Engineering & Management Specialists Inc.

SUMP PUMP VALVE POTENTIAL PRESSURE

LOCKING EFFECTS ANALYSIS

D.C. COOK NUCLEAR STATION UNITS 1& 2

AMERICAN ELECTRIC POWER SERVICE CORP.

PREPARED BY

EMS, INC.

CALC. NO.: AE-DC-010

REV. 00, DATE: 07/12/1996

1401 BRANDING LANE, SUITE 240 • DOWNERS GROVE, ILLINOIS 60515 • PHONE: (708) 971-9791 • FAX: (708) 971-9795

EMS Engineering & Management Specialists Inc.

CERTIFICATE OF CONFORMANCE

July 12, 1996

Client:	AEP Service Corp.
Utility:	Indiana Michigan Power Co.
Plant Name:	D.C. Cook
Client Order:	A-2261
Tag Numbers:	1/2ICM-305, 1/2ICM-306

This is to certify that, all the work in the following report # AE-DC-010, Revision 0 was performed in accordance with the approved EMS Inc. Quality Assurance Program, EMS Inc. Quality Assurance Manual, Revision 01, dated 12/16/93.

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EMS Engineering & Management Specialists Inc.

Analysis for Sump Pump Valve Potential Pressure Locking Effects

AMERICAN ELECTRIC POWER SERVICE CORP.

Station: D.C. COOK NUCLEAR STATION UNIT 1 AND 2

Valve Tag Nos.: 1/2ICM-305, 1/2ICM-306

Calculation No. / Rev. No.: AE-DC-010 Rev. 00

Issue Date: 07/12/1996

Pressure rise due to heating:	Δp = 202.60. 26 psi
Operator Output Thrust Capability based on the Rated Output Torque and stem COF $\mu = 0.20$:	$OTC_R = 67003.48$ lb
Available margin based on the Rated Output Torque, stem COF $\mu = 0.20$ and wedge coefficient of friction $\mu_w = 0.47$:	$M_1 = 7643.54$ lb
Operator Output Thrust Capability based on the Degraded Voltage (17%) Output Torque, stem COF $\mu_2 = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$:	$OTC_D = 61518.87$ lb
Available margin based on the Degraded Voltage (17%) Output Torque, stem COF $\mu = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$:	$M_2 = 2158.93$ lb

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Pressure rise due to heating:	Δp = 101. 20 psi
Operator Output Thrust Capability based on the Degraded Voltage (17%) Output Torque, stem COF μ_1 = 0.20 and wedge coefficient of friction μ_w = 0.47:	OTC_D = 51233.72 lb
Available margin based on the Degraded Voltage (17%) Output Torque, stem COF μ = 0.20 and wedge coefficient of friction μ_w = 0.47:	M_3 = 14487.61 lb

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Engineering & Management Specialists Inc.

CALCULATION ISSUE SUMMARY

☒ Safety-Related

☐ Non-Safety-Related

Client: AEP Project No.: AE-002

Project Name/Station/Unit: D.C. COOK NUCLEAR STATION / UNITS 1 & 2

Calculation Title: SUMP PUMP POTENTIAL PRESSURE LOCKING EFFECTS Calc. No.: AE-DC-01(

PURPOSE: TO DETERMINE THE ACTUAL PRESSURE IN THE BONNET, THE UNWEDGING FORCE, ITS COMPARISON TO THE ACTUATOR'S CAPABILITY AND AVAILABLE MARGIN DUE TO SPECIFIED TEMPERATURE CHANGE

REV.	DESCRIPTION	RESPONSIBILITY	DATE
00	ORIGINAL ISSUE	PREPARER: [signature] J. K. BIENIA	7/12/96
		REVIEWER: [signature] Y. A. PATEL	7/12/96
		APPROVER: [signature] E. GEORGOPOULOS	7/12/96
		PREPARER:	
		REVIEWER:	
		APPROVER:	
		PREPARER:	
		REVIEWER:	
		APPROVER:	
		PREPARER:	
		REVIEWER:	
		APPROVER:	

EMS Engineering & Management Specialists Inc.

Calcs for Sump Pump Valve Potential Pressure Locking Effects		Calc No. AE-DC-010	
		Rev. 00	Date 07/12/96
☒ Safety-Related	☐ Non Safety-Related	Page 1 of 21	
Client AEP	Prepared by: Jamm L Brini	Date 7/12/96	
Project D.C. COOK NUCLEAR STATION	Reviewed by: X A. Patel	Date 7/12/96	
Proj. No. AE-002	Approved by: EGeorgopoulos	Date 7/12/96	

1.0 PURPOSE

The purpose of this analysis is to determine the actual pressure in the bonnet, the unwedging force, its comparison to the actuator's capability and available margin due to specified temperature change.

EQUIPMENT DESCRIPTION

Valve Mfg. : ANCHOR/DARLING VALVE COMPANY

Type / Size : DOUBLE DISC GATE VALVES / 18 inch

Model No. : CLASS S70 Stainless Steel Double Disc with SMB-2-60 Limitorque Actuator

A/DV I.D.	Tag Nos. (Ref. 2)
E5071-73	1/2ICM-305, 1/2ICM-306

2.0 DESIGN INPUT

Temperature change $\Delta T = 4.4° F$	Ref. 4
Packing Load: $T_p = 1575$ lb	Ref. 4
Wedging force from closing stroke: $F_{sc} = 44470$ lb	Ref. 4
Pullout efficiency = 0.4	Ref. 4
Overall Gear Ratio = 80 : 1	Ref. 4
Rated voltage = 575 V	Ref. 4
Motor start torque = 60 ft-lb	Ref. 4
Disc mean seat dia. = 17.38 inch	Ref. 4

Calcs for Sump Pump Valve Potential Pressure Locking Effects			Calc No. AE-DC-010	
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Client AEP	Prepared by: JKB		Date	
Project D.C. COOK NUCLEAR STATION	Reviewed by:		Date	
Proj. No. AE-002	Approved by:		Date	

3.0 SUMMARY AND CONCLUSIONS

3.1 Valve bonnet pressurization rate:

The U.S. NRC Generic Letter (GL) 95-07 requires all nuclear plant licensees to perform evaluation or confirm previously performed evaluations of safety related power operated gate valves for susceptibility to thermally induced pressure locking. It further requires the licensees to take proper actions to ensure that the valves will perform their intended safety functions during the accident condition. One important factor to assure that the valve will operate under thermally induced pressure locking condition is to verify that adequate opening pull capability is available in the valve actuator for overcoming the additional loads due to thermal pressure locking condition.

Since the publication of GL 95-07, the thermally induced pressure locking of gate valves has been extensively evaluated, primarily by testing. Ref. 8 presents an analytical method to predict the increase in bonnet pressure due to increase in temperature of water inside the bonnet. This reference also performs a review of the actual valve experience described in the literature to determine the expected pressurization rates in the existing hardware designs.

It applies a statistical approach to reconcile the differing pressurization rates reported in the literature. An averaging technique is then introduced to capture the wide scatter associated with the measured test data.

Based on this study, it is concluded in Ref. 8 that a pressurization rate of 23 psi/°F is a reasonable number to use for estimating valve bonnet pressurization levels.

The analysis presented here is conservative because it is based on a solid water filled bonnet with no air entrapment. In most valves, especially the low cycle valves such as the one analyzed here, it is impossible to flush out all the air and not to have any air pocket from cycle to cycle. The existence of an air pocket reduces the thermal pressurization rate to a much lower level than what is considered in this analysis (46.046 psi/°F).

3.2 Summary of Results

Pressure rise due to heating:	Δp = 202.60. 26 psi
Operator Output Thrust Capability based on the Rated Output Torque and stem COF $\mu = 0.20$:	$OTC_R = 67003.48$ lb
Available margin based on the Rated Output Torque, stem COF $\mu = 0.20$ and wedge coefficient of friction $\mu_w = 0.47$:	$M_1 = 7643.54$ lb
Operator Output Thrust Capability based on the Degraded Voltage (17%) Output Torque, stem COF $\mu_2 = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$:	$OTC_D = 61518.87$ lb
Available margin based on the Degraded Voltage (17%) Output Torque, stem COF $\mu = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$:	$M_2 = 2158.93$ lb

Pressure rise due to heating:	Δp = 101. 20 psi
Operator Output Thrust Capability based on the Degraded Voltage (17%) Output Torque, stem COF μ_1 = 0.20 and wedge coefficient of friction μ_w = 0.47:	OTC_D = 51233.72 lb
Available margin based on the Degraded Voltage (17%) Output Torque, stem COF μ = 0.20 and wedge coefficient of friction μ_w = 0.47:	M_3 = 14487.61 lb

4.0 CRITERIA AND ASSUMPTIONS

The valve is acceptable if the pullout capability of the actuator is greater than the sum of drag force, packing load and unwedging force.

There are no assumptions made in this calculation.

5.0 CALCULATIONS AND RESULTS

5.1 Analysis of pressure rise in bonnet due to heating

The bonnet is treated as a cylinder capped by a hemisphere and filled with water. The component volumes are expressed in terms of of the inner radius and cylinder height by the following equations:

$H := 13.625 \cdot in$ Ref. 1 ✓

$R := 10.6875 \cdot in$ Ref. 1 ✓

$$V_c := \pi \cdot R^2 \cdot H \qquad (1)$$

$$V_c = 4889.20941 \cdot in^3$$

$$V_h := \frac{2}{3} \cdot \pi \cdot R^3 \qquad (2)$$

$$V_h = 2556.74254 \cdot in^3$$

The volume of water is given by:

$$V_w := V_c + V_h \qquad (3)$$

$$V_w = 7445.95195 \cdot in^3$$

The volume change for the water due to thermal expansion and compressibility is expressed as:

$$\Delta V_w = V_w (\alpha_w \Delta T - \beta \Delta p) \qquad (4)$$

where:

α_w = volumetric coefficient of expansion

β = compressibility

ΔT = temperature change

Δp = pressure change

The volume change for cylindrical section is given by:

$$\Delta V_c = 3\alpha_b V_c \Delta T + K_c \Delta p \qquad (5)$$

where:

α_b = linear coefficient of expansion of the bonnet

K_c = cylinder stiffness parameter

The factor of 3 in equation 5 converts the linear coefficient to a volumetric coefficient to a first order in ΔV_c

In order to evaluate K_c, we first consider the stresses in a cylinder due to internal pressurization. The stresses in the tangential and axial directions due to pressurization are given by:

$$\sigma_\Theta = R\,\Delta p / t \qquad (6)$$

$$\sigma_z = R\,\Delta p / 2t \qquad (7)$$

where:

t = the wall thickness

and the resulting strains are given by:

$\varepsilon_\Theta = 1/E\,(\sigma_\Theta - \nu\,\sigma_z)$ (8)

$\varepsilon_z = 1/E\,(\sigma_z - \nu\,\sigma_\Theta)$ (9)

The cylinder volume change due to these strains is given as follows:

$\Delta V_c\ / V_c = 2\Delta R / R\ +\ \Delta H / H = 2\varepsilon_\Theta + \varepsilon_z$ (10)

where:

ε_Θ and ε_z are the strains in the tangential and axial directions.

The stiffness parameter can be evaluated using the following data:

$t := 1.125\cdot in$ Ref. 1 ✓

$E := 30\cdot 10^6\cdot psi$ Ref. 12 ✓

$\nu := 0.3$

and the following formula which can be deduced from equations 6 through 10 and the definition of K_c in equation 5.

$K_c := \left(\frac{5}{2} - 2\cdot\nu\right)\cdot\frac{R\cdot(V_c)}{E\cdot t}$ $K_c = 0.00294\cdot lb^{-1}\cdot in^5$ (11)

For the hemisphere section the volume change is given by:

$\Delta V_h = 3\,\alpha_b\,V_h\,\Delta t + K_h\,\Delta p$ (12)

The volume change due to pressure only is given by:

$\Delta V_h / V_h = 3\,\Delta R / R = 3\varepsilon = 3(1-\nu)\,\sigma / E$ (13)

where the stress is given by:

$$\sigma = R\,\Delta p / 2t \qquad (14)$$

Combining equations 13 and 14 and using the definition of K_c in equation 12 we obtain the following:

$$K_h := \frac{3}{2}\cdot(1-\nu)\cdot\frac{V_h\cdot R}{E\cdot t} \qquad (15)$$

$$K_h = 0.00085\cdot lb^{-1}\cdot in^5$$

For calculations we need the following additional data:

$\alpha_b := 9.19\cdot 10^{-6}\cdot deg^{-1}$ Ref. 12

$p_o := 14.7\cdot psi$

$\Delta T := 4.4\cdot deg$ Ref. 4

For Water at 94.4° F:

$\alpha_w := 0.000191\cdot deg^{-1}$ $\beta_w := 3.04\cdot 10^{-6}\cdot psi^{-1}$ Ref. 11, pages: 2130 & 2148

The following equation is obtained by setting the volume change for water equal to the sum of the changes for the cylinder and hemisphere (equations 5 and 12 and solving for the pressure:

$$\Delta p := \frac{(\alpha_w - 3\cdot\alpha_b)\cdot V_w}{(V_w\cdot\beta_w + K_c + K_h)}\cdot\Delta T \qquad (16)$$

$\Delta p = 202.60439\cdot psi$ $\Delta p / ° F = 46.046$ psi/° F $\Delta p + p_o = 217.30439\cdot psi$

5.2 Evaluate Operator Output Thrust Capability based on the Rated Output Torque and stem COF $\mu = 0.20$, Ref. 10, page 6-3, page 6-4

Motor Torque, Parameters are based on Ref. 4:

Motor Torque based on rated voltage of 575 V

$MT_R := 60 \cdot ft \cdot lb$

Operator Output Torque based on Rated Voltage:

Overall gear ratio

$OAR := \frac{80}{1}$

Pullout efficiency of the gear train

$PE := 0.4$

Application factor

$AF := 0.9$

$OOT_R := OAR \cdot PE \cdot AF \cdot MT_R$

$OOT_R = 1728 \cdot lb \cdot ft$

Stem Factor based on $\mu = 0.20$

$Lead := \frac{2}{3}$ $Dia := 2.0$

Refs. 4 & 7

$Pitch := \frac{1}{3}$ $\mu_1 := 0.20$

Stem Factor based on $\mu = 0.20$ for stub ACME thread:

$\mu_1 := 0.20$

$$F_{s1} := \frac{\frac{Lead}{77.88} + \mu_1 \cdot \left(\frac{2 \cdot Dia - 0.6 \cdot Pitch}{48}\right)}{0.9682 - \frac{2 \cdot \mu_1 \cdot Lead}{\pi \cdot (2 \cdot Dia - 0.6 \cdot Pitch)}} \cdot ft \qquad \text{Ref. 9}$$

$F_{s1} = 0.0257897 \cdot ft$

Operator Output Thrust Capability based on Rated Output Torque and and COF $\mu = 0.20$:

$$OTC_R := \frac{OOT_R}{F_{s1}}$$

$OTC_R = 67003.48762 \cdot lb$

Disc Drag Force:

F_{dt} = Total drag force

$\mu_w := 0.47$ Wedge face coefficient of friction, per NUREG/CR-5807, Ref. 13, page 9

$d_s := 17.38 \cdot in$ Disc sealing diameter, mean seat diameter, Ref. 4

$P_b := 202.60439 \cdot psi$ Valve body cavity pressure (Δp)

$$F_{dt} := \frac{\mu_w \cdot \pi \cdot d_s^{2} \cdot P_b}{2} \qquad \text{Ref. 13}$$

$$F_{dt} = 45182.07067 \cdot lb$$

Unwedging load F_s in "parallel expanding" gate valve is calculated based on Equation in NUREG/CR-5807, Ref. 13

$\theta := 25 \cdot deg$ Lower wedge angle, Ref. 1

$\mu_w := 0.47$ Ref. 13

$F_{sc} := 44470 \cdot lb$ Wedging force from closing stroke, Ref. 4

Calculate F_n from equation 2.6a, Ref. 13

$$F_n := \frac{\cos(\theta) - \mu_w \cdot \sin(\theta)}{\sin(\theta) \cdot \left(1 - \mu_w^{2}\right) + 2 \cdot \mu_w \cdot \cos(\theta)} \cdot F_{sc}$$

$$F_n = 26642.93898 \cdot lb$$

Calculate F_s from equation 2.7a, Ref. 13

$$F_s := \frac{\sin(\theta) \cdot \left(\mu_w^{2} - 1\right) + 2 \cdot \mu_w \cdot \cos(\theta)}{\cos(\theta) + \mu_w \cdot \sin(\theta)} \cdot F_n$$

$$F_s = 12602.87169 \cdot lb$$

$OTC_R = 67003.48762 \cdot lb$ Operator capability

$T_p := 1575 \cdot lb$ Packing load, Ref. 4

M_1 = Margin based on Rated Actuator Torque and $\mu_1 = 0.2$

$M_1 := OTC_R - F_{dt} - T_p - F_s$

$M_1 = 7643.54526 \cdot lb$

Margin available is 7.643 kips, however the stem coefficient of friction $\mu_1 = 0.2$ and wedge coefficient of friction $\mu_w = 0.47$ are very conservative.
Based on testing, industry commonly uses a stem coefficient of friction less than $\mu = 0.15$.
Since actual testing value for the stem coefficient of friction is not available, a more realistic value for stem coefficient of friction $\mu_2 = 0.15$ is used.
If this coefficient of friction is used with 17% degraded voltage on the motor torque, the results are as follows:

5.3 Evaluate Operator Output Thrust Capability based on the degraded voltage, stem coefficient of friction $\mu_2 = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$.

Motor Torque based on degraded voltage of 17%

Min. available voltage based on 17% degradation: $V_{17} := 477 \ V$

Rated voltage, Ref. 4 $V_R := 575 \ V$

$$MT_D := MT_R \cdot \left(\frac{V_{17}}{V_R}\right)^2$$ Ref. 10, page 6-3

$MT_D = 41.29071 \cdot lb \cdot ft$

Operator Output Torque based on 17% degraded voltage:

$$AF := 1.0$$

$$OOT_D := OAR \cdot PE \cdot AF \cdot MT_D$$

$$OOT_D = 1321.30262 \cdot lb \cdot ft$$

Stem Factor based on $\mu = 0.15$ for stub ACME thread:

$$\mu_2 := 0.15$$

$$F_{s2} := \frac{\frac{Lead}{77.88} + \mu_2 \cdot \left(\frac{2 \cdot Dia - 0.6 \cdot Pitch}{48}\right)}{0.9682 - \frac{2 \cdot \mu_2 \cdot Lead}{\pi \cdot (2 \cdot Dia - 0.6 \cdot Pitch)}} \cdot ft \qquad \text{Ref. 9}$$

$$F_{s2} = 0.021478 \cdot ft$$

Operator Output Thrust Capability based on Degraded Voltage Output Torque and and stem COF $\mu = 0.15$:

$$OTC_D := \frac{OOT_D}{F_{s2}}$$

$$OTC_D = 61518.87758 \cdot lb$$

Disc Drag Force:

F_{dt} = Total drag force

$\mu_w := 0.47$ Wedge face coefficient of friction

$d_s := 17.38 \cdot in$ Disc sealing diameter, mean seat diameter

$P_b := 202.60439 \cdot psi$ Valve body cavity pressure

$$F_{dt} := \frac{\mu_w \cdot \pi \cdot d_s^2 \cdot P_b}{2}$$

$$F_{dt} = 45182.07067 \cdot lb$$

Unwedging load F_s in "parallel expanding" gate valve is calculated based on Equation in NUREG/CR-5807, Ref. 13

$\theta := 25 \cdot deg$ Lower wedge angle

$\mu_w := 0.47$

$F_{sc} := 44470 \cdot lb$ Wedging force from closing stroke

Calculate F_n from equation 2.6a

$$F_n := \frac{\cos(\theta) - \mu_w \cdot \sin(\theta)}{\sin(\theta) \cdot \left(1 - \mu_w^2\right) + 2 \cdot \mu_w \cdot \cos(\theta)} \cdot F_{sc}$$

$$F_n = 26642.93898 \cdot lb$$

Calculate F_s from equation 2.7a

$$F_s := \frac{\sin(\theta)\cdot\left(\mu_w^2 - 1\right) + 2\cdot\mu_w\cdot\cos(\theta)}{\cos(\theta) + \mu_w\cdot\sin(\theta)}\cdot F_n$$

$$F_s = 12602.87169\cdot lb$$

$OTC_D = 61518.87758\cdot lb$ Operator capability

$T_p := 1575\cdot lb$ Packing load

M_2 = Margin based on Degraded voltage (17%) actuator torque and $\mu_2 = 0.15$

$$M_2 := OTC_D - F_{dt} - T_p - F_s$$

$$M_2 = 2158.93522\cdot lb$$

5.4 Evaluate Operator Output Thrust Capability based on the degraded voltage (17%), stem coefficient of friction $\mu_1 = 0.20$, wedge coefficient of friction $\mu_w = 0.47$ and the pressurization rate of 23 psi/° F discussed on page 2, see Ref 15.

Motor Torque based on degraded voltage of 17%

Min. available voltage based on 17% degradation: $V_{17} := 477\cdot V$

Rated voltage, Ref. 4 $V_R := 575\ V$

$$MT_D := MT_R\cdot\left(\frac{V_{17}}{V_R}\right)^2$$ Ref. 10, page 6-3

$$MT_D = 41.29071\cdot lb\cdot ft$$

Operator Output Torque based on 17% degraded voltage:

$$AF = 1$$

$$OOT_D := OAR \cdot PE \cdot AF \cdot MT_D$$

$$OOT_D = 1321.30262 \cdot lb \cdot ft$$

Stem Factor based on $\mu = 0.20$ for stub ACME thread:

$$\mu_1 := 0.20$$

$$F_{s1} := \frac{\dfrac{Lead}{77.88} + \mu_1 \cdot \left(\dfrac{2 \cdot Dia - 0.6 \cdot Pitch}{48}\right)}{0.9682 - \dfrac{2 \cdot \mu_1 \cdot Lead}{\pi \cdot (2 \cdot Dia - 0.6 \cdot Pitch)}} \cdot ft \qquad \text{Ref. 9}$$

$$F_{s1} = 0.0257897 \cdot ft$$

Operator Output Thrust Capability based on Degraded Voltage (17%) Output Torque and and stem COF $\mu = 0.20$:

$$OTC_D := \frac{OOT_D}{F_{s1}}$$

$$OTC_D = 51233.72916 \cdot lb$$

Disc Drag Force:

F_{dt} = Total drag force

$\mu_W := 0.47$ Wedge face coefficient of friction

$d_s := 17.38 \cdot in$ Disc sealing diameter, mean seat diameter

$P_b := 101.2 \cdot psi$ Valve body cavity pressure 23 psi/° F X 4.4°

$$F_{dt} := \frac{\mu_w \cdot \pi \cdot d_s^2 \cdot P_b}{2}$$

$F_{dt} = 22568.2452 \cdot lb$

Unwedging load F_s in "parallel expanding" gate valve is calculated based on Equation in NUREG/CR-5807, Ref. 13

$\theta := 25 \cdot deg$ Lower wedge angle

$\mu_w := 0.47$

$F_{sc} := 44470 \cdot lb$ Wedging force from closing stroke

Calculate F_n from equation 2.6a

$$F_n := \frac{\cos(\theta) - \mu_w \cdot \sin(\theta)}{\sin(\theta) \cdot \left(1 - \mu_w^2\right) + 2 \cdot \mu_w \cdot \cos(\theta)} \cdot F_{sc}$$

$F_n = 26642.93898 \cdot lb$

Calculate F_s from equation 2.7a

$$F_s := \frac{\sin(\theta)\cdot\left(\mu_w^2 - 1\right) + 2\cdot\mu_w\cdot\cos(\theta)}{\cos(\theta) + \mu_w\cdot\sin(\theta)}\cdot F_n$$

$F_s = 12602.87169\cdot lb$

$OTC_D = 51233.72916\cdot lb$ Operator capability

$T_p := 1575\cdot lb$ Packing load

M_3 = Margin based on Degraded voltage (17%) actuator torque and $\mu_1 = 0.20$

$M_3 := OTC_D - F_{dt} - T_p - F_s$

$M_3 = 14487.61228\cdot lb$

RESULTS:

Pressure rise due to heating:	Δp = 202.60. 26 psi
Operator Output Thrust Capability based on the Rated Output Torque and stem COF $\mu = 0.20$:	OTC_R = 67003.48 lb
Available margin based on the Rated Output Torque, stem COF $\mu = 0.20$ and wedge coefficient of friction $\mu_w = 0.47$:	M_1 = 7643.54 lb
Operator Output Thrust Capability based on the Degraded Voltage (17%) Output Torque, stem COF $\mu_2 = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$:	OTC_D = 61518.87 lb

Available margin based on the Degraded Voltage (17%) Output Torque, stem COF $\mu = 0.15$ and wedge coefficient of friction $\mu_w = 0.47$: $M_2 = 2158.93$ lb

Pressure rise due to heating: $\Delta p = 101.20$ psi

Operator Output Thrust Capability based on the Degraded Voltage (17%) Output Torque, stem COF $\mu_1 = 0.20$ and wedge coefficient of friction $\mu_w = 0.47$: $OTC_D = 51233.72$ lb

Available margin based on the Degraded Voltage (17%) Output Torque, stem COF $\mu = 0.20$ and wedge coefficient of friction $\mu_w = 0.47$: $M_3 = 14487.61$ lb

6.0 REFERENCES:

1. Telecopy from Ron Farrell (Anchor Darling) to J.K. Bienia (EMS) dated 07/08/96. EMS Document No. CD-AEP-96-357.

2. Anchor Darling Report No. R93.186 Rev. - for 18" - Class S70 Stainless Steel Double Disc Gate Valve with SMB-2-60 Limitorque Actuator. EMS Document No. CD-AEP-96-358.

3. Not used

4. Design Input for the Sump Pump Valve from Greg Nogrady (AEPSC) to Lia Georgopoulos (EMS Inc.) dated 07/12/96. EMS Document No. CD-AEP-96-371.

EMS Engineering & Management Specialists Inc.

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5. Not used.

6. Not used.

7. Anchor Darling Drawing No. 93-13173, Rev. B. EMS Document No. CD-AEP-96-361.

8. "Thermally induced pressure locking of gate valves: A survey of valve bonnet pressurization rates" - Ezekoye and Moore - ASME - PVP Paper - July 1996.

9. White Paper 139, Basis for using static, as-left stem friction coefficient in design basis calculations, Draft revision 0, June 16, 1994. EMS Document CE-94-158.

10. Application Guide for Motor-Operated Valves in Nuclear Power Plants, EPRI, NP-6660-D, Research Project 2814-6, Final Report, March 1990.

11. Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., 41st Edition.

12. ASME Boiler & Pressure Vessel Code, Section III, Div. 1, Appendices, Table I-5.0, 1977.

13. NUREG/CR-5807 KEI No. 1721 Improvements in Motor Operated Gate Valve Design and Prediction Models for Nuclear Power Plant Systems.

14. Not used.

15. Fax from Greg Nogrady (AEPSC) to Lia Georgopoulos (EMS) dated 7/12/96 regarding sump pump calculation. EMS Document No. CD-AEP-96-362

7.0 ATTACHMENTS

A. Fax from Greg Nogrady (AEPSC) to Lia Georgopoulos (EMS) dated 7/12/96 regarding design input data.
EMS Document No. AEP-96-371

B. Telecopy from Ron Farrell (Anchor Darling) to J.K. Bienia (EMS) dated 07/08/96. EMS Document No. CD-AEP-96-357.

C. Anchor Darling Drawing No. 93-13173, Rev. B. EMS Document No. CD-AEP-96-361.

Computer software, MathCAD 5.0 was used and has been validated by EMS Inc Validation No. CE-ZI-001 Rev. 01.

Global definitions:

$\theta \equiv 1$ $Y \equiv 1$ $L_x \equiv 1$ $M \equiv 1$ $G \equiv 1$

$g \equiv 1$ $b \equiv 0$ $bolt \equiv 1$ $psi \equiv \frac{lb}{in^2}$ $ksi \equiv 10^3 \cdot psi$ $OK \equiv 1$ $lbs \equiv lb$

$o \equiv 1$ $lb \equiv 1 \cdot lb$ $ft \equiv 12 \cdot in$ $F \equiv 1$ $cycle \equiv 1$

RECEIVED 7/12/96

AEP-96-371-
WNB

FROM: Greg Nogrady (AEPSC)

TO: Lia Georgopoulos (EMS Inc.)

You are authorized to use the following parameters (listed below) as design input for Sump Pump Valve Potential Pressure Locking Analysis. The analysis is performed on 18" Anchor Darling Double Disc Gate Valves, Tag Nos.: 1/2ICM-305 and 1/2ICM-306.

Temperature change $\Delta T = 4.4°$ F

Packing Load: $Tp = 1575$ lb

Wedging force from closing stroke: $F_{sa} = 44470$ lb

Pullout efficiency = 0.4

Overall Gear Ratio = 80 : 1

Rated voltage = 575 V

Degraded voltage = 477 V

Motor start torque = 60 ft-lb

Disc mean seat dia. = 17.38 inch

Stem Lead = 2/3

Stem Pitch = 1/3

Signed By: [signature]

Date: 07/12/96

CONTROLLED DOCUMENT

Doc. Control No. CD/AEP-96-371

Control Copy No. 01

Released To J K Bieniek

Date Released 7/12/96

Issued By [signature]

WNB

ATTACHMENT "A"

Calc. No. AE-DC-010 Rev. 00

Project No. AE-002 Station D.C. COOK

Date 7/12/96 page 41 of 41

EMS Engineering & Management Specialists Inc.

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AEP-96-357
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for 18" - Class S70 Stainless Steel Double Disc Gate Valve with SMB-2-60 Limitorque Actuator. A/D Assy. Dwg. No. 93-13173.

t_1 = $1\frac{1}{8} \pm \frac{1}{8}$ (in) Material: A351-CF8M

t_2 = $1\frac{1}{8} \pm \frac{1}{8}$ (in) Material: A351-CF8M

R = $10\frac{11}{16}$ (in)

H = $13\frac{5}{8}$ (in)

X = $10\frac{11}{16}$ (in)

Θ = 25° (Lower wedge angle)

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~~Doc. Control No. CD-AEP-96-357~~
~~Control Copy No. 01~~
~~Released To J K Biernia~~
~~Date Released 7/11/96~~
~~Issued By W Burkamper~~
WVB - 7/11/96

Post-it® Fax Note 7671	Date 7/8/96	# of pages ▸ 1
To J. BIENIA	From RON FARRELL	
Co./Dept. EMS	Co. A/DV	
Phone #	Phone #	
Fax # 708-971-9795	Fax # 717-327-4805	

1401 BRANDING LN, SUITE 285, DOWNERS GROVE, IL 60515, PHONE:(708)971-9791, FAX:(708)971-9795

ATTACHMENT "B"
Calc. No. AE-DC-010 Rev. 00
Project No. AE-002 Station D.C. Cook

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AEP-96-361
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Doc. Control No: CD-AEP-96-361

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Released To: J K Bienia

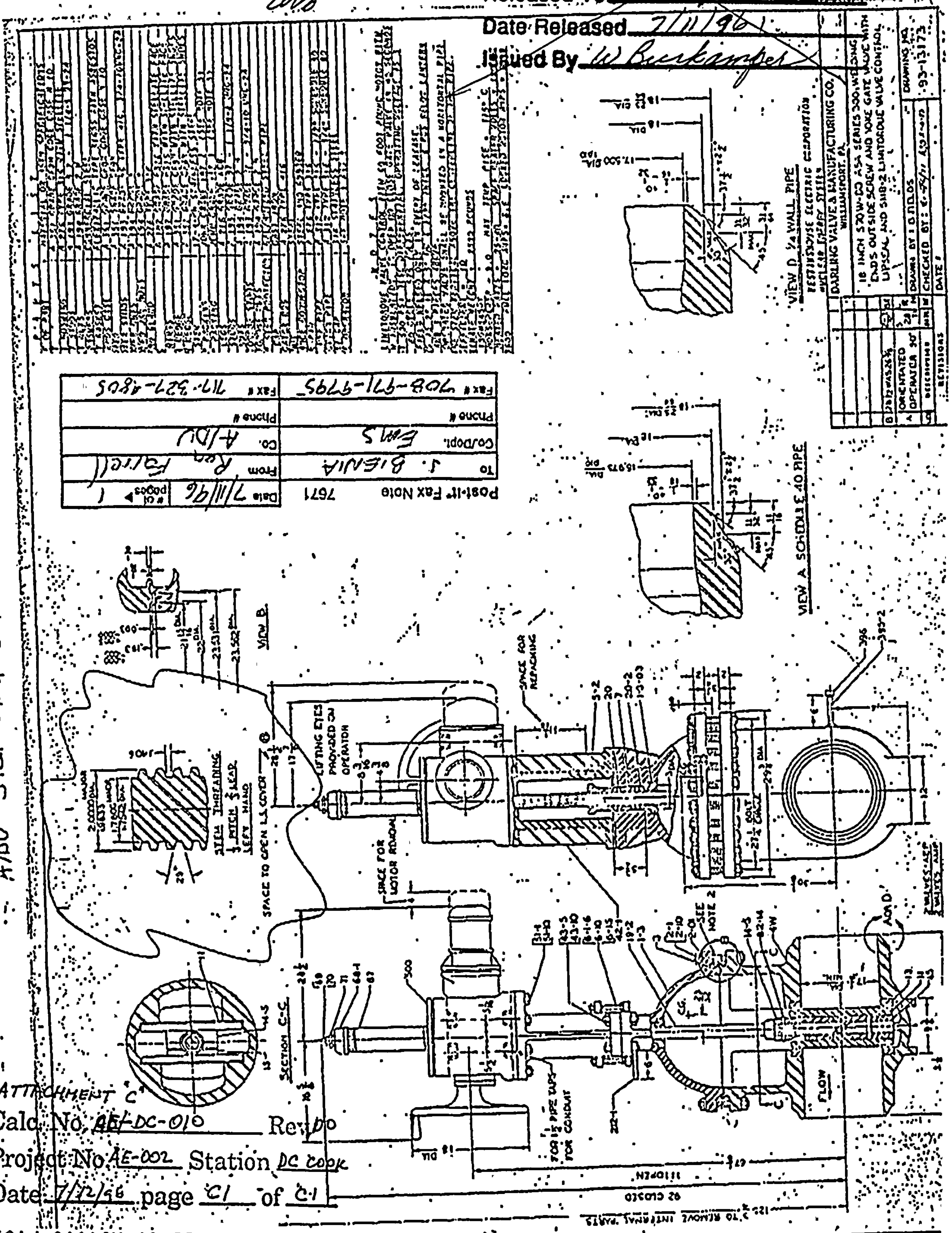
Date Released: 7/11/96

Issued By: W Burkamper

WVB 7/11/96

A/DU Std. Stem friction for: Stem factor: Calculation = 0.15

Post-it® Fax Note 7671		Date 7/11/96	# of pages 1
To J. Bienia		From Ron Farrell	
Co./Dept. EMS		Co. A/DU	
Phone #		Phone #	
Fax # 708-971-9795		Fax # 717-327-4805	



ATTACHMENT C

Calc. No. AE-DC-010 Rev. 0

Project No AE-002 Station DC Cook

Date 7/12/96 page C1 of C1