Palo Verde Nuclear Generating Station

CALCULATION REVISION/TITLE SHEET

CALCULATION NO.	REV.	CLASS:	AFFECTED SHEET NO(S)
13-MC-ZZ-217	2	Q ☒ QAG ☐ NQR ☐	Attachment 1 & Indicated Sheets

CALCULATION TITLE	ISSUED
Gate Valve Open Thrust Required During Potential Pressure Locking Conditions	9/10/99

PLANT CHANGE DOCUMENT	REFERENCE(S)
DMWO 00677651, 00714670, 00741855, 00767747, 00746122, 00768975, 00768974, 00768977 00787911, 00799119	Generic Letter 95-07 Engineering Study 13-MS-A96 CRDR 9-5-0836 CRDR 9-8-1207

REASON FOR CHANGE

This calculation revision is an update to Attachment 1 of the pressure locking analysis model inputs to reflect implemention of the referenced plant change document DMWO EDC's listed below. The model was also updated to reflect Limitorque Technical Update 98-01 degraded voltage. Attachment 1 was reformated to incorporate the below listed EDC's and associated information as identified in the comments listed below.

DESCRIPTION OF CHANGE

Item) TAG/COMMENT

1) 1JAFBUV34/Incorporated EDC 97-00055 and updated data.
2) 2JAFBUV34/Incorporated EDC 97-00056 and updated data.
3) 3JAFBUV34/Incorporated EDC 97-00059 and updated data.
4) 1JAFBUV35/Incorporated EDC 97-00054 and updated data.
5) 2JAFBUV35/Incorporated EDC 97-00057 and updated data.
6) 3JAFBUV35/Incorporated EDC 97-00058 and updated data.
7) 1JAFCUV36/Incorporated EDC 97-00233 and updated data.
8) 2JAFCUV36/Incorporated EDC 97-00235 and updated data.
9) 3JAFCUV36/Incorporated EDC 97-00237 and updated data.
10) 1JAFAUV37/Incorporated EDC 97-00234 and updated data.
11) 2JAFAUV37/Incorporated EDC 97-00236 and updated data.
12) 3JAFAUV37/Incorporated EDC 97-00238 and updated data.
13) 2JSGAUV134/Incorporated EDC 98-00280 and updated data.
14) 3JSGAUV134/Incorporated EDC 98-00282 and updated data.
15) 2JSGAUV138/Incorporated EDC 98-00281 and updated data.
16) 3JSGAUV138/Incorporated EDC 98-00283 and updated data.
17) 3JSIAUV651/Incorporated EDC 98-00804 and updated data.

(Continued)

	Preparer Date	RE Date	Second Party Verification Date	Mech. Date	Civil Date	Elec. Date	I & C Date	Independent Verification Date	Other (Specify Org.) Date	Section Leader Date
EDCs Incorporation ☒ Direct Revision ☒ Electronically Available? Yes ☐ No ☒	[signature] 9-1-99	[signature] 9-1-99	N.A.	N.A.	N.A.	N.A.	N.A.	Rafael Rios 9-2-99	N.A.	[signature] 9-3-99

CROSS DISCIPLINE REVIEW

9910200193 991008
PDR ADOCK 05000528
P PDR

Palo Verde Nuclear Generating Station

CALCULATION REVISION/TITLE SHEET

CALCULATION NO.	REV.	CLASS:	AFFECTED SHEET NO(S)
13-MC-ZZ-217	2	Q ☒ QAG ☐ NQR ☐	Attachment 1 & Indicated Sheets

CALCULATION TITLE	ISSUED
Gate Valve Open Thrust Required During Potential Pressure Locking Conditions	

PLANT CHANGE DOCUMENT	REFERENCE(S)
DMWO 00677651, 00714670, 00741855, 00767747, 00746122, 00768975, 00768974, 00768977 00787911, 00799119	NRC Generic letter 95-07 Engineering Study 13-MS-A96 CRDR 9-5-0836 CRDR 9-8-1207

REASON FOR CHANGE

This calculation revision includes an update to Attachment 1 of the pressure locking analysis model inputs to reflect implemention of the referenced plant change document DMWO EDC's listed below. The model was also updated to reflect Limitorque Technical Update 98-01 degraded voltage. Attachment 1 was reformated to incorporate the below listed EDC's and associated information as identified below.

DESCRIPTION OF CHANGE

18) 2JSIAUV655/Incorporated EDC 96-01132 and updated data.
19) 3JSIAUV655/Incorporated EDC 97-00337 and updated data.
20) 3JSIAUV656/Incorporated EDC 97-00337 and updated data.
21) 2JSIAUV672/Incorporated EDC 97-00044 and updated data.
22) 3JSIAUV672/Incorporated EDC 97-00046 and updated data.
23) 1JSIBUV671/Incorporated EDC 97-00038 and updated data.
24) 2JSIBUV671/Incorporated EDC 97-00043 and updated data.
25) 3JSIBUV671/Incorporated EDC 97-00045 and updated data.
26) 2JSIAHV686/Incorporated EDC 97-00250 and updated data.
27) 3JSIAHV686/Incorporated EDC 97-00252 and updated data.
28) 1JSIBHV696/Incorporated EDC 97-00249 and updated data.
29) 2JSIBHV696/Incorporated EDC 97-00251 and updated data.
30) Updated mimimum voltage values utilized in Attachment 1 in accordance with evaluation of current electrical calculations 01, 02, 03-EC-MA-221 & 01, 02, 03-EC-PK-207.
31) Updated OAR efficiencies, and AC voltage degradation factors based on Limitorque Technical Update (TU) 98-01 and supplement to TU 98-01.
32) Updated pressure locking model and attachment 1 and 4 to account for residual load adjustment and adjusted efficiencies and factors.
33) Added Attachment 6 to compare pressure locking model with NUREG/CR-6611 INEEL test results.
35) UPDATED ATTACHMENT 2 BONNET FLUID PRESSURE VS BONNET FLUID TEMPERATURE CURVE

EDCs Incorporation ☒ Direct Revision ☒ Electronically Available? Yes ☐ No ☒	Preparer / Date	RE / Date	Second Party Verification / Date	Mech. / Date	Civil / Date	Elec. / Date	I & C / Date	Independent Verification / Date	Other (Specify Org.) / Date	Section Leader / Date
	[signature] 9-1-99	[signature] 9-1-99	N.A.	N.A.	N.A.	N.A.	N.A.	Rafael Rios 9-2-99	N.A.	[signature] 9-3-99

CROSS DISCIPLINE REVIEW

Palo Verde Nuclear Generating Station

CALCULATION REVISION/TITLE SHEET

CALCULATION NO.	REV.	CLASS:	AFFECTED SHEET NO(S)
13-MC-ZZ-217	1	Q [X] QAG [ ] NQR [ ]	ALL (SH. 1 TO 126)

CALCULATION TITLE	ISSUED
Gate Valve Open Thrust Required during Potential Pressure Locking Conditions	12-13-96

PLANT CHANGE DOCUMENT	REFERENCE(S)
DMWO 00677651, 00714670, 00741855, 00767747, 00746122, 00768975, 00768974, 00768977	Engineering Study 13-MS-A96 CRDR 9-5-0836

REASON FOR CHANGE

This calculation revision is an update to the pressure locking analysis model to include the effect of line pressure (Hub Loads) and adjust the residual load component based on further evaluation of industry and test data.

DESCRIPTION OF CHANGE

Updated Section 2.0 Background/Summary, Section 3.0 Criteria/Assumptions, Section 4.0 Input Data, Section 5.0 Calculation/Results, Section 6.0 References, Attachment 1: Pressure Locking Susceptibility Evaluation, Attachment 4: Pressure Locking Model Validation, Attachment 5: Pressure Locking Special Test Procedure due to updated model and available information.

Preparer / Date	RE / Date	Second Party Verification / Date	Mech. / Date	Civil / Date	Elec. / Date	I & C / Date	Independent Verification / Date	Other (Specify Org.) / Date	Other (Specify Org.) / Date	
[signature]	[signature]	N.A.	[signature]	N.A.	N.A.	N.A.	Rafael Rios	N.A.	N.A.	
12/10/96	12/10/96		12/12/96				12/12/96			

CROSS DISCIPLINE REVIEW (Mech., Civil, Elec., I & C)

10CFR50.59
SCREENING AND EVALUATION

ACTION UNDER REVIEW: (NAME/TITLE)	50.59 REVISION:
MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

DESCRIPTION OF PROPOSED CHANGE:
Revise 13-MC-ZZ-217, Gate Valve Open Thrust Required during Potential Pressure Locking Conditions per G.L. 95-07, to update the pressure locking model, selected available electrical minimum voltage inputs, actuator voltage degradation factors, gear box efficiencies, peak cracking limits, associated formats and model validation evaluation, and incorporation of modification EDC's.

Applicability:	NO	YES
A. Is the proposed change programmatically eliminated from the 10 CFR 50.59 program? (Reference Section 3.2)	X	

___ If question A is answered "YES," a 10 CFR 50.59 Screening/Evaluation is NOT required.

X If question A is answered "NO," a 10 CFR 50.59 Screening must be performed.

10CFR50.59 SCREENING *(Provide References on Response Justification Page)* Does the proposed change:	NO	YES
1. Make changes in the facility as described in the Palo Verde Licensing Documents? (refer to Section 4.1.4 and Appendix C)	X	
NOTE: Prior to modification of radioactive waste systems, review the modification against the specific criteria in IEC 80-18 (Appendix G).		
2. Make changes in procedures as described in the Palo Verde Licensing Documents? (refer to Section 4.1.4 and Appendix C)	X	
3. Involve tests or experiments not described in the Palo Verde Licensing Documents? (refer to Section 4.1.4 and Appendix C)	X	
3a. Is PRB approval required? (Refer to Appendix C)	X	
4. Involve a change to the technical specifications? (Refer to Appendix C) (Technical Specifications in this case refers to both the Current Technical Specifications and the Improved Technical Specifications)	X	

___ If any answer to questions 1, 2, or 3 is "YES," then a 10 CFR 50.59 evaluation is required. When the evaluation is completed, and prior to the review, contact Document Control at ext. 82-5439 to obtain a tracking log number and enter the number in the Evaluation Log number block above.

___ If answer 1, 2, or 3 is "YES," refer to 93DP-0LC03 and determine if an LDCR is required. If an LDCR is required, contact NRA for a tracking # and enter the number here ________
If an LDCR is not required, include justification in the response section.

___ If answer 4 is "YES," then a Technical Specification Change Request per procedure 93DP-0LC03 and PRB and NRC approval is required prior to implementation. (See the procedure for an explanation of exceptions to this.)

X If all answers 1 through 4 are "NO," no 10 CFR 50.59 Evaluation is required or Technical Specification change is required, recommend action approval.

X Send a copy of this screening to NRA station 7636.

I verify that the above screening is adequate and accurate and that I am currently qualified to perform 10 CFR 50.59 Screenings.

[signature]	7-9-99	[signature]	7/14/99
SCREENER	DATE	50.59 REVIEWER	DATE
STEVEN A. LOPEZ		ROGER Laine	
SCREENER (PRINT)		50.59 REVIEWER (PRINT)	

10CFR50.59
SCREENING AND EVALUATION

.TION UNDER REVIEW: (NAME/TITLE)
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.

10CFR50.59 EVALUATION *(Provide References on Response Justification Page)*
Reference Appendix C of 93DP-0LC07 for detailed explanation of each question

		NO	YES
5.	May the probability of an accident previously evaluated in the UFSAR be increased?	___	___
6.	May the consequences of an accident previously evaluated in the UFSAR be increased?	___	___
7.	May the probability of a malfunction of equipment important to safety be increased?	___	___
8.	May the consequences of a malfunction of equipment important to safety be increased?	___	___
9.	May the possibility of an accident of a different type than any previously evaluated in the UFSAR be created?	___	___
10.	May the possibility of a different type of malfunction than any previously evaluated in the UFSAR be created?	___	___
11.	Is the margin of safety as defined in the basis for any technical specification reduced?	___	___

N.A
SRC
7-9-99

Call NFM at Ext. 82-5314 (alt 82-5092). Duty Pager 2667.
Review Requested by NFM and Completed Yes ____ No Review Requested by NFM ___
Name of individual contacted in NFM ______________________

___ If any answer to questions 5 through 11 is "YES," then an unreviewed safety question is identified. PRB and NRC approval is required prior to implementation.

___ If answers 5 through 11 are all "NO," there is no unreviewed safety question and NRC approval is not required prior to implementation under 10 CFR 50.59.

___ If UFSAR Chapter 6 or 15 are potentially affected, forward a copy of evaluation to Nuclear Fuels Management.

___ Send a copy of this evaluation to NRA station 7636 and NIRM station 7714.

I verify that the above evaluation is adequate and accurate and that I am currently qualified to perform 10 CFR 50.59 Evaluations..

EVALUATOR	DATE	50.59 REVIEWER	DATE
EVALUATOR (PRINT)		50.59 REVIEWER (PRINT)	

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
.3-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

A. SUMMARY

13-MC-ZZ-217 Rev 2 is updated to incorporate the resulting Generic Letter 95-07 pressure locking modifications Engineering Document Changes (EDC); incorporate the guidance for AC Valve Motor Actuators (VMA) of the Original Equipment Manufacturer (OEM) Limitorque Technical Update (TU) 98-01, Actuator Output Torque Calculation, and TU 98-01 Supplement 1. In addition the pressure locking analysis model is updated to account for additional industry testing (NUREG/CR-6611) and updating of the available electrical minimum voltage based on evaluation of the current electrical calculations (01, 02, 03-EC-MA-221 and 01, 02, 03-EC-PK-207).

B. BACKGROUND

Pressure Locking is postulated to occur when a flexible wedge gate valve bonnet is filled with a trapped fluid at a pressure that produces additional forces above the valve actuator capacity. To overcome these pressure locking forces the valve actuator is required to develop a sufficient thrust force to overcome the forces due to the associated bonnet and piping pressure, wedging, and the frictional forces required to unseat the valve disc. The source of the trapped bonnet pressure may be from either a high process fluid pressure being trapped in the valve bonnet and a subsequent decrease in the connecting system piping system pressure or from a heatup of a trapped fluid in the valve bonnet and the resulting bonnet pressure increase due to the fluid thermal expansion. The resultant bonnet pressure and accompanying unseating forces may require an opening stem thrust above the actuator capability or valve or actuator thrust/torque limits. This has the potential of preventing the valve from being capable of opening when called upon to perform the associated safety function.

The Nuclear Regulatory Commission (NRC) issued Generic Letter (G.L.) 95-07, Pressure Locking and Thermal Binding of safety-Related Power Operated Gate Valves, in August 97. This Generic Letter required all applicable Nuclear licensees to perform a screening evaluation to identify potentially susceptible valves and documentation of the basis for operability of these valves within 90 days. The Generic Letter also required evaluation, performance of further analyses and appropriate corrective actions (or justify extensions) within 180 days to ensure that the potentially susceptible valves are capable of performing their intended safety functions.

The Palo Verde Nuclear Generating Station (PVNGS) pressure locking and thermal binding screening evaluation was performed and documented by the PVNGS Engineering Study 13-MS-A96, Gate Valve Pressure Locking and Thermal Binding Evaluations. CRDR 9-5-0836 documented the evaluation of the operational configurations of these gate valves and identified the valves that are susceptible to pressure locking and thermal binding. In addition this CRDR presented the PVNGS methodology used to develop an analytical model to evaluate the pressure locking susceptibility of these valves. This methodology was used along with operational considerations to demonstrate the basis for operability of these valves and their capable of performing their associated safety functions.

ACTION UNDER REVIEW: (NAME/TITLE)	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0
PROCEDURE/PCP/TEMPORARY MODIFICATION NO.: Calculation 13-MC-ZZ-217 Rev 2	

QUESTION	RESPONSE JUSTIFICATION

The Palo Verde Nuclear Generating Station (PVNGS) required G.L. 95-07 analysis conclusions were documented in APS letter 102-03608-WLS/AKK/RJR, February 21, 1996, to the NRC. This letter identified the PVNGS valves that were considered susceptible to the postulated pressure locking conditions and indicated that the schedule for the required corrective actions for long term compliance were being developed. In addition APS letter 102-03725-WLS/AKK/RJR, June 28, 1999, to the NRC provided the implementation schedule for the corrective actions required to eliminate the potential for susceptibility of the identified values to the postulated pressure locking phenomena.

PVNGS Calculation 13-MC-ZZ-217 R/0 was issued in April 1996 to document the PVNGS pressure locking analysis methodology as part of the plant design basis. This evaluation identified the theoretical level of design basis susceptibility of the identified valves identified as potentially susceptible to pressure locking. This calculation identified the need for modifications to these identified susceptible valves to eliminate the potential for this susceptible. This calculation also documented the validation of this PVNGS pressure locking analysis methodology based on the results of the Commonwealth Edison-APS testing of the 10" class 300# Borg Warner flexible gate valve. 13-MC-ZZ-217 R/1 was issued in December 1996 to updated this Palo Verde pressure locking analysis methodology and validation based on review and determination of the necessary modifications to the identified susceptible valves and final Commonwealth Edison test results.

Design Modification Work Orders/Deficiency Work Orders (DMWO's/DFWO's) and the associated Engineering Document Changes (EDC's) were developed as identified in table 1 of this document. These modifications involved the addition of a bonnet relief or check valve to limit bonnet pressure; upgrading the Motor Operated Valve (MOV) with a larger actuator, valve weak-link, alternate stem and stem-nut thread fit and/or; overall gear ratio (OAR) to provide additional available MOV capacity to overcome the postulated locking loads.

NUREG/CR-6478, Motor-Operated Valve (MOV) Actuator Motor and Gearbox Testing, was issued in February 1997. This testing indicated that analytical methods for some AC motors may not be conservative in predicting performance under degraded voltage conditions and with the use of published running efficiencies. Limitorque Technical Update (TU) 98-01 and TU 98-01 Supplement 1, Actuator Ouput Torque Calculation, were issued providing current guidance in conservatively evaluating the capacity of certain Limitorque AC actuator motors. This guidance primarily involves using an application factor of 0.9 instead of 1 in addition to the ratio of Minimum Voltage to Rated Voltage (Vmin/Vrated) when this ratio is less than 0.9 and utilizing the lower Pullout efficiency in lieu of the running efficiency.

NUREG/CR-6611, Results of Pressure Locking and Thermal Binding Tests of Gate Valves, was issued in May 1998. This test report including the results of a 6" class 600# Walworth flexible gate valve pressure locking and thermal binding testing. This testing also included testing of thermal pressurization test rates for this valve, the increase in bonnet pressure due to trapped fluid expansion due to heating effects.

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

C. DESCRIPTION OF CHANGE

Calculation 13-MC-ZZ-217 R/2, Gate Valve Open Thrust Required During Potential Pressure Locking Conditions, is being updated to incorporate the pressure locking modification Engineering Document Changes (EDC) for the implemented Design Modification Work Orders/Deficiency Work Orders (DMWO's/DFWO's) listed in table 1 of this document. These DMWOs were initiated and implemented to eliminate the potential pressure locking susceptibility of these valves. The pressure locking susceptibility evaluation spreadsheet, Attachment 1 of 13-MC-ZZ-217 was reformated to include a separate line for each modified/updated listed valve analysis. The initial pressure locking susceptibility results for the valves before resulting modifications have been removed from the calculation since they are no longer applicable to the modified valves. Additional associated and editorial and typo changes are also made.

This calculation is also being updated to incorporate the guidance for AC motor actuators provided by the Valve Motor Actuator (VMA) Original Equipment Manufacturer (OEM) Limitorque Technical Update (TU) 98-01, Actuator Output Torque Calculation, and TU 98-01 Supplement 1. This guidance primarily involves using an application factor of 0.9 instead of 1 in addition to the ratio of Minimum Voltage/Rated Voltage (Vmin/Vrated) squared when this ratio is less than 0.9 and utilizing the lower Pullout efficiency in lieu of the running efficiency for AC valves. The DC valve minimum voltage factors were also updated to utilize an application of 1.0 with the ratio of the Vmin/Vrated. Some credit is also taken for the hammerblow and spring compensator pack features of Limitorque SMB/SB actuators that result in the reduction of the required inrush current and corresponding increase in the available minimum voltage since the VMA starts unloaded. This is similar to the guidance provided in 13-JC-ZZ-201, MOV Thrust, Torque and Actuator Sizing Calculation, (Criteria and Assumption 4.2.3); IEEE 1290, IEEE Guide for Motor Operated Valve (MOV) Motor Application, Protection, Control, and Testing in Nuclear Power Generating Stations; and is supported by review of applicable MOVATS test results.

This calculation is also updated to include a slight adjustment of the PVNGS pressure locking analysis model to account for additional industry testing (NUREG/CR-6611). A comparison of the PVNGS pressure locking analysis model is including as Attachment 6 to this calculation. NUREG/CR-6611, Pressure Locking and Thermal Binding Tests of Gate Valves, includes the results of 6" class 600# Walworth flexible gate valve pressure locking and thermal binding tests.

In addition this calculation update includes the updating of the available electrical minimum voltage based on evaluation of the current electrical calculations (01, 02, 03-EC-MA-221 and 01, 02, 03-EC-PK-207 and associated EDC's). In a number of cases these electrical calculations have been rerun with current MOV motor characteristics to determine the available motor terminal minimum.

This calculation also includes a review and updating of the peak cracking of the identified valves in table1. These updated limits are based on the available post modification test results documented in the associated DMWO packages. Review of weaklink valve values resulted in adjustment for identified valves as indicated in table 1 based on evaluation of 13-JS-A41. Review of 13-MC-SI-229, the updated SI valve bonnet pressure relief valve sizing calculation, involved updating of the associated maximum bonnet pressures as indicated in table 1.

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

D. CALCULATION UPDATE IMPACT

The resulting changes from the incorporated EDC's were evaluated and documented in their respective modification packages (DMWO's/DFWO's). 10CFR50.59 screening/evaluations are documented and included in the corresponding DMWO documentation. The resulting changes due to the latest value of the input information do not result in significant changes such that they would cause an unacceptable or nonconservative analyzed design margin. Updating of the (minimum) degraded voltage inputs from further review of the 01, 02, 03-EC-MA-221, Electrical "AC" Distribution Calculations, and 01, 02, 03-EC-PK-207, Electrical DC Battery Sizing and Minimum Voltage Calculations, were reflected on the appropriate impacted valve considering the potential impact on the output design and the cumulative effect of valve design variable input changes. A number of MOV pressure locking results were updated to include the impact of updated motor application factors based on Limitorque Technical Update 98-01 and associated supplement 1. These changes did not result in any unreviewed 10CFR50.59 safety screening/evaluation physical changes, unacceptable nonconservative decrease in analyzed design margins, or a change in the valve safety function or method of achieving that safety function.

ACTION UNDER REVIEW: (NAME/TITLE)	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

10CFR50.59 SCREENING QUESTION RESPONSE JUSTIFICATION:

1. No. This update of the Generic Letter (G.L.) 95-07 PVNGS pressure locking analysis calculation does not result in a change in the facility as described in the PVNGS Licensing Basis since these calculation changes only reflect a refinement in the design and analysis reflecting the state of the existing field conditions, current test results, industry guidance, and/or updated plant configurations based on exiting implemented modifications and 10CFR50.59 safety screening/evaluations. The PVNGS model has been slightly updated to adequately address currently available applicable industry test data. Evaluation of current minimum available electrical motor terminal Voltages (01, 02, 03-EC-MA-221 and 01, 02, 03-EC-PK-207), updated OEM capacity analysis guidance for utilization of minimum voltage application factors and actuator pullout efficiencies (Limitorque Technical Update (TU) 98-01 and TU 98-01 Supplement 1), are utilized to determine the available actuator capacity. Updated peak cracking limits (32MT-9ZZ56), and review of a weaklink evaluation (13-JS-A41), and review of relief valve setpoints (13-MC-SI-229) were utilized to determine the required and limited capacity of the associated MOV's to over come the respective postulated pressure locking conditions. This re-evaluation utilizing the updated values and analysis model ensure that acceptable design margins are maintained so that these valves are able to continue to meet their safety related functional design and licensing requirements. Changes to the inputs and other parameters related to the associated modifications are reviewed, evaluated and documented for impact to the facility as described in the Design or Licensing basis in the associated Design Modification Work Order/Deficiency Work Order (DMWO/DFWO) package including appropriate 10CFR50.59 screening/evaluations.

   Existing plant as-left peak cracking limits were evaluated for those valves identified in table 1 to insure that the related analysis changes did not adversely impact the identified potentially pressure locking susceptible MOV gate valves in such a manner that they did not retain ability to perform their safety related functions. These evaluations demonstrated that these MOV's remain operable based on the updated analysis, as-left peak cracking values, and the current established and accepted valve/valve operator design and performance variables. These evaluations are documented in CRDR 98-1207.

2. No. No procedural changes as described in the PVNGS Licensing Documents are associated with this update of the Generic Letter 95-07 PVNGS pressure locking analysis, incorporation of Limitorque Technical Update (TU) 98-01 and TU 98-01 Supplement 1, updated AC motor actuator output torque calculation guidance, and incorporation of the current minimum available voltage and valve performance values and limits. This update to the Generic Letter 95-07 PVNGS pressure locking analysis calculation includes incorporation of changes to the MOV 's identified in table 1 of this screening as a result of installed modifications, updated valve test variables based on evaluation of prior test results, current vendor and industry information, updated degraded voltage, and minor numerical, note and format changes.

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
.3-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

Since these calculation changes only reflect a refinement in the design and analysis reflecting the state of the existing field conditions, current test results, industry guidance, and/or updated plant configurations based on exiting implemented modifications and 10CFR50.59 safety screening/evaluations no plant procedures as generally described in UFSAR Section 13.5, Plant Programs and Procedures, and 13.5.2, Operating and Maintenance Procedures, are impacted.

3. No. No special tests or experiments not described in the licensing basis are associated with this update of the Generic Letter 95-07 PVNGS pressure locking calculation. This update to the PVNGS pressure locking analysis; incorporation of Limitorque Technical Update (TU) 98-01 and TU 98-01 Supplement 1, updated AC motor actuator output torque calculation guidance; and incorporation of the current minimum available voltage and valve performance values and limits have no related special test or experimental requirements. The associated setpoint checks and valve performance testing required by the associated DMWO/DFWO identified in table 1 of this screening are addressed and evaluated in the appropriate referenced DMWO/DFWO package and is not included in the scope of this screening. UFSAR Chapter 14, Initial Test program, was reviewed to verify that no special licensing basis type test or experiment required but not previously evaluated in the UFSAR could be related to this calculation and analysis update.

4. No. This update to the PVNGS pressure locking analysis; incorporation of Limitorque Technical Update (TU) 98-01 and TU 98-01 Supplement 1, updated AC motor actuator output torque calculation guidance; and incorporation of the current minimum available voltage and valve performance values and limits does not involve a change to the improved technical specifications or the related technical specification basis. If any associated modifications were to result in any technical specification or technical specification basis change, those reviews would be completed and documented in the associated Modification (DMWO/DFWO) package. These actions do not impact the technical specifications since the nature of the MOV pressure locking modifications, valve performance parameters, and peak cracking setpoint limits are not included in the technical specifications.

   PVNGS Technical Specifications Section 5.4; Administrative Controls, Procedures; and Section 5.5; Administrative Controls, Programs and Manuals; are not impacted by this action. The Generic Letter 89-10 MOV procedures and programs are not included in the Improved Technical Specifications or the PVNGS Technical Requirements Manual.

ACTION UNDER REVIEW: *(NAME/TITLE)* 13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	REVISION: 0
PROCEDURE/PCP/TEMPORARY MODIFICATION NO.: Calculation 13-MC-ZZ-217 Rev 2	

QUESTION	RESPONSE JUSTIFICATION

REFERENCES:

1. UFSAR (Revision 10 w/SARCN Supplements 6/16/99)
   - 1. - Introduction and General Description of Plant
     - 1.8 - Conformance to NRC Regulatory Guides
     - 1.9 - Standard Design
       - 1.9.2 - Exceptions to the CESSAR
         - 1.9.2.4 - System Deviations
   - 3. - Design of Structures, Components, Equipment and Systems
     - 3.9 - Mechanical Systems and Components
       - 3.9.3 - ASME Class 1, 2, & 3 Components...
         - 3.9.3.2 Pump and Valve Operability Assurance
   - 5. - Reactor Coolant System and Connected Systems
     - 5.1 – Summary Description
       - Table 5.1-4 – Shutdown Cooling System FMEA (CESSAR Table 5.4.7-3)
     - 5.2 - Integrity of Reactor Pressure Boundary
       - 5.2.4 - Inservice Inspection and Testing of Reactor Coolant Pressure Boundary
     - 5.4 - Component and Subsystem Design
       - 5.4.7 - Residual Heat Removal System
       - 5.4.12 - Valves
   - 6. - Engineered Safety Features
     - 6.2 - Containment Systems
       - 6.2.4 - Containment Isolation System
         - Table 6.2.4-1 – Containment Isolation System (Applicable EDC's)
         - Table 6.2.4-2 – Containment Isolation System (Valve Position)
     - 6.3 - Emergency Core Cooling System
       - 6.3.2 – System Description
         - Table 6.3.2-3 – Safety Injection System FMEA (CESSAR Table 6.3.2-2)
   - 7. - Instrument and Controls
     - 7.3 - Engineered Safety Feature Systems
       - 7.3.1 - Description
         - 7.3.1.1 - Engineered Safety Features Actuation System (ESFAS)
           - 7.3.1.1.10 - Actuated Systems
             - 7.3.1.1.10.1 - Containment Isolation System
     - 7.4 - Systems Required for Safe Shutdown
       - 7.4.1 - Description
         - 7.4.1.1 - System Description
           - 7.4.1.1.8 - Shutdown Cooling System
   - 8. – Electrical Power
     - 8.3 – Onsite Power Systems
       - Table 8.3-1 – Class 1E Loads
       - Table 8.3-3 – Diesel Generator Load Sequencing
       - Table 8.3-6 – Class 1E DC System Loads

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
.3-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0
PROCEDURE/PCP/TEMPORARY MODIFICATION NO.: Calculation 13-MC-ZZ-217 Rev 2	

QUESTION	RESPONSE JUSTIFICATION

9. - Auxiliary Systems
    9.3 - Process Auxiliaries
        9.3.4 - Chemical and Volume Control System
10. - Steam and Power Conversion System
    10.3 - Main Steam Supply System
    10.4 - Other Features of Steam and Power Conversion System
        10.4.9 - Auxiliary Feedwater System
12. – Radiation Protection
    12.3 – Radiation Protection Design Features
        12.3.1 – Facility Design Features
            12.3.1.1 – Plant Design Description for ALARA
                12.3.1.1.1 – Common Equipment and Component Design for ALARA
                    12.3.1.1.1.8 – Valves
13. - Conduct of Operations
    13.5 - Plant Procedures
        13.5.2.2 - Other Procedures
14. - Initial Test Program
    14.2 - Specific Information to be Included in FSAR
        14.2.1 - Summary of Test Program and Objectives
        14.2.3 - Test Procedures
    14A - Responses to NRC Request for Information
    14B - Preoperational Test Description
15. - Accident Analysis
    15.1 - Increase in heat Removal by Secondary
    15.2 - Decrease in Heat Removal By the Secondary
    15.3 - Decrease in Reactor Coolant Flow-Rate
    15.4 - Reactivity and Power Distribution Anomalies
    15.5 - Increase in RCS Inventory
    15.6 - Decrease in Reactor Coolant System Inventory
17. - Quality Assurance
    17.2 - Quality Assurance during the Operations Phase
        17.2.3 - Control of Station Activities
        17.2.6 - Control of Documents and Records
18. - TMI - 2 Lessons Learned Implementation Report
    18.II.F - Instrument and Controls
    18.II.K - Measures to Mitigate Small-Break LOCAs and Loss of Feedwater Accidents
        18.II.K.1 - IE Bulletins on Measures to Mitigate Small-Break LOCAs and Loss of Feedwater Accidents
        18.II.K.1.5 - Review of ESF Valves

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0
PROCEDURE/PCP/TEMPORARY MODIFICATION NO.: Calculation 13-MC-ZZ-217 Rev 2	

QUESTION	RESPONSE JUSTIFICATION

2. CESSAR Amendment 9 (2/27/84)
   5.1.4 - Nuclear Steam Supply System-Balance of Plant Interface Requirements
   5.2 - Integrity of Reactor Pressure Boundary
   5.4.7.1 - Residual Heat Removal System
      Table 5.4.7-3 Shutdown Cooling System FMEA
   5.4.12 - Valves, Component & Subsystem Design, Reactor Coolant System and Connected Systems
   6.2.4 - Containment Isolation System
      Table 6.2.4-1 Containment Isolation System
   6.3 - Emergency Core Cooling System
      Table 6.3.2-2 Safety Injection System FMEA
   Appendix 6A – Containment Spray System Licensing Report
      Table 4.5 Containment Spray System FMEA
   7.3.1.1.10 – Actuated Systems, Engineered Safety Features Actuation System (ESFAS)
   7.4.1.1.8 - Shutdown Cooling System
   9.3.4 - Chemical and Volume Control System
      Table 9.3-7 Chemical and Volume Control System (CVCS) Failure Mode and Effects Analysis
   12.3.1.2 – Equipment and System Design Features for Control of On-site Exposure
      F. Valves

3. PVNGS Technical Specifications & Bases Through Amendment 119 (Effective 12/23/98)
   3.4- Reactor Coolant System
      3.4.4- RCS Loops- Modes 1 and 2
      3.4.5- RCS Loops- Modes 3
      3.4.6- RCS Loops- Modes 4
      3.4.7- RCS Loops- Mode 5, Loops Filled
      3.4.8- RCS Loops- Mode 5, Loops Not Filled
   3.5- Emergency Core Cooling System (ECCS)
      3.5.3 ECCS- Operating
      3.5.4 ECCS- Shutdown
   3.6- Containment Systems
      3.6.6- Containment Spray System
   3.7- Plant Systems
      3.7.5- Auxiliary Feedwater (AFW) System
   3.8- Electrical Power Systems
      3.8.9- Distribution Systems- Operating
      3.8.10 - Distribution Systems- Shutdown
   3.9- Refueling Operations
      3.9.4- Shutdown Cooling (SDC) and Coolant Circulation – High Water Level
      3.9.5- Shutdown Cooling (SDC) and Coolant Circulation – Low Water Level

4. PVNGS Technical Specification Bases Rev 0 Plus LDCR's (7/7/99)

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0
PROCEDURE/PCP/TEMPORARY MODIFICATION NO.: Calculation 13-MC-ZZ-217 Rev 2	

QUESTION	RESPONSE JUSTIFICATION

5. PVNGS Technical Requirements Manual (TRM) REV 3 (1/22/99)
   - T3.4- Reactor Coolant System (RCS)
     - T3.4.103- Structural Integrity
   - T3.5- Emergency Core Cooling System (ECCS)
     - T3.5.201- Shutdown Cooling System
   - T3.5.202- ECCS- Operating
   - T3.5.203- ECCS- Shutdown
   - T3.7- Plant Systems
     - T3.7.201 AFW System
   - T3.8- Electrical Power Systems
     - T3.8.102- MOV Thermal Overload Protection and Bypass Devices
   - T3.9- Refueling Operations

   - T6.0- TRM Specifications Specification Bases
     - T3.4.103- Structural Integrity
     - T3.5.201- Shutdown Cooling System
     - T3.8.102- MOV Thermal Overload Protection and Bypass Devices
   - T7.0- Component Lists
     - T7.0.300- Containment Isolation Valves
     - T7.0.400- MOV Thermal Overload Protection and Bypass Devices

6. NRC Documents
   a. Generic Letter 89-10 Supplements 1-7, Safety-Related Motor-Operated Valve Testing And Surveillance.
   b. Generic Letter 95-07, Pressure Locking & Thermal Binding Of Safety-Related Power-Operated Gate Valves.
   c. Generic Letter 96-05, Periodic Verification Of Design-Basis Capability Of Safety-Related Motor-Operated Valves.

7. Design Basis Manuals (DBM)
   a. Auxiliary Feedwater System (AF) DBM R/10 (1/20/99)
   b. Chemical and Volume Control System (CVCS/CH) DBM R/7 (12/29/98)
   c. Containment Integrity (leakage and Isolation) Topical (CL) DBM R/5 (6/11/99)
   d. Main Steam System (SG) DBM R/13 (11/23/98)
   e. Safety Injection System (SI) DBM R/12 (5/14/99)

8. Calculations
   a. 13-JC-ZZ-201 R/11, (6/18/98), MOV Thrust, Torque, and Actuator Sizing Calculation.
   b. 13-MC-SI-229 R/2, (6/18/98), PRV Sizing Calculation for SI System Valve Bonnets.

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

9. Studies
   a. 13-MS-A96 R/0, (9/19/95), Gate Valve Pressure Locking and Thermal Binding Evaluations
   b. 13-MS-B07 R/3 (8/12/98), Evaluation of Dynamic Performance Parameters for Generic Letter 89-10 MOVs.

10. Drawings
   a. 03-J-ZZI-004 R/19, (12/23/98), Controlled Motor Operator Data Base (CMODB).
   b. 02-J-ZZI-004 R/16, (2/15/99), Controlled Motor Operator Data Base (CMODB).
   c. 01-J-ZZI-004 R/19, (6/4/99), Controlled Motor Operator Data Base (CMODB).

11. Procedures
   a. 93DP-0LC07 R/2, (7/29/98), 10CFR50.59 Screenings and Evaluations.
   b. 81DP-9ZZ03 R/0, (1/15/97), Nuclear Engineering Support for the Motor Operated Valve Program.
   c. 81DP-4DC10 R/2, (10/15/96), Motor Operated Valve Design Basis Review and Thrust/Torque Calculation.
   d. 39DP-9ZZ01 R/6, (4/9/99), PVNGS Guidelines for Evaluation of Motor Operated Valve Dynamic Test Data.
   e. 39DP-9ZZ03 R/1, (1/22/99), Motor Operated Valve Program.
   f. 39DP-9ZZ04 R/3, (3/27/99), Valve Services Maintenance.
   g. 39MT-9ZZ02 R/8, (2/13/98), PM/EQPM Inspection of the GL 89-10 Limitorque SMB/SB Valve Motor Operators.
   h. 39MT-9ZZ03 R/4, (11/26/97), PM/EQPM Inspection of the GL 89-10 Limitorque SMC Valve Motor Operators.
   i. 32MT-9ZZ49 R/8, (3/25/99), PM Inspection of the Rotork Valve Motor Operators.
   j. 32MT-9ZZ56 R/20, (3/18/99), Motor Operator Testing Using MOVATS 3500 System

12. Other Documents
   a. CRDR 98-1207 (09/17/98), PVNGS G.L. 89-10 MOV Evaluation of Limitorque Technical Update (TU) 98-01 and TU 98-01 Supplement 1.
   b. CRDR 95-0836 (02/16/96), PVNGS G.L. 95-07 MOV Evaluation of Identified Gate Valves Potentially Susceptible to Pressure Locking and Thermal Binding.
   c. IEEE 1290, IEEE Guide for Motor Operated Valve (MOV) Motor Application, Protection, Control, and Testing in Nuclear Power Generating Stations.

13. Table 1 Change Sources (Listed below Table 1).

[illegible] [illegible]

10CFR50.59 SCREENING AND EVALUATION

RESPONSE JUSTIFICATION

ACTION UNDER REVIEW: *(NAME/TITLE)* REVISION: 0

.3-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:

Calculation 13-MC-ZZ-217 Rev 2

QUESTION | RESPONSE JUSTIFICATION

TABLE 1: 13-MC-ZZ-217 R/2 GENERIC LETTER 95-07 MOV PRESSURE LOCKING ANALYSIS REVISIONS

VALVE ID	ENGINEERING DESIGN BASIS DESCRIPTION	SOURCE
JAFAUV0037	AUX FEEDWATER PUMP A SUPPLY TO SG 2 ISOLATION	4, 8
JAFBUV0034	AUX FEEDWATER PUMP B SUPPLY TO SG 1 ISOLATION	3, 5, 8
JAFBUV0035	AUX FEEDWATER PUMP B SUPPLY TO SG2 ISOLATION	3, 5, 8
JAFCUV0036	AUX FEEDWATER PUMP A SUPPLY TO SG 1 ISOLATION	4, 8
JCHEHV053	ISOLATION FOR RWT GRAVITY FEED LINE TO CHARGING PUMPS	3, 5, 8
JSIAHV0604	HPSI LONG TERM RECIRC ISOL TRAIN A	3, 5, 6
JSIBHV0609	HPSI LONG TERM RECIRC ISOL VLV TRAIN B	3, 5, 6
JSGAUV013	SG 1 STEAM SUPPLY TO AUX FEED PUMP TURB	4, 8
JSGAUV013	SG 2 STEAM SUPPLY TO AUX FEED PUMP TURB	4, 8
JSIAHV0685	LPSI CROSS CONNECT TO SDCHX TRAIN A	3, 5, 8
JSIAHV0686	CROSSOVER VALVE SDCHX AND LPSI HDR TRAIN A	3, 5, 8
JSIAHV0688	CTMT SPRAY BYPASS TRAIN A	3, 5, 8
JSIAUV0651	SHUTDOWN COOLING SUCTION ISOL VLV TRAIN A	3, 5, 7, 8, 9
JSIAUV0655	SHUTDOWN COOLING SUCTION CTMT ISOL VLV TRAIN A	3, 5, 8
JSIAUV0672	CTMT SPRAY CONTROL VLV TRAIN A	3, 5, 8, 9
JSIBHV0693	CTMT SPRAY BYPASS TRAIN B	3, 5, 8
JSIBHV0694	LPSI CROSS CONNECT TO SDCHX TRAIN B	3, 5, 8
JSIBHV0696	CROSSOVER SDCHX AND LPSI HDR TRAIN B	3, 5, 8
JSIBUV0652	SHUTDOWN COOLING SUCTION ISOL VLV TRAIN B	3, 5, 7, 9
JSIBUV0656	SHUTDOWN COOLING SUCTION CTMT ISOL VLV TRAIN B	3, 5, 8
JSIBUV0671	CTMT SPRAY CONTROL VLV TRAIN B	3, 5, 8, 9
JSICUV0653	SHUTDOWN COOLING SUCTION CTMT ISOL VLV TRAIN A	1, 5
JSIDUV0654	SHUTDOWN COOLING SUCTION CTMT ISOL VLV TRAIN B	1, 5

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION	

CHANGE SOURCES

1. 13-JC-ZZ-201 R/11 (6/18/99), Update of Valve Data Sheets and Notes for Clarification.
2. 13-MS-B07 R/3 (8/12/98), Evaluation of Dynamic Performance Parameters for Generic Letter 89-10 MOVs.
3. 01, 02, 03-EC-MA-221 R/3, R/4, R/3, (5/7/98), AC Distribution Calculation, Updated Minimum Voltage.
   a. EDC 97-00125, 1EPHBM3612/1JSIBUV671, Valve Actuator and Motor Upgrade.
   b. EDC 97-00124, 1EPHAM3511/1JSIAUV672, Valve Actuator and Motor Upgrade.
   c. EDC 97-00127, 2EPHBM3612/2JSIBUV671, Valve Actuator and Motor Upgrade.
   d. EDC 97-00126, 2EPHAM3511/2JSIAUV672, Valve Actuator and Motor Upgrade.
   e. EDC 97-00121, 3EPHBM3612/3JSIBUV671, Valve Actuator and Motor Upgrade.
   f. EDC 97-00128, 3EPHAM3511/3JSIAUV672, Valve Actuator and Motor Upgrade.
   g. EDC 98-00169, 1EPHAM3312/1JSIAHV686, Valve Actuator Upgrade Motor Replacement.
   h. EDC 98-00166, 1EPHAM3415/1JSIBHV696, Valve Actuator Upgrade Motor Replacement.
   i. EDC 98-00168, 2EPHAM3312/2JSIAHV686, Valve Actuator Upgrade Motor Replacement.
   j. EDC 97-00859, 2EPHAM3415/2JSIBHV696, Valve Actuator Upgrade Motor Replacement.
   k. EDC 98-00167, 3EPHAM3312/3JSIAHV686, Valve Actuator Upgrade Motor Replacement.
   l. EDC 98-00170, 3EPHAM3415/3JSIBHV696, Valve Actuator Upgrade Motor Replacement (Pending).
4. 01, 02, 03-EC-PK-207 R/0, R/2, R/0, (2/17/95, 2/3/95, 2/17/95), DC Battery Sizing and Minimum Voltage.
   a. EDC 98-00065, 3EPKAM4115/3JSGAUV134, Valve Actuator and Motor Upgrade.
   b. EDC 98-00068, 3EPKAM4116/3JSGAUV138, Valve Actuator and Motor Upgrade.
   c. EDC 98-00064, 2EPKAM4115/2JSGAUV134, Valve Actuator and Motor Upgrade.
   d. EDC 98-00067, 2EPKAM4116/2JSGAUV138, Valve Actuator and Motor Upgrade.
   e. EDC 98-00063, 1EPKAM4115/2JSGAUV134, Valve Actuator and Motor Upgrade.
   f. EDC 98-00066, 1EPKAM4116/2JSGAUV138, Valve Actuator and Motor Upgrade.
5. Limitorque Technical Update 98-01 and TU 98-01 Supplement 1, Actuator Output Torque Calculation.
6. 13-JS-A41 R/0 (12/18/91), Technical Study to Support G.L. 89-10 MOV Program.
7. 13-MC-SI-229 R/2 (6/18/99, PRV Sizing Calculation for SI System Valve Bonnets.
8. Unit 3 R6 through Unit 2 R8 EDC's:
   a. EDC 97-00055, 1JAFBUV34 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
   b. EDC 97-00056, 2JAFBUV34 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
   c. EDC 97-00059, 3JAFBUV34 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
   d. EDC 97-00054, 1JAFBUV35 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
   e. EDC 97-00057, 2JAFBUV35 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.

ACTION UNDER REVIEW: *(NAME/TITLE)*	REVISION:
13-MC-ZZ-217 Rev 2, Update Motor Operated Valve (MOV) GL 95-07 Gate Valve Pressure Locking Calculation.	0

PROCEDURE/PCP/TEMPORARY MODIFICATION NO.:
Calculation 13-MC-ZZ-217 Rev 2

QUESTION	RESPONSE JUSTIFICATION

f. EDC 97-00058, 3JAFBUV35 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
g. EDC 97-00233, 1JAFCUV36 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
h. EDC 97-00235, 2JAFCUV36 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
i. EDC 97-00237, 3JAFCUV36 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
j. EDC 97-00234, 1JAFAUV37 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
k. EDC 97-00236, 2JAFAUV37 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
l. EDC 97-00238, 3JAFAUV37 Stem/Stem-Nut, Valve Disc Change and Bonnet Relief Valve Addition /DMWO 00741855.
m. EDC 97-00280, 2JSGAUV134 Stem/Stem-Nut, Valve Disc Change and Actuator Upgrade/DMWO 00767747.
n. EDC 97-00282, 3JSGAUV134 Stem/Stem-Nut, Valve Disc Change and Actuator Upgrade/DMWO 00767747.
o. EDC 97-00281, 2JSGAUV138 Stem/Stem-Nut, Valve Disc Change and Actuator Upgrade/DMWO 00767747.
p. EDC 97-00283, 3JSGAUV138 Stem/Stem-Nut, Valve Disc Change and Actuator Upgrade/DMWO 00767747.
q. EDC 98-00804, 3JSIAUV651 Peak Cracking Adjustment/DFWO 00855414.
r. EDC 96-01132, 2JSIAUV655 Gear Change and Bonnet Check Valve Relief Addition/DMWO 00746122.
s. EDC 97-00337, 3JSIAUV655 Gear Change and Bonnet Check Valve Relief Addition/DMWO 00746122.
t. EDC 97-00337, 3JSIAUV656 Bonnet Check Valve Relief/DMWO 00746122.
u. EDC 97-00044, 2JSIAUV672 Actuator Upgrade/DMWO 00768975.
v. EDC 97-00046, 3JSIAUV672 Actuator Upgrade/DMWO 00768975.
w. EDC 97-00038, 1JSIBUV671 Actuator Upgrade/DMWO 00768975.
x. EDC 97-00043, 2JSIBUV671 Actuator Upgrade/DMWO 00768975.
y. EDC 97-00045, 3JSIBUV671 Actuator Upgrade/DMWO 00768975.
z. EDC 97-00250, 2JSIAHV686 Actuator Upgrade/DMWO 00787911.
aa. EDC 97-00252, 3JSIAHV686 Actuator Upgrade/DMWO 00787911.
bb. EDC 97-00249, 1JSIBHV696 Actuator Upgrade/DMWO 00787911.
cc. EDC 97-00251, 2JSIBHV696 Actuator Upgrade/DMWO 00787911.

9. SIMS WO's, As-Left Peak Cracking Values
   a. 13JSIA(B)UV651(652), SIMS WO 759321, 862201, 836251, 819636, 734937, 788236
   b. 13JSIA(B)UV672(671), SIMS WO 777774, 784227, 778713, 696518, 784226, 775810

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 1

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
2	[signature]	7/16/99	[signature]	9/2/99						

TABLE OF CONTENTS

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 2

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
2	[signature]	9/1/99	Rafael Rios	9-2-99						

1.0 PURPOSE:

Determine the level of pressure locking susceptibility of the identified PVNGS power-operated gate valves, having an active open safety function.

2.0 BACKGROUND/SUMMARY:

2.1 BACKGROUND:

Pressure locking occurs when the valve bonnet is pressurized from high process fluid pressure and the line pressure subsequently is reduced and/or when a bonnet is pressurized cold and subsequent heatup increases the pressure of fluid trapped in the bonnet above line pressure. The resultant bonnet pressure and accompanying seating forces may require an opening stem thrust above an actuator or valve thrust/ torque limit, and in some cases prevent opening of the valve.

The industry has reported events involving the failure of power-operated gate valves to open due to pressure locking and thermal binding. The NRC has issued a number of reports/notices (e.g., GL 95-07, NUREG 1275, GL 89-10 Supplement 6, and various AEOD and operating experience reports) describing these events and requesting Licensees to perform susceptibility analyses and take appropriate corrective actions. Because the gate valve pressure locking and thermal binding failure rate was determined to not have sufficiently decreased, the NRC decided to issue Generic Letter 95-07 (Reference 16) to formally require Licensees to take appropriate actions to analyze and eliminate the potential for gate valve pressure locking events.

2.2 SUMMARY:

This calculation presents the PVNGS Motor Operated Valve (MOV) Pressure Locking Analytical Model developed to predict the maximum required open thrust utilizing conservative potential pressure locking conditions based on design basis information. Those gate valves identified, in the "Gate Valve Pressure Locking and Thermal Binding Evaluation" (Reference 9), as being normally closed and having an active safety function to open are reviewed in this calculation for potential susceptibility to pressure locking . The sample results of the application of this model are then validated by comparison to representative test data.

All the identified valves evaluated in this calculation except CH-536 were initially found to be susceptible to pressure locking. Required G.L. 95-07 (Reference 16) susceptibility and operability of these valves was established in CRDR 9-5-0836 (Reference 15). This evaluation was updated to account for Limitorque Technical Update 98-01 (Reference 32) CRDR 9-8-1207 (Reference 33). The relative level of susceptibility/nonsusceptibility is established in this calculation based on the PVNGS pressure locking model and the associated modifications implemented between outages Unit 3 R5 (Fall 95) and Unit 3 R8 (Spring 2000) using the presented analytical model.

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 3

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
2	[signature]	7/16/99	Rafael Rios	9-2-99						

Table 1 shows the numerical results from the Attachment 1 Excel spreadsheet for the safety-related power-operated gate valves that were identified as potentially susceptible to pressure locking (Reference 9). This table shows the results after implementation of the recommended pressure locking modifications for the WA projects 950018, 950019, & 950020 (Phase I-Units 1, 2, & 3) and WA projects 960079, 960078, & 960070 (Phase II- Units 1, 2, & 3).

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potental CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L. 95-07 SHEET NO. 4

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
2	[signature]	9/1/99	Rafael Rios	9-2-99						

Table 1: Calculation Post Modification Results

Valve ID	Valve Size (inches-rating)	Valve Vendor	Predicted Bonnet Pressure (psig)	Total Stem Thrust Req'd/ PL (lbf)	Min. Avail. or Limiting Thrust (lbf)
AF-34/35	6-900#	Anchor/ Darling	1,880	43,718	50,000
AF-36/37	6-900#	Anchor/ Darling	1,880	43,718	50,000
SG-134/138	6-900#	Anchor/ Darling	1,383	38,248	46,270
CH-536	3-1500#	Borg-Warner	97	5413	6,940
SI-604/609	3-1500#	Borg-Warner	2,008	10,043	12,097
SI-651/652	12-1500#	Borg-Warner	2,936	160,815	179,786
SI-653/654	12-1500#	Borg-Warner	465	42,982	51,548
SI-655/656	12-300#	Borg-Warner	465	40,693	53,235
SI-671/672	8-300#	Borg-Warner	326	18,616	24,983
SI-685/694	10-330#	Borg-Warner	458	28,403	31,909
SI-686/696	20-300#	Borg-Warner	458	67,657	77,499
SI-688/693	10-300#	Borg-Warner	458	28,353	31,909

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 5

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator
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3.0 CRITERIA/ASSUMPTIONS

The following conservative assumptions (1-8) are made to ensure that the estimated maximum required stem thrust to open the identified valves in this calculation during potential pressure locking conditions are conservatively high.

1. In cases involving bonnet pressure increases due to increased bonnet fluid temperatures, the pressure in the line downstream of the valve is assumed to be zero (0) psig. The pressure in the line upstream is either assumed to be zero (0) psig or conservatively low based on design basis calculations.The line pressure reduces the differential pressure across the disk, reducing the stem thrust required to open the valve, therefore; utilizing the low design basis values for line pressure is conservative.

2. The "unwedging load" (Section 5.1.5) is assumed to be zero (0). The unwedging force theoretically aids in opening the valve, hence, assuming the unwedging load to be zero (0) is a conservative assumption.

3. The seating friction factor mu (μ) is derived as a function of the Valve Factor (VF) and Seating Angle theta (θ). This derivation is developed from the equations for the Differential Pressure presented in Reference 11 (Sections 5.1.2.4 and 5.1.3). The resulting equation is: $\mu = [VF * \cos(\theta)] / [1 - (VF * \sin(\theta))]$. Utilizing a representative valve factor of 0.6 results in a seating friction factor of 0.6307 for θ of 5^o and 0.6322 for θ of 5.25^o. These values are conservative with respect to the coefficient of friction for sliding presented by EPRI (Reference 25).

4. The valve body is conservatively modelled as a rigid structure when analyzing the load transferred from the perimeter of the valve gate disks to the valve body seats. Actual elastic deformation of the valve body seat when loaded by the valve gate disk results in a lower seat load than that obtained by modelling the seats as rigid structure. A reduction in the normal load results in a reduction in the "Seat Friction Load" and the resultant actuator thrust.

The valve gate and valve body are conservatively modelled as a rigid structure in determining the effects of differential pressure across the valve on seat loads. Differential pressure across the gate valve applied to the vertical cross-sectional area of the gate "hub" causes a transfer of a portion of the normal force from one seat to the other, however, with a rigid disk the normal load on the two seats combined is unchanged. Therefore, the effect of the differential pressure may be conservatively neglected when establishing the stem thrust required to open the valves during "pressure locking" conditions.

The valve disk is modelled conservatively as an elastic structure to maximize the seat friction load during "pressure locking" conditions. The model is described in more detail in Criteria/Assumption #7.

5. Conservative values for the valve factor (VF) are used throughout this calculation. These values are from the specific open valve factors for the individual valves found in Reference 1 and/or Reference 28. Conservative specific test values of VF per reference 28 are utilized for modifications to SI-604/609. SI-651/652, SI-653/654, SI-655/656, & SI-672/671. Reduced VF values are utilized for modifications to

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 6

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
1	[signature]	12/10/96	[signature]	12/12/96						

AF-34/35, AF-36/37, SI-685/694, SI-686/696, & SI-688/693 based on expected modification test results.

6. When the stem moves upward in the bonnet to engage the lugs in the upper portion of the gate the bonnet volume is increased slightly reducing the specific volume but significantly reducing the bonnet pressure. The drop in pressure due to stem movement out of the valve bonnet is conservatively neglected in this calculation.

7. The model used to establish the normal force on the valve seat (see Fig. 2) assumes (a) the disks are flat, uniform in thickness, and of homogeneous isotropic material; (b) the thickness is not more than about one-quarter of the least transverse dimension, and the maximum deflection is not more than about one-half the thickness; (c) all forces, loads and reactions are normal to the plane of the plate; and (d) the plate is nowhere stressed beyond its elastic limit. Although the disks of the gates do not strictly meet assumption (b), use of this "thin plate" model conservatively estimates the disk perimeter line load, and therefore conservatively estimates the normal force in the seat. The use of this model is consistent with the methodology employed by Borg-Warner in the original design report (Ref. 10). A thin plate model predicts greater flex in the disk, and a corresponding higher load in the seat, than would actually be present for the relatively thick disks of these gate valves. Therefore, use of the thin plate model results in additional conservatism in prediction of the stem thrust required to open the valve.

8. Many of the gate valve dimensions/tolerances are considered proprietary information by the vendors, Anchor Darling and Borg-Warner. The gate dimensions of similar spare gate valves were measured in the PVNGS Warehouse and verified and compared with vendor supplied information. Dimensions were confirmed to be conservative for this calculation. The disk hub and seat angle dimensions are recorded in Attachment 3 for use in this calculation. The valve Seat Radius dimensions were taken from Reference 1.

Other significant assumptions/criteria, not identified explicitly in the base of the calculation, are identified below:

9. The mean diameter of the seat is used to establish the portion of the valve gate disk susceptible to internal valve pressure. This assumption is consistent with the methodology used in the initial Borg-Warner design report (Ref. 10) and that recommended by EPRI (Ref.11) in their design guidelines.

10. The initial load in the valve seat, the seating load, is developed during valve closure by compression of the gate hub and bending the perimeter of the valve disks inward. This hub compression is partially relieved as the stem begins to travel upward, however, the majority of the compressive load remains in the hub due to the flex remaining in the perimeter of the disks. As pressurization of the bonnet takes place, the perimeter of the disks is forced outward by the bonnet pressure relieving a portion of the initial compression on the hub and the initial bending in the disks. A further increase in the bonnet pressure bends the perimeter of the disks outward loading the seats beyond the initial seating load and begins to place the gate hub in tension. This outward flex in the disks creates the "friction load" identified in

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 7

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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place the gate hub in tension. This outward flex in the disks creates the "friction load" identified in Section 5.1.2.

11. The weight of the valve stem and disk assembly is negligible (Ref. 1).

12. Conservative values for the stem/stem-nut coefficient are used throughout this calculation. These values are taken from Reference 1 and/or Reference 28.

13. A nomimal seat angle value of 5^{o} is used throughout this calculation unless otherwise specified. This value is found to be consistant with available vendor information, various field observations and Ref 10.

14. An average value for Poisson's ratio of 0.3 is used in this calculation to evaluate the value of the constants used in Roark's equation for perimeter load (Reference 12, Table 24, Case 2d) used to determine the disk load. These results of these equations are not very sensitive to the specific value used for Poisson's ratio. This value is established as representative based on evaluation of Table 5.1.3, Elastic Constants of metals in Mark's Standard Handbook (Reference 17). Mark's Standard Handbook lists a Poisson's ratio for Stainless Steel of 0.305 and a Poisson's ratio for steels, including high-carbon, heat treated, in the range of 0.283 to 0.292.

15. The original Actuator Rated Thrust Limit is increased 140% for nomal conditions for SMB-000, SMB-00, SMB-0, SMB-1 actuators. The total number of cycles under this increased thrust limit is limted to 2000 cycles. This increase of the original published Actuator Rated Thrust Limit supported by Reference 18 is endorsed by Limitorque in Reference 22.

16. Limitorque Engineering considers any size SMB actuator capable of withstanding a one-time allowable overload of up to 2 1/2 times the thrust load and up to 2 times the published torque load rating without damage or sacrifice to the actuator qualification per reference 31. This one-time actuator allowable is utilized for the Shutdown Cooling System isolation valve modifications to SI-651/652, SI-653/654, & SI-655/656.

17. Pullout efficiencies identified in Calculation 13-JC-ZZ-201 (reference 1) are typically used in actuator/thrust output determinations.

18. The minimum voltage used in this calculation is the available percentage of the motor rated voltage. These minimum voltages are developed from 01, 02, 03-EC-MA-221 (Ref. 35) and 01, 02, 03-EC-PK-207 (Ref. 36) for AC and DC MOV's respectively. In some cases the specific available minimum voltages are based on running unseating voltage and specific motor characteristics. Running currents after starting can be assumed when determining the worse case degraded voltage condition for MOV's with hammerblow or spring compensator pack since these devices allow the motor to reach running conditions prior to valve unseating. (13-MC-ZZ-201 (Ref 1, 4.2.3) and IEEE 1290 (Ref 34, 4.3))

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 8

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator
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4.0 INPUT DATA

The input data is included in the "Pressure Locking Susceptibility Evaluation" spreadsheet (Attachment 1). Table 2 below includes the values along with the references from which these values were obtained. Additional definition of terms along with common reference sources for the balance of the input data is included in the listing which follows this table.

Table 2: System Inputs

Valve ID	Tinitial (F)	Tfinal (F)	Pinitial (psig)	Pup (psig)	Pdown (psig)
AF-34/35	104 (Ref. 2)	123 (Ref. 2)	1801 (Ref. 26)	0 (Asmpt. 1)	0 (Asmpt. 1)
AF-36/37	104 (Ref. 2)	125 (Ref. 2)	1816 (Ref. 26)	0 (Asmpt. 1)	0 (Asmpt. 1)
SG-134/138	587 (Note 1)	587 (Note 1)	1383 (Ref. 4)	650 (Ref. 29)	0 (Asmpt. 1)
CH-536	104 (Ref. 2)	104 (Ref. 2)	97 (Ref. 8)	0 (Asmpt. 1)	0 (Asmpt. 1)
SI-604/609	104 (Ref. 2)	120 (Ref. 19)	1960 (Note 4)	660 (Note 2)	0 (Asmpt. 1)
SI-651/652	120 (Ref. 3)	160 (Ref. 20)	2561 (Ref. 6)	465 (Ref 6)	5 (Note 5)
SI-653/654	120 (Ref. 3)	160 (Ref. 20)	465 (Ref. 6)	465 (Ref 6)	5 (Note 5)
SI-655/656	104 (Ref. 2)	120 (Ref. 20)	470 (Ref. 6)	465 (Ref 6)	12 (Note 5)
SI-671/672	104 (Ref. 2)	104 (Ref. 2)	326 (Ref. 6)	5 (Note 5)	0 (Asmpt. 1)
SI-685/694	104 (Ref. 2)	104 (Ref. 2)	458 (Ref. 6)	12 (Note 5)	12 (Note 5)
SI-686/696	104 (Ref. 2)	104 (Ref. 2)	458 (Ref. 6)	12 (Note 5)	12 (Note 5)
SI-688/693	104 (Ref. 2)	104 (Ref. 2)	458 (Ref. 6)	13 (Note 5)	13 (Note 5)

NOTES:

1. Temperature is based on saturation temperature of steam at maximum pressure of 1383 psig (1398 psia) from Reference 4.
2. Pressure is based on lowest available total dynamic head at maximum flow of HPSI Pumps (Ref 23).
3. DELETED
4. Pressure is based on maximum upstream pressure at valves due to HPSI Pump total dynamic head (Ref. 5).
5. Piping Pressure (P_{up} & P_{down}) is conservatively based on Minimum RWT Level (Ref 6).

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 9

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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SYSTEM INPUTS: (Table 2)

$T_{initial}$ = Initial Bonnet Temperature
T_{final} = Final Bonnet Temperature
$P_{initial}$ = Initial Bonnet Pressure
P_{up} = Upstream Piping Pressure
P_{down} = Downstream Piping Pressure

VALVE INPUTS

a = Mean Seating Radius = Mean Seating Diameter/2 (Attachment 3)
b = Hub Radius = Hub Diameter/2 (Attachment 3)
θ = theta = Seat Angle (Attachment 3)
ν = nu = Poisson's Ratio (Assumption 14)
VF = Valve Factor (Assumption 5)

VALVE STRUCTURAL LIMIT

Thrust = Valve Thrust (Ref. 1)
Torque = Valve Torque (Ref. 1)

MOV ACTUATOR/STEM INPUTS

OAR = Overall (Gear) Ratio (Ref. 1)
P.O. Ef = Pullout Efficiency (Ref 1)
COF = Stem Coefficient of Friction (Assumption 12)
Dstem = Diameter of Stem (Ref 1)
Pstem = Stem Thread Pitch (Ref. 1)
Lstem = Stem Thread Lead (Ref. 1)

ACTUATOR STRUCTURAL LIMITS

Thrust = Actuator Thrust (Ref. 1)
Torque = Actuator Torque (Ref. 1)

MOTOR INPUTS

Vfull = Motor Rated Voltage (Ref. 1)
Vmin = Minimum Voltage (Assumption 18) |
VDF = Voltage Degradation Factor (Section 5.1.9.2)
M_{torq} = Rated Motor Torque (Ref. 1)
n = Voltage Degradation Factor Exponent, n = 1 for DC & n = 2 AC motors (Ref. 1)
TDF = Temperature Degradation Factor (Ref. 1)

MOV MISC INPUTS

Max Close Load = Maximum Closure Thrust (Ref. 1)
% Residual Load = Coefficient of Residual Maximum Closure Thrust (Assumption 10)

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 10

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
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5.0 CALCULATIONS/RESULTS

The term "Pressure Locking" is applied to a condition in which pressurization of the bonnet of a gate valve beyond the adjacent line pressure results in a higher stem thrust than the actuator is capable of delivering, preventing opening of the valve.

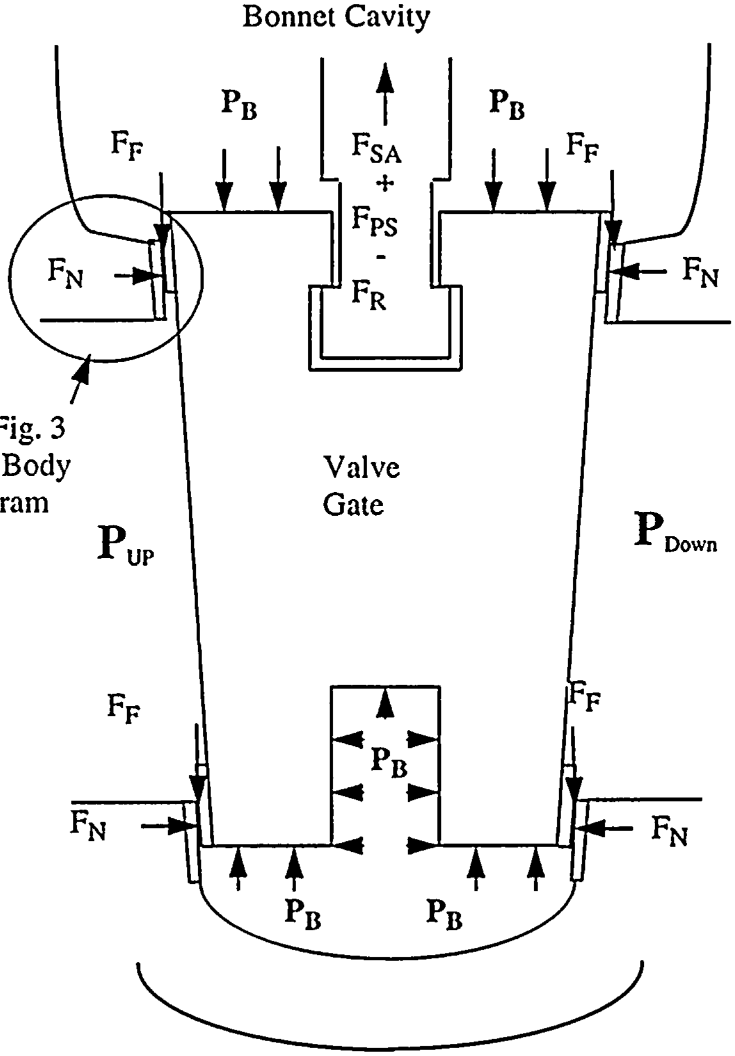

Figure 1:
Valve Gate/Body/Bonnet Interface

F_N= Normal Force at Seat
F_F =Friction Force Between Seats
F_{SA}=Stem Force of Motor Actuator
F_{PS}=Stem Piston Effect Force
F_R = Stem Force due to Residual Closing Load
P_{UP}=Pressure in Upstream Piping
P_{Down}=Pressure in Downstream Piping
P_B= Bonnet Pressure

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 11

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
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5.1 Calculation Methodology

If potential "Pressure Locking (PL)" condition occurs, the following forces may be affecting the stem thrust required of the actuator to open the valve (see Figure 1):

Packing Load (Pkgld)- The load (opposed to valve motion) due to friction between the stem and the packing. This load is included in the value used for the Residual Load.

Disk Load (F_{disk})- The load (opposed to valve motion) transmitted to the valve stem due to friction between the seating surface of the gate and the seat of the valve body created by application of a differential pressure between the internals of the valve and the piping across the disks of the gate.

Hub Load (F_{hub}) The additional load transmitted to the valve stem due to friction between the seating surface of the gate and the seat of the valve body created by the upstream and downstream piping differential pressure acting on the area of the disk hub.

Residual Load (F_{resid})- The Load opposing valve opening caused by wedging the valve gate into the seat. This load includes running loads.

Vertical Load (F_{vert})- The vertical unbalanced load forcing the gate into the seat created by the bonnet pressure on the valve gate.

Unwedging Load- The force in the open direction due to the mechanical advantage of the seat angle when valve internal pressure is applied to the inner surface of a gate disk. The disk acts as a wedge being pushed up an incline. This load is conservatively neglected (Assumption 2).

Stem Piston Load (F_{piston})- A load in the open direction created by application of the differential pressure between the valve internals and the ambient pressure on the net cross-sectional area of the valve stem. The net affect is to drive the stem, like a piston, out of the valve.

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 12

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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5.1.1 Packing Load-

The packing load is conservatively approximated in "MOV Thrust and Actuator Sizing Calculation" (Ref. 1) by using the empirical equation of:

$$\textbf{Packing Load (Pkgld)} = D_{stem} \times 1000 \text{ lbf}$$

This is consistent with EPRI recommended methodologies for calculation of Packing Load (Ref.4). This load is included in the value used for the Residual load (F_{resid}).

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
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5.1.2 Disk and Hub Load

5.1.2.1 Disk Load-

The Disk Load (F_{disk}), the load at the valve stem due to friction at the interface of the valve gate and valve body seat, is a function of the force normal to the seat, the angle between the plane of the valve seat and the valve stem axis, and the coefficient of friction at the valve seat. The normal force at the seat is a function of the valve internal (bonnet) pressure, the pressure in the piping upstream and downstream of the valve, as well as the cross-sectional areas upon which the pressures are applied. Many of the forces on the disk of the gate are balanced by forces of equal magnitude but opposite in direction (Reference Figure 1). Only the unbalanced forces on the disk contribute to the normal load on the seat.

For the purpose of determining the Seat Friction Load, the unbalanced load applied on each seat can be conservatively estimated by modelling the flex-wedge gate valve as a parallel disk gate valve. The hub connecting the two disks of the gate is modelled as a rigid, fixed structure. The force applied across the disk due to the difference in bonnet pressure and line pressure results in a deflection of the outer perimeter of the seat and resultant normal load on the seat (see Figure 2).

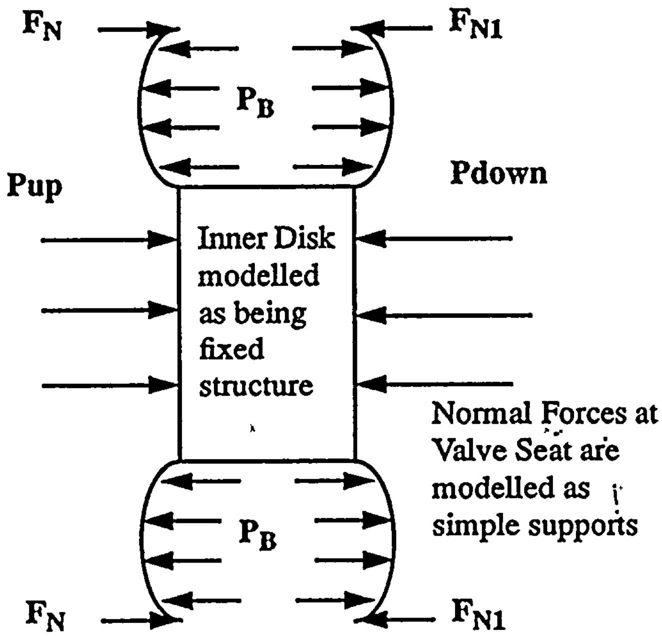

Figure 2: Model Utilized in Calculating the Forces on the Disk in the Axis of the pipe

The force on the seat at the perimeter of the disks, due to disk deflection, (F_N in Figure 3) will be conservatively assumed to be the net unbalanced horizontal force on the gate due to Bonnet Pressure

(F_{BG} in Figure 3). The friction force (F_F in Figure 3) lies in the plane of the valve seats and places a load on the stem (F_F (cos 5^o). The full friction force will be conservatively assumed to be transmitted to the valve stem.

F_{BW}= Net Vertical Force on Gate due to Bonnet Pressure

F_{BG}= Net Horizontal Force on Gate due to Bonnet Pressure

F_F= Friction Force between Gate Seat & Valve Body Seat

F_{LP}= Force on Gate due to Line Pressure on one side of Gate

F_N= Normal Force of Seat (opposing disk deflection)

F_S= Net Stem Force required at Stem/Gate interface to unseat Gate

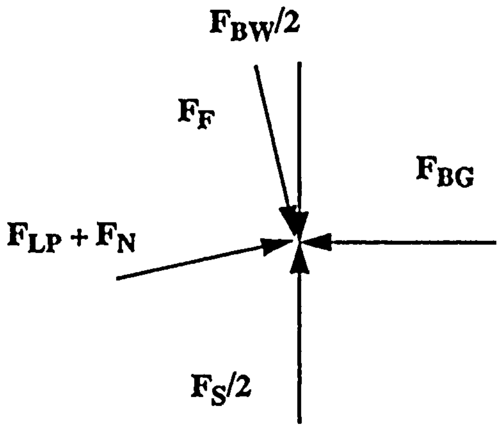

Figure 3: Free Body Diagram of the Valve Seat

The Disk Load conservatively taken to be the horizontal disk load caused by the differential pressure between the average line pressure and the bonnet pressure at both of the seats is given by:

Disk Load (F_{disk}) = $2(Q_a)P_L(\mu)$

with,

P_L= length of Disk perimeter= $2\pi a$

μ= Coefficient of Friction at Valve Seat = $[VF*\cos\theta]/[1-(VF*\sin\theta)]$ Assumption 3)

Q_a = Force/inch exerted at the perimeter of the gate disk

where,

$Q_a = -[Q_b(b/a)-((P_b-P_{ave})/2a)(a^2-r^2)]$ (Ref. 12, Table 24, Case 2d)

$Q_b = (P_b-P_{ave})(a)[C_2(L_{17})-C_8(L_{11})]/[C_2(C_9)-C_3(C_8)]$ Note: $q = (P_b - P_{ave})$

$C_2= 0.25\{1-(b/a)^2[1+2\ln(a/b)]\}$

$C_3= (b/4a)\{[(b/a)^2+1]\ln(a/b)+(b/a)^2-1\}$

$C_8= 0.5[1+\nu+(1-\nu)(b/a)^2]$

$C_9= (b/a)\{[(1+\nu)/2]\ln(a/b)+[(1-\nu)/4][1-(b/a)^2]\}$

$L_{11}= 0.015625\{1+4(r/a)^2-5(r/a)^4-4(r/a)^2[2+(r/a)^2]\ln(a/r)\}$ Note: r = b

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
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$L_{17} = 0.25\{1-[(1-v)/4][1-(r/a)^4]-(r/a)^2[1+(1+v)\ln(a/r)]$

and,

$P_b = P_B$ = Valve Bonnet (Valve Internal) Pressure
P_{ave} = Average Line Pressure $(P_{up} + P_{down})/2$
P_{up} = Line pressure upstream of the Valve Gate
$P_{down} = P_{DP}$ = Line pressure downstream of the Valve Gate
b= Radius of Hub between Valve Gate Disks
a= Mean Radius of Disk Seat
r= Minimum Radius of Disk subjected to pressure
v= Poisson's ratio

5.1.2.2 Hub Load

The Hub Load (F_{hub}), The additional load at the valve stem due to friction at the interface of the valve gate and valve body seat as a result of the differential pressure between the upstream and downstream piping pressure acting on the area of the disk hub.

Hub Load $(F_{hub}) = Q_a' P_L(\mu)$

with,

P_L= length of Disk perimeter= $2\pi a$
μ= Coefficient of Friction at Valve Seat = $[VF*\cos\theta]/[1-(VF*\sin\theta)]$ (Assumption 3)
Q_a'= Force on the perimeter of the disk at the seat ring at the low pressure disk due to differential upstream and downstream piping pressure

where,

$Q_a' = W(b/a)$ (Ref. 12, Table 24, Case 1b & 2d)
$W = Q_b' + q'\pi b^2/2\pi b = (Q_b/DP_{avg}+b/2)(P_{up}-P_{down})$ Note: $q' = (P_{up} - P_{down})$
$Q_b' = (Q_b/DP_{avg})(P_{up}-P_{down})$ (Section 5.1.2.1)

5.1.3 Residual Load

The residual load is the load opposing valve opening caused by wedging the valve into the seat during closing. This empirically derived load includes the running loads. This load is adjusted to compensate for the relaxation in the wedging load which occurs when stem motion is initiated in the open direction and the substitution with the bonnet pressure induced load that has been determined to replace increasing proportions of the residual load as the bonnet pressure increases (Criteria/Assumption 10). The residual load is calculated by taking the peak cracking load identified in Reference 1, inclusive of inertia and instrument uncertainty, and dividing by 0.67 and multiplying by a residual coefficient which is developed from the experimentally derived corrolation presented in Appendix 4. This corrolation was established based on test results (Attachment 5). This corrolation indicates that as the bonnet pressure increases the residual load percentage of the effective closing thrust is reduced. The following resulting relationship

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 16

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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for the Residual Load are used:

Residual Load (F_{resid}) = ($F_{eff.\ closing}$) (C_{resid})

$F_{eff.\ closing}$ = Effective Closing Force

where,

$F_{eff.\ closing}$ = Static Peak Cracking/0.67 (Ref. 1)

C_{resid} = Coefficient of Residual Load (Attachment 4)

The Coefficient of Residual Load is the emphirically derived coefficient that assumes 33% relaxation in load between closure and when the open stem motion is initiated (with zero bonnet pressure) and a reduction in the residual load due to a proportional replacement by the effect of the bonnet pressure load. The static peak cracking is value of the unwedging load with zero bonnet pressure.

The static peak cracking (with zero bonnet pressure is divided by 0.67 to determine the effective closing thrust using 33% relaxation in the wedging load. This is similar to the coefficient utilized in the EPRI MOV Performance Prediction Program Topical Report (Ref 14) for correlating test data to develop a simplified unwedging thrust equation.

The product of the Static Peak Cracking/0.67 is then multiplied by the experimentally derived coefficient (C_{resid}) based on the ratio of the bonnet pressure/effective closing thrust.

5.1.4 <u>Vertical Load</u>-

The vertical load is the force due to bonnet pressure (P_b) driving the gate into the seat. This vertical unbalanced load across the valve disk is driven by the differential pressure between the bonnet and average of the upstream and downstream piping pressure directed into the valve seat ($Pb - (P_{up} + P_{down})/2$). The vertical load is conservatively calculated by multiplying the average differential pressure between the valve bonnet and the average of the upstream and downstream pressure by the unbalanced horizontal area of the gate disks. The unbalanced horizontal area is a sum of the two ellipses projected on to the horizontal plane whose perimeter is bounded by the seat inside perimeter. The actual force down on the disk is due to the horizontal projection of the circular geometry of the seat which the unbalance differential pressure (P_b-P_{avc}) is applied across. The net cross-sectional area of each gate disk seat which

the pressure acts upon is an ellipse (see Figure 4).

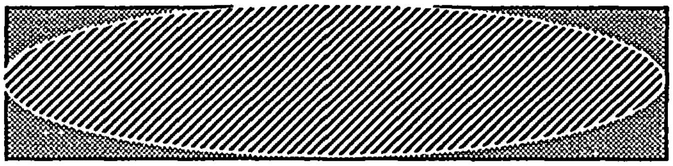

Figure 4: Plan View of Net Cross-Sectional Area on which the Bonnet Pressure may be Applied for a Single Disk of a Valve Gate
(Elliptical Area is the Effective Area which DP is applied across)

The Vertical Load is then:

$$\textbf{Vertical Load } (F_{vert}) = (A_e)(P_b - P_{up}) + (A_e)(P_b - P_{down})$$

$$2(A_e)\,(P_b - (P_{up} + P_{down})/2)$$

conservatively assuming,

$$P_{avg} = (P_{up} + P_{down})/2$$

$$F_{vert} = 2(A_e)(P_b - P_{ave})$$

$$= 2(\pi(\sin(\theta))a^2(P_b - P_{ave})$$

where, A_e = Elliptical Area, Effective Single Seat Area projected on to the horizontal plane susceptible to differential pressure.

$A_e = \pi(a)d = \pi(\sin(\theta))a^2$

- a = Ellipse major Radius = $D_{seat}/2$
  - D_{seat} = Diameter of Seat (inches)
- d = Ellipse minor Radius = $(\sin(\theta)(D_{seat}))/2$
- θ = theta = Seat Angle (degrees)

and,

P_b = Bonnet Presure (psig)

P_{up} = Upstream Piping Pressure (psig)

P_{down} = Downstream Piping Pressure (psig)

$P_{ave} = (P_{up} + P_{down})/2$ (psig)

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator
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5.1.5 Unwedging Load-

This load is conservatively assumed to be zero in calculating the Required Stem Thrust to overcome a potential Pressure Locking condition, therefore, the following discussion is included to provide a measure for the relative degree of conservatism associated with this assumption. Application of the horizontal Disk Load (F_{disk}) (identified as F_{BG} in Figure 3 and quantified as $F_{BG} = Q_aP = 2\pi a Q_a$ per the analysis of Disk Load in section 5.1.2) caused by Bonnet Pressure to the inclined valve seat can be theoretically represented as two force vectors, a vector normal to the seat , and a vector coplanar with the seat. The force vector coplanar to the seat is $F_{BG}(\sin 5^o)$ and the vertical component of this vector (parallel to stem axis) for both seats is the Unwedging Load=2 $F_{BG}(\sin 5^o)(\cos 5^o)$. Since $F_{disk} = 2F_{BG}(\cos 5^o)(\mu)$, with μ=0.5680 the Unwedging Load may be expressed as:

Unwedging Load= $F_{disk}(\sin 5^o)/0.5680 = 0.153\ F_{disk}$

Neglecting the Unwedging Load can theoretically result in a conservatism of up to roughly 15% of the Disk Load (F_{disk}).

5.1.6 Stem Piston Load-

The Stem Piston Load is conservatively determined by calculating the product of the bonnet pressure and the stem cross-sectional area (Ref. 11):

Stem Piston Load $(F_{piston}) = (\pi/4)(D_{stem}{}^2)P_B$

5.1.7 The Total Required Stem Thrust -

The total required stem thrust is the sum of these various forces acting on the stem. If the "unwedging force" is neglected the total required stem thrust can be calculated as:

Required Stem Thrust = Disk load + Hub Load + Vertical Load + Residual Load - Stem Piston Load

$$(F_{total}) = (F_{disk}) + (F_{hub}) + (F_{vert}) + (F_{resid}) - (F_{piston})$$

5.1.8 Bonnet Pressure and Average Differential Pressure

5.1.8.1 Bonnet Pressure

The relationship between bonnet pressure and temperature used to evaluate the effects of bonnet water temperature increases on bonnet pressure was developed based on testing of a PVNGS spare 10" Borg-Warner gate valve at Commonwealth Edison's Braidwood Station test facility. The water solid valve assembly was heated in separate tests at different heat rates and the internal bonnet fluid temperature and pressure were recorded at various time intervals. This test data is compared to theoretical pressurization and the model presented below and in Attachment 2 to identify the relative apparent conservatisms and validate this Bonnet Pressurization Model.

CALCULATION SHEET

CALC. TITLE: Gate Valve Open Thrust Required during Potential — CALC. NO: 13-MC-ZZ-217

SUBJECT: Pressure Locking Conditions per G.L 95-07 — SHEET NO. 19

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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The heat-up testing indicates two distinctive pressurization regions. The first region [Region I] which indicates the initial 60 °F bonnet temperature increase can be conservatively modeled using a pressurization rate of 3 psig/ °F, the maximum dP/dT identified in Region I. Although the first region spans the first 60 °F bonnet fluid temperature increase, additional conservatism was added by assuming this gradual pressurization rate (3 psig/ °F) through only the first 30 °F of the thermal transient. Then for Region I,

$dP_I/dT = 3$ psig/°F [Region I, first 30 °F temperature change only]

$P_I = P_0 + 3 \text{ psig/}^oF(T_2 - T_1)$

where P_0 is the initial bonnet pressure and P_I is the bonnet pressure increase in Region I. If $T_2 - T_1$ is greater than 30 °F, substitute 30 °F for $T_2 - T_1$.

The second region [Region II] which includes the bonnet temperature increase greater than 60 °F can be conservatively modelled using the highest two applicable pressurization rates: 42 psig/ °F at 150 °F and 65 psig/ °F at 290 °F. For Region II ($T_2 - T_1$ must be greater than 30 °F),

$dP_{II}/dT = mT + b$ [Region II, after first 30 °F temperature change only]

where:

$m = (65 \text{ psig/}^oF - 42 \text{ psig/}^oF)/(290\,^oF - 150\,^oF) = 0.16429 \text{ psig/}^oF^2$

$b = 42 \text{ psig/}^oF - (0.16429 \text{ psig/}^oF^2)(150\,^oF) = 17.3565 \text{ psig/}^oF$

Thus, dP/dT becomes:

$dP_{II}/dT = (0.16429 \text{ psig/}^oF^2)T + 17.3565 \text{ psig/}^oF$

Integrating the Region II dP/dT equation from an initial Region II temperature (T_1 + 30 °F) to a final Region II temperature (T_2) yields the following equation:

$$P_{II} = 0.08215 \text{ psig/}^oF^2(T_2^2 - (T_1 + 30)^2) + 17.3565 \text{ psig/}^oF(T_2 - (T_1 + 30)) \text{ [Region II]}$$

The Region I and Region II pressure equations can be added together to determine the total pressure increase due to a bonnet fluid temperature increase from T_1 to T_2, this equation can be expressed in two forms depending on the magnitude of the bonnet temperature increase.

This first equation applies to temperature increases less than or equal to 30 °F ($T_2 - T_1 <= 30$ °F):

$$P_I = Pb = P_0 + 3 \text{ psig/}^oF(T_2 - T_1)$$

This second equation applies to temperature increases greater than 30 °F ($T_2 - T_1 > 30$ °F):

$$P_{TOTAL} = P_b = P_0 + 90 \text{ psig} + 0.08215 \text{ psig/}^oF^2(T_2^2 - (T_1 + 30)^2) + 17.3565 \text{ psig/}^oF(T_2 - (T_1 + 30))$$

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 20

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
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5.1.8.2 Average Differential Pressure

$$DP_{avg} = P_b - ((P_{up} + P_{down})/2)$$

DP_{avg} = Average Differential Pressure

P_{up} = Piping Upstream Pressure

P_{down} = Piping Downstream Pressure

5.1.9 <u>Available Torque and Thrust Limits</u>

This section of the methodology is taken from the "MOV Thrust and Actuator Sizing Calculation" ,Reference 1. The available Motor Torque is derived utilizing the rated motor torque, overall gear ratio, Pullout efficiency, voltage degradation factor, temperature degradation factor and the stem factor similar to Reference 1. The minimum limiting Thrusts and Torques for the valve and actuator are identified. The torque values are converted to thrust values utilizing an updated derived stem factor similar to that in Reference 1 but with a stem/stem-nut coefficient of friction of 0.12 (Assumption 12).

5.1.9.1 Stem Factor

$$FS = (D * ((0.96815 * \tan \alpha) + COF))/(24 * (0.96815 - (COF * \tan \alpha)))$$ (Reference 1)

FS = Stem Factor

D = Acting Thread Diameter (inches) = $D_{stem} - (0.5 * P_{stem})$

D_{stem} = Stem Diameter (inches)

P_{stem} = Stem Pitch (inches/thread)

COF = Stem/Stem Nut Coefficient of Friction (Assumption 12) |

Tan α = Tangent of thread helix angle = $L_{stem} /(\pi * D)$

L_{stem} = Stem Lead (inches/revolution)

π = Ratio of circumference to diameter = 3.141592654...

5.1.9.2 Available Torque

$$A_{torq} = M_{torq} * OAR * P.O. Ef * VDF * TDF$$ (Reference 1)

OAR = Overall (Gear) Ratio

A_{torq} = Available Torque

M_{torq} = Rated Motor Torque

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 21

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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P.O. Ef = Pullout Efficiency (Reference 1)

5.1.9.2.1 VDF = Voltage Degradation Factor (Reference 24)
V_{min} = Minimum Voltage
V_{full} = Motor Rated Voltage

5.1.9.2.1.1 VDF and related Factors for AC Motors (Reference 33)
If $V_{min}/V_{full} >= 0.9$ Then use 0.9
If $V_{min}/V_{full} < 0.9$ Then use 0.9 and $(V_{min}/V_{full})^2$ Factors

1.9.2.1.1 VDF for DC Motors (Reference 34)
Use 1.0 and $(V_{min}/V_{full})^1$ Factors

5.1.9.2.2TDF = Temperature Degradation Factor (Reference 1 App. M)

5.1.9.3 Available Thrust

$A_{thrust} = A_{torq} /SF$ (Reference 1)
A_{thrust} = Available Thrust

5.1.9.4 MOV Minimum Available Thrust or Torque Limit

Thrust Limits
A = Valve Structural Thrust Limit (Reference 1)

B = Actuator Structural Thrust Limit (Reference 1)

C = Available Thrust (Section 5.1.9.3)

Torque Limits
D = Actuator Structural Torque Limit / Stem Factor (Ref. 1/Section 5.1.9.1)

E = Valve Structural Torque Limit / Stem Factor (Ref. 1/Section 5.1.9.1)

The mimimum limiting case from the above listed parameters A, B, C, D or E is controlling.

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 22

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
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5.1.10 Pressure Lock Susceptibility

Pressure Lock susceptibility is checked by comparing the minimum limiting value of the available thrust, allowable torque and thrust limits for the valve and actuator (Section 5.1.9) to the "Total Required Stem Thrust" for potential pressure locking conditions (Section 5.1.7). A valve is identified as susceptible to pressure locking when the conservatively calculated "Total Required Stem Thrust" exceeds the identified minimum limiting value of torque or thrust.

If (Total Required Stem Thrust) > (MOV Minimum Thrust or Torque Limit)

$$\text{If } F_{total} > F_{min}$$

then the MOV is susceptible to pressure locking

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator
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5.2 Calculation

The following hand calculation is applicable to the 3" Borg Warner 1500# gate valve 1SI-604 and is presented as a representative check to validate the results of the Excel computer spread sheet calculations in Attachment 1. A calculator with 10 digit floating point significant figures with standard rounding is used for this hand calculation. Efforts were taken to maintain as much precision as reasonable when working through each equation to minimize the effects of rounding. The maximum available Excel spreadsheet full precision was utilized in the calculation of loads and determination of coefficients and factors presented in Attachment 1. |

5.2.1 Bonnet Pressure

Input Data

$T_1 = T_{initial} = 104\ ^oF$

$T_2 = T_{final} = 120\ ^oF$

$P_o = P_{initial} = 1{,}960$ psig

Output Data

$\Delta T = T_2 - T_1 = 120\ ^oF - 104\ ^oF = 16\ ^oF < 30\ ^oF$ (Use Equation for P_I Section 5.1.8)

$P_b = P_{final} = P_I = P_o + 3$ psig/^{o}F(T2 - T1) = 1,960 +3(120-104) = 2,008 psig

5.2.2 Average Differential Pressure

Input Data

$P_{up} = 660$ psig

$P_{down} = 0$ psig

Output Data

$DP_{avg} = P_b - ((P_{up} + P_{down})/2) = 2008 - ((660 + 0)/2) = 1{,}678$ psig

5.2.3 Stem Factor

Input Data

$D_{stem} =$ 0.875 (in.)

$P_{stem} =$ 0.16667 (in./thread)

COF = 0.20 |

L_{stem} = 0.33333 (in./rev)

Output Data

$D = D_{stem} - (0.5 * P_{stem}) = 0.875 - (0.16667/2) = 0.79166$ (in.)

$\text{Tan}\ \alpha = L_{stem} / (\pi * D) = 0.33333/(\pi * 0.79166) = 0.13402$

$FS = (D * ((0.96815 * \text{Tan}\ \alpha) + COF))/(24 * (0.96815 - (COF * \text{Tan}\ \alpha)))$

$= (0.79166((0.96815*0.13402)+0.2))/(24*(0.96815-(0.20*0.13402) = 0.011555$ |

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 24

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi- cator ↓
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5.2.4 Available Torque

Input Data

M_{torq} = 15 ft-lbs

OAR = 36.2

P.O. Ef = 0.4

V_{min} = 414 volts

V_{full} = 460 volts

n = 2 (for AC motors)

TDF = 0.97

Output Data

V_{min}/V_{full} = (414/460) = 0.9; Then use VDF = 0.9

$A_{torq} = M_{torq}$ * OAR * P.O. Ef * VDF * TDF

= 15(36.2)(0.4)(0.9)(0.97) = 189.62 ft-lbf

5.2.5 Available Thrust

Output Data

$A_{thrust} = A_{torq}$ /SF = 189.62/.011555 = 16,410 lbf

5.2.6 Disk Load & Hub Load

Input data

b = r = 1.11 (in.) (Attachment 3)

a = 1.375 (in.) (Attachment 3)

ν = nu = 0.3 (Section 3.0 14.)

θ = theta = 5.25° (Attachment 3)

μ = mu = [VF*Cos θ]/[1-(VF*Sin θ)]

[0.5*cos(5.25°))/(1-(0.5*sin(5.25°))] = 0.5218

Output Data

Perimeter Load

$C_2 = 0.25\{1-(b/a)^2[1+2\ln(a/b)]\} = 0.25\{1-(1.11/1.375)^2[1+2\ln(a/b)]\} = 0.0173$

$C_3 = (b/4a)\{[(b/a)^2+1]\ln(a/b)+(b/a)^2-1\}$

$= (1.11/(4(1.375))\{[(1.11/1.375)^2+1]\ln(1.375/1.11)+(1.11/1.375)^2-1\} = 0.0010$

$C_8 = 0.5[1+\nu+(1-\nu)(b/a)^2] = 0.5[1+0.3+(1-0.3)(1.11/1.375)^2] = 0.878$

$C_9 = (b/a)\{[(1+\nu)/2]\ln(a/b)+[(1-\nu)/4][1-(b/a)^2]\}$

$= (1.11/1.375)\{[(1+0.3)/2]\ln(1.375/1.11)+[(1-0.3)/4][1-(1.11/1.375)^2]\} = 0.161$

$L_{11}= (0.015625)\{1+4(r/a)^2-5(r/a)^4-4(r/a)^2[2+(r/a)^2]\ln(a/r)\}$

$= (0.015625)\{1+4(1.11/1.375)^2-5(1.11/1.375)^4-4(1.11/1.375)^2[2+(1.11/1.375)^2*$

$n(1.375/1.11)\} = 0.0000528$

$L_{17}= 0.25\{1-[(1-\nu)/4][1-(r/a)^4]-(r/a)^2[1+(1+\nu)\ln(a/r)]$

$= 0.25\{1-((1-0.3)/4)[1-(1.11/1.375)^4]-(1.11/1.375)^2[1+(1+0.3)\ln(1.375/1.11)]\} =0.0166$

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 25

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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$$Q_b = (DP_{avg})(a)[C_2(L_{17})-C_8(L_{11})]/[C_2(C_9)-C_3(C_8)]$$
$$= (1678)(1.375)[0.0173(0.0166)-0.878(0.0000528)]/[0.0173(0.161)-0.00107(0.878)]=301$$
$$Q_a = -[Q_b(b/a)-(((P_b-P_{avc})/2a)(a^2-r^2))]$$
$$= -[301(1.11/1.375)-(1678/(2(1.375))(1.375^2-1.11^2))] = -159$$

5.2.6.1 Disk Load

$$(F_{disk}) = -4(\pi)a(Q_a)(\mu) = -4(\pi)1.375(-159)(0.5218) = 1{,}434 \text{ lbf}$$

5.2.6.2 Hub Load

$$(F_{hub}) = (Q_b/DP_{avg} + b/2)(P_{up}-P_{down})(b/a)2(\pi)a(\mu)$$
$$(301/1678 + 1.11/2)(660-0)(1.11/1.375)2(\pi)1.375(0.5218) = 1764 \text{ lbf}$$

5.2.7 Residual Load

Input Data

SPC (Static Peak Cracking) = 6836 lbf (Ref. 38 & 39)

P_{final} (Bonnet Pressure) = 2008 psig (Sect. 5.2.1)

Output Data

$$F_{eff.\ closing} = SPC/0.67 = 6836/0.67 = 10{,}203 \text{ lbf}$$
$$C_{resid} = -0.149(x) + 0.67 = -0.149(0.407) + 0.67 = 0.59$$
$$x = (P_{final}(\pi)(a^2-b^2)/F_{eff.\ closing} = (2008(\pi)(1.375^2-1.11^2)/10203 = 0.3663$$
$$(F_{resid}) = C_{resid} * F_{eff.\ closing} = 0.609 * 10{,}203 = 6214 \text{ lbf}$$

5.2.8 Vertical Load

Input Data

θ = theta = 5.25° (Attachment 3)

a = 1.375 in. (Attachment 3)

Output Data

$$F_{vert} = 2(\pi(Sin(\theta))a^2(P_b - P_{avg}) = 2(\pi)(Sin(5.25))(1.375)^2(1678) = 1{,}824 \text{ lbf}$$

5.2.9 Stem Piston Load

Input Data

$D_{stem} = 0.875$

Output Data

$$F_{piston} = (\pi/4)(D_{stem}{}^2)P_b = (\pi/4)(0.875)2(2{,}008) = 1{,}207 \text{ lbf}$$

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 26

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
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5.2.10 The Total Required Stem Thrust (to overcome pressure locking conditions)

Output Data

$F_{total} = F_{disk} + F_{hub} + F_{vert} + F_{resid} - F_{piston}$ = 1,434 + 1764 + 1,824 + 6214 - 1,207 = 10,029 lbf

5.2.11 The Total Required Stem Torque (to overcome pressure locking conditions)

Output Data

$T_{required} = F_{total}$ * SF = 10,029 * 0.011555 = 116 ft-lbf

5.2.12 MOV Minimum Trust or Torque Limit

Thrust Limits

A = Valve Structural Thrust Limit = 12,097 lbf (Reference 1)

B = Actuator Structural Thrust Limit = 19,600 lbf (Reference 1)

C = Available Thrust = 16,410 lbf (Section 5.1.9.3)

Torque Limits

D = Actuator Structural Torque Limit / Stem Factor (Ref. 1/Section 5.1.9.1)
= 275/0.011555 = 23,799 lbf

E = Valve Structural Torque Limit / Stem Factor (Ref. 1/Section 5.1.9.1)
= 130/0.011555 = 11,250 lbf

Note: the valve structural torque limit was increased by 5% (124 * 1.05= 130) based on study 13-JS-A41 (Reference 37) which increased the allowable stress by approximately 13% based on and acceptable lower temperature limit of 225 ^{O}F.

The mimimum limiting value for Valve 1SI-604 from the above listed parameters is the Thrust associated with the Valve Structural Torque Limit of 11250 lbf.

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 27

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
2	[signature]	7/16/99	Rafael Rios	9-2-99						

5.2.13 Pressure Lock Susceptibility

If the (Total Required Stem Thrust) for potential pressure locking conditions, from Section 5.1.7 is (less than) the (MOV Minimum Thrust or Torque Limit) from Section 5.1.9.4 then the MOV is not susceptible to pressure locking

Total Required Trust < Valve/Actuator Limiting Thrust

10,029 lbf < 11,250 lbf (Section 5.2)

therefore; MOV 1SI-604 is not susceptible to pressure locking

5.3 Calculation Results

The hand calculation numerical results in section 5.2 above are in agreement with the computer Excel spreadsheet calculation. The small difference in Total Required Thrust and Torque Limit is in the order of less than 0.2% and due to rounding. Therefore; the Excel spreadsheet results are validated by this representative sample hand calculation.

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 28

EV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator ↓
2	[signature]	7/16/99	Rafael Rios	9.2.99						

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CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potential CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L 95-07 SHEET NO. 29

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indicator
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24. Limitorque Technical Update 93-03, Reliance 3-Phase Limitorque Corporation Actuator Motors.

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26. 13-MC-AF-401, Rev 2, "AFW System MOV Maximum Differential Pressure".

27. ASME Steam Tables, Fifth Edition (1983).

28. 13-MS-B07, Rev 3, "Evaluation of Dynamic Performance Parameters for Generic Letter 89-10 MOV's".

29. 13-N001-1900-550-1, CE Calculation Number V-FS-C-008 Rev. 00, "Analysis of Steam Line Break Events for Palo Verde for License Condition 21" (August 1985).

30. Limitorque Maintenance Update 92-01, 4. Allowable Overloads of Limitorque SMB Actuator.

31. NUREG/CR-6611 INEEL/EXT-98/00161, Results of Pressure Locking and Thermal Binding Tests of Gate Valves (May 1998).

32. Limitorque Technical Update 98-01 and Supplement 1, "Actuator Output Torque Calculation; SMB/SB/SBD Actautors" (July 1998).

CALCULATION SHEET

CALC. TITLE Gate Valve Open Thrust Required during Potental CALC. NO 13-MC-ZZ-217

SUBJECT Pressure Locking Conditions per G.L. 95-07 SHEET NO. 30

REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	REV	ORIGINATOR	DATE	INDEPENDENT VERIFICATION	DATE	Rev. Indi-cator ↓
2	[signature]	7/14/99	Rafael Rios	9.2.99						

33. CRDR 9-8-1207, Limitorque Technical Update 98-01 PVNGS MOV Operability Evaluation.

34. IEEE 1290-1996, IEEE Guide for Motor Operated Valve (MOV) Motor Application, Protection, Control, and Testing in Nuclear Power Generating Stations.

35. 01, 02, 03-EC-MA-221; Rev 4, 5, 4; AC Distribution (Minimum Voltage Calculation).

36. 01, 02, 03-EC-PK-207; Rev 0, 2, 0; DC Battery Sizing and Minimum Voltage Calculation.

37. 13-JS-A41, Rev 0, Technical Study to Support G.L. 89-10 MOV Program.

38. 32MT-9ZZ56, Rev 20, Motor Operator Testing Using MOVATS 3500 System.

39. 39DP-9ZZ05, Rev 0, Trending Performance Monitoring and Failure Data Trending.

40. 13-MC-SI-229, Rev 2, PRV Sizing Calculation for SI System Valve Bonnets.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Steven A. Lopez [signature] 9-1-99												
2	Rafael Rios [signature] 9-2-99		PRESSURE LOCKING										
3	Revision 9		CALCULATIONS										
4													
5	**Valve Tag (size)**	**SYSTEM INPUTS**					**VALVE INPUTS**						
6		Tinitial	Tfinal	Pinitial	Pup	Pdown	a	b	theta	nu	VF	***Valve Structural Limit***	
7		(degf)	(degf)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			***Thrust (lbf)***	***Torque (ft-lbf)***
8	**A/D Gate Valves:**												
9	1AF-34 (6")/Modification	104	123	1,801	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
10	2AF-34 (6")/Modification	104	123	1,801	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
11	3AF-34 (6")/Modification	104	123	1,801	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
12	1AF-35 (6")/Modification	104	123	1,801	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
13	2AF-35 (6")/Modification	104	123	1,801	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
14	3AF-35 (6")/Modification	104	123	1,801	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
15													
16													
17	1AF-36 (6")/Modification	104	125	1,816	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
18	2AF-36 (6")/Modification	104	125	1,816	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
19	3AF-36 (6")/Modification	104	125	1,816	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
20	1AF-37 (6")/Modification	104	125	1,816	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
21	2AF-37 (6")/Modification	104	125	1,816	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
22	3AF-37 (6")/Modification	104	125	1,816	0	0	2.63	0.88	5	0.3	0.55	*50,000*	*802*
23													
24													
25	1SG-134 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*50,000*	*802*
26	2SG-134 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*50,000*	*802*
27	3SG-134 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*50,000*	*802*
28	1SG-138 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*50,000*	*802*
29	2SG-138 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*50,000*	*802*
30	3SG-138 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*50,000*	*802*
31													
32													
33													

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Steven A. Lopez ________________												
2	Rafael Rios ______________	PRESSURE LOCKING											
3	Revision 9		CALCULATIONS										
4													
5	Valve Tag (size)	SYSTEM INPUTS					VALVE INPUTS						
6		Tinitial	Tfinal	Pinitial	Pup	Pdown	a	b	theta	nu	VF	*Valve Structural Limit*	
7		(degf)	(degf)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			*Thrust (lbf)*	*Torque (ft-lbf)*
34	**BW/IP Gate Valves:**												
35	1CH-536 (3")/Evaluation	104	104	97	0	0	1.50	1.11	5.25	0.3	0.6	*10,705*	*124*
36	2CH-536 (3")/Evaluation	104	104	97	0	0	1.50	1.11	5.25	0.3	0.6	*10,705*	*124*
37	3CH-536 (3")/Evaluation	104	104	97	0	0	1.50	1.11	5.25	0.3	0.6	*10,705*	*124*
38													
39													
40	1SI-604 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*12,097*	*140*
41	2SI-604 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*12,097*	*140*
42	3SI-604 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*12,097*	*140*
43	1SI-609 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*12,097*	*140*
44	2SI-609 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*12,097*	*140*
45	3SI-609 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*12,097*	*140*
46													
47													
48	1SI-651 (12")/Modification	120	160	2,561	465	5	5.25	2.97	5.25	0.3	0.6	*179,786*	*5,009*
49	2SI-651 (12")/Modification	120	160	2,561	465	5	5.25	2.97	5.25	0.3	0.6	*179,786*	*5,009*
50	3SI-651 (12")/Modification	120	160	2,561	465	5	5.25	2.97	5.25	0.3	0.6	*179,786*	*5,009*
51	1SI-652 (12")/Modification	120	160	2,561	465	5	5.25	2.97	5.25	0.3	0.6	*179,786*	*5,009*
52	2SI-652 (12")/Modification	120	160	2,561	465	5	5.25	2.97	5.25	0.3	0.6	*179,786*	*5,009*
53	3SI-652 (12")/Modification	120	160	2,561	465	5	5.25	2.97	5.25	0.3	0.6	*179,786*	*5,009*
54													
55													
56													
57													
58													
59													

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Steven A. Lopez ________________												
2	Rafael Rios ____________	PRESSURE LOCKING											
3	Revision 9		CALCULATIONS										
4													
5	Valve Tag (size)	SYSTEM INPUTS					VALVE INPUTS						
6		Tinitial	Tfinal	Pinitial	Pup	Pdown	a	b	theta	nu	VF	*Valve Structural Limit*	
7		(degf)	(degf)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			*Thrust (lbf)*	*Torque (ft-lbf)*
60	1SI-653 (12")/Modification	120	160	465	465	5	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
61	2SI-653 (12")/Modification	120	160	465	465	5	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
62	3SI-653 (12")/Modification	120	160	465	465	5	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
63	1SI-654 (12")/Modification	120	160	465	465	5	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
64	2SI-654 (12")/Modification	120	160	465	465	5	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
65	3SI-654 (12")/Modification	120	160	465	465	5	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
66													
67													
68	1SI-655 (12")/Modification	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
69	2SI-655 (12")/Modification	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
70	3SI-655 (12")/Mod (w/OAR)	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
71	1SI-656 (12")/Modification	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
72	2SI-656 (12")/Modification	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
73	3SI-656 (12")/Mod (w/OAR)	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
74	3SI-656 (12")/Mod (w/o OAR)	104	120	465	465	12	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
75													
76													
77	1SI-672 (8")/Modification	104	104	326	5	0	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
78	2SI-672 (8")/Mod	104	104	326	5	0	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
79	3SI-672 (8")/Mod (see notes)	104	104	326	5	0	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
80	1SI-671 (8")/Modification	104	104	326	5	0	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
81	2SI-671 (8")/Modification	104	104	326	5	0	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
82	3SI-671 (8")/Modification	104	104	326	5	0	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
83													
84													
85													

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Steven A. Lopez												
2	Rafael Rios	PRESSURE LOCKING											
3	Revision 9	CALCULATIONS											
4													
5	Valve Tag (size)	SYSTEM INPUTS					VALVE INPUTS						
6		Tinitial	Tfinal	Pinitial	Pup	Pdown	a	b	theta	nu	VF	*Valve Structural Limit*	
7		(degf)	(degf)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			*Thrust (lbf)*	*Torque (ft-lbf)*
86	1SI-685 (10")/Modification	104	104	458	12	12	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
87	2SI-685 (10")/Modification	104	104	458	12	12	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
88	3SI-685 (10")/Modification	104	104	458	12	12	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
89	1SI-694 (10")/Modification	104	104	458	12	12	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
90	2SI-694 (10")/Modification	104	104	458	12	12	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
91	3SI-694 (10")/Modification	104	104	458	12	12	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
92													
93													
94	1SI-686 (20")/Modification	104	104	458	12	12	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
95	2SI-686 (20")/Modification	104	104	458	12	12	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
96	3SI-686 (20")/Modification	104	104	458	12	12	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
97	1SI-696 (20")/Modification	104	104	458	12	12	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
98	2SI-696 (20")/Modification	104	104	458	12	12	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
99	3SI-696 (20")/Modification	104	104	458	12	12	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
100													
101													
102	1SI-688 (10")/Modification	104	104	458	13	13	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
103	2SI-688 (10")/Modification	104	104	458	13	13	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
104	3SI-688 (10")/Modification	104	104	458	13	13	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
105	1SI-693 (10")/Modification	104	104	458	13	13	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
106	2SI-693 (10")/Modification	104	104	458	13	13	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*
107	3SI-693 (10")/Modification	104	104	458	13	13	5.13	2.63	5.25	0.3	0.55	*37,835*	*597*

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA
1	Steven A. Lopez ____________												
2	Rafael Rios ______________												
3	Revision 9												
4													
5	**Valve Tag (size)**	**MOV ACTUATOR/STEM INPUTS**								**MOTOR INPUTS**			
6		OAR	P.O. Eff	COF	Dstem	Pstem	Lstem	***Actuator Structural Limit***		Vfull	Vmin	MTorq	n
7					(in.)	(in./th.)	(in./rev.)	***Thrust (lbf***	***Torque (ft-lbf)***	(volts)	(volts)	(ft-lbf)	
8	**A/D Gate Valves:**												
9	1AF-34 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2
10	2AF-34 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2
11	3AF-34 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2
12	1AF-35 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2
13	2AF-35 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2
14	3AF-35 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2
15													
16													
17	1AF-36 (6")/Modification	60.15	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1
18	2AF-36 (6")/Modification	60.15	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1
19	3AF-36 (6")/Modification	60.15	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1
20	1AF-37 (6")/Modification	60.15	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1
21	2AF-37 (6")/Modification	60.15	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1
22	3AF-37 (6")/Modification	60.15	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1
23													
24													
25	1SG-134 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1
26	2SG-134 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1
27	3SG-134 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1
28	1SG-138 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1
29	2SG-138 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1
30	3SG-138 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1
31													
32													
33													

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA
1	Steven A. Lopez ___________												
2	Rafael Rios ___________												
3	Revision 9												
4													
5	**Valve Tag (size)**	**MOV ACTUATOR/STEM INPUTS**								**MOTOR INPUTS**			
6		OAR	P.O. Eff	COF	Dstem	Pstem	Lstem	*Actuator Structural Limit*		Vfull	Vmin	MTorq	n
7					(in.)	(in./th.)	(in./rev.)	*Thrust (lbf*	*Torque (ft-lbf)*	(volts)	(volts)	(ft-lbf)	
34	**BW/IP Gate Valves:**												
35	1CH-536 (3")/Evaluation	30	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	7.5	2
36	2CH-536 (3")/Evaluation	30	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	7.5	2
37	3CH-536 (3")/Evaluation	30	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	7.5	2
38													
39													
40	1SI-604 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2
41	2SI-604 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2
42	3SI-604 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2
43	1SI-609 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2
44	2SI-609 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2
45	3SI-609 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2
46													
47													
48	1SI-651 (12")/Modification	132.81	0.38	0.12	2.75	0.333	0.667	*350,000*	*6,600*	460	414	100	2
49	2SI-651 (12")/Modification	132.81	0.38	0.12	2.75	0.333	0.667	*350,000*	*6,600*	460	414	100	2
50	3SI-651 (12")/Modification	132.81	0.38	0.12	2.75	0.333	0.667	*350,000*	*6,600*	460	414	100	2
51	1SI-652 (12")/Modification	132.81	0.38	0.12	2.75	0.333	0.667	*350,000*	*6,600*	460	414	100	2
52	2SI-652 (12")/Modification	132.81	0.38	0.12	2.75	0.333	0.667	*350,000*	*6,600*	460	414	100	2
53	3SI-652 (12")/Modification	132.81	0.38	0.12	2.75	0.333	0.667	*350,000*	*6,600*	460	414	100	2
54													
55													
56													
57													
58													
59													

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA
1	Steven A. Lopez ___________												
2	Rafael Rios _____________												
3	Revision 9												
4													
5	Valve Tag (size)	MOV ACTUATOR/STEM INPUTS								MOTOR INPUTS			
6		OAR	P.O. Eff	COF	Dstem	Pstem	Lstem	*Actuator Structural Limit*		Vfull	Vmin	MTorq	n
7					(in.)	(in./th.)	(in./rev.)	*Thrust (lbf*	*Torque (ft-lbf)*	(volts)	(volts)	(ft-lbf)	
60	1SI-653 (12")/Modification	124.1	0.35	0.16	2.75	0.333	0.667	*112,500*	*1,700*	460	456	40	2
61	2SI-653 (12")/Modification	124.1	0.35	0.16	2.75	0.333	0.667	*112,500*	*1,700*	460	456	40	2
62	3SI-653 (12")/Modification	124.1	0.35	0.16	2.75	0.333	0.667	*112,500*	*1,700*	460	456	40	2
63	1SI-654 (12")/Modification	124.1	0.35	0.16	2.75	0.333	0.667	*112,500*	*1,700*	460	456	40	2
64	2SI-654 (12")/Modification	124.1	0.35	0.16	2.75	0.333	0.667	*112,500*	*1,700*	460	456	40	2
65	3SI-654 (12")/Modification	124.1	0.35	0.16	2.75	0.333	0.667	*112,500*	*1,700*	460	456	40	2
66													
67													
68	1SI-655 (12")/Modification	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
69	2SI-655 (12")/Modification	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
70	3SI-655 (12")/Mod (w/OAR)	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
71	1SI-656 (12")/Modification	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
72	2SI-656 (12")/Modification	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
73	3SI-656 (12")/Mod (w/OAR)	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
74	3SI-656 (12")/Mod (w/o OAR)	88.4	0.40	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2
75													
76													
77	1SI-672 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2
78	2SI-672 (8")/Mod	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2
79	3SI-672 (8")/Mod (see notes)	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2
80	1SI-671 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2
81	2SI-671 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2
82	3SI-671 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2
83													
84													
85													

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA
1	Steven A. Lopez ___________												
2	Rafael Rios ___________												
3	Revision 9												
4													
5	Valve Tag (size)	MOV ACTUATOR/STEM INPUTS								MOTOR INPUTS			
6		OAR	P.O. Eff	COF	Dstem	Pstem	Lstem	*Actuator Structural Limit*		Vfull	Vmin	MTorq	n
7					(in.)	(in./th.)	(in./rev.)	*Thrust (lbf*	*Torque (ft-lbf)*	(volts)	(volts)	(ft-lbf)	
86	1SI-685 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
87	2SI-685 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
88	3SI-685 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
89	1SI-694 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
90	2SI-694 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
91	3SI-694 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
92													
93													
94	1SI-686 (20")/Modification	80	0.4	0.15	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2
95	2SI-686 (20")/Modification	80	0.4	0.15	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2
96	3SI-686 (20")/Modification	80	0.4	0.15	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2
97	1SI-696 (20")/Modification	80	0.4	0.15	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2
98	2SI-696 (20")/Modification	80	0.4	0.15	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2
99	3SI-696 (20")/Modification	80	0.4	0.15	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2
100													
101													
102	1SI-688 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
103	2SI-688 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
104	3SI-688 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
105	1SI-693 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
106	2SI-693 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2
107	3SI-693 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2

	A	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Steven A. Lopez ___________									
2	Rafael Rios ____________									
3	Revision 9									
4					*Calculation of Minimum Available*				CALCULATION	
5	Valve Tag (size)		MOV MISC INPUTS		*Torque and Thrust at Motor Stall*				DP X DISKS	
6		TDF	Max Close	% Residual	Stem Factor	*Avail Torque*	*Avail Thrust*	VDF	Pfinal	DPavg
7			Load (lbf)	Load		(ft-lbf)	(lbf)		(psig)	(psig)
8	A/D Gate Valves:									
9	1AF-34 (6")/Modification	0.96	50,000	52%	0.0160	881	54,927	0.900	1,880	1880
10	2AF-34 (6")/Modification	0.96	50,000	52%	0.0160	881	54,927	0.900	1,880	1880
11	3AF-34 (6")/Modification	0.96	50,000	52%	0.0160	881	54,927	0.900	1,880	1880
12	1AF-35 (6")/Modification	0.96	50,000	52%	0.0160	881	54,927	0.900	1,880	1880
13	2AF-35 (6")/Modification	0.96	50,000	52%	0.0160	881	54,927	0.900	1,880	1880
14	3AF-35 (6")/Modification	0.96	50,000	52%	0.0160	881	54,927	0.900	1,880	1880
15										
16										
17	1AF-36 (6")/Modification	0.98	50,000	52%	0.0160	807	50,298	0.856	1,880	1880
18	2AF-36 (6")/Modification	0.98	50,000	52%	0.0160	807	50,298	0.856	1,880	1880
19	3AF-36 (6")/Modification	0.98	50,000	52%	0.0160	807	50,298	0.856	1,880	1880
20	1AF-37 (6")/Modification	0.98	50,000	52%	0.0160	807	50,298	0.856	1,880	1880
21	2AF-37 (6")/Modification	0.98	50,000	52%	0.0160	807	50,298	0.856	1,880	1880
22	3AF-37 (6")/Modification	0.98	50,000	52%	0.0160	807	50,298	0.856	1,880	1880
23										
24										
25	1SG-134 (6")/Modification	0.9	33,600	55%	0.0160	*742*	*46,270*	0.809	1,383	1058
26	2SG-134 (6")/Modification	0.9	50,000	55%	0.0160	*742*	*46,270*	0.809	1,383	1058
27	3SG-134 (6")/Modification	0.9	50,000	55%	0.0160	*742*	*46,270*	0.809	1,383	1058
28	1SG-138 (6")/Modification	0.9	33,600	55%	0.0160	*742*	*46,270*	0.809	1,383	1058
29	2SG-138 (6")/Modification	0.9	50,000	55%	0.0160	*742*	*46,270*	0.809	1,383	1058
30	3SG-138 (6")/Modification	0.9	50,000	55%	0.0160	*742*	*46,270*	0.809	1,383	1058
31										
32										
33										

	A	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Steven A. Lopez ____________									
2	Rafael Rios ____________									
3	Revision 9									
4					***Calculation of Minimum Available***				**CALCULATION**	
5	**Valve Tag (size)**		**MOV MISC INPUTS**		***Torque and Thrust at Motor Stall***				**DP X DISKS**	
6		TDF	Max Close	% Residual	Stem Factor	***Avail Torque***	***Avail Thrust***	VDF	Pfinal	DPavg
7			Load (lbf)	Load		(ft-lbf)	(lbf)		(psig)	(psig)
34	**BW/IP Gate Valves:**									
35	1CH-536 (3")/Evaluation	0.99	11,000	66%	0.0116	*80*	*6,940*	0.900	97	97
36	2CH-536 (3")/Evaluation	0.99	11,000	66%	0.0116	*80*	*6,940*	0.900	97	97
37	3CH-536 (3")/Evaluation	0.99	11,000	66%	0.0116	*80*	*6,940*	0.900	97	97
38										
39										
40	1SI-604 (3")/Modification	0.97	11,194	61%	0.0116	*190*	*16,410*	0.900	2,008	1678
41	2SI-604 (3")/Modification	0.97	11,194	61%	0.0116	*190*	*16,410*	0.900	2,008	1678
42	3SI-604 (3")/Modification	0.97	11,194	61%	0.0116	*190*	*16,410*	0.900	2,008	1678
43	1SI-609 (3")/Modification	0.97	11,194	61%	0.0116	*190*	*16,410*	0.900	2,008	1678
44	2SI-609 (3")/Modification	0.97	11,194	61%	0.0116	*190*	*16,410*	0.900	2,008	1678
45	3SI-609 (3")/Modification	0.97	11,194	61%	0.0116	*190*	*16,410*	0.900	2,008	1678
46										
47										
48	1SI-651 (12")/Modification	0.95	153,000	36%	0.0224	*4,315*	*192,533*	0.900	2,936	2701
49	2SI-651 (12")/Modification	0.95	153,000	36%	0.0224	*4,315*	*192,533*	0.900	2,936	2701
50	3SI-651 (12")/Modification	0.95	153,000	36%	0.0224	*4,315*	*192,533*	0.900	2,936	2701
51	1SI-652 (12")/Modification	0.95	153,000	36%	0.0224	*4,315*	*192,533*	0.900	2,936	2701
52	2SI-652 (12")/Modification	0.95	153,000	36%	0.0224	*4,315*	*192,533*	0.900	2,936	2701
53	3SI-652 (12")/Modification	0.95	153,000	36%	0.0224	*4,315*	*192,533*	0.900	2,936	2701
54										
55										
56										
57										
58										
59										

	A	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Steven A. Lopez ____________									
2	Rafael Rios ______________									
3	Revision 9									
4					***Calculation of Minimum Available***				**CALCULATION**	
5	**Valve Tag (size)**		**MOV MISC INPUTS**		***Torque and Thrust at Motor Stall***				**DP X DISKS**	
6		TDF	Max Close	% Residual	Stem Factor	*Avail Torque*	*Avail Thrust*	VDF	Pfinal	DPavg
7			Load (lbf)	Load		(ft-lbf)	(lbf)		(psig)	(psig)
60	1SI-653 (12")/Modification	0.89	46,517	52%	0.0270	*1,392*	*51,548*	0.900	465	230
61	2SI-653 (12")/Modification	0.89	46,517	52%	0.0270	*1,392*	*51,548*	0.900	465	230
62	3SI-653 (12")/Modification	0.89	46,517	52%	0.0270	*1,392*	*51,548*	0.900	465	230
63	1SI-654 (12")/Modification	0.89	46,517	52%	0.0270	*1,392*	*51,548*	0.900	465	230
64	2SI-654 (12")/Modification	0.89	46,517	52%	0.0270	*1,392*	*51,548*	0.900	465	230
65	3SI-654 (12")/Modification	0.89	46,517	52%	0.0270	*1,392*	*51,548*	0.900	465	230
66										
67										
68	1SI-655 (12")/Modification	0.88	46,517	54%	0.0258	*1,376*	*53,235*	0.900	465	227
69	2SI-655 (12")/Modification	0.88	46,517	54%	0.0258	*1,376*	*53,235*	0.900	465	227
70	3SI-655 (12")/Mod (w/OAR)	0.88	46,517	54%	0.0258	*1,376*	*53,235*	0.900	465	227
71	1SI-656 (12")/Modification	0.88	46,517	54%	0.0258	*1,376*	*53,235*	0.900	465	227
72	2SI-656 (12")/Modification	0.88	46,517	54%	0.0258	*1,376*	*53,235*	0.900	465	227
73	3SI-656 (12")/Mod (w/OAR)	0.88	46,517	54%	0.0258	*1,376*	*53,235*	0.900	465	227
74	3SI-656 (12")/Mod (w/o OAR)	0.88	46,517	54%	0.0258	*1,120*	*43,338*	0.900	465	227
75										
76										
77	1SI-672 (8")/Modification	0.98	30,248	55%	0.0173	*432*	*24,983*	0.900	326	323
78	2SI-672 (8")/Mod	0.98	30,248	55%	0.0173	*432*	*24,983*	0.900	326	323
79	3SI-672 (8")/Mod (see notes)	0.98	30,248	56%	0.0173	*432*	*24,983*	0.900	326	323
80	1SI-671 (8")/Modification	0.98	30,248	55%	0.0173	*432*	*24,983*	0.900	326	323
81	2SI-671 (8")/Modification	0.98	30,248	55%	0.0173	*432*	*24,983*	0.900	326	323
82	3SI-671 (8")/Modification	0.98	30,248	55%	0.0173	*432*	*24,983*	0.900	326	323
83										
84										
85										

	A	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Steven A. Lopez ____________									
2	Rafael Rios ____________									
3	Revision 9									
4					*Calculation of Minimum Available*				CALCULATION	
5	Valve Tag (size)		MOV MISC INPUTS		*Torque and Thrust at Motor Stall*				DP X DISKS	
6		TDF	Max Close	% Residual	Stem Factor	*Avail Torque*	*Avail Thrust*	VDF	Pfinal	DPavg
7			Load (lbf)	Load		(ft-lbf)	(lbf)		(psig)	(psig)
86	1SI-685 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	446
87	2SI-685 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	446
88	3SI-685 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	446
89	1SI-694 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	446
90	2SI-694 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	446
91	3SI-694 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	446
92										
93										
94	1SI-686 (20")/Modification	0.98	53,429	22%	0.0219	*1,693*	*77,499*	0.900	458	446
95	2SI-686 (20")/Modification	0.98	53,429	22%	0.0219	*1,693*	*77,499*	0.900	458	446
96	3SI-686 (20")/Modification	0.98	53,429	22%	0.0219	*1,693*	*77,499*	0.900	458	446
97	1SI-696 (20")/Modification	0.98	53,429	22%	0.0219	*1,693*	*77,499*	0.900	458	446
98	2SI-696 (20")/Modification	0.98	53,429	22%	0.0219	*1,693*	*77,499*	0.900	458	446
99	3SI-696 (20")/Modification	0.98	53,429	22%	0.0219	*1,693*	*77,499*	0.900	458	446
100										
101										
102	1SI-688 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	445
103	2SI-688 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	445
104	3SI-688 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	445
105	1SI-693 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	445
106	2SI-693 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	445
107	3SI-693 (10")/Modification	0.98	17,910	45%	0.0170	*544*	*31,909*	0.900	458	445

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Steven A. Lopez ___________									
2	Rafael Rios ____________									
3	Revision 9									
4										
5	**Valve Tag (size)**	**Calculation of Disk Load Perpendicular to the Seat/Roak Thin Plate Theory**								
6		C2	C3	C8	C9	L11	L17	mu	Qb	Qa
7										
8	**A/D Gate Valves:**									
9	1AF-34 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
10	2AF-34 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
11	3AF-34 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
12	1AF-35 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
13	2AF-35 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
14	3AF-35 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
15										
16										
17	1AF-36 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
18	2AF-36 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
19	3AF-36 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
20	1AF-37 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
21	2AF-37 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
22	3AF-37 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,329	-1,084
23										
24										
25	1SG-134 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.6307	1,874	-610
26	2SG-134 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.6307	1,874	-610
27	3SG-134 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.6307	1,874	-610
28	1SG-138 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.6307	1,874	-610
29	2SG-138 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.6307	1,874	-610
30	3SG-138 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.6307	1,874	-610
31										
32										
33										

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Steven A. Lopez ____________									
2	Rafael Rios ______________									
3	Revision 9									
4										
5	**Valve Tag (size)**	**Calculation of Disk Load Perpendicular to the Seat/Roak Thin Plate Theory**								
6		C2	C3	C8	C9	L11	L17	mu	Qb	Qa
7										
34	**BW/IP Gate Valves:**									
35	1CH-536 (3")/Evaluation	0.0304	0.0025	0.8423	0.2027	0.00017	0.0286	0.6322	26	-13
36	2CH-536 (3")/Evaluation	0.0304	0.0025	0.8423	0.2027	0.00017	0.0286	0.6322	26	-13
37	3CH-536 (3")/Evaluation	0.0304	0.0025	0.8423	0.2027	0.00017	0.0286	0.6322	26	-13
38										
39										
40	1SI-604 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	299	-161
41	2SI-604 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	299	-161
42	3SI-604 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	299	-161
43	1SI-609 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	299	-161
44	2SI-609 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	299	-161
45	3SI-609 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	299	-161
46										
47										
48	1SI-651 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,767	-2,123
49	2SI-651 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,767	-2,123
50	3SI-651 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,767	-2,123
51	1SI-652 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,767	-2,123
52	2SI-652 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,767	-2,123
53	3SI-652 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,767	-2,123
54										
55										
56										
57										
58										
59										

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Steven A. Lopez ___________									
2	Rafael Rios _____________									
3	Revision 9									
4										
5	Valve Tag (size)	Calculation of Disk Load Perpendicular to the Seat/Roak Thin Plate Theory								
6		C2	C3	C8	C9	L11	L17	mu	Qb	Qa
7										
60	1SI-653 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	406	-181
61	2SI-653 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	406	-181
62	3SI-653 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	406	-181
63	1SI-654 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	406	-181
64	2SI-654 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	406	-181
65	3SI-654 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	406	-181
66										
67										
68	1SI-655 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
69	2SI-655 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
70	3SI-655 (12")/Mod (w/OAR)	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
71	1SI-656 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
72	2SI-656 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
73	3SI-656 (12")/Mod (w/OAR)	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
74	3SI-656 (12")/Mod (w/o OAR)	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	400	-178
75										
76										
77	1SI-672 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	447	-198
78	2SI-672 (8")/Mod	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	447	-198
79	3SI-672 (8")/Mod (see notes)	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	447	-198
80	1SI-671 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	447	-198
81	2SI-671 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	447	-198
82	3SI-671 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	447	-198
83										
84										
85										

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Steven A. Lopez ___________									
2	Rafael Rios ___________									
3	Revision 9									
4										
5	**Valve Tag (size)**	**Calculation of Disk Load Perpendicular to the Seat/Roak Thin Plate Theory**								
6		C2	C3	C8	C9	L11	L17	mu	Qb	Qa
7										
86	1SI-685 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	901	-380
87	2SI-685 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	901	-380
88	3SI-685 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	901	-380
89	1SI-694 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	901	-380
90	2SI-694 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	901	-380
91	3SI-694 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	901	-380
92										
93										
94	1SI-686 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	1,488	-653
95	2SI-686 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	1,488	-653
96	3SI-686 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	1,488	-653
97	1SI-696 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	1,488	-653
98	2SI-696 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	1,488	-653
99	3SI-696 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	1,488	-653
100										
101										
102	1SI-688 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	899	-379
103	2SI-688 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	899	-379
104	3SI-688 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	899	-379
105	1SI-693 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	899	-379
106	2SI-693 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	899	-379
107	3SI-693 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5767	899	-379

	A	AT	AU	AV	AW	AX	AY
1	Steven A. Lopez ____________						
2	Rafael Rios ____________						
3	Revision 9						
4				Static	**Residual Closing**	**Vertical Load**	**Stem piston**
5	**Valve Tag (size)**	**Disk Load**	**Hub Load**	Peak	**Load at Cracking**	**On Disks**	**Load**
6		w/DPavg	Pup-Pdown	Cracking	Residual Load	Fvert	Fpiston
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
8	**A/D Gate Valves:**						
9	1AF-34 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
10	2AF-34 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
11	3AF-34 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
12	1AF-35 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
13	2AF-35 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
14	3AF-35 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
15							
16							
17	1AF-36 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
18	2AF-36 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
19	3AF-36 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
20	1AF-37 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
21	2AF-37 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
22	3AF-37 (6")/Modification	20,571	-	24,765	19,375	7,094	3,322
23							
24							
25	1SG-134 (6")/Modification	12,687	4,977	23,000	19,035	3,992	2,444
26	2SG-134 (6")/Modification	12,687	4,977	23,000	19,035	3,992	2,444
27	3SG-134 (6")/Modification	12,687	4,977	23,000	19,035	3,992	2,444
28	1SG-138 (6")/Modification	12,687	4,977	23,000	19,035	3,992	2,444
29	2SG-138 (6")/Modification	12,687	4,977	23,000	19,035	3,992	2,444
30	3SG-138 (6")/Modification	12,687	4,977	23,000	19,035	3,992	2,444
31							
32							
33							

	A	AT	AU	AV	AW	AX	AY
1	Steven A. Lopez ____________						
2	Rafael Rios ____________						
3	Revision 9						
4				Static	Residual Closing	Vertical Load	Stem piston
5	**Valve Tag (size)**	**Disk Load**	**Hub Load**	Peak	**Load at Cracking**	**On Disks**	**Load**
6		w/DPavg	Pup-Pdown	Cracking	Residual Load	Fvert	Fpiston
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
34	**BW/IP Gate Valves:**						
35	1CH-536 (3")/Evaluation	160	-	5,233	5,187	125	58
36	2CH-536 (3")/Evaluation	160	-	5,233	5,187	125	58
37	3CH-536 (3")/Evaluation	160	-	5,233	5,187	125	58
38							
39							
40	1SI-604 (3")/Modification	1,449	1,761	6,836	6,217	1,824	1,207
41	2SI-604 (3")/Modification	1,449	1,761	6,836	6,217	1,824	1,207
42	3SI-604 (3")/Modification	1,449	1,761	6,836	6,217	1,824	1,207
43	1SI-609 (3")/Modification	1,449	1,761	6,836	6,217	1,824	1,207
44	2SI-609 (3")/Modification	1,449	1,761	6,836	6,217	1,824	1,207
45	3SI-609 (3")/Modification	1,449	1,761	6,836	6,217	1,824	1,207
46							
47							
48	1SI-651 (12")/Modification	88,561	17,648	55,000	29,247	42,795	17,436
49	2SI-651 (12")/Modification	88,561	17,648	55,000	29,247	42,795	17,436
50	3SI-651 (12")/Modification	88,561	17,648	55,000	29,247	42,795	17,436
51	1SI-652 (12")/Modification	88,561	17,648	55,000	29,247	42,795	17,436
52	2SI-652 (12")/Modification	88,561	17,648	55,000	29,247	42,795	17,436
53	3SI-652 (12")/Modification	88,561	17,648	55,000	29,247	42,795	17,436
54							
55							
56							
57							
58							
59							

	A	AT	AU	AV	AW	AX	AY
1	Steven A. Lopez ____________						
2	Rafael Rios ____________						
3	Revision 9						
4				Static	Residual Closing	Vertical Load	Stem piston
5	**Valve Tag (size)**	**Disk Load**	**Hub Load**	Peak	**Load at Cracking**	**On Disks**	**Load**
6		w/DPavg	Pup-Pdown	Cracking	Residual Load	Fvert	Fpiston
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
60	1SI-653 (12")/Modification	8,215	19,212	18,750	14,671	3,647	2,762
61	2SI-653 (12")/Modification	8,215	19,212	18,750	14,671	3,647	2,762
62	3SI-653 (12")/Modification	8,215	19,212	18,750	14,671	3,647	2,762
63	1SI-654 (12")/Modification	8,215	19,212	18,750	14,671	3,647	2,762
64	2SI-654 (12")/Modification	8,215	19,212	18,750	14,671	3,647	2,762
65	3SI-654 (12")/Modification	8,215	19,212	18,750	14,671	3,647	2,762
66							
67							
68	1SI-655 (12")/Modification	6,782	15,860	21,300	17,221	3,592	2,762
69	2SI-655 (12")/Modification	6,782	15,860	21,300	17,221	3,592	2,762
70	3SI-655 (12")/Mod (w/OAR)	6,782	15,860	21,300	17,221	3,592	2,762
71	1SI-656 (12")/Modification	6,782	15,860	21,300	17,221	3,592	2,762
72	2SI-656 (12")/Modification	6,782	15,860	21,300	17,221	3,592	2,762
73	3SI-656 (12")/Mod (w/OAR)	6,782	15,860	21,300	17,221	3,592	2,762
74	3SI-656 (12")/Mod (w/o OAR)	6,782	15,860	21,585	17,506	3,592	2,762
75							
76							
77	1SI-672 (8")/Modification	5,851	112	10,500	8,558	3,079	484
78	2SI-672 (8")/Mod	5,851	112	10,500	8,558	3,079	484
79	3SI-672 (8")/Mod (see notes)	5,851	112	12,000	10,058	3,079	484
80	1SI-671 (8")/Modification	5,851	112	10,500	8,558	3,079	484
81	2SI-671 (8")/Modification	5,851	112	10,500	8,558	3,079	484
82	3SI-671 (8")/Modification	5,851	112	10,500	8,558	3,079	484
83							
84							
85							

	A	AT	AU	AV	AW	AX	AY
1	Steven A. Lopez ___________						
2	Rafael Rios _____________						
3	Revision 9						
4				Static	**Residual Closing**	**Vertical Load**	**Stem piston**
5	**Valve Tag (size)**	**Disk Load**	**Hub Load**	Peak	**Load at Cracking**	**On Disks**	**Load**
6		w/DPavg	Pup-Pdown	Cracking	Residual Load	Fvert	Fpiston
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
86	1SI-685 (10")/Modification	14,120	-	12,500	8,352	6,741	809
87	2SI-685 (10")/Modification	14,120	-	12,500	8,352	6,741	809
88	3SI-685 (10")/Modification	14,120	-	12,500	8,352	6,741	809
89	1SI-694 (10")/Modification	14,120	-	12,500	8,352	6,741	809
90	2SI-694 (10")/Modification	14,120	-	12,500	8,352	6,741	809
91	3SI-694 (10")/Modification	14,120	-	12,500	8,352	6,741	809
92							
93							
94	1SI-686 (20")/Modification	40,694	-	20,000	6,499	22,089	1,624
95	2SI-686 (20")/Modification	40,694	-	20,000	6,499	22,089	1,624
96	3SI-686 (20")/Modification	40,694	-	20,000	6,499	22,089	1,624
97	1SI-696 (20")/Modification	40,694	-	20,000	6,499	22,089	1,624
98	2SI-696 (20")/Modification	40,694	-	20,000	6,499	22,089	1,624
99	3SI-696 (20")/Modification	40,694	-	20,000	6,499	22,089	1,624
100							
101							
102	1SI-688 (10")/Modification	14,086	-	12,500	8,352	6,725	809
103	2SI-688 (10")/Modification	14,086	-	12,500	8,352	6,725	809
104	3SI-688 (10")/Modification	14,086	-	12,500	8,352	6,725	809
105	1SI-693 (10")/Modification	14,086	-	12,500	8,352	6,725	809
106	2SI-693 (10")/Modification	14,086	-	12,500	8,352	6,725	809
107	3SI-693 (10")/Modification	14,086	-	12,500	8,352	6,725	809

	A	AZ	BA	BB	BF
1	Steven A. Lopez ___________				
2	Rafael Rios _____________			MOV Min Avail	
3	Revision 9	Total Stem Thrust	Total Torque Required	Thrust due to	MARGIN
4		Req'd to Overcome	to Overcome Pressure	Structural Limit or	LIMITING THRUST
5	Valve Tag (size)	Press Locking	Locking	Motor Torque Limit	subtract
6		Ftotal	Required Torque	Limiting Thrust	REQUIRED THRUST
7		(lbf)	(ft-lbf)	(lbf)	(lbf)
8	A/D Gate Valves:				
9	1AF-34 (6")/Modification	43,718	701	50,000	6,282
10	2AF-34 (6")/Modification	43,718	701	50,000	6,282
11	3AF-34 (6")/Modification	43,718	701	50,000	6,282
12	1AF-35 (6")/Modification	43,718	701	50,000	6,282
13	2AF-35 (6")/Modification	43,718	701	50,000	6,282
14	3AF-35 (6")/Modification	43,718	701	50,000	6,282
15					
16					
17	1AF-36 (6")/Modification	43,718	701	50,000	6,282
18	2AF-36 (6")/Modification	43,718	701	50,000	6,282
19	3AF-36 (6")/Modification	43,718	701	50,000	6,282
20	1AF-37 (6")/Modification	43,718	701	50,000	6,282
21	2AF-37 (6")/Modification	43,718	701	50,000	6,282
22	3AF-37 (6")/Modification	43,718	701	50,000	6,282
23					
24					
25	1SG-134 (6")/Modification	38,248	614	46,270	8,023
26	2SG-134 (6")/Modification	38,248	614	46,270	8,023
27	3SG-134 (6")/Modification	38,248	614	46,270	8,023
28	1SG-138 (6")/Modification	38,248	614	46,270	8,023
29	2SG-138 (6")/Modification	38,248	614	46,270	8,023
30	3SG-138 (6")/Modification	38,248	614	46,270	8,023
31					
32					
33					

	A	AZ	BA	BB	BF
1	Steven A. Lopez ____________				
2	Rafael Rios ____________			MOV Min Avail	
3	Revision 9	Total Stem Thrust	Total Torque Required	Thrust due to	MARGIN
4		Req'd to Overcome	to Overcome Pressure	Structural Limit or	LIMITING THRUST
5	Valve Tag (size)	Press Locking	Locking	Motor Torque Limit	subtract
6		Ftotal	Required Torque	Limiting Thrust	REQUIRED THRUST
7		(lbf)	(ft-lbf)	(lbf)	(lbf)
34	BW/IP Gate Valves:				
35	1CH-536 (3")/Evaluation	5,413	63	6,940	1,526
36	2CH-536 (3")/Evaluation	5,413	63	6,940	1,526
37	3CH-536 (3")/Evaluation	5,413	63	6,940	1,526
38					
39					
40	1SI-604 (3")/Modification	10,043	116	12,097	2,054
41	2SI-604 (3")/Modification	10,043	116	12,097	2,054
42	3SI-604 (3")/Modification	10,043	116	12,097	2,054
43	1SI-609 (3")/Modification	10,043	116	12,097	2,054
44	2SI-609 (3")/Modification	10,043	116	12,097	2,054
45	3SI-609 (3")/Modification	10,043	116	12,097	2,054
46					
47					
48	1SI-651 (12")/Modification	160,815	3,604	179,786	18,971
49	2SI-651 (12")/Modification	160,815	3,604	179,786	18,971
50	3SI-651 (12")/Modification	160,815	3,604	179,786	18,971
51	1SI-652 (12")/Modification	160,815	3,604	179,786	18,971
52	2SI-652 (12")/Modification	160,815	3,604	179,786	18,971
53	3SI-652 (12")/Modification	160,815	3,604	179,786	18,971
54					
55					
56					
57					
58					
59					

	A	AZ	BA	BB	BF
1	Steven A. Lopez ___________				
2	Rafael Rios ____________			MOV Min Avail	
3	Revision 9	Total Stem Thrust	Total Torque Required	Thrust due to	MARGIN
4		Req'd to Overcome	to Overcome Pressure	Structural Limit or	LIMITING THRUST
5	Valve Tag (size)	Press Locking	Locking	Motor Torque Limit	subtract
6		Ftotal	Required Torque	Limiting Thrust	REQUIRED THRUST
7		(lbf)	(ft-lbf)	(lbf)	(lbf)
60	1SI-653 (12")/Modification	42,982	1,160	51,548	8,567
61	2SI-653 (12")/Modification	42,982	1,160	51,548	8,567
62	3SI-653 (12")/Modification	42,982	1,160	51,548	8,567
63	1SI-654 (12")/Modification	42,982	1,160	51,548	8,567
64	2SI-654 (12")/Modification	42,982	1,160	51,548	8,567
65	3SI-654 (12")/Modification	42,982	1,160	51,548	8,567
66					
67					
68	1SI-655 (12")/Modification	40,693	1,052	53,235	12,542
69	2SI-655 (12")/Modification	40,693	1,052	53,235	12,542
70	3SI-655 (12")/Mod (w/OAR)	40,693	1,052	53,235	12,542
71	1SI-656 (12")/Modification	40,693	1,052	53,235	12,542
72	2SI-656 (12")/Modification	40,693	1,052	53,235	12,542
73	3SI-656 (12")/Mod (w/OAR)	40,693	1,052	53,235	12,542
74	3SI-656 (12")/Mod (w/o OAR)	40,978	1,059	43,338	2,360
75					
76					
77	1SI-672 (8")/Modification	17,116	296	24,983	7,868
78	2SI-672 (8")/Mod	17,116	296	24,983	7,868
79	3SI-672 (8")/Mod (see notes)	18,616	322	24,983	6,368
80	1SI-671 (8")/Modification	17,116	296	24,983	7,868
81	2SI-671 (8")/Modification	17,116	296	24,983	7,868
82	3SI-671 (8")/Modification	17,116	296	24,983	7,868
83					
84					
85					

	A	AZ	BA	BB	BF
1	Steven A. Lopez ___________				
2	Rafael Rios ___________			MOV Min Avail	
3	Revision 9	Total Stem Thrust	Total Torque Required	Thrust due to	MARGIN
4		Req'd to Overcome	to Overcome Pressure	Structural Limit or	LIMITING THRUST
5	Valve Tag (size)	Press Locking	Locking	Motor Torque Limit	subtract
6		Ftotal	Required Torque	Limiting Thrust	REQUIRED THRUST
7		(lbf)	(ft-lbf)	(lbf)	(lbf)
86	1SI-685 (10")/Modification	28,403	484	31,909	3,506
87	2SI-685 (10")/Modification	28,403	484	31,909	3,506
88	3SI-685 (10")/Modification	28,403	484	31,909	3,506
89	1SI-694 (10")/Modification	28,403	484	31,909	3,506
90	2SI-694 (10")/Modification	28,403	484	31,909	3,506
91	3SI-694 (10")/Modification	28,403	484	31,909	3,506
92					
93					
94	1SI-686 (20")/Modification	67,657	1,478	77,499	9,842
95	2SI-686 (20")/Modification	67,657	1,478	77,499	9,842
96	3SI-686 (20")/Modification	67,657	1,478	77,499	9,842
97	1SI-696 (20")/Modification	67,657	1,478	77,499	9,842
98	2SI-696 (20")/Modification	67,657	1,478	77,499	9,842
99	3SI-696 (20")/Modification	67,657	1,478	77,499	9,842
100					
101					
102	1SI-688 (10")/Modification	28,353	483	31,909	3,557
103	2SI-688 (10")/Modification	28,353	483	31,909	3,557
104	3SI-688 (10")/Modification	28,353	483	31,909	3,557
105	1SI-693 (10")/Modification	28,353	483	31,909	3,557
106	2SI-693 (10")/Modification	28,353	483	31,909	3,557
107	3SI-693 (10")/Modification	28,353	483	31,909	3,557

	A	BG	BH	BI	BJ	BK	BL
1	Steven A. Lopez ___________						
2	Rafael Rios _____________			Additional			CHAPTER 15 EVENT RESULTING
3	Revision 9			PL		FRACTION	IN THE MAXIMUM INCREASE IN
4				Load	DIMEN.	RESIDUAL	BONNET TEMPERATURE PRIOR TO
5	Valve Tag (size)	MARGIN		"(PL Load	CORR.	OF CLOSING	REQ'D ACTIVE OPEN FUNCTION
6		DESIGN	Suscept?	-Res. Load)"			Reqd by GL 95-07
7		(%)		(lbf)			
8	A/D Gate Valves:						
9	1AF-34 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
10	2AF-34 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
11	3AF-34 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
12	1AF-35 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
13	2AF-35 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
14	3AF-35 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
15							
16							
17	1AF-36 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
18	2AF-36 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
19	3AF-36 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
20	1AF-37 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
21	2AF-37 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
22	3AF-37 (6")/Modification	12.6	No	24,343	0.979	0.524	HELB
23							
24							
25	1SG-134 (6")/Modification	17.3	No	19,213	0.775	0.554	ALL (Normal Conditions)
26	2SG-134 (6")/Modification	17.3	No	19,213	0.775	0.554	ALL (Normal Conditions)
27	3SG-134 (6")/Modification	17.3	No	19,213	0.775	0.554	ALL (Normal Conditions)
28	1SG-138 (6")/Modification	17.3	No	19,213	0.775	0.554	ALL (Normal Conditions)
29	2SG-138 (6")/Modification	17.3	No	19,213	0.775	0.554	ALL (Normal Conditions)
30	3SG-138 (6")/Modification	17.3	No	19,213	0.775	0.554	ALL (Normal Conditions)
31							
32							
33							

	A	BG	BH	BI	BJ	BK	BL
1	Steven A. Lopez						
2	Rafael Rios			Additional			CHAPTER 15 EVENT RESULTING
3	Revision 9			PL		FRACTION	IN THE MAXIMUM INCREASE IN
4				Load	DIMEN.	RESIDUAL	BONNET TEMPERATURE PRIOR TO
5	Valve Tag (size)	MARGIN		"(PL Load	CORR.	OF CLOSING	REQ'D ACTIVE OPEN FUNCTION
6		DESIGN	Suscept?	-Res. Load)"			Reqd by GL 95-07
7		(%)		(lbf)			
34	BW/IP Gate Valves:						
35	1CH-536 (3")/Evaluation	22.0	No	226	0.039	0.664	ALL (Normal Conditions)
36	2CH-536 (3")/Evaluation	22.0	No	226	0.039	0.664	ALL (Normal Conditions)
37	3CH-536 (3")/Evaluation	22.0	No	226	0.039	0.664	ALL (Normal Conditions)
38							
39							
40	1SI-604 (3")/Modification	17.0	No	3,826	0.407	0.609	LOCA
41	2SI-604 (3")/Modification	17.0	No	3,826	0.407	0.609	LOCA
42	3SI-604 (3")/Modification	17.0	No	3,826	0.407	0.609	LOCA
43	1SI-609 (3")/Modification	17.0	No	3,826	0.407	0.609	LOCA
44	2SI-609 (3")/Modification	17.0	No	3,826	0.407	0.609	LOCA
45	3SI-609 (3")/Modification	17.0	No	3,826	0.407	0.609	LOCA
46							
47							
48	1SI-651 (12")/Modification	10.6	No	131,568	2.105	0.356	LOCA
49	2SI-651 (12")/Modification	10.6	No	131,568	2.105	0.356	LOCA
50	3SI-651 (12")/Modification	10.6	No	131,568	2.105	0.356	LOCA
51	1SI-652 (12")/Modification	10.6	No	131,568	2.105	0.356	LOCA
52	2SI-652 (12")/Modification	10.6	No	131,568	2.105	0.356	LOCA
53	3SI-652 (12")/Modification	10.6	No	131,568	2.105	0.356	LOCA
54							
55							
56							
57							
58							
59							

	A	BG	BH	BI	BJ	BK	BL
1	Steven A. Lopez ____________						
2	Rafael Rios ____________			Additional			CHAPTER 15 EVENT RESULTING
3	Revision 9			PL		FRACTION	IN THE MAXIMUM INCREASE IN
4				Load	DIMEN.	RESIDUAL	BONNET TEMPERATURE PRIOR TO
5	Valve Tag (size)	MARGIN		"(PL Load	CORR.	OF CLOSING	REQ'D ACTIVE OPEN FUNCTION
6		DESIGN	Suscept?	-Res. Load)"			Reqd by GL 95-07
7		(%)		(lbf)			
60	1SI-653 (12")/Modification	16.6	No	28,311	0.978	0.524	LOCA
61	2SI-653 (12")/Modification	16.6	No	28,311	0.978	0.524	LOCA
62	3SI-653 (12")/Modification	16.6	No	28,311	0.978	0.524	LOCA
63	1SI-654 (12")/Modification	16.6	No	28,311	0.978	0.524	LOCA
64	2SI-654 (12")/Modification	16.6	No	28,311	0.978	0.524	LOCA
65	3SI-654 (12")/Modification	16.6	No	28,311	0.978	0.524	LOCA
66							
67							
68	1SI-655 (12")/Modification	23.6	No	23,472	0.861	0.542	HELB
69	2SI-655 (12")/Modification	23.6	No	23,472	0.861	0.542	HELB
70	3SI-655 (12")/Mod (w/OAR)	23.6	No	23,472	0.861	0.542	HELB
71	1SI-656 (12")/Modification	23.6	No	23,472	0.861	0.542	HELB
72	2SI-656 (12")/Modification	23.6	No	23,472	0.861	0.542	HELB
73	3SI-656 (12")/Mod (w/OAR)	23.6	No	23,472	0.861	0.542	HELB
74	3SI-656 (12")/Mod (w/o OAR)	5.4	No	23,472	0.850	0.543	HELB
75							
76							
77	1SI-672 (8")/Modification	31.5	No	8,558	0.740	0.546	LOCA
78	2SI-672 (8")/Mod	31.5	No	8,558	0.740	0.546	LOCA
79	3SI-672 (8")/Mod (see notes)	25.5	No	8,558	0.647	0.562	LOCA
80	1SI-671 (8")/Modification	31.5	No	8,558	0.740	0.546	LOCA
81	2SI-671 (8")/Modification	31.5	No	8,558	0.740	0.546	LOCA
82	3SI-671 (8")/Modification	31.5	No	8,558	0.740	0.546	LOCA
83							
84							
85							

	A	BG	BH	BI	BJ	BK	BL
1	Steven A. Lopez						
2	Rafael Rios			Additional			CHAPTER 15 EVENT RESULTING
3	Revision 9			PL		FRACTION	IN THE MAXIMUM INCREASE IN
4				Load	DIMEN.	RESIDUAL	BONNET TEMPERATURE PRIOR TO
5	Valve Tag (size)	MARGIN		"(PL Load	CORR.	OF CLOSING	REQ'D ACTIVE OPEN FUNCTION
6		DESIGN	Suscept?	-Res. Load)"			Reqd by GL 95-07
7		(%)		(lbf)			
86	1SI-685 (10")/Modification	11.0	No	20,051	1.492	0.448	ALL (Normal Conditions)
87	2SI-685 (10")/Modification	11.0	No	20,051	1.492	0.448	ALL (Normal Conditions)
88	3SI-685 (10")/Modification	11.0	No	20,051	1.492	0.448	ALL (Normal Conditions)
89	1SI-694 (10")/Modification	11.0	No	20,051	1.492	0.448	ALL (Normal Conditions)
90	2SI-694 (10")/Modification	11.0	No	20,051	1.492	0.448	ALL (Normal Conditions)
91	3SI-694 (10")/Modification	11.0	No	20,051	1.492	0.448	ALL (Normal Conditions)
92							
93							
94	1SI-686 (20")/Modification	12.7	No	61,158	3.035	0.218	ALL (Normal Conditions)
95	2SI-686 (20")/Modification	12.7	No	61,158	3.035	0.218	ALL (Normal Conditions)
96	3SI-686 (20")/Modification	12.7	No	61,158	3.035	0.218	ALL (Normal Conditions)
97	1SI-696 (20")/Modification	12.7	No	61,158	3.035	0.218	ALL (Normal Conditions)
98	2SI-696 (20")/Modification	12.7	No	61,158	3.035	0.218	ALL (Normal Conditions)
99	3SI-696 (20")/Modification	12.7	No	61,158	3.035	0.218	ALL (Normal Conditions)
100							
101							
102	1SI-688 (10")/Modification	11.1	No	20,001	1.492	0.448	ALL (Normal Conditions)
103	2SI-688 (10")/Modification	11.1	No	20,001	1.492	0.448	ALL (Normal Conditions)
104	3SI-688 (10")/Modification	11.1	No	20,001	1.492	0.448	ALL (Normal Conditions)
105	1SI-693 (10")/Modification	11.1	No	20,001	1.492	0.448	ALL (Normal Conditions)
106	2SI-693 (10")/Modification	11.1	No	20,001	1.492	0.448	ALL (Normal Conditions)
107	3SI-693 (10")/Modification	11.1	No	20,001	1.492	0.448	ALL (Normal Conditions)

	A	BM
1	Steven A. Lopez ____________	
2	Rafael Rios ______________	
3	Revision 9	VALVE
4		RATING
5	Valve Tag (size)	CLASS
6		
7		
8	A/D Gate Valves:	
9	1AF-34 (6")/Modification	900#
10	2AF-34 (6")/Modification	900#
11	3AF-34 (6")/Modification	900#
12	1AF-35 (6")/Modification	900#
13	2AF-35 (6")/Modification	900#
14	3AF-35 (6")/Modification	900#
15		
16		
17	1AF-36 (6")/Modification	900#
18	2AF-36 (6")/Modification	900#
19	3AF-36 (6")/Modification	900#
20	1AF-37 (6")/Modification	900#
21	2AF-37 (6")/Modification	900#
22	3AF-37 (6")/Modification	900#
23		
24		
25	1SG-134 (6")/Modification	900#
26	2SG-134 (6")/Modification	900#
27	3SG-134 (6")/Modification	900#
28	1SG-138 (6")/Modification	900#
29	2SG-138 (6")/Modification	900#
30	3SG-138 (6")/Modification	900#
31		
32		
33		

	A	BM
1	Steven A. Lopez ___________	
2	Rafael Rios ___________	
3	Revision 9	VALVE
4		RATING
5	Valve Tag (size)	CLASS
6		
7		
34	BW/IP Gate Valves:	
35	1CH-536 (3")/Evaluation	1500#
36	2CH-536 (3")/Evaluation	1500#
37	3CH-536 (3")/Evaluation	1500#
38		
39		
40	1SI-604 (3")/Modification	1500#
41	2SI-604 (3")/Modification	1500#
42	3SI-604 (3")/Modification	1500#
43	1SI-609 (3")/Modification	1500#
44	2SI-609 (3")/Modification	1500#
45	3SI-609 (3")/Modification	1500#
46		
47		
48	1SI-651 (12")/Modification	1500#
49	2SI-651 (12")/Modification	1500#
50	3SI-651 (12")/Modification	1500#
51	1SI-652 (12")/Modification	1500#
52	2SI-652 (12")/Modification	1500#
53	3SI-652 (12")/Modification	1500#
54		
55		
56		
57		
58		
59		

	A	BM
1	Steven A. Lopez ___________	
2	Rafael Rios _____________	
3	Revision 9	VALVE
4		RATING
5	Valve Tag (size)	CLASS
6		
7		
60	1SI-653 (12")/Modification	1500#
61	2SI-653 (12")/Modification	1500#
62	3SI-653 (12")/Modification	1500#
63	1SI-654 (12")/Modification	1500#
64	2SI-654 (12")/Modification	1500#
65	3SI-654 (12")/Modification	1500#
66		
67		
68	1SI-655 (12")/Modification	300#
69	2SI-655 (12")/Modification	300#
70	3SI-655 (12")/Mod (w/OAR)	300#
71	1SI-656 (12")/Modification	300#
72	2SI-656 (12")/Modification	300#
73	3SI-656 (12")/Mod (w/OAR)	300#
74	3SI-656 (12")/Mod (w/o OAR)	300#
75		
76		
77	1SI-672 (8")/Modification	300#
78	2SI-672 (8")/Mod	300#
79	3SI-672 (8")/Mod (see notes)	300#
80	1SI-671 (8")/Modification	300#
81	2SI-671 (8")/Modification	300#
82	3SI-671 (8")/Modification	300#
83		
84		
85		

	A	BM
1	Steven A. Lopez ___________	
2	Rafael Rios ___________	
3	Revision 9	VALVE
4		RATING
5	Valve Tag (size)	CLASS
6		
7		
86	1SI-685 (10")/Modification	330#
87	2SI-685 (10")/Modification	330#
88	3SI-685 (10")/Modification	330#
89	1SI-694 (10")/Modification	330#
90	2SI-694 (10")/Modification	330#
91	3SI-694 (10")/Modification	330#
92		
93		
94	1SI-686 (20")/Modification	300#
95	2SI-686 (20")/Modification	300#
96	3SI-686 (20")/Modification	300#
97	1SI-696 (20")/Modification	300#
98	2SI-696 (20")/Modification	300#
99	3SI-696 (20")/Modification	300#
100		
101		
102	1SI-688 (10")/Modification	330#
103	2SI-688 (10")/Modification	330#
104	3SI-688 (10")/Modification	330#
105	1SI-693 (10")/Modification	330#
106	2SI-693 (10")/Modification	330#
107	3SI-693 (10")/Modification	330#

NOTES:

13JAFBUV0034/0035

1) Electrical voltage is based on a conservatively interpolated available 414 volts @ 44 amps at unseating. (Curve M5204)

13JSGAUV0134/138

1) Electrical voltage is based on a conservatively interpolated available 93 volts @ 165 amps at unseating. (Curve K11350)

2) 1JSGAUV0134/138 valves are scheduled for modification in U1 R8 (Fall 99)

13JAFC(A)UV0036/(0037)

1) Electrical voltage is based on a conservatively interpolated available 98.44 volts @ 104 amps at unseating. (Curve 5013)

13JCHEHV0536

1) Electrical voltage is based on a conservatively interpolated available 414 volts @ 44 amps at unseating. (Curve M1468)

13JSIA(B)UV0604(609)

1) The valve structural limits for thrust and torque reflect the re-evalation based on design basis temperature of 225 DEGF. This re-evaluation of BW/IP weaklink analysis (Valve Part No. 77910/13-N001-2101-94-8) is documented in study 13-JS-A41.

13JSIA(B)UV0651/(652)

1) Electrical voltage is based on a conservatively interpolated available 414 volts @ 118 amps at unseating. (Curve SK-34176)

13JSIA(B)UV0653/(654)

1) Electrical voltage is based on 95% of nominal inverter AC output voltage of 480 volts & manual operation time requirements. (13--JC-ZZ-210)

13JSIA(B)UV0655/(656)

1) Bounding Coefficient Of Friction (COF) for applicable 13-MS-B07 R/3, Evaluation of Dynamic Performance Parameters for Generic Letter 89-10 MOVs, valve group 19, Borg-Warner 12 inch 300 lb & 1500 lb Class Flex Wedge Gate Valves is 0.18. Specific Open COF for this valve based on dynamic testing is recorded as 0.10. A COF value of 0.15 is used to consevatively estimate maximum COF for this valve.

2) Electrical voltage is based on a conservatively interpolated 414 volts @ 30.8 amps at unseating. (Curve M1488)

3) 1JSIAUV0655 valve is schedule for modification in U1R8 (Fall 99). 3JSIBUV0656 is scheduled for OAR change in U3 R8 (Spring 2000).

13JSIBUV0671

1) Electrical voltage is based on a conservatively interpolated available 414 volts @ 47.3 amps at unseating. (Curve M-4635)

13JSIAUV0672

1) The lowest voltage that may occur during the actuation of this MOV is 405 VAC: however, this voltage ony occurs for a duration of approximately 1.44 seconds @ 5 seconds after SIAS/CSAS. Available voltage is at time 0 is 425 VAC, at approximately 6.5 seconds the available voltage increases to 414 VAC. 414 VAC is conservatively used as the effective available voltage during unseating since the actuator motor is rated for 10 seconds stall without permanent damage and the short duration of the 405 min voltage does not impact the ability of the actuator to unseat given the postulated pressure locking loads.
Limitorque motors can go to a locked rotor condition for 10 seconds without sustaining damage per Limitorque fax date 9-30-94 and review of the motor thermal limit curve.

2) 1JSIAUV0672 valve is schedule for modification in U1R8 (Fall 99).

13JSIA(B)HV685(694)

1) 1JSIAHV0685 valve is schedule for modification in U1R8 (Fall 99). 3JSIBUV0694 is scheduled for OAR change in U3 R8 (Spring 2000).

13JSIA(B)HV686(696)

1) Electrical voltage is based on a conservatively interpolated available 414 volts @ 33 amps at unseating. (Curve E2272A-A-001)

2) 1JSIAHV0686 valve is schedule for modification in U1R8 (Fall 99). 3JSIBUV0696 is scheduled for OAR change in U3 R8 (Spring 2000).

13JSIA(B)HV688(693)

1) 1JSIAHV0688 valve is schedule for modification in U1R8 (Fall 99). 3JSIBUV0693 is scheduled for OAR change in U3 R8 (Spring 2000).

Attachment #2- Bonnet Pressure/Temperature Relationship

Calculation of the Theoretical Increases in Bonnet Pressure in Gate Valves

The theoretical curve for pressure vs temperature plotted in this attachment is based on the following theory. A significant increase in valve temperature is accompanied with an increase in bonnet fluid pressure and temperature. The valve body will expand as the fluid temperature and pressure increases. A coarse calculation of the increase in process fluid pressure with an increase in room temperature wll be performed conservatively neglecting the expansion of the valve body and bonnet.

The increase in process pressure can be calculated by modelling the isolated valve bonnet as a closed system with constant mass (dM/dt= 0). The specific volume at initial temperature and pressure is assumed to be maintained constant throughout since the bonnet cavity volume is constant and zero leakage is assumed (dM/dt=0). The final pressure is calculated using the following algorithms with the final temperature and the initial specific volume as inputs [Ref. 27, ASME Steam Tables (subregion 1, compressed water region)].

These algorithms were taken from Appendix 1 of Reference 27 where they were presented for use with digital computers for the calculation of the associated thermodynamic properties. These algorithms were programed and the associated thermodynamic properties were calculated utilizing T-K Solver. This approach is similar to that used in Reference 5. The resulting Pressure-Temperature corrolation is plotted on the attached graph and has been validated by corrolation with the tabular values for these thermodynamic properities in Table 3 of Reference 27.

$$v = v_r(0.00317)(16.018)$$
$$T_r = (T+459.67)/[(647.3)(9/5)]$$
$$P_r = P/(3207)$$
$$v_r = C1+C2-C3-C4+C5+C6$$

where,

$v=$ Specific Volume (ft^3/lbm)
$v_r=$ Reduced Specific Volume
$T=$ Temperature (^oF)
$T_r=$ Reduced Temperature
$P=$ Pressure (psia)
$P_r=$ Reduced Pressure

and,

$$C1= A11(B5)(Z)^{-5/17}$$
$$C2= A12+A13(T_r)+A14(T_r)^2+A15(B6\ T_r)^{10}+A16(B7+T_r^{19})^{-1}$$
$$C3= (B8+T_r^{11})^{-1}[A17+2(A18)(P_r)+3(A19)(P_r)^2]$$
$$C4= A20(T_r)^{18}(B9+T_r^2)[-3(B10+P_r)^{-4}+B11]$$
$$C5= 3(A21)(B12-T_r)(P_r)^2$$
$$C6= 4(A22)(T_r^{-20})(P_r)^3$$

SH ~~45~~ ~~34~~ 66

7-16-99 SAL 11/7/96 SAL 9/1/99

Sta A. Long 4/19/96   I.V. Rafael Rios 4-19-96

when,

$$Z= Y+[(B3)(Y^2)-2(B4)(T_r)+2(B5)(P_r)]^{0.5}$$
$$Y= 1-(B1)(T_r)^2-(B2)(T_r)^{-6}$$

Constants (Ref. ASME Steam Tables)

A11= 7.982692717
A12=-2.616571843E-2
A13= 1.522411790E-3
A14= 2.284279054E-2
A15= 2.421647003E2
A16= 1.269716088E-10
A17= 2.074838328E-7
A18= 2.174020350E-8
A19= 1.105710498E-9
A20= 1.293441934E1
A21= 1.308119072E-5
A22= 6.047626338E-14
B1= 8.438375405E-1
B2= 5.362162162E-4
B3= 1.720000000
B4= 7.342278489E-2
B5= 4.975858870E-2
B6= 6.537154300E-1
B7= 1.150000000E-6
B8= 1.510800000E-5
B9= 1.418800000E-1
B10= 7.002753165
B11= 2.995284926E-4
B12= 2.040000000E-1

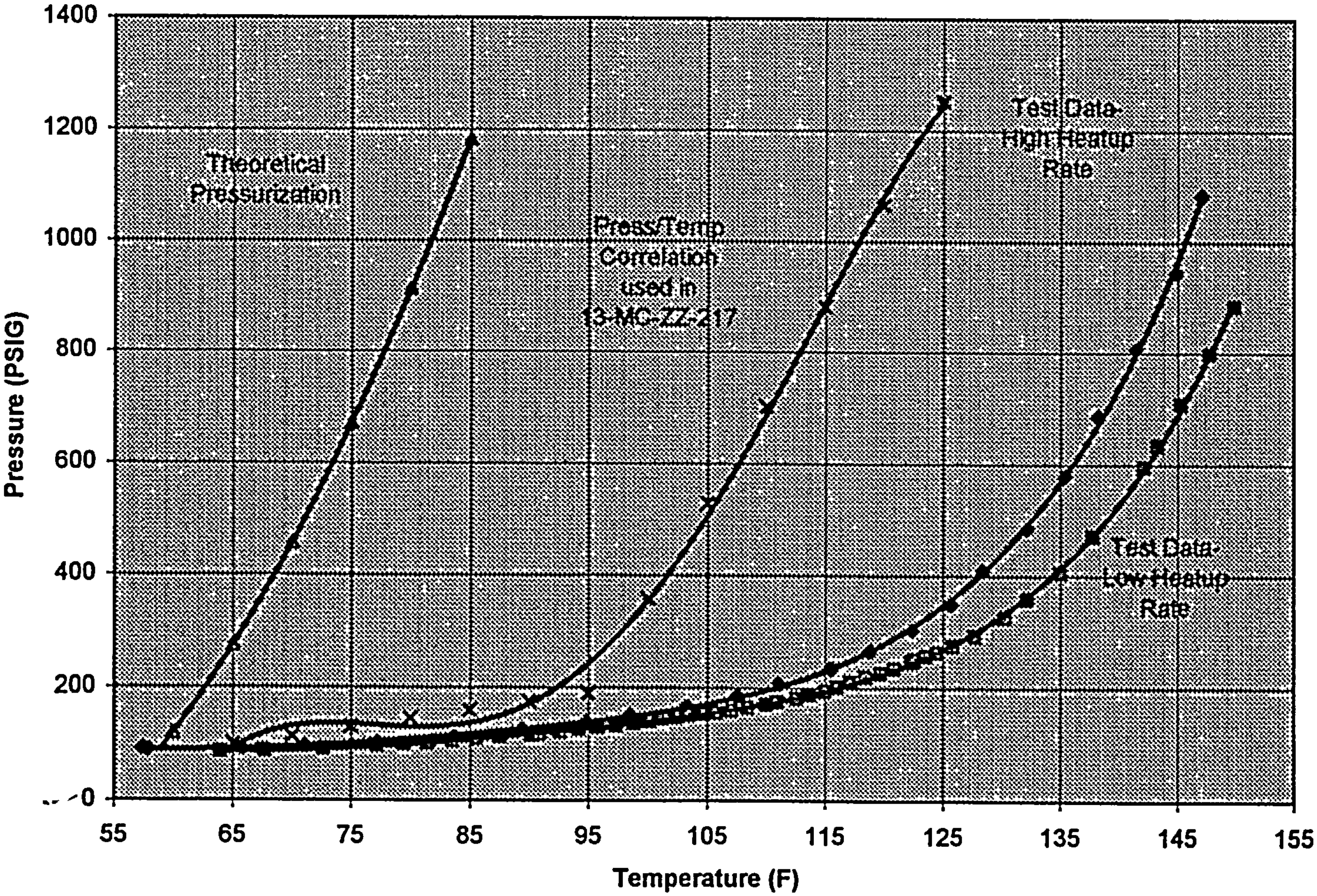
13-MC-ZZ-217 R/2 SH 67

ATTACHMENT 2

R.E. Steven A. Long 9/1/99

I.V. Rafael Rios 9/2/99

Bonnet Fluid Pressure vs Bonnet Fluid Temperature



4/19/96 I.V. Rafael Rios 4-19-96

	PVNGS PRESSURE LOCKING SUSCEPTIBILTY EVALUATION					
	VALVE FIELD DIMENSIONAL DATA					
			2a	2b	theta	
VALVE SIZE (IN.)	PVNGS TAG	VENDOR MODEL #	MEAN SEAT DIA. (IN.)	MIN. DISK HUB DIA. (IN.)	SEAT ANGLE (DEG.,MIN.)	
6	21-AF-34	A/D 3897-3	5.25	1.75	5	
6	03-AF-34	A/D W8321892	5.25	1.75	5	
6	21-AF-35	A/D 3897-3	5.25	1.75	5	
6	03-AF-35	A/D W8321892	5.25	1.75	5	
6	13-AF-36	A/D 3896-3	5.25	1.75	5	
6	13-AF-37	A/D 3897-3	5.25	1.75	5	
6	13-SG-134	A/D 3994-3	5.25	1.75	5	
6	13-SG-138	A/D 3994-3	5.25	1.75	5	
3	13-SI-604	B/W 77910	2.75	2.22	5 ,15	
3	13-SI-609	B/W 77910	2.75	2.22	5 ,15	
3	13-CH-536	B/W 77910	2.995	2.22	5 ,15	
8	13-SI-671	B/W 79510	8.14	4.58	5 ,15	
8	13-SI-672	B/W 79510	8.14	4.58	5 ,15	
10	13-SI-685	B/W 77780	10.25	5.26	5 ,15	
10	13-SI-688	B/W 77780	10.25	5.26	5 ,15	
10	13-SI-693	B/W 77780	10.25	5.26	5 ,15	
10	13-SI-694	B/W 77780	10.25	5.26	5 ,15	
12	13-SI-651	B/W 77850	10.505	5.94	5 ,15	
12	13-SI-652	B/W 77850	10.505	5.94	5 ,15	
12	13-SI-653	B/W 77850-1	10.505	5.94	5 ,15	
12	13-SI-654	B/W 77850-1	10.505	5.94	5 ,15	
12	13-SI-655	B/W 77850-2	10.505	5.94	5 ,15	
12	13-SI-656	B/W 77850-2	10.505	5.94	5 ,15	
20	13-SI-686	B/W 77890-2	19.03	10.5	5	
20	13-SI-696	B/W 77890-2	19.03	10.5	5	

0000 0000 0049

R.E. [signature] 9-1-99 I.V. Rafael Rios 9-2-99

Attachment 4- Validation of Pressure Locking Thrust vs Bonnet Pressure Model

Arizona Public Service, in partnership with Commonwealth Edison and the Westinghouse Users Group, performed testing of a Borg Warner 10", 300# class flexible wedge gate valve to determine the stem thrust required to open a flexible wedge gate valve with the fluid pressure in the valve bonnet greater than the fluid pressure in the upstream and downstream piping. The test methodology instrumentation, and final results are identified in Attachment #5.

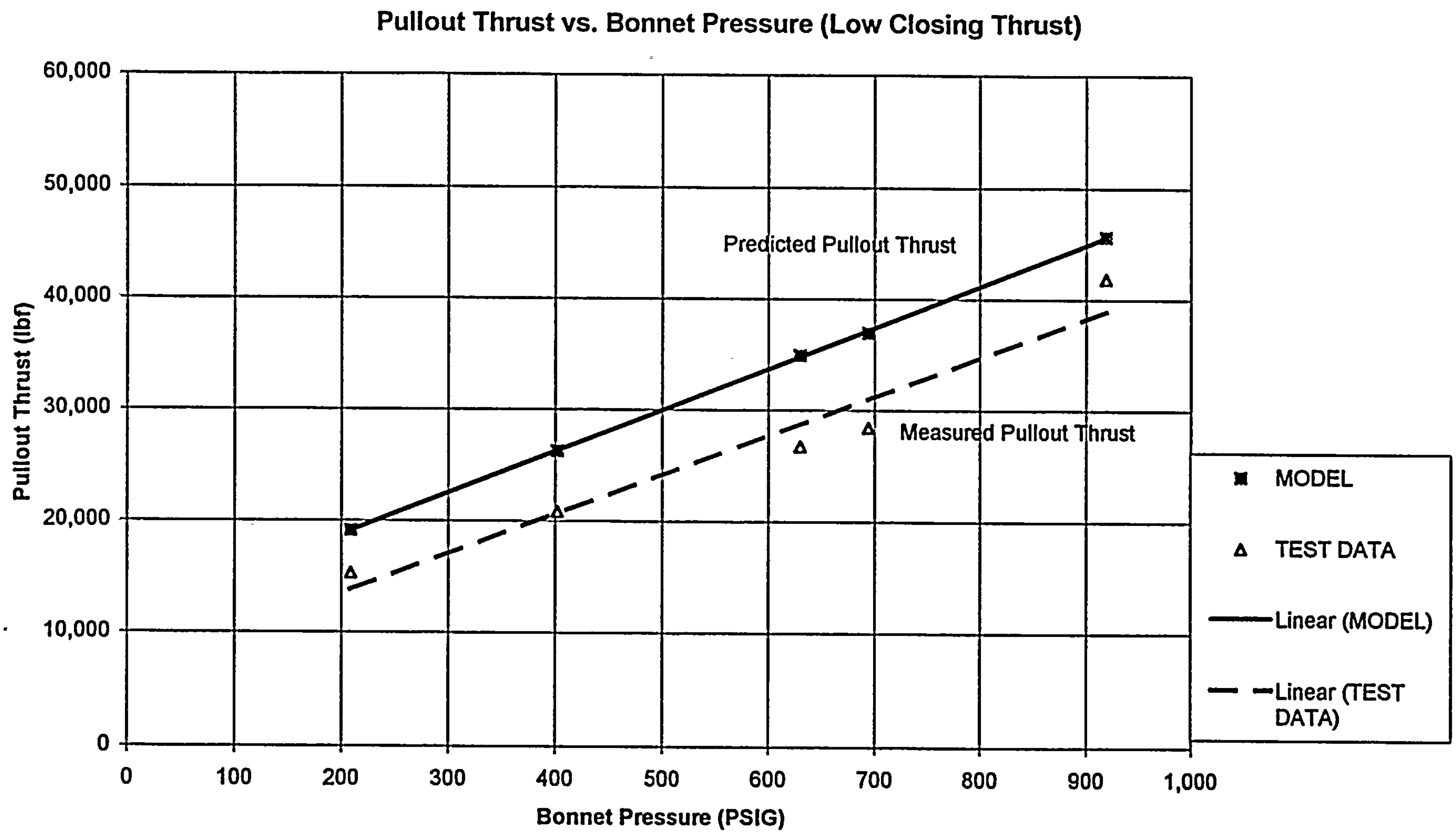
Testing performed to measure the stem thrust at several different bonnet pressures was performed with two different closed torque switch settings. A plot of the peak stem thrust required to open the valve as a function of the bonnet pressure has been generated for both of these torque switch settings (see charts 1 & 2 of this attachment). For comparison, the predicted stem pullout thrust, calculated using the methodology of 13-MC-ZZ-217, is plotted as a function of bonnet pressure.

The inputs required to calculate the predicted stem pullout thrust are provided in Attachment 5. Analysis of the data resulted in the development of an experimental dimensional correlation to determine the percentage of residual load as a function of the bonnet pressure induced load. This correlation was established based on the test results in Attachment 5 and is represented in chart 3 of this attachment. The correlation indicates that as the bonnet pressure increases the residual load percentage of the effective closing thrust is reduced. The test value for the residual closing load components, without residual load, from the total measured load. This value is then divided by the measured test value of the prior closing thrust to determine the measured residual percentage of closing force.

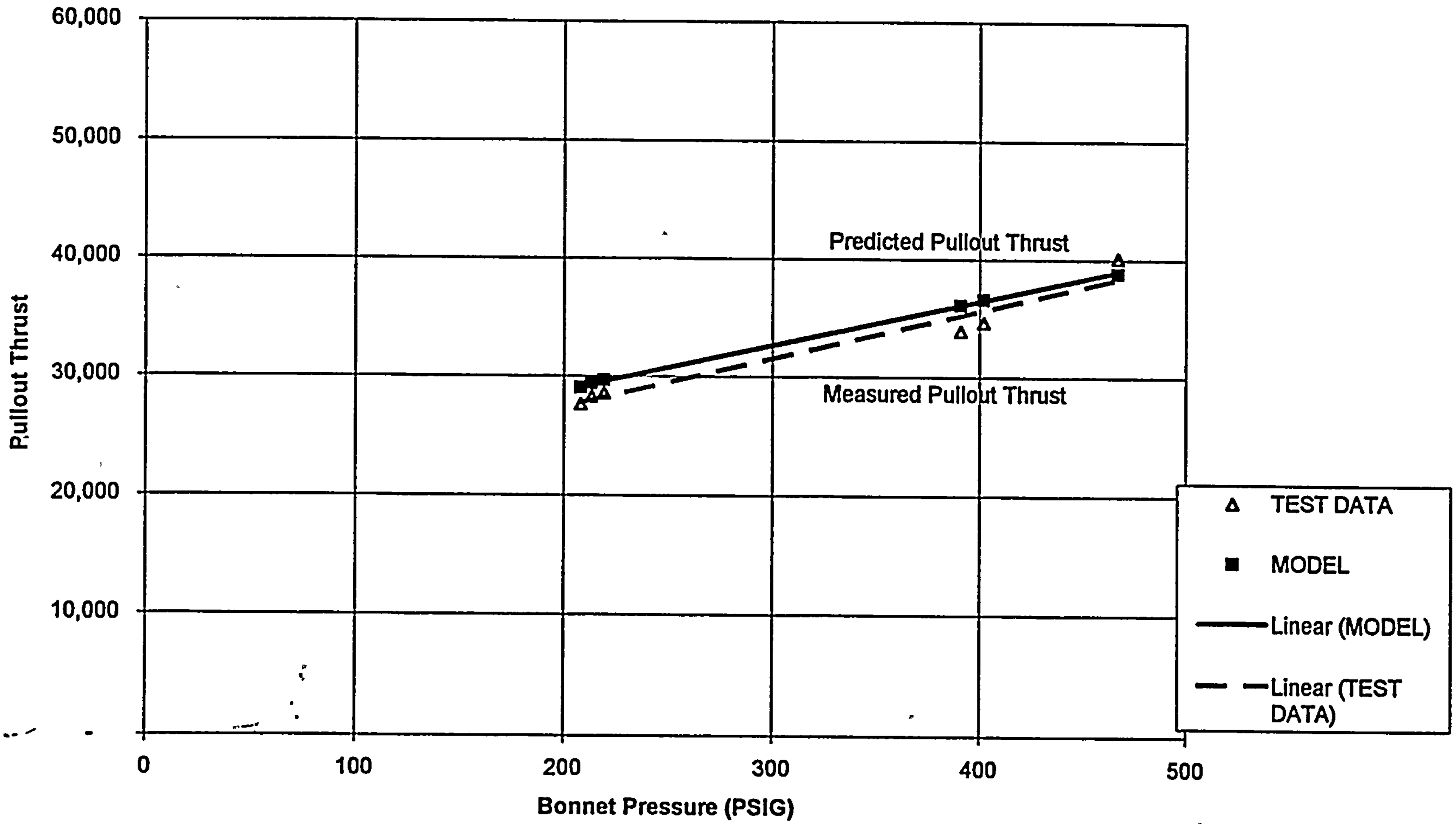
The measured data and predicted values from selected tests are plotted and fit with linear regressions on charts 1 & 2 of this attachment. Chart 1 includes selected tests with a measured bonnet pressure greater than 200 psig and prior closing thrust less than 17,000 lbs (Low closing Thrust). Chart 2 includes selected tests with a measured bonnet pressure greater than 200 psig and prior closing thrust greater than 31,000 lbs (High closing Thrust). In general a good correlation between the regression for the measured data and for the predicted values is demonstrated by the similarity in slope between the plotted lines on chart 1. The margin between the measured data and predicted data presented in chart 1 ranges from a high of 30.9% for the measured pressure locking load of 26, 705 lbf with a bonnet pressure of 630 psig (Test #52) to a minimum margin of 8.9% between the measured and predicted values of the pressure locking load of 41,872 lbf with a bonnet pressure of 919 psig (Test #56). However, the measured data presented in chart 2 tracks the predicted values calculated utilizing the methodology of 13-MC-ZZ-217. There is one set of data (Test #80) where the measured PL load exceeds the calculated stem thrust required to open by 3.1%. Therefore, for applications of this 13-MC-ZZ-217 model with postulated bonnet pressure of above 200 psig an additional minimum 10% margin is maintained between the minimum actuator load limit and the calculated required pressure locking load unless otherwise specified.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1		BORG WARNER 10" 300# TEST GATE VALVE																									
2														MOV MISC INPUTS													
3		TEST PRESSURES					VALVE INPUTS							Max Clos	% Residual		Calculation of Disk Load Perpindicular to the Seat Using Roark Thin Plate Theory										
4	TEST	Pinital	Pup	Pdown	DPavg		a	b	theta	nu	VF	Dstem		Load	Load		C2	C3	C8	C9	L11	L17	mu	Qb	Qa	Disk Load	
5	Test #42	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,783	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
6	Test #43	205	0	0	205		5.13	2.7	5	0.3	0.6	1.5		32,032	61%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	397	-170	6,911	
7	Test #44	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,731	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
8	Test #45	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,162	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
9	Test #46	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,659	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
10	Test #47	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,859	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
11	Test #48	209	0	0	209		5.13	2.7	5	0.3	0.6	1.5		16,809	56%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	405	-173	7,046	
12	Test #49	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,659	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
13	Test #50	402	0	0	402		5.13	2.7	5	0.3	0.6	1.5		16,708	46%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	779	-334	13,552	
14	Test #51	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,807	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
15	Test #52	630	0	0	630		5.13	2.7	5	0.3	0.6	1.5		16,958	34%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	1,221	-523	21,238	
16	Test #53	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,460	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
17	Test #54	694	0	0	694		5.13	2.7	5	0.3	0.6	1.5		16,361	29%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	1,345	-576	23,395	
18	Test #55	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		16,956	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
19	Test #56	919	0	0	919		5.13	2.7	5	0.3	0.6	1.5		16,709	18%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	1,782	-763	30,980	
20																											
21	Test #58	950	0	0	950		5.13	2.7	5	0.3	0.6	1.5		15,665	13%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	1,842	-788	32,025	
22																											
23																											
24	Test #72	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,521	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
25	Test #73	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,670	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
26	Test #74	208	0	0	208		5.13	2.7	5	0.3	0.6	1.5		31,670	61%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	403	-173	7,012	
27	Test #75	213	0	0	213		5.13	2.7	5	0.3	0.6	1.5		31,920	61%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	413	-177	7,180	
28	Test #76	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,822	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
29	Test #77	391	0	0	391		5.13	2.7	5	0.3	0.6	1.5		32,017	56%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	758	-325	13,181	
30	Test #78	402	0	0	402		5.13	2.7	5	0.3	0.6	1.5		32,168	56%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	779	-334	13,552	
31	Test #79	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,671	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
32	Test #80	467	0	0	467		5.13	2.7	5	0.3	0.6	1.5		31,868	54%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	905	-388	15,743	
33	Test #81	219	0	0	219		5.13	2.7	5	0.3	0.6	1.5		31,971	61%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	425	-182	7,383	
34	Test #82	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		32,417	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
35	Test #83	110	0	0	110		5.13	2.7	5	0.3	0.6	1.5		32,318	64%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	213	-91	3,708	
36	Test #84	54	0	0	54		5.13	2.7	5	0.3	0.6	1.5		31,820	65%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	105	-45	1,820	
37	Test #85	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,722	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
38	Test #86	1	0	0	1		5.13	2.7	5	0.3	0.6	1.5		32,464	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	2	-1	34	
39	Test #87	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		32,413	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
40	Test #88	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		32,267	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
41																											
42	Test #92	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		31,951	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
43	Test #93	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		17,392	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
44	Test #94	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		17,244	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
45	Test #95	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		17,443	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	
46	Test #96	557	0	0	557		5.13	2.7	5	0.3	0.6	1.5		17,394	39%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	1,080	-462	18,777	
47	Test #97	504	0	0	504		5.13	2.7	5	0.3	0.6	1.5		17,691	42%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	977	-418	16,990	
48	Test #98	0	0	0	0		5.13	2.7	5	0.3	0.6	1.5		17,393	67%		0.0917	0.0127	0.7471	0.2861	0.00163	0.0824	0.6307	0	0	0	

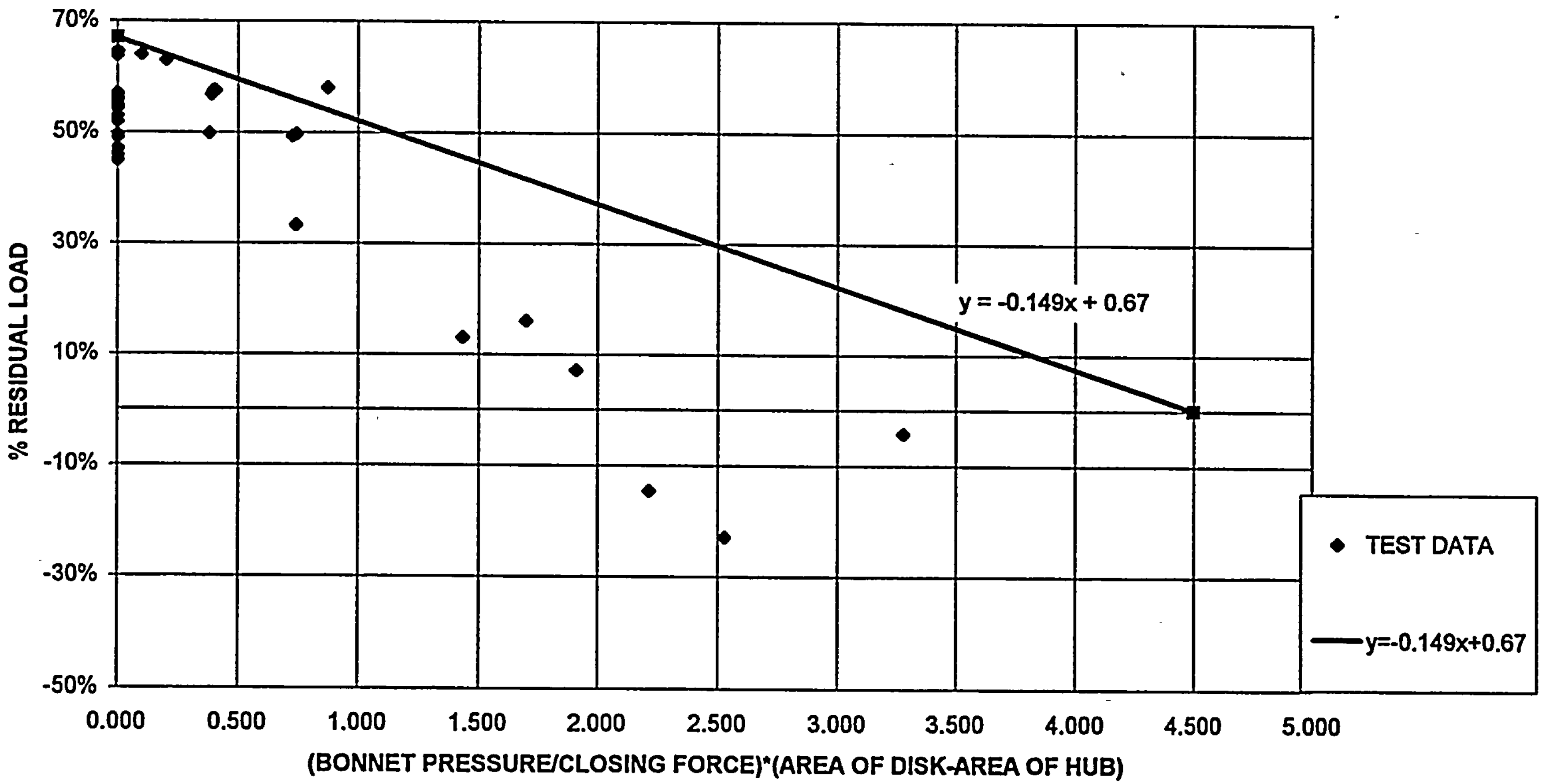
	A	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1														
2		Residual Closing	Vertical Load	Stem Piston		Calculated Stem Thrust	Measured	Margin %		Residual Closing	% Residual Load	Exp.Dimensional	Meas. Residual %	Model Residual %
3		Load at Cracking	On Disks	Load		Req'd to Open	PL Load		Bonnet	Load at Opening	of Total Load	Corrolation	of Closing Thrust	of Closing Thrust
4	TEST	Residual Load	Fvert	Fpiston		Ftotal			Pressure	(Measured Load-PL Loads)		(BP*SA/Closing)		
5	Test #42	21,295	0	0		21,295	16,513	29.0	0	16,513	100%	0.000	52%	67%
6	Test #43	19,641	2,949	362		29,138	25,467	14.4	205	15,970	63%	0.382	50%	61%
7	Test #44	21,260	0	0		21,260	17,357	22.5	0	17,357	100%	0.000	55%	67%
8	Test #45	10,829	0	0		10,829	7,261	49.1	0	7,261	100%	0.000	45%	67%
9	Test #46	11,162	0	0		11,162	7,509	48.6	0	7,509	100%	0.000	45%	67%
10	Test #47	11,296	0	0		11,296	7,907	42.9	0	7,907	100%	0.000	47%	67%
11	Test #48	9,406	3,006	369		19,088	15,268	25.0	209	5,586	37%	0.741	33%	56%
12	Test #49	11,162	0	0		11,162	7,857	42.1	0	7,857	100%	0.000	47%	67%
13	Test #50	7,624	5,782	710		26,247	20,786	26.3	402	2,163	10%	1.434	13%	46%
14	Test #51	11,261	0	0		11,261	7,707	46.1	0	7,707	100%	0.000	46%	67%
15	Test #52	5,766	9,062	1,113		34,952	26,705	30.9	630	-2,481	-9%	2.215	-15%	34%
16	Test #53	11,028	0	0		11,028	8,105	36.1	0	8,105	100%	0.000	49%	67%
17	Test #54	4,797	9,982	1,226		36,948	28,395	30.1	694	-3,756	-13%	2.529	-23%	29%
18	Test #55	11,361	0	0		11,361	7,658	48.3	0	7,658	100%	0.000	45%	67%
19	Test #56	3,032	13,218	1,624		45,607	41,872	8.9	919	-703	-2%	3.279	-4%	18%
20														
21	Test #58	2,057	13,664	1,679		46,068	5,023	817.1	950	-38,988	-776%	3.615	-249%	13%
22														
23														
24	Test #72	21,119	0	0		21,119	16,705	26.4	0	16,705	100%	0.000	53%	67%
25	Test #73	21,219	0	0		21,219	17,202	23.4	0	17,202	100%	0.000	54%	67%
26	Test #74	19,371	2,992	368		29,007	27,643	4.9	208	18,007	65%	0.392	57%	61%
27	Test #75	19,494	3,064	376		29,362	28,241	4.0	213	18,373	65%	0.398	58%	61%
28	Test #76	21,321	0	0		21,321	17,751	20.1	0	17,751	100%	0.000	56%	67%
29	Test #77	17,978	5,624	691		36,092	33,906	6.4	391	15,792	47%	0.728	49%	56%
30	Test #78	17,982	5,782	710		36,605	34,604	5.8	402	15,981	46%	0.745	50%	56%
31	Test #79	21,220	0	0		21,220	17,949	18.2	0	17,949	100%	0.000	57%	67%
32	Test #80	17,203	6,717	825		38,838	40,121	-3.2	467	18,486	46%	0.874	58%	54%
33	Test #81	19,475	3,150	387		29,621	28,540	3.8	219	18,394	64%	0.408	58%	61%
34	Test #82	21,719	0	0		21,719	17,700	22.7	0	17,700	100%	0.000	55%	67%
35	Test #83	20,676	1,582	194		25,772	25,457	1.2	110	20,361	80%	0.203	63%	64%
36	Test #84	20,840	777	95		23,341	22,871	2.1	54	20,369	89%	0.101	64%	65%
37	Test #85	21,254	0	0		21,254	17,352	22.5	0	17,352	100%	0.000	55%	67%
38	Test #86	21,742	14	2		21,788	20,980	3.9	1	20,934	100%	0.002	64%	67%
39	Test #87	21,717	0	0		21,717	18,494	17.4	0	18,494	100%	0.000	57%	67%
40	Test #88	21,619	0	0		21,619	18,197	18.8	0	18,197	100%	0.000	56%	67%
41														
42	Test #92	21,407	0	0		21,407	17,541	22.0	0	17,541	100%	0.000	55%	67%
43	Test #93	11,653	0	0		11,653	8,000	45.7	0	8,000	100%	0.000	46%	67%
44	Test #94	11,553	0	0		11,553	8,547	35.2	0	8,547	100%	0.000	50%	67%
45	Test #95	11,687	0	0		11,687	11,132	5.0	0	11,132	100%	0.000	64%	67%
46	Test #96	6,706	8,012	984		32,511	27,035	20.3	557	1,231	5%	1.909	7%	39%
47	Test #97	7,376	7,249	891		30,725	26,189	17.3	504	2,840	11%	1.698	16%	42%
48	Test #98	11,653	0	0		11,653	8,547	36.3	0	8,547	100%	0.000	49%	67%


Pullout Thrust vs. Bonnet Pressure (Low Closing Thrust)
Pullout Thrust (lbf)
60,000
50,000
40,000
30,000
20,000
10,000
0
0
100
200
300
400
500
600
700
800
900
1,000
Bonnet Pressure (PSIG)
Predicted Pullout Thrust
Measured Pullout Thrust
MODEL
TEST DATA
Linear (MODEL)
Linear (TEST DATA)

Pullout Thrust vs. Bonnet Pressure (High Closing Thrust)



RESIDUAL LOAD PRESSURE BONNET RELATIONSHIP



12/10/96

Rafael Rios 12/12/96

PRESSURE LOCKING SPECIAL TEST PROCEDURE
BORG WARNER VALVE
COMMONWEALTH EDISON COMPANY PROCEDURE PL/TB-2

SAL 9/1/99 13-MC-ZZ-217 R/1 SH ~~54~~ 76

PRESSURE LOCKING SPECIAL TEST PROCEDURE

BORG WARNER VALVE

PROCEDURE PL/TB-2

Revision 0

November 28, 1995

Commonwealth Edison Company

Prepared by: R.C. Bedford
Robert C.Bedford
Program Support

Approved by: Dan Christiana 12/4/95
Dan Christiana
Programs Supv.

Test Results

Prepared by: R.C. Bedford

Approved by: D. Christiana 3/6/96

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TABLE OF CONTENTS

A. PURPOSE

The purpose of this special test is to validate the proposed model and input assumptions for quantifying capability margin for valves susceptible to pressure locking. Specifically, testing will be performed on a Borg Warner valve to verify:

- the model for estimating MOV presssure lock pullout forces
- bonnet ability to retain pressure when upstream presssure source is removed
- bonnet pressure response to temperature changes

The MOV for this special test is a Borg Warner valve. This procedure provides the test requirements, procedures, and equipment to be used.

B. REFERENCES

1. Generic Letter 95-07, Pressure Locking and Thermal Binding
2. ComEd Quality Assurance Program

C. TEST EQUIPMENT AND INSTRUMENTATION

1. All instrumentation, measuring, and test equipment used in the performance of this test program should be calibrated in accordance with ComEd's Quality Assurance Program
2. Measurement Equipment is listed in Table 1
3. Thrust, torque, motor power, and motor current shall be monitored
4. Upstream, downstream, and bonnet pressure and temperature should be recorded as specified herein
5. Teledyne Quick Stem Sensor
6. Hydro-pump capable of generating 2000 psi
7. Miscellaneous valves and fittings

D. PRECAUTIONS

1. Standard safe work practices shall be followed when working around high pressure and electrical test equipment.

13-MC-ZZ-217 R/1 SH. ~~57~~ 79

SMC 9/1/99

E. REQUIREMENTS AND PROCEDURES

Table 2 specifies the testing to be performed and the test sequence. This test sequence and requriements may be modified during the special test. Sections may be added or omitted based on testing results at the discretion of the test engineer. New or revised test sequences should be added to Table 2.

1. Pre-Test Preparation
   a. Record valve and actuator nameplate data into the test datasheets (Appendix A-8)
   b. The required measurements and associated instruments to be installed are listed in Table 1
   c. The data acquisition method will consist of the VOTES system, motor power monitor (if required), associated support equipment and cables.
   d. Pressures and temperatures will be recorded manually or electronically.
   e. Prior to any testing or stroking of the valve, actuator switches shall be set as follows:
      1) The open limit switch shall be set to prevent back-seating of the valve
      2) The open torque switch should be bypassed a minimum of 25% of the open travel distance.
   f. Calibration of the VOTES Force Sensor and/or Teledyne Quick Stem Sensor shall be documented on Appendix A1.

2. Static Break-in Test

   Verify that the valve has been stroked a minimum of 15 strokes open and 15 strokes closed. If not, cycle valve until the specified strokes are achieved.

3. LLRT Test

   An LLRT Leakage Rate Test shall be performed at specified torque switch settings <u>in both directions</u> to verify seat leakage requirements in accordance with approved station procedures. This testing will be documented in Appendix A2.

4. Differential Pressure Test to Determine Valve Factor

   a. With the valve open fill the specimen with water .
   b. With the valve unpressurized, stroke test specimen open and then closed at the lower torque switch setting and record test data.
   c. Pressurize upstream disk side per Table 2.
   d. Vent downstream disk side to atmosphere.
   e. Open the valve , record diagnostic test data, and record upstream pressure.
   f. With the valve unpressurized, stroke test specimen closed and record test data in Appendix A3.
   g. Perform valve factor calculation as described in Appendix A3 and record results.

5. Bonnet Pressure Response

   a. With the valve open fill the specimen with water.
   b. With the valve unpressurized and setup per Table 2, stroke test specimen open and then closed and record test data.
   c. With downstream disk side vented to atmosphere pressurize upstream disk side to the pressure indicated in Table 2 for this test.
   d. Vent upstream disk side to atmosphere and record bonnet pressure as a function of time in Appendix A4.

6. Pressure Lock Test

   a. With the valve open fill the specimen with water such that all air pockets are vented and bonnet is filled solid with water.
   b. With the valve unpressurized and setup per Table 2, stroke test specimen open and then closed and record test data.
   c. Pressurize bonnet to the pressure indicated in Table 2 for this test
   d. Vent downstream and upstream disk side to atmosphere.
   e. Record bonnet pressure and open/close the valve while recording diagnostic test data in Appendix A5.

7. Bonnet Pressure Response to Temperature Changes

   a. With the valve open fill the specimen with water such that all air pockets are vented and bonnet is filled solid with water.
   b. With the valve unpressurized and setup per Table 2, stroke test specimen open and then closed and record test data.
   c. Pressurize bonnet to the pressure indicated in Table 2 for this test.
   d. Heat bonnet to maximum achievable temperature.
   e. Monitor and record fluid temperature and bonnet pressure until stable. Record results in Appendix A6.

8. Thermal Binding Response to Temperature Changes

   a. With the valve open fill the specimen with water.
   b. With the valve unpressurized, stroke test specimen open, closed and open at the lower torque switch setting and record test data.
   c. With the upstream and downstream disk sides vented to atmosphere heat valve body and bonnet to temperature indicated in Table 2 for this test.
   d. Close valve and record test and temperature data. Temperatures will be recorded at various locations on the valve body to establish overall temperature.
   e. When valve has cooled to room temperature open valve and record diagnostic test and temperature data in Appendix A7.

F. RESULTS/ACCEPTANCE CRITERIA

The results of this test will be used as technical input for evaluations and calculations to resolve/assess the pressure locking issue. This test has no acceptance criteria.

G. DATA SHEETS

Appendix A provides Data Sheets for recording the results of the testing.

TABLE 1
MEASUREMENT EQUIPMENT AND TOLERANCES

Measurement Parameter	Device Name	QA/Serial #	Calibration Date/Due Date
Pressure Gage Upstream Disk Side	ASHCROFT MT 111	MT111	12/3/95 / POST TEST
Pressure Gage Downstream Side	ASHCROFT MT 111	MT 111	12/3/95 / POST TEST
Pressure Gage Bonnet	MT8003	MT8003	12/3/95 / POST TEST
Temperature Gage Bonnet	OMEGA	—	12/3/95 / POST TEST
Stem Torque	Teledyne Quick Stem Sensor	NONE	DURING TEST
Stem Torque	Liberty , VTC	2754606BR	8/95 / 2/96
Stem Thrust	Teledyne Quick Stem Sensor	NONE	DURING TEST
Stem Thrust (Verification)	Liberty, C-Clamp	2789816R	
Motor Power	Liberty, MPM	IC04076	1/96
Motor Current	Liberty, MPM	IC04076	1/96
Motor Voltage	Liberty, MPM	IC04076	1/96

[illegible]

TABLE 2
TESTING SEQUENCE AND NUMBERING

Procedure Section (NOTES TEST #)	Test Title
18	STATIC HIGHER TSS (2.0)
F.4 19/20/21	Differential pressure test to quantify disk friction factor at 200 psi (BONNET 72)
F.4 22	Differential pressure test to quantify disk friction factor at 500 psi
F.4 23	Differential pressure test to quantify disk friction factor at 800 psi
F.5	Bonnet Pressure Response at 500 psi and lower torque switch setting
F.5	Bonnet Pressure Response at 1000 psi and lower torque switch setting
F.5 26	Bonnet Pressure Response at 500 psi and higher torque switch setting
F.5	Bonnet Pressure Response at 1000 psi and higher torque switch setting
F.6 43/48	Pressure Lock Un-wedging at 200 psi and lower torque switch setting
F.6 50	Pressure Lock Un-wedging at 400 psi and lower torque switch setting
F.6 52	Pressure Lock Un-wedging at 700 psi and lower torque switch setting
F.6 54	Pressure Lock Un-wedging at 1000 psi and lower torque switch setting
F.7	Bonnet pressure start at 0 psig. Temperature start at ambient. Torque switch at higher setting
F.7	Bonnet pressure start at 50 psig. Temperature start at ambient. Torque switch at higher setting
F.7	Bonnet pressure start at 100 psig. Temperature start at ambient. Torque switch at higher setting
F.8	Valve body temperature maximum approximately 212 °F
F.8	Valve body temperature maximum approximately 350 °F

5/6/97

13-MC-22-217 R/1 SH. 62 84

VFS CALIBRATION FEILD DATA SHEET

VALVE TAG NUMBER: BORGW1	VOTES SYSTEM SERIAL NO.: 278951BR
VOTES SYSTEM QA NO.: 278951BR	CAL DUE DATE: 1/96

CALIBRATOR LOCATION: THREADED UN-THREADED SLOTTED TRANSITION

DESCRIPTION: VOTES SYSTEM WITH QSS. QSS CALIBRATED WITH C-CLAMP #1C005 QA # 278981BR. BFSL USED FOR CALIBRATION ONLY

NEW EFFECTIVE STEM DIA. 1.154	CB3-100 LENGTH: 31 ft	AMP PROBE SETTING: 2V 20A
ANTI-ROTATION DEVICE: yes (no)		

CALIBRATION TABLE

RUN #	Test Number	VOTES SENS NO.	CAL DEV. NO.	CLAMP PRE-TENSION READING	TSS	MAX THRUST	RSQ	CFA	BFSL SENS	BFSL % CHG	STEM TEMP (F)	GAIN
1	–	N/A	N/A		2.0	32940	1.0	N/A	4.10 E-2		–	2
2	–	N/A	N/A			32919	1.0	N/A	4.09 E-2	0.24	–	2

SM 9/1/99

LLRT RESULTS DATA SHEET

LOW FLOW METER 4499478BR CAL 2/95 DUE 2/96
HI FLOW METER 1049552BR; CAL 2/95 DUE 2/96
PRESSURE GAGE 0332016R CAL 8/95 DUE 8/96

VOTES Test #	TSS	C14, lbf	C16, lbf	Pullout, lbf	Leakage, scfh	Comments, Note upstream or downstream test.
18	2.0	20902	23241	7863	11.5 SCFH	Upstream, 45.6 psid
24	1.0	7662	12638	3781	10.5 SCFH	Upstream, 45.6 psid
24	1.0	7662	12638	3781	< 0.4 SCFH	Downstream, 45.6 psid
25	2.0	22438	24826	7612	< 0.4 SCFH	Downstream, 45.6 psid
25	2.0	22438	24826	7612	3.5 SCFH	Upstream, 45.6

13-MC-ZZ-217 R/1 SH. 63 85

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Test #	C16 Thrust, lbf	Pullout Thrust, lbf	Upstream Disk Side Pressure, psi	Downstream Disk Side Pressure, psi	O10 Thrust, lbf	Open Run Thrust, lbf	Open Valve Factor[1]	Comments
18	23241	7863	–	–	–	669	–	STATIC AT TSS 2.0
19	25430	8858	≈ 100 ~~200~~	0	1543	617		DP TEST AT TSS 2.0 @ 200 PSI
20	25825	7663	≈ 100 ~~200~~	0	1841			REPEAT TEST 19
21	26172	11096	200	0	2587	540	0.148	
22	25477	13535	450	0	5424	535	0.151	
23	23436	16420	730	0	9902	555	0.174	
28	26459	13330	760	0	14475	605 ~~597~~	0.24	FOR CONDITIONING TEST AFTER NUMEROUS DP TESTS
29	28945	18799	530	0	14025	406	0.327	

$$^{1}\text{Valve Factor} = \frac{\text{O10} - \text{Run Load} + \left[\text{Upstream Pressure} \times \frac{\pi}{4}(1.\overset{5}{\cancel{25}})^2\right]}{\text{Upstream Pressure} \times \frac{\pi}{4}(\underset{10.386}{\cancel{3.445}})^2}$$

RCB 12/4/95

RCB 12/4/95

9/11/99

13-MC-22-217 R/1 SH. ~~64~~ 86

0.4900 0000 0000

SR 9/1/95

13-MC-ZZ-217 R/1 SH. 65 87

Test #	C16 Thrust, lbf	Pullout Thrust, lbf	Upstream Disk Side Pressure, psi	Downstream Disk Side Pressure, psi	O10 Thrust, lbf	Open Run Thrust, lbf	Open Valve Factor[1]	Comments
30	28550	14722	540	0	15767	435	.359	
31	29395	15966	245	0	7311	482	.360	
32	29446	14126	285	0	8257	500	.345	
33	29843	11291	455	0	13529	426	.364	
34	29245	11539	475	0	14573	448	.375	
35	29794	13927	450	0	13828	528	.373	
36	29344	10494	550	550	6863	499	.159	
37	29344	9102	0	505	9599	439	.239	CONDITIONING STROKES PERFORMED PRIOR TO THIS TEST (DP)

RCB 12/1/95

$$^{1}\text{Valve Factor} = \frac{\text{O10} - \text{Run Load} + \left[\text{Upstream Pressure} \times \frac{\pi}{4}\left(1.\cancel{25}\,5\right)^2\right]}{\text{Upstream Pressure} \times \frac{\pi}{4}\left(\cancel{3.445}\right)^2}$$

10.336 RCB 12/1/95

Test #	C16 Thrust, lbf	Pullout Thrust, lbf	Upstream Disk Side Pressure, psi	Downstream Disk Side Pressure, psi	O10 Thrust, lbf	Open Run Thrust, lbf	Open Valve Factor[1]	Comments
38	28966	9549	0	550	14821	479	.332	
39	29096	12683	0	520	15269	447	.361	
59	9845	16757	510	510	17553	350	.423	
66	31722	22474	~~208~~ 0	~~0~~ 208	6165	525	.344	
67	31722	22126	0	198	6066	653	.347	
68	31922	21513	0	370	11834	614	.382	
69	31873	24414	0	413	13922	623	.405	
70	32069	25506	0	575	18346	557	.390	

$$^{1}\text{Valve Factor} = \frac{\text{O10} - \text{Run Load} + \left[\text{Upstream Pressure} \times \frac{\pi}{4}(1.25 \to 5)^2\right]}{\text{Upstream Pressure} \times \frac{\pi}{4}(3.445 \to 10.386)^2}$$

13-MC-22-217 R/1 SH.66 88

Test #	C16 Thrust, lbf	Pullout Thrust, lbf	Upstream Disk Side Pressure, psi	Downstream Disk Side Pressure, psi	O10 Thrust, lbf	Open Run Thrust, lbf	Open Valve Factor[1]	Comments
71	31721	27545	0	610	20633	638	.413	
99	19164	21022	0	610	20177 ~~217~~16			TEST NO GOOD
100	16101	19729	0	578	20325	748	.425	

13-MC-ZZ-217 R/1 SA.67 89

$$^{1}\text{Valve Factor} = \frac{\text{O10} - \text{Run Load} + \left[\text{Upstream Pressure} \times \frac{\pi}{4}\left(1.\not{2}5\right)^2\right]}{\text{Upstream Pressure} \times \frac{\pi}{4}\left(\not{3.445}\right)^2}$$

5 10.536

SRL 9/1/99 | 13-MC-ZZ-217 R/1 SH ~~68~~ 90

VOTES Test #: 25 C16 Thrust: 24826

Time	Bonnet Pressure, Psig
0	504
1:00	503
2:00	502
3:00	501
4:00	500
5:00	500
6:00	499
7:00	498
0	938
1:00	928
2:00	918
3:00	910
4:00	900
5:00	892
6:00	883
7:00	875
8:00	867
9:00	858
10:00	850

Note: Packing region and all external seals remained dry during test

SAL 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~69~~ 91

BONNET PRESSURE RESPONSE RESULTS DATA SHEET

VOTES Test #: ____________ C16 Thrust: ______________

Time	Bonnet Pressure, Psig
11:00	842
12:00	835
13:00	827
14:00	820
15:00	812

13-MC-ZZ-217 R/1 SH. ~~70~~ 92

VOTES Test #: ____________ C16 Thrust: ______________

Time	Bonnet Pressure, Psig

SAL 9/1/99 | 13-MC-ZZ-217 R/1 SH. 93

BONNET PRESSURE RESPONSE RESULTS DATA SHEET

VOTES Test #: ____________ C16 Thrust: ______________

Time	Bonnet Pressure, Psig

SM 9/1/99

Test Description	VOTES Test #	MPM Title	C16 Thrust, lbf	09 Thrust, lbf	Bonnet Pressure, psi	Pullout Motor Power, kW	Pullout Torque, lbf	Comments
STATIC TEST	42	—	31,783	16,513	0 ~~700~~	—	162.4	
PRESSURE LOCK TEST	43	12-6-95 11:26 AM	32,032	25,467	205	4.197	251.9	TSS - 2
STATIC TEST	44	11:41 AM	31,731	17,357	0	2.61	166.5 ~~294.2~~	
STATIC TEST	45	11:51 AM	16,162	7,261	0	1.48	70.8	LOWER TS TO 1
Static Test	46	12:10 P.M	16,659	7509	0	1.63	73.5	TSS = 1
Static Test	47	12:14 P.M	16,859	7907	0	1.569	77.0	TSS = 1
PRESSURE LOCK TEST	48	Press Lock Low TSS 200psi	16809	15268	209	2.56	148.5	TSS = 1
STATIC TEST	49	STATIC Low TSS	16659	7857	0	1.61	76.3	TSS = 1
PRESSURE LOCK TEST	50	Low TSS PL AT 400psi	16708	20786	402	3.08	202.6	TSS = 1
STATIC TEST	51	STATIC TEST 1:12 LOWER TSS	16807	7707	0	1.55	75.6	TSS = 1
PRESSURE LOCK TEST	52	PRESS LOCK LOW TSS [illegible] 700psi	16958	26705	630	4.35	262.9	TSS = 1
Static Test	53	Static test 1:20pm Lower TSS	16460	8105	0	1.53	79.1	TSS = 1
PRESSURE LOCK TEST	54	Press Lock Low TSS 1000psi	16361	28395	694	4.77	279.6	

13-MC-ZZ-217 R/1 SH. ~~72~~ 94

SML 9/1/99

Test Description	VOTES Test #	MPM Title	C16 Thrust, lbf	09 Thrust, lbf	Bonnet Pressure, psi	Pullout Motor Power, kW	Pullout Torque, lbf	Comments
STATIC TEST	55	STATIC TEST LOWER TSS	16956	7658	0	1.58	74.9	
PRESS LOCK TEST	56	PRES LOCK LOWER TSS 1000 PSI	16109	41872	919	9.77	427.3	
STATIC TEST w/1000 PSI	58	STATIC LOW TSS 1000	15665	5023	850	1.24	49.3.	
STATIC TEST AFTER DP	72	STATIC HIGH TSS	31521	16705	0	2.51	168.0	
STATIC REPEAT TEST AFTER DP	73	STATIC HIGH TSS	31670	17202	0	2.55	164.4	
PRESS LOCK TEST	74	PRESS LOCK VALVE HIGH TSS 200 PSIG	31670	27613	208	4.19	271.2	
Press Lock Test	75	PRESS LOCK HIGH TSS 200 PSIG	31920	28241	213	4.86	277.5	
Static	76	11:53am	31822	17751	0	2.70	171.3	
Pres Lock Test	77	PRESS LOCK HIGH TSS 400 PSIG	32017	33906	391	6.36	343.3	
PRESS LOCK TEST	78	PRESS LOCK HIGH TSS 400 PSIG	32168	34604	402	6.37	344.0	
STATIC TEST	79	STATIC HIGH TSS	31671	17949	0	2.78	169.9	
PRESS LOCK TEST	80	PRESS LOCK HIGH TSS 400 PSIG	31868	40121	467	7.91	410.6	PRESS WHOLE VALVE AND CLOSED
PRESS LOCK TEST	81	PRESS LOCK HIGH TSS 200 PSI	31971	28540	219	4.82	278.8	"

13-MC-EE-217 R/1 SH 7/3 95

SM 9/1/99

13-MC-22-217 R/1 SH 34 96

Test Description	VOTES Test #	MPM Title	C16 Thrust, lbf	09 Thrust, lbf	Bonnet Pressure, psi	Pullout Motor Power, kW	Pullout Torque, lbf	Comments
STATIC TEST	82	STATIC HIGH TSS	32417	17700	0	2.69	170.6	
PRESSURE LOCK	83	PRESS LOCK HIGH TSS 100 PSIG	32318	25457	110	4.36	246.9	
PRESSURE LOCK	84	PRESS LOCK HIGH TSS 50 PSIG	31820	22871	54	3.45	222.0	
STATIC TEST	85	STATIC HIGH TSS	31722	17352	0	2.54	167.8	
STATIC TEST	86	STATIC HIGH TSS	32464	20480	1	3.09	205.3	PRESSURIZED DOWNSTREAM TO 520 AND DEPRESSURIZED
STATIC TEST	87	STATIC HIGH TSS	32413	18494	0	2.85	177.6 ~~157.7~~	" 200 PSID
Static test	88	Static High TSS	32267	18197	0	2.61	175.5	
STATIC TEST	92	STATIC HIGH TSS	31951	17541	0	2.78	167.8	POST ~~PRESS~~ THERMAL BINDING
STATIC TEST	93	STATIC LOW TSS	17392	8000	0	1.67	77.0	TSS = 1 PRE-MEMORY-STATIC
STATIC TEST (Memory Effect)	94	Memory Effect Orsi Low TSS	17244	8547	0	1.84	83.2	TSS = 1 CHECK OF MEMORY ← air in bonnet
~~Static (Memory Effect)~~ Static Mem Effect Test	95	"	17443	11132	0	1.92	106.1	" ← bonnet water-sol
PRESSURE LOCK	96	PRESS LOCK LOW TSS 520 psig	17394	27035	557	4.44	269.0	
PRESSURE LOCK	97	"	17691	26189	504	3.95	259.3	

SM 9/1/99

Test Description	VOTES Test #	MPM Title	C16 Thrust, lbf	09 Thrust, lbf	Bonnet Pressure, psi	Pullout Motor Power, kW	Pullout Torque, lbf	Comments
STATIC TEST	98	STATIC [illegible]	17393	8547	0	1.71	82.5	

13-MC-22-217 R/1 5H.25 97

SM 9/1/99 | 13-MC-ZZ-217 R/1 SH. 76 98

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 60 C16 Thrust: 31,327

O9 Thrust: 16,609

HIGH HEAT RATE

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F Outside top	Internal fluid	
0	93	61.2	57.4	
10:00	90	62.2	59.7	
15:00	93	63.4	65.8	
17:30	97	65.4	71.1	
20:00	104	68.0	77.2	
22:30	113	70.4	83.7	
25:00	125	73.6	89.4	
27:30	139	77.4	94.9	
30:00	150	80.2	98.5	
32:30	166	84.0	103.3	
35:00	185	87.6	107.5	
37:30	207	90.4	111.1	
40:00	233	93.8	115.5	
42:30	265	97.4	118.9	
45:00	302	99.8	122.4	
47:30	347	103.2	125.7	

0000 0000 0079

SML 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~21~~ 99

Pg 2

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 50　　C16 Thrust: 31327

O9 Thrust: 16609

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F OUTSIDE TOP	INTERNAL FLUID	
50:00	409	105.4	128.4	
52:30	484	108.0	132.2	
55:00	578	110.0	135.4	
57:30	687	112.0	138.2	
60:00	808	115.4	141.4	
62:30	946	119.2	144.9	
65:00	1084	122.0	147.1	
67:30				
70:00				
72:30				
75:00				
77:30				
80:00				
82:30				
85:00				
87:30				

SM 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~28~~ 100

Pg 0

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 88 C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F OUTSIDE TOP	INTERNAL FLUID
~~90:62~~			
00:00	86	65.0	64.0
10:00	86	76.0*	64
20:00	88	73	67.7
25:00	92	75.4	72.7
30:00	96	78.2	77.1
32:30	100	80.0	79.5
35:00	102	80.8	81.4
37:30	105	82.4	83.5
40:00	109	83.8	85.5
42:30	113	85.8	87.6
45:00	116	88	90.2
47:30	118	88.8	90.9
50:00	122	90.2	92.6
52:30	126	92	94.2
55:00	130	93.2	95.9

* PICKED UP HEAT FROM HEATERS / DISCARD POINT

00000 00000 0081

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 38 C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F OUTSIDE BODY TOP	INTERNAL FLUID
57:30	133	94.4	97.3
60:00	137	95.6	98.8
1:02:30	140	96.8	100.1
1:05:00	145	97.6	101.2
1:07:30	148	97.8	102.4
1:10:00	151	98.2	103.5
1:12:30	154	98.8	104.7
1:15:00	156	99.4	105.8
1:17:30	160	100.2	107.1
1:20:00	165	101.0	108.4
1:22:30	170	102.0	110.0
1:25:00	175	103.0	110.9
1:27:50	181	104.2	112.6
1.30.00	187	105.2	113.7
1.32:50	194	106.4	115.0
1:35:00	201	107.4	116.0
1:37:30	209	108.6	117.1
1:40:00	219	110.0	118.4
1:42:30	225	111.0	119.7

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 88 C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F OUTSIDE	INSIDE
1:45:00	233	112.0	120.9
1:48:30 ← Really 1:48:30	245	113.4	122.3
1:50:00	249	114.0	122.6
1:52:30	256	115.0	123.6
1:55:00	262	116.0	124.5
1:57:30	274	117.0	125.8
2:00:00	291	118.2	127.7
2:02:30	324	119.7	130.3
2:05:00	357	121.2	132.2
2:07:30	405	123	135
2:10:00	470	125	137.7
2:14 (2:12:30 missed)	595	128.6	142.1
2:15	633	129.6	143.3
2:17:30	708	131.4	145.3
2:20	798	133.8	147.8
2:22:30	885	136.0	149.9

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 58   C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F BODY TEMP	 FLUID TEMP
2:44:00	71	177.0	173.4
2:46:30	75	171.8	176.4
2:49:00	MISSED	—	—
2:51:30	MISSED	—	—
2:54:00	96	179.2	184.9
2:56:30	105	182.8	187.6
2:59:00	115	184.6	190.3
3:01:30	127	184.6	192.9
3:03:00	138	186.4	194.8
3:05:30	151	187.6	196.8
3:08:00	170	189.8	199.2
3:10:30	194	193.0	201.0
3:13:00	224	196.6	203.0
3:15:30	262	196.4	206.0
3:18:00	309	197.6	208.0
3:20:30	362	202.2	211.0

DECREASED PRESSURE THR BONNET GA

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 88 C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F Bonnet Temp	Fluid Temp
3:23:00	431	202.6	213
3:25:30	514	201.8	215
3:28:00	615	203.8	217
3:30:30	729	206.2	220
3:34:00	225	212.4	222
3:36:30	MISSED	—	—
3:39:00	320	216.8	228
3:41:30	391	216.4	230
3:43:00	MISSED	—	—
3:45:30	540	218.8	233
3:48:00	659	221.4	236
3:50:30	169	221.4	238
3:53:00	193	228.2	240
3:55:30	228	230.4	242
3:58:00	276	233	245

DECREASED BONNET PRESS THROUGH GLAND.

DECREASED BONNET PRES.

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 88 C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F Bonnet Temp	Fluid Temp
4:00:30	332	235	247
4:03:00	409	237.2	249
4:05:30	523	239.2	252
4:08:00	626	241.4	253
4:10:30	181	247	257
4:13:00	194	218.6	258
4:15:30	232	251	260
4:18:00	282	252.4	262
4:20:30	348	253.2	264
4:23:00	430	254.4	266
4:25:30	526	256.4	268
4:28:00	184	262.6	270
4:30:30	212	266.2	272
4:33:00	246	270.6	274
4:35:30	285	273.4	276
4:38:00	339	275	277

DEPRESS

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: 48 C16 Thrust: 32267

O9 Thrust: 18197

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F BONNET TEMP	FLUID TEMP	
4:40:30	384	277	278	
4:43:00	442	269.4	280	
4:45:30	490	268.8	281	DEPRESS
4:48:00	172	271	281	
4:50:30	184	272	283	
4:53:00	200	272	284	
4:55:30	218	272.6	285	
4:58:00	237	273.2	286	
5:00:30	258	273.6	286	
5:03:00	279	274.4	287	
5:05:30	305	275.6	288	
5:08:00	347	276.6	290	
5:10:30	412	277.4	291	
5:13:00	504	278.8	293	
5:15:30	595	279.6	294	

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: Low TSS C16 Thrust: N/A

O9 Thrust: N/A INITIAL WTR TEMP 103 °F

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F FLUID TEMP	UPSTREAM TEMP	V/v Body disk	V/v Body Dust upside
00:00	37	65.3	103°F		
14:00	40	67.2	102		
20:00	40	67.8	101.2		
25:00	41	68.3	111.8		
30:00	42	69.2	124.2	68.0	68.1
35:00	44	70.6	140	71.2	7~~1~~.4
40:00	46	71.5	149	72	71.6
45:00	49	72.8	159.2	74.4 ~~86.4~~	71.6
50:00	53	74.8	170	74.6	72.6
55:00	58	76.9	179.8	76.0	74.8
60:00	69	79.8	189.4	77.8	76.4
1:05:00	82 Late	82.7	195.8	80.4	78.1
1:10:00	90	83.9	198.4	81.6	78.6
1:15:00	107	86.4	201.8	82.4	80.2
1:20:00	131	88.7	205.6	84.6	81.4
1:25:00	172 Late	91.9	209.0	87.8	82.2

PRESSURE RESPONSE TO TEMPERATURE DATA SHEET

VOTES Test #: Low TSS C16 Thrust: N/A

O9 Thrust: N/A

Time	Bonnet Pressure, Psig	Bonnet Temperature, °F FLUID TEMP	UPSTR TEMP	V/v Body disk	V/v Rest
1:30:00	198	93.5	210.8	88.0 ~~210.8~~	84
1:35:00	242	95.8	213.2	89.4	86.5
1:40:00	361	98.4	215.6	92.0	87.
1:45:00	395	100.3	217.4	93.4	89.
1:50:00	394	102.2	219.4	96.0	89.
1:55:00	443	104.3	221.2	96.6	92. ~~95.~~
2:00:00	488	106.2	223.0	97.8	95.
2:05:00	531	108.0	224.0	98.6	96.8
2:10:00	562	110.0	226.2	100.6	98.
2:15:00	588	112.0	228.0	101.2	99.
2:20:00	609	113.8	229.8	102.2	~~100.~~ 100
2:25:00	626	115.5	229.2	102.0 ~~102.8~~	96
2:30:00	643	117.2	229.6	100.0	97
2:35:00	673	119.0	231.8	100.0	98
2:40:00	684	120.5	232.4	102.2	98
2:45:00	720	122.3	233.8	102.2	99.
2:50:00	772	123.9	235.4	104.4	99.
2:55:00	826	125.4	237.0	104.6	
3:00:00					

SRC 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~87~~ 109

THERMAL BINDING TEST RESULTS DATA SHEET

	HIGH TEMP	COOL
Bonnet Temperature	152 °F	77 °F
Valve Body Temperature	160 °F	72 °F

~~Pre~~ heating test data		Post Cooling test data	
Votes Test #	63	Votes Test #	~~90~~ 64
O9	16008	O9	15995
C16	32264	C16	~~2597~~ 31973

Bonnet Temperature	203 °F	75 °F
Valve Body Temperature	287 °F	72 °F

~~Pre~~ heating test data		Post Cooling test data	
Votes Test #	89, 90 ~~91~~	Votes Test #	91
O9	24052	O9	24244
C16	25942	C16	31348

DATA SUSPECT DUE TO HEATING OF SENSOR SEE TEST #92

Bonnet Temperature	________
Valve Body Temperature	________

Pre heating test data		Post Cooling test data	
Votes Test #		Votes Test #	
O9		O9	
C16		C16	

VALVE DATA SHEET

Valve	
Type	GATE (FLEX WEDGE)
Vendor	BORG WARNER
Size	10 INCH
Model No.	77780
Mean Seat Diameter	10.199 INNER SEAT DIA 10.473 OUTER
Stem Diameter	1.5 INCH
Actuator	
Type	SMB
Vendor	LIMITORQUE
Size	0
Model No.	O/N 3A6606A
Serial No	261003
OAR	31.11
Spring Pack No.	017
Motor	
Type	RY INSULATION CLASS B, FRAME P56
Vendor	RELIANCE
Motor Rating	25 FT LB START 5 RUN
Model No.	—
RPM	1700
Voltage	460
Motor Power (AC/DC)	AC

SAL 9/1/99 | 13-MC-ZZ-217 R/1 SH.82 111

Borg Warner Valve
Pressure Locking Thermal Binding Test Notes

12/04/95 Test Setup

The Borg Warner valve was received from the stand fabricator and is shown in figure 1. The stand was designed such that the valve could be rotated about the center of gravity to remove air from the valve bonnet. The instrument maintenance department calibrated and installed the test equipment as shown in figure 2. Two holes were drilled and tapped into the bonnet to accept a thermowell/temperature meter and a pressure transducer/indicator. This pressure transducer was input into the VOTES system spare channel to obtain bonnet pressure traces.

A high pressure air/water accumulator was used to pump high pressure water into either the upstream or downstream side of the valve. The accumulator would supply a constant water pressure during unseating of the valve.

Data Acquisition

The VOTES and MPM systems were used as data acquisition devices for the test. The VOTES system was used to monitor stem thrust, switch actuation, spare channel bonnet pressure and motor current. The MPM system was used to monitor motor voltage parameters. The Borg Warner valve stem (threads) were machined to the minor diameter for approximately 3 inches in stem length. In this area a Teledyne QSS was mounted and connected to the VOTES system. This QSS was then calibrated using a Liberty C-Clamp on the machined section of stem. Because the QSS is a linear device a best fit straight line was used to fit the calibration data.

A calibration was performed at a high valve torque switch setting of 2.0. Two calibrations were performed which were within 0.24 percent of each other.

Conditioning strokes

After performance of the calibration the valve was stroked approximately 15 times in accordance with the procedure. These strokes were performed without data acquisition.

SKL 9/1/99 | 13-MC-ZZ-217 R/1 SH.92 112

12/05/95 Local leak rate testing

A Local Leak Rate Test (LLRT) was performed in accordance with procedural step E.3 after initial differential pressure testing. This LLRT testing was performed in accordance with plant procedures with a test pressure of 45.6 psig. Initial results on the upstream side of the valve indicated leakage rates of 11.5 scfh at a TSS of 2.0 and 10.5 scfh at a TSS of 1.0. On the downstream side of the valve the indicated leakage rates were zero or the test equipment accuracy of 0.4 scfh. Based on these results the upstream side of the valve was retested at a TSS of 2.0 and leakage rates were 3.5 scfh. It is believed that leakage path existed outside the valve during the original upstream leakrate tests.

Bonnet Pressure Response

In accordance with test section E.5 a bonnet depressurization test was performed. The valve was set at a TSS of 2.0 to run this test. The bonnet was pressurized through the upstream seat to a pressure of approximately 500 psig and the upstream and downstream sides of the valve were depressurized. The bonnet depressurization rate at approximately 500 psig was approximately 1 psi per minute and at approximately 940 psi the depressurization rate was approximately 10 psi per minute decreasing to 7 psi per minute at approximately 820 psig. It should be noted that the packing area remained dry during this test. It should also be noted that the packing leak off line was capped during all of the testing.

12/05/95 Differential pressure testing
12/06/95

Differential pressure tests were started on the upstream side of the valve at a TSS of 2.0. Tests 19 through 23 were performed at differential pressures of 100, 200, 450, and 730 with valve factors ranging from 0.143 to 0.174. It was decided to run some conditioning differential pressure tests and approximately eight unmonitored tests were performed at a differential pressure of approximately 600 psig. Differential pressure test 28 and 29 were performed with valve factors of 0.24 and 0.32. Differential pressure tests 30 through 35 were performed at various pressures between 200 and 500 psid and valve factors ranged between 0.34 and 0.37. Based on this it was believed that the valve factor had stabilized. Differential pressure test 36 was performed by pressurizing on the downstream side of the valve and at a dp of 550 a valve factor of 0.16 was achieved. Based

on this low valve factor numerous unmonitored conditioning dp tests were performed. This raised the valve factor to 0.361 on test 39. It was believed that the valve factor had stabilized on both seats of the valve.

Pressure locking testing

Pressure locking data acquisition started with static test 42 and pressure lock test 43 at a TSS of 2.0. After this test the TSS was lowered to 1.0 and static tests 45 through 47 were run. Tests 48 through 56 were performed alternating between static and pressure lock with bonnet pressures ranging between 200 and 900 psig.

Pressure response to temperature

During this test the valve was set up with high temperature heating coils placed around the center of the valve body around where the disk seats are such that the center of the valve could be heated. During this test the temperature was monitored and recorded both on the outside of the bonnet and the inside water temperature. The bonnet internal pressure was also recorded. The valve was tipped to remove all the air from the bonnet as water was run into the valve. VOTES test 60 was run at a TSS of 2.0 prior to this test. The bonnet pressure started at 93 psig prior to the heating coils being energized. During this test each of the heating coils were fully energized and remained energized throughout the heatup process (labeled high heat input test). After cooling of the valve a similar test was run with the same setup and VOTES test 88. The only difference with this test is that the heatup was slower. The heating coils were cycled on and off while constantly increasing the heat setpoint. The results of these two tests matched very closely relative to pressure increase versus temperature. During this second test, the pressure was bleed off as it approached approximately 900 psig. After bleed off the heatup continued. As can be seen by later testing it is believed that not all the air was removed from the bonnet during both of these tests.

SRL 9/1/99 | 13-MC-ZZ-217 R/1 SH.78 114

Test Summary and Conclusions

Differential Pressure Testing

The first set of DP tests were run at 100 to 700 psid on the upstream side of the valve and indicated a valve factor in the range of 0.13 to 0.17. In an effort to increase the valve factor an unmonitored set of ten dp tests were performed at approximately 600 psid. The valve factor slowly increased to approximately 0.37. Differential pressure tests were then run on the downstream side of the valve and initial testing indicated a valve factor of 0.16. In an effort to increase the valve factor an unmonitored set of ten dp tests were performed at approximately 600 psid. The valve factor slowly increased to approximately 0.40. This testing indicates that static testing does not increase the initially very low valve factor but rather high load differential pressure testing was needed to increase the valve factor. The valve factor appeared to become stable in the range of 0.37 to 0.41.

Pressure Locking Test

Initial pressure locking tests at a TSS of 1 and bonnet pressures between 200 and 700 psid indicated that the model for prediction of pullout thrust was under predicting by approximately 3100 lbs. Pressure locking tests at a TSS of 2 indicated that the model for prediction of pullout thrust was under predicting by approximately 3500 lbs. In an effort to resolve this discrepancy a test was performed in which the downstream side of the valve was pressurized to approximately 500 psid and then vented and a pressure lock test was performed with 0 pressure in the bonnet. This test indicated that there was an increase in the pullout thrust of 3628 lbs at a TSS of 2 and 3132 lbs at a TSS of 1. Therefore, it appeared that when the bonnet was pressurized through the upstream or downstream side of the valve a set in the disk was created which added to the pullout thrust. This set was measured in two subsequent tests to be 3628 lbs at a TSS of 2 and 3132 lbs at a TSS of 1. During the last two pressure lock tests at a TSS of 1 and bonnet pressures of 557 and 504 the pullout thrust was under predicted by 2667 and 3377 lbs which are both very close to the set at a TSS of 1. The comparison of testing results (pressure locking forces) to model predictions is summarized in DOC ID#DG96-000078.

Bonnet Pressure Response Test

The valve was closed with a static seating thrust of approximately 30000 lbs. The bonnet was pressurized through the upstream seat to approximately 500 psig and the upstream and downstream sides of the valve were vented. The bonnet

depressurization rate at this pressure was approximately 1 psig per minute. The valve was then opened and pressurized to approximately 1000 psig and the valve was closed with a similar seating thrust. Bonnet pressure after seating was 940 psig where this test was started. The depressurization rate started at 10 psig per minute decreasing to 7-8 psig per minute at 820 psig.

Bonnet Pressure Response to Temperature

During the first two temperature tests, pressure vs temperature results were identical with the only difference between the two tests being the rate of heat input. The setup for this test consisted of utilizing three large heating coils which were wrapped around the lower center section of the valve body. These coils could be set to achieve a saturated metal temperature or could be constantly energized. The valve was then wrapped in thermal blankets and these were tie wrapped to the valve body. The first test was run with all the heating coils energized (high heat input) and the pressurization rate is shown in the attached charts. This test was run for approximately 65 minutes with a pressure increase from 90 to 1000 psig and a pressurization rate of 0.5 to 40 psig/degree F. The second test was run with the heating coils cycling on and off (low heat rate input) and the pressurization rate is shown in the attached charts. This test was run for approximately 140 minutes with a pressure increase from 90 to 800 psig with a similar pressurization rate.

The last pressure response to temperature test was performed by heating up only one side of the valve. The only other difference during this test is the valve was shook while trying to remove air from the bonnet. Based on the pressurization rate shown in the attached charts, it is believed that all the air was not removed from the previous two tests. This test was run for approximately 175 minutes with a pressure increase from approximately 40 to 800 psig and pressurization rate of 1 to 23 psig/degree F.

Thermal Binding Test

The setup for this test consisted of utilizing three large heating coils which were wrapped around the lower center section of the valve body. These coils could be set to achieve a saturated metal temperature or could be constantly energized. The valve was then wrapped in thermal blankets and these were tie wrapped to the valve body. Temperatures were measured on the valve body in the bonnet area using a temperature probe and the internal water temperature was measured using the bonnet temperature thermowell. After heating of the valve body to an average temperature of 156 F a static VOTES test was performed which indicated a final seating thrust of 32264 lbs and a pullout thrust of 16008 lbs. After overnight cooling of the valve to an average valve body temperature of 74.5 F another VOTES test was

performed. This test indicated a static pullout thrust of 18995 lbs with static seating thrust remaining constant within 0.9 percent. Therefore, there was approximately a 19 percent in pullout thrust with a delta temperature of approximately 80 F.

The second test was performed similar to the first, however, the valve body was heated to an average temperature of 295 F. A VOTES test was performed at this point but the results were discarded due to heat up of the thrust sensor. The valve was cooled to an average body temperature of 73.5 F. A VOTES test was performed and the pullout thrust was 24244 lbs. A subsequent static VOTES test was performed as a baseline and the pullout thrust was 17541 with a static seating thrust of 31951 lbs. Between these two tests static seating remained within 1.9 percent. Therefore, there was approximately a 38 percent increase in pullout thrust with a delta temperature of approximately 220 F.

Flex of Valve Disk

This test was performed (although not part of the procedure) to determine at what pressure the disk would deflect and allow pressure to enter the bonnet. The valve was closed with a TSS of 2.0. With the bonnet pressure at zero psig, the upstream side of the disk was pumped up slowly until an increase in bonnet pressure was observed. An increase in bonnet pressure was observed slightly above 550 psid and pressure did not increase rapidly until above approximately 600 psig.

During the test the downstream side of the valve was pumped up to pressurize the bonnet. It was found that the bonnet could not be pressuized to greater than approximately 620 psig. If the bonnet was pressurized to 1000 psig through the downstream side disk, when the downstream side was depressurized the bonnet followed until approximately 620 at which point the downstream side disk sealed and held pressure. This information indicates that there is a maximum pressure which could be trapped in the bonnet under a sudden depressurization event. A calculation was performed utilizing a flat plate model to determine the point at which the disk would flex or rather at what point the seating force would become zero. This calculation indicated a force of 574 psig indicating a good correlation between the calculational model and the test. This calculation is attached.

SKL 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~95~~ 117

Thermal binding test

The first thermal binding test was performed at the end of this day such that the valve could cool overnight. The valve was wrapped in thermal blankets such that the temperature of the whole valve was fairly constant. Static test 63 was performed after the valve was heated to an internal bonnet temperature of 152 F and an external valve body temperature of 160 F. After cooling the valve to an internal bonnet temperature of 77 F and valve body temperature of 72 F another static test 64 was run. During this test the static pullout thrust increased from 16008 lbs to 18995 lbs with static seating remaining constant within 0.9 percent. Results of this test indicate that static pullout increased approximately 19 percent with a delta temperature of approximately 80 F.

12/07/95 Additional differential pressure tests were performed during VOTES tests 66 through 71 where the valve was pressurized from the downstream side. The differential pressures ranged from approximately 200 to 600 psid and valve factors range from 0.34 to 0.41.

Additional pressure locking and associated static tests were performed during VOTES tests 72 through 85 where the bonnet pressure ranged between 50 and 500 psid at a TSS of 2.0.

The pressure locking test results to this point have been indicating that the measured pressure locking force is approximately 2000 lbs above the predicted value at a TSS of 1.0 and approximately 4000 lbs above the predicted value at a TSS of 2.0. Because of this VOTES tests 86 through 94 were run to check what was believed to be a memory effect. So a static test was performed with the valve completely depressurized. Next with a bonnet pressure of zero the downstream side of the valve was pressurized to 500 psid and then depressurized. Another static test was performed and this test indicated an increase in static pullout forces approximately equal to the increase in actual pullout forces versus the predicted values.

SAC 9/1/99 | 13-MC-ZZ-217 R/1 SH. 118

Disk deflection test

This test was performed to determine at what pressure the disk would deflect and allow pressure to enter the bonnet. The valve was closed with a TSS of 2.0. With the bonnet pressure at zero psig the upstream side of the disk was pumped up slowly until an increase in bonnet pressure was observed. An increase in bonnet pressure was observed slightly above 550 psid and pressure did not increase rapidly until above approximately 600 psig.

During the test the downstream side of the valve was pressurized to pressurize the bonnet. It was found that the bonnet could not be pressurized to greater than approximately 620 psig. If the bonnet was pressurized to 1000 psig when the downstream side was depressurized the bonnet followed until approximately 620 at which point the downstream side disk sealed and held pressure. This test was performed again, however, the downstream side of the valve was depressurized very rapidly. The results were the same regardless of depressurization rate.

Thermal binding test

The second thermal binding test was performed similar to the first with the exception of a higher temperature. Static test 89 and 90 were performed after the valve was heated to an internal bonnet temperature of 303 F and an external valve body temperature of 287 F. After cooling the valve to an internal bonnet temperature of 75 F and valve body temperature of 72 F another static test 91 was run. Review of tests 89 and 90 indicated that the thrust values were affected by the high temperature of the valve which heated the stem and affected the sensor thrust output. Therefore, after test 91 was performed static test 92 was performed to compare data. Between tests 91 and 92 the static pullout thrust increased from 17541 lbs to 24244 lbs with static seating remaining constant within 1.9 percent. Results of this test indicate that static pullout increased approximately 38 percent with a delta temperature of approximately 220 F.

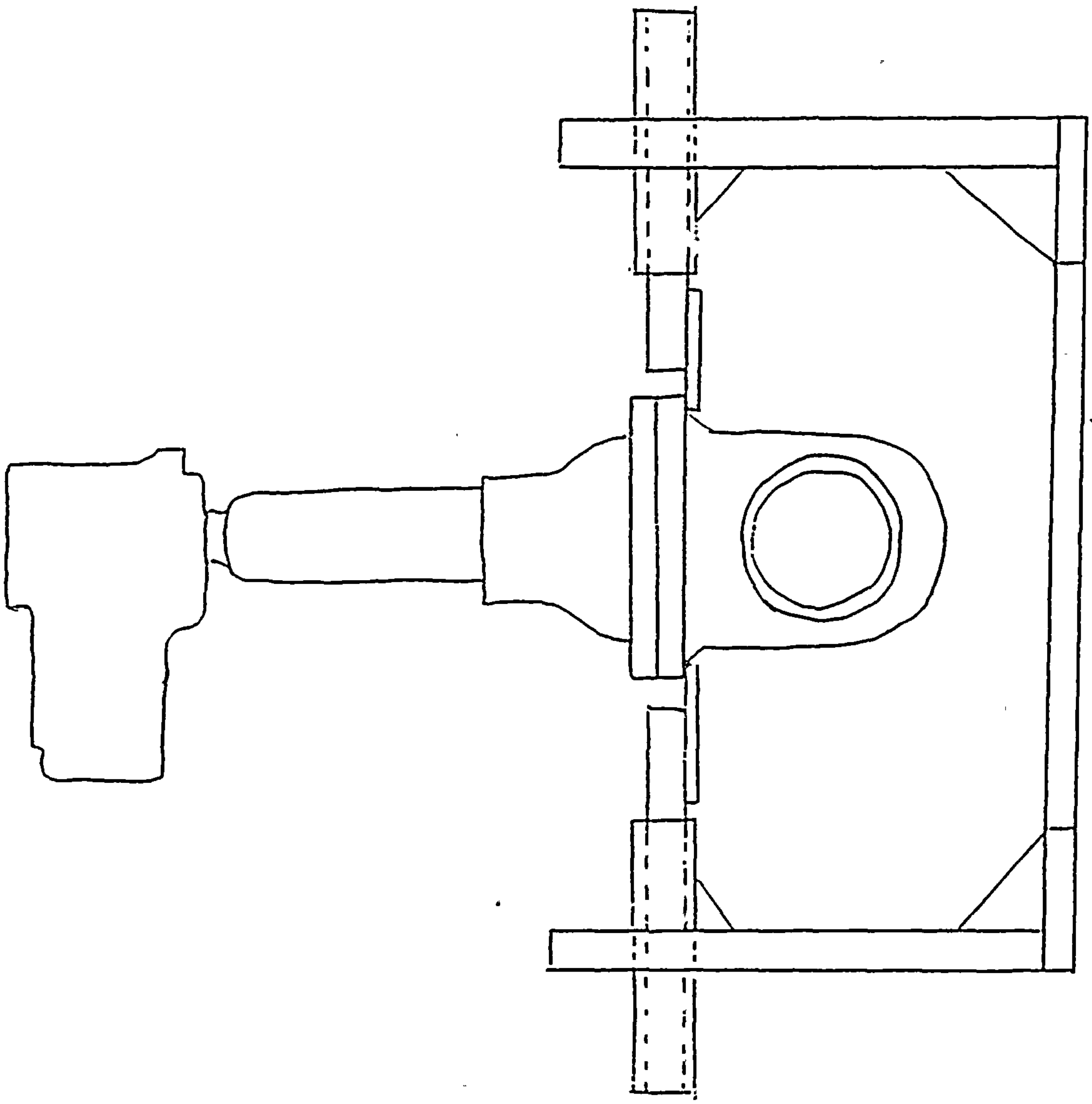
12/08/95 Pressure response to temperature test

A final test was performed in which the heating coils were moved to the downstream side of the valve (independent of which side) and placed around the pipe flanges. Only the downstream flanges were insulated to prevent heat loss. During this test the valve was closed at a TSS of 1.0 and a water solid condition in

SAL 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~97~~ 119

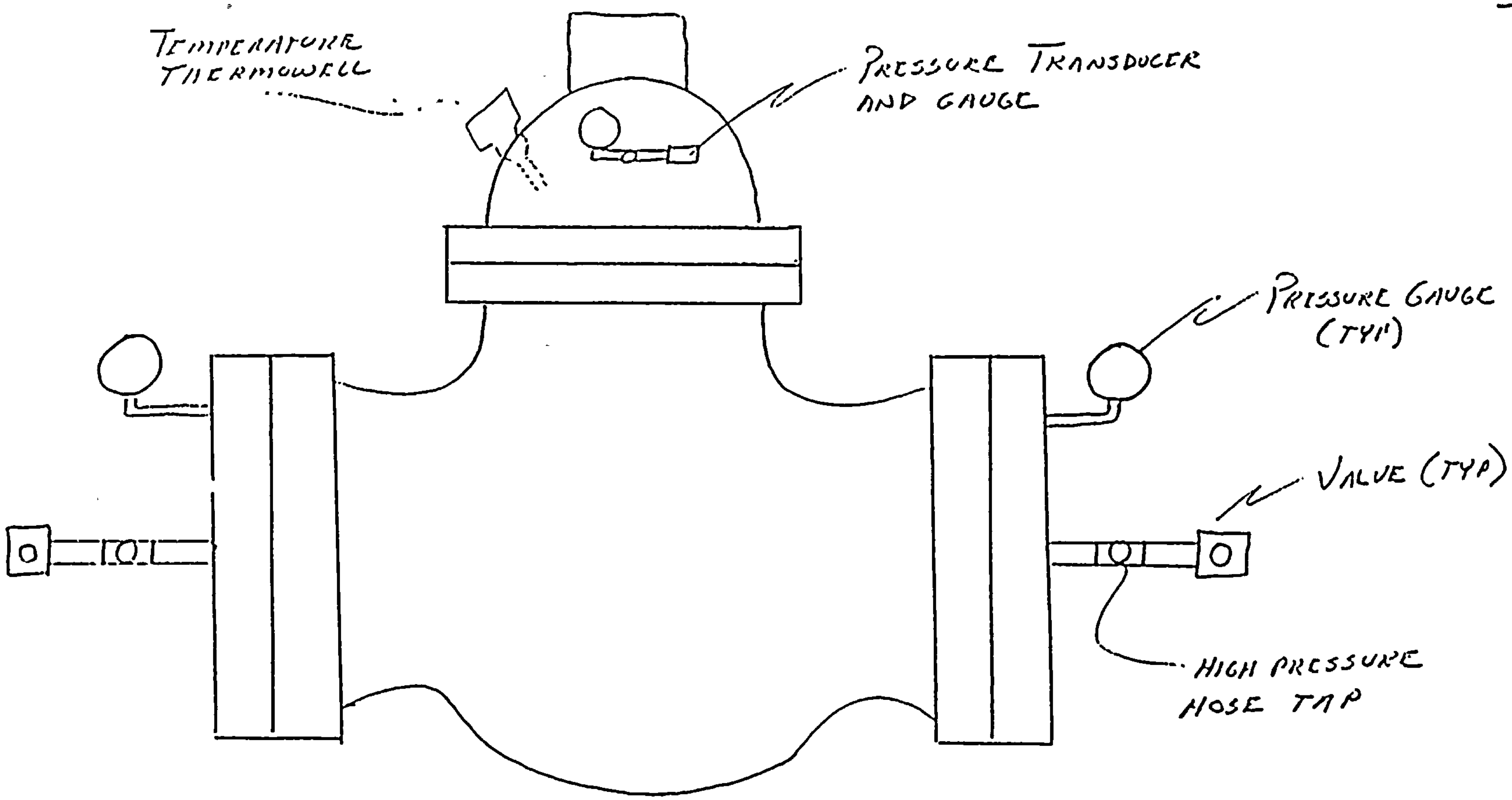
the bonnet at a starting pressure of 37 psig. The difference between this test and the previous two pressure response to temperature tests is that the valve was shook while tipped on its side and during this process of shaking, air could be seen exiting the discharge hose. This shaking was continued until no air could be seen exiting the discharge hose. Water at a temperature of approximately 100 F was injected into the downstream side of the valve and the heating coils were turned on. Temperature and pressure were monitored and recorded in the bonnet and temperatures were recorded on the downstream flange, center bottom and upstream side of the valve body. During this test two heating coils were operating and after approximately 20 minutes into the test one of the remaining two coils stopped functioning.

SAL 9/1/99 | 13-MC-ZZ-217 R/1 SH ~~98~~ 120
FIGURE 1



0000 0000 0101

FIGURE



SM 9/1/99

13-MC-ZZ-217 R/1 SH. 92 121

0000 0000 0102

SKR 9/1/99 | 13-MC-ZZ-217 R/1 SH. TOQ 122

Borg Warner valve, Point at which disk flexes

This Mathcad Program is designed to calculate the estimated flexing point for a valve disk. This calculational methodology accounts for wedge stiffness. This calculation methodology was prepared similar to Braidwood Calculation 95-158. References numbers are changed.

INPUTS:

Load Value	$q = 1000000 \cdot psi$	
Load Value	$w = 1000000 \cdot \frac{lbf}{in}$	
Disk Thickness	$t = 1.5 \cdot in$	Valve Data Sheet
Seat Radius	$a = 5.168 \cdot in$	Valve Data Sheet
Hub Radius	$b = 3.158 \cdot in$	Valve Data Sheet
Hub Length	$L = 0.156 \cdot in$	Valve Data Sheet
Seat Angle	$theta = 5 \cdot deg$	Valve Data Sheet
Poisson's Ratio (disk)	$v = .3$	Typical of Stainless Steel
Mod. of Elast. (disk)	$E = 27.6 \cdot 10^6 \cdot psi$	Attachment
Force of Packing	$Fp = 600 \cdot lbf$	
Static Seating Force	$Fs = 32000 \cdot lbf$	Avg of Seating High TSS
Open Valve Factor	$VF = .37$	Valve Testing Avg.
Stem Diameter	$D_{stem} = 1.5 \cdot in$	Valve Data Sheet

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat: (Reference 2)

$$mu = VF \cdot \frac{\cos(theta)}{1 - VF \cdot \sin(theta)}$$ $mu = 0.381$

Disk Stiffness Constants (Reference 1 Table 24, Reference 3)

$$D = \frac{E \cdot (t)^3}{12 \cdot (1 - v^2)}$$ $D = 8.53 \cdot 10^6 \cdot lbf \cdot in$

$$G = \frac{E}{2 \cdot (1 - v)}$$ $G = 1.062 \cdot 10^7 \cdot psi$

Geometry Factors: (Reference 1, Table 24)

$$C_2 := \frac{1}{4}\left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right] \qquad C_2 = 0.06469$$

$$C_3 := \frac{b}{4 \cdot a}\left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right] \qquad C_3 = 0.00762$$

$$C_8 := \frac{1}{2}\left[1 + v + (1 - v) \cdot \left(\frac{b}{a}\right)^2\right] \qquad C_8 = 0.78069$$

$$C_9 := \frac{b}{a}\left[\frac{1 + v}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - v}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right] \qquad C_9 = 0.26264$$

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

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

$$L_{11} := \frac{1}{64}\left[1 - 4 \cdot \left(\frac{b}{a}\right)^2 - 5 \cdot \left(\frac{b}{a}\right)^4 - 4 \cdot \left(\frac{b}{a}\right)^2 \cdot \left[2 - \left(\frac{b}{a}\right)^2\right] \cdot \ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.00079$$

$$L_{17} := \frac{1}{4}\left[1 - \frac{1 - v}{4}\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2 \cdot \left[1 - (1 - v) \cdot \ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.05923$$

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

$$M_{rb} := \frac{-q \cdot a^2}{C_8} \cdot \left[\frac{C_9}{2 \cdot a \cdot b} \cdot \left(a^2 - b^2\right) - L_{17}\right] \qquad M_{rb} = -2.581 \cdot 10^6 \cdot \text{lbf}$$

$$Q_b := \frac{q}{2 \cdot b} \cdot \left(a^2 - b^2\right) \qquad Q_b = 2.65 \cdot 10^6 \cdot \frac{\text{lbf}}{\text{in}}$$

Deflection due to pressure and bending: (Reference 1, Table 24, Case 2L)

$$y_{bq} := M_{rb} \cdot \frac{a^2}{D} C_2 + Q_b \cdot \frac{a^3}{D} \cdot C_3 - \left(q \cdot \frac{a^4}{D}\right) \cdot L_{11} \qquad y_{bq} = -0.2619 \cdot \text{in}$$

Deflection due to pressure and shear stress: (Reference 1, Table 25, Case 2L)

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.10755$$

$$y_{sq} := \frac{K_{sa}\cdot q\cdot a^2}{t\cdot G} \qquad y_{sq} = -0.1804\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} \qquad y_q = -0.4423\cdot in$$

Deflection due to seat contact force and shear stress (per lbf/in.): (Reference 1, Table 25, Case 1L)

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot w\cdot a}{t\cdot G}\right] \qquad y_{sw} = -0.1918\cdot in$$

Deflection due to seat contact force and bending (per lbf/in.): (Reference 1, Table 24, Case 1L)

$$y_{bw} := -\left[\frac{(w\cdot a^3)}{D}\right]\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -0.375\cdot in$$

Total deflection due to seat contact force :

$$y_w := y_{bw} + y_{sw} \qquad y_w = -0.566\cdot in$$

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POINT OF DISK FLEX B&W VALUE

$y_\omega = -0.566$

$y_q = -0.4423$

$F_s = 32000$ } AVG OF TESTING

$F_p = 600$

$a = 5.168$

$F_N = (F_s - F_p)/2(\sin\theta + \mu\cos\theta)$

$= (32000 - 600)/2(\sin 5° + .381\cos 5°)$

$= 31400 / 2(.4667)$

$= 31400 / .9334$

$= 33640$

$$P = \frac{F_N \times y_\omega}{\pi \times a} \times \frac{1}{y_q + (q/2) \times y_\omega}$$

$$= \frac{31400 \cdot (-0.566)}{3.14159 \cdot 5.168} \times \frac{1}{(-0.4423 + (2.584 \cdot -0.566)}$$

$$= \frac{17772}{16.23} \times .524$$

$= 1094.6 \times .524$

$= 574.6$ LBS

0000 0000 0106

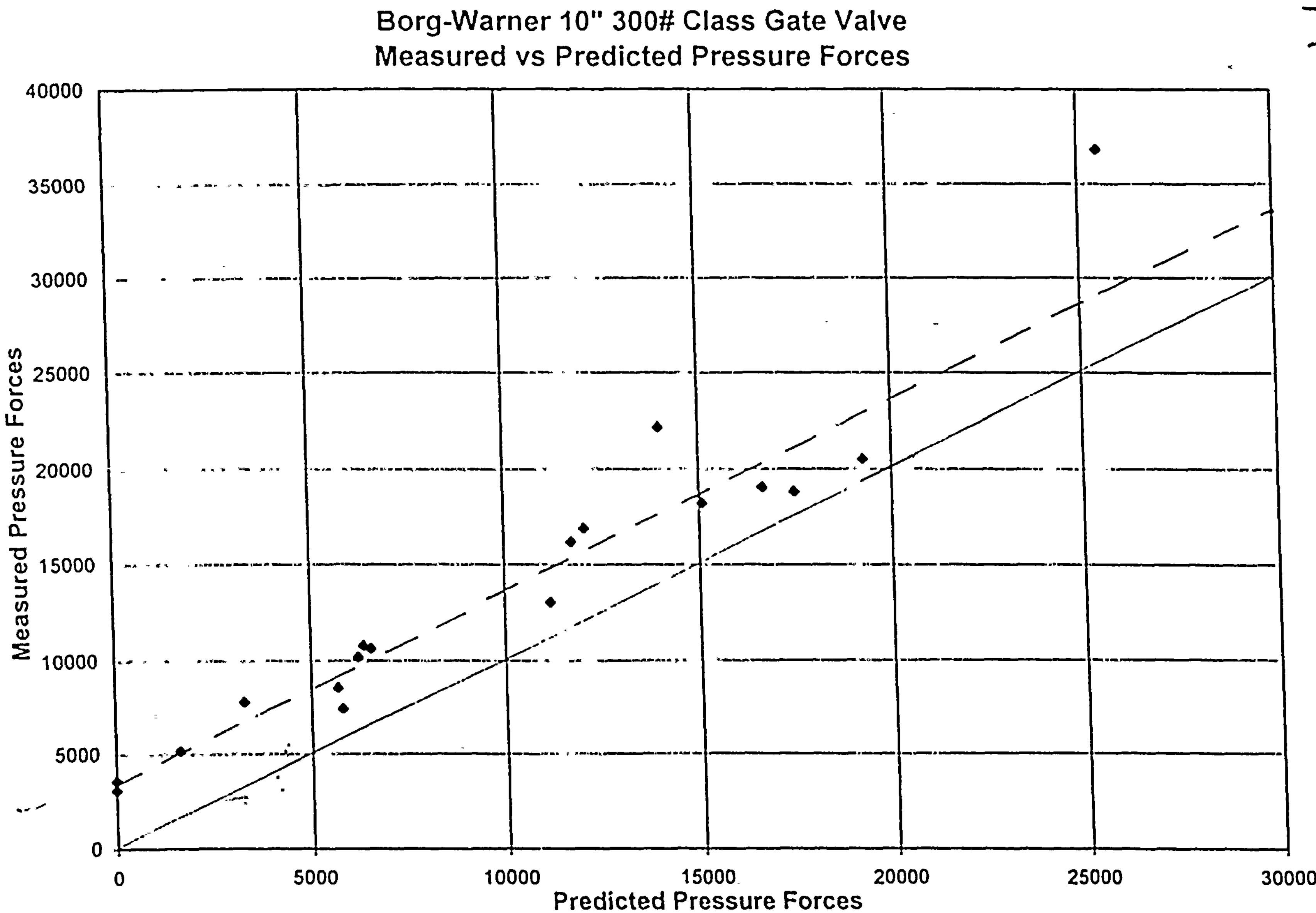
REFERENCES:

1. SIXTH EDITION OF ROARKS FORMULAS FOR STRESS & STRAI

2. MOV WHITE PAPER WP-134 REV 0

3. MECHANICAL ENGINEERING DESIGN FOURTH EDITION, SHIGLEY AND MITCHELL

THIS METHOLOGY AND CALC FOLLOWS CALCULATION 95-158 AT BRAIDWOOD



13-MC-ZZ-217 R/1 SH. 127

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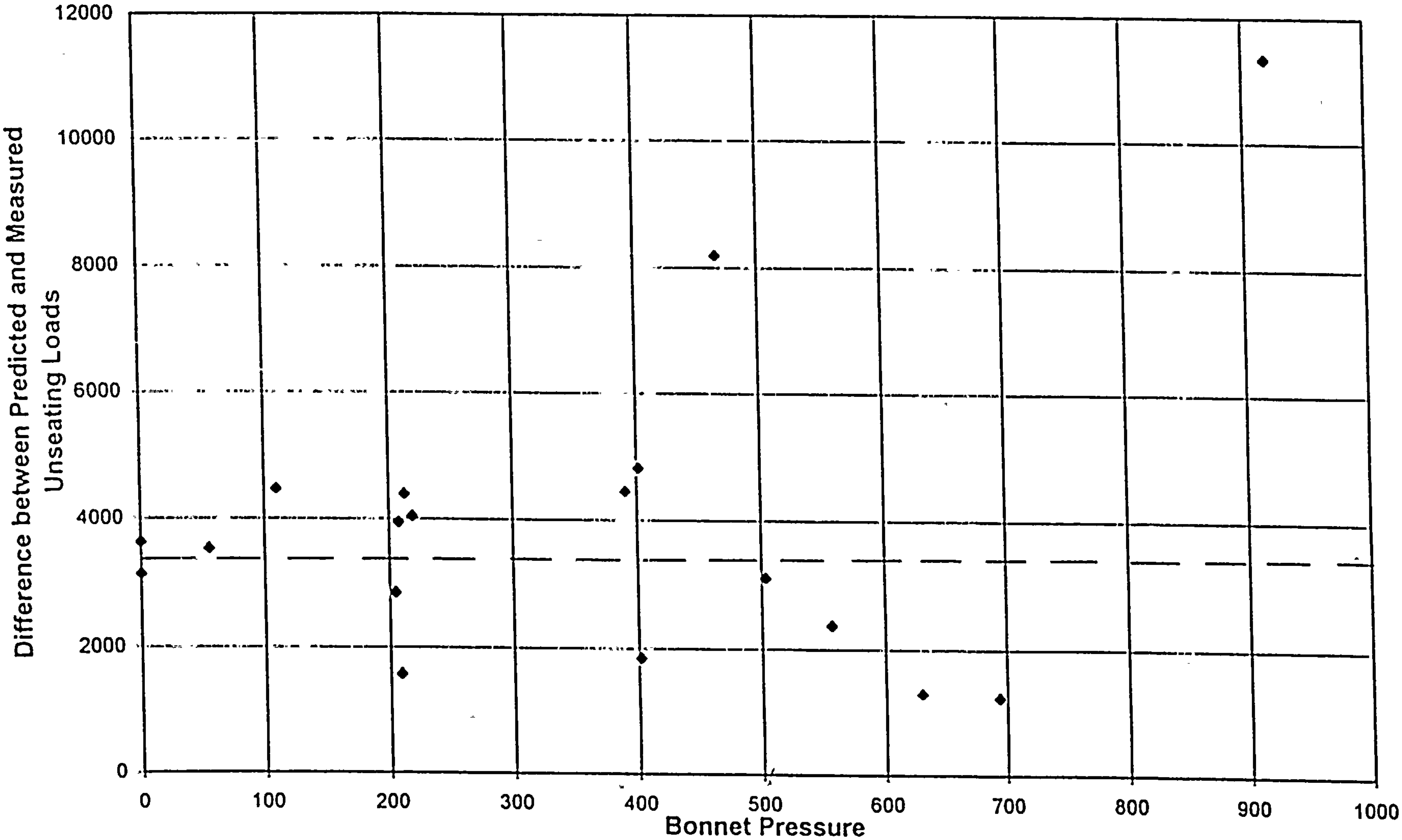
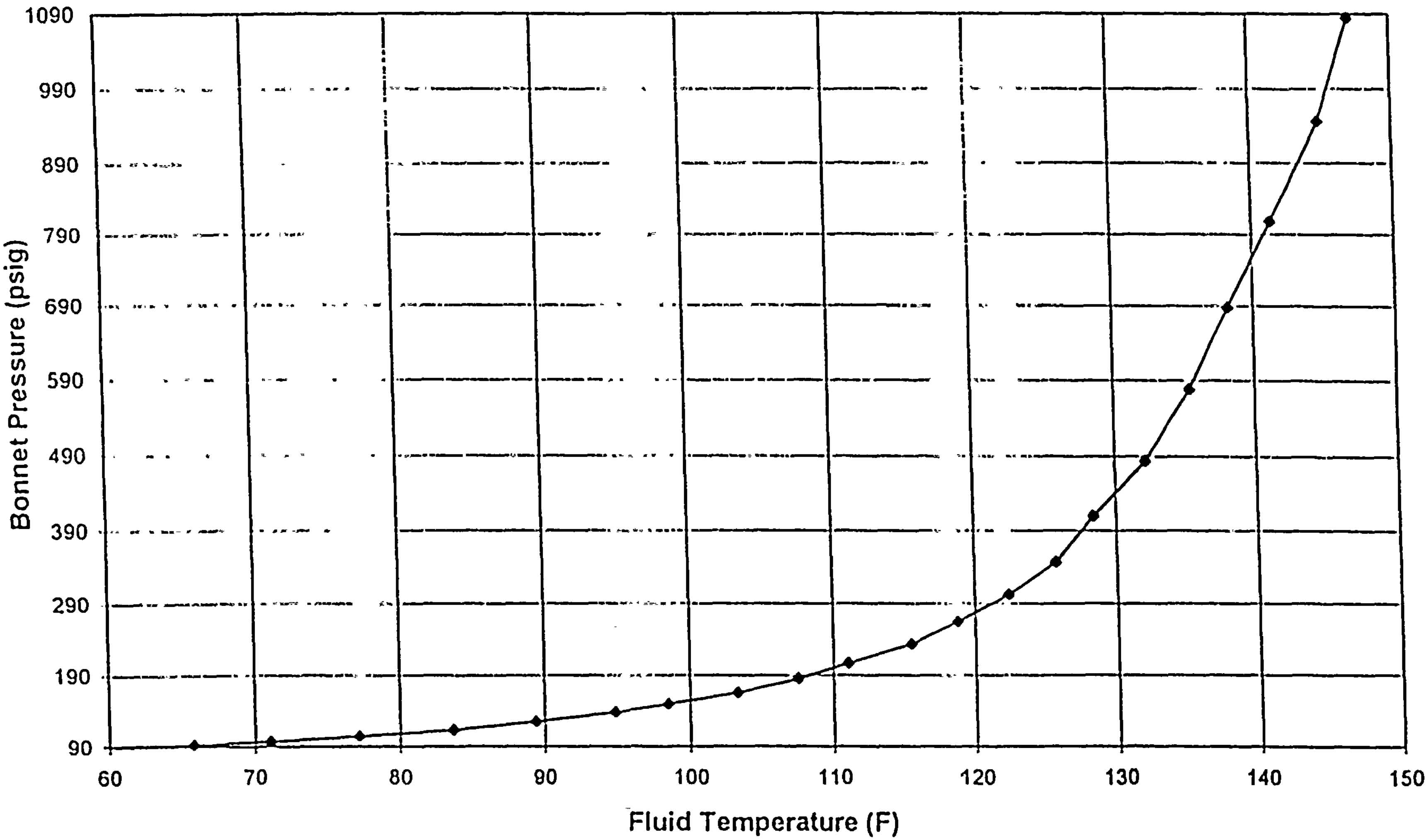
9010 0000 0000

Borg-Warner 10" 300# Class Gate Valve
Deviation in Unseating Load vs Bonnet Pressure



9/1/99 | 13-MC-ZZ-217 R/1 SH. 128

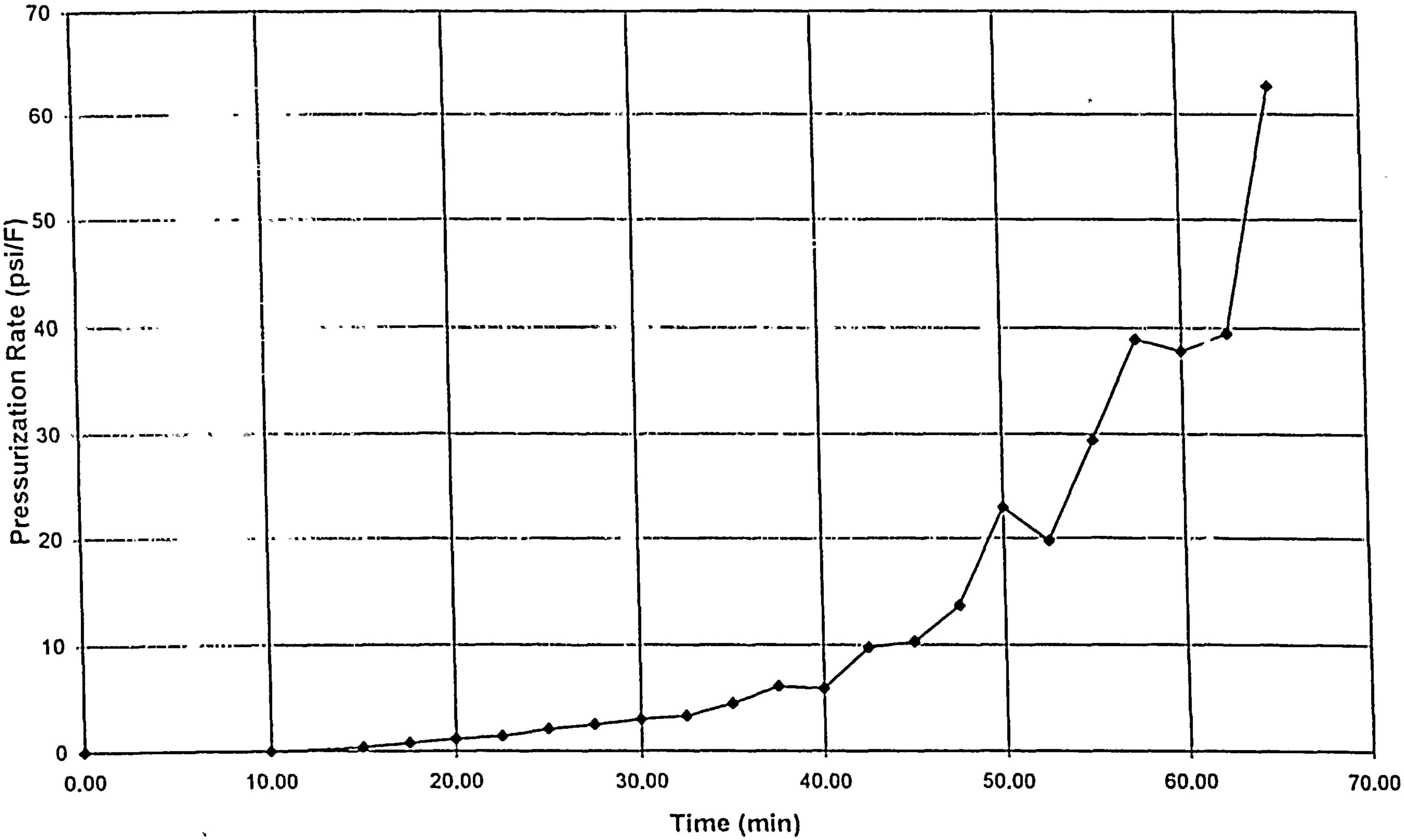
Borg-Warner 10" 300# Class Gate Valve
Bonnet Pressure vs. Temperature (High Heat Input Rate)



SKL 9/1/99 | 13-MC-22-217 R/1 SH. 107 129

0110 0000 0000

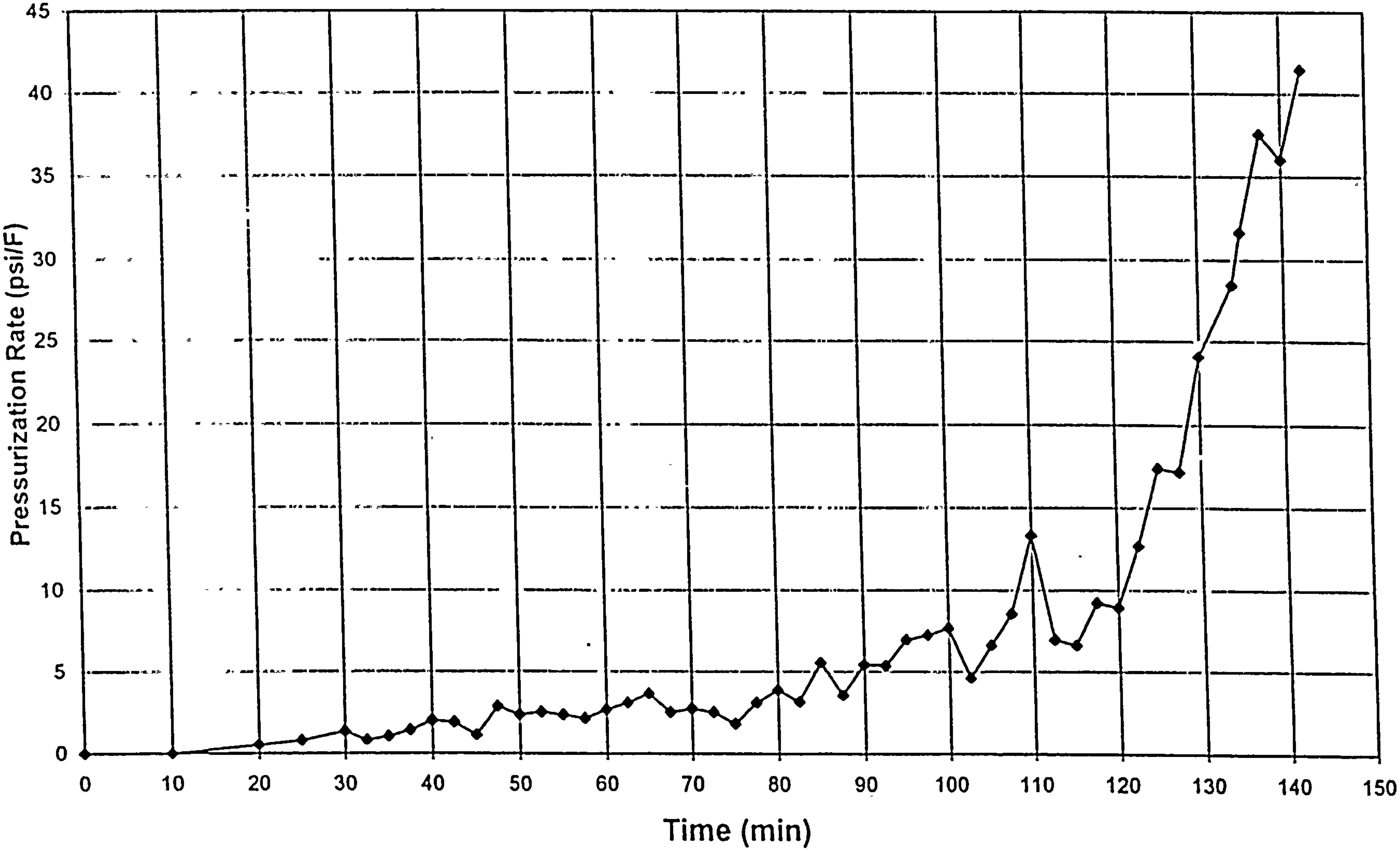
Borg-Warner 10" 300# Class Gate Valve
Pressurization Rate vs. Time (High Heat Input Rate)



SKL 9/1/99

13-MC-ZZ-217 R/1 SH. ~~108~~ 130

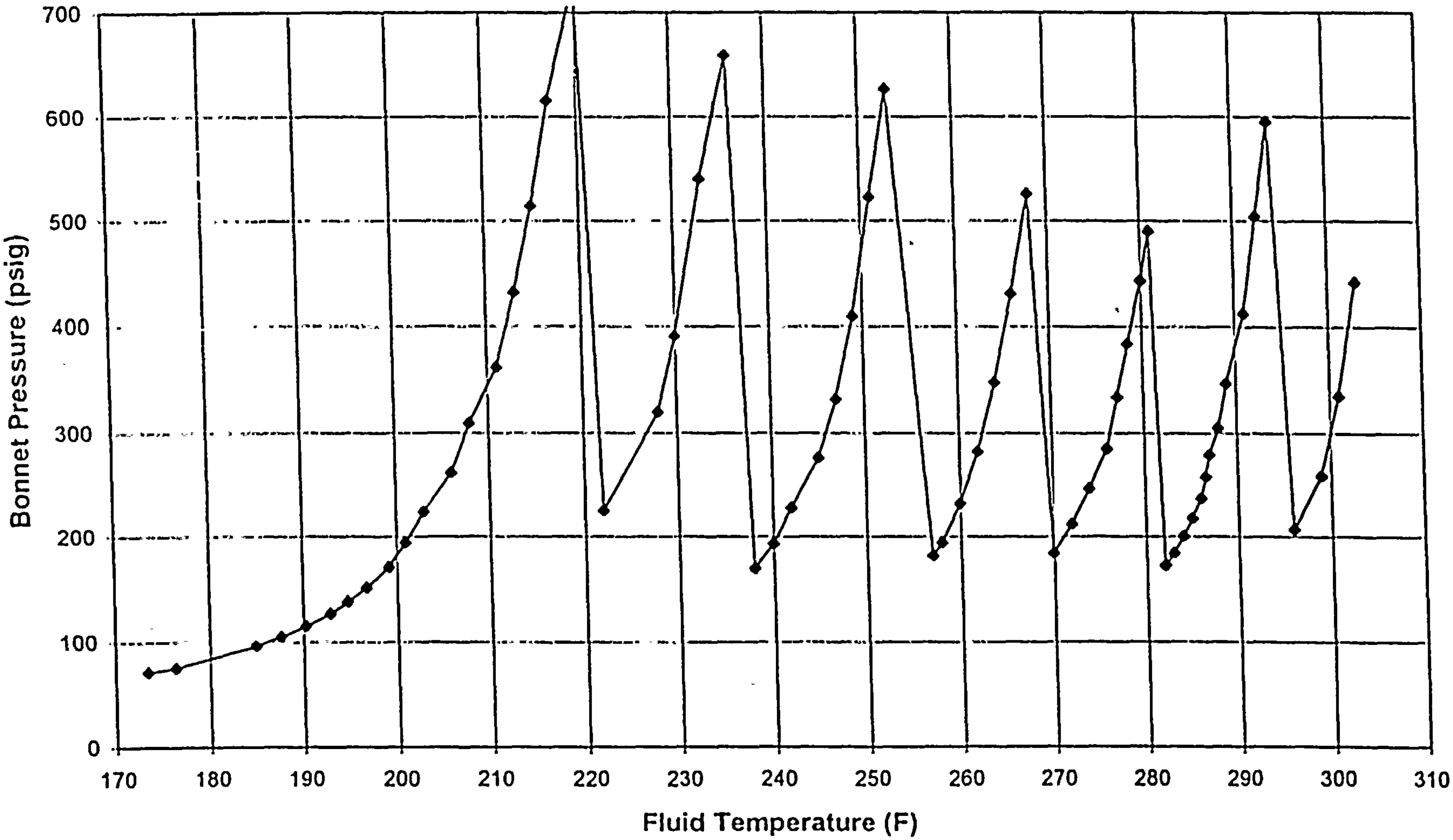
Borg-Warner 10" 300# Class Gate Valve
Pressurization Rate vs. Time (Low Heat Input Rate)



SM 9/1/99

13-MC-ZZ-217 R/1 SH. 131

Borg-Warner 10" 300# Class Gate Valve
Bonnet Pressure vs. Temperature
(Valve Bonnet Periodically Vented)



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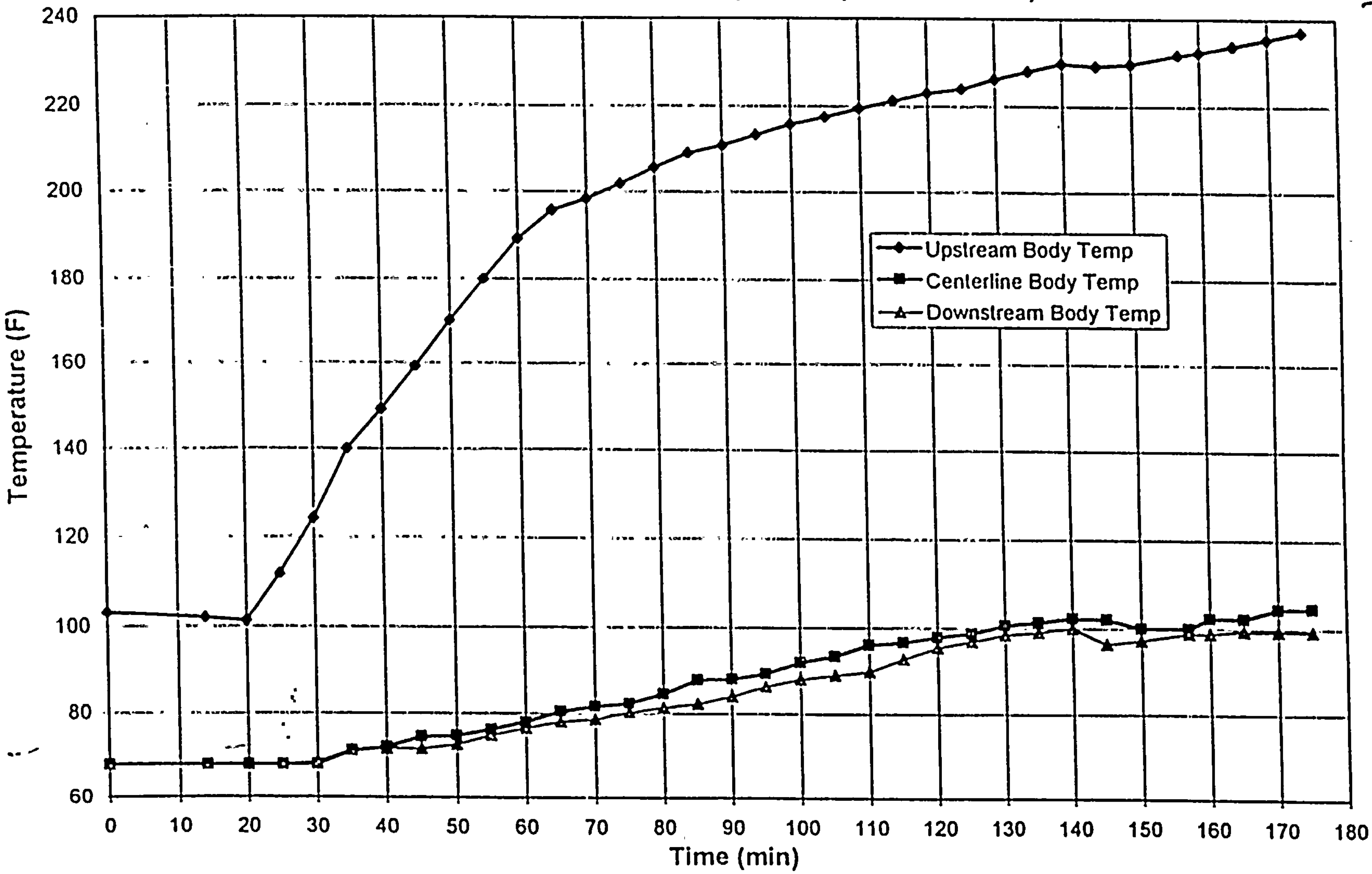
13-MC-ZZ-217 R/1 SH. 110 132

Borg-Warner 10" 300# Class Gate Valve
Body Temperature vs Time (Heat Input from Side)



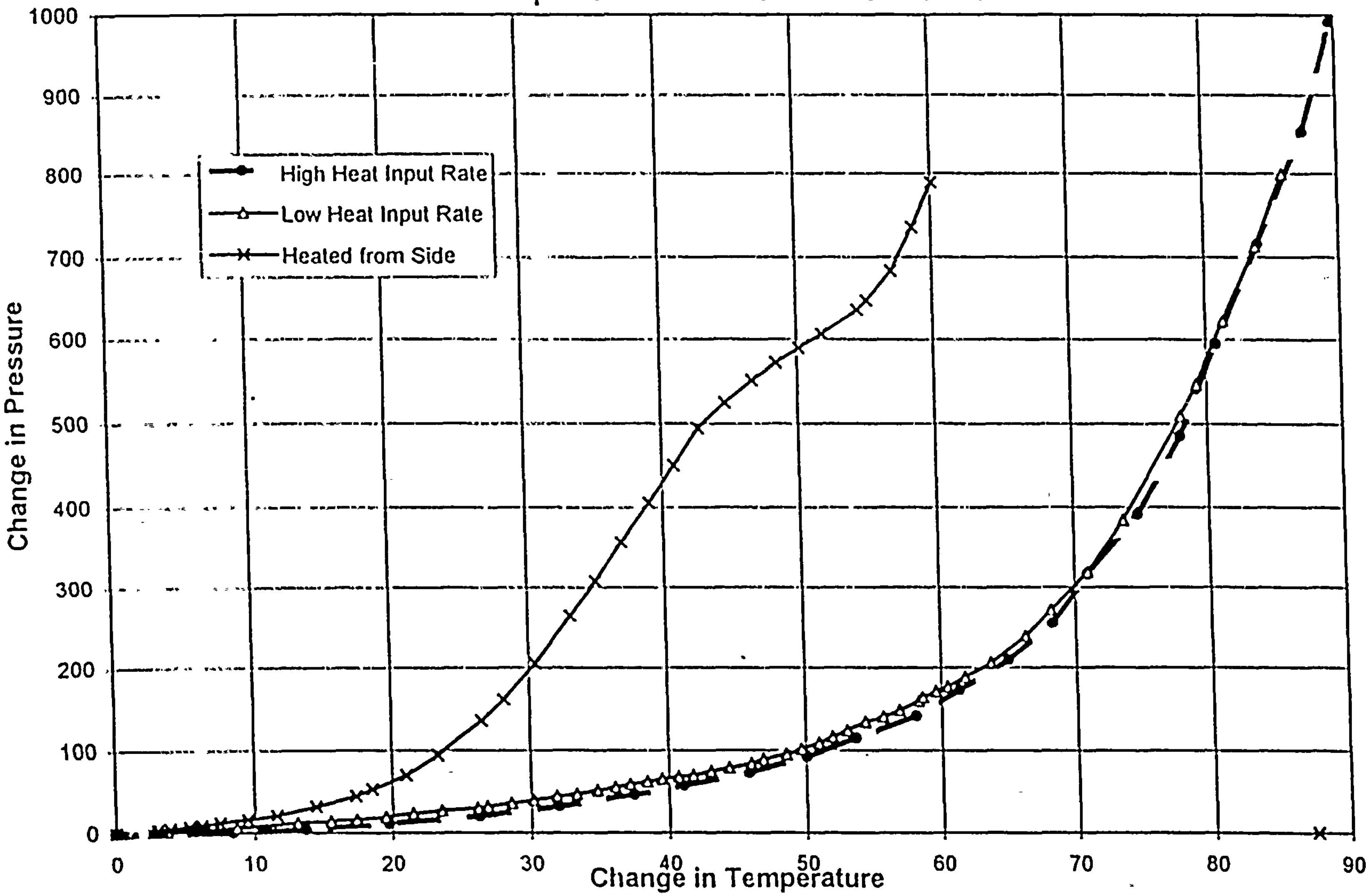
13-MC-ZZ-217 R/1 SH. ~~148~~ 133 SN 12/10/96

SN 9/1/99

9/1/99 SK

13-MC-ZZ-217 R/1 SH. 134

Borg-Warner 10" 300# Class Gate Valve
Comparison of Pressurization Rates



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13-MC-22-217 R/1 SH. ~~H3~~ 135

SR 9/1/99

Memorandum

In Reference
Refer to DOC ID # DG96-000078

ComEd

Date: January 16, 1996

To:

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B. K. Smith (Byron)	H. L. Mulderink (Dresden)	J. G. O'Neill (Dresden)
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B. Gebhardt (Quad Cities)	R. Mika (Zion)	G. C. Lauber (Zion)
S. Raborn (Zion)	S. A. Korn	I. Garza

Subject: Pressure Locking / Thermal Binding Test Data

The purpose of this memorandum is to provide a summary of the initial results from pressure locking and thermal binding testing that has been performed at ComEd Stations. A formal report documenting the final test results and analyzing test valve performance against pressure locking and thermal binding model predictions will be issued early in 1996.

This testing was performed on a 10" Crane 900# Class gate valve, a 4" Westinghouse 2500# Class gate valve, and a 10" Borg-Warner 300# Class gate valve. The Crane valve was tested at the Quad Cities Station training building; the Westinghouse and Borg-Warner valves were tested at the Braidwood Station training building and warehouse facilities.

Attachment 1 provides the bonnet depressurization test results for the subject valves. Attachment 2 compares the measured pressure locking loads to the ComEd MathCad model for predicting pressure locking unseating load. The MathCad pressure locking calculation models and Excel spreadsheets with test results for these valves are available on the NODWORLD/SYS network drive in the PRESLOCK directory. Attachment 3 provides the thermally-induced, bonnet pressurization rates for the test valves. Excel spreadsheets containing this data are also contained in the PRESLOCK directory. Attachment 4 provides the results of thermal binding tests.

If you have any questions concerning this memorandum or its attachments, please call me at Downers Grove extension 3824.

Brian D. Bunte
MOV Program Lead
Commonwealth Edison Company

Attachments

ATTACHMENT 1

BONNET DEPRESSURIZATION RATE DATA

Valve	Torque Switch Setting	Initial Pressure	Maximum Closing Thrust	Initial Depressurization Rate (psi/min)
Crane 10"	1	1040 psig	63805 lbf	45 psi/min
Westinghouse 4"	1	2000 psig	13816 lbf	400 psi/min
Westinghouse 4"	1	900 psig	13804 lbf	200 psi/min
Westinghouse 4"	2	1980 psig	19869 lbf	40 psi/min
Borg-Warner 10"	2	504 psig	24826 lbf	1 psi/min
Borg-Warner 10"	2	938 psig	24826 lbf	10 psi/min

13-MC-ZZ-217 R/1 SH. ~~115~~ 137

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ATTACHMENT 2

MathCad Model Predictions versus Pressure Locking Unseating Loads

Valve	Test #	TSS	Static Unseating Thrust	Bonnet Pressure	Predicted Increase	Measured Increase	Percent Conservatism (Non-Cons.)	Notes
Crane 10"	6	1	25000	650	5103	4539	-2%	6
Crane 10"	7	1	25000	850	7213	8191	4%	6
Crane 10"	9	1	26000	1040	9421	11500	8%	6
Crane 10"	10	1	26000	1040	9922	12140	9%	6
Crane 10"	13	1	28000	1195	19462	22140	10%	
Crane 10"	14	1	28000	1375	22974	25480	9%	
Crane 10"	15	1	28000	1375	23126	25480	8%	
Crane 10"	34	2.5	38000	655	6243	5796	-1%	6
Crane 10"	35	2.5	38000	655	5142	5796	2%	6
Crane 10"	38	2.5	37500	1055	13164	13870	2%	6
Crane 10"	39	2.5	37500	1055	13065	13870	2%	6
Crane 10"	42	2.5	40000	1365	30028	29190	-2%	
Crane 10"	43	2.5	40000	1165	30428	24913	-14%	5
Crane 10"	46	2.5	40000	1575	32231	33680	4%	
Crane 10"	47	2.5	40000	1575	31931	33680	4%	
Crane 10"	50	2.5	40000	1775	37749	37950	1%	3,4
West. 4"	30	2	1450	496	1537.6	1555	-1%	
West. 4"	31	2	1450	514	1593.4	1538	2%	
West. 4"	33	2	900	1000	3100	3007	2%	
West. 4"	35	2	900	1000	3100	2990	3%	
West. 4"	37	2	50	1500	4650	4775	-3%	
West. 4"	39	2	50	1500	4650	4672	0%	
West. 4"	42	2	-400	2000	6200	5989	4%	
West. 4"	44	2	-400	2000	6200	6126	1%	
Borg-W. 10"	43	2	16935	205	5691	8532	4%	1
Borg-W. 10"	48	1	7882	209	5802	7386	19%	1
Borg-W. 10"	50	1	7782	402	11160	13004	16%	1
Borg-W. 10"	52	1	7906	630	17489	18799	23%	1
Borg-W. 10"	54	1	7882	694	19265	20514	23%	1
Borg-W. 10"	56	1	5023	919	25511	36849	-164%	1,2
Borg-W. 10"	74	2	17477	208	6225	10167	-2%	1
Borg-W. 10"	75	2	17477	213	6375	10765	-5%	1
Borg-W. 10"	77	2	17751	391	11703	16155	-5%	1
Borg-W. 10"	78	2	17751	402	12032	16853	-7%	1
Borg-W. 10"	80	2	17949	467	13977	22172	-26%	1,2
Borg-W. 10"	81	2	17949	219	6555	10591	-2%	1
Borg-W. 10"	83	2	17700	110	3292	7757	-5%	1
Borg-W. 10"	84	2	17700	55	1646	5171	0%	1
Borg-W. 10"	86	2	17352	0	0	3628	0%	3
Borg-W. 10"	95	1	8000	0	0	3132	0%	3
Borg-W. 10"	96	1	8000	557	16671	19035	9%	1
Borg-W. 10"	97	1	8000	504	15085	18189	0%	1

[illegible]

NOTES:

1. The percent conservatism values are calculated after a "memory effect" of 3100 lbf (at TSS=1) or 3500 lbf (at TSS=2) is added to the calculated pressure locking increase. Testing indicated that the process of applying and then relieving pressure against one side of the closed valve was sufficient to cause the unseating force to increase by these amounts, even when no pressure was captured in the valve bonnet. This effect was only noted for the Borg-Warner test valve.

2. When bonnet pressure significantly exceeds the pressure class rating of the test valve, the pressure locking calculation methodology appears to become non-conservative.

3. Tests 86 and 95 were performed to quantify the "memory effect" for the Borg-Warner valve. These tests were performed like a pressure locking test in that high pressure (~ 600 psig) was put against one side of the valve disk and then bled off. However, any pressure that entered the valve bonnet was relieved prior to the opening stroke.

4. The AC motor for the test valve stalled during this test and the valve did not fully unseat. Test data suggests that open valve motion was initiated prior to the stall. Consequently, the measured increase due to pressure locking is believed to be correct.

5. The pressure data for this test is questionable and is being evaluated at this time.

6. The upstream and downstream pressure during these tests was approximately 350 psig. This was done to approximate the LPCI and LPCS injection valve pressure conditions which could exist in the event of a LOCA.

SRL 9/1/99 | 13-MC-ZZ-217 R/1 SH. ~~117~~ 139

ATTACHMENT 3

BONNET PRESSURIZATION RATE
DUE TO BONNET TEMPERATURE RISE

Valve	Torque Switch Setting	Initial Pres. & Temp.	Maximum Closing Thrust	Initial Pressurization Rate (psi / °F)	Final Pressurization Rate (psi / °F)	Final Pres. & Temp.
Westinghouse 4"	2	102 psig 78.5 °F	20041 lbf	0.5 psi / °F	2.0 psi / °F	201.7 psig 263 °F
Borg-Warner 10"	2	93 psig 61 °F	31327 lbf	0.5 psi / °F	50 psi / °F	1084 psig 147 °F
Borg-Warner 10"	2	86 psig 64 °F	32267 lbf	0.75 psi / °F	40 psi / °F	885 psig 150 °F
Borg-Warner 10"	2	37 psig 65 °F	32267 lbf	1.0 psi / °F	37 psi / °F	826 psig 125 °F

ATTACHMENT 4

THERMAL BINDING TEST RESULTS

Valve	Torque Switch Setting	Static Unseating Load	Temperature Decrease (°F)	Measured Increase in Unseating Load Due to Thermal Binding
Westinghouse 4"	2	1909 lbf	100 °F	330 lbf
Borg-Warner 10"	2	16008 lbf	88 °F	2987 lbf
Borg-Warner 10"	2	17541 lbf	215 °F	6703 lbf

SAL 9/1/99 | 13-MC- Z ~~Z-217 R/1~~ SH. ~~N2~~ 141

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type		Location	
Instrument Name	Gauge	Tolerance	±2% of span or ±20 PSIG
Instr.Model Mfr.		References	BWIP 2400-026 Rev 2.1
Instr.Serial No.	MTI 8008	Procedure No.	BWIP 2400-026 Rev 2.2
Head Correction	N/A	Setpoint	N/A
Technician	Speed		
Date Calibrated	12-3-95	Range	0-1000 PSIG

INPUT TEST POINT		OUTPUT TEST POINT		
INPUT		REQUIRED	AS FOUND	AS LEFT
%	PSIG	PSIG	PSIG	PSIG
0	0	0	0	0
25	250	250	252	251
50	500	500	502	501
75	750	750	752	751
100	1000	1000	1005	1003
75	750	750	755	752
50	500	500	504	502
25	250	250	~~250~~ 253	251
0	0	0	0	0

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET		N/A	
SETPOINT			
RESET			

REMARKS: Pre cal for Special Test on Valve Pressure Locking

TEST EQUIPMENT					
ID#	AF/AL	MODEL#	RANGE	DATE	CERT DUE
031	PF/AL	Gauge	0-1000 PSIG	N/A	3-96

DOCUMENT REVIEW

SUPERVISOR: [signature]

DATE REVIEWED: 12-3-95

DATE ENTRY:

SYS ID:

WR#: 950003824-03

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APPROVED
AUG 27 1992
BRAIDWOOD
ON-SITE REVIEW

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13-MC-ZZ-217 R/1 SH. 120 142

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type		Location	
Instrument Name	Gauge	Tolerance	±2% of span or ±20 PSIG
Instr.Model Mfr.	Ashcroft	References	BwIP 2400-026 Rev 2.2
Instr.Serial No.	MTT 111	Procedure No.	BwIP 2400-026 Rev 2.1
Head Correction	N/A	Setpoint	N/A
Technician	Speed		
Date Calibrated	12-3-95	Range	0-1000 PSIG

INPUT TEST POINT / OUTPUT TEST POINT

INPUT %	INPUT PSIG	REQUIRED PSIG	AS FOUND PSIG	AS LEFT PSIG
0	0	0	0	0
25	250	250	250	250
50	500	500	500	500
75	750	750	750	750
100	1000	1000	998	998
75	750	750	752	752
50	500	500	502	502
25	250	250	250	250
0	0	0	0	0

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT		N/A	
RESET			
SETPOINT			
RESET			

REMARKS: Pre cal for Special Test on Valve Pressure Locking

TEST EQUIPMENT

ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
C.3'	AF/AL	[illegible]	0-1000 PSIG	[illegible]	3-96

DOCUMENT REVIEW

SUPERVISOR: [signature]

DATE REVIEWED: 12-3-95

DATE ENTRY:

SIS ID:

WR#: 950003824-07

(Final)

.93(082093)
[illegible]

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AUG 27 1992
BRAIDWOOD ON-SITE REVIEW

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MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type		Location	
Instrument Name	FLUKE	Tolerance	2% = 2.8°F
Instr.Model Mfr.		References	
Instr.Serial No.		Procedure No.	
Head Correction		Setpoint	
Technician	J Harvey		
Date Calibrated	12-3-95	Range	

INPUT TEST POINT / OUTPUT TEST POINT

INPUT		REQUIRED	AS FOUND	AS LEFT
	%	°F	°F	°F
	0	70	69.8	69.8
	50	141	139.6	139.6
	100	212	210.8	210.8

SWITCH OPERATION

	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET		N	
SETPOINT		A	
RESET			

REMARKS:

As Found

For Test

950003824-09

TEST EQUIPMENT

ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
BR751	AF/AL	Gordon	E		10-96

DOCUMENT REVIEW

SUPERVISOR:

DATE REVIEWED: 12-3-95

DATE ENTRY:

STS ID:

WR#: 950003824-03

(Final)

.92(082092)

ZWBHIP

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BRAIDWOOD ONSITE REVIEW

0000 0000 0124

Revision 2

Date: 13-MC-ZZ-~~217 R/1 SH. 128~~ 144

SM 9/1/99

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type		Location	
Instrument Name	OMEGA	Tolerance	2% = 20 psi
Instr.Model Mfr.		References	
Instr.Serial No.		Procedure No.	
Head Correction		Setpoint	
Technician	Santa Arenas		
Date Calibrated	12-3-95	Range	

INPUT TEST POINT / OUTPUT TEST POINT

INPUT ~~PSI~~ % (12-3-95)	INPUT PSI	REQUIRED PSI	AS FOUND PSI	AS LEFT PSI
0	0	0	0	0
25	250	250	246	246
50	500	500	496	496
75	750	750	744	744
100	1000	1000	993	993
75	750	750	744	744
50	500	500	495	495
25	250	250	246	246
0	0	0	0	0

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET			
SETPOINT			
RESET			

REMARKS:

As Found
For Test:
950003824.09

TEST EQUIPMENT

ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
BR 266	AF/AL		0/1000 psi	NA	12-30-95

DOCUMENT REVIEW

SUPERVISOR: [signature]

DATE REVIEWED: 12-3-95

DATE ENTRY:

SYS ID:

NWR#: 950003824.03

(Final)

.92(082092)
CHEMIP

APPROVED
AUG 27 1992
BRAIDWOOD
ONSITE REVIEW

0000 0000 0125

Source Document: 3-MC-ZZ-217 R/1 SH ~~T23~~ 145
Revision:
Date:

BWIP 2000-T0
Revision 2

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type: MTT 8008
Location:
Instrument Name: test Gauge
Tolerance: 2% = 20 PSI
Instr.Model Mfr.: Ashcroft 1082
References:
Instr.Serial No.:
Procedure No.: BwIP 2400-00
Head Correction: N/A
Setpoint:
Technician: M Bord
Date Calibrated: 1-12-96
Range: 0-1000 psi

INPUT TEST POINT / OUTPUT TEST POINT

INPUT		REQUIRED	AS FOUND	AS LEFT
	psi	psi	psi	psi
	0	0	0	0
	250	250	252	250
	500	500	505	500
	750	750	760	746
	1000	1000	1015	996
	750	750	760	750
	500	500	510	500
	250	250	255	250
	0	0	0	0

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET		N/A	
SETPOINT			
RESET			

REMARKS:

Post Cal
950003824.09

TEST EQUIPMENT					
ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
SR 266	AF/AL	Ashcroft 1082	0-1000 psi	N/A	1-26-96

DOCUMENT REVIEW
SUPERVISOR: [signature]
DATE REVIEWED: 2-5-96
DATE ENTRY:
SYS ID:
NWR#: 950003824.03

(Final)
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.92(082092)
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APPROVEL
AUG 27 1992
BRAIDWOOD
ON-SITE REVIEW

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Source Document: ~~N/A~~ 9/1/99 13-MC-ZZ-217 R/1 SH. ~~124~~ 146
Revision:
Date:

BWIP 2000-TC
Revision 2

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type	MTT 111	Location	
Instrument Name	test gauge	Tolerance	2% = 20 PSI
Instr.Model Mfr.	Ashcroft 1279	References	
Instr.Serial No.	N/A	Procedure No.	
Head Correction		Setpoint	
Technician	M Bond		
Date Calibrated	1-12-96	Range	0-1000 psi

INPUT TEST POINT / OUTPUT TEST POINT

INPUT		REQUIRED	AS FOUND	AS LEFT
	psi	psi	psi	psi
	0	0	0	0
	250	250	250	250
	500	500	500	500
	750	750	750	750
	1000	1000	1000	1000
	750	750	750	750
	500	500	500	500
	250	250	250	250
	0	0	0	0

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET		N/A	
SETPOINT			
RESET			

REMARKS:

Post Cal
950003824.09

TEST EQUIPMENT

ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
BR 266	AF/AL	Ashcroft 1082	0-1000 psi	N/A	1-23-96

DOCUMENT REVIEW
SUPERVISOR: [signature]
DATE REVIEWED: 2-5-96
DATE ENTRY:
SYS ID:
NWR#: 950003824.03

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.92(082092)
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APPROVED
AUG 27 1992
BRAIDWOOD
ON-SITE REVIEW

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Source Document: SN 9/1/99 13-MC-ZZ-217 R/1 SH. ~~125~~ 147
Revision:
Date:

BWIP 2000-T0
Revision 2

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type		Location	
Instrument Name	OMEGA	Tolerance	2% = 20 psi
Instr.Model Mfr.		References	
Instr.Serial No.		Procedure No.	
Head Correction		Setpoint	
Technician	[signature]		
Date Calibrated	1-17-96	Range	

INPUT TEST POINT / OUTPUT TEST POINT

INPUT %	INPUT PSI	REQUIRED PSI	AS FOUND PSI	AS LEFT PSI
0	0	0	0	0
25	250	250	247	247
50	500	500	499	499
75	750	750	747	747
100	1000	1000	995	995
75	750	750	747	747
50	500	500	499	499
25	250	250	250	250
0	0	0	~~0~~ 3	3 ~~0~~

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET			
SETPOINT			
RESET			

REMARKS:

POST CAL
950003824-09

TEST EQUIPMENT

ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
BR 1053	AF/AL	CMM	0-1000	NA	2-2-96

DOCUMENT REVIEW
SUPERVISOR: [signature]
DATE REVIEWED: 2-5-96
DATE ENTRY:
SYS ID:
NWR#: 950003824-03

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AUG 27 1992
BRAIDWOOD
ON-SITE REVIEW

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Source Document: 13-MC-ZZ-217 R/1 SH. ~~126~~ 148
Revision:
Date:

BWIP 2000-TU
Revision 2

MULTIPLE USE

CALIBRATION TEST REPORT FORM

Instr. No/Type		Location	
Instrument Name	test meter	Tolerance	2%
Instr.Model Mfr.	Omega HH 25TF	References	
Instr.Serial No.	N/A	Procecure No.	
Head Correction		Setpoint	
Technician	[illegible]		
Date Calibrated	1-12-96	Range	0-200°F T T/C

INPUT TEST POINT		OUTPUT TEST POINT		
INPUT		REQUIRED	AS FOUND	AS LEFT
	°F	°F	°F	°F
	75	75	75.2	75.2
	125	125	124.3	124.3
	175	175	173.6	173.6

SWITCH OPERATION	AS FOUND	AS LEFT	ACTUATION INC/DEC
SETPOINT			
RESET			
SETPOINT			
RESET			

REMARKS:

PostCal
950003824 09

for Chris Bedford
x2440

TEST EQUIPMENT

ID#	AF/AL	MODEL#	RANGE	RATE	CERT DUE
32 750	AF/	Gordon TJ10	type "K" T/C	N/A	4-96

DOCUMENT REVIEW
SUPERVISOR: [illegible]
DATE REVIEWED: 2-5-96
DATE ENTRY:
SYS ID:
NWR#: 950003824-03

(Final)
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APPROVEL
AUG 27 1992
BRAIDWOOD
ON-SITE REVIEW

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R.E. [signature] 9-1-99 I.V. Rafael Rios 9-2-99

Attachment 6- PVNGS Pressure Locking Model Comparison to NUREG/CR-6611

This attachment was added to the PVNGS 13-MC-ZZ-217, Gate Valve Open Thrust Required during Pressure Locking Conditions per G. L. 95-07, calculation to document comparison of the PVNGS pressure locking model with INEEL pressure locking test results published under NUREG/CR-6611 in May 1998. The US Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research funded the Idaho National Engineering and Environmental Laboratory (INEEL) pressure locking testing of a Walworth flexible gate and a Anchor Darling double disk gate valve. PVNGS has compared the Walworth flexible gate pressure locking test results to the PVNGS pressure locking model that was used to evaluate the identified potentially susceptible PVNGS Anchor Darling and Borg-Warner flexible wedge gate valves.

The applicable INEEL 6", 600 lb class flexible wedge Walworth test valve parameters and test inputs included bonnet pressure, Up and down stream pressures, and peak unwedging from NUREG/CR-6611. These test values from NUREG/CR-6611, Appendix A, Table 5; Walworth Gate Valve, Cold Pressure Locking Test Results; and Table 7; Walworth Gate Valve, Thermally Induced Pressure Locking Test Results; were input into a speadsheet similar to that used in Attachment 1 of this calculation 13-MC-ZZ-217. Reasonable assumptions for parameters not available in NUREG/CR-6611 were made for inputs that were not sensitive to the comparison of these results and these assumptions were checked by conversations with one of the principal INEEL testers.

The comparison of these INEEL measured opening thrust pressure locking test results to the PVNGS pressure locking model predicted opening thrust for the 6" 600# Walworth flexible wedge gate valves is shown in the attached Excel spreadsheet and represented in the two subsequent charts. These charts present a least square linear regression of the PVNGS Pressure Locking model with the corresponding INEEL Pressure locking test results. These charts present a plot of the peak stem thrust required to open the valve as a function of the bonnet pressure.

Attachment 6 chart 1 shows the comparison of the PVNGS pressure locking analysis model to the INEEL cold pressure locking test results. All these test cases were identified as restricted to pressure locking at temperatures near around 75 °F. In general the least square linear regression comparisons shown in chart 1 of the PVNGS pressure locking model with the INEEL pressure locking test results indicate a good correlation. However, the overall scatter of the test results indicate some inconsistency in these results which could be partially attributed to the effect of varying upstream and down steam pressures. There were also a number of specific data points, most notably tests 229 and 230, where the PVNGS model under predicted the INEEL test results. These were data points corresponding to points where the bonnet pressure was relatively high with essentially no or negative upstream and downstream pressures. This inconsistency and underprediction may be attributed to the characteristics of this more flexibleWalworth flexible gate valve with its typically thinner disk and smaller hub dimensions and the reported instability in the friction factors under ambient temperature conditions.

R.E. [signature] 9-1-99 I.V. [signature] 9-2-99

Attachment 6 chart 2 shows the comparison for the PVNGS pressure locking model to the INEEL thermally induced pressure locking test results. These test cases were identified as varying in pressure locking temperatures from 65 °F to 217 °F. In general the least square linear regression comparison shown in chart 2 of the PVNGS pressure locking model with the INEEL pressure locking test results shows a conservative divergent correlation. Although there appears to be some scatter of the test results that may be attributed to the effect of varying upstream and down steam pressure, there was less of a tendency of the PVNGS model to under predict the INEEL thermally induced pressure locking test results for specific data points then for the cold pressure locking test results. The margin between the INEEL measured test data and the PVNGS model's predicted data presented in chart 2 ranged from a high margin of 77% for the measured pressure locking load of 10,429 lbf with a bonnet pressure of 922 psig and down stream pressure of 916 psig at 187 °F (Test 310) to a minimum margin of (negative) –10.5% for the measures pressure locking load of 19,501 lbf with a bonnet pressure 1050 psig and essentially no upstream or down stream pressure at 65 °F (Test 343). There also appears to be no discernible pattern to the two nonstatic data points (Test 329 and Test 343) that were slightly underpredicted by the PVNGS model other then the fact that point which was most underpredicted by the model was identified at the relatively low temperature of 65 °F with a high bonnet pressure of 1050 psig and essentially no piping pressure (Test 343). This data point appears not to be consistent with the results of Test 307 which also had a relatively high bonnet pressure of 1073 psig and a relatively low upstream pressure of 34 psig yet the PVNGS pressure locking model accurately predicted the corresponding measured INEEL test results. These apparent inconsistency may be attributed to the characteristics of this more flexibleWalworth gate valve disk with its typically thinner disk and smaller hub dimensions and the reported instability in the friction factors under ambient temperature conditions.

It is difficult to conclude that the PVNGS pressure locking analysis model is accurate in predicting the indicated INEEL measured pressure locking loads. There was some apparent inconsistency in the INEEL data that could be attributed to the characteristics of this apparently more flexible Walworth gate valve disk with its typically thinner disk and smaller hub dimensions and the reported instability in the friction factors under ambient temperature conditions. However, when the INEEL test and PVNGS model results for the required opening thrust versus the bonnet pressure were fit with least square linear regression accounting for inherent errors it appears that the Palo Verde model does reasonably approach conservatively predicting the trends of this data (see charts 1 & 2). Further it is apparent that the results of this INEEL pressure locking test data does not invalidate the PVNGS model that was developed for the relatively more rigid disk of the Borg-Warner 300 # class flexible wedge gate valve based on the APS/Commonwealth pressure locking test data documented in Attachment 5. It is apparent that the more flexible the gate valve is the more sensitive the valve is to pressure locking conditions.

B - 1

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Steven A. Lopez [signature] 7-16-99												
2	Rafael Rios ______												
3	Revision 9												
4		PRESSURE LOCKING CALCULATION											
5	Walworth 600 # Gate Valve	SYSTEM INPUTS						VALVE INPUTS					
6		Tinitial	Tfinal	Pinitial	Pup	Pdown	Pini-Pav	a	b	theta	nu	VF	*Valve Str*
7		(degf)	(degf)	(psig)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			*Thrust (lbf)*
8	PRESSURE LOCKING TEST												
9	Test 226	74	74	3	1	1	3	2.7575	1.29	5	0.3	0.6	30000
10	Test 227	72	72	1075	1072	-4	-1	2.7575	1.29	5	0.3	0.6	30000
11	Test 228	77	77	1039	-3	1031	5	2.7575	1.29	5	0.3	0.6	30000
12	Test 229	73	73	495	-3	-1	493	2.7575	1.29	5	0.3	0.6	30000
13	Test 230	69	69	1065	-3	-3	1065	2.7575	1.29	5	0.3	0.6	30000
14	Test 231	72	72	1127	-3	363	761	2.7575	1.29	5	0.3	0.6	30000
15	Test 232	73	73	1056	318	-3	735	2.7575	1.29	5	0.3	0.6	30000
16	Test 233	70	70	1	-1	-2	0	2.7575	1.29	5	0.3	0.6	30000
17	Test 234	71	71	1012	1009	-2	1	2.7575	1.29	5	0.3	0.6	30000
18	Test 235	71	71	1041	-3	1034	4	2.7575	1.29	5	0.3	0.6	30000
19	Test 237	70	70	-2	-3	-4	-3	2.7575	1.29	5	0.3	0.6	30000
20													
21	PRESSURE LOCKING TEST												
22	Test 307	203	203	1073	34	-2	1037	2.7575	1.29	5	0.3	0.6	30000
23	Test 308	217	217	16	14	12	14	2.7575	1.29	5	0.3	0.6	30000
24	Test 309	190	190	1024	1022	-2	0	2.7575	1.29	5	0.3	0.6	30000
25	Test 310	187	187	922	0	916	6	2.7575	1.29	5	0.3	0.6	30000
26	Test 312	71	71	207	200	196	203	2.7575	1.29	5	0.3	0.6	30000
27	Test 313	69	69	1056	1053	5	8	2.7575	1.29	5	0.3	0.6	30000
28	Test 314	67	67	1062	6	1055	13	2.7575	1.29	5	0.3	0.6	30000
29	Test 316	205	205	1141	-1	-3	1139	2.7575	1.29	5	0.3	0.6	30000
30	Test 317	179	179	9	9	8	8	2.7575	1.29	5	0.3	0.6	30000
31	Test 318	181	181	1061	1059	-4	-2	2.7575	1.29	5	0.3	0.6	30000
32	Test 319	182	182	1010	-3	1003	4	2.7575	1.29	5	0.3	0.6	30000
33	Test 322	69	69	44	41	57	28	2.7575	1.29	5	0.3	0.6	30000

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Steven A. Lopez_______________												
2	Rafael Rios _______________												
3	Revision 9												
4		PRESSURE LOCKING CALCULATION											
5	Walworth 600 # Gate Valve	SYSTEM INPUTS						VALVE INPUTS					
6		Tinitial	Tfinal	Pinitial	Pup	Pdown	Pini-Pav	a	b	theta	nu	VF	*Valve Str*
7		(degf)	(degf)	(psig)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			*Thrust (lbf)*
34	Test 323	67	67	1007	1004	44	47	2.7575	1.29	5	0.3	0.6	30000
35	Test 324	76	76	1015	39	1009	45	2.7575	1.29	5	0.3	0.6	30000
36	Test 325	71	71	49	46	44	47	2.7575	1.29	5	0.3	0.6	30000
37	Test 326	66	66	1100	1097	-4	-1	2.7575	1.29	5	0.3	0.6	30000
38	Test 327	70	70	1073	-3	1066	4	2.7575	1.29	5	0.3	0.6	30000
39	Test 329	125	125	1105	35	-3	1067	2.7575	1.29	5	0.3	0.6	30000
40	Test 330	148	148	42	67	55	30	2.7575	1.29	5	0.3	0.6	30000
41	Test 331	136	136	1083	1080	-4	-1	2.7575	1.29	5	0.3	0.6	30000
42	Test 332	133	133	1047	-2	1040	5	2.7575	1.29	5	0.3	0.6	30000
43	Test 341	66	66	1119	-1	1114	4	2.7575	1.29	5	0.3	0.6	30000
44	Test 342	70	70	2	1	2	1	2.7575	1.29	5	0.3	0.6	30000
45	Test 343	65	65	1050	2	3	1049	2.7575	1.29	5	0.3	0.6	30000

	A	N	P	Q	R	S	T	U	V	W	Y	Z
1	Steven A. Lopez											
2	Rafael Rios											
3	Revision 9											
4												
5	**Walworth 600 # Gate Valve**		**MOV ACTUATOR/STEM INPUTS**									**MOT**
6		*ctural Limit*	OAR	P.O. Ef	COF	Dstem	Pstem	Lstem	*Actuator Structural Limit*		Vfull	Vmin
7		*Torque (ft-lbf)*				(in.)	(in./th.)	(in./rev.)	*Thrust (lbf*	*Torque (ft-lbf)*	(volts)	(volts)
8	PRESSURE LOCKING TEST											
9	Test 226	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
10	Test 227	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
11	Test 228	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
12	Test 229	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
13	Test 230	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
14	Test 231	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
15	Test 232	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
16	Test 233	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
17	Test 234	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
18	Test 235	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
19	Test 237	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
20												
21	PRESSURE LOCKING TEST											
22	Test 307	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
23	Test 308	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
24	Test 309	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
25	Test 310	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
26	Test 312	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
27	Test 313	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
28	Test 314	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
29	Test 316	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
30	Test 317	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
31	Test 318	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
32	Test 319	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
33	Test 322	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415

	A	N	P	Q	R	S	T	U	V	W	Y	Z
1	Steven A. Lopez											
2	Rafael Rios											
3	Revision 9											
4												
5	**Walworth 600 # Gate Valve**		**MOV ACTUATOR/STEM INPUTS**									**MOT**
6		***ctural Limit***	OAR	P.O. Ef	COF	Dstem	Pstem	Lstem	***Actuator Structural Limit***		Vfull	Vmin
7		***Torque (ft-lbf)***				(in.)	(in./th.)	(in./rev.)	***Thrust (lbf***	***Torque (ft-lbf)***	(volts)	(volts)
34	Test 323	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
35	Test 324	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
36	Test 325	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
37	Test 326	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
38	Test 327	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
39	Test 329	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
40	Test 330	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
41	Test 331	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
42	Test 332	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
43	Test 341	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
44	Test 342	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415
45	Test 343	475	48.95	0.4	0.12	1.25	0.250	0.500	*24,000*	*500*	460	415

	A	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Steven A. Lopez										
2	Rafael Rios										
3	Revision 9										
4							*Calculation of Minimum Available*				CALCULA
5	Walworth 600 # Gate Valve	R INPUTS			MOV MISC INPUTS		*Torque and Thrust at Motor Stall*				DP X DISK
6		MTorq	n	TDF	Max Close	% Residual	Stem Factor	*Avail Torque*	*Avail Thrust*	VDF	Pfinal
7		(ft-lbf)			Load (lbf)	Load		(ft-lbf)	(lbf)		(psig)
8	PRESSURE LOCKING TEST										
9	Test 226	25	2	0.98	6,200	67%	0.0127	*432*	*34,093*	0.900	3
10	Test 227	25	2	0.98	6,200	21%	0.0127	*432*	*34,093*	0.900	1,075
11	Test 228	25	2	0.98	6,200	23%	0.0127	*432*	*34,093*	0.900	1,039
12	Test 229	25	2	0.98	6,200	46%	0.0127	*432*	*34,093*	0.900	495
13	Test 230	25	2	0.98	6,200	21%	0.0127	*432*	*34,093*	0.900	1,065
14	Test 231	25	2	0.98	6,200	19%	0.0127	*432*	*34,093*	0.900	1,127
15	Test 232	25	2	0.98	6,200	22%	0.0127	*432*	*34,093*	0.900	1,056
16	Test 233	25	2	0.98	6,200	67%	0.0127	*432*	*34,093*	0.900	1
17	Test 234	25	2	0.98	6,200	36%	0.0127	*432*	*34,093*	0.900	1,012
18	Test 235	25	2	0.98	6,200	35%	0.0127	*432*	*34,093*	0.900	1,041
19	Test 237	25	2	0.98	6,200	67%	0.0127	*432*	*34,093*	0.900	-2
20											
21	PRESSURE LOCKING TEST										
22	Test 307	25	2	0.98	6,200	36%	0.0127	*432*	*34,093*	0.900	1,073
23	Test 308	25	2	0.98	6,200	67%	0.0127	*432*	*34,093*	0.900	16
24	Test 309	25	2	0.98	6,200	37%	0.0127	*432*	*34,093*	0.900	1,024
25	Test 310	25	2	0.98	6,200	40%	0.0127	*432*	*34,093*	0.900	922
26	Test 312	25	2	0.98	6,200	60%	0.0127	*432*	*34,093*	0.900	207
27	Test 313	25	2	0.98	6,200	33%	0.0127	*432*	*34,093*	0.900	1,056
28	Test 314	25	2	0.98	6,200	33%	0.0127	*432*	*34,093*	0.900	1,062
29	Test 316	25	2	0.98	6,200	31%	0.0127	*432*	*34,093*	0.900	1,141
30	Test 317	25	2	0.98	6,200	67%	0.0127	*432*	*34,093*	0.900	9
31	Test 318	25	2	0.98	6,200	36%	0.0127	*432*	*34,093*	0.900	1,061
32	Test 319	25	2	0.98	6,200	38%	0.0127	*432*	*34,093*	0.900	1,010
33	Test 322	25	2	0.98	6,200	65%	0.0127	*432*	*34,093*	0.900	44

	A	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Steven A. Lopez										
2	Rafael Rios										
3	Revision 9										
4							*Calculation of Minimum Available*				CALCULA
5	Walworth 600 # Gate Valve	R INPUTS			MOV MISC INPUTS		*Torque and Thrust at Motor Stall*				DP X DISK
6		MTorq	n	TDF	Max Close	% Residual	Stem Factor	*Avail Torque*	*Avail Thrust*	VDF	Pfinal
7		(ft-lbf)			Load (lbf)	Load		(ft-lbf)	(lbf)		(psig)
34	Test 323	25	2	0.98	6,200	30%	0.0127	*432*	*34,093*	0.900	1,007
35	Test 324	25	2	0.98	6,200	30%	0.0127	*432*	*34,093*	0.900	1,015
36	Test 325	25	2	0.98	6,200	65%	0.0127	*432*	*34,093*	0.900	49
37	Test 326	25	2	0.98	6,200	15%	0.0127	*432*	*34,093*	0.900	1,100
38	Test 327	25	2	0.98	6,200	16%	0.0127	*432*	*34,093*	0.900	1,073
39	Test 329	25	2	0.98	6,200	15%	0.0127	*432*	*34,093*	0.900	1,105
40	Test 330	25	2	0.98	6,200	65%	0.0127	*432*	*34,093*	0.900	42
41	Test 331	25	2	0.98	6,200	27%	0.0127	*432*	*34,093*	0.900	1,083
42	Test 332	25	2	0.98	6,200	28%	0.0127	*432*	*34,093*	0.900	1,047
43	Test 341	25	2	0.98	6,200	25%	0.0127	*432*	*34,093*	0.900	1,119
44	Test 342	25	2	0.98	6,200	67%	0.0127	*432*	*34,093*	0.900	2
45	Test 343	25	2	0.98	6,200	34%	0.0127	*432*	*34,093*	0.900	1,050

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Steven A. Lopez________									
2	Rafael Rios ____________									
3	Revision 9									
4		ION								
5	Walworth 600 # Gate Valve		Calculation of Disk Load Perpendicular to the Seat/Roak Thin Plate Theory							
6		DPavg	C2	C3	C8	C9	L11	L17	mu	Qb
7		(psig)								
8	PRESSURE LOCKING TEST									
9	Test 226	2	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	2
10	Test 227	541	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	671
11	Test 228	525	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	652
12	Test 229	497	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	617
13	Test 230	1068	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,325
14	Test 231	947	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,175
15	Test 232	899	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,115
16	Test 233	3	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	3
17	Test 234	509	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	631
18	Test 235	526	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	652
19	Test 237	2	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	2
20										
21	PRESSURE LOCKING TEST									
22	Test 307	1057	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,312
23	Test 308	3	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	4
24	Test 309	514	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	638
25	Test 310	464	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	576
26	Test 312	9	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	11
27	Test 313	527	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	654
28	Test 314	532	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	660
29	Test 316	1143	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,418
30	Test 317	1	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1
31	Test 318	534	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	662
32	Test 319	510	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	633
33	Test 322	-5	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	-6

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	Steven A. Lopez___________									
2	Rafael Rios _____________									
3	Revision 9									
4		ION								
5	Walworth 600 # Gate Valve		Calculation of Disk Load Perpendicular to the Seat/Roak Thin Plate Theory							
6		DPavg	C2	C3	C8	C9	L11	L17	mu	Qb
7		(psig)								
34	Test 323	483	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	599
35	Test 324	491	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	609
36	Test 325	4	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	5
37	Test 326	554	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	687
38	Test 327	542	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	672
39	Test 329	1089	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,351
40	Test 330	-19	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	-24
41	Test 331	545	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	676
42	Test 332	528	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	655
43	Test 341	563	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	698
44	Test 342	1	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1
45	Test 343	1048	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1,300

	A	AT	AU	AV	AW	AX	AY	AZ
1	Steven A. Lopez____________							
2	Rafael Rios ______________							
3	Revision 9							
4					Static	Residual Closing	Vertical Load	Stem piston
5	Walworth 600 # Gate Valve		Disk Load	Hub Load	Peak	Load at Cracking	On Disks	Load
6		Qa	w/DPavg	Pup-Pdown	Cracking	Residual Load	Fvert	Fpiston
7			(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
8	PRESSURE LOCKING TEST							
9	Test 226	-1	22	-	4,353	4,345	8	4
10	Test 227	-269	5,870	10,374	4,353	1,364	2,253	1,319
11	Test 228	-261	5,696	9,969	4,353	1,464	2,186	1,275
12	Test 229	-247	5,392	19	4,353	2,977	2,069	607
13	Test 230	-530	11,588	-	4,353	1,392	4,447	1,307
14	Test 231	-470	10,275	3,529	4,353	1,220	3,943	1,383
15	Test 232	-446	9,749	3,095	4,353	1,417	3,741	1,296
16	Test 233	-1	27	10	6,065	6,062	10	1
17	Test 234	-252	5,517	9,747	6,065	3,251	2,117	1,242
18	Test 235	-261	5,702	9,998	6,065	3,171	2,188	1,277
19	Test 237	-1	16	10	10,612	10,618	6	2
20								
21	PRESSURE LOCKING TEST							
22	Test 307	-525	11,469	347	6,354	3,371	4,401	1,317
23	Test 308	-1	33	19	6,354	6,310	12	20
24	Test 309	-255	5,577	9,872	6,354	3,507	2,140	1,257
25	Test 310	-230	5,034	8,831	6,354	3,791	1,932	1,131
26	Test 312	-4	98	39	5,866	5,290	37	254
27	Test 313	-262	5,718	10,104	5,866	2,930	2,194	1,296
28	Test 314	-264	5,767	10,114	5,866	2,913	2,213	1,303
29	Test 316	-567	12,402	19	5,866	2,694	4,759	1,400
30	Test 317	0	5	10	6,404	6,379	2	11
31	Test 318	-265	5,789	10,248	6,404	3,454	2,221	1,302
32	Test 319	-253	5,534	9,699	6,404	3,596	2,124	1,239
33	Test 322	2	54	154	5,102	4,980	21	54

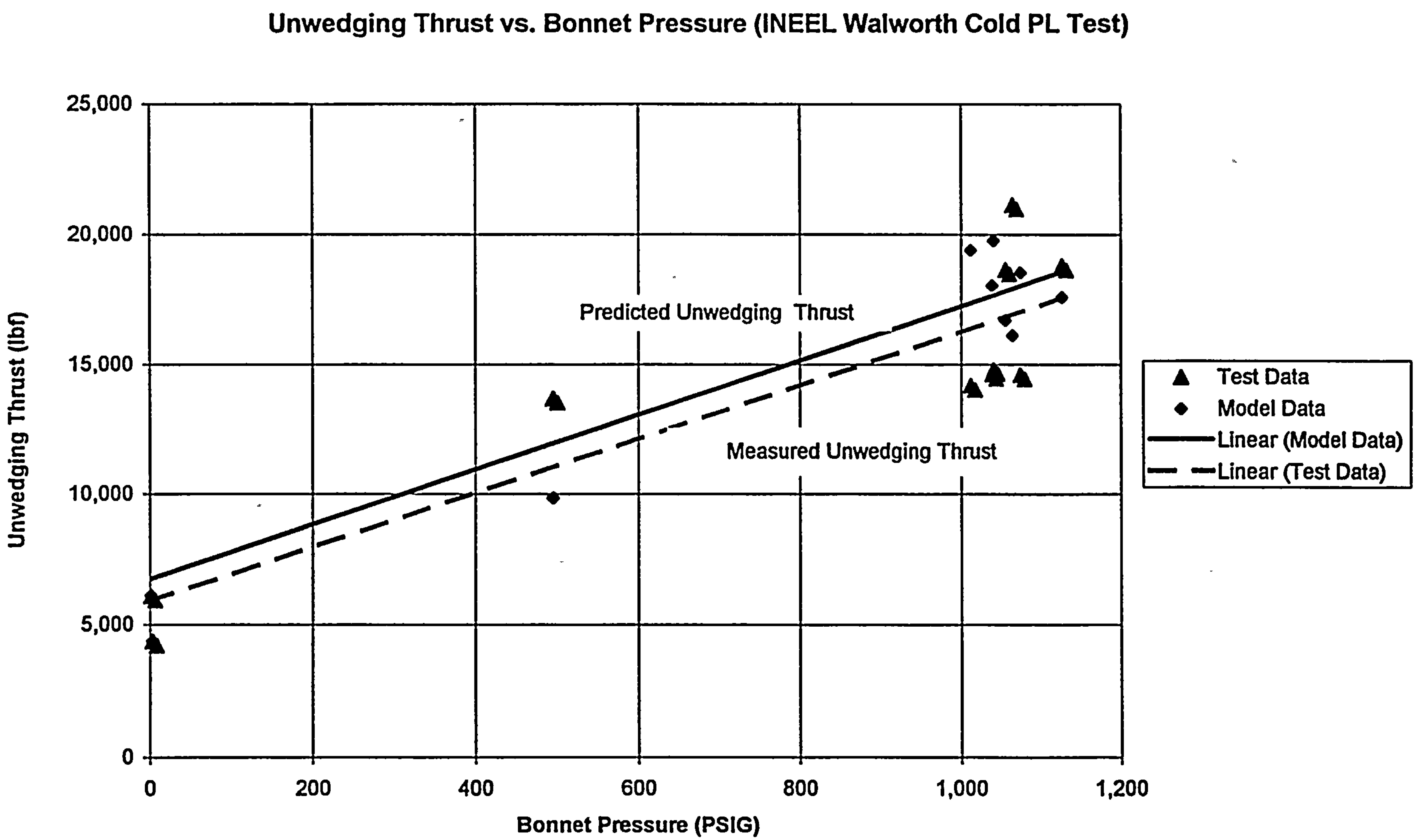
	A	AT	AU	AV	AW	AX	AY	AZ
1	Steven A. Lopez							
2	Rafael Rios							
3	Revision 9							
4					Static	Residual Closing	Vertical Load	Stem piston
5	Walworth 600 # Gate Valve		Disk Load	Hub Load	Peak	Load at Cracking	On Disks	Load
6		Qa	w/DPavg	Pup-Pdown	Cracking	Residual Load	Fvert	Fpiston
7			(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
34	Test 323	-240	5,241	9,255	5,102	2,302	2,011	1,236
35	Test 324	-244	5,327	9,352	5,102	2,280	2,045	1,246
36	Test 325	-2	43	19	3,944	3,808	17	60
37	Test 326	-275	6,006	10,615	3,944	886	2,305	1,350
38	Test 327	-269	5,875	10,306	3,944	961	2,255	1,317
39	Test 329	-541	11,816	366	3,944	872	4,535	1,356
40	Test 330	9	206	116	5,022	4,905	79	52
41	Test 331	-271	5,913	10,451	5,022	2,011	2,269	1,329
42	Test 332	-262	5,729	10,046	5,022	2,111	2,199	1,285
43	Test 341	-279	6,103	10,750	5,022	1,911	2,342	1,373
44	Test 342	0	5	10	5,924	5,918	2	2
45	Test 343	-520	11,365	10	5,924	3,005	4,362	1,289

	A	BA	BB	BC	BG
1	Steven A. Lopez____				
2	Rafael Rios ________			MOV Min Avail	
3	Revision 9	**Total Stem Thrust**	**Total Torque Required**	**Thrust due to**	**MARGIN**
4		**Req'd to Overcome**	**to Overcome Pressure**	**Structural Limit or**	LIMITING THRUST
5	**Walworth 600 # Gate Valve**	**Press Locking**	**Locking**	**Motor Torque Limit**	subtract
6		Ftotal	Required Torque	Limiting Thrust	REQUIRED THRUST
7		(lbf)	(ft-lbf)	(lbf)	(lbf)
8	PRESSURE LOCKING TEST				
9	Test 226	4,371	55	24,000	19,629
10	Test 227	18,541	235	24,000	5,459
11	Test 228	18,040	228	24,000	5,960
12	Test 229	9,851	125	24,000	14,149
13	Test 230	16,120	204	24,000	7,880
14	Test 231	17,583	223	24,000	6,417
15	Test 232	16,706	212	24,000	7,294
16	Test 233	6,108	77	24,000	17,892
17	Test 234	19,391	246	24,000	4,609
18	Test 235	19,781	250	24,000	4,219
19	Test 237	10,647	135	24,000	13,353
20					
21	PRESSURE LOCKING TEST				
22	Test 307	18,271	231	24,000	5,729
23	Test 308	6,354	80	24,000	17,646
24	Test 309	19,840	251	24,000	4,160
25	Test 310	18,457	234	24,000	5,543
26	Test 312	5,210	66	24,000	18,790
27	Test 313	19,650	249	24,000	4,350
28	Test 314	19,703	250	24,000	4,297
29	Test 316	18,474	234	24,000	5,526
30	Test 317	6,385	81	24,000	17,615
31	Test 318	20,410	258	24,000	3,590
32	Test 319	19,713	250	24,000	4,287
33	Test 322	5,155	65	24,000	18,845

	A	BA	BB	BC	BG
1	Steven A. Lopez				
2	Rafael Rios			MOV Min Avail	
3	Revision 9	Total Stem Thrust	Total Torque Required	Thrust due to	MARGIN
4		Req'd to Overcome	to Overcome Pressure	Structural Limit or	LIMITING THRUST
5	Walworth 600 # Gate Valve	Press Locking	Locking	Motor Torque Limit	subtract
6		Ftotal	Required Torque	Limiting Thrust	REQUIRED THRUST
7		(lbf)	(ft-lbf)	(lbf)	(lbf)
34	Test 323	17,574	223	24,000	6,426
35	Test 324	17,758	225	24,000	6,242
36	Test 325	3,827	48	24,000	20,173
37	Test 326	18,461	234	24,000	5,539
38	Test 327	18,080	229	24,000	5,920
39	Test 329	16,232	206	24,000	7,768
40	Test 330	5,255	67	24,000	18,745
41	Test 331	19,315	245	24,000	4,685
42	Test 332	18,800	238	24,000	5,200
43	Test 341	19,733	250	24,000	4,267
44	Test 342	5,933	75	24,000	18,067
45	Test 343	17,453	221	24,000	6,547

	A	BH	BI	BJ	BK	BL	BM	BN	BO
1	Steven A. Lopez___								
2	Rafael Rios ___			Additional					
3	Revision 9			PL		FRACTION	MEASURED	MARGIN	LOADING
4				Load	DIMEN.	RESIDUAL	PEAK	(P-M/M)	TYPE
5	Walworth 600 # Gate Valve	MARGIN		"(PL Load	CORR.	OF CLOSING	UNWEDGING	*100	
6		DESIGN	Suscept?	-Res. Load)"				%	
7		(%)		(lbf)					
8	PRESSURE LOCKING TEST								
9	Test 226	81.8	No	26	0.009	0.669	4,353	0.4	S
10	Test 227	22.7	No	17,177	3.088	0.210	14,590	27.1	HD
11	Test 228	24.8	No	16,576	2.984	0.225	14,612	23.5	HU
12	Test 229	59.0	No	6,874	1.422	0.458	13,652	-27.8	PL
13	Test 230	32.8	No	14,728	3.059	0.214	21,132	-23.7	PL
14	Test 231	26.7	No	16,364	3.237	0.188	18,798	-6.5	PL
15	Test 232	30.4	No	15,289	3.033	0.218	18,634	-10.3	PL
16	Test 233	74.5	No	46	0.002	0.670	6,065	0.7	S
17	Test 234	19.2	No	16,140	2.086	0.359	14,177	36.8	HD
18	Test 235	17.6	No	16,610	2.146	0.350	14,778	33.9	HU
19	Test 237	55.6	No	30	-0.002	0.670	6,065	75.6	S
20									
21	PRESSURE LOCKING TEST								
22	Test 307	23.9	No	14,900	2.111	0.355	18,251	0.1	PL
23	Test 308	73.5	No	45	0.031	0.665	6,354	0.0	S
24	Test 309	17.3	No	16,333	2.015	0.370	11,895	66.8	HD
25	Test 310	23.1	No	14,666	1.814	0.400	10,429	77.0	HU
26	Test 312	78.3	No	-80	0.441	0.604	5,866	-11.2	S
27	Test 313	18.1	No	16,720	2.251	0.335	11,226	75.0	HD
28	Test 314	17.9	No	16,790	2.263	0.333	12,142	62.3	HU
29	Test 316	23.0	No	15,780	2.432	0.308	18,096	2.1	PL
30	Test 317	73.4	No	6	0.018	0.667	6,404	-0.3	S
31	Test 318	15.0	No	16,956	2.071	0.361	12,108	68.6	HD
32	Test 319	17.9	No	16,117	1.972	0.376	12,703	55.2	HU
33	Test 322	78.5	No	175	0.108	0.654	5,102	1.0	S

	A	BH	BI	BJ	BK	BL	BM	BN	BO
1	Steven A. Lopez								
2	Rafael Rios			Additional					
3	Revision 9			PL		FRACTION	MEASURED	MARGIN	LOADING
4				Load	DIMEN.	RESIDUAL	PEAK	(P-M/M)	TYPE
5	Walworth 600 # Gate Valve	MARGIN		"(PL Load	CORR.	OF CLOSING	UNWEDGING	*100	
6		DESIGN	Suscept?	-Res. Load)"				%	
7		(%)		(lbf)					
34	Test 323	26.8	No	15,271	2.468	0.302	11,936	47.2	HD
35	Test 324	26.0	No	15,478	2.487	0.299	12,636	40.5	HU
36	Test 325	84.1	No	19	0.155	0.647	3,944	-3.0	S
37	Test 326	23.1	No	17,575	3.487	0.150	14,801	24.7	HD
38	Test 327	24.7	No	17,120	3.401	0.163	15,256	18.5	HU
39	Test 329	32.4	No	15,361	3.503	0.148	17,010	-4.6	PL
40	Test 330	78.1	No	349	0.105	0.654	5,022	4.6	S
41	Test 331	19.5	No	17,305	2.696	0.268	14,893	29.7	HD
42	Test 332	21.7	No	16,689	2.607	0.282	15,242	23.3	HU
43	Test 341	17.8	No	17,822	2.786	0.255	15,742	25.4	HU
44	Test 342	75.3	No	15	0.004	0.669	5,924	0.2	S
45	Test 343	27.3	No	14,448	2.216	0.340	19,501	-10.5	PL


Unwedging Thrust vs. Bonnet Pressure (INEEL Walworth Cold PL Test)
25,000
20,000
15,000
10,000
5,000
0
Unwedging Thrust (lbf)
0
200
400
600
800
1,000
1,200
Bonnet Pressure (PSIG)
Predicted Unwedging Thrust
Measured Unwedging Thrust
Test Data
Model Data
Linear (Model Data)
Linear (Test Data)

Unwedging Thrust vs. Bonnet Pressure (INEEL Walworth Thermal PL Test)