CALCULATION/EVALUATION COVER SHEET AND REVIEW REPORT

SECTION I:

Calculation/Evaluation No.: C10873 Revision: 0

Originating Document No.: GL 95-07 System No.: 36

Title: PR-1A&B Potential for Pressure Locking

Purpose: Determine the potential susceptibility of PR-1A&B to pressure locking.

Safety-Related: ☑ Yes ☐ No

SECTION II: (Note: This section required for safety-related calculations/evaluations only.)

Special Instructions from Preparer: The method used in the calculation was developed by The Westinghouse Owners Group PLTB Task Team based on methods developed by Commonwealth Edison.

Review Method and References Used by Reviewer:

Design Review
Reference material per Section 2 and 4. of the calculation.

Review Results and Recommendations:

no comments

Resolution of Recommendations:

Reviewed By: Mark Ortmayer Initials: MJO Date: 7/18/96

SECTION III:

Performed By: Bruce R Heida Initials: BRH Date: 7/18/96

Distribution: KNPP QA Vault (Original)

9607240237 960718
PDR ADOCK 05000305
P PDR

CALCULATION

CALC. NO.: C10873
PREPARED BY: Bruce R. Heida
REVIEWED BY: Mark Oostmeyer 7/18/96

DATE: 2/29/96
Rev. 0

1.0 PURPOSE:

Determine potential susceptibility of the pressurizer PORV block valves, PR-1A&B, to pressure locking when valve bonnet is pressurized to RCS pressure, upstream pressure at 1500 psi , and downstream pressure is a PRT pressure of 0 psi. The calculation confirms the capability of the actuator to open the valve when considering the additional force applied by pressure locking. The PORV block valve must be operable to provide an additional alternate means of mitigating a design basis steam generator tube rupture (SGTR), TS 3.1.a.5 basis. If a PORV block valve is closed due to a leaking PORV the block valve has to be capable of re-opening. This is in response to NRC Generic Letter 95-07.

2.0 REFERENCES:

2.1 Roark's Formulas for Stress and Strain, Sixth Edition, McGraw-Hill
2.2 PO 97686; Required Thrust and Weak Link Calculation, Velan Report #DC-028, 4/08/91
2.3 C10836; MOV Valve Factor and Load Sensitive Behavior Evaluation
2.4 GMP 236-1; Diagnostic Testing of Limitorque MOVs Using the Torque Thrust Cell
2.5 GMP 238; MOV Thrust and Torque Evaluations
2.6 Users Guide for PRESLOCK, rev 1, A Westinghouse Owners Group Gate Valve Pressure Locking Analysis Program using the Commonwealth Edison Model
2.7 NRC GL 95-07, Pressure Locking and Thermal Binding of Safety Related Power Operated Gate Valves.

3.0 ASSUMPTIONS:

3.1 Formulas listed in Reference 2.1 are accurate.
3.2 Valve body and seat rings have infinite stiffness ($K=\infty$). Conservative assumption.
3.3 Wedge material is elastic, homogeneous, and conforms to Hooke's law (stress is proportional to strain).
3.4. Valve disk is assumed to act as two ideal disks connected by a hub. Disks are assumed to be round, of uniform thickness, and perpendicular to a cylindrical, concentric hub. Fillets between hub and disks, and the increased thickness at the disk seating surface which would make the valve disk stiffer are ignored. A stiffer disk will have a smaller deflection for a given differential pressure, therefore lower pressure locking forces. A more flexible disk will yield more conservative results .
3.5 Normally steam filled bonnet 100% filled with condensate.
3.6 All non-condensable gas dissipated through packing.
3.7 No bleed down of bonnet pressure (both upstream and downstream disk seats leak tight.)
3.8 Stem motion in opening direction prior to disk "Tee Slot" contact does not change bonnet free volume (with the potential of reducing bonnet pressure).
3.9 Upstream pressure is based on an assumed worst case pressure at which point the SI pump would be in operation. This would be during a design basis Steam Generator Tube Rupture with the SI pump operating to maintain RCS inventory. This is a very conservative pressure. SI pump shutoff head is roughly 2200 psi. USAR Figure 14.2-1 shows the balance between SI flow and a SGTR flow to be roughly 60 GPM at 2000 psig. For the purpose of this calculation, 1500 psig was arbitrarly selected. A higher upstream pressure will reduce the potential for pressure locking.
3.10 Calculation is based on the PRESLOK pressure locking analysis program developed by the Westinghouse Owners Group, PLTB Task Team in conjunction with ComEd.
3.11 The calculation uses test data from PR-1A. The results bound PR-1B.

4.0 INPUTS:

4.1 C10836
4.2 GMP 236-1 Data Sheets (PR-1A 4/21/94, WR 36/204977 log file L09, PR-1B 4/21/94, WR 36/204978 log file L15)
4.3 GMP 238 Rev.C
4.4 PO 97686
4.5 GMP 238 Calculation sheet for PR-1A dated 6/8/94, PR-1B dated 4/17/94
4.6 Machine Design, AD Deutschman, WJ Michels, CE Wilson, Macmillan Publishing Co., Copyright 1975
4.7 GMP 238-A1,MOV Data Tables

5.0 CONCLUSIONS:

Adequate margin exists for the valves to operate under potential pressure locking conditions.

6.0 CALCULATION:

Pressure Locking of Gate Valves

Valve parameters:

Physical dimensions:

		References:
$\theta := 5 \cdot deg$	Seat Angle	Ref. 4.4, pg 19
$Seat_{OD} := 2.997 \cdot in$	Seat ring outside diameter	Ref. 4.4, pg 50
$Seat_{ID} := 2.245 \cdot in$	Seat ring inside diameter	Ref. 4.4, pg 50
$b := 0.813 \cdot in$	Disk hub radius	Ref. 4.4, pg 14,19
$t := 0.753 \cdot in$	Disk thickness	Ref. 4.4, pg 19
$L := 0.1875 \cdot in$	Hub length	Measured, Stock #2068305
$D_{stem} := 1.125 \cdot in$	Stem diameter	Ref. 4.7, pg 7

Data from MOV testing:

$T_q := 226.8 \cdot ft \cdot lbf$	Actuator torque at degraded voltage	Ref. 4.5, sec. 4.4.4
$SF := 0.0128 \cdot ft$	Stem Factor (opening)	Ref. 4.2
$F_{po} := 6461 \cdot lbf$	Pullout Force	Ref. 4.2
$F_{vo} := 0.55$	Valve open factor	Ref. 4.1, Table 1

System parameters:

$P_{up} := 1500 \cdot psi$	Pipe pressure, upstream	Ref. 3.9
$P_{dn} := 0 \cdot psi$	Pipe pressure, downstream	
$P_b := 2235 \cdot psi$	Bonnet pressure	Normal RCS Pressure

Material properties, CF8 A-351:

$\upsilon := 0.3$	Poisson's ratio	Ref. 4.6
$E := 28 \cdot 10^6 \cdot psi$	Modulus of Elasticity	Ref. 4.6, Table A1

COMPUTATION:

Mean seat radius

$$a := \sqrt{\frac{Seat_{OD}^2 + Seat_{ID}^2}{8}}$$

$a = 1.324 \cdot in$

Disk Stiffness Constants

$$D := \frac{E \cdot t^3}{12 \cdot \left(1 - \upsilon^2\right)}$$ $D = 1.095 \cdot 10^6 \cdot lbf \cdot in$

$$G := \frac{E}{2 \cdot (1 + \upsilon)}$$ $G = 1.077 \cdot 10^7 \cdot psi$

Average pressure difference:

$$\Delta P_{avg} := P_b - \left(\frac{P_{up} + P_{dn}}{2}\right)$$ $\Delta P_{avg} = 1485 \cdot psi$

Coefficient of friction between disk and seat:

μ

$$\mu := \frac{F_{vo} \cdot \cos(\theta)}{1 - F_{vo} \cdot \sin(\theta)}$$

Coefficient of friction

$\mu = 0.575$

Moment (Ref. 2.1, Table 24, Case 2L)

$r_o := b$

Geometry Factors: Ref. 1, Table 24

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right]$$ $C_2 = 0.064$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$ $C_3 = 0.007$

$$C_8 := \frac{1}{2} \cdot \left[1 + \upsilon + (1 - \upsilon) \cdot \left(\frac{b}{a}\right)^2\right]$$ $C_8 = 0.782$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \upsilon}{2} \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{1 - \upsilon}{4}\right) \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$ $C_9 = 0.262$

$$L_{11} := \frac{1}{64} \cdot \left[1 + 4 \cdot \left(\frac{b}{a}\right)^2 - 5 \cdot \left(\frac{b}{a}\right)^4 - 4 \cdot \left(\frac{b}{a}\right)^2 \cdot \left[2 + \left(\frac{b}{a}\right)^2\right] \cdot \ln\left(\frac{a}{b}\right)\right]$$ $L_{11} = 7.648 \cdot 10^{-4}$

$$L_{17} := \frac{1}{4} \cdot \left[1 - \left(\frac{1 - \upsilon}{4}\right) \cdot \left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2 \cdot \left[1 + (1 + \upsilon) \cdot \ln\left(\frac{a}{b}\right)\right]\right]$$ $L_{17} = 0.058$

Moments

$M_{rb} := \frac{-\Delta P_{avg} \cdot a^2}{C_8} \cdot \left[\frac{C_9}{2 \cdot a \cdot b} \cdot \left(a^2 - b^2\right) - L_{17} \right]$ $\qquad M_{rb} = -247.1 \cdot \frac{in \cdot lbf}{in}$

$Q_b := \frac{\Delta P_{avg}}{2 \cdot b} \cdot \left(a^2 - r_o^2\right)$ $\qquad Q_b = 997 \cdot \frac{lbf}{in}$

Deflection due to pressure and bending — Ref. 2.1, Table 24, case 2L

$y_{bq} := M_{rb} \cdot \frac{a^2}{D} \cdot C_2 + Q_b \cdot \frac{a^3}{D} \cdot C_3 - \frac{\Delta P_{avg} \cdot a^4}{D} \cdot L_{11}$ $\qquad y_{bq} = -1.265 \cdot 10^{-5} \cdot in$

Deflection due to pressure and shear stress — Ref. 2.1, Table 24, case 2L

$K_{sa} := -0.3 \cdot \left[2 \cdot \ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2 \right]$ $\qquad K_{sa} = -0.106$

$y_{sq} := \frac{K_{sa} \cdot \Delta P_{avg} \cdot a^2}{t \cdot G}$ $\qquad y_{sq} = -3.393 \cdot 10^{-5} \cdot in$

Deflection due to hub stretch (from center of hub to disk):

$P_{force} := \pi \cdot \left(a^2 - b^2\right) \cdot \Delta P_{avg}$ $\qquad P_{force} = 5093 \cdot lbf$

$y_{stretch} := \frac{P_{force}}{\pi \cdot b^2} \cdot \frac{L}{(2 \cdot E)}$ $\qquad y_{stretch} = 8.213 \cdot 10^{-6} \cdot in$

Total deflection due to pressure forces:

$y_q := \left(y_{bq} + y_{sq}\right) - y_{stretch}$ $\qquad y_q = -5.479 \cdot 10^{-5} \cdot in$

Deflection due to seat contact force and shear stress (per lbf/in): — Ref. 2.1, Table 25, case 1L

$r_o := a$

Geometry Factors: — Ref. 1, Table 24

$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right) \right]$ $\qquad C_2 = 0.064$

$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1 \right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1 \right]$ $\qquad C_3 = 0.007$

$C_8 := \frac{1}{2} \cdot \left[1 + \upsilon + (1 - \upsilon) \cdot \left(\frac{b}{a}\right)^2 \right]$ $\qquad C_8 = 0.782$

$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \upsilon}{2} \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{1 - \upsilon}{4}\right) \cdot \left[1 - \left(\frac{b}{a}\right)^2 \right] \right]$ $\qquad C_9 = 0.262$

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

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

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

$$y_{sw} := - \frac{1.2 \cdot \frac{r_o}{a} \cdot \ln\left(\frac{r_o}{b} \right)}{t \cdot G} \cdot a \qquad y_{sw} = -9.553 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in} \right)}$$

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

Ref. 2.1, Table 24, case 1L

$$y_{bw} := - \left(\frac{a^3}{D} \right) \cdot \left[\left(\frac{C_2}{C_8} \right) \cdot \left(\frac{r_o \cdot C_9}{b} - L_9 \right) - \frac{r_o \cdot C_3}{b} + L_3 \right] \qquad y_{bw} = -4.789 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in} \right)}$$

Deflection due to hub compression (per lbf/in), (from center of hub to disk):

$$y_{compr} := \frac{2 \cdot a \cdot \pi}{\pi \cdot b^2} \cdot \frac{L}{2 \cdot E} \qquad y_{compr} = 1.341 \cdot 10^{-8} \cdot \frac{in}{\left(\frac{lbf}{in} \right)}$$

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

$$y_w := y_{bw} + y_{sw} - y_{compr} \qquad y_w = -1.568 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in} \right)}$$

Seat contact force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2 \cdot \pi \cdot a \cdot \frac{y_q}{y_w} \qquad F_s = 2906 \cdot lbf$$

UNSEATING FORCES

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

$$F_{piston} := \pi \cdot \frac{D_{stem}^2}{4} \cdot P_b \qquad F_{piston} = 2222 \cdot lbf$$

$$F_{vert} := \pi \cdot a^2 \cdot \sin(\theta) \cdot \left[\left(P_b - P_{up} \right) + \left(P_b - P_{dn} \right) \right] \qquad F_{vert} = 1425 \cdot lbf$$

$$F_{preslock} := 2 \cdot F_s \cdot (\mu \cdot \cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 2825 \cdot lbf$$

$F_{po} = 6461 \cdot lbf$

$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po}$ $\qquad$ $F_{total} = 8490 \cdot lbf$

CALCULATIONS:

$T_q = 226.8 \cdot ft \cdot lbf$

$F_a := \frac{T_q}{SF}$ $\qquad$ $F_a = 17719 \cdot lbf$

$Margin := \frac{F_a - F_{total}}{F_{total}}$

$Margin = 1.087$ $\qquad$ $Margin = 109 \cdot \%$

Determine margin based on valve weak link analysis.

$F_{weak\_link} := 9046 \cdot lbf$ $\qquad$ Ref. 4.4, pg 7 (One time limit-Valve disk)

$Margin := \frac{F_{weak\_link} - F_{total}}{F_{total}}$

$Margin = 0.065$ $\qquad$ $Margin = 7 \cdot \%$

Determine the minimum margin based on maximum test measurement uncertainty. Minimum margin will exist at the maximum pull out thrust measured (F_{po}) plus uncertainity.

$TTCRRDE := 0.05 \cdot F_{po}$	$TTCRRDE = 323 \cdot lbf$	Ref 4.3, step 4.25.1
$TTCRFSE := 421 \cdot lbf$		Ref 4.5, step 4.10.4
$TTCRDE := .01 \cdot F_{po}$	$TTCRDE = 65 \cdot lbf$	Ref 4.3, step 4.25.1
$TTCFSE := 117 \cdot lbf$		Ref 4.5, step 4.10.3
$SMRDE := 0.01503 \cdot F_{po}$	$SMRDE = 97 \cdot lbf$	Ref 4.3, step 4.25.1
$SMFSE := 6 \cdot lbf$		Ref 4.5, step 4.10.2
$AoverDE := 57 \cdot lbf$		Ref 4.5, step 4.10.1

$$uncertainty := \sqrt{(AoverDE)^2 + (SMFSE + SMRDE)^2 + (TTCFSE + TTCRDE)^2 + (TTCRFSE + TTCRRDE)^2}$$

$uncertainty = 775 \cdot lbf$

$F_{total.max} := -F_{piston} + F_{vert} + F_{preslock} + \left[F_{po} + (uncertainty)\right]$ $\qquad$ $F_{total.max} = 9265 \cdot lbf$

$Margin_{min} := \frac{F_a - F_{total.max}}{F_{total.max}}$

$Margin_{min} = 0.912$ $\qquad$ $Margin_{min} = 91 \cdot \%$

MOTOR-OPERATED VALVE THRUST & TORQUE CALCULATION SHEET

(Sheet 1 of 3)

Operation Valve No. PR-1A
Actuator No. 32089
Motor No. 1-355

Date 6/8/94

4.1

ACTUATOR TYPE-SIZE:	SMB 00		VALVE TYPE:	Flex Wedge
SPRING PACK NO.:	022		VALVE SIZE:	3 in.
OVERALL ACTUATOR RATIO:	63		SEAT DIAMETER:	2.25 in.
MOTOR START TORQUE:	15	ft.-lbs.	STEM DIAMETER:	1.125 in.
MOTOR NAMEPLATE SPEED:	1700	RPM	STEM PITCH:	0.3333 in.
MOTOR NP VOLTAGE:	460	V	STEM LEAD:	0.6667 in.
			SAFETY FUNCTION:	Closed

SOURCE OF DATA:
Limitorque BOM, Valve Weak Link P.O., ESR 92-02, and IST Plan Licensing Basis Document

4.2.1 Valve Factor Used (Fv) 0.50

4.2.2 Stem to Stem Nut Coefficient of Friction Use 0.15

4.2.3 Stem Factor Used (Fs) 0.0156

4.2.4 Required System Data
- a.) Differential Pressure Value (DP) 2335 psi
- b.) Line Pressure Value 2335 psi
- c.) Momentum Pressure Value (Pm) 2 psi

4.2.5 Packing Load Allowance 500 lbs.

4.3.1 Allowable Actuator Thrust Limit = Actuator Seating Thrust Rating X 110% =
14000 X 1.1 = 15400 lbs.

4.3.2 Valve Manufacturer Limiting Components and Thrust Limits
- a.) Open direction Wedge @ 7479 lbs.
- b.) Close direction Stem @ 15360 lbs.

4.3.3 Stem Area = $(\text{Stem Dia.})^2 \times \frac{3.141593}{4} = (1.125)^2 \times \frac{3.141593}{4} = 0.99$ in.^{2}

4.3.4 Orifice Area = $(\text{Seat Dia.})^2 \times \frac{3.141593}{4} = (2.25)^2 \times \frac{3.141593}{4} = 3.98$ in.^{2}

MOTOR-OPERATED VALVE THRUST & TORQUE CALCULATION SHEET
(Sheet 2 of 3)

Operation Valve No. PR-1A
Actuator No. 32089
Motor No. 1-355

Date 6/8/94

4.3.5 Differential Pressure Thrust Component = Orifice Area X (DP + Pm) X Valve Factor =
3.98 X (2335 + 2) X 0.50 = 4651 lbs.

4.3.6 Stem Rejection Load (SRL) = Stem Area X Line Pressure =
0.99 X 2335 = 2312 lbs.

4.3.7 MINIMUM REQUIRED OPENING STEM THRUST =
Packing Load + DP Thrust Component = 500 + 4651 = 5151 lbs.

4.3.8 Is the minimum required opening stem thrust greater than the actuator or valve limiting thrust component in the open direction? *If YES, then document resolution. YES*/NO NO

4.3.9 MINIMUM REQUIRED CLOSING STEM THRUST =
Packing Load + DP Thrust Component + SRL =
500 + 4651 + 2312 = 7463 lbs.

4.3.10 Is the minimum required closing stem thrust greater than the actuator or valve limiting thrust component in the close direction? *If YES, then document resolution. YES*/NO NO

4.4.1 Allowable Actuator Torque Limit = Actuator Maximum Torque Rating X 110% =
250 X 1.1 = 275.0 ft.-lbs.

4.4.2 Maximum Actuator Output Torque at Full Voltage =
Motor Start Torque X Overall Actuator Ratio X Efficiency X Application Factor =
15 X 63 X 0.4 X 0.9 = 340.2 ft.-lbs.

4.4.3 Percent of Motor Rated Voltage at DV = (Degraded Motor Voltage / Motor NP Voltage) X 100 =
(386.7 / 460) X 100 = 84.1 %

4.4.4 Maximum Actuator Output Torque at Degraded Voltage =
Motor Start Torque X Overall Actuator Ratio X Efficiency X Application Factor X DVF =
15 X 63 X 0.40 X 1.0 X 0.60 = 226.8 ft.-lbs.

4.4.5 Spring Pack Unit Output Torque Rating = 277 ft.-lbs.

4.4.6 Minimum Required Actuator Output Torque =
Minimum Required Closing Stem Thrust X Stem Factor =
7463 X 0.0156 = 116.4 ft.-lbs.

4.4.7 Is minimum required actuator torque greater than any limiting component torque? *If YES, then document resolution. YES*/NO NO

MOTOR-OPERATED VALVE THRUST & TORQUE CALCULATION SHEET
(Sheet 3 of 3)

Operation Valve No. PR-1A
Actuator No. 32089
Motor No. 1-355

Date 6/8/94

4.5.1 Maximum Allowable Torque Value = Lesser of Following 4 Torque Limits = 239.6 ft.-lbs.

a.) Allowable Actuator Thrust Limit X Stem Factor =
15400 X 0.0156 = 240.2 ft.-lbs.

b.) Valve Closing Thrust Limit X Stem Factor =
15360 X 0.0156 = 239.6 ft.-lbs.

c.) Allowable Actuator Torque Limit = 275 ft.-lbs.

d.) Spring Pack Unit Output Torque Rating = 277 ft.-lbs.

4.5.2 Estimated Maximum Torque Switch Setting 2.75

4.5.3 Estimated Minimum Torque Switch Setting 1.50

COMMENTS:
This is a post-test calculation.

Packing load changed to 500 lbs based on static test data.
0.15 coefficient of friction envelopes that determined from static testing.

4.18 Performed by [signature] Date 6/8/94
Checked & Approved by [signature] Date 6-9-94

MOV TARGETS CALCULATION AND EQUIPMENT SET-UP DETERMINATION SHEET

(Sheet 1 of 6)

Operations Valve No. PR-1A
Actuator No. 32089
Motor No. 1-355

Date 6/8/94
Work Request No. 204977

4.6 ACTUATOR TYPE-SIZE: SMB 00
TTC M&TE NO.: 92350
TTC SERIAL NO. RB-023
TTC TYPE: RB

TTC FULL SCALE THRUST: 23380 lbs.
THRUST 3000 SPAN NO.: 1416.70 lbs./mV
TTC FULL SCALE TORQUE: 434 ft.-lbs.*
TORQUE 3000 SPAN NO.: 66.974 ft.-lbs./mV
*Convert in.-lbs. to ft.-lbs.

4.7.1 Maximum Expected Thrust Reading = 15400 lbs.

4.7.2 3500 System Thrust Gain = Thrust 3000 Span No. X 20000 / Maximum Expected Thrust Reading =
= 1416.7 X 20000 / (15400) = 1840

4.7.3 Thrust Gain Setting = Next lower setting of 200, 500, 1000, 2000, or 4000 = 1000

4.7.4 3500 System Thrust Sensor Coefficient (#2) = Thrust 3000 Span No. X 2000 / Thrust Gain =
= 1416.7 X 2000 / (1000) = 2833.40 lbs./V

4.7.5 3500 System Thrust Full Scale = 3500 System Thrust Sensor Coefficient (#2) X 10 V =
= 2833.40 X 10 = = 28334.0 lbs.

4.8.1 Maximum Expected Torque Reading = 275 ft.-lbs.

4.8.2 3500 System Torque Gain = Torque 3000 Span No. X 20000 / Maximum Expected Reading =
= 66.974 X 20000 / (275) = = 4871

4.8.3 Torque Gain Setting = Next lower setting of 200, 500, 1000, 2000, or 4000 = 4000

4.8.4 3500 System Torque Sensor Coefficient (#2) = Torque 3000 Span No. X 2000 / Torque Gain =
= 66.974 X 2000 / (4000) = 33.487 ft.-lbs./V

4.8.5 3500 System Torque Full Scale = 3500 System Torque Sensor Coefficient (#2) X 10 V =
= 33.487 X 10 = 334.87 ft.-lbs.

MOV TARGETS CALCULATION AND EQUIPMENT SET-UP DETERMINATION SHEET

(Sheet 2 of 6)

Operations Valve No. PR-1A
Actuator No. 32089
Motor No. 1-355

Date 6/8/94
Work Request No. 204977

4.9.1 LSBA	= Load Sensitive Behavior/Rate of Loading Allowance =				14	%
4.9.2 SLDA	= Stem Lubrication Degradation Allowance =				5	%
4.10.1 A/DE	= Analog/Digital FS Thrust Error =	± 0.002	X	28334.0	= ± 56.7	lbs.
	= Analog/Digital FS Torque Error =	± 0.002	X	334.87	= ± 0.67	ft.-lbs.
4.10.2 SMFSE	= Strain Module FS Thrust Error =	± 0.0002	X	28334.0	= ± 5.7	lbs.
	= Strain Module FS Torque Error =	± 0.0002	X	334.87	= ± 0.07	ft.-lbs.
4.10.3 TTCFSE	= Torque/Thrust Cell FS Th. Error =	± 0.005	X	23380	= ± 116.9	lbs.
	= Torque/Thrust Cell FS Tq. Error =	± 0.005	X	434	= ± 2.17	ft.-lbs.
4.10.4 TTCRFSE	= TTC Repositioning FS Th. Error =	± 0.018	X	23380	= ± 420.8	lbs.
	= TTC Repositioning FS Tq. Error =	± 0.009	X	434	= ± 3.91	ft.-lbs.

4.11.1 Mimumum Thrust Requirement = 7463 lbs.

4.11.2 Adjusted Thrust Requirement at Torque Switch Trip =
Min. Thrust Requirement X (LSBA + SLDA + 1) =

7463 X (0.14 + 0.05 + 1) = 8881.0 lbs.

4.11.3 SMRDE =	± 0.01503	X	8881.0	=	± 133.5	lbs.
TTCRDE =	± 0.01	X	8881.0	=	± 88.8	lbs.
TTCRRDE=	± 0.05	X	8881.0	=	± 444.1	lbs.
TSRE =	± 0.2	X	8881.0	=	± 1776.2	lbs.
TSRE =	± 0.1	X	8881.0	=	± 888.1	lbs.
TSRE =	± 0.05	X	8881.0	=	± 444.1	lbs.

4.11.4 TTCRE = ± (TTCRFSE + TTCRRDE) = 444.05 + 420.80 = ± 864.9 lbs.

4.11.5 Minimum Thrust Reading at Torque Switch Trip = Adjusted Thrust Requirement
+ SQRT[A/DE² + (SMRDE + SMFSE)² + (TTCRDE + TTCFSE)² + ((TTCRRDE + TTCRFSE)² or TSRE²)] =

20% Case: 10675 lbs.
10% Case: 9805 lbs.
5% Case: 9783 lbs.

MOV TARGETS CALCULATION AND EQUIPMENT SET-UP DETERMINATION SHEET
(Sheet 3 of 6)

Operations Valve No. PR-1A
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Motor No. 1-355

Date 6/8/94
Work Request No. 204977

4.12.1 Closing Thrust Weak Link = Stem
Closing Thrust Weak Link Limit = 15360 lbs.

4.12.2 SMRDE =	±	0.01503	X	15360	=	± 230.9	lbs.
TTCRDE =	±	0.01	X	15360	=	± 153.6	lbs.
TTCRRDE=	±	0.05	X	15360	=	± 768.0	lbs.
TSRE =	±	0.2	X	15360	=	± 3072.0	lbs.
TSRE =	±	0.1	X	15360	=	± 1536.0	lbs.
TSRE =	±	0.05	X	15360	=	± 768.0	lbs.

4.12.3 TTCRE = ± (TTCRFSE + TTCRRDE) = 768.0 + 420.8 = ± 1188.8 lbs.

4.12.4 Maximum Closing Thrust Reading = Closing Thrust Weak Link Limit
+ SQRT[A/DE² + (SMRDE + SMFSE)² + (TTCRDE + TTCFSE)² + ((TTCRRDE + TTCRFSE)² or TSRE²)] =

20% Case: 12267 lbs.
10% Case: 13782 lbs.
5% Case: 14117 lbs.

4.13.1 Opening Thrust Weak Link = Wedge
Opening Thrust Weak Link Limit = 7479 lbs.

4.13.2 SMRDE =	±	0.01503	X	7479	=	± 112.41	lbs.
TTCRDE =	±	0.01	X	7479	=	± 74.79	lbs.
TTCRRDE=	±	0.05	X	7479	=	± 373.95	lbs.

4.13.3 Maximum Opening Thrust Reading = Opening Thrust Weak Link Limit
- SQRT[A/DE² + (SMRDE + SMFSE)² + (TTCRDE + TTCFSE)² + (TTCRRDE + TTCRFSE)²] =

6651 lbs.

MOV TARGETS CALCULATION AND EQUIPMENT SET-UP DETERMINATION SHEET
(Sheet 4 of 6)

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Motor No. 1-355

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4.14.1 Closing Torque Weak Link = Actuator
Closing Torque Weak Link Limit = 275 ft.-lbs.

4.14.2 SMRDE =	± 0.01503	X	275	=	± 4.13	ft.-lbs.
TTCRDE =	± 0.02	X	275	=	± 5.50	ft.-lbs.
TTCRRDE=	± 0.05	X	275	=	± 13.75	ft.-lbs.
TSRE =	± 0.2	X	275	=	± 55.00	ft.-lbs.
TSRE =	± 0.1	X	275	=	± 27.50	ft.-lbs.
TSRE =	± 0.05	X	275	=	± 13.75	ft.-lbs.

4.14.3 TTCRE = ±(TTCRFSE + TTCRRDE) = 13.75 + 3.91 = ± 17.66 ft.-lbs.

4.14.4 **Maximum Closing Torque Reading** = Closing Torque Weak Link Limit
+ SQRT[A/DE² + (SMRDE + SMFSE)² + (TTCRDE + TTCFSE)² + ((TTCRRDE + TTCRFSE)² or TSRE²)] =

20% Case: 219.3 ft.-lbs.
10% Case: 246.1 ft.-lbs.
5% Case: 255.3 ft.-lbs.

4.15.1 Opening Torque Weak Link = Actuator
Opening Torque Weak Link Limit = 275 ft.-lbs.

4.15.2 SMRDE =	± 0.01503	X	275	=	± 4.13	ft.-lbs.
TTCRDE =	± 0.02	X	275	=	± 5.50	ft.-lbs.
TTCRRDE=	± 0.05	X	275	=	± 13.75	ft.-lbs.

4.15.3 **Maximum Opening Torque Reading** = Opening Torque Weak Link Limit
- SQRT[A/DE² + (SMRDE + SMFSE)² + (TTCRDE + TTCFSE)² + (TTCRRDE + TTCRFSE)²] =

255.3 ft.-lbs.

MOV TARGETS CALCULATION AND EQUIPMENT SET-UP DETERMINATION SHEET
(Sheet 5 of 6)

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4.16.1 Degraded Voltage Torque Limit = 226.8 ft.-lbs.

4.16.2 SMRDE =	±	0.01503	X	226.8	=	± 3.41	ft.-lbs.
TTCRDE =	±	0.02	X	226.8	=	± 4.54	ft.-lbs.
TTCRRDE=	±	0.05	X	226.8	=	± 11.34	ft.-lbs.
TSRE =	±	0.2	X	226.8	=	± 45.36	ft.-lbs.
TSRE =	±	0.1	X	226.8	=	± 22.68	ft.-lbs.
TSRE =	±	0.05	X	226.8	=	± 11.34	ft.-lbs.

4.16.3 TTCRE = ± (TTCRFSE + TTCRRDE) = 11.34 + 3.91 = ± 15.25 ft.-lbs.

4.16.4 **Maximum Torque Reading at Torque Switch Trip** = Degraded Voltage Torque Limit + SQRT[A/DE² + (SMRDE + SMFSE)² + (TTCRDE + TTCFSE)² + ((TTCRRDE + TTCRFSE)² or TSRE²)] =

20% Case: 180.8 ft.-lbs.
10% Case: 202.9 ft.-lbs.
5% Case: 209.8 ft.-lbs.

MOV TARGETS CALCULATION AND EQUIPMENT SET-UP DETERMINATION SHEET
(Sheet 6 of 6)

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4.17 **CALCULATION AND EQUIPMENT SET-UP RESULTS**

TTC M & TE NO. (Step 4.6) 92350
TTC SERIAL NO. (Step 4.6) RB-023

Stem Diameter (Step 4.1) 1.125 in.
Stem Pitch (Step 4.1) 0.333 in.
Stem Lead (Step 4.1) 0.667 in.

Thrust Gain Setting (Step 4.7.3) 1000
Torque Gain Setting(Step 4.8.3) 4000

Thrust Sensor Coefficient #2(4.7.4) -2833.40 lbs./V
Torque Sensor Coefficient #2(4.8.4) 33.487 ft-lbs./V

CLOSING TARGETS:	20% Case	10% Case	5% Case	
Minimum Thrust at TST (Step 4.11.5)	10675	9805	9783	lbs.
Maximum Torque at TST (Step 4.16.4)	180.8	202.9	209.8	ft.-lbs.
Maximum Thrust Limit (Step 4.12.4)	12267	13782	14117	lbs.
Maximum Torque Limit (Step 4.14.4)	219.3	246.1	255.3	ft.-lbs.

OPENING TARGETS:
Maximum Thrust Limit (Step 4.13.3) 6651 lbs.
Maximum Torque Limit (Step 4.15.3) 255.3 ft.-lbs.

Maximum Packing Load Allowance* (Step 4.2.5) 500 lbs.

Spring Pack Unit Output* (Step 4.4.5) 277 ft.-lbs.

*If these values are approached during testing, contact Maintenance Engineering.

COMMENTS:
This is a post-test calculation.

A 500 lb packing load allowance envelopes that determined from testing.

4.18 Performed by [signature] Date 6/8/94
Checked & Approved by [signature] Date 6-9-94