WASHINGTON PUBLIC POWER SUPPLY SYSTEM	CALCULATION COVER SHEET		BDC Page NONE	
Equipment Piece No. RCIC-V-31, RCIC-MO-31		Project WNP 2	Page 1.000	Cont'd On Page 1.100
		Discipline MECHANICAL	Calculation No. ME-02-96-23	
			Quality Class 1	
		Remarks c:\mov\files\rcic\plcalc.doc		

TITLE/SUBJECT/PURPOSE

Title/Subject

PRESSURE LOCKING EVALUATION FOR RCIC-V-31

Purpose

DETERMINE THE OPEN THRUST REQUIREMENT FOR A POSTULATED PRESSURE LOCKING CONDITION CAUSED BY PRESSURE AT THE SUCTION LINE RELIEF VALVE SET PRESSURE BECOMING TRAPPED IN THE VALVE BONNET.

CALCULATION REVISION RECORD

REVISION NO.	STATUS/ F,P or S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	INITIAL ISSUE	GL 95-07	17230

PERFORMANCE VERIFICATION RECORD

REVISION NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	JE FELLMAN [signature] 7/11/96	W. H. Kelso [signature] 7/12/96	P. Hanes [signature] 7/12/96

* Study calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

REFERENCE CROSS-INDEX RMCS INPUT SHEET

Calculation No. ME-02-96-23

Revision No. 0

	INPUT INTERFACE DOCUMENTS (INP)*			OUTPUT INTERFACE DOCUMENTS (OUT)*		
	ADD	DELETE	DOCUMENT NUMBER	ADD	DELETE	DOCUMENT NUMBER
1	X		C106-92-03.05			
2	X		216-92-053			
3	X		E/I-02-92-02			
4	X		ME-02-92-150			
5				X		TM-2107
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* NOTE TO RECORDS MANAGEMENT: If a document is listed as an INPUT INTERFACE DOCUMENT (INP) to the calculation, then the calculation should be entered into RMCS as an OUTPUT INTERFACE DOCUMENT (OUT) to the document listed as an INP.

* NOTE TO RECORDS MANAGEMENT: If a document is listed as an OUTPUT INTERFACE DOCUMENT (OUT) to the calculation, then the calculation should be entered into RMCS as an INPUT INTERFACE DOCUMENT (INP) to the document listed as an OUT.

968-25405 (10/93)

RESPONSE TO REQUEST FOR PLANT SPECIFIC CALCULATION

This attachment does not constitute an LBD.

This attachment does not constitute an LBD.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM	CALCULATION INDEX	Page 1.100 / Cont'd On Page 1.200
		Calculation No. ME-02-96-23
		Revision No. 0

This attachment does not constitute an LBD.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM	VERIFICATION CHECKLIST FOR CALCULATIONS AND CMRs	Page 1.200	Cont'd On Page 1.300

Calculation/~~CMR~~ ME-02-96-23 Revision 0 was verified using the following methods:

☐ Checklist Below ☐ Alternate Calculations

Checklist Item	Initial
Clear statement of purpose of analysis	WHK
Methodology clearly stated and sufficiently detailed and appropriate to proposed application	WHK
Logical consistency of analysis	WHK
• Completeness of documenting references	WHK
• Completeness of documenting and updating output interface documents	WHK
• Completeness of input	WHK
Consistency of input data with approved criteria	WHK
Completeness in stating assumptions	WHK
Validity of assumptions	WHK
Calculation sufficiently detailed	WHK
• Arithmetical accuracy	WHK
• Physical units specified and correctly used	WHK
Reasonableness of output conclusions	WHK
Supervisor independency check (if acting as Verifier) - Did not specify analysis approach - Did not rule out specific analysis options - Did not establish analysis inputs	N/A
• If a computer program was used:	N/A
- Is the program appropriate for the proposed application? - Have the program error notices been reviewed to determine if they pose any limitations for this application? - Is the program name, revision number, and date of run inscribed on the output? - Is the program identified on the Calculation Method form? If so, is it listed in Chapter 10 of the Engineering Standards Manual?	N/A

Other Elements Considered

None

- If a separate verifier was used for validating these functions or a portion of these functions, sign and initial below.

Based on the foregoing, the calculation is adequate for the purpose intended.

Verifier Signature(s) / Date	Verifier Initials
WHKeller 7/12/96	WHK

WASHINGTON PUBLIC POWER SUPPLY SYSTEM	CALCULATION REFERENCE LIST	Page 1.301 / Con't On Page 1.400 / Calculation No. ME-02-96-23
		Revision No. 0

SEQUENCE NO.	AUTHOR	ISSUE DATE, EDITION OR REVISION	TITLE	DOCUMENT NO.
			See References Section of Appendix A p.2	

WASHINGTON PUBLIC POWER SUPPLY SYSTEM	CALCULATION OUTPUT INTERFACE DOCUMENTS REVISION INDEX	Page 1.400 / Con't On Page 2.000
		Calculation No. ME-02-96-23
Prepared By / Date: JE FELLMAN 7/11/96	Verified By / Date: W.H. Kalco 7/12/96	Revision No. 0

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (eg: BDC,SCN,CMR,Rev.)	CHANGE DEFERRED (RFTS NO.)	DEPT. MANAGER*
None			

* Required for deferred changes only.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM	CALCULATION OUTPUT SUMMARY	Page 2.000	Con't On Page 3.000
		Calculation No. ME-02-96-23	
		Revision No. 0	REV. BAR

Discussion of Results

1. THE TOTAL REQUIRED THRUST TO OPEN RCIC-V-31 WITH THE VALVE PRESSURIZED TO 116 PSIG IS 10244 LB.

2. THE ACTUATOR OPEN THRUST CAPABILITY IS 13,454 LB. (31.3% POSITIVE THRUST MARGIN)

3. THE MAXIMUM PREFERRED STATIC UNSEATING LOAD IS 9,948 LB TO ENSURE THAT THRUST LIMITATIONS OF THE VALVE OR ACTUATOR ARE NOT EXCEEDED.

Conclusions

RCIC-V-31 REMAINS OPERABLE UNDER THE POSTULATED PRESSURE LOCKING CONDITIONS.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM	CALCULATION METHOD	Page: 3.000	Cont'd On Page: Appendix A
		Calculation No. ME-02-96-23	
Prepared by/Date: JE Fellman 7/11/96	Verified by/Date: W. H. Kelso 7/12/96	Revision No. 0	

Analysis Method (Check appropriate boxes)

- [x] Manual (As required, document source of equations in Reference List)
- [ ] Computer [ ] Main Frame [ ] Personal
  - [ ] In-House Program
  - [ ] Computer Service Bureau Program
    - [ ] BCS [ ] CDC [ ] PCC [ ] Other ____________
  - [ ] Verified Program: Code name/Revision ____________
  - [ ] Unverified Program: Document in Appendix B

Approach/Methodology | REV. BAR

THIS CALCULATION IS BASED ON THE METHOD PRESENTED IN THE PROCEEDINGS OF THE WORKSHOP ON GATE VALVE PRESSURE LOCKING AND THERMAL BINDING HELD BY THE NRC FEB. 4, 1994, NUREG/CP-0146. THE METHOD DIRECTLY APPLIES THE EQUATIONS CONTAINED IN THE 5TH EDITION OF ROARK & YOUNGS FORMULAS FOR STRESS AND STRAIN, REF. 6.

THE TOTAL REQUIRED THRUST FOR OPENING ANY VALVE, UNDER PRESSURIZED BONNET CONDITIONS, IS DEPENDENT ON THE FINAL WEDGING FORCE FROM THE PREVIOUS CLOSING CYCLE. FOR A GIVEN TORQUE SWITCH SETTING, THE WEDGING FORCE CAN VARY BECAUSE INERTIAL OVERSHOOT IS AFFECTED BY THE MAGNITUDE OF THE DIFFERENTIAL PRESSURE ACROSS THE DISC. TYPICALLY, THE HIGHEST WEDGING FORCE WOULD BE INTRODUCED WHEN THE VALVE IS CLOSED WITHOUT DIFFERENTIAL PRESSURE. THIS CALCULATION CONSERVATIVELY QUANTIFIES THE UNWEDGING FORCE BASED ON AN ACTUAL AS-TESTED UNWEDGING FORCE UNDER STATIC CONDITIONS, AND GIVEN BONNET PRESSURE AND UPSTREAM AND DOWNSTREAM EXTERNAL PRESSURES.

THE CALCULATION ALSO MODELS A WEDGE PISTON EFFECT FOR FLEX WEDGE GATE VALVES WHEREBY LOWER EXTERNAL PRESSURES THAN THE INTERNAL BONNET PRESSURE CAN RESULT IN A NET DOWNWARD FORCE WHICH OPPOSES THE STEM PISTON EFFECT. CONVERSELY, HIGHER EXTERNAL PRESSURES CAN RESULT IN A NET UPWARD FORCE. THE NET FORCE IS EITHER POSITIVE OR NEGATIVE IN THE OVERALL DETERMINATION OF THE FORCE REQUIRED TO OPEN THE VALVE.

[illegible]

RC31PLR0.MCD

Appendix A

7/8/96

CALCULATION ME-02-96-23 REV. 0
Prepared By: ________
Verified By: ________

OPENING THRUST CAPABILITY CALCULATION FOR RCIC-V-31; SUPPRESSION POOL SUCTION VALVE TO RCIC PUMP UNDER POTENTIAL PRESSURE LOCKED CONDITION

GIVEN:

Wetwell Chamber Pressure	WW_P := 0 psig	Assumed
Elevation Head on Valve, Wetwell Side	V_EHW := (466 - 453)·0.433	Ref. 2, pg. D-28
(due to minimum WW level)	V_EHW = 5.6 psig	
Elevation Head from Relief Valve to Valve	V_EHRV := (453 - 431)·0.433	Ref. 2, pg. D-27,28
(relief valve is below RCIC-V-31)	V_EHRV = 9.5 psig	
Internal Bonnet Pressure (relief valve setpoint)	PB := 125.5 - V_EHRV psig	Ref. 2, pg. D-28
Suction Pressure	P_CST := (448 - 426)·0.433	Ref. 19, 20
(CST head, keepfull pump off)	P_CST = 9.5 psig	
Valve Open Pressure	V_OP := WW_P psig	
Mean Seat Diameter	MSD := 8.17 in	Ref. 4
Valve Hub Radius	H_R := 3.38 in	Measured
Poisson's Ratio for carbon steel	v := 0.30	Ref. 7,p5-06
Valve Seat Angle (degrees), θ (radians)	VSA := 5θ := VSA·.01745 θ = 0.1	Ref. 4, DR-1078, pg. 82
Measured Static Unwedging Load	SUW := 7646 lbf	Ref. 13
Measured Unwedging Load Reading Error	SUW_re := 0.104	Ref. 13
Measured Unwedging Load Full Scale Error	SUW_fse := 0 lbf	Ref. 13
Stem Diameter	SD := 1.625 in	Ref. 10
Measured Running Load	RL := 441 lbf	Ref. 13
Measured Stem Coefficient of Friction	μ := 0.0863	Ref. 13
Measured Valve Factor	VF := .6	Ref. 13
Degraded Voltage	DV := 0.8	Ref. 14
Threads Per Inch	TPI := 4	Ref. 15
Thread Starts (Lead x TPI)	TS := 2	Ref. 15
Motor Speed	MS := 1900 rpm	Ref. 15
Unit Overall Ratio	OAR := 36.2	Ref. 15
Motor Torque	MOT_TQ := 15 ft-lbs	Ref. 15
Torque Loss @ 250 F	MOT_TQ_loss := 0.0	Ref. 16, Att. 6.3, pg. 3
Torque Loss Temperature	TLT := 250 F	Ref. 16, Att. 6.3, pg. 3
Minimum Ambient Temp. for Torque Loss	ATL := 104 F	Ref. 16, Att. 6.3, Am. 93-14
Pullout Efficiency	PO_eff := 0.4	Ref. 16, Att. 6.5, Am. 93-05
Run Efficiency	RUN_eff := 0.5	Ref. 16, Att. 6.5, Am. 93-05
Stall Efficiency	STALL_eff := 0.6	Ref. 16, Att. 6.5, Am. 93-05
Operator Thrust Limit (162%)	OTL := 22680 lbf	Ref. 16 & 17
Valve Open Thrust Limit	VOL := 25167 lbf	Ref. 11
Max. Operating Temp.	T_max := 220F	Ref. 8
Gear Rating	GR := 250 ft - lbs	Ref. 17
Measured Stem Factor	SFM := 0.0123	@ Unseating, Ref. 13

CALCULATION ME-02-96-23 REV. 0
Prepared By: [signature]
Verified By: [signature]

WANTED:

1) Determine the operability of the valve with the bonnet pressurized to suction line relief valve set pressure with a 5% stem factor degradation. The motor operator should have sufficient capability to open the valve with the bonnet pressurized without exceeding the thrust limitations of the valve or the operator.

2) Determine the maximum preferred static unwedging force with a 5% stem factor degradation to provide increased assurance that the valve or operator open thrust limit will not be exceeded.

REFERENCES:

1) WNP-2 Pressure Locking and Thermal Binding Report, WPPSS-ENT-0136, December 29, 1993.
2) RCIC System MOV Design Basis Review, C106-92-03.05.
3) PPM 2.4.6, Reactor Core Isolation Cooling System
4) QID 361701
5) EPRI Performance Prediction Program, EPRI TR-103119
6) Formulas for Stress and Strain, Roark and Young, 5th Edition.
7) Handbook of Engineering Fundamentals, Eshbach, John Wiley and Sons, 1969.
8) QID 221001
9) NUREG/CR-5807, Improvements in Motor Operated Gate Valve Design and Prediction Models for Nuclear Power Systems.
10) CVI 41A-00,23
11) Weak Link Calculation, 216-92-053, CMR 96-0234
12) Limitorque SEL-3
13) RCIC-V-31 MOVATS Test WO #AP3465, test date May 25, 1993.
14) Calculation E/I 02-92-02.
15) Calculation ME-02-92-150, Rev. 0, CMR 94-0018
16) MES-10; Limitorque operator can withstand a one time thrust overload of up to twice the nominal rating or up to 162% for 2 cycles.
17) Limitorque Selection Procedure, SEL-7.
18) NUREG/CP-0146, Workshop on Gate Valve Pressure Locking and Thermal Binding, Feb. 4, 1994
19) Instrument Master Data Sheet, RCIC-LS-15A, LOW LOW CST Level causing RCIC-V-31 to open
20) CVI 215-00-3195, RCIC suction piping isometric

ASSUMPTIONS:

1) The absence or existence of a vapor pocket in the bonnet does not change the total required stem thrust to open the valve.
2) External pressure on the disc will not reduce the static unwedging load.
3) Assume the static unwedging load is directly additive to the differential pressure dynamic load due to bonnet pressure.
4) Running load is assumed to remain constant over the interval between baseline tests. Running load is accounted for indirectl since running load is included in the measured unseating load and the measured unseating load is added directly to the calculated pressure locking load in determining the required thrust to open.
5) The CST is at the low level switchover point, RCIC keepfull pump is not running, and the wetwell is at atmospheric pressure. This will create the largest differential pressure across each side of the disc when the bonnet is pressurized to the suction line relief valve set pressure minus elevation head.

CALCULATION ME-02-96-23 REV. 0

Prepared By: [signature]
Verified y: [signature]

SOLUTION:
Calculate the force exerted on the seat ring by the disc due to internal pressure using Reference 6, Table 24, Case 2d.

$a := 0.5\cdot MSD$ $b := H\_R$ $q\_i := PB$ $ro := b$
$a = 4.1$ $b = 3.4$ $q\_i = 116$ $ro = 3.4$

$$C2 := 0.25\cdot\left[1 - \left(\frac{b}{a}\right)^2\cdot\left(1 + 2\cdot\ln\left(\frac{a}{b}\right)\right)\right] \qquad C2 = 0.014$$

$$C3 := \frac{b}{4\cdot a}\cdot\left[\left[\left(\frac{b}{a}\right)^2 + 1\right]\cdot\ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right] \qquad C3 = 0$$

$$C8 := 0.5\cdot\left[1 + v + (1 - v)\cdot\left(\frac{b}{a}\right)^2\right] \qquad C8 = 0.9$$

$$C9 := \frac{b}{a}\cdot\left[\frac{1+v}{2}\cdot\ln\left(\frac{a}{b}\right) + \left[\frac{1-v}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^2\right]\right]\right] \qquad C9 = 0.1$$

$$L11 := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{ro}{a}\right)^2 - \left[5\cdot\left(\frac{ro}{a}\right)^4\right] - \left[4\cdot\left(\frac{ro}{a}\right)^2\right]\cdot\left[2 + \left(\frac{ro}{a}\right)^2\right]\cdot\ln\left(\frac{a}{ro}\right)\right] \qquad L11 = 0$$

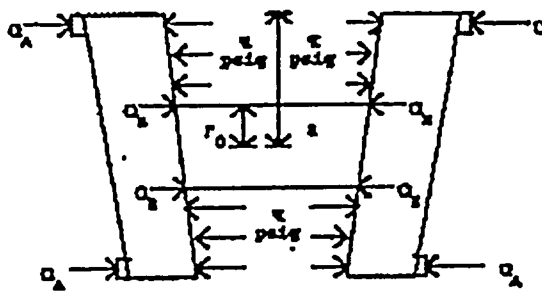
$$L17 := 0.25\cdot\left[1 - \left(\frac{1-v}{4}\right)\cdot\left[1 - \left(\frac{ro}{a}\right)^4\right] - \left(\frac{ro}{a}\right)^2\cdot\left[1 + (1 + v)\cdot\ln\left(\frac{a}{ro}\right)\right]\right] \qquad L17 = 0$$

Determine the force on the perimeter of the disc hub (Qb_i, lb/in)

$$Qb\_i := q\_i\cdot\frac{a\cdot(C2\cdot L17 - C8\cdot L11)}{C2\cdot C9 - C3\cdot C8} \qquad Qb\_i = 54.4416$$

Determine the force on the perimeter of the disc (Qa_i, lb/in) at the seat ring

$$Qa\_i := Qb\_i\cdot\left(\frac{b}{a}\right) - \left(\frac{q\_i}{2\cdot a}\right)\cdot\left(a^2 - ro^2\right) \qquad Qa\_i = -29.6604$$



Case 2d for Internal Pressure

CALCULATION ME-02-96-23 REV. 0

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Verified By: [signature]

Determine the forces exerted by external pressures on the high pressure side and on the low pressure side using Reference 6, Table 24, Case 2d and Case 1b.

WW_side := V_OP + V_EHW

PUMP_side := P_CST

q_h := if(WW_side≥PUMP_side, WW_side, PUMP_side)   PUMP_side = 9.5

q_l := if(WW_side<PUMP_side, WW_side, PUMP_side)   WW_side = 5.6

q_h = 9.5   q_l = 5.629

Determine the force on the perimeter of the disc hub (Qb_h, lb/in) due to the high pressure side

$$Qb\_h := q\_h \cdot \frac{a \cdot (C2 \cdot L17 - C8 \cdot L11)}{C2 \cdot C9 - C3 \cdot C8}$$

Qb_h = 4.4718

Determine the force on the perimeter of the disc (Qa_h, lb/in) at the seat ring due to the high pressure side

$$Qa\_h := Qb\_h \cdot \left(\frac{b}{a}\right) - \left(\frac{q\_h}{2 \cdot a}\right) \cdot \left(a^2 - ro^2\right)$$

Qa_h = -2.4363

Determine the force on the perimeter of the disc hub (Qb_l lb/in) due to the low pressure side

$$Qb\_l := q\_l \cdot \frac{a \cdot (C2 \cdot L17 - C8 \cdot L11)}{C2 \cdot C9 - C3 \cdot C8}$$

Qb_l = 2.6424

Determine the force on the perimeter of the disc (Qa_l, lb/in) at the seat ring due to the low pressure side

$$Qa\_l := Qb\_l \cdot \left(\frac{b}{a}\right) - \left(\frac{q\_l}{2 \cdot a}\right) \cdot \left(a^2 - ro^2\right)$$

Qa_l = -1.4396

Determine the force on the perimeter of the hub (W_hub, lb/in) due to the differential pressure over the hub area.

$$W\_hub := \frac{(q\_h - q\_l) \cdot \pi \cdot b^2}{\pi \cdot 2 \cdot b}$$

W_hub = 6.5859

Determine the differential force on the perimeter of the hub (W_hub_h_l, lb/in) due to the high and low pressure side, which excludes the hub area.

W_hub_h_l := Qb_h - Qb_l   W_hub_h_l = 1.8294

Determine the total differential force on the perimeter of the hub (W_hub_ΔF, lb/in)

W_hub_ΔF := W_hub + W_hub_h_l   W_hub_ΔF = 8.4153

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CALCULATION ME-02-96-23 REV. 0

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Determine the force on the perimeter of the disc (Qa_Δhl, lb/in) on the low pressure side due to the external differential pressure.

$Qa\_\Delta hl := 0 - W\_hub\_\Delta F \cdot \frac{ro}{a}$ $Qa\_\Delta hl = -6.963$

Determine the force on each seat ring due to the four pressure loading conditions

Determine the ring load on the high pressure side (Qr_h, lb/in)

$Qr\_h := Qa\_i - Qa\_h$ $Qr\_h = -27.2241$

Determine the ring load on the low pressure side (Qr_l, lb/in)

$Qr\_l := Qa\_i - Qa\_l + Qa\_\Delta hl$ $Qr\_l = -35.1838$

Determine the total disc force on the high pressure side (F_h, lbf)

$F\_h := \pi \cdot MSD \cdot Qr\_h$ $F\_h = -699$

$F\_h := if(F\_h \geq 0, (-1) \cdot F\_h, F\_h)$ $F\_h = -698.7571$

Determine the total disc force on the low pressure side (F_l)

$F\_l := \pi \cdot MSD \cdot Qr\_l$ $F\_l = -903$

$F\_l := if(F\_l \geq 0, 0, F\_l)$ $F\_l = -903$ lbf

Determine Disc Area (DA, in^2)

$DA := \frac{\pi \cdot MSD^2}{4}$ $DA = 52.4$ in^2

Valve Disc Factor

$DF := VF$ $DF = 0.6$

Determine the total required thrust (RT, lbf)

Determine thrust required due to pressure only (RT_p, lbf)

$RT\_p := (F\_l + F\_h) \cdot DF$

$RT\_p := if(RT\_p > 0, RT\_p, (-1) \cdot RT\_p)$ $RT\_p = 961$ lb_f

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CALCULATION ME-02-96-23 REV. 0

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Determine Stem Piston Effect (SPE, lbf)

Determine Stem Area (SA, in^2)

$SA := \pi \cdot \frac{SD^2}{4}$ $SA = 2.1$

Calculate the Stem Piston Effect

$SPE := SA \cdot PB$ $SPE = 241$

Determine the Net Wedge Piston Effect (NDPE, lbf)

Determine the top half of the projected area of one of the discs only due to the angle of the wedge (PAT, in^2)

The top width = $TW := MSD \cdot \sin(\theta)$ $TW = 0.7$

The projected shape of the wedge area is an ellipse.

$PAT := \pi \cdot 0.5 \cdot MSD \cdot 0.5 \cdot TW$ $PAT = 4.6$ Ref. 7, pg. 2-56

Determine total projected area that would result in a downward force from internal bonnet pressure (TPAT, in^2). TPAT also represents the area over which the upward forces from external disc pressures would act.

$TPAT := 2 \cdot PAT$ $TPAT = 9.1$

Determine the Internal Wedge Piston Effect (IDPE, lbf)

$IDPE := TPAT \cdot PB$ $IDPE = 1060$

Determine the External Wedge Piston Effect for the high pressure side (EDPEH, lbf)

$EDPEH := PAT \cdot q\_h$ $EDPEH = 44$

Determine the External Wedge Piston Effect for the low pressure side (EDPEL, lbf)

$EDPEL := PAT \cdot q\_l$ $EDPEL = 26$

Determine the Net Wedge Piston Effect

$NDPE := IDPE - EDPEH - EDPEL$ $NDPE = 990$

Determine the corrected Static Unwedging Load (SUWC, lbf)

$SUWC := \frac{SUW}{1 - SUW\_re} + SUW\_fse$ $SUWC = 8533$

TOTAL REQUIRED THRUST TO OPEN (RTO, lbf)

$RTO := SUWC + RT\_p - SPE + NDPE$ $RTO = 10244$

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OPEN THRUST CAPABILITY OF THE OPERATOR (OTC, lbf)

Determine Stem Factor (SF, ft)

$$TANa := \frac{\frac{TS}{TPI}}{\pi \cdot \left[SD - \left(\frac{1}{TPI} \right) \cdot 0.5 \right]}$$ TANa = 0.1

$$SF1 := \frac{\left(SD - .5 \cdot \frac{1}{TPI} \right) \cdot (.96815 \cdot TANa + \mu)}{24 \cdot (.96815 - \mu \cdot TANa)}$$ SF1 = 0

SF := if(SFM>0, SFM, SF1) SF = 0

Determine Torque Loss at Max. Operating Temperature (TL)

$i := 1..2$ $vx_i :=$ $vy_i :=$

vx	vy
ATL	0
TLT	MOT_TQ_loss

TL := linterp(vx, vy, T_max) TL = 0

Determine Motor Start Torque (MST, ft-lbs)

MST := MOT_TQ·(1 − TL) MST = 15

Determine Reduced Voltage Factor (RVF)

RVF := DV RVF = 0.8 DC motor

Determine Pullout Torque (POT)

POT := MST·OAR·PO_eff·RVF POT = 173.8 ft − lbs

POT := if(POT>GR, GR, POT) POT = 173.8 ft − lbs

OPERATOR OPEN THRUST CAPABILITY

$$OTC := \frac{POT}{SF}$$ OTC = 14127

lbf

MARGIN := OTC − RTO MARGIN = 3882

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CALCULATION ME-02-96-23 REV. 0

Prepared By: [signature]
Verified By: [signature]

OPEN THRUST CAPABILITY OF THE OPERATOR WITH 5% STEM FACTOR DEGRADATION (OTC1, lbf)

$$OTC1 := \frac{POT}{SF \cdot 1.05}$$ OTC1 = 13454 lbf

MAXIMUM PREFERRED STATIC UNWEDGING FORCE (MSUW)

T_LIM := if(VOL>OTC, OTC, VOL)

T_LIM := if(T_LIM>OTL, OTL, T_LIM)

T_LIM := if(T_LIM>OTC1, OTC1, T_LIM)

T_LIM = 13454 lbf

VOL = 25167 OTC1 = 13454 OTL = 22680

MSUW := SUWC - (RTO - T_LIM) - 1000 - SUW_fse - SUW·SUW_re MSUW = 9948 lbf

T_LIM = 13454 RTO = 10244
SUWC = 8533 SUW_fse = 0
SUW = 7646 SUW_re = 0.1

CONCLUSION :

1) The highest total required thrust to open (RTO = 10244 lbf) is less than the operator capability with 5% stem factor degradation (OTC1 = 13454 lbf). Therefore, the valve is capable of performing its safety function with a bonnet pressure of PB = 116 psig, pumpside pressure of P_CST = 9.5 psig, and wetwell chamber pressure of WW_P = 0 psig.

2) The maximum preferred static unwedging force was determined to be MSUW = 9948 lbf. The measured static unwedging force of SUW = 7646 lbf is less than the maximum preferred value. The maximum preferred unwedging force ensures the calculated required thrust to open will not exceed the thrust limitations of either the valve or the operator with a 1000 lb margin.