ATTACHMENT 3

PRESSURE LOCKING ANALYSIS FOR VALVE(S) 871A/B

Calculation No. 96190-C-68

Revision 1

Volume 1 of 1

prepared for:
Rochester Gas And Electric Co.
R. E. Ginna Nuclear Power Plant

JUNE 1997

VENDOR DESIGN ANALYSIS REVIEW

- [x] Approved - No Comments / No Impact on COLR values
- [ ] Approved - No Comments / Impact on COLR Values / NS&L Review Required

Approval of this design analysis does not relieve supplier from full compliance with contract or purchase order requirements.

Approved By: K A Muller Date: 2/13/98

NS&L Review By: N/A KAM Date:

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Report Record

Document No. 96190-C-68

Rev. No.: 1

No. of Sheets 12

Subject: Pressure locking analyses for motor-operated valve(s) 871A/B at Ginna Station.

REVISION DESCRIPTION:

Revision 1 incorporates comments from Kalsi Engineering Inc. and revises valve data based on valve grouping data from Reference 13.

COMPUTER RUNS (identified on Computer File Index): YES ____ N/A X

Error reports evaluated by: ____________ Date: ________

Impacted by error reports No X Yes ____ (if yes, attach explanation)

Originator(s)	Date:	Checker(s):	Date:
F. A. Mulcahy (signature)	6/30/97	(signature)	6/30/97

DESIGN VERIFICATION: Required X Not Required ____

Performed by: (signature) Date: 6/30/97

Method of design verification: ✓ Design Review ____ Alternate Calculations (Attached)

____ Qualification Test (Data/Results) Attd.)

Comments resolved by: N/A Date: ________

Design verifier concurrence: N/A Date: ________

APPROVED FOR RELEASE

PROJECT MANAGER: (signature) D. Williams Date: 6/30/97

ENGINEERING MANAGER: (signature) M. Eissa Date: 6/30/97

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Analysis Summary Sheet

Sheet 2

Calc. No. 96190-C-68 By: F. A. Mulcahy Date: 6/30/97

Rev. No. 1 Chk: J. Lyon Date: 6/30/97

Calculation Subject.

Calculation of required thrust to open valve(s) 871A/B under design bases pressure locking conditions at Ginna Station. Revision 1 incorporates comments from Kalsi Engineering Inc. and revises valve data based on valve grouping data from Reference 13.

Objective of Calculation

The objective of this calculation is to determine the required thrust to open valve(s) 871A/B under design bases pressure locking conditions.

Calculation Methods and Assumptions

The methodology used for this calculation is based on References 1 and 9. The methodology determines the total force required to open a flexable wedge gate valve under pressure locking conditions.

Valve Seat/Disc Coefficient of Friction = 0.477

Valve packing load is included in the static unwedging force taken from test data.

Static unwedging load taken from test data for valve 871B. Not available for valve 871A.

Design Basis And References

See page 9 for a list of references used for this calculation.

Conclusions

The required thrust to open valve(s) 871A/B under design bases pressure locking conditions is 4378 lbs. This is less than the actuator motor capability of 6897 lbs, the actuator thrust limit of 14000 lbs, and the valve unseating limit of 12533 lbs. Therefore, this valve is capable of opening under design bases pressure locking conditions with degraded voltage.

OBJECTIVES:

Determine the required thrust to open the valve(s) when the bonnet is pressurized to design basis line pressure.

METHODS:

The force required to open a flexible wedge gate valve when its bonnet is pressurized consists of several components.

1. Static Unwedging Load (Fpo)
   From the static condition closing thrust there is a residual seat force which together with the seat angle and friction coefficient determines the unwedging force. This residual force remains if the wedge is "locking" (that is the friction coefficient is greater than the tangent of the wedge angle). The static unwedging force is taken from static test data.

2. Seat Contact Force (Fpreslock)
   An additional force requirement comes from the bending load on the wedge halves due to internal pressure. This force consists of a bending component, a shear component and a hub stretching component. These forces are found using the methods found in References 1 and 9.

3. Differential Pressure Load (Fvert)
   Because the wedge halves are not parallel a third force component results from the vertical component of the differential pressure load acting on the seat area. This force is calculated using the methods described in Reference 8.

4. Piston Effect Load (Fpiston)
   The stem end load or "piston effect" results from the internal pressure action on the stem end area. This force helps to open the valve. This force is calculated using the methods described in Reference 8.

5. Packing Load (Fpkg)
   The packing drag load resists stem motion. This load is included in the static unwedging load (Fpo) discussed in 1, above.

6. Torque Reaction Friction Load
   The torque in the stem is reacted in the valve by surfaces which engage and slide. The Torque Reaction Factor (TRF) accounts for this load. See Reference 8 for a detailed analysis of this load.

The total force to open the valve is then:

Ftotal = (Fvert + Fpreslock + Fpo + Fpkg - Fpiston)/TRF

ASSUMPTIONS:

1. Reaction loads and the friction coefficient at the seat surfaces are equal both upstream and downstream and for opening (unwedging) and closing (wedging).

2. The packing load is assumed to be 0 lbs since it is included in the static unwedging load (Fpo) taken from test data.

3. Young's modulus of elasticity (E) and Poisson's Ratio (v) for the steel wedge are 2.76E+07 psi and 0.3, respectively.

4. The static unwedging load is 2202 lbs, taken from test data for valve 871B. Static test data not available for valve 871A.

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Calculation Sheet

Sheet 4

Calc. No.	96190-C-68	By:	F. A. Mulcahy	Date:	6/30/97
Rev. No.	1	Chk:	J. Lyon	Date:	6/30/97

Valve ID 871A/B

Description: SIP 1A to 1C Crossover

INPUT DATA

		Ref.			Ref.
Valve Manufacturer	Velan	3	Disk Angle (DA)	5.0 degrees	3
Valve Size (Nominal)	3 in	3	Valve Type	Gate	3
Hub Length (L)	0.250 in	3	Pullout Force (Fpo)	2202 lbs	12
Hub Radius (b)	0.813 in	3	Packing Load (Fpkg)	0 ft-lbs	12
Disk Radius (a)	1.28 in	5	Valve Factor (VF)	0.46	13
Disk Thickness (t)	0.750 in	3	Poisson Ratio (v)	0.3	7
Stem Diameter (Ds)	1.125 in	3	Mod. Elasticity (E)	27600000 psi	7
Bonnet Pressure (q)	1533.0 psig	2	Downstream Pres (Pd)	33.0 psig	2
Upstream Pres (Pu)	33.0 psig	2	Motor Capability	6897.0 lbs	10,11
Actuator Thrust Limit	14000.0 lbs	10,11	Valve Unseating Limit	12533.0 lbs	3
Stem Factor (FS)	0.0116 ft	10,11	Torque Surface COF-μ t	0.50	8

SUMMARY OF RESULTS

Piston Load	1524 lbs	Pullout Load	2202 lbs
Vertical Load	1349 lbs	Packing Load	0 lbs
Seat Contact Load	2113 lbs	Total Unwedging Load	4378 lbs
		Motor Capability	6897 lbs
		Unseating Limit	12533 lbs
		Actuator Thrust Limit	14000 lbs

1. **Average Differential Pressure Across Disk:**

$$DPA = q - \frac{Pu + Pd}{2} = 1533 - \frac{33 + 33}{2}$$

DPA = 1500.0 psi

2. **Disk Stiffness Constants: (Reference 1, Table 24)**

$$D = \frac{E \times (t)^3}{12 \times (1 - v^2)} = \frac{27600000 \times (0.750)^3}{12 \times (1 - 0.3^2)} = 1{,}066{,}277 \text{ lbf in}$$

$$G = \frac{E}{2 \times (1+v)} = \frac{27600000}{2 \times (1 + .3)} = 10{,}615{,}385 \text{ psi}$$

3. **Geometry Factors: (Reference 1, Table 24)**

$$C2 = \frac{1}{4} \times \left[1 - (b/a)^2 \times (1 + 2 \times \ln(a/b))\right] \qquad C2 = 0.0578$$

$$C3 = \frac{b}{4a} \times \left[\left[(b/a)^2 + 1\right] \times \ln(a/b) + (b/a)^2 - 1\right] \qquad C3 = 0.0065$$

$$C8 = \frac{1}{2} \times \left[1 + v + (1 - v \times (b/a)^2\right] \qquad C8 = 0.7909$$

$$C9 = \frac{b}{a} \times \left[(1 + v)/2 \times \ln(a/b) + (1-v)/4 \times \left[1 - (b/a)^2\right]\right] \qquad C9 = 0.2540$$

$$L3 = \frac{a}{4a} \times \left[\left[(a/a)^2 + 1\right] \times \ln(a/a) + (a/a)^2 - 1\right] \qquad L3 = 0.0000$$

$$L9 = \frac{a}{a} \times \left[(1 + v)/2 \times \ln(a/a) + (1-v)/4 \times \left[1 - (a/a)^2\right]\right] \qquad L9 = 0.0000$$

$$L11 = \frac{1}{64} \times \left[1 + 4 \times (b/a)^2 - 5 \times (b/a)^4 - 4 \times (b/a)^2 \times \left[2 + (b/a)^2\right] \times \ln(a/b)\right] \qquad L11 = 0.0006$$

$$L17 = \frac{1}{4} \times \left[1 - (1 - v)/4 \times \left[1 - (b/a)^4\right] - (b/a)^2 \times \left[1 + (1 + v) \times \ln(a/b)\right]\right] \qquad L17 = 0.0532$$

4. Moment (Reference 1, Table 24, Case 2L)

$$Mrb = \frac{-DPA \times a^2}{C8} \times \left[\frac{C9}{2ab} \times (a^2 - b^2) - L17 \right]$$ Mrb = -206.9 lbf

$$Qb = \frac{DPA}{2b} \times (a^2 - b^2)$$ Qb = 905.2 lbf/in

5. Deflection Due To Pressure And Bending (Reference 1, Table 24, Case 2L)

$$Ybq = (Mrb \times a^2 \times C2)/D + (Qb \times a^3 \times C3)/D - (DPA \times a^4 \times L11)/D$$ Ybq = -9.254E-06 in

6. Deflection Due To Pressure And Shear Stress (Reference 1, Table 25, Case 2L)

$$Ksa = -0.3 \times \left[2 \times \ln(a/b) - 1 + (b/a)^2 \right]$$ Ksa = -0.0938

$$Ysq = (Ksa \times DPA \times a^2)/(t \times G)$$ Ysq = -2.9015E-05 in

7. Deflection Due To Hub Stretch (from center of hub to disk)

$$Pforce = pi \times (a^2 - b^2) \times DPA$$ Pforce = 4624.1 lbf

$$Ystretch = \frac{Pforce \times L}{pi \times b^2 \times 2 \times E}$$ Ystretch = 1.0086E-05 in

8. Total Deflection Due To Pressure Forces:

$$Yq = Ybq + Ysq - Ystretch$$ Yq = -4.8355E-05 in

9. Deflection Due To Seat Contact Force And Shear Stress (per lbf/in): (Reference 1, Table 25, Case 1L)

$$Ysw = \frac{-1.2 \times (a/a) \times \ln(a/b) \times a}{t \times G}$$

Ysw = -8.7896E-08 in/lbf/in

10. Deflection Due To Seat Contact Force And Bending (per lbf/in): (Reference 1, Table 24, Case 1L)

$$Ybw = -(a^3 / D) \times \left[(C2/C8) \times \left[(a \times C9)/b - L9 \right] - \left[(a/b) \times C3 \right] + L3 \right]$$

Ybw = -3.7679E-08 in/lbf/in

11. Deflection Due To Hub Compression (per lbf/in), (from center of hub to disk):

$$Ycompr = \frac{2 \times a \times pi \times L}{pi \times b^2 \times 2 \times E}$$

Ycompr = 1.7562E-08 in/lbf/in

12. Total Deflection Due To Seat Contact Force (per lbf/in):

Yw = Ybw + Ysw - Ycompr

Yw = -1.4314E-07 in/lbf/in

13. Seat Contact Force For Which Deflection Is Equal To Previously Calculated Deflection From Pressure Forces (per lbf/in):

Fs = 2 x pi x a x (Yq/Yw)

Fs = 2720 lbf

14. Torque Reaction Factor (TRF)

$$TRF = 1 - \frac{\mu_t \times FS}{r_t} = 1 - \frac{0.50 \times .0116}{0.107} = 0.9457$$

where: μ_t = Coefficient of friction for torque reaction surface

FS = Stem factor, ft

r_t = Disc radius, ft

15. Disc/Seat Coefficient of Friction

$$\mu_s = \frac{VF \times \cos(DA)}{1 - VF \times \sin(DA)} = \frac{0.46 \times \cos(5.0)}{1 - 0.46 \times \sin(5.0)} = 0.4774$$

where: VF = Valve factor (opening)

DA = Disc angle in degrees

μ_s = Disc/seat coefficient of friction

16. Unseating Forces

		Fpo =	2202 lbf
		Fpkg =	0 lbf
Fpiston =	$(pi/4) \times Ds^2 \times q$	Fpiston =	1524 lbf
Fvert =	$\sin(DA)*[(pi \times a^2) \times (2 \times q - Pu - Pd)]$	Fvert =	1349 lbf
Fpreslock =	$2 \times Fs \times (\mu_s \times \cos(DA) - \sin(DA))$	Fpreslock =	2113 lbf
Ftotal =	$\frac{(-Fpiston + Fvert + Fpreslock + Fpo + Fpkg)}{TRF}$	Ftotal =	4378 lbf

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Calculation Sheet

Sheet 9

Calc. No. 96190-C-68 By: F. A. Mulcahy Date: 6/30/97

Rev. No. 1 Chk: J. Lyon Date: 6/30/97

REFERENCES

List of Calculation References Used For 871A/B

Ref. No.	Title	Rev. No.	Rev. Date
1	Young, Warren C., Roark's Formulas for Stress & Strain, 6th Edition, McGraw Hill, 1989.		
2	Altran Technical Report No. 94108-TR-01, Investigation Of Pressure Locking/Thermal Binding	0	11/1/94
3	Altran Calculation No. 90170-C-03, Valve Thrust Calculation for 3" Velan Gate Valve MOV 871A & B	3	
4	Velan Valve Drawing 88405-1	C	9/26/68
5	Velan letter, Seat Diameters For Various Valves: Altran PO No. APO-96190-4		10/3/96
6	EPRI MOV Performance Prediction Program Topical Report, TR-103237, Final Draft, 9/21/94		
7	Marks' Standard Handbook for Mechanical Engineers, Ninth Edition		
8	NP-6660-D, Application Guide for Motor-Operated Valves in Nuclear Power Plants, EPRI, March 1990		3/1/90
9	Commonwealth Edison Pressure Locking Methodology presented at Summer 1995 MOV Users Group Meeting		
10	Altran Calculation No. 91190-C-44, Analysis of Thrust And Torque Limits For Motor-Operated Valve 871A	0	
11	Altran Calculation No. 91190-C-45, Analysis of Thrust And Torque Limits For Motor-Operated Valve 871B	0	
12	WR/TR Number 9221428 and 19404023		
13	RG&E EWR 5111, Motor Operated Valve Program Plan	3	

ATTACHMENT A

PROJECT QA RECORD
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Project File Index

VELAN

550 McArthur, Ville St-Laurent
Quebec, Canada H4T 1X8

DATE : Oct. 03, 1996
FROM : Bertil Nilsson
PHONE: (514) 748-7748 ext 241
FAX : (514) 342-2311
REF : BN-610-021

PAGE: 1 OF 1
FAX : 617-330-1055
TO : Altran Corp.
ATT. : Steve Greer
C.C. :

SUBJECT: Your P.O. #APO-96190-4 Velan Ref.: P9-81243-K

Per your request we are pleased to provide following information regarding Seats:

1) Drawing 88405-4 Tag No. 0871A & B

O.D. of Stellite: 2 3/4"
I.D. of Stellite: 2 3/8"
Waterway bore: 2 1/4"

2) Drawing 88701-3 Tag No. 0852A & B

O.D. of Stellite: 5 3/4"
I.D. of Stellite: 5 3/16"
Waterway bore: 5 1/16"

We trust this information meets with your acceptance.

B. Nilsson

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CERTIFIED TO ISO 9001
QUALITY STANDARDS

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