4	308	0.2	0.0179	17222	11931	69.3
0.4	313	0.2	0.0179	17475	12507	71.6
0.4	313	0.2	0.0179	17475	9991	57.2
0.4	315	0.2	0.0179	17602	12169	69.1
	Pullout Efficiency 0.4 0.4 0.4 0.4 0.4 0.4	Pullout Efficiency Operator Capability 0.4 306 0.4 304 0.4 308 0.4 313 0.4 313 0.4 313 0.4 315	Pullout Efficience Operator Capability MOV/plan Avg COF 0.4 306 0.2 0.4 304 0.2 0.4 308 0.2 0.4 313 0.2 0.4 313 0.2 0.4 313 0.2 0.4 313 0.2	Pullout EfficiencyOperator CapabilityMOV/plan Avg COFStem Factor0.43060.20.01790.43040.20.01790.43080.20.01790.43130.20.01790.43130.20.01790.43150.20.0179	Pullout Efficiency Operator Capability MOV/plan Avg COF Stem Factor Operator Thrust Capability 0.4 306 0.2 0.0179 17095 0.4 304 0.2 0.0179 16969 0.4 308 0.2 0.0179 17222 0.4 313 0.2 0.0179 17475 0.4 313 0.2 0.0179 17475 0.4 313 0.2 0.0179 17475 0.4 315 0.2 0.0179 17602	Pullout Efficiency Operator Capability MOV/plan Avg COF Stem Factor Operator Thrust Capability Capability -Pullout (margin) 0.4 306 0.2 0.0179 17095 11132 0.4 304 0.2 0.0179 16969 9590 0.4 308 0.2 0.0179 17222 11931 0.4 313 0.2 0.0179 17475 12507 0.4 313 0.2 0.0179 17475 9991 0.4 315 0.2 0.0179 17602 12169

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Table 2 - Stem Factor Calculations SURRY

Mark	Stem	TPI	Pitch	Lead	St	Fs		Fs
Number	Diam.						COF	
				· <u> </u>		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

6-25-96 6-25. 6-25-96 2

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Table 2 - con 7. naps

VALV	STEM I	NFO						
Mark	Stem	TPI	Pitch	Lead	St	Fs		Fs
Number	Diam.						COF	
						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, 8 SI-2836	51-1869A ar , <i>St</i> -2869	10 SI-1869 A& S±-7	B are all 3 28698 a /	' velans w/ حما ہے	1.125" 2st 3 <i>'' Vela</i>	and 3101	1.125," 25	tart, 3,
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
	4 050		0.000	0.000		0.0400	0.00	0.0470

1870 6-25-94 1870 6-25-94 194 6-25-96

ME-0498 (Cev. O Add- 0.A °. 146/b

Doc. No.: ME-0498, Rev. 0,Add.0A Sheet 15 of 15

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: Reviewed By: Reviewed By: MOV Evaluation/ME-0498

6-25-96 Date: 6-25-96 Date: 6-25-86 Date:

Doc. No.: ME-0498, Rev. 0, add. 0A

ATTACHMENT 1 - CALCULATION REVIEW CHECKLIST AND

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ATTACHED REFERENCES

ATTACHMENT 8.5 NDCM 3.7 Rev. 5

CALCULATION REVIEW CHECKLIST								
CALCULATION NO. ME-0498	REV. NO. O	ATTACHMENT 1_	PAG	<u> </u>	0F <u>4</u>			
CALCULATION TITLE:	Pressure Locking/Th	nermal Binding Ana	lysis	for GL	89-10			
A "NO" answer to a NOTE: Reference m	ny questions require ay be made to explar	es that an explana nations contained	tion b in the	e provi calcul	ded. ation.			
QUE	STIONS		YES	NO	<u>N/A</u>			
1. Is the calcula on each page o	tion number and revi of the calculation ar	ision identified nd attachments?	[x]	[]	[]			
2. Does the object for performing background inf	tive statement ident the calculation and ormation?	ify the reason give sufficient	[x]	[]	[]			
3. Have the source selected and r	es of design inputs eferenced in the cal	been correctly Lculation?	[x]	[]	[]			
4. Are the source retrievable (a	s of design inputs und/or a copy attached	p-to-date and d to the calc.)?	[x]	[]	[]			
5. Where appropri reviewed or pr they are respo	ate, have the other ovided the design ir nsible?	disciplines uputs for which	[]	[]	[x]			
6. Have design in test, measurem pertinent mean analyzed?	puts been confirmed ent, field walkdown, s as appropriate for	by analysis, or other the configuration	[x] n	[]	[]			
7. Are assumption the Station De	s adequately describ sign Basis?	ed and bounded by	[x]	[]	[]			
8. Have the bases adequately and	for engineering jud clearly presented?	lgements been	[x]	[]	[]			
9. Were appropria used and are o to inputs?	te calculation/analy utputs reasonable wh	tic methods nen compared	[x]	[]	[]			
10. Are computatio the calculatio for instrument errors? (Refe	ns technically accur n made appropriate a errors and calibrat rence STD-FEN-0304)	ate and has allowances ion equipment	[x]	[]	[]			
11. Have those com been listed in ment been plac which states -	puter codes used in the "references" or ed in the "methods o "No computer code u	the calculation has a state- of analysis" sections used.", if no	[x] on	[]	[]			
computer codes 12. Have all excep criteria and r identified and	were used? tions to station des egulatory requiremen justified in accord	sign basis hts been lance with	[x]	[]	[]			
Comments: (N/A if	none) <u>NA</u>	+		<u> </u>				
[] Additional com	ment pages added.		·					
Prepared By:	Date: 6-25-96	Reviewed By:	Dato	e: · 25 - 9	6			
								

6- 25.96

ME-0498 ADD. 001 JUN 25 '96 11:18 -P.1/5 ATTACHMENT 1 317271-01 5 REF. Walnator: 2007homan - Tag-Number: 2-51-23698 · AS LEFT AFTER. Test Huber: 9 4/30 195 COF TESTING RESULTS Test late: 4/38/95 Close **Onen** · COF = 0.11 Stroke Time 9.961 Stroke Time 9.918 seconds seconds seconds **Bupass Time** 8.953 seconds **Bypass Time** 2.268 · LIMIT- GLOSE HOV lbs lks · CYLLIC LOADING IN Max Bunning Force -3469 Max Running Force 2798 CLOSE DIRECTION ; -2549 lbs Avy Running Force 2022 lbs Avg Running Force NOT ADVERSELY AFFECTING OFERATION -1394 lls Disc Pullout Force 4449 lbs 4 Thrust at CST -8295 Maximum Thrust lbs Available Thrust Margin -839 lbs Torque Sr. Setting 0/C 3.868/3.868 Spring Pack Preload lhs Downstream Pressure (psi) Start/Finish..... Ô 0/ General Comments: Vtc no. 658 sens. .c-clamp 672,Votes 513,Amp probe 532 Actuator Motor Voltage Type: AC Valve Information Valve Actuator Actuator Type .. LIMITORO Plant: NASI Unit. TWO Volts...... 460 Amp rating..: 2.60 amps Nom. Speed..: 1750.00 rpm Start torque: 15.00 ft-lb Size..... SNB-00 Max Thrust Rate: 14000 lbs Serial #....: 115917 Order #....: 345804J Tag Number.....: 2-SI-28698 Target Thrust...: VERT Wore Gear Teeth: Gear Ratio....: Spring Pack # Run Torque..: 3.00 ft-1b Horse Power.: 0.00 h.p. 0 1bs 70 Location..... AB 244 PEN Stam Material...: 17-4PH 22 Stem Diameter...: 1.125 inches Threads per Inch: 3.00 E/Poisson Ratio.: 106.0 x 10E6 psi VOTES Serial #... SFSL Sensitivity 1.376E-0002 Votes Force Offset: -2300 lbs Signal Conditioner Calibration Due Date 06/20/95 1.376E-0002 fv/v/1b ٩.

JUN 25 '96 11:19

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P.2/5 MÉ-0498 AUD. 001 ATTACHMENT I REF. 5 AS-LEPT AFTER COF TESTING

Evaluator: <u>MThoman</u> Date: 512.195 TEST RESULTS	Tay Hunder: 2-SI-2836 Test Hunder: 9 Test Date: 5/2/95	COF = 0.15
Stroke Time 18.319 seconds	Stroke Tine 18.661 seconds	
Bypass Tine 1.348 seconds	Bypass Time 2.166 seconds	
Max Running Force -678 lbs	Max Running Force 1868 lbs	
Avg Running Force -513 lbs	Arg Imming Force 748 Ibs	· ·
Thrust at CST -1574 lbs -	list fullout force 3984 lis	· · · · · ·
Maximum Thrust -6883 lbs -	• •	
Available Thrust Margin -968 lbs	Tarque Sr. Setting 0/C 2.899/2.888	~
Spring Pack Preload Ibs		· ·
Calibration Range:	191 to -7731 lbs.	
	~	
Torque Switch Setting Open/Clos Limit Switch Rotor Adjustment (Flow (gpm) Start/Finish Upstream Pressure (psi) Start/F Downstream Pressure (psi) Start General Comments: W.O.#317310-01 THIS IS THE AS L TEST 7 AND 8. ESK-6DP-1 REV 4	EFT TEST VALUE AFTER VTC. ENG HAS TH 5/2/95 @ 0545	E DATA FOR
Valve Information Plant: NASI Unit.: TWO Tag Number: 2-SI-2836 Type: GATE Size: GATE Size	Valve Actuator Actuator Type: LIMITORO Size SMB-00 Max Thrust Rate: 14000 lbs Serial # 115926 Order # 345804J Wore Gear Teeth: Gear Ratio 70 Spring Pack # 22	Actuator Motor Voltage Type: AC Volts 460 Amp rating 2.60 amps Nom. Speed 1700.00 rps Start torque: 15.00 ft-10 Run Torque 3.00 ft-10 Horse Power.: 1.00 h.p.

JUN 25 '96 11:19

late.

TEST RESILTS Close

Stroke Tine

Bugass Tine

Threat at CST

laxium Threat

P.3/5 As-left and COF AND. 001 Baluator: Buy/1 _Tag=Number: 1-SI-19653-1 ATTACHMENT 1 Test Mader: 8 12 22 Feb 96 REF. 5 Test late: 2/22/96 ânea Stroke Time 9.7% 9.885 seconds seconds rof = 0.1041.137 seconde **Jupass Tine** 2.213 servide thrust band : Nax Imaging Force Nax Junning Force lks 20 Ibs -12 limit to 12122 Ang Lunning Force Avg Lunning Force -15 lie 17 The 3775 Disc Pullout Force 3 max allowable : 12,122 lbs 1 He accuracy 9.4 % Torque Su. Setting 0/C-1.588/1.528-Available Thrust Margin -12 Ibs toque switch set to Spring Pack Preload Ik 5.0 and 5.0 after completion of testing c- clamp used as NOTES sensor. All face readings are in UV/V. Divide by eat device force sens. of \$.007774 to find true thrust readings in log. Limit Switch Rotor Adjustment (Y/N) N Flow (gpm) Start/Finish....: 0/ 0 Upstream 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-\$I-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 0.000B+0000 µv/v/lb Votes Force Offset: 1.44 µv/v

Downstream Pressure (psi) Start/Finish.....:

Valve Actuator Actuator Type ...: Max Thrust Rate: 14000 lbs Serial #..... Order #..... Worm Gear Teeth: 46 Gear Ratio: 72 Spring Pack # -22 and the NI SD

0/

0

Actuator Motor Voltage Type: AC Volts..... 460 Start torque: 45.00 ft-1b 15 Run Torque..: 3-00 ft-1b 3 Horse Power .: 4.00 h.p. 1

Signal Conditioner Calibration Due Date 08/05/96

R): Calibrator mounted in solid transition your 3/4" below threads. 3-5-96

	Test Results Sum	mary	ME-0498 ATTACHM	ADD. 00A
PLANT: NASI			Unit: ONE	Rer. S
Evaluator: <u>Welhow</u>	n zliglas	Valve Tag Number: Test Number: Test Date:	1-SI-1836-1 11 2/18/96 . ·	
Test Conditions				
	FUIT Open F			
Dostream Pressure (PS)	() ()	0		
Downstream Pressure ()	PSI) O	0		
Motor Voltage	460.00 Volts A	NC .		
eeseeeeeiteeseesee Cuitada Dattimaa				•
Switch Settings	ting 1 250			
Close Torque Switch Se	etting 1.250	•		
Durations (second	3)			~
_	Closing	·		
Stroke Time		2.064		
Seating Time	-	0.205		
Contactor Dropout Tim		0.010		
	opening			
Motor Currents (Amps rms) Closing			
Inrush Current	_	12.0		
Current at Contactor 1	Dropout	2.5		
	Opening		-	
Inrush Current		12_3		
		$\varphi_{i} = \varphi_{i} = \varphi_{i}$		
Thrust verification to ALTMAN AND RIORDAN	: est - C clamp-20104	sens .6982,cdfs .0077	4 votes 513	
C-clamp mounted .75* :	from threads - PARTI	LAL STROKE		•
AS LEFT AF	TER COF TES	TING (COF=	0.148)	
C	14 6438 LB	s / I	· ·	·
Ci	16 9131 LBS		- 22055)	
0	9 4979 - 83	5 / .		
	· · · · · · · · · · · · · · · · · · ·	•		_

RD 3-4-96.

P.5/5 JUN 25 '96 11:20 ha-left and COF Balator: TPaura Ter Masher: 1-51-19698 ME- 6498 ADD. 001 Test Mader: 1 late: / 4°Eb % ATTACHMENET 1 Test hate: 2/15/94 TEST DESILIS REF. 5 Close . Stroke Time 8.718 secenit -Stroke Time 1.857 seconds / Brass Tine 1.819 seconds **.** Burst Time 1.551 stants LOF Ø.118 Nax Renainy Force -1495 . Ibs Nax lenging force (547 Iks for limits force 1125 Avg Innaing Force -1133 lie 🖍 lk 🗸 ₽ list fullout force 635 Timust at CST -395 Ĩk: The -Naximum Threat -7569 limit closed Available Throst Nergin -2188 Ibs Targae Sa. Setting 0/C 1.008/1.000 value. T.S to Spring Pack Preloud lks he set at 5.0 1 5.0 Calibration Report 668 to -7258 lbs. Limit Switch Rotor Adjustment (Y/N)..... N C Flow (gpm) Start/Finish..... 0/ Upstream Pressure (psi) Start/Finish.....: 0/ 0 Downstream Pressure (psi) Start/Finish.....: 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 DRY SLV RPM. TORQUE SWITCH SET TO 5 & 5 POST THIS TEST COLEMAN/ WARREN R.E.ANGLE Valve Information Valve Actuator Actuator Motor Voltage Type: AC **Plant: NASI** Actuator Type..: LIMITORQ Unit.: ONE Size....: \$MB-00 Volts....: 460 Tag Number....: 1-SI-1869A **Hax Thrust Rate:** 14000 lbs Amp rating ..: 2.80 amps Type..... GATE Serial #.....: 115921 Nom. Speed..: 1700.00 rpm Start torque: 15.00 ft-1b Size..... 3* Order #.....: 345804J Run Torque..: 3.00 ft-1b Target Thrust...: 0 1bs Worm Gear Teeth: 38 Orientation....: VERT Gear Ratio....: 63 Horse Power.: :1.00 h.p. Location.....: AB 244 PEN Spring Pack F 22 Stem Materia1...: 17-4PH Stem Diameter...: 1.125 inches -Threads per Inch: 3.00 Threads per Rev.: 2 E/Poisson Ratio.: 106.0 x 10E6 psi/ Signal Conditioner Calibration Due Date 05/29/96 VOTES Serial #..: A6114 BFSL Sensitivity 2.845E-0002 µv/v/Tb RD 3-9-96 net slike

	•			MF- 0498 Paro
				A II
Test Result	s Summry			Add OA
		'Unit: 0	le internet interne	
				Attachment
	Value	Tag Hubers St-1842		
	Test	kaber: 15		
2 2	Tast	Nates 9/15/95		Pat 9
Test Conditions	Full . Blood		·	Ket, I
รเลย (เวชเก 🌼 🖓			•	· · · · · ·
Upstrees Pressure (PSI) 0	0			
Downstream Pressure (PSI) 0	. O	•••••	••••	
Notor Voltage 460.00 Vo	Lts AG			
Switch Sattings	•		•••-	
Open Torque Switch Setting 5.000			•	
Close Torque Switch Setting 5,000				
	 			
Durations (seconds) Closing		•		
Stroke Time		15.234	•••	
To Clove Indicator Light On	seconds	15.234 % stroke	100.00	
Close Torque Bypess Switch Opens	seconds	12.217 % stroke	80.20	
To Open Indicator Light Off	seconds	15,234 % stroke	103.00	
Sesting line .		U.917 0.022		
	•	o-ull		•
Stroke Time	•	14.932		
To Open Indicator Light On	seconds	14.932 % stroke	100.00	·
Open Torque Bypass Switch Opens	Records	12.233 % stroke	81.92	
To close indicator Light Off	Beconds	14,932 % STFCKB	100.00	

Forces (lbs) Calibra	tion Range: 315	to -14518 lbs.		
Closing New Remains Econo	-044			
Ave Running Force	-698		•	
Thrust at Start of Wadging	-1002			
Spring Pack Preload	-3191		•	
Thrust at CST	-7657			
Thrust at Contactor Dropout	-8381	•		
INTERNA INCLASE Naviman Theorem	-1938			
Available Thrust Margin	-6855		•	
Opening				
Initial Thrust (At Notor Start)	-19181	1		
Disc Pullout Force	3553			
Nax Running Force	607			
Avg kuming force	69/		-	
Notor Currents (and Pos)				·
Elesing				• .
Inruth Current	27.1			
Average Running Current	2.8			
Carrier at concercor proport				
Inrush Current	26.1			
Current at Maximum Pullout Force	3.1			
Average Running Current	2.9			
Concral Cramerter		 		
W290898-03 ENGR TRANSMITTAL USED	FOR THRUST BANDS	te .		
KINITED CLOSED VALVE LATU?000-12000	MX ALL.#21000	SYPASS 60-90X		
VOTES SYSN2 /CLANP USED:10041 SENS.52	59 AS USED.0050	5 DEFF USED:1.25		
TESTED ON U CLANP ANP USED 16120				
ISTED BITTE MILLO/RHUNDLEY/NCKINLEY			•	

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	./	••		· · ·	ME OLIAR ROLD
	/		• •		ME -0498, NEV. U
• /	Time	Force (lbs)	Current	Description	Add. OA
: /	(nsecs)	(Uncorrectes)			
· . 🖌	224	- 10181	19.7	HOLOF STAFE	- Attachmant 1
701	231	-10245	26.1	Inner Curren Perk	· · · · · · · · · · · · · · · · · · ·
6 2	284 .	-10203	2.3	LOST ROTION REGION (NEW PROPERTION	P_{1}
03	644	-10128	2.5	Harmerpick/Start of Starting	Ket-
- 05	1198	· 739 ·	3.1	STOR LAKES UP DISC CLEAR AND	
* 09	1238	. 3553	3,1 ::	-Naximum Force. Bt Disc. Puttout	
-013	1358	607	-2.9	Opening Running Contriction (New Contrict)	
012	12457	· 684 ·	3.0	Open Torque sypes surten open	-
015	15156	684	3.2	Close Indicator Light Ort (unwer)	
011	15156	684	3.2	Open Indicator Light un (keu)	
016	15156	684	3.2	Open Limit Suiten Opens	
· 017	15170	717	2.8	Notor Current Cutory	
ĊŬ	17799	519	18.5	Hotor Start	
C1 ·	17806	574	27.1	Inrush Current Pesk	
C2 .	17861	· · 486	2.5	Lost Motion Region (Near Micale)	,
CF	18222	0	3.1 .	Zeroing Point for CF Calibration	
C4	18293	-802	2.7 ·	Closing Running Condition (Near Vegin's)	
C7	30016	-769	2.5	Close Torque Bypass Switch Opens	
C5	32650	-845	2.7	Closing Running Condition (Rear End)	
C11	32690	-1002	2.6	Disc Notion Stops / Start of Wedging	•
C13	32810	-3191	2.9	Spring Pack Starts to Compress	
65	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	Notor Current Cutoff	
C16	33207	-10331	Q.Q`	Naxiala Thrust Value	
. c17	33250	+10267	. 0.0	Finel Thrust Velue -	<u> </u>
• ""				·	



PRELOAD & 3242

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TMD

LST'= # 7747 JOT = # 10395

MARK NUMBERS: 19-00-21-WOY-1863 MON TEN NO: * MFR: L635 MODEL NO.: 5WR-00, 3458041 TASK TITLE : RE-SET TOROUGE SHITCH LOCATION CODE: AB - AUXILIANA BUILDING LOCATION CODE: AUXILIANA BUILDING LOCATION CODE: AUXILIANA BUILDING LOCATION CODE:	
LIC GEN XY : 7.3 J ELF 2 VING FR: " LOCKTICN CODE: A - ANTICIANT BULLIARY BULLIARY LOCKTICN CODE: A - ANTICAL ANY BULLIARY LOCKTICN CODE: A - ANTICAL	QCL: *
TASK PROBLEM TORQUE SWITCH NOT SET IAR REVISED DAP DESCRIPTION: INSTRUCTIONS, 1-DRP-007 PL/JE RETAIN PALLED EQUIPMENT FOR CAUSE DETERMINATION EVALUATION EQ HOST : Y EQ RELATED : Y HUMAN FACTORS: • ENVIRONMENTAL SOME: AB-28 EQ OF EQ HOST : Y APPEND R : N APPEND R AREA: 17 MESSC: Y INFO STEM : Y INSUL COMP : TECH SPECE MEINATION DATE/TIME: • TASK INFORMATION DATE/TIME: • TASK INFORMATION DATE/TIME: • PMT REQD : Y WELD/FL REQD : N ASME PROM : Y DEV RPT IND : Y PMT REQD : Y SCAP REQD : N INS REW REDD : N DEV RPT IS : S-1674 MESSES : 95-3025 EXPRESS : 95-3025 EXPRESS : 95-3025 INFORMATIONS PERATIONS CANTERS END : • DEFT: • TASK SIG NATURES DEFERSION: N END SECURE TIME: • PERATIONS CONTINGENT MERS: S/-95-5/-20 CAUGHING VERIFIED BY: • CAUGHING VERIFIED BY: • NOTE ••• DEPENDENCE SIGE SOON AND CAUGHING AND THE CAUGHING VERIFIED BY: • NOTE ••• DEPENDENCE SIGE SOON AND CAUGHING AND THE CAUGHING VERIFIED BY: • NOTE ••• DEPENDENCE SIGE SOON AND CAUGHING AND THE CAUGHING VERIFIED BY: • NOTE ••• DEPENDENCE SIGE BOAS ONLY.11 TASK JOB STEPS TASK JOB STEPS TASK TO DE STEP DESCRIPTION	ate
NETAIN FAILED BOULMENT FOR CAUSE DETERMINITION EVALUATION EVALUATION EQ. HOST Y APPEND R Y APPEND R Y APPEND R APPE	LITY: 4
EQ HOST : Y EQ RELATE : Y EVENTIONE : HUMAN FACTORS: * ENVIRONMENTAL ROME: AP-2B REG 1.97 : Y APPEND R : N APPEND R AREA: 17 MRSSC: Y INFOS ITEM : Y INSUL COMP : TECH SPECE EXPERIMENTION DATE/TIME: * * NERDS ITEM : Y INSUL COMP : TECH SPECE EXPERIMENT DATE/TIME: * * TASK INFO R MATION TASK INFO R MATION DATE/TIME: * * PART REQD : Y SCAP REQD : N ASME PRGM : Y DEV RPT IND : Y SECURE REL : N COATING REQD : N ENG RETINE : * SECURE REL : N COATING REQD : N ENG DES DOC : DRP-007 *** SECURE REL : N COATING REQD : N ENG DES DOC : DRP-007 *** DET : * * DET : * *** DE	
TASK INFORMATION PREATIONS PRE	 . 1
TASOUT REQD : Y WELD/FL REQD : N ASME PROM : Y DEV RPT IND : Y PMT REQD : Y SCAF REQD : N INS REM REDD : N DEV RPT 14'S : S-1674 * * RMP REQD : Y CONF ENTRY : N IND SR : N ENG REVIEW : Y SECURE REL : N COATING REQD : N ENG DES DOC : DRP-007 * * CONF ENTRY : N IND SR : N ENG DES DOC : DRP-007 * * DEPT : * COATING REQD : N ENG DES DOC : DRP-007 * * DEPT : * TROUBLE/BREAKDOWN: N //R APPROVED BY : * * DEPT : * TROUBLE/BREAKDOWN: N //R APPROVED BY : * * DEPT : * TROUBLE/BREAKDOWN: N //R APPROVED BY : * * DATE : * PERATIONS : $MAGE PROM PROVED PY = POP PROVED PY $	iso z Benat e 1
WITH MURBERS : 95-3025 * * * * * UCR: 5 LMD: E TASK TYPE PLANNER: GENNFEO BOOZE N UCR: 5 LMD: E TASK TYPE V/R APPROVED BY: * * DEPT: * TROUBLE/BERAADOWN: N //R APPROVED BY: * * DATE: * DATE/TIME: $\frac{9.13-55}{1.0.55}$ D200 LCO : DATE/TIME: $\frac{9.13-55}{1.0.55}$ D200 LCO : PC NOTIFIED : CAGGING VERIFIED BY: CAGGING REPORT NERS: $\frac{5/-95-5/-20}{1.0.558}$ SIGN AT EXT. 2747 OR JIM STAUFFER EXT. 2558 FOR AN QUESTIONS *** NOTE ** CONTACT SYSTEM ENGINEER A.WRIGHT AT EXT. 2747 OR JIM STAUFFER EXT. 2558 FOR AN QUESTIONS *** NOTE *** DEMATURED ALCOHOL TO BE CARRIED INTO THE RCA ON SATURATED RAGS, IN PLASTIC BAGS ONLY.11 TA S K JOB STEP 5 TEP NO STEP DESCRIPTION CRAFT REQUIRED HOURS TOT HOURS	
DARKE: GENNERG DECRIPTION CRAFT REQUIRED HOURS TOT HOURS DARKE: GENNERGU HOURS TOT HOURS DARE TASK JOB STEP DESCRIPTION CRAFT REQUIRED HOURS TOT HOURS	
TASK SIGNATURES DEPENDING : DATE/TIME: $\frac{9 \cdot 13 \cdot 95}{1200}$ C NOTIFIED : DATE/TIME: $\frac{9 \cdot 13 \cdot 95}{1200}$ C NOTIFIED BY: DATE/TIME: $\frac{9 \cdot 13 \cdot 95}{1200}$ C NOTES : SIGNATURES C NOTE STOP CONTACT SYSTEM ENGINEER A. WRIGHT AT EXT. 2747 OR JIM STAUFFER ET. 2558 FOR ANY QUESTIONS *** NOTE *** CONTACT SYSTEM ENGINEER A. WRIGHT AT EXT. 2747 OR JIM STAUFFER ET. 2558 FOR ANY QUESTIONS *** NOTE *** DENATURED ALCOHOL TO BE CARRIED INTO THE RCA ON SATURATED RAGS, IN PLASTIC BAGS ONLY. 11 TASK JOB STEPS TEP NO STEP DESCRIPTION CRAFT REQUIRED HOURS TOT HOURS	י ע <i>י</i> ן :: י
DC NOTIFIED PoD Date/time: $5 \cdot 13 \cdot 5 \cdot 5 \cdot 10 \cdot 5 \cdot $, , , , , , , , , , , , , , , , , , ,
CAGGING VERIFIED BY: Dury Date/TIME: $9/14/94$ $1/9:19$ CAGGING REPORT NBRS: $SI-95-5I-2c$ $SI-95-5I-5I$ 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.!! TA S K J O B S T E P S TTEP NO STEP DESCRIPTION	۲ ۲
TAGGING REPORT NBRS: SI-95-SI-2C SI-95-SI-5I 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.!! TA S K J O B S T E P S TEP NO STEP DESCRIPTION CRAFT REQUIRED HOURS TOT HOURS	· •
INPECIAL 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 TEP NO STEP DESCRIPTION CRAFT REQUIRED HOURS TOT HOURS	920088222 1 1
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TEP 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	*

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Test Results	Summary			
			Unit:	ONE
	Valve	Tag Numbe	r: SI-1869	A
	Test N	umber:	27	
- conditions	lest u	ate:	9/14/92	
Full Doen	Full Closed			
	0			
Instream Pressure (PSI) 0	0			
Downstream Pressure (PSI) 0	0			
Notor Voltage 440.00 Volt	S AC			

Switch Settings				
Open Torque Switch Setting 5.000				
Close Torque Switch Setting 5.000				
Durations (seconds)				
GLOSING		0 940		
JULICE LINC To Close Indicator Light On	sacondo	9.01U 0.910	Y etecko	100 00
Close Torque Rypass Suitch Coops	seconds	2 524	Y stroke	25 73
To Open Indicator Light Off	seconds	0 810	X stroke	100.00
Seating Time	3000 183	0.104	A Stione	100100
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) Calibrati	on Range: 1674	to -1617	6 lbs.	
Closing				
Max Running Force	-2368			
Avg Running Force	-2037			
Thrust at Start of Weoging	-2308			
Infust at Contraton Decreut	-4912			
Inertial Thrust	- 29/3			
Neximm Thrust	-8822			
Available Thrust Margin	-2543			
Doening	2545			
Initial Thrust (At Motor Start)	-9083			
Disc Pullout Force	2293			
Max Running Force	2293			
Avg Running Force	1976			
Notor Currents (amps mms)				
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 kunning Current	4. U			
Ceberal Commentsi				

1 308182-01 RESET TO 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 9715/95 ME-0498, Rev. O, Add oA Attachment 1 ReF-9

	Time	Force (lbs)	Current	Description
	/ (msecs)	(Uncorrected)	(amps mus)	
- /	81	-9015	9.6	Motor Start
	8 6	-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	Notor Current Cutoff
C 0	13785	1926	6.9	Notor Start
C1	13790	1998	15.3	Inrush Current Peak
C2	13982	2071	4.2	Lost Motion Region (Near Middle)
C3	14218	6 8	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)
C 8	23595	-4844	4.3	Open Indicator Light Off (Red)
C6	23595	-4844	4.3	Close Indicator Light On (Green)
C15	23608	-5911	3.0	Notor Current Cutoff
C16	23662	-8754	0.0	Maximum Thrust Value
C17	23822	-8582	0.0	Final Thrust Value

ME 0498, Rev. O, Add OA Attachment / Ref. 9



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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 Valve Actuator Actuator Motor Plant: SURRY Actuator Type..: 9BN/6BX Voltage Type: AC Unit.: ONE Size....: SMB-00 Volts....: 440 Tag Number....: SI-1869A Max Thrust Rate: 14000 lbs Amp rating..: 2.70 amps Serial #....: Type..... GATE Nom. Speed..: 1750.00 rpm Size..... 3 INCH Order #....: 3458041 Start torgue: 15.00 ft-lb Target Thrust...: Worm Gear Teeth: 25 Run Torque..: 0.00 ft-lb 9075 lbs Orientation....: HORIZ. Gear Ratio....: 28.2 Horse Power.: 1.00 h.p. Location.....: AB BASE. Spring Pack # 022 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 Signal Conditioner Calibration Due Date 12/08/95 SL Sensitivity 1.250E-0002 #v/v/lb x. Sensor Offset: -1309.73 lbs Spare Channel Offset: -D.00 in

				1E-04	Sun	21-0	AJJ.C	N/O TASK	- 7	*******	ENTERE
P. 16	L 2	PRINTED 08/22/	1995	PAGE 01	OF 05	WR TAG:	PROG-M005-5	WR TAG L	OC: NOT	HUNG	AN 8-29
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MN DESC: CH	ARGING PUN	IP DISCHARGE TO	LOOP				UTC NUMBE	R: *	•		
BOM ITEM NO	: *	MFR: 1553 M	NO.: "	SB-00, 3A514	19C		SERIAL NO	: *		17	TEM QCL: *
TASK TITLE	: * PERFOR	M VOTES VIC AN	id return t Idfeesesses	o serv.			TYPE: PLA	NNED MAIN	TENANCE	ی محمد محمد	SR «TASK: #Y
LOC GRID X/	Y:7.3 J	ELEV: 2	VIMS	FR: *							
LOCATION COL	DE: AB - SC: 20 FT	SOUTH OF GATE	LDING 1. 15 FT F	AST OF CON	ATNMENT	WALL 3	FT 🗖				_
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			111 1041-001			MINATION	-ENALINETO	3	-		
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EQ HOST	: Y	EQ RELATED	: Y	HUMAN F	CTORS: *	7	ENVIRONMENTAL	ZONE: A	B-2B		
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NPRDS ITEM	: Y	INSUL COMP	: *	TECH SPI	C EXPIRA	TION DAT	E/TIME: *	*			J
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TAGOUT REOD	: N	WELD/FL REO	D:N	ASME PRO	M : Y		DEV RPT IND	: N			
RWP REQD	. I : Y	CONF ENTRY	: N	IND SR	NEQD : N		ENG REVIEW	: Y	-		-
		SECURE REL	: N	COATING	REQD : N		ENG DES DOC	: *			
RWP NUMBERS	: 95-302	5 * <u></u>		*							
PLANNER: GEN	INFBO B	OOZE	N					UCR: 5	LMD: E	TASK 1	TYPE: SV
W/R SUBMITTH	ED BY: *		* *	DEPT:	*		TROUT	BLE/BREAK	DOWN: N		
W/R APPROVEL) BY : *			DATE:				******	Sobwierie		
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QC NOTIFIED TAGGING VERI TAGGING REPO	FIED BY:	NORK SAFE" ** NOTE ** DEN (RCA) ON SATUR	ATURED ALCO	A DHOL TO BE IN PLASTIC	CARRIED BAGS ONL	1 	DATE/TIME		<u>6/25</u>	n <u>o 20</u> <u>, ~ ~</u>	<u>1</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE	FIED BY:	POD N//2 WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR	ATURED ALCO	A DHOL TO BE IN PLASTIC	CARRIED BAGS ONL	INTO THE	DATE/TIME	2/// 3:	<u>6/25</u>		<u>1</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE	FIED BY:	Pol N//2 WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR	ATURED ALCO	A DHOL TO BE IN PLASTIC A S K J	CARRIED O B	INTO THE Y.III	DATE/TIME		<u>6/25</u>		
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE	FIED BY:	Pol Nork Safe" ** Note ** Den (RCA) ON SATUR	ATURED ALCO ATED RAGS, J T	A DHOL TO BE IN PLASTIC A S K J	CARRIED BAGS ONL	INTO THE Y.1111 S T E P I CRAFT	DATE/TIME		<u>б /25</u> 	1 <u>2</u> 1 <u>~</u> <u>~</u> HOURS	<u>2</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01	FIED BY:	NOTE ** DEN WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR. ET-UP AND RECL	ATURED ALCO ATED RAGS, I IPTION AMATION	A DHOL TO BE IN PLASTIC A S K J	CARRIED BAGS ONL	INTO THE Y.IIII CRAFT HP	DATE/TIME	HOURS 4.0	<u>б/25</u> . д. 	<u>о 20</u> <u>, ~ ~ ~</u> ноикs 8.0	<u>2</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02	SURVEY, S REVIEW W	Pol N//2 WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR ET-UP AND RECL DRK PACKAGE, (PI	ATURED ALCO ATED RAGS, 1 IPTION AMATION MT) REQUIRA	A DHOL TO BE IN PLASTIC A S K J	CARRIED BAGS ONL O B	INTO THE Y.IIII CRAFT HP ELEC	DATE/TIME	HOURS 4.0 0.3	<u>б /95</u> тот	HOURS 8.0 0.6	<u>1</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04	SURVEY, S CONTACT (I VED IV	Pol Nork SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR ET-UP AND RECL DORK PACKAGE, (PM MOV) COORDINATOR RODER MARK 4	ATURED ALCO ATED RAGS, J T IPTION AMATION MT) REQUIRM R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B	INTO THE Y. IIII STEPI CRAFT HP ELEC ELEC ELEC	DATE/TIME DATE/TIME DATE/TIME DATE/TIME REQUIRED 2 2 1	HOURS 4.0 0.1 0.1	TOT	HOURS 8.0 0.1 0.1	<u>1</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04 05	SURVEY, S CONTACT (I VERTY P	POD POD POD POD POD POD POD POD	ATURED ALCO ATTED RAGS, J IPTION AMATION MT) REQUIRM R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL BAGS ONL O B	INTO THE Y. 1111 STEP CRAFT HP ELEC ELEC ELEC ELEC	DATE/TIME DATE/T	HOURS 4.0 0.3 0.1 0.5	TOT	HOURS 8.0 0.1 0.1	<u>1</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04 05 06	SURVEY, S REVIEW W CONTACT (I VERIFY P SET UP W FME, IAW Y	POD WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR ET-UP AND RECL DRK PACKAGE, (PI MOV) COORDINATOR ROPER MARK # DRK AREA VPAP-1302	ATURED ALCO ATED RAGS, 1 IPTION AMATION MT) REQUIRA R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B	INTO THE Y.1111 S T E P I CRAFT HP ELEC ELEC ELEC ELEC ELEC	DATE/TIME DATE/T	HOURS 4.0 0.1 0.1 0.1	<u>б /25</u> . <u>д</u>	HOURS 8.0 0.1 0.1 0.1	<u>A</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04 05 06 07 08	SURVEY, S REVIEW W CONTACT (I VERIFY P SET UP W FME, IAW PERFORM 1 PERFORM 1	POD WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR: ET-UP AND RECLI ORK PACKAGE, (PM MOV) COORDINATOR ROPER MARK # ORK AREA VPAP-1302 VTC VOTES TEST RETURN TO SERV:	ATURED ALCO ATED RAGS, J IPTION AMATION MT) REQUIRA R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B RWP) ORK	INTO THE Y.IIII CRAFT HP ELEC ELEC ELEC ELEC ELEC ELEC ELEC ELE	DATE/TIME DATE/T	HOURS 4.0 0.3 0.1 0.1 5.0 5.0	TOT	HOURS 8.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0	<u>1</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04 05 06 07 08	SURVEY, S REVIEW W SET UP W VERIFY P SET UP W PERFORM D PERFORM D	POD NORK SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR: ET-UP AND RECLI ORK PACKAGE, (PM MOV) COORDINATOR ROPER MARK # ORK AREA VPAP-1302 VTC VOTES TEST RETURN TO SERV:	ATURED ALCO ATED RAGS, J IPTION AMATION MT) REQUIRA R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B RWP) ORK	INTO THE Y. 1111 S T E P I CRAFT HP ELEC ELEC ELEC ELEC ELEC ELEC ELEC	DATE/TIME DATE/T	HOURS 4.0 0.3 0.1 0.5 0.1 5.0 5.0	6/25 . A. 	HOURS 8.0 0.1 0.1 10 10	<u>2</u>
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QC NOTIFIED TAGGING VERI TAGGING REPC SPECIAL NOTE STEP NO 01 02 03 04 05 06 07 08	SURVEY, S REVIEW W CONTACT (I VERIFY P PERFORM D PERFORM D	POD WORK SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR ET-UP AND RECL DRK PACKAGE, (PI MOV) COORDINATOR ROPER MARK # DRK AREA VPAP-1302 VTC VOTES TEST RETURN TO SERV:	ATURED ALCO ATED RAGS, J IPTION AMATION MT) REQUIRA R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B	INTO THE Y.1111 S T E P S CRAFT HP ELEC ELEC ELEC ELEC ELEC ELEC ELEC	DATE/TIME DATE/T	HOURS 4.0 0.3 0.1 0.1 0.5 0.1 5.0	TOT	HOURS 8.0 0.6 0.1 0.1 10 10	<u>A</u>
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04 05 06 07 08	SURVEY, S REVIEW W CONTACT (I VERIFY P) SET UP W FME, IAW Y PERFORM D PERFORM D	Pol Mork Safe" ** Note ** Den (RCA) ON SATUR STEP DESCR: ET-UP AND RECLI ORK PACKAGE, (PM MOV) COORDINATOR ROPER MARK # ORK AREA VPAP-1302 VTC VOTES TEST RETURN TO SERV.	ATURED ALCO ATURED ALCO ATED RAGS, J IPTION AMATION MT) REQUIRA R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B RWP) ORK	INTO THE Y.IIII STEPS CRAFT HP ELEC ELEC ELEC ELEC ELEC ELEC	DATE/TIME	HOURS 4.0 0.3 0.1 0.1 5.0 5.0	TOT	HOURS 8.0 0.6 0.1 0.1 0.1 0.1 0.1 0.1 0.1	
QC NOTIFIED TAGGING VERI TAGGING REPO SPECIAL NOTE STEP NO 01 02 03 04 05 06 07 08 AUG	SURVEY, S REVIEW W CONTACT (I VERIFY P) SET UP W PERFORM D PERFORM D	Pol Nork SAFE" ** NOTE ** DEN (RCA) ON SATUR STEP DESCR ET-UP AND RECL ORK PACKAGE, (PM MOV) COORDINATOR ROPER MARK # ORK AREA VPAP-1302 VTC VOTES TEST RETURN TO SERV 5	ATURED ALCO ATED RAGS, J IPTION AMATION MT) REQUIRA R PRIOR TO	A DHOL TO BE IN PLASTIC A S K J MENTS AND (STARTING W	CARRIED BAGS ONL O B RWP) ORK	INTO THE Y. 1111 STEP CRAFT HP ELEC ELEC ELEC ELEC ELEC ELEC ELEC	DATE/TIME	HOURS 4.0 0.3 0.1 0.5 0.1 5.0 5.0	TOT	HOURS 8.0 0.1 0.1 0.1 0.1	

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	Valve	Tag Numbe	er: SI=1869	В	ME-00	198 Rei DA
	Test	Number:	13	-	,	
\sim	Test i	Date:	9/16/95	i	Attack	+1
Test Conditions					FJ IMCK	met 1
Full Open	Full Closed				` ^ C	~
FLOW (GPM) U	U				Ket.	- 7
Downstream Pressure (PSI)	0	•				
Notor Voltage 460.00 Vol	ts AC					
Switch Settings						
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				
Upening Stroke Time		8 741				
To Open Indicator Light On	seconde	8.261	% stroke	100.00		
Doen Torrale Rynass Switch Coens	seconds	2.069	Z stroke	25-05		
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Contactor Dropout Time		0.011				
Forces (lbs) Calibrat	ion Range: 224	to -16626	lbs.			
Forces (lbs) Calibrat Closing Max Running Force	ion Range: 224	to -16626	ilbs.		•	
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Description Current Force (lbs) Time (amps rms) (Uncorrected) (msecs) Motor Start 19.6 -4727 215 Inrush Current Peak 27.0 -4598 Lost Motion Region (Near Hiddle) 221 2.4 Hammerblow/Start of Stem Decompression -4468 282 3.2 -4336 486 Stem Takes up Disc Clearance മ് 3.0 -0 849 Maximum Force at Disc Pullout oб 3.1 Opening Running Condition (Near Begin'g) 3100 890 09 2.9 Open Torque Bypass Switch Opens 310 1050 013 2.7 Opening Running Condition (Near End) 155 2284 012 2.7 310 8409 Open Indicator Light On (Red) 014 2.8 Close Indicator Light Off (Green) 155 8476 011 2.8 155 8476 Open Limit Switch Opens 015 2.8 155 8476 016 Motor Current Cutoff 3.0 310 8487 017 Motor Start 12.7 310 12954 Inrush Current Peak **C**0 26.3 155 Lost Motion Region (Near Middle) 12964 C1 310 2.4 Zeroing Point for CF Calibration 13017 C2 3.2 Closing Running Condition (Near Begin'g) -0 13298 CF 3.2 Close Torque Bypass Switch Opens -177 13718 C4 3.2 -177 Closing Running Condition (Near End) 15685 **c7** 3.1 -177 Disc Motion Stops / Start of Wedging 21369 C5 3.2 -525 Close Torque Switch Opens (or CST) 21409 C11 3.6 -1531 Close Indicator Light On (Green) 21479 C14 3.6 -1531 Open Indicator Light Off (Red) 21479 C5 3.6 -1531 21479 Motor Current Cutoff **C**8 3.5 -2012 21496 C15 Maximum Thrust Value 0.0 -4598 21702 C16 Final Thrust Value 0.0 -4598 21742

C17

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Secure Rel : N Coating Regid : RWP MARDERS : *	N EN N EN 975 A A T 975 A A T R EN INTO THE INTO THE INTO THE INTO THE ELY. INTO ELSC ELSC	REPUIRED	: N : N : N : N : N : N : N : N		5 5 5 5 5 5 5 5 5 5 5 5 5 5	***************************************
SECURE REL : N AUG ON SECURE REL : N COATING REDD : PLANNER: GENNTBO BODZE N W/R SUBMITTED BY: HERRY H * W/R APPROVED BY: BODZE N DPERATIONS :	N EN N EN 995 A T U R E S 975 A T U R E S 1NTO THE INTO THE S T E P S CRAFT HP ELSC ELSC ELSC	REPUIRED	: * : N : N : * USR: 5 L DELE/AREAKDO E: E: E: HDURS 4.0 0.3 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.1 0.5 0.1 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.5 0.1 0.1 0.1 0.5 0.1 0.1 0.1 0.5 0.1 0.1 0.1 0.5 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.5 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1		5 5 6 6 1 1 1 0 0 0	**************************************
ME-0498, Rer. 0, Add OA Attachment 1 Test Results Summary Unit: TWO Valve Tag Number: SI-2842 Reference 9 Test Number: 18 Test Date: 3/15/95 Test Conditions Full Open Full Closed Flow (GPM) n n n n Upstream Pressure (PSI) Downstream Pressure (PSI) ĥ n 460.00 Volts AC Motor Voltage ------Switch Settings VOTES SEN . AUX SEN. Open Torque Switch Setting 5.000 Close Torque Switch Setting 5.000 3822 ______ TST: 3789 Durations (seconds) MAX = 22,041 20,937 Closing Stroke Time 9.323 To Close Indicator Light On 9.323 % stroke 100.00 seconds 20,748 9.323 % stroke 100.00 TOTA 1: 21,987 Close Torque Bypass Switch Opens seconds To Open Indicator Light Off seconds Seating Time 0.152 Contactor Dropout Time 0.012 Opening 9.030 Stroke Time To Open Indicator Light On seconds 9.030 % stroke 100.00 Open Torque Bypass Switch Opens 8.489 % stroke 94.01 seconds To Close Indicator Light Off seconds 9.030 % stroke 100.00 0.016 **Contactor Dropout Time** ------------------(lbs) Calibration Range: 1517 to -20973 lbs. Forces Closing Max Running Force -6137 -2276 Avg Running Force -153 Thrust at Start of Wedging Thrust at CST -1523 Thrust at Contactor Dropout -3186 Inertial Thrust -15507Maximum Thrust -18693 Available Thrust Margin -1371 Opening Initial Thrust (At Motor Start) -18344 Disc Pullout Force 1156 763 Max Running Force 467 Avg Running Force Motor Currents (amps rms) Closing Inrush Current 25.4 Average Running Current 2.4 Current at Contactor Dropout 2.5 Opening 25.5 Inrush Current Current at Maximum Pullout Force 2:2 Average Running Current 2.3 General Comments: HO# 3147322-01 BYPASSES SET AT 90 TO 95 % BOTH WAYS. SYSTEM #2 USED USED A1176 , SENS. 5494 ; TV DEV SENS. .00406 TESTED ON SOLID R 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-049P, Rev.O, Addon Attachment 1 Ref. 9

	Time	Force (lbs)	Current	Description
	(msecs)	(Uncorrected)	(ampsrms)	
	41	-18344	22.3	Motor Start
	45	-18344	25.5	Inrush Current Peak
03	9 2	-20950	4.9	Hammerblow/Start of Stem Decompression
02	101	-15877	2.1	Lost Motion Region (Near Middle)
05	561	200	2.4	Stem Takes up Disc Clearance
09	65 0	1156	2.2	Maximum Force at Disc Pullout
013	9 81	478	2.4	Opening Running Condition (Near Begin'g)
012	853 0	374	2.2	Open Torque Bypass Switch Opens
014	8911	263	2.4	Opening Running Condition (Near End)
016	9071	226	2.3	Open Limit Switch Opens
011	9071	226	2.3	Open Indicator Light On (Red)
015	907 1	226	2.3	Close Indicator Light Off (Green)
017	9087	200	2.3	Notor Current Cutoff
C 0	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
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	Attachment 1	CH ME-04	2-6 - 75 0150 - 02 98. Rev. 0, A	2- OF	RIGINAL
NAPONER NEINBO36 NORIGINAL	TRINTED 01/12/1775 PAGE		HA GANNANANAN G: PROG 3	Nir Task : 002 Nr Task : Pro	5789 01 Ref. 9
	00000 60	100 00000 2000 00 00 20 55 10 00 20 2003 10 00 20 00 00 0025 2002	23 2399953 28 62 23 39995 23 99 23 99 23 99	0622333 000113 40 08 93 70 08 93 70 08 32 73 36 32 73 36 25	00 00<
 HARK NUMBER: 38-02-51 HN DESC: HHSI TO HOT 1 BOM ITEM NO: * TASK TITLE : * PERFORM 	HOV-2869A-VALVOP- EGS NFR: L553 HODEL NO.: SHB-00,; 1 VOTES TEST OF HOV.	345804I	QUAL CLASS: SR UTC NUMBER: # SERIAL NO : # TYPE: PLANNED	Main renance	ITEN QUAL CL: * SR TASK: Y
LOC GRID X/Y : 10.5 J LOCATION CODE: AB - LOCATION DESC: 20 FT I FLOOR	Elev: 2 VINS FR: * Auxiliary Building North of South Wall 20 ft West (of East Hall 4 ft	UFF St	afeiy	Relater
TASK PROBLEM VOTES DESCRIPTION: PERFOR CTB-21 CTS-16	TEST 1 VOTES TESTING TO RESET WITHIN 19 14,GL-87-10	BAND DRI 5-93-074	1		TASK PRIDRITY: 3
ED HOST : Y REG 1.97 : * ISI REGD : * NPRDS ITEM : Y	EQ RELATED : Y HUNA APPEND R : Y APPED TECH SPECS : *. SEIS INSUL COMP : * TECH	N FACTORS: * OD R AREA: 17 1IC : Y SPEC EXPIRATION ()	ENVIRONMENTAL	ZDNE: A D-2A NRESC: Y *	EQ
TAGOUIT REED : N PHT REED : Y RMP REED : Y NUMBERS : * <u>707</u>	TASK MELD/FLREDD:NASHE SCAFREDD:NINSR CONFENTRY:NINDS SECUREREL:NCOATI	INFORMATI PREM : Y SEM REEDD : N SR : N ING REEDD : N	DEV RPT IND DEV RPT 1ND DEV RPT 3'S ENG REVIEW ENG DES DOC	: Y : S-7/3-0741 * : N : *	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
W/R SUBNITIED BY: HI W/R APPROVED BY : HI	1027E N. IGHES Di Def INE F.P. Dat	PT: SENG TE: 08/09/1993	TROUB	ucr: 5 LMD: E Le/breakdown: N	TASK TYPE: RG
OPERATIONS : .	3. Jurecercy	SIGNATUR	LCD	2-6-95	, <u>1630</u>
OC NOTIFIED : .	<u> </u>		DATE/TIME	: <u>2/1/95</u>	, /6:00
TAGGING REPORT NERS: .	~/				
SPECIAL NOTES : 1	IORX SAFE" WIT				,
(2) jan karn	TASK	JOB STK	P 3		,
STEP NO 01 SURVEY, SE	STEP DESCRIPTION	H» CKA	FT REPUIRED	HOURS TOT 2.0	HOURS 4
UZ REVIEW M 03 CONTACT 04 PRIOR TO 05 VERIFY PF 06 SET UP MO 07 PERFORM MO 08 CLEAN MOR 09 CONTACT	NG, PREZENCE, (PAT) RESULTEMENTS A MOV) COORDINATOR, J. STAUFFER, EX INSTARTING WORK REF MARK & REF AREA ROTES DIAGNOSTIC TEST IAW PROCED MOV) COORDINATOR WITH TEST REFU	NURE ELE LTS ELE	U 2 U 1 U 1 U 1 U 2 U 2 U 2 U 1 U 1 U 1 U 1	0.5 0.1 0.1 0.1 5.0 0.5 0.1	1.0 4 0.1 4 0.1 4 0.1 4 0.1 4 0.1 4 0.1 4 0.1 4
	NORK PERFORMED ALL PAPER NORK AND REVIEW NORK	PACKAGE ELE	C 1 C 1 Total	1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0	1.0 # 1.0 # 18.0 #
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- Stippy	5 Summary	•	llmi + -	TUN	ME MAR Day = ALL
JI: SURRI			Unit:		11-0448, Kev. 0, Had. (
valuator: D. Gills.	Valve	Tag Numbe	r: SI-2869	PA	Attachment (
	Test	Number:	28		P C Q
Test Conditions	iest	Date:			Ket. 7
Full Open	Full Closed				
Flow (GPM) 0	D				
ipstream Pressure (PSI) 0	0				
Downstream Pressure (PSI) 0	0				
totor Voltage 440.00 Vol	Lts AC				
Switch Settings					
Open Torque Switch Setting 5.000					
liose Torque Switch Setting 5.000					
Durations (seconds)					
Closing		10 207			
lruke inne lose Tornik Runnes Suitch Grans	secondo	202.01	2 etraba	28 07	
o Open indicator light Off	seconde	2.000 10_304	* Stroke	100-01	
eating Time		0.256	A GLIOKE	100101	
Contactor Dropout Time		0.013			
Opening					
troke Time		9.362			
pen Torque Bypass Switch Opens	seconds	2.259	% stroke	24.13	
o Close Indicator Light Off	seconds	9.362	% stroke	100.00	
ontactor Dropout Time		0.016			
Forces (1bs) Calibrat	ion Range: 641	to -15176	1.50		•
Closing		10 10 10			
ax Running Force	-564				
vg Running Force	-104				
hrust at Start of Wedging	-564				
pring Pack Preload	-5272				
hrust at CST	-871				
nrust at contactor Dropout	-128/				
aximum Thrust	-1471				
vailable Thrust Margin	-307				
Opening					
nitial Thrust (At Motor Start)	-5584				
isc Pullout Force	6725				
ax Running Force	822				
vg Running Force	364				
Motor Currents (amos rms)					
Closing					
nrush Current	16.0				
verage Running Current	2.5				
urrent at Contactor Dropout	2.5				
Opening	 -				
hrush Current	16.0				
Versee Running Custont	2.5				
	6.J 				
General Comments:					
04 00285789-01 VALVE CHANGED TO LIM	IT CLOSE USING	WO# 002995	78-01 RE	SET	-

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ME -0498, Rev. 0, Add. 0A Attachment 1 Ref. 9 Thrust verifition Force Sensor osing CST = 847.1 # @ .001 TOTAL = 8642 * C. 042; FINAL = 8557 * C. 0121

2. Ails 2-8-95

VERIFICO BY RANDY Handley 2-8-55

Valve Information Valve Actuator Actuator Motor Ctant: SURRY Actuator Type ..: 9BN/6BX Voltage Type: AC Size....: SMB/00 Unit.: TWO Volts....: 440 Tag Number....: SI-2869A Max Thrust Rate: 12500 lbs Amp rating..: 2.70 amps Type..... GATE Serial #....: 114534 Nom. Speed..: 1750.00 rpm Size..... 3INCH Order #....: 3458041 Start torque: 15.00 ft-lb Target Thrust...: 8517 lbs Worm Gear Teeth: 25 Run Torque..: 0.00 ft-lb Gear Ratio....: 72 Horse Power .: 1.00 h.p. Orientation....: HORIZ .ocation..... AUX-BAS Spring Pack # 022 Stem Material...: 17-4PH Stem Diameter...: 1.125 inches Tareads per Inch: 3.00 Inreads per Rev.: 2 E/Poisson Ratio.: 106.0 x 10E6 psi VDTES Serial #...: A5452 Signal Conditioner Calibration Due Date 07/04/95 BFSL Sensitivity -1.280E-0002 #v/v/lb Spare Channel Offset: -0.13 in

ME-0498, Attachmet | Rev. 0 Add 04 Ref. 9

<i>p</i> -	Time	Force (lbs)	Current	Description
	(msecs)	(Uncorrected)	-(amps mms)	
	124	-5584	3.2	Motor Start
	131	-5 73 2	16.0	Inrush Current Peak
02	157	-5000	7.9	Lost Motion Region (Near Middle)
09	1991	6725	2.5	Maximum Force at Disc Pullout
012	2383	6282	2.5	Open Torque Bypass Switch Opens
013	2769	306	2.6	Opening Running Condition (Near Begin'g)
014	9459	295	2.5	Opening Running Condition (Near End)
016	9486	271	2.6	Open Limit Switch Opens
015	9486	271	2.6	Close Indicator Light Off (Green)
017	9502	351	1.8	Motor Current Cutoff
C 0	14826	1037	4.1	Motor Start
C 0-	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
C 5	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	25 36 3	-8784	.0.0	Maximum Thrust Value
C17	2556 5	-8689	0.0	Final Thrust Value
VC1	25565	-8689	0.0	

-			ME-C	<u>2498, Nej</u>	. 0, Add (0A		ULJ			5(1-
أذور. /14- :	A POWER NORMER	36		**********	5	URRY (Zef.	9	11/D TASK	: 00341652 02	2
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) } 	************	******	*****	*****		******	*****	*******	****	*****	*****
	HANK NUMBER: 3	70 HOT !	LEES	VALVO				UTC NUMBE	b; br(R: ≱		
	BON ITEN NO: #	÷	MFR: 1553	MODEL NO. :	SMD-00,15229	7-01		SERIAL NO	: *		TEH QCL: *
_	TASK TITLE : E	LECTRIC	AL DISCONNE	CT AND RECON	ECT.			TYPE: DOR	RECTIVE MAD	INTENANCE	SR TASK: Y
	LOC GRID X/Y :	10.7 J	ELEV	: 2 VINS	FR: #					-	
	LOCATION CODE:	AB -	AUXILIARY 1	BUILDING				-			\$
	LUCHIION DEBC.	FLOOR	NUKIN UP DU	BIT WHILL ZV I			o ri urr	-			
	<u> </u>								2008 25 7.1.320825		A
	TASK PROBLEM	ELECTR	ICAL DISCON	NECT AND RED	DINNECT TO SUP	PORT MED	H.TASK 1			Task f	RIORITY: A
	PEGNICE FEET										هر
	-	RETAIN	FAILED	ECUIPMENT	FOR CAUSE	DETERM	INATION	EVALUATIO	N		
	EQ REL :	N	EQML	; Y	HUMAN FAC	TOR5: *	E	NVIRONMENTA	LZCHL AB	- 2 B	
	REG 1.97 :	N	APPEND R	: N	APPEND R	AREA: 17	7		HREDIN Y		
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	<u></u>			т	ASK .IN	FDRM	ATID	N			
							_				
	TAGOUT REQU	Y	WELD/FL I	REED :N	ASME PRGM	1 : N 2501) - N	. 1	EV RPT IND	: Y - 5-95-404	10 ¥	*
	RWP REGD :	Ý	CONF ENTI	RY N	IND SR	: N	Ē	NG REVIEW	-		-
			SECURE R	EL : N	COATING R	EQD : N	E	NG DES DOC	: *		
	RUP NUMBERS :	*	*	<u> </u>	*						
<u> </u>	PLANNER: GENWI	YN T	YNES JR	H Li		<u> </u>			UCR: 61	MD: E TASK	TYPE: DE
	W/R SUBMITTED	BY: *		* *	DEPT: *	ł		- TROU	BLE/SREAKD	JAIN: N	
	W/R APPROVED B	iY: ¥		* *	DATE: *			UI VI	NDO4 :	FEG:	
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	OPERATIONS	••••		<u></u>	<u></u>		-		⊨: <u> </u>		-0
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	SPECIAL NOTES	: t	WORK SAFE!!	WHT							
		4	** NOTE ** 1	DENATURED ALI	COHOL TO BE C	ARRIED I	NTO THE				
		۱ ۲	(RCA) ON SAT	iurated Rags	IN PLASTIC B	AGS DNLY					
			THIS OPERAT	DR MUST BE C	ECKED FOR PR	OPEK GRE	ASE LEVE	1			
		3	BY THE MECH	ANICS BEFORE	THIS OPERATO	r is ene	RGIZED.				
		4	***********	*******	***********	*******					
				•	TASK J	DB E	TEPE	;			
	STEP NO		STEP DES	SERIFTION			CRAFT	REGUIRED	HOURE	TUT HOURS	
	01 5	URVEY/SI	ETUF/RECLAN	ATION.			HP .	2	2.0	4.0	
	V1 1					14P)	ELEC	2	0.2	0.4	
	02 R	EVIEN W	UKK THUNHUE;	(PTII) COMULI	AMENTS AND AR		-			A 4	
	02 R 03 V	EVIEW W ERIFY PI	Roper Mark		(Thein 15 minu) (K		ELEC	1	0.1	0.1	
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Test Resul	ts Summary		
SURRY		_	Unit: TWO
	Va	lve Tag Number	51-2869B
	Te	st Number:	10
	Te	st Date:	5/17/96
Test Conditions			
Full Open	Full Clo	sed	
Flow (GPM) 0) (0	
Upstream Pressure (PSI) 0		0	
Downstream Pressure (PSI) U) Alto AC	J	
	TOLLS AL		
Switch Settings			
Open Torque Switch Setting 5.000			
Close Torque Switch Setting 5.000			
Durations (seconds)			
Closing			
Stroke Time	<u>-</u>	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	-4	0.145	
Contactor Dropout Time		0.014	
Opening Stocke Time		0 676	
Struke Hime Open Terrus Purses Suiteb Opens	cocordo	9.373 7.0// 9	Votroko 31 70
To Close Indicator Light Off	secondo	0 575	Keteoke 100 00
Contector Dropout Time	Securas	0 012	N 3110KE 100.00
Forces (lbs) Calibr	ation Range: 1	273 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 Inrust	-0983		
Available infust Margin	-944		
Upening	-4042		
Diec Pullout Force	-0y02 77//		
Max Pumping Force	1223		
Avg Running Force	10/3		
Motor Currents (amos 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		

ME-0498, Rev-0, Add. 0A Attachm at 1

Ref. 9

General Comments:

V.O.#341652-02 THRUST VERICIATION PERFORMED WITH CST ONLY, C-CLAMP USED 1069 SEN..5432 AUX.SEN..00695 TCF.SEN..00575 THRUST BANDS AS PRE. CG.TRANSMITTAL MIN. HSC BUT LEAST THAN 2XRL MAX. 12478 BYPASS 252-35% BOTH DIR. SYSTEM #1 USED TESTED BY SLAYTON, JODRY, FULLER

,	Time	Force (lbs)	Current	Description	ME-0498 Roy 0 Add OA
2	- (msecs)	(Uncorrected)	(amps mms)		
1	73	-6962	4.6	Motor Start	Ata 1 1-1
	82	-6962	16.6	Inrush Current Peak	silven and
	361	-6862	2.9	Lost Motion Region (Near Middle)	
03	622	-6674	3.0	Hammerblow/Start of Stem Decompression	Ket. Y
04	725	-695	3.1	Stem Compression Fully Relieved	
05	841	962	3.1		
09	913	3744	3.3	Maximum Force at Disc Pullout	
013	1481	1049	3.0	Opening Running Condition (Near Begin'g)	
012	3117	1020	3.1	Open Torque Bypass Switch Opens	
014	8793	1078	3.1	Opening Running Condition (Near End)	· ·
016	9648	1136	2.9	Open Limit Switch Opens	
015	9648	1136	2.9	Close Indicator Light Off (Green)	
017	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	

Attachment 8.1 NDCM 3.7 Rev. 5

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VIRGINIA POWER CALCULATION COVER/INPUT SHEET									
Type Sub Station Unit Status System Total [CALC] [_MEC_] [99] [00] [_AC] [] 10	pages:								
Doc. No. Rev. QA Class Aprvd Date Attack [ME-0498] [] [] [] 1 the second s	nments: nru <u>3</u>								
CALC. Title/Subject: <u>Pressure Locking and Stem Effect Thermal Bind</u> (Plus any Key Words for Re- trieval purposes)	ing								
REFERENCE NUMBERS: IR NO.: JOB No: Initiating Document (DCP, EWR, etc.):									
ORIGINATOR: VP [X] Discipline <u>Mechanical Engineering</u> A/E [_] Firm Name Vendor Code: A/E Calc. No.:									
Mark Number References: (Sample on first line) Station Unit System Prefix/ID Component/ID									
IJ I									
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									
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Attachment 8.7 NDCM 3.7 Rev. 5

ASSOCIATED) INFORMATION
CALCULATION NUMBER: ME-0498	REV. NO. SHEET 0 _2 OF _16
In addition to the Engineering Data on the Calculation Cover Sheet, the Structures, and/or Programs are asso (SEE STD-GN-	System (EDS)/Mark Numbers identified following Systems, Components, ociated with this calculation: -0008 FOR CODES)
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Affected Structures:CODEUse additional[]Sheets as needed[]() see attached[]	DESCRIPTION]]]]]
Additional Mark Nos.: Station Unit System Pref [38] [01] [RC] [MOV] [38] [01] [RC] [MOV] [38] [01] [RC] [MOV] [38] [01] [RC] [MOV] [38] [02] [RC] [MOV] [10] [RC] [MOV] [RC] [10] [RC] [RC]	fix/ID Component/ID [1535] [VALVE]] [1536] [VALVE]] [1536] [VALVOP]] [1536] [VALVOP]] [1536] [VALVE]] [1536] [VALVE]] [2535] [VALVE]] [2536] [VALVE]] [36] [VALVE]]
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Prepared By: Reviewed By: Reviewed By: MOV Evoluation/ME-0498

Mars

Date: 2-20-96 2-21-96 Date: 2-21-96 Date:

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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.

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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.

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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_{op}=seat outer diameter, in. Seat_D=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

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thrust required to open the valve. The stem rejection force equation is:

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

where: $F_{\text{stem rej}}$ =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.

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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%

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DESIGN INPUTS

- 1. The valve wedge dimensional data was supplied by Westinghouse (reference 8) and Velan (reference 7) for their valves.
- 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.

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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.

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REFERENCES

- 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.
- 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.

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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.

<u>Table 1</u> - Pressure Locking Results and Comparison Between VP and WOG Methods

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

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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.

<u>Table 2</u> - Stem effect thermal binding Results Based Upon WOG Methods

Mark	Pullout	Operator	Capability	
Number/Station	thrust	Capability	Margin (%)	
	w/thermal	(lbs)		
	binding			
	(lbs)			
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	

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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
RC-1535	2235	1500	3	2.25	2.25	11791	0.3	3537.3	1.125	2220.5	4075	5392	11.4	0.9
RC-1536	2235	1500	3	2.25	2.25	11791	0.3	3537.3	1.125	2220.5	3785	5102	11.2	0.9
RC-2535	2235	1500	3	2.25	2.25	11791	0.3	3537.3	1.125	2220.5	4556	5873	11.3	0.9
RC-2536	2235	1500	3	2.62	2.62	15988	0.55	8793.3	1.25	2741.4	1285	7337	10.2	0.9
					-									

•

				Operator	Capability	Capability
	Pullout	Operator MOV/plan	Stem	Thrust	-Pullout	Margin
OGR	Efficiency	Capability Avg COF	Factor	Capability	(margin)	(%)

55.8	0.4	229	0.2	0.0179	12/00	1384	51.0
63	0.4	254	0.2	0.0179	14183	9081	64.0
63	0.4	256	0.2	0.0179	14310	8437	59.0
52.2	0.45	216	0.2	0.0140	15370	8033	52.3

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CONCLUSION

The results of this evaluation show that all the values 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%.

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ATTACHMENT 1 - STEM GROWTH (THERMAL BINDING) ANALYSIS

Program STEMGROW for NAPS 1-RC-MOV-1535

Typical Thrust Trace



Inputs:

Stem Travel (in)

Change in Temperature (F)

Mod. of Therm. Exp. (in/in F)

Max. Static Closing Force (lbf) Max. Static Unseating Force (lbf) Control Switch Trip Thrust (lbf) Control Switch Trip Time (sec) Thrust at Seating (lbf) Time of Seating (sec)

Motor Speed (rpm)

Actuator Overall Ratio

Stem Lead (in)

Travel = 2.25 ·in DeltaTemp = $300 \cdot F$ TempCoef = $0.000006 \cdot \frac{in}{in \cdot F}$ Max close = $9304 \cdot lbf$ Max open = $4075 \cdot lbf$ CST thrust = $3573 \cdot lbf$ CST time = $8.644 \cdot sec$ Seat thrust = $498 \cdot lbf$ Seat time = $8.564 \cdot sec$ MotorSpeed = $1700 \cdot \frac{1}{min}$ OAR = 55.8

Lead = 0.667 • in

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Program STEMGROW

Calculations:

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

Static rate := $\frac{\text{CST}_{\text{thrust}} - \text{Seat}_{\text{thrust}}}{\text{CST}_{\text{time}} - \text{Seat}_{\text{time}}}$

Stiffness := $\frac{\text{Static}_{rate}}{\text{Stem}_{speed}}$

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

StemElongation := Travel.DeltaTemp.TempCoef

Final thrust = Max close + StemElongation Stiffness

Final unseating := UnseatingRatio Final thrust

Stem speed = $0.339 \cdot \frac{\text{in}}{\text{sec}}$

Static rate = $38437 \cdot \frac{\text{lbf}}{\text{sec}}$

Stiffness = $113492 \cdot \frac{\text{lbf}}{\text{in}}$

UnseatingRatio = 0.438

StemElongation = $0.0043 \cdot in$

Final thrust = 9787 · lbf

Final unseating = $4286 \cdot lbf$

STEMGROW, Rev. 0, 12/29/95

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Program STEMGROW for NAPS 1-RC-MOV-1536

Typical Thrust Trace Seating Control Switch Trip Maximum Thrust

Inputs:

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

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ME - 0498, Rev. 0

Program STEMGROW

Calculations:

Stem speed := MotorSpeed. $\frac{\min}{60 \cdot \sec OAR}$

Static rate := $\frac{\text{CST thrust} = \text{Seat thrust}}{\text{CST time} = \text{Seat time}}$

Stiffness := $\frac{\text{Static}_{rate}}{\text{Stem}_{speed}}$

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

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

UnseatingRatio = 0.5146

StemElongation := Travel.DeltaTemp.TempCoef

Final thrust := Max close + StemElongation Stiffness

Final unseating = UnseatingRatio Final thrust

StemElongation = $0.0043 \cdot in$

Final thrust = $7411 \cdot lbf$

Final unseating = 3814 · lbf

STEMGROW, Rev. 0, 12/29/95

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Program STEMGROW for NAPS 2-RC-MOV-2535

Typical Thrust Trace

Scating **Control Switch Trip** Maximum Thrust

Inputs:

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

Lead = $0.667 \cdot in$

STEMGROW, Rev. 0, 12/29/95

Stem Lead (in)

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ME-0498, Rev. O

Program STEMGROW

Calculations:

Stem speed = $0.3 \cdot \frac{\text{in}}{\text{sec}}$

CST thrust - Seat thrust Static _{rate} = $12275 \cdot \frac{\text{lbf}}{\text{sec}}$ Static rate := CST time - Seat time

Static rate Stiffness := Stem speed

Max open UnseatingRatio := $\frac{1}{Max}$ close

StemElongation := Travel.DeltaTemp.TempCoef

Final thrust := Max close + StemElongation Stiffness

Final unseating := UnseatingRatio Final thrust

Stiffness = $40919 \cdot \frac{\text{lbf}}{\text{in}}$

UnseatingRatio = 0.6244

StemElongation = $0.0043 \cdot in$

Final thrust = $7471 \cdot lbf$

Final unseating = $4665 \cdot lbf$

STEMGROW, Rev. 0, 12/29/95

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Program STEMGROW for SPS 1-RC-MOV-1535

Typical Thrust Trace



Inputs:

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

Lead = $0.2 \cdot in$

Stem Lead (in)

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Program STEMGROW

Calculations:

- Stem speed := MotorSpeed. $\frac{\min}{60 \cdot \sec}$ $\frac{\text{Lead}}{\text{OAR}}$ Stem speed = $0.056 \cdot \frac{\text{in}}{\text{sec}}$
- Static rate := $\frac{\text{CST}_{\text{thrust}} \text{Seat}_{\text{thrust}}}{\text{CST}_{\text{time}} \text{Seat}_{\text{time}}}$ Static _{rate} = $10529 \cdot \frac{\text{lbf}}{\text{sec}}$

Static rate Stiffness := Stem speed

Stiffness = $188222 \cdot \frac{\text{lbf}}{\text{in}}$

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

Final thrust = 12005 ·lbf

Final unseating = $7491 \cdot lbf$

StemElongation = $0.0043 \cdot in$

UnseatingRatio = 0.624

StemElongation := Travel.DeltaTemp.TempCoef

Final thrust := Max close + StemElongation Stiffness

Final unseating := UnseatingRatio Final thrust

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Program STEMGROW for SPS 1-RC-MOV-1536

Typical Thrust Trace



Inputs:

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

Stem Lead (in)

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Lead = $0.2 \cdot in$

in sec

-Program STEMGROW

Calculations:

Stem speed = MotorSpeed Go.sec OAR	Stem speed := M	otorSpeed $\frac{\min}{60 \cdot \sec} \frac{\text{Lead}}{\text{OAR}}$	Stem speed = 0.056
------------------------------------	-----------------	---	----------------------

CST thrust - Seat thrust Static rate = $15290 \cdot \frac{\text{lbf}}{100}$ Static rate = CST time - Seat time

Static rate Stiffness := Stem speed

Stiffness = $273328 \cdot \frac{\text{lbf}}{\text{in}}$

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

StemElongation := Travel DeltaTemp TempCoef

Final thrust := Max close + StemElongation Stiffness

Final unseating = UnseatingRatio Final thrust

UnseatingRatio = 0.624

StemElongation = $0.0043 \cdot in$

Final thrust = $12847 \cdot lbf$

Final unseating = $8016 \cdot lbf$

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Program STEMGROW for SPS 2-RC-MOV-2536

Typical Thrust Trace



Inputs:

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

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Program STEMGROW

Calculations:

Stem speed := MotorSpeed $\frac{\min}{60 \cdot \sec \text{ OAR}}$ Stem speed = 0.056 $\cdot \frac{\min}{\sec}$

Static rate = $\frac{\text{CST}_{\text{thrust}} - \text{Seat}_{\text{thrust}}}{\text{CST}_{\text{time}} - \text{Seat}_{\text{time}}}$ Static rate = 10711 $\cdot \frac{\text{lbf}}{\text{sec}}$

Stiffness := $\frac{\text{Static rate}}{\text{Stem speed}}$

Stiffness = $191482 \cdot \frac{\text{lbf}}{\text{in}}$

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

UnseatingRatio = 0.53

StemElongation := Travel.DeltaTemp.TempCoef

Final thrust := Max close + StemElongation Stiffness

Final unseating := UnseatingRatio Final thrust

StemElongation = $0.0043 \cdot in$

Final thrust = $12697 \cdot lbf$

Final unseating $= 6730 \cdot lbf$

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Program STEMGROW for SPS 2-RC-MOV-2536

Typical Thrust Trace



Inputs:

Stem Travel (in) Change in Temperature (F) Mod. of Therm. Exp. (in/in F) Max. Static Closing Force (lbf) Max. Static Unseating Force (lbf) Control Switch Trip Thrust (lbf) Control Switch Trip Time (sec) Thrust at Seating (lbf) Time of Seating (sec) Motor Speed (rpm) Actuator Overall Ratio

Travel = 2.25 ·in DeltaTemp = $300 \cdot F$ TempCoef = $0.000006 \cdot \frac{in}{in \cdot F}$ Max close = $13757 \cdot lbf$ Max open = $5365 \cdot lbf$ CST thrust = $11995 \cdot lbf$ CST time = $45.517 \cdot sec$ Seat thrust = $1077 \cdot lbf$ Seat time = $44.792 \cdot sec$ MotorSpeed = $1700 \cdot \frac{1}{min}$ OAR = 101.3Lead = $0.2 \cdot in$

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Program STEMGROW

Calculations:

Stem speed = MotorSpeed	in Lead	St	$em_{speed} = 0.056 \cdot $	in sec
speed - 60.	sec OAR			sec

Static rate := $\frac{\text{CST}_{\text{thrust}} - \text{Seat}_{\text{thrust}}}{\text{CST}_{\text{time}} - \text{Seat}_{\text{time}}}$ Static rate = $15059 \cdot \frac{\text{lbf}}{\text{sec}}$

Static rate Stiffness := Stem speed

UnseatingRatio :=

UnseatingRatio = 0.39

Stiffness = $269207 \cdot \frac{lbf}{in}$

StemElongation := Travel.DeltaTemp.TempCoef

Max open

Max close

Final thrust = Max close + StemElongation Stiffness

Final unseating := UnseatingRatio Final thrust

StemElongation = $0.0043 \cdot in$

Final thrust = 14902 ·lbf

Final unseating = $5811 \cdot lbf$

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ATTACHMENT 2 - PRESSURE LOCKING ANALYSIS USING WOG METHODS

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-- 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 • 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 •in
Seat Angle	$\theta = 5 \cdot \text{deg}$
Poisson's Ratio (disk material at temperature)	v = 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	Hub length = $0.25 \cdot in$

(from inside face of disk to inside face of disk)

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Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

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

Average DP across disks:

DPavg := P
$$\frac{P_{up} + P_{down}}{2}$$
 DPavg = 1483.5 ·psi

Disk Stiffness Constants

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

$$D = 1.15 \cdot 10^6 \cdot lbf \cdot in$$

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

$$G = 1.096 \cdot 10^7 \cdot psi$$

Geometry Factors:

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

$$C_{8} := \frac{1}{2} \left[1 + v + (1 - v) \cdot \left(\frac{b}{a}\right) \right]$$

$$C_{8} := 0.7598$$

$$C_{9} := \frac{b}{a} \cdot \left[\frac{1 + v}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - v}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^{2} \right] \right]$$

$$C_{9} := 0.2783$$

$$L_{3} := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^{2} + 1 \right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^{2} - 1 \right]$$

$$L_{3} := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^{2} + 1 \right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^{2} - 1 \right]$$

$$L_{9} := \frac{a}{a} \cdot \left[\frac{1 + v}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - v}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right]$$

$$L_{9} := \frac{a}{a} \cdot \left[\frac{1 + v}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - v}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right]$$

$$L_{9} := \frac{a}{a} \cdot \left[\frac{1 + v}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - v}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right]$$

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

Moment

$$\mathbf{M}_{rb} := \frac{-\mathbf{DPavg} \cdot \mathbf{a}^2}{\mathbf{C}_8} \cdot \left[\frac{\mathbf{C}_9}{2 \cdot \mathbf{a} \cdot \mathbf{b}} \cdot \left(\mathbf{a}^2 - \mathbf{b}^2 \right) - \mathbf{L}_{17} \right] \qquad \qquad \mathbf{M}_{rb} = -241 \cdot \mathbf{lbf}$$

$$Q_{b} = \frac{DPavg}{2 \cdot b} \cdot (a^{2} - b^{2}) \qquad \qquad Q_{b} = 1022.8 \cdot \frac{lbf}{in}$$

Deflection due to pressure and bending:

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

Deflection due to pressure and shear stress:

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

$$K_{sa} = -0.142$$

$$K_{sa} = -0.142$$

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

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

Deflection due to hub stretch:

P force :=
$$\pi \cdot (a^2 - b^2) \cdot DPavg$$

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

Total Deflection due to pressure forces:

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

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

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

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

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in ĺbf

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

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

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

$$y_{bw} := -\left(\frac{a^{3}}{D}\right) \cdot \left[\left(\frac{C_{2}}{C_{8}}\right) \cdot \left[\left(\frac{a \cdot C_{9}}{b}\right) - L_{9}\right] - \left[\left(\frac{a}{b}\right) \cdot C_{3}\right] + L_{3}\right] \qquad y_{bw} = -4.205 \cdot 10^{-8} \quad \frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2 \cdot \pi \cdot a}{\pi \cdot b^2} \cdot \frac{Hub}{2 \cdot E}\right)$$

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

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

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

$$F_s = 2 \cdot \pi \cdot a \cdot \frac{y_q}{y_w}$$
 $F_s = 2499.1 \cdot lbs$

UNSEATING FORCES

F_{packing} is included in measured static pullout Force

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

$$\mathbf{F}_{\text{vert}} \coloneqq \pi \cdot \mathbf{a}^2 \cdot \sin(\theta) \cdot \left(2 \cdot \mathbf{P}_{\text{bonnet}} - \mathbf{P}_{\text{up}} - \mathbf{P}_{\text{down}} \right)$$

$$\mathbf{F}_{\text{preslock}} \coloneqq 2 \cdot \mathbf{F}_{s} \cdot (\mu \cdot \cos(\theta) - \sin(\theta))$$

$$^{\mathbf{F}}$$
 total ^{:= - \mathbf{F}} piston ^{+ \mathbf{F}} vert ^{+ \mathbf{F}} preslock ^{+ \mathbf{F}} po

 $F_{total} = 3896.1 \cdot lbf$

-8 in ĺbf in

$$y_{cmpr} = -2.486 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$$

$$y_w = -1.607 \cdot 10^{-7} \quad \frac{in}{\left(\frac{lbf}{in}\right)}$$

$$F_{s} = 2499.1 \cdot lbf$$

$$F_{vert} = 1028.2 \cdot lbf$$

$$F_{\text{preslock}} = 1014.5 \cdot \text{lbf}$$

$$F_{no} = 4075 \cdot lbf$$

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

INPUTS:	
Bonnet Pressure	P bonnet = 2235 · 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 • 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 • in
Seat Angle	$\theta = 5 \cdot \text{deg}$
Poisson's Ratio (disk material at temperature)	v = 0.3
Modulus of Elasticity (disk material at temperature)	$\mathbf{E} = 2.85 \cdot 10^7 \mathbf{\cdot psi}$
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 = $0.25 \cdot in$

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--- Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

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

Average DP across disks:

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

Disk Stiffness Constants

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

$$D = 1.15 \cdot 10^6 \cdot lbf in$$

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

$$G = 1.096 \cdot 10^7 \cdot psi$$

Geometry Factors:

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

$$C_{3} := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a} \right)^{2} + 1 \right] \cdot \ln \left(\frac{a}{b} \right) + \left(\frac{b}{a} \right)^{2} - 1 \right]$$

$$C_{3} := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a} \right)^{2} \right]$$

$$C_{8} := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a} \right)^{2} \right]$$

$$C_{8} := 0.7598$$

$$C_{9} \coloneqq \frac{b}{a} \cdot \left[\frac{1+v}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1-v}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^{2} \right] \right] \qquad C_{9} \equiv 0.2783$$

$$L_{3} \coloneqq \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^{2} + 1 \right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^{2} - 1 \right] \qquad L_{3} \equiv 0$$

$$L_{9} \coloneqq \frac{a}{a} \cdot \left[\frac{1+v}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1-v}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right] \qquad L_{9} \equiv 0$$

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

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Geometry Factors: (continued)

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

$$L_{11} := 0.0012$$

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

$$L_{17} := 0.0731$$

Moment

$$\mathbf{M}_{rb} \coloneqq \frac{-\mathbf{DPavg} \cdot \mathbf{a}^2}{\mathbf{C}_8} \cdot \left[\frac{\mathbf{C}_9}{2 \cdot \mathbf{a} \cdot \mathbf{b}} \cdot \left(\mathbf{a}^2 - \mathbf{b}^2 \right) - \mathbf{L}_{17} \right] \qquad \mathbf{M}_{rb} = -241 \cdot \mathbf{lbf}$$

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

Deflection due to pressure and bending:

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

Deflection due to pressure and shear stress:

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

$$K_{sa} = -0.142$$

$$K_{sa} = -0.142$$

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

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

Deflection due to hub stretch:

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

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

Total Deflection due to pressure forces:

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

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

$$y_q = -5.6832 \cdot 10^{-5}$$
 •in

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 $y_{w} = -1.607 \cdot 10^{-7}$

 $F_{po} = 3785 \cdot lbf$

 $\ln/$

 $\frac{\text{in}}{\frac{1\text{bf}}{\cdot}}$

Program PRESLOK, Version 1

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

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

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

$$\mathbf{y}_{\mathbf{bw}} = -\left(\frac{\mathbf{a}^{3}}{\mathbf{D}}\right) \cdot \left[\left(\frac{\mathbf{C}_{2}}{\mathbf{C}_{8}}\right) \cdot \left[\left(\frac{\mathbf{a} \cdot \mathbf{C}_{9}}{\mathbf{b}}\right) - \mathbf{L}_{9}\right] - \left[\left(\frac{\mathbf{a}}{\mathbf{b}}\right) \cdot \mathbf{C}_{3}\right] + \mathbf{L}_{3}\right] \qquad \mathbf{y}_{\mathbf{bw}} = -4.205 \cdot 10^{-8} \cdot \frac{\mathrm{in}}{\left(\frac{\mathrm{lbf}}{\mathrm{in}}\right)}$$

Deflection due to hub compression:

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

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

$$y_{w} = y_{bw} + y_{sw} + y_{cmpr}$$

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

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

UNSEATING FORCES

F_{packing} is included in measured static pullout Force

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

$$\mathbf{F}_{\text{vert}} \coloneqq \pi \cdot \mathbf{a}^2 \cdot \sin(\theta) \cdot \left(2 \cdot \mathbf{P}_{\text{bonnet}} - \mathbf{P}_{\text{up}} - \mathbf{P}_{\text{down}}\right) \qquad \mathbf{F}_{\text{vert}} \equiv 1028.2 \cdot \mathbf{lbf}$$

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

$$\mathbf{F}$$
 total := - \mathbf{F} piston + \mathbf{F} vert + \mathbf{F} preslock + \mathbf{F} po

 $F_{total} = 3606.1 \cdot lbf$

PRESLOK, Ver. 1, Rev. 0 12/22/95 Westinghow

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ME-0498, Rev. 0

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 •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 • in
Seat Angle	$\theta = 5 \cdot \deg$
Poisson's Ratio (disk material at temperature)	v = 0.3
Modulus of Elasticity (disk material at temperature)	$E = 2.85 \cdot 10^7 \cdot psi$
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 = $0.25 \cdot in$

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--- Program-PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := \mathbf{VF} \cdot \frac{\cos(\theta)}{1 + \mathbf{VF} \cdot \sin(\theta)} \qquad \qquad \mu = 0$$

Average DP across disks:

DPavg := P bonnet -
$$\frac{P_{up} + P_{down}}{2}$$

Disk Stiffness Constants

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

$$\mathbf{D} = 1.15 \cdot 10^6 \cdot \mathbf{lbf}$$

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

Geometry Factors:

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

$$C_{3} := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^{2} + 1 \right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^{2} - 1 \right]$$

$$C_{8} := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^{2} \right]$$

$$C_{9} := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^{2} \right] \right]$$

$$L_{3} := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^{2} + 1 \right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^{2} - 1 \right]$$

$$L_{9} := \frac{a}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right]$$

.291

in

 $G = 1.096 \cdot 10'$ •psi

 $C_2 = 0.0807$

 $C_3 = 0.0105$

 $C_8 = 0.7598$

 $C_9 = 0.2783$

 $L_{3} = 0$

 $L_{9} = 0$

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--- Program PRESLOK, Version 1

Geometry Factors: (continued)

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

$$L_{11} := 0.0012$$

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

$$L_{17} := 0.0731$$

Moment

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

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

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:

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

$$y_{\text{stretch}} \coloneqq \frac{P_{\text{force}}}{\pi \cdot b^2} \cdot \frac{Hub}{(2 \cdot E)} \underset{\text{gretch}}{\text{horegoin}} = 1.4241 \cdot 1000$$

Total Deflection due to pressure forces:

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

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

$$y_q = -5.6832 \cdot 10^{-5}$$
 ·in

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 $y_{\text{cmpr}} = -2.486 \cdot 10^{-8} \cdot \frac{\text{in}}{\left(\frac{\text{lbf}}{\text{in}}\right)}$

 $y_w = -1.607 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

 $F_{vert} = 1028.2 \cdot lbf$

 $F_{po} = 4556 \cdot lbf$

F preslock = $1014.5 \cdot lbf$

in

Program PRESLOK, Version 1

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

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

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:

$$y_{cmpr} := -\left(\frac{2 \cdot \pi \cdot a}{\pi \cdot b^2} \cdot \frac{Hub}{2 \cdot E}\right)$$

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

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

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

$$F_{s} := 2 \cdot \pi \cdot a \cdot \frac{y_{q}}{y_{w}} \qquad \qquad F_{s} = 2499.1 \cdot lbf$$

UNSEATING FORCES

Fpacking is included in measured static pullout Force

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

$$\mathbf{F}_{\text{vert}} \coloneqq \pi \cdot \mathbf{a}^2 \cdot \sin(\theta) \cdot \left(2 \cdot \mathbf{P}_{\text{bonnet}} - \mathbf{P}_{\text{up}} - \mathbf{P}_{\text{down}}\right)$$

$$\mathbf{F}_{\text{preslock}} \coloneqq 2 \cdot \mathbf{F}_{s} \cdot (\mu \cdot \cos(\theta) - \sin(\theta))$$

 $F_{total} = 4377.1 \cdot lbf$

Westinghouse Owner's Group PRESLOK, Ver. 1, Rev. 0 12/22/95

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ME-0498, Rev. 0

--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 • 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 • in
Seat Angle	$\theta = 7 \cdot \deg$
Poisson's Ratio (disk material at temperature)	v = 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 = $0.61 \cdot in$

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-Program-PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

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

Average DP across disks:

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

Disk Stiffness Constants

$$\mathbf{D} \coloneqq \frac{\mathbf{E} \cdot (\mathbf{t})^3}{12 \cdot (1 - v^2)} \qquad \qquad \mathbf{D} = 2.689 \cdot 10^6 \quad \text{elbf in}$$

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

Geometry Factors:

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

 $\mathbf{C}_{3} := \frac{\mathbf{b}}{4 \cdot \mathbf{a}} \cdot \left[\left[\left(\frac{\mathbf{b}}{\mathbf{a}} \right)^{2} + 1 \right] \cdot \ln \left(\frac{\mathbf{a}}{\mathbf{b}} \right) + \left(\frac{\mathbf{b}}{\mathbf{a}} \right)^{2} - 1 \right] \qquad \mathbf{C}_{3} = 0.0057$

$$C_{8} := \frac{1}{2} \cdot \left[1 + v + (1 - v) \cdot \left(\frac{b}{a} \right)^{2} \right]$$
 $C_{8} = 0.7987$

$$C_{9} := \frac{b}{a} \cdot \left[\frac{1+v}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1-v}{4} \cdot \left[1-\left(\frac{b}{a}\right)^{2} \right] \right]$$

$$C_{9} = 0.2469$$

$$L_{3} := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a}\right)^{2} + 1 \right] \cdot \ln\left(\frac{a}{a}\right) + \left(\frac{a}{a}\right)^{2} - 1 \right]$$

$$L_{3} = 0$$

$$L_{9} := \frac{a}{a} \left[\frac{1+v}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1-v}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right] \qquad L_{9} = 0$$

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Geometry Factors: (continued)

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

$$L_{11} = 5.1809 \cdot 10^{-4}$$

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

$$L_{17} = 0.0488$$

Moment

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

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

Deflection due to pressure and bending:

$$y_{bq} := M_{rb} \cdot \frac{a^2}{D} \cdot C_2 + Q_b \cdot \frac{a^3}{D} \cdot C_3 - \frac{DPavg \cdot a^4}{D} \cdot L_{11}$$
 $y_{bq} = -7.6059 \cdot 10^{-6} \cdot in$

Deflection due to pressure and shear stress:

 $K_{sa} := -0.3 \cdot \left[2 \cdot \ln \left(\frac{a}{b} \right) - 1 + \left(\frac{b}{a} \right)^2 \right]$ $K_{sa} = -0.0842$ $y_{sq} := \frac{K_{sa} \cdot DPavg \cdot a^2}{t \cdot G}$ $y_{sq} = -2.9623 \cdot 10^{-5} \cdot in$

Deflection due to hub stretch:

P force :=
$$\pi \cdot (a^2 - b^2) \cdot DPavg$$

y stretch := $\frac{P \text{ force }}{\pi \cdot b^2} \cdot \frac{Hub}{(2 \cdot E)}$

Total Deflection due to pressure forces:

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

$$y_{\text{stretch}} = 2.1487 \cdot 10^{-5}$$
 ·in

$$y_q = -5.8716 \cdot 10^{-5}$$
 ·in

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Program PRESLOK, Version 1

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

$$y_{sw} := -\left[\frac{1.2 \cdot \left(\frac{a}{a}\right) \cdot \ln\left(\frac{a}{b}\right) \cdot a}{t \cdot G}\right]$$

$$y_{sw} = -7.514 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$$

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

$$y_{bw} := -\left(\frac{a^{3}}{D}\right) \cdot \left[\left(\frac{C_{2}}{C_{8}}\right) \cdot \left[\left(\frac{a \cdot C_{9}}{b}\right) - L_{9}\right] - \left[\left(\frac{a}{b}\right) \cdot C_{3}\right] + L_{3}\right] \qquad y_{bw} = -2.592 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2 \cdot \pi \cdot a}{\pi \cdot b^2} \cdot \frac{Hub}{2 \cdot E}\right) \qquad y_{cmpr} = -3.109 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$$

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

$$y_w := y_{bw} + y_{sw} + y_{cmpr}$$

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

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

UNSEATING FORCES

F_{packing} is included in measured static pullout Force

 $\mathbf{F}_{\text{piston}} \coloneqq \frac{\pi}{4} \cdot \mathbf{D}_{\text{stem}}^2 \cdot \mathbf{P}_{\text{bonnet}}$ $F_{piston} = 2742.8 \cdot lbf$

$$\mathbf{F}_{vert} \coloneqq \pi \cdot \mathbf{a}^2 \cdot \sin(\theta) \cdot \left(2 \cdot \mathbf{P}_{bonnet} - \mathbf{P}_{up} - \mathbf{P}_{down}\right) \qquad \mathbf{F}_{vert} = 2981.2 \cdot lbf$$

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

$$^{\mathbf{F}}$$
 total ^{:= - \mathbf{F}} piston ^{+ \mathbf{F}} vert ^{+ \mathbf{F}} preslock ^{+ \mathbf{F}} pc

 $F_{total} = 5013.9 \cdot lbf$

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$$y_w = -1.322 \cdot 10^{-7} \quad \frac{in}{\left(\frac{lbf}{in}\right)}$$

$$F_s = 4522.2 \cdot lbf$$

 $F_{po} = 1285 \cdot lbf$

Doc. No.: ME-0498, Rev. 0

ATTACHMENT 3 - CALCULATION REVIEW

CHECKLIST AND

ATTACHED REFERENCES

ATTACHMENT 8.5 NDCM 3.7 Rev. 5

CALCULATION REVIEW CHECKLIST							
CALCULATION NO. ME-0498	REV. NO. O	ATTACHMENT 3	PAGE	1	OF _1		
CALCULATION TITLE:	Pressure Locking/Tl	hermal Binding Ana	lysis fo	or GL	89-10		
A "NO" answer to a NOTE: Reference m	ny questions require ay be made to explan	es that an explana nations contained	tion be in the o	prov calcu	ided. lation.		
OUE	STIONS	··	YES	NO	<u>_N/A</u> _		
1. Is the calcula on each page o	tion number and rev f the calculation a	ision identified nd attachments?	[x]	[]	[]		
2. Does the objec for performing background inf	tive statement ident the calculation and ormation?	tify the reason d give sufficient	[x]	[]	[]		
3. Have the sourc selected and r	es of design inputs eferenced in the cal	been correctly lculation?	[×]	[]	[]		
4. Are the source retrievable (a	s of design inputs ι nd/or a copy attache	<pre>up-to-date and ed to the calc.)?</pre>	[x]	[]	[]		
5. Where appropri reviewed or pr they are respo	ate, have the other ovided the design in nsible?	disciplines nputs for which	[]	[]	[x]		
6. Have design in test, measurem pertinent mean analyzed?	puts been confirmed ent, field walkdown, s as appropriate for	by analysis, , or other r the configuratio	[x] n	[]	[]		
7. Are assumption	s adequately describ	ed and bounded by	[x]	[]	[]		
8. Have the bases adequately and	for engineering juc clearly presented?	lgements been	[x]	[]	[]		
9. Were appropria used and are of to inputs?	te calculation/analy utputs reasonable wh	tic methods hen compared	[X]	[]	[]		
10. Are computation the calculation for instrument errors? (Refe	ns technically accur n made appropriate a errors and calibrat rence STD-FEN-0304)	rate and has allowances tion equipment	[x]	[]	[]		
11. Have those comp been listed in ment been place which states -	puter codes used in the "references" or ed in the "methods o "No computer code u	the calculation has a state- of analysis" sections used.", if no	[x] on	[]	[]		
12. Have all except criteria and re identified and ANSI N45.2.11-	wele used? tions to station des egulatory requiremen justified in accord 1974?	ign basis hts been lance with	[x]	[]	[]		
Comments: (N/A if none)NA							
[] Additional com	[] Additional comment pages added.						
Prepared By:	Date: 2-20-96	Reviewed By: John Wolak	Date: Z	-Z/-	96		
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Memorandum

ME-0498, Rev. O Référence 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-1535/1536Bonnet pressure - 2235 psig2-RC-MOV-2535/2536Upstream pressure - 1500 psigDownstream 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

Page 1

ME-0498, Rei Reference S							8, Rev. 0 .e. 5.
MARK NO.	TEST DATE	09	C11	C11 TIME	C14	C14 TIME	C16
1-RC-1535	9-16-94	4075#	498#	8.564s	3573#	8.6445	9304#
1-RC-1536	9-16-94	3785#	1109#	8.4885	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#

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	TEST DATE	9/18/95	9/18/95	2/28/95	2/22/	95
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· · ·	TST # US	99996	10530	10531	11999	
 وعسود	TOT #	11205	11685	//883	13757	;
£	ULR	N/A.	NIA	53%	39%	·
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	HSC 70	0,805	0,520	0,738	0,724	
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ATTENTION: B. DEMARS
LOCATION:
TELECOPY NO .: 804-273-2188
CONFIRMATION NO.:
NOTES: VALVE DATA for 3" value built to drawing
8373D77.
Seat Awale 7°
Disc thickness - 1.01"
Seat Radius - 1.620
Hub Radius - 1.056
Hub Length - 0.61
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USER'S GUIDE FOR PRESLOK, A GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

REVISION 0

January 2, 1996

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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.

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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.

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- 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.

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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.

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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

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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.



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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

$$a = \sqrt{\frac{OD_{seat}^2 + ID_{seat}^2}{8}}$$
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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 insi	ide the packing.
, T	Static Unseating Thrust		· s
	Static Pullout Force:	Fpo	pounds
	This is the static pullout force obtained from calculation is being performed.	om testing of the valve	e for which the
	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:

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dimensionless

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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:	Pdown	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

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Hub Length:

Seat Angle:

Hub_{length} A

inches 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:	. V	dimensionless
Modulus of Elasticity:	Ε	psi
Valve Stem Diameter		
Stem Diameter:	D _{stem}	inches

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

Static Unseating Thrust

Static Pullout Force: F_{po} poundsThis 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.

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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

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

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

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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

 $(r_0 = b \text{ for Case 2L})$

$$L_{11} = \frac{1}{64} \left\{ 1 + 4 \cdot \left(\frac{r_0}{a}\right)^2 - 5 \cdot \left(\frac{r_0}{a}\right)^4 - 4 \cdot \left(\frac{r_0}{a}\right)^2 \left[2 + \left(\frac{r_0}{a}\right)^2\right] \ln\left(\frac{a}{r_0}\right) \right\}$$
$$L_{17} = \frac{1}{4} \left\{ 1 - \frac{1 - \nu}{4} \left[1 - \left(\frac{r_0}{a}\right)^4\right] - \left(\frac{r_0}{a}\right)^2 \left[1 + (1 + \nu) \ln\left(\frac{a}{r_0}\right)\right] \right\}$$

Moment Factors

$$(r_0 = b \text{ for Case } 2L)$$

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

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

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

 $(r_0 = b \text{ for Case } 2L)$

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

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

Deflection from Hub Stretch due to Pressure

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

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

Total Deflection due to Pressure

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

Q. ц.

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

$$y_{bw} = -\frac{a^{3}}{D} \cdot \left[\frac{C_{2}}{C_{8}} \cdot \left(\frac{r_{0} \cdot C_{9}}{b} - L_{9} \right) - \frac{r_{0} \cdot C_{3}}{b} + L_{3} \right]$$

Shear Deflection due to Seat Load

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

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

Deflection from Hub Compression Due to Seat Load (w = 1, \therefore 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)

 $(r_0 = a)$

 $(r_0 = a)$

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

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

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

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) × [$\mu \cos \theta - \sin \theta$] × 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 (Fvert)

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).

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



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.

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

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

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

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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 := input₀.psi

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

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

 $t := input_3 \cdot in$

a := input₄. in

 $b := input_{s} \cdot in$

Hub length := input₆ · in

 $\theta := input_7 \cdot deg$

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 $v := input_8$ $E := input_9 \cdot psi$ $D_{stem} := input_{10} \cdot in$ $F_{po} := input_{11} \cdot lbf$

 $VF := input_{12}$

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	USER'S GUIDE TO PRESLO Program PRESLOK, Version 1	DK Page 22 Ref. 9
	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 · 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 • 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)	$F_{po} = 15409 \cdot lbf$
	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 = $0.5 \cdot in$

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Program PRESLOK, Version 1
Geometry Factors: (continued)
L₁₁ =
$$\frac{1}{64} \left[1 + 4 \left(\frac{b}{a} \right)^2 - 5 \cdot \left(\frac{b}{a} \right)^4 - 4 \cdot \left(\frac{b}{a} \right)^2 \cdot \left[2 + \left(\frac{b}{a} \right)^2 \right] \cdot \ln \left(\frac{a}{b} \right) \right]$$

L₁₁ = $\frac{1}{64} \left[1 + 4 \cdot \left(\frac{b}{a} \right)^2 - 5 \cdot \left(\frac{b}{a} \right)^4 - 4 \cdot \left(\frac{b}{a} \right)^2 \cdot \left[2 + \left(\frac{b}{a} \right)^2 \right] \cdot \ln \left(\frac{a}{b} \right) \right]$
L₁₁ = $\frac{1}{64} \left[1 + 4 \cdot \left(\frac{b}{a} \right)^2 - 5 \cdot \left(\frac{b}{a} \right)^4 - 4 \cdot \left(\frac{b}{a} \right)^2 \cdot \left[2 + \left(\frac{b}{a} \right)^2 \right] \cdot \ln \left(\frac{a}{b} \right) \right]$
L₁₁ = 0.0069
L₁₇ = $\frac{1}{4} \left[1 - \frac{1 - v}{4} \left[1 - \left(\frac{b}{a} \right)^4 \right] - \left(\frac{b}{a} \right)^2 \cdot \left[1 + (1 + v) \cdot \ln \left(\frac{a}{b} \right) \right] \right]$
Moment
M_{1b} := $\frac{-DPavg \cdot a^2}{C_8} \left[\frac{C \cdot 9}{2 \cdot a \cdot b} \left(a^2 - b^2 \right) - L_{17} \right]$
M_{1b} = -5265 · lbf
Q_b := $\frac{DPavg}{2 \cdot b} \cdot \left(a^2 - b^2 \right)$
Q_b = 4466.5 · $\frac{lbf}{ln}$
Deflection due to pressure and bending:
y_{bq} := M_{1b} $\frac{a^2}{D} \cdot C_2 + Q_b \cdot \frac{a^3}{D} \cdot C_3 - \frac{DPavg \cdot a^4}{D} \cdot L_{11}$
y_{bq} = -3.9041 \cdot 10^{-4} \cdot in
Deflection due to pressure and shear stress:
K_{sa} := -0.3 · $\left[2 \cdot \ln \left(\frac{a}{b} \right) - 1 + \left(\frac{b}{a} \right)^2 \right]$
K_{sa} = -0.4743
y_{sq} := $\frac{K_{sa} \cdot DPavg \cdot a^2}{t \cdot G}$
y_{sq} := $\pi \cdot (a^2 - b^2) \cdot DPavg$
y_{stretch} := $\frac{P \cdot force}{\pi \cdot b^2} \cdot DPavg}$
y_{stretch} := $\frac{P \cdot force}{\pi \cdot b^2} \cdot DPavg}$
y_{stretch} := $\frac{P \cdot force}{\pi \cdot b^2} \cdot DPavg}$
y_{stretch} := $\frac{P \cdot force}{\pi \cdot b^2} \cdot DPavg}$
y_{stretch} := $\frac{P \cdot force}{\pi \cdot b^2} \cdot DPavg}$
y_{stretch} := $\frac{P \cdot force}{\pi \cdot b^2} \cdot DPavg}$

 $y_q = -7.2691 \cdot 10^{-4}$ ·in

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

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Program PRESLOK, Version 1

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

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

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:

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

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

$$y_w := y_{bw} + y_{sw} + y_{cmpr}$$

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

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

UNSEATING FORCES

F_{packing} is included in measured static pullout Force

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

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

$$F_{\text{preslock}} \coloneqq 2 \cdot F_{s} \cdot (\mu \cdot \cos(\theta) - \sin(\theta))$$

$$F_{\text{total}} = -F_{\text{piston}} + F_{\text{vert}} + F_{\text{preslock}} + F_{\text{po}}$$

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

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$$y_{\rm cmpr} = -5.055 \cdot 10^{-8} \cdot \frac{{\rm in}}{\left(\frac{{\rm lbf}}{{\rm in}}\right)}$$

$$y_w = -9.597 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$$

$$F_{s} = 20750.5 \cdot lbf$$

$$F_{\text{preslock}} = 16871 \cdot \text{lbf}$$

 $\dot{F}_{vert} = 6662.4 \cdot lbf$

$$y_{gw} = 13.079 \cdot 10^{-7} \cdot \frac{\text{in}}{\left(\frac{\text{lbf}}{\text{in}}\right)} \quad \rho_{\mu} u^{\mu}$$

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

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

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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 := input₆ · in

 $\theta := input_{\gamma} \cdot deg$

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 $v := input_{o}$

 $E := input_{o} \cdot psi$

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

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

 $\mu := input_{12}$

USER'S CUIDE FOR PRESLOCK	ME-0498, Lev. 0 Page 28
Program PRESLOK, Version 2	Ref. 9
INPUTS:	
Bonnet Pressure	$P_{bonnet} = 1005 \cdot psi$
Upstream Pressure	$P_{up} = 380 \cdot psi$
Downstream Pressure	P _{down} = 350 • psi
Disk Thickness (taken at centerline of the hub vertically)	$t = 2 \cdot in$
Seat Radius (corresponding to mean seat diameter)	a =4.36 • 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 • 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 = $0.5 \cdot in$

PRESLOK, Ver. 2, Rev. 0 12/22/95

ME-0498, Rev. 0 Page 29 USER'S GUIDE FOR PRESLOCK Ref 9 Program PRESLOK, Version 2 PRESSURE FORCE CALCULATIONS Average DP across disks: $DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$ DPavg = 640 • psi **Disk Stiffness Constants** $D = 2.022 \cdot 10^7 \cdot lbf \cdot in$ $D := \frac{E \cdot (t)^3}{12 \cdot (1 - v^2)}$ $G = 1.062 \cdot 10^7 \cdot psi$ $\mathbf{G} \coloneqq \frac{\mathbf{E}}{2 \cdot (1 + \mathbf{v})}$ **Geometry Factors:** $C_2 := \frac{1}{4} \left[1 - \left(\frac{b}{a} \right)^2 \cdot \left(1 + 2 \cdot \ln \left(\frac{a}{b} \right) \right) \right]$ $C_2 = 0.1781$ $C_{3} := \frac{b}{4a} \cdot \left[\left[\left(\frac{b}{a} \right)^{2} + 1 \right] \cdot \ln \left(\frac{a}{b} \right) + \left(\frac{b}{a} \right)^{2} - 1 \right]$ $C_3 = 0.0311$ $C_{8} := \frac{1}{2} \cdot \left[1 + v + (1 - v) \cdot \left(\frac{b}{a} \right)^{2} \right]$ C₈ = 0.6788 $C_{9} \coloneqq \frac{b}{a} \left[\frac{1+v}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1-v}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^{2}\right] \right]$ $C_9 = 0.2789$ $L_{3} := \frac{a}{4 \cdot a} \cdot \left[\left[\left(\frac{a}{a} \right)^{2} + 1 \right] \cdot \ln \left(\frac{a}{a} \right) + \left(\frac{a}{a} \right)^{2} - 1 \right]$ $L_{3} = 0$ $L_{9} := \frac{a}{a} \left[\frac{1+v}{2} \cdot \ln\left(\frac{a}{a}\right) + \frac{1-v}{4} \cdot \left[1 - \left(\frac{a}{a}\right)^{2} \right] \right]$ $L_{q} = 0$

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USER'S GUIDE FOR PRESLOCK Program PRESLOK, Version 2

Geometry Factors: (continued)

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

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

Moment

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

$$Q_{b} := \frac{DPavg}{2 \cdot b} \cdot (a^{2} - b^{2})$$
 $Q_{b} = 4466.5 \cdot \frac{lbf}{in}$

Deflection due to pressure and bending:

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

Deflection due to pressure and shear stress:

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

$$K_{sa} = -0.4743$$

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

$$y_{sq} = -2.7177 \cdot 10^{-4} \cdot in$$

Deflection due to hub stretch:

P force :=
$$\pi \cdot (a^2 - b^2) \cdot DPavg$$

$$y_{\text{stretch}} = \frac{f_{\text{force}}}{\pi \cdot b^2} \frac{f_{\text{force}}}{(2 \cdot E)}$$

Total Deflection due to pressure forces:

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

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$$y_{\text{stretch}} = 6.4731 \cdot 10^{-5} \cdot \text{in}$$

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$$y_q = -7.2691 \cdot 10^{-4} \cdot in$$

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-Program PRESLOK, Version 2

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

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

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:

$$y_{cmpr} := -\left(\frac{2 \cdot \pi \cdot a}{\pi \cdot b^2} \cdot \frac{\text{Hub length}}{2 \cdot E}\right)$$

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

$$y_{w} \coloneqq y_{bw} + y_{sw} + y_{cmpr}$$

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

$$F_{s} := 2 \cdot \pi \cdot a \cdot \frac{y_{q}}{y_{W}}$$
 $F_{s} = 20750.5$

UNSEATING FORCES

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Fpacking is included in measured static pullout Force

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

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

$$F_{\text{preslock}} \coloneqq 2 \cdot F_{s} \cdot (\mu \cdot \cos(\theta) - \sin(\theta))$$

 $F_{total} = -F_{piston} + F_{vert} + F_{preslock} + F_{po}$

 $F_{total} = 36185.5 \cdot lbf$ PRESLOK, Ver. 2, Rev. 0 12/22/95 Westinghouse Owner's Group

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$$y_w = -9.597 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$$

$$F_{s} = 20750.5 \cdot lbf$$

 $F_{vert} = 6662.4 \cdot lbf$

 $F_{po} = 15409 \cdot lbf$

 $F_{\text{preslock}} = 16889.1 \cdot lbf$

$$y_{\text{cmpr}} = -5.055 \cdot 10^{-8} \cdot \frac{\text{in}}{\left(\frac{\text{lbf}}{\text{in}}\right)}$$

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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."

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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

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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.

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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.

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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.

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°F

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

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

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(VOTES Event Number C11)





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.

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

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Time at Seating: (VOTES Event Number C11)

Seat_{time}

seconds

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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
$$\cdot \frac{1 \text{ minute}}{60 \text{ seconds}} \cdot \frac{\text{Lead}}{OAR}$$

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 = 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

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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 · DeltaTemp · 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 · 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 · 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.

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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:

103000.000011500090001200017.874100016.994360062.50.250.250.250.25

The input file corresponds to input values as shown:

Travel	10 inches
DeltaTemp	300 °F
TempCoef	0.00001 inches/inch/°F
Max _{close}	15000 pounds
Max _{open}	9000 pounds
CST _{thrust}	12000 pounds
CST _{time}	17.874 seconds
Seat _{thrust}	1000 pounds
Seat _{time}	16.994 seconds
MotorSpeed	3600 RPM
OAR	62.5 (dimensionless)
Lead	0.25 inches
	Travel DeltaTemp TempCoef Max _{close} Max _{open} CST _{thrust} CST _{time} Seat _{thrust} Seat _{thrust} MotorSpeed OAR

The next three pages contain the output of the STEMGROW program, Revision 0, using the above input.