APS

Palo Verde Nuclear
Generating Station

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102-04493-CDM/SAB/JAP
October 5, 2000

U.S. Nuclear Regulatory Commission
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Mail Station P1-37
Washington, DC 20555-0001

Reference: 1) Letter dated August 3, 2000, Generic Letter 95-07, Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves, Request for Additional Information, from USNRC, to G.R. Overbeck, APS

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Supplemental Response to Generic Letter 95-07, Request for Additional Information (TAC Nos. M93497, M93498, M93499)

In Reference 1, the NRC requested that Arizona Public Service Company (APS) provide additional information to support their review of APS' resolution of Generic Letter 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves." On September 27, 2000, APS and the NRC staff met to discuss the information request and the APS model for evaluating pressure locking conditions. Based on the information request and the results of the meeting, the additional information is provided in Enclosure 1. Attachments 1, 4 and 6 of APS Calculation 13-MC-ZZ-217 have been updated as a result of this request for additional information and are provided in Enclosure 2. APS calculation 13-MC-ZZ-217 will be revised to incorporate the updates to these attachments.

APS identified in earlier responses to Generic Letter 95-07 that a number of valves required modification to eliminate their susceptibility to pressure locking. These modifications have been completed.

A056

No commitments are being made to the NRC by this letter. If you have any questions, please contact Scott A. Bauer at (623) 393-5978.

Sincerely,

David Mauldin

CDM/SAB/JAP/kg

Enclosures

cc:

E. W. Merschoff	(w/ enclosure 1 only)
M. B. Fields	(w/ enclosures)
J. H. Moorman	(w/ enclosure 1 only)

ENCLOSURE 1

RESPONSE TO GENERIC LETTER 95-07, "PRESSURE LOCKING AND THERMAL BINDING OF SAFETY-RELATED POWER-OPERATED GATE VALVES," REQUEST FOR ADDITIONAL INFORMATION

Each of the questions from the RAI is repeated below directly followed by the APS response.

NRC QUESTION #1:

Arizona Public Service Company (the licensee) discussed the test results used to validate its pressure locking thrust prediction methodology in response to Generic Letter 95-07 in submittals dated October 8, 1999, and March 31, 2000. The licensee used test results from a Borg Warner and a Crane flexible wedge gate valve to support its determination that the pressure locking prediction methodology accurately predicts the amount of thrust required to open a pressure-locked valve. The NRC staff reviewed the submittals and has concluded that, in lieu of the design assumptions for valve factors, it would be more appropriate to use the actual valve factors for Borg Warner and Crane test valves to validate the methodology. Please resubmit Attachments 4 and 6 of Engineering Calculation 13-MC-ZZ-217 included in the March 31, 2000, submittal, using the valve factors based on the test results and discuss the determination of the appropriate valve factor from the test results.

APS RESPONSE:

APS reviewed the 10" 300# class Borg-Warner and 10" 900# class Crane flexible wedge gate valve test results to confirm that the valve factors used to validate the Palo Verde Nuclear Generating Station (PVNGS) Pressure Locking (PL) model were consistent with these test results. This review included analysis of the VOTES data acquisition system test traces and recalculation of the resulting valve factors based on this test data. Specific values were obtained from the identified test points in a manner similar to the published test results. The maximum force after peak cracking (VOTES point O10), and the opening running force (between VOTES points O13 and O14) were determined. These values were used with the values for the valve seat area and the measured maximum line pressure to calculate the range of valve factors in accordance with standard methodology. The highest established valve factor based on the review of these test results was utilized similar to the APS grouping methodology.

This review resulted in valve factors of 0.44 and 0.31 for the Borg-Warner and Crane valves, respectively. These valve factors compare favorably to valve factors determined for these valves by other licensees. Enclosure 2 includes the corresponding update of Attachment 4, Pressure Locking Model Validation, and Attachment 6, PVNGS PL Model Comparison, of PVNGS engineering calculation 13-MC-ZZ-217, Gate Valve Open Thrust Required During Potential Pressure Locking Conditions per Generic Letter (GL) 95-07.

NRC QUESTION #2:

The licensee's submittal dated October 8, 1999, discusses the recommended margin between actuator capability and the calculated thrust requirement when using the pressure locking thrust prediction methodology. This submittal states that, at postulated bonnet pressures above 200 psig, an "additional" 10% margin to account for model uncertainty is maintained between pressure locking load unless otherwise justified. The reference to "additional" margin above an unidentified margin needs to be clarified.

APS RESPONSE:

APS's October 8, 1999 submittal indicated that for applications of the PVNGS PL model with postulated bonnet pressure above 200 psig, at least an additional 10% margin is maintained. This margin is to account for PVNGS PL model uncertainty and is maintained between the minimum actuator capability or load limit and the calculated required pressure locking load. As described and justified in APS' response to NRC Question #5, there are two sets of valves that do not currently have the full 10% additional margin.

The 10% margin referred to is in addition to the basic margin that exists between the measured PL test results and the PVNGS PL model. This basic margin consists of the difference between the measured test points and the model predictions. This margin is depicted as the distance between the linear regression lines shown in Attachment 4, Pressure Locking Model Validation, of calculation 13-MC-ZZ-217. Attachment 4 is provided in Enclosure 2.

The identified basic margin ranged between 24.8% (Borg-Warner test #52) to 3.3% (Borg-Warner test #56) for the low closing thrust and from 12.4% (Borg-Warner test #43) to 0.1% (Borg-Warner test #83) for the high closing thrust Borg-Warner test results. The identified nonlinear anomalous test data point (Borg-Warner test #80) does not possess any basic margin. The closing thrusts for this data point are outside the range of values for 10" or smaller 300# class valves found in PVNGS applications. However, it should be noted that the test results for this data point are enveloped by the 10% additional margin to ensure a level of conservatism to address any related uncertainties.

There are other inherent uncredited margins in the inputs used for application of the methodology to PVNGS plant valves. These margins include the conservatisms in the valve test variables used for long term design basis evaluations. These inputs include the postulated high bonnet pressure and low line pressures, high valve factors, and high stem-stem-nut coefficient of friction for each valve group. Also, the maximum closing load resulting from control of the established peak cracking limit for each group of valves is utilized for determination of the residual load component of the postulated total pressure locking load to ensure a level of conservatism. In addition, minimum available voltage values were used to determine actuator capability in accordance with

the latest industry guidance.

These margins ensure that the validation test and application measurement uncertainties are adequately addressed. They can be expressed as a band of positive and negative errors. Borg-Warner and Crane valve validation test uncertainties were reported as less than +/- 10%. An evaluation of the validation test data and the PVNGS field static test results was performed to establish the measured maximum closing load values utilized for determination of the residual loads. These evaluations resulted in the development of two terms to identify the relative uncertainties associated with the validation and application of the PVNGS PL model. These terms are as follows:

1) Validation Test Uncertainty. This value is conservatively estimated based on the maximum PVNGS PL model under-prediction of the Borg-Warner test point 80 that is identified as a nonlinear anomaly. In addition, an adjustment is made based on a typical value of the VOTES sensor sensitivity error. This uncertainty can be calculated as:

$$\frac{\text{Model PL Predicted Load} - \text{Test PL Measured Load}}{\text{Test PL Measured Load}} * 100 = 6.2\%$$

VOTES Sensitivity Error = +/- 7.7%

Validation Test Uncertainty = 6.2 * (1 + 0.077) = +/- 6.7%

2) Application Residual Load Uncertainty. This value is conservatively calculated based on the use of the maximum MOVATS test diagnostic equipment error associated with the field measurements for the maximum closing forces for the in-plant PVNGS valves. This error is adjusted for the limiting ratio of residual load to seating loads utilized for determination of the residual load.

Maximum Total Closing Force Measurement Error = 11.18%

$$\frac{\text{Residual Opening Load}}{\text{Maximum Closing Load}} = 0.67$$

Application Residual Load Uncertainty = 0.67 * 11.18 = +/- 7.5%

Combining these uncertainties in a similar manner as that published for other pressure locking industry models utilizing the square root sum of the squares, results in a maximum uncertainty value for the overall PVNGS PL model methodology of 10.0%. This uncertainty estimate is based on the best estimates and is of the same order of magnitude as the normally applied 10% margin. This margin is in addition to the 2.6% average basic margin for the more conservative Borg-Warner high thrust test results and does not take credit for other inherent margins in the model.

NRC QUESTION #3:

The submittal indicates that the additional 10% margin is needed to account for a relatively high closing thrust but the submittal does not relate the closing thrust to bonnet pressure. Discuss the basis for using the 200 psig criterion when applying the additional 10% margin.

APS RESPONSE:

APS's October 8, 1999 submittal indicated that an additional 10% margin was necessary to envelop a singular relatively high closing force (greater than 31,000 lbf) data point (Borg-Warner test #80). This data point was also subjected to relatively high bonnet pressure (greater than 450 psig). The establishment of the 200 psig limit was due to observed convergence of the measured test results and the predicted test results at pressures above 400 psig with high closing force when reviewing the Borg-Warner 300# class test results during analysis and development of the initial PVNGS PL model. Additionally, the 10% margin allows for other uncertainties due to the small sample of data points above 400 psig bonnet pressure and 31,000 lbf closing force.

NRC QUESTION #4:

Update the actual and minimum margins following the reevaluation of the test results indicated in the first question.

APS RESPONSE:

Updates of the minimum design margins for each valve are included in Attachment 1, Pressure Locking Susceptibility Evaluation, of calculation 13-MC-ZZ-217. Attachment 1 is provided in Enclosure 2. The minimum design margins and range of actual (as-left) margins are depicted on the graph on page 6. The minimum design margins range from a low or worst case value of over 7% for the 6" 900# class Anchor Darling, 13-AF-36/37 valve group (Point A on the graph), to a best case value of greater than 40% for the 12" 1500# class Borg-Warner, 13-SI-653/654 valve group (Point B on the graph). The actual (as-left) calculated margins for individual valves range from a low value of 15% for the worst case valve in the 6" 900# class Anchor Darling, 13-AF-36/37 valve group (Point C on the graph), to a high of over 200% for the best case valve in the 20" 300# class Borg-Warner, 13-SI-686/696 valve group (Point D on the graph).

NRC QUESTION #5:

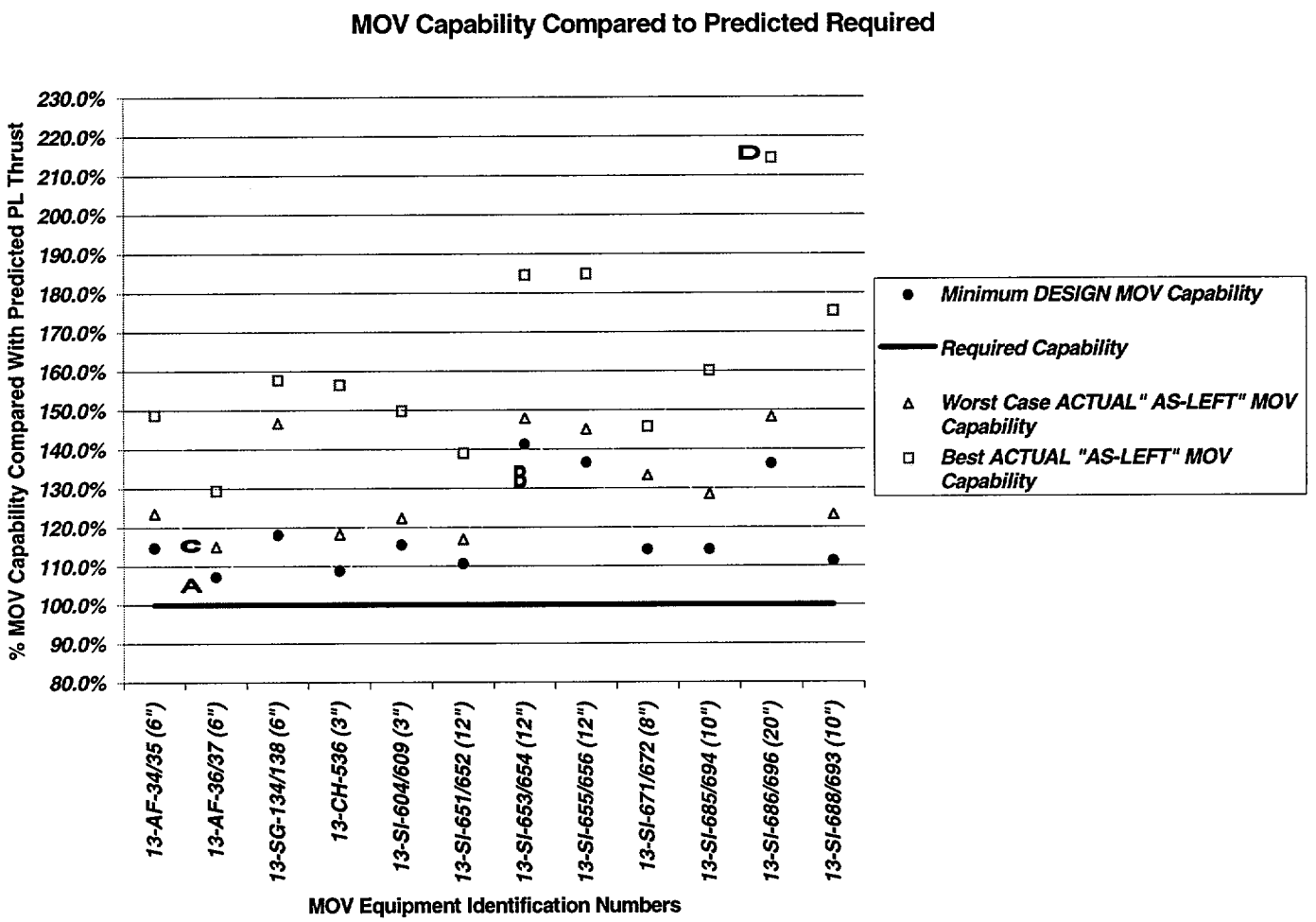
Discuss any valves where the additional 10% margin is not required.

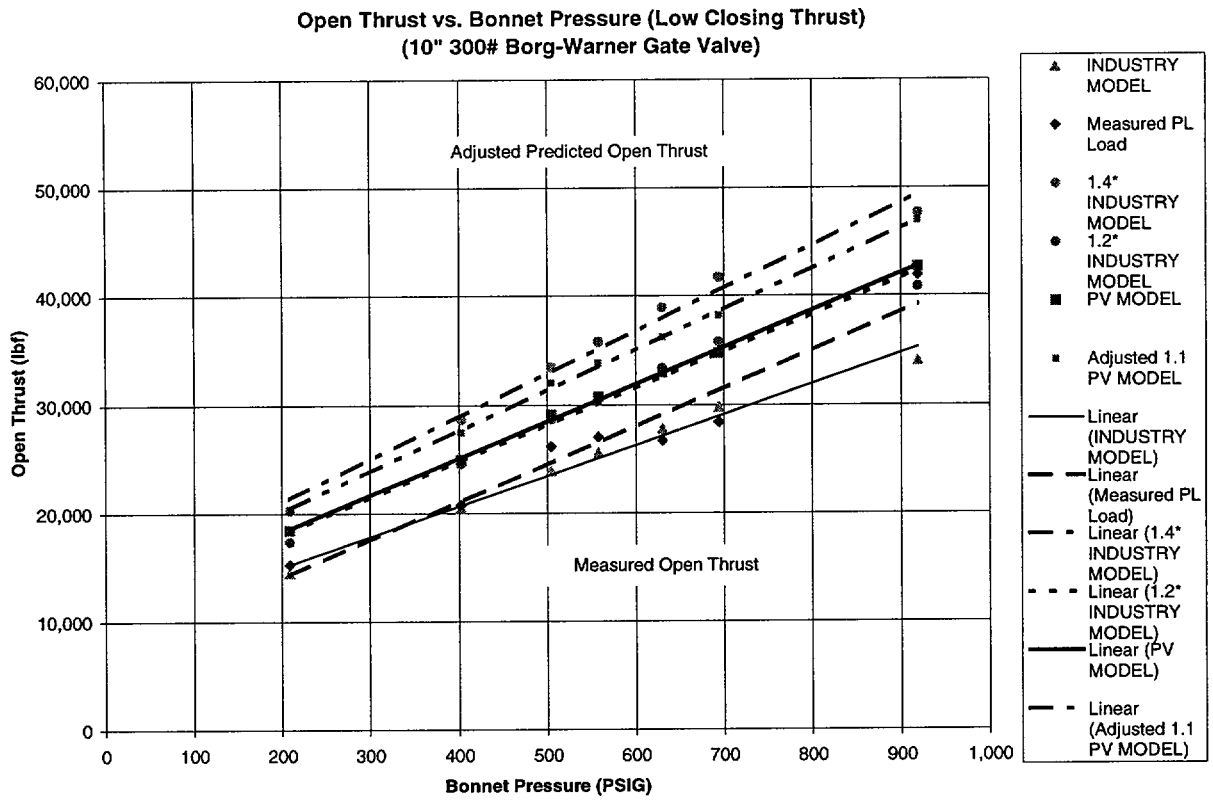
APS RESPONSE:

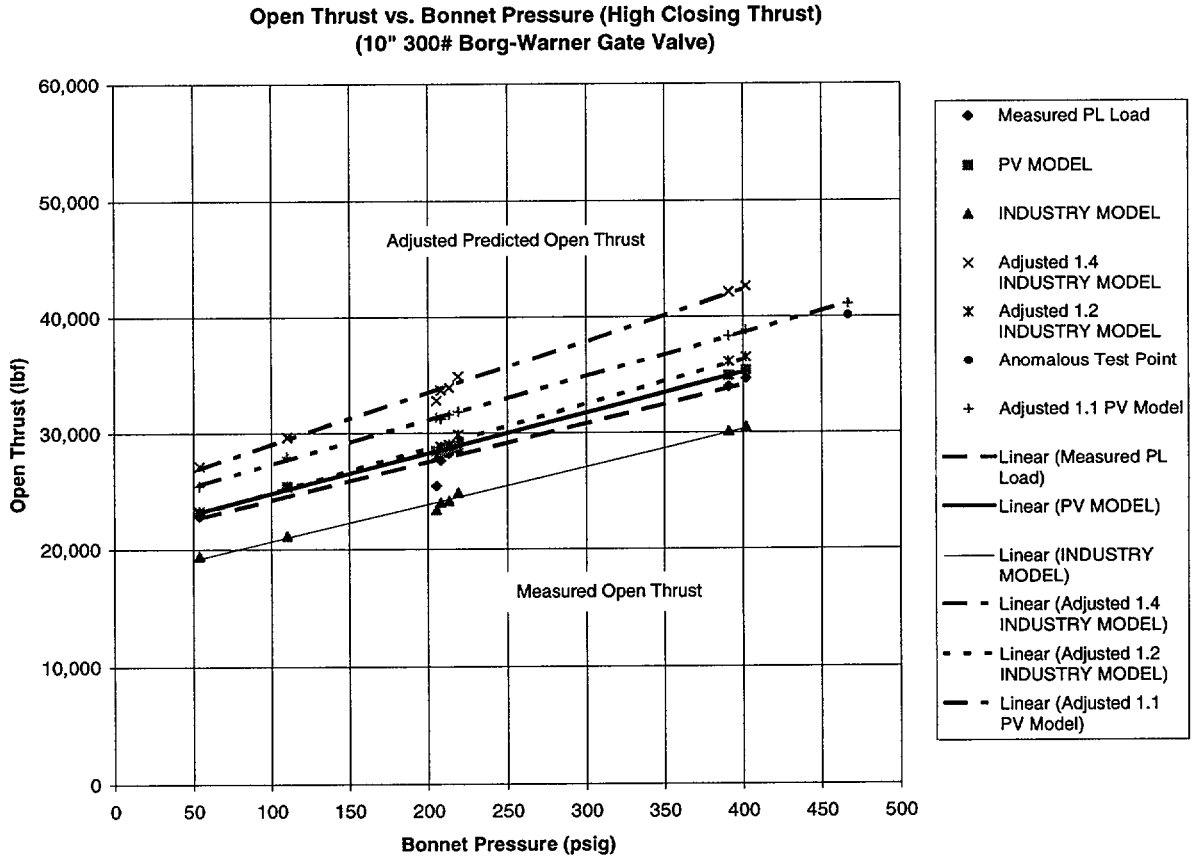
There are two sets of valves in the PVNGS Generic Letter 95-07 scope that do not meet the 10% margin criterion of the PL model.

The first set of valves are the 3" 1500# class Borg-Warner flexible wedge gate valves 13-CH-536, Refueling Water Tank Gravity Feed Charging Pump Suction Valves. The postulated pressure locking conditions for these valves include a maximum bonnet pressure less than 100 psig with a calculated design margin of over 8%. The actual minimum calculated margins for these valves range from 18% to 57%. Since the bonnet pressure is below 200 psig, the 10% margin criterion does not apply to these valves. The relatively low postulated bonnet pressure and the low closing force along with the relatively rigid disk make it unnecessary to maintain the 10% minimum design margin.

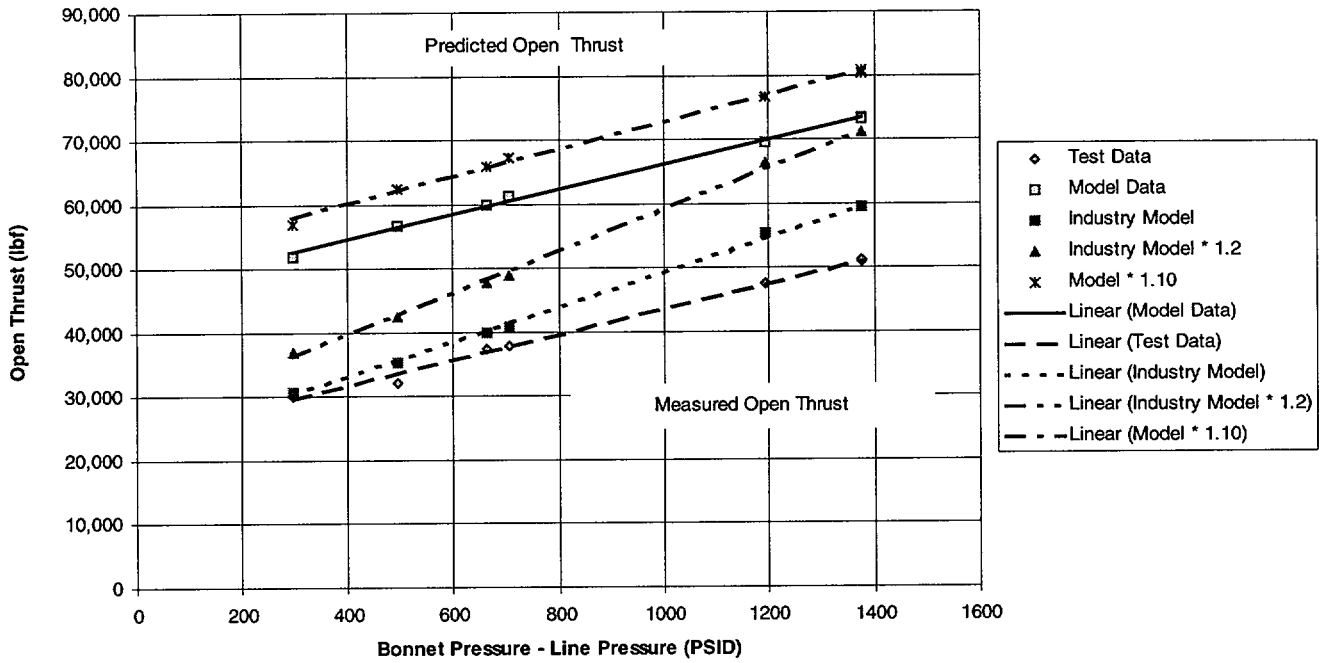
The second set of valves are 6" 900# class Anchor Darling flexible wedge gate valves AF-36/37, Auxiliary Feedwater Isolation Valves. The pressure locking bonnet pressure conditions assumed for these valves are highly conservative in that the postulated bonnet pressure is based on the full shutoff head of the auxiliary feedwater pump (1816 psig) being trapped in the bonnet. In order to trap this high pressure in the bonnet it is required that full pump shutoff head leak past a closed globe (CCI drag) valve, push the closed gate valve disk off its seat, and trap this pressure in the bonnet with no loss of pressure energy and no available leakage path out of the bonnet. This unexpected design condition would result in a minimum calculated design margin of just over 7%. A small reduction in the maximum bonnet pressure to 1715 psig would result in a minimum design margin of 10%. Furthermore, these valves are more rigid than the 10", 300# class Borg-Warner valve which was tested and used as a basis for the PVNGS PL model. As demonstrated by the graphs on pages 7 and 8 plotting opening thrust vs. the bonnet or differential bonnet pressure, the PL model predicts increasingly more conservative pressure locking loads as valve rigidity increases. The graphs demonstrate that the PVNGS PL model is essentially equivalent to the industry model (adjusted by 20%) for the less rigid Borg-Warner test results. However, the PVNGS PL model is significantly more conservative when compared to the industry model (adjusted by 20%) for the more rigid Crane valve test results. Therefore, there is more inherent margin in the model when applied to the 6", 900# class Anchor Darling valves. Based on the highly conservative assumed bonnet pressure and the increased basic margin of the model for valves with higher rigidity, the full 10% minimum design margin is not necessary.


MOV Capability Compared to Predicted Required
% MOV Capability Compared With Predicted PL Thrust
230.0%
220.0%
210.0%
200.0%
190.0%
180.0%
170.0%
160.0%
150.0%
140.0%
130.0%
120.0%
110.0%
100.0%
90.0%
80.0%
A
B
C
D
13-AF-34/35 (6")
13-AF-36/37 (6")
13-SG-134/138 (6")
13-CH-536 (3")
13-SI-604/609 (3")
13-SI-651/652 (12")
13-SI-653/654 (12")
13-SI-655/656 (12")
13-SI-671/672 (8")
13-SI-685/694 (10")
13-SI-686/696 (20")
13-SI-688/693 (10")
MOV Equipment Identification Numbers
Minimum DESIGN MOV Capability
Required Capability
Worst Case ACTUAL " AS-LEFT" MOV Capability
Best ACTUAL "AS-LEFT" MOV Capability

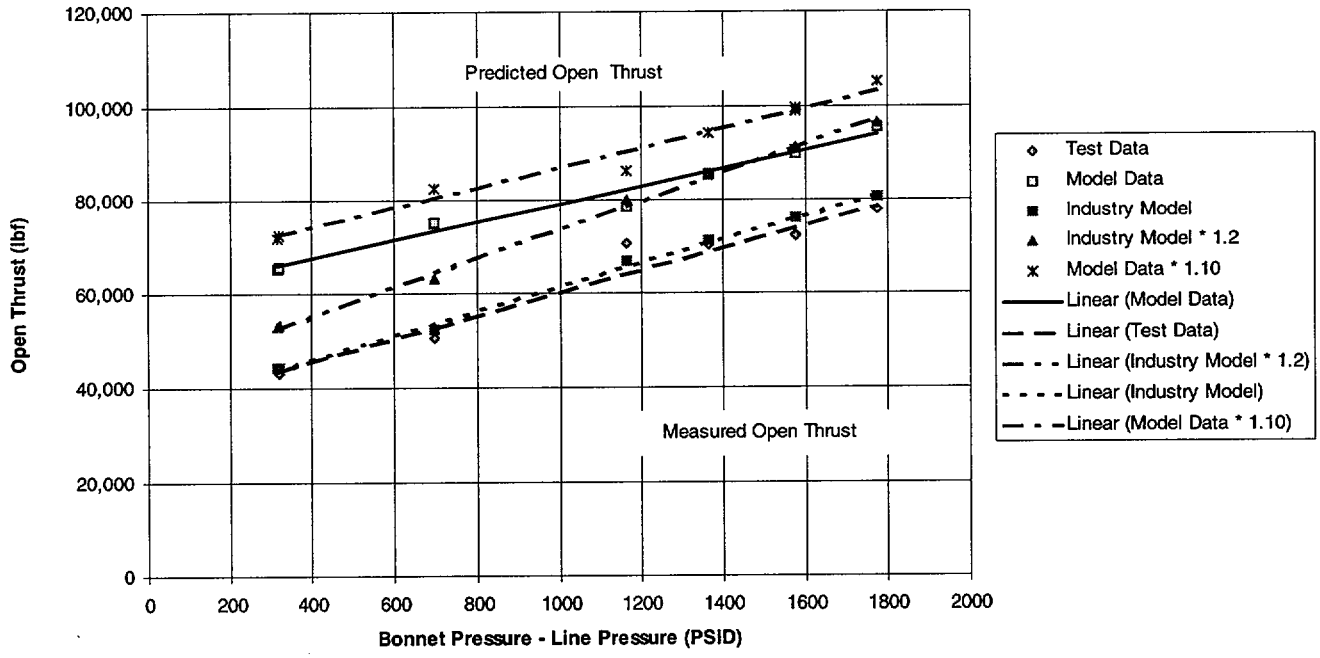

Open Thrust vs. Bonnet Pressure (Low Closing Thrust)
(10" 300# Borg-Warner Gate Valve)
Adjusted Predicted Open Thrust
Measured Open Thrust
Open Thrust (lbf)
Bonnet Pressure (PSIG)
0
10,000
20,000
30,000
40,000
50,000
60,000
0
100
200
300
400
500
600
700
800
900
1,000
INDUSTRY MODEL
Measured PL Load
1.4* INDUSTRY MODEL
1.2* INDUSTRY MODEL
PV MODEL
Adjusted 1.1 PV MODEL
Linear (INDUSTRY MODEL)
Linear (Measured PL Load)
Linear (1.4* INDUSTRY MODEL)
Linear (1.2* INDUSTRY MODEL)
Linear (PV MODEL)
Linear (Adjusted 1.1 PV MODEL)


Open Thrust vs. Bonnet Pressure (High Closing Thrust)
(10" 300# Borg-Warner Gate Valve)
Adjusted Predicted Open Thrust
Measured Open Thrust
Open Thrust (lbf)
Bonnet Pressure (psig)
0
10,000
20,000
30,000
40,000
50,000
60,000
0
50
100
150
200
250
300
350
400
450
500
Measured PL Load
PV MODEL
INDUSTRY MODEL
Adjusted 1.4 INDUSTRY MODEL
Adjusted 1.2 INDUSTRY MODEL
Anomalous Test Point
Adjusted 1.1 PV Model
Linear (Measured PL Load)
Linear (PV MODEL)
Linear (INDUSTRY MODEL)
Linear (Adjusted 1.4 INDUSTRY MODEL)
Linear (Adjusted 1.2 INDUSTRY MODEL)
Linear (Adjusted 1.1 PV Model)

Open Thrust vs. DP (Low Closing Thrust)
(10" 900# Crane Flexible Wedge Gate Valve)



Open Thrust vs. DP (High Closing Thrust)
(10" 900# Crane Flexible Wedge Gate Valve)



ENCLOSURE 2

ATTACHMENTS 1, 4 AND 6 OF PVNGS ENGINEERING CALCULATION 13-MC-ZZ-217, "GATE VALVE OPEN THRUST REQUIRED DURING POTENTIAL PRESSURE LOCKING CONDITIONS"

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Peter G. Knaggs												
2	Joe Daza	**PRESSURE LOCKING CALCULATIONS**											
3													
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	127	1,801	200	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
10	2AF-34 (6")/Modification	104	127	1,801	200	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
11	3AF-34 (6")/Modification	104	127	1,801	200	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
12	1AF-35 (6")/Modification	104	127	1,801	200	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
13	2AF-35 (6")/Modification	104	127	1,801	200	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
14	3AF-35 (6")/Modification	104	127	1,801	200	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
15													
16													
17	1AF-36 (6")/Modification	104	104	1,816	29	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
18	2AF-36 (6")/Modification	104	104	1,816	29	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
19	3AF-36 (6")/Modification	104	104	1,816	29	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
20	1AF-37 (6")/Modification	104	104	1,816	29	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
21	2AF-37 (6")/Modification	104	104	1,816	29	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
22	3AF-37 (6")/Modification	104	104	1,816	29	29	2.63	0.88	5	0.3	0.55	*60,000*	*926*
23													
24													
25	1SG-134 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*55,000*	*882*
26	2SG-134 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*55,000*	*882*
27	3SG-134 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*55,000*	*882*
28	1SG-138 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*55,000*	*882*
29	2SG-138 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*55,000*	*882*
30	3SG-138 (6")/Modification	587	587	1,383	650	0	2.63	0.88	5	0.3	0.6	*55,000*	*882*
31													
32													

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA	AB
1	Peter G. Knaggs													
2	Joe Daza													
3														
4														
5	**Valve Tag (size)**	**MOV ACTUATOR/STEM INPUTS**								**MOTOR INPUTS**				
6		OAR	P.O. Ef	COF	Dstem	Pstem	Lstem	***Actuator Structural Limit***		Vfull	Vmin	MTorq	n	TDF
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	0.11	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2	0.96
10	2AF-34 (6")/Modification	42.5	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2	0.96
11	3AF-34 (6")/Modification	42.5	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2	0.96
12	1AF-35 (6")/Modification	42.5	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2	0.96
13	2AF-35 (6")/Modification	42.5	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2	0.96
14	3AF-35 (6")/Modification	42.5	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	460	414	60	2	0.96
15														
16														
17	1AF-36 (6")/Modification	60.15	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1	0.98
18	2AF-36 (6")/Modification	60.15	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1	0.98
19	3AF-36 (6")/Modification	60.15	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1	0.98
20	1AF-37 (6")/Modification	60.15	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1	0.98
21	2AF-37 (6")/Modification	60.15	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1	0.98
22	3AF-37 (6")/Modification	60.15	0.4	0.11	1.5	0.333	0.667	*63,000*	*935*	115	98.4	40	1	0.98
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	0.9
26	2SG-134 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1	0.9
27	3SG-134 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1	0.9
28	1SG-138 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1	0.9
29	2SG-138 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1	0.9
30	3SG-138 (6")/Modification	42.5	0.4	0.12	1.5	0.333	0.667	*63,000*	*935*	115	93	60	1	0.9
31														
32														

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1	Peter G. Knaggs									
2	Joe Daza	Static				***Calculation of***				
3		Peak				***Minimum Available***				
4		Cracking				***Torque and Thrust***			**CALCULATION**	
5	**Valve Tag (size)**	Control	**MOV MISC INPUTS**			***at Motor Stall***			**DP X DISKS**	
6		Limit	Max Close	% Residual	Stem Factor	***Avail Torque***	***Avail Thrust***	VDF	Pfinal	DPavg
7		(lbf)	Load (lbf)	at cracking		(ft-lbf)	(lbf)		(psig)	(psig)
8	**A/D Gate Valves:**									
9	1AF-34 (6")/Modification	24,765	42,760	62%	0.0154	881	57,103	0.900	1,880	1766
10	2AF-34 (6")/Modification	24,765	42,760	62%	0.0154	881	57,103	0.900	1,880	1766
11	3AF-34 (6")/Modification	24,765	42,760	62%	0.0154	881	57,103	0.900	1,880	1766
12	1AF-35 (6")/Modification	24,765	42,760	62%	0.0154	881	57,103	0.900	1,880	1766
13	2AF-35 (6")/Modification	24,765	42,760	62%	0.0154	881	57,103	0.900	1,880	1766
14	3AF-35 (6")/Modification	24,765	42,760	62%	0.0154	881	57,103	0.900	1,880	1766
15										
16										
17	1AF-36 (6")/Modification	24,765	41,068	62%	0.0154	807	52,291	0.856	1,816	1787
18	2AF-36 (6")/Modification	24,765	41,068	62%	0.0154	807	52,291	0.856	1,816	1787
19	3AF-36 (6")/Modification	24,765	41,068	62%	0.0154	807	52,291	0.856	1,816	1787
20	1AF-37 (6")/Modification	24,765	41,068	62%	0.0154	807	52,291	0.856	1,816	1787
21	2AF-37 (6")/Modification	24,765	41,068	62%	0.0154	807	52,291	0.856	1,816	1787
22	3AF-37 (6")/Modification	24,765	41,068	62%	0.0154	807	52,291	0.856	1,816	1787
23										
24										
25	1SG-134 (6")/Modification	23,000	37,118	62%	0.0160	*742*	*46,270*	0.809	1,383	1058
26	2SG-134 (6")/Modification	23,000	37,118	62%	0.0160	*742*	*46,270*	0.809	1,383	1058
27	3SG-134 (6")/Modification	23,000	37,118	62%	0.0160	*742*	*46,270*	0.809	1,383	1058
28	1SG-138 (6")/Modification	23,000	37,118	62%	0.0160	*742*	*46,270*	0.809	1,383	1058
29	2SG-138 (6")/Modification	23,000	37,118	62%	0.0160	*742*	*46,270*	0.809	1,383	1058
30	3SG-138 (6")/Modification	23,000	37,118	62%	0.0160	*742*	*46,270*	0.809	1,383	1058
31										
32										

	A	AL	AM	AN	AO	AP	AQ	AR	AS	AT
1	Peter G. Knaggs									
2	Joe Daza									
3										
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	3,126	-1,018
10	2AF-34 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,126	-1,018
11	3AF-34 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,126	-1,018
12	1AF-35 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,126	-1,018
13	2AF-35 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,126	-1,018
14	3AF-35 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,126	-1,018
15										
16										
17	1AF-36 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,164	-1,030
18	2AF-36 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,164	-1,030
19	3AF-36 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,164	-1,030
20	1AF-37 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,164	-1,030
21	2AF-37 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,164	-1,030
22	3AF-37 (6")/Modification	0.1612	0.0276	0.6889	0.2899	0.00550	0.1393	0.5755	3,164	-1,030
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										

	A	AU	AV	AX	AY	AZ	BA	BB
1	Peter G. Knaggs							
2	Joe Daza	PRESSURE LOCKING CALCULATION						
3								
4		**Disk**	**Hub**	**Residual Closing**	**Vertical**	**Stem**	**Total Stem Thrust**	**Total Torque**
5	**Valve Tag (size)**	**Load**	**Load**	**Load at Cracking**	**Load**	**piston**	**Req'd to Overcome**	**Req'd to Overcome**
6		w/DPavg	Pup-Pdown	Residual Load	**On Disks**	**Load**	**Press Locking**	**Pressure Locking**
7		(lbf)	(lbf)	(lbf)	Fvert (lbf)	Fpiston (lbf)	Ftotal (lbf)	Required Torque (ft-lbf)
8	**A/D Gate Valves:**							
9	1AF-34 (6")/Modification	19,318	571	26,565	6,662	3,322	49,793	768
10	2AF-34 (6")/Modification	19,318	571	26,565	6,662	3,322	49,793	768
11	3AF-34 (6")/Modification	19,318	571	26,565	6,662	3,322	49,793	768
12	1AF-35 (6")/Modification	19,318	571	26,565	6,662	3,322	49,793	768
13	2AF-35 (6")/Modification	19,318	571	26,565	6,662	3,322	49,793	768
14	3AF-35 (6")/Modification	19,318	571	26,565	6,662	3,322	49,793	768
15								
16								
17	1AF-36 (6")/Modification	19,553	145	25,502	6,743	3,209	48,734	752
18	2AF-36 (6")/Modification	19,553	145	25,502	6,743	3,209	48,734	752
19	3AF-36 (6")/Modification	19,553	145	25,502	6,743	3,209	48,734	752
20	1AF-37 (6")/Modification	19,553	145	25,502	6,743	3,209	48,734	752
21	2AF-37 (6")/Modification	19,553	145	25,502	6,743	3,209	48,734	752
22	3AF-37 (6")/Modification	19,553	145	25,502	6,743	3,209	48,734	752
23								
24								
25	1SG-134 (6")/Modification	12,687	1,775	23,189	3,992	2,444	39,199	629
26	2SG-134 (6")/Modification	12,687	1,775	23,189	3,992	2,444	39,199	629
27	3SG-134 (6")/Modification	12,687	1,775	23,189	3,992	2,444	39,199	629
28	1SG-138 (6")/Modification	12,687	1,775	23,189	3,992	2,444	39,199	629
29	2SG-138 (6")/Modification	12,687	1,775	23,189	3,992	2,444	39,199	629
30	3SG-138 (6")/Modification	12,687	1,775	23,189	3,992	2,444	39,199	629
31								
32								

	A	BC	BG	BH	BI	BJ	BK
1	Peter G. Knaggs						
2	Joe Daza	**MOV Min Avail**				Additional	
3		**Thrust due to**	**MARGIN**			PL	
4		**Structural Limit or**	LIMITING THRUST			Load	**DIMEN.**
5	**Valve Tag (size)**	**Motor Torque Limit**	subtract	**MARGIN**		"(PL Load	**CORR.**
6		Limiting Thrust	REQUIRED THRUST	DESIGN	Suscept?	-Res. Load)"	
7		(lbf)	(lbf)	(%)		(lbf)	
8	**A/D Gate Valves:**						
9	1AF-34 (6")/Modification	57,103	7,310	14.7	No	23,228	0.485
10	2AF-34 (6")/Modification	57,103	7,310	14.7	No	23,228	0.485
11	3AF-34 (6")/Modification	57,103	7,310	14.7	No	23,228	0.485
12	1AF-35 (6")/Modification	57,103	7,310	14.7	No	23,228	0.485
13	2AF-35 (6")/Modification	57,103	7,310	14.7	No	23,228	0.485
14	3AF-35 (6")/Modification	57,103	7,310	14.7	No	23,228	0.485
15							
16							
17	1AF-36 (6")/Modification	52,291	3,557	7.3	No	23,232	0.488
18	2AF-36 (6")/Modification	52,291	3,557	7.3	No	23,232	0.488
19	3AF-36 (6")/Modification	52,291	3,557	7.3	No	23,232	0.488
20	1AF-37 (6")/Modification	52,291	3,557	7.3	No	23,232	0.488
21	2AF-37 (6")/Modification	52,291	3,557	7.3	No	23,232	0.488
22	3AF-37 (6")/Modification	52,291	3,557	7.3	No	23,232	0.488
23							
24							
25	1SG-134 (6")/Modification	46,270	7,071	18.0	No	16,010	0.450
26	2SG-134 (6")/Modification	46,270	7,071	18.0	No	16,010	0.450
27	3SG-134 (6")/Modification	46,270	7,071	18.0	No	16,010	0.450
28	1SG-138 (6")/Modification	46,270	7,071	18.0	No	16,010	0.450
29	2SG-138 (6")/Modification	46,270	7,071	18.0	No	16,010	0.450
30	3SG-138 (6")/Modification	46,270	7,071	18.0	No	16,010	0.450
31							
32							

	A	BL	BM
1	Peter G. Knaggs		
2	Joe Daza		**CHAPTER 15 EVENT RESULTING**
3		**Residual % of**	**IN THE MAXIMUM INCREASE IN**
4		**Cracking**	**BONNET TEMPERATURE PRIOR TO**
5	**Valve Tag (size)**	**Load Limit**	**REQ'D ACTIVE OPEN FUNCTION**
6			Reqd by GL 95-07
7			
8	**A/D Gate Valves:**		
9	1AF-34 (6")/Modification	92.72%	HELB
10	2AF-34 (6")/Modification	92.72%	HELB
11	3AF-34 (6")/Modification	92.72%	HELB
12	1AF-35 (6")/Modification	92.72%	HELB
13	2AF-35 (6")/Modification	92.72%	HELB
14	3AF-35 (6")/Modification	92.72%	HELB
15			
16			
17	1AF-36 (6")/Modification	92.68%	POST - HELB, NO AFAS
18	2AF-36 (6")/Modification	92.68%	POST - HELB, NO AFAS
19	3AF-36 (6")/Modification	92.68%	POST - HELB, NO AFAS
20	1AF-37 (6")/Modification	92.68%	POST - HELB, NO AFAS
21	2AF-37 (6")/Modification	92.68%	POST - HELB, NO AFAS
22	3AF-37 (6")/Modification	92.68%	POST - HELB, NO AFAS
23			
24			
25	1SG-134 (6")/Modification	93.24%	ALL (Normal Conditions)
26	2SG-134 (6")/Modification	93.24%	ALL (Normal Conditions)
27	3SG-134 (6")/Modification	93.24%	ALL (Normal Conditions)
28	1SG-138 (6")/Modification	93.24%	ALL (Normal Conditions)
29	2SG-138 (6")/Modification	93.24%	ALL (Normal Conditions)
30	3SG-138 (6")/Modification	93.24%	ALL (Normal Conditions)
31			
32			

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Peter G. Knaggs												
2	Joe Daza	**PRESSURE LOCKING CALCULATIONS**											
3													
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	35	0	1.50	1.11	5.25	0.3	0.6	*10,705*	*124*
36	2CH-536 (3")/Evaluation	104	104	97	35	0	1.50	1.11	5.25	0.3	0.6	*10,705*	*124*
37	3CH-536 (3")/Evaluation	104	104	97	35	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	*13,484*	*156*
41	2SI-604 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*13,484*	*156*
42	3SI-604 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*13,484*	*156*
43	1SI-609 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*13,484*	*156*
44	2SI-609 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*13,484*	*156*
45	3SI-609 (3")/Modification	104	120	1,960	660	0	1.38	1.11	5.25	0.3	0.5	*13,484*	*156*
46													
47													
48	1SI-651 (12")/Modification	120	160	2,561	360	50	5.25	2.97	5.25	0.3	0.6	*197,765*	*5,009*
49	2SI-651 (12")/Modification	120	160	2,561	360	50	5.25	2.97	5.25	0.3	0.6	*197,765*	*5,009*
50	3SI-651 (12")/Modification	120	160	2,561	360	50	5.25	2.97	5.25	0.3	0.6	*197,765*	*5,009*
51	1SI-652 (12")/Modification	120	160	2,561	360	50	5.25	2.97	5.25	0.3	0.6	*197,765*	*5,009*
52	2SI-652 (12")/Modification	120	160	2,561	360	50	5.25	2.97	5.25	0.3	0.6	*197,765*	*5,009*
53	3SI-652 (12")/Modification	120	160	2,561	360	50	5.25	2.97	5.25	0.3	0.6	*197,765*	*5,009*
54													
55													
56													
57													
58													
59													

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA	AB
1	Peter G. Knaggs													
2	Joe Daza													
3														
4														
5	**Valve Tag (size)**	**MOV ACTUATOR/STEM INPUTS**								**MOTOR INPUTS**				
6		OAR	P.O. Ef	COF	Dstem	Pstem	Lstem	***Actuator Structural Limit***		Vfull	Vmin	MTorq	n	TDF
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	0.99
36	2CH-536 (3")/Evaluation	30	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	7.5	2	0.99
37	3CH-536 (3")/Evaluation	30	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	7.5	2	0.99
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	0.97
41	2SI-604 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2	0.97
42	3SI-604 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2	0.97
43	1SI-609 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2	0.97
44	2SI-609 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2	0.97
45	3SI-609 (3")/Modification	36.2	0.4	0.2	0.875	0.167	0.333	*19,600*	*275*	460	414	15	2	0.97
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	0.95
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	0.95
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	0.95
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	0.95
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	0.95
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	0.95
54														
55														
56														
57														
58														
59														

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1	Peter G. Knaggs									
2	Joe Daza	Static				***Calculation of***				
3		Peak				***Minimum Available***				
4		Cracking				***Torque and Thrust***			**CALCULATION**	
5	**Valve Tag (size)**	Control	**MOV MISC INPUTS**			***at Motor Stall***			**DP X DISKS**	
6		Limit	Max Close	% Residual	Stem Factor	***Avail Torque***	***Avail Thrust***	VDF	Pfinal	DPavg
7		(lbf)	Load (lbf)	at cracking		(ft-lbf)	(lbf)		(psig)	(psig)
34	**BW/IP Gate Valves:**									
35	1CH-536 (3")/Evaluation	5,233	9,242	67%	0.0116	*80*	*6,940*	0.900	97	80
36	2CH-536 (3")/Evaluation	5,233	9,242	67%	0.0116	*80*	*6,940*	0.900	97	80
37	3CH-536 (3")/Evaluation	5,233	9,242	67%	0.0116	*80*	*6,940*	0.900	97	80
38										
39										
40	1SI-604 (3")/Modification	6,836	12,665	65%	0.0116	*190*	*16,410*	0.900	2,760	2430
41	2SI-604 (3")/Modification	6,836	12,665	65%	0.0116	*190*	*16,410*	0.900	2,760	2430
42	3SI-604 (3")/Modification	6,836	12,665	65%	0.0116	*190*	*16,410*	0.900	2,760	2430
43	1SI-609 (3")/Modification	6,836	12,665	65%	0.0116	*190*	*16,410*	0.900	2,760	2430
44	2SI-609 (3")/Modification	6,836	12,665	65%	0.0116	*190*	*16,410*	0.900	2,760	2430
45	3SI-609 (3")/Modification	6,836	12,665	65%	0.0116	*190*	*16,410*	0.900	2,760	2430
46										
47										
48	1SI-651 (12")/Modification	61,500	97,325	56%	0.0224	*4,315*	*192,533*	0.900	2,936	2731
49	2SI-651 (12")/Modification	61,500	97,325	56%	0.0224	*4,315*	*192,533*	0.900	2,936	2731
50	3SI-651 (12")/Modification	61,500	97,325	56%	0.0224	*4,315*	*192,533*	0.900	2,936	2731
51	1SI-652 (12")/Modification	61,500	97,325	56%	0.0224	*4,315*	*192,533*	0.900	2,936	2731
52	2SI-652 (12")/Modification	61,500	97,325	56%	0.0224	*4,315*	*192,533*	0.900	2,936	2731
53	3SI-652 (12")/Modification	61,500	97,325	56%	0.0224	*4,315*	*192,533*	0.900	2,936	2731
54										
55										
56										
57										
58										
59										

	A	AL	AM	AN	AO	AP	AQ	AR	AS	AT
1	Peter G. Knaggs									
2	Joe Daza									
3										
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	21	-11
36	2CH-536 (3")/Evaluation	0.0304	0.0025	0.8423	0.2027	0.00017	0.0286	0.6322	21	-11
37	3CH-536 (3")/Evaluation	0.0304	0.0025	0.8423	0.2027	0.00017	0.0286	0.6322	21	-11
38										
39										
40	1SI-604 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	433	-233
41	2SI-604 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	433	-233
42	3SI-604 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	433	-233
43	1SI-609 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	433	-233
44	2SI-609 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	433	-233
45	3SI-609 (3")/Modification	0.0173	0.0011	0.8781	0.1615	0.00005	0.0166	0.5218	433	-233
46										
47										
48	1SI-651 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,820	-2,147
49	2SI-651 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,820	-2,147
50	3SI-651 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,820	-2,147
51	1SI-652 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,820	-2,147
52	2SI-652 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,820	-2,147
53	3SI-652 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6322	4,820	-2,147
54										
55										
56										
57										
58										
59										

	A	AU	AV	AX	AY	AZ	BA	BB
1	Peter G. Knaggs							
2	Joe Daza	PRESSURE LOCKING CALCULATION						
3								
4		**Disk**	**Hub**	**Residual Closing**	**Vertical Load**	**Stem piston**	**Total Stem Thrust Req'd to Overcome**	**Total Torque Req'd to Overcome**
5	**Valve Tag (size)**	**Load**	**Load**	**Load at Cracking**	**On Disks**	**Load**	**Press Locking**	**Pressure Locking**
6		w/DPavg	Pup-Pdown	Residual Load	Fvert	Fpiston	Ftotal	Required Torque
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(ft-lbf)
34	**BW/IP Gate Valves:**							
35	1CH-536 (3")/Evaluation	131	31	6,173	102	58	6,379	74
36	2CH-536 (3")/Evaluation	131	31	6,173	102	58	6,379	74
37	3CH-536 (3")/Evaluation	131	31	6,173	102	58	6,379	74
38								
39								
40	1SI-604 (3")/Modification	2,098	409	8,187	2,641	1,660	11,676	135
41	2SI-604 (3")/Modification	2,098	409	8,187	2,641	1,660	11,676	135
42	3SI-604 (3")/Modification	2,098	409	8,187	2,641	1,660	11,676	135
43	1SI-609 (3")/Modification	2,098	409	8,187	2,641	1,660	11,676	135
44	2SI-609 (3")/Modification	2,098	409	8,187	2,641	1,660	11,676	135
45	3SI-609 (3")/Modification	2,098	409	8,187	2,641	1,660	11,676	135
46								
47								
48	1SI-651 (12")/Modification	89,541	4,489	54,273	43,268	17,436	174,135	3,903
49	2SI-651 (12")/Modification	89,541	4,489	54,273	43,268	17,436	174,135	3,903
50	3SI-651 (12")/Modification	89,541	4,489	54,273	43,268	17,436	174,135	3,903
51	1SI-652 (12")/Modification	89,541	4,489	54,273	43,268	17,436	174,135	3,903
52	2SI-652 (12")/Modification	89,541	4,489	54,273	43,268	17,436	174,135	3,903
53	3SI-652 (12")/Modification	89,541	4,489	54,273	43,268	17,436	174,135	3,903
54								
55								
56								
57								
58								
59								

	A	BC	BG	BH	BI	BJ	BK
1	Peter G. Knaggs						
2	Joe Daza	**MOV Min Avail**				Additional	
3		**Thrust due to**	**MARGIN**			PL	
4		**Structural Limit or**	LIMITING THRUST			Load	**DIMEN.**
5	**Valve Tag (size)**	**Motor Torque Limit**	subtract	**MARGIN**		"(PL Load	**CORR.**
6		Limiting Thrust	REQUIRED THRUST	DESIGN	Suscept?	-Res. Load)"	
7		(lbf)	(lbf)	(%)		(lbf)	
34	**BW/IP Gate Valves:**						
35	1CH-536 (3")/Evaluation	6,940	561	8.8	No	206	0.021
36	2CH-536 (3")/Evaluation	6,940	561	8.8	No	206	0.021
37	3CH-536 (3")/Evaluation	6,940	561	8.8	No	206	0.021
38							
39							
40	1SI-604 (3")/Modification	13,484	1,808	15.5	No	3,489	0.234
41	2SI-604 (3")/Modification	13,484	1,808	15.5	No	3,489	0.234
42	3SI-604 (3")/Modification	13,484	1,808	15.5	No	3,489	0.234
43	1SI-609 (3")/Modification	13,484	1,808	15.5	No	3,489	0.234
44	2SI-609 (3")/Modification	13,484	1,808	15.5	No	3,489	0.234
45	3SI-609 (3")/Modification	13,484	1,808	15.5	No	3,489	0.234
46							
47							
48	1SI-651 (12")/Modification	192,533	18,398	10.6	No	119,862	1.118
49	2SI-651 (12")/Modification	192,533	18,398	10.6	No	119,862	1.118
50	3SI-651 (12")/Modification	192,533	18,398	10.6	No	119,862	1.118
51	1SI-652 (12")/Modification	192,533	18,398	10.6	No	119,862	1.118
52	2SI-652 (12")/Modification	192,533	18,398	10.6	No	119,862	1.118
53	3SI-652 (12")/Modification	192,533	18,398	10.6	No	119,862	1.118
54							
55							
56							
57							
58							
59							

	A	BL	BM
1	Peter G. Knaggs		
2	Joe Daza		**CHAPTER 15 EVENT RESULTING**
3		**Residual % of Cracking**	**IN THE MAXIMUM INCREASE IN**
4			**BONNET TEMPERATURE PRIOR TO**
5	**Valve Tag (size)**	**Load Limit**	**REQ'D ACTIVE OPEN FUNCTION**
6			Reqd by GL 95-07
7			
34	**BW/IP Gate Valves:**		
35	1CH-536 (3")/Evaluation	99.69%	ALL (Normal Conditions)
36	2CH-536 (3")/Evaluation	99.69%	ALL (Normal Conditions)
37	3CH-536 (3")/Evaluation	99.69%	ALL (Normal Conditions)
38			
39			
40	1SI-604 (3")/Modification	96.49%	LOCA
41	2SI-604 (3")/Modification	96.49%	LOCA
42	3SI-604 (3")/Modification	96.49%	LOCA
43	1SI-609 (3")/Modification	96.49%	LOCA
44	2SI-609 (3")/Modification	96.49%	LOCA
45	3SI-609 (3")/Modification	96.49%	LOCA
46			
47			
48	1SI-651 (12")/Modification	83.23%	LOCA
49	2SI-651 (12")/Modification	83.23%	LOCA
50	3SI-651 (12")/Modification	83.23%	LOCA
51	1SI-652 (12")/Modification	83.23%	LOCA
52	2SI-652 (12")/Modification	83.23%	LOCA
53	3SI-652 (12")/Modification	83.23%	LOCA
54			
55			
56			
57			
58			
59			

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Peter G. Knaggs												
2	Joe Daza	**PRESSURE LOCKING CALCULATIONS**											
3													
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	360	50	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
61	2SI-653 (12")/Modification	120	160	465	360	50	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
62	3SI-653 (12")/Modification	120	160	465	360	50	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
63	1SI-654 (12")/Modification	120	160	465	360	50	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
64	2SI-654 (12")/Modification	120	160	465	360	50	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
65	3SI-654 (12")/Modification	120	160	465	360	50	5.25	2.97	5.25	0.3	0.65	*74,133*	*2,342*
66													
67													
68	1SI-655 (12")/Modification	104	120	465	360	50	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
69	2SI-655 (12")/Modification	104	120	465	360	50	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
70	3SI-655 (12")/Modification	104	120	465	360	50	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
71	1SI-656 (12")/Modification	104	120	465	360	50	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
72	2SI-656 (12")/Modification	104	120	465	360	50	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
73	3SI-656 (12")/Modification	104	120	465	360	50	5.25	2.97	5.25	0.3	0.55	*80,000*	*2,300*
74													
75													
76													
77	1SI-672 (8")/Modification	104	104	326	50	12	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
78	2SI-672 (8")/Modification	104	104	326	50	12	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
79	3SI-672 (8")/Modification	104	104	326	50	12	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
80	1SI-671 (8")/Modification	104	104	326	50	12	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
81	2SI-671 (8")/Modification	104	104	326	50	12	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
82	3SI-671 (8")/Modification	104	104	326	50	12	4.07	2.29	5.25	0.3	0.55	*30,248*	*478*
83													
84													

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA	AB
1	Peter G. Knaggs													
2	Joe Daza													
3														
4														
5	**Valve Tag (size)**	**MOV ACTUATOR/STEM INPUTS**								**MOTOR INPUTS**				
6		OAR	P.O. Ef	COF	Dstem	Pstem	Lstem	***Actuator Structural Limit***		Vfull	Vmin	MTorq	n	TDF
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	0.89
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	0.89
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	0.89
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	0.89
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	0.89
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	0.89
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	0.88
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	0.88
70	3SI-655 (12")/Modification	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2	0.88
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	0.88
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	0.88
73	3SI-656 (12")/Modification	124.1	0.35	0.15	2.75	0.333	0.667	*112,500*	*1,700*	460	414	40	2	0.88
74														
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	0.98
78	2SI-672 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2	0.98
79	3SI-672 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2	0.98
80	1SI-671 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2	0.98
81	2SI-671 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2	0.98
82	3SI-671 (8")/Modification	27.2	0.45	0.19	1.375	0.250	0.500	*63,000*	*935*	460	414	40	2	0.98
83														
84														

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1	Peter G. Knaggs									
2	Joe Daza	Static				***Calculation of***				
3		Peak				***Minimum Available***				
4		Cracking				***Torque and Thrust***			**CALCULATION**	
5	**Valve Tag (size)**	Control	**MOV MISC INPUTS**			***at Motor Stall***			**DP X DISKS**	
6		Limit	Max Close	% Residual	Stem Factor	***Avail Torque***	***Avail Thrust***	VDF	Pfinal	DPavg
7		(lbf)	Load (lbf)	at cracking		(ft-lbf)	(lbf)		(psig)	(psig)
60	1SI-653 (12")/Modification	18,750	34,094	61%	0.0270	*1,392*	*51,548*	0.900	465	260
61	2SI-653 (12")/Modification	18,750	34,094	61%	0.0270	*1,392*	*51,548*	0.900	465	260
62	3SI-653 (12")/Modification	18,750	34,094	61%	0.0270	*1,392*	*51,548*	0.900	465	260
63	1SI-654 (12")/Modification	18,750	34,094	61%	0.0270	*1,392*	*51,548*	0.900	465	260
64	2SI-654 (12")/Modification	18,750	34,094	61%	0.0270	*1,392*	*51,548*	0.900	465	260
65	3SI-654 (12")/Modification	18,750	34,094	61%	0.0270	*1,392*	*51,548*	0.900	465	260
66										
67										
68	1SI-655 (12")/Modification	21,300	40,783	63%	0.0258	*1,376*	*53,235*	0.900	465	260
69	2SI-655 (12")/Modification	21,300	40,783	63%	0.0258	*1,376*	*53,235*	0.900	465	260
70	3SI-655 (12")/Modification	21,300	40,783	63%	0.0258	*1,376*	*53,235*	0.900	465	260
71	1SI-656 (12")/Modification	21,300	40,783	63%	0.0258	*1,376*	*53,235*	0.900	465	260
72	2SI-656 (12")/Modification	21,300	40,783	63%	0.0258	*1,376*	*53,235*	0.900	465	260
73	3SI-656 (12")/Modification	21,300	40,783	63%	0.0258	*1,376*	*53,235*	0.900	465	260
74										
75										
76										
77	1SI-672 (8")/Modification	12,000	21,641	64%	0.0173	*432*	*24,983*	0.900	326	295
78	2SI-672 (8")/Modification	12,000	21,641	64%	0.0173	*432*	*24,983*	0.900	326	295
79	3SI-672 (8")/Modification	12,000	21,641	64%	0.0173	*432*	*24,983*	0.900	326	295
80	1SI-671 (8")/Modification	12,000	21,641	64%	0.0173	*432*	*24,983*	0.900	326	295
81	2SI-671 (8")/Modification	12,000	21,641	64%	0.0173	*432*	*24,983*	0.900	326	295
82	3SI-671 (8")/Modification	12,000	21,641	64%	0.0173	*432*	*24,983*	0.900	326	295
83										
84										

	A	AL	AM	AN	AO	AP	AQ	AR	AS	AT
1	Peter G. Knaggs									
2	Joe Daza									
3										
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	459	-204
61	2SI-653 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	459	-204
62	3SI-653 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	459	-204
63	1SI-654 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	459	-204
64	2SI-654 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	459	-204
65	3SI-654 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.6882	459	-204
66										
67										
68	1SI-655 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	459	-204
69	2SI-655 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	459	-204
70	3SI-655 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	459	-204
71	1SI-656 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	459	-204
72	2SI-656 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	459	-204
73	3SI-656 (12")/Modification	0.0788	0.0102	0.7620	0.2768	0.00119	0.0715	0.5767	459	-204
74										
75										
76										
77	1SI-672 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	408	-181
78	2SI-672 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	408	-181
79	3SI-672 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	408	-181
80	1SI-671 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	408	-181
81	2SI-671 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	408	-181
82	3SI-671 (8")/Modification	0.0798	0.0104	0.7608	0.2776	0.00122	0.0723	0.5767	408	-181
83										
84										

	A	AU	AV	AX	AY	AZ	BA	BB
1	Peter G. Knaggs							
2	Joe Daza	PRESSURE LOCKING CALCULATION						
3								
4		**Disk**	**Hub**	**Residual Closing**	**Vertical Load**	**Stem piston**	**Total Stem Thrust Req'd to Overcome**	**Total Torque Req'd to Overcome**
5	**Valve Tag (size)**	**Load**	**Load**	**Load at Cracking**	**On Disks**	**Load**	**Press Locking**	**Pressure Locking**
6		w/DPavg	Pup-Pdown	Residual Load	Fvert	Fpiston	Ftotal	Required Torque
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(ft-lbf)
60	1SI-653 (12")/Modification	9,282	4,887	20,957	4,120	2,762	36,484	985
61	2SI-653 (12")/Modification	9,282	4,887	20,957	4,120	2,762	36,484	985
62	3SI-653 (12")/Modification	9,282	4,887	20,957	4,120	2,762	36,484	985
63	1SI-654 (12")/Modification	9,282	4,887	20,957	4,120	2,762	36,484	985
64	2SI-654 (12")/Modification	9,282	4,887	20,957	4,120	2,762	36,484	985
65	3SI-654 (12")/Modification	9,282	4,887	20,957	4,120	2,762	36,484	985
66								
67								
68	1SI-655 (12")/Modification	7,778	4,095	25,744	4,120	2,762	38,975	1,007
69	2SI-655 (12")/Modification	7,778	4,095	25,744	4,120	2,762	38,975	1,007
70	3SI-655 (12")/Modification	7,778	4,095	25,744	4,120	2,762	38,975	1,007
71	1SI-656 (12")/Modification	7,778	4,095	25,744	4,120	2,762	38,975	1,007
72	2SI-656 (12")/Modification	7,778	4,095	25,744	4,120	2,762	38,975	1,007
73	3SI-656 (12")/Modification	7,778	4,095	25,744	4,120	2,762	38,975	1,007
74								
75								
76								
77	1SI-672 (8")/Modification	5,338	372	13,830	2,809	484	21,866	378
78	2SI-672 (8")/Modification	5,338	372	13,830	2,809	484	21,866	378
79	3SI-672 (8")/Modification	5,338	372	13,830	2,809	484	21,866	378
80	1SI-671 (8")/Modification	5,338	372	13,830	2,809	484	21,866	378
81	2SI-671 (8")/Modification	5,338	372	13,830	2,809	484	21,866	378
82	3SI-671 (8")/Modification	5,338	372	13,830	2,809	484	21,866	378
83								
84								

	A	BC	BG	BH	BI	BJ	BK
1	Peter G. Knaggs						
2	Joe Daza	**MOV Min Avail**				Additional	
3		**Thrust due to**	**MARGIN**			PL	
4		**Structural Limit or**	LIMITING THRUST			Load	**DIMEN.**
5	**Valve Tag (size)**	**Motor Torque Limit**	subtract	**MARGIN**		"(PL Load	**CORR.**
6		Limiting Thrust	REQUIRED THRUST	DESIGN	Suscept?	-Res. Load)"	
7		(lbf)	(lbf)	(%)		(lbf)	
60	1SI-653 (12")/Modification	51,548	15,065	41.3	No	15,526	0.550
61	2SI-653 (12")/Modification	51,548	15,065	41.3	No	15,526	0.550
62	3SI-653 (12")/Modification	51,548	15,065	41.3	No	15,526	0.550
63	1SI-654 (12")/Modification	51,548	15,065	41.3	No	15,526	0.550
64	2SI-654 (12")/Modification	51,548	15,065	41.3	No	15,526	0.550
65	3SI-654 (12")/Modification	51,548	15,065	41.3	No	15,526	0.550
66							
67							
68	1SI-655 (12")/Modification	53,235	14,260	36.6	No	13,231	0.386
69	2SI-655 (12")/Modification	53,235	14,260	36.6	No	13,231	0.386
70	3SI-655 (12")/Modification	53,235	14,260	36.6	No	13,231	0.386
71	1SI-656 (12")/Modification	53,235	14,260	36.6	No	13,231	0.386
72	2SI-656 (12")/Modification	53,235	14,260	36.6	No	13,231	0.386
73	3SI-656 (12")/Modification	53,235	14,260	36.6	No	13,231	0.386
74							
75							
76							
77	1SI-672 (8")/Modification	24,983	3,117	14.3	No	8,035	0.308
78	2SI-672 (8")/Modification	24,983	3,117	14.3	No	8,035	0.308
79	3SI-672 (8")/Modification	24,983	3,117	14.3	No	8,035	0.308
80	1SI-671 (8")/Modification	24,983	3,117	14.3	No	8,035	0.308
81	2SI-671 (8")/Modification	24,983	3,117	14.3	No	8,035	0.308
82	3SI-671 (8")/Modification	24,983	3,117	14.3	No	8,035	0.308
83							
84							

	A	BL	BM
1	Peter G. Knaggs		
2	Joe Daza		**CHAPTER 15 EVENT RESULTING**
3		**Residual % of**	**IN THE MAXIMUM INCREASE IN**
4		**Cracking**	**BONNET TEMPERATURE PRIOR TO**
5	**Valve Tag (size)**	**Load Limit**	**REQ'D ACTIVE OPEN FUNCTION**
6			Reqd by GL 95-07
7			
60	1SI-653 (12")/Modification	91.75%	LOCA
61	2SI-653 (12")/Modification	91.75%	LOCA
62	3SI-653 (12")/Modification	91.75%	LOCA
63	1SI-654 (12")/Modification	91.75%	LOCA
64	2SI-654 (12")/Modification	91.75%	LOCA
65	3SI-654 (12")/Modification	91.75%	LOCA
66			
67			
68	1SI-655 (12")/Modification	94.22%	HELB
69	2SI-655 (12")/Modification	94.22%	HELB
70	3SI-655 (12")/Modification	94.22%	HELB
71	1SI-656 (12")/Modification	94.22%	HELB
72	2SI-656 (12")/Modification	94.22%	HELB
73	3SI-656 (12")/Modification	94.22%	HELB
74			
75			
76			
77	1SI-672 (8")/Modification	95.38%	LOCA
78	2SI-672 (8")/Modification	95.38%	LOCA
79	3SI-672 (8")/Modification	95.38%	LOCA
80	1SI-671 (8")/Modification	95.38%	LOCA
81	2SI-671 (8")/Modification	95.38%	LOCA
82	3SI-671 (8")/Modification	95.38%	LOCA
83			
84			

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Peter G. Knaggs												
2	Joe Daza	**PRESSURE LOCKING CALCULATIONS**											
3													
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)***
85													
86	1SI-685 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
87	2SI-685 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
88	3SI-685 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
89	1SI-694 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
90	2SI-694 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
91	3SI-694 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
92													
93													
94	1SI-686 (20")/Modification	104	104	458	425	50	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
95	2SI-686 (20")/Modification	104	104	458	425	50	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
96	3SI-686 (20")/Modification	104	104	458	425	50	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
97	1SI-696 (20")/Modification	104	104	458	425	50	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
98	2SI-696 (20")/Modification	104	104	458	425	50	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
99	3SI-696 (20")/Modification	104	104	458	425	50	9.52	5.25	5	0.3	0.5	*128,368*	*2,805*
100													
101													
102	1SI-688 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
103	2SI-688 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
104	3SI-688 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
105	1SI-693 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
106	2SI-693 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*
107	3SI-693 (10")/Modification	104	104	458	425	50	5.13	2.63	5.25	0.3	0.5	*37,835*	*597*

	A	O	P	Q	R	S	T	U	V	X	Y	Z	AA	AB
1	Peter G. Knaggs													
2	Joe Daza													
3														
4														
5	**Valve Tag (size)**	**MOV ACTUATOR/STEM INPUTS**								**MOTOR INPUTS**				
6		OAR	P.O. Ef	COF	Dstem	Pstem	Lstem	***Actuator Structural Limit***		Vfull	Vmin	MTorq	n	TDF
7					(in.)	(in./th.)	(in./rev.)	***Thrust (lbf)***	***Torque (ft-lbf)***	(volts)	(volts)	(ft-lbf)		
85														
86	1SI-685 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
87	2SI-685 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
88	3SI-685 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
89	1SI-694 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
90	2SI-694 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
91	3SI-694 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
92														
93														
94	1SI-686 (20")/Modification	80	0.4	0.12	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2	0.98
95	2SI-686 (20")/Modification	80	0.4	0.12	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2	0.98
96	3SI-686 (20")/Modification	80	0.4	0.12	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2	0.98
97	1SI-696 (20")/Modification	80	0.4	0.12	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2	0.98
98	2SI-696 (20")/Modification	80	0.4	0.12	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2	0.98
99	3SI-696 (20")/Modification	80	0.4	0.12	2.125	0.333	0.667	*98,000*	*1,980*	460	414	60	2	0.98
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	0.98
103	2SI-688 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
104	3SI-688 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
105	1SI-693 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
106	2SI-693 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98
107	3SI-693 (10")/Modification	61.64	0.4	0.17	1.5	0.250	0.500	*33,600*	*550*	460	414	25	2	0.98

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1	Peter G. Knaggs									
2	Joe Daza	Static				***Calculation of***				
3		Peak				***Minimum Available***				
4		Cracking				***Torque and Thrust***			**CALCULATION**	
5	**Valve Tag (size)**	Control	**MOV MISC INPUTS**			***at Motor Stall***			**DP X DISKS**	
6		Limit	Max Close	% Residual	Stem Factor	***Avail Torque***	***Avail Thrust***	VDF	Pfinal	DPavg
7		(lbf)	Load (lbf)	at cracking		(ft-lbf)	(lbf)		(psig)	(psig)
85										
86	1SI-685 (10")/Modification	12,500	24,553	61%	0.0170	*544*	*31,909*	0.900	458	221
87	2SI-685 (10")/Modification	12,500	24,553	61%	0.0170	*544*	*31,909*	0.900	458	221
88	3SI-685 (10")/Modification	12,500	24,553	61%	0.0170	*544*	*31,909*	0.900	458	221
89	1SI-694 (10")/Modification	12,500	24,553	61%	0.0170	*544*	*31,909*	0.900	458	221
90	2SI-694 (10")/Modification	12,500	24,553	61%	0.0170	*544*	*31,909*	0.900	458	221
91	3SI-694 (10")/Modification	12,500	24,553	61%	0.0170	*544*	*31,909*	0.900	458	221
92										
93										
94	1SI-686 (20")/Modification	20,000	38,621	55%	0.0192	*1,693*	*88,137*	0.900	458	221
95	2SI-686 (20")/Modification	20,000	38,621	55%	0.0192	*1,693*	*88,137*	0.900	458	221
96	3SI-686 (20")/Modification	20,000	38,621	55%	0.0192	*1,693*	*88,137*	0.900	458	221
97	1SI-696 (20")/Modification	20,000	38,621	55%	0.0192	*1,693*	*88,137*	0.900	458	221
98	2SI-696 (20")/Modification	20,000	38,621	55%	0.0192	*1,693*	*88,137*	0.900	458	221
99	3SI-696 (20")/Modification	20,000	38,621	55%	0.0192	*1,693*	*88,137*	0.900	458	221
100										
101										
102	1SI-688 (10")/Modification	12,500	25,691	61%	0.0170	*544*	*31,909*	0.900	458	221
103	2SI-688 (10")/Modification	12,500	25,691	61%	0.0170	*544*	*31,909*	0.900	458	221
104	3SI-688 (10")/Modification	12,500	25,691	61%	0.0170	*544*	*31,909*	0.900	458	221
105	1SI-693 (10")/Modification	12,500	25,691	61%	0.0170	*544*	*31,909*	0.900	458	221
106	2SI-693 (10")/Modification	12,500	25,691	61%	0.0170	*544*	*31,909*	0.900	458	221
107	3SI-693 (10")/Modification	12,500	25,691	61%	0.0170	*544*	*31,909*	0.900	458	221

	A	AL	AM	AN	AO	AP	AQ	AR	AS	AT
1	Peter G. Knaggs									
2	Joe Daza									
3										
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										
85										
86	1SI-685 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
87	2SI-685 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
88	3SI-685 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
89	1SI-694 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
90	2SI-694 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
91	3SI-694 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
92										
93										
94	1SI-686 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	736	-323
95	2SI-686 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	736	-323
96	3SI-686 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	736	-323
97	1SI-696 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	736	-323
98	2SI-696 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	736	-323
99	3SI-696 (20")/Modification	0.0834	0.0111	0.7566	0.2804	0.00134	0.0754	0.5208	736	-323
100										
101										
102	1SI-688 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
103	2SI-688 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
104	3SI-688 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
105	1SI-693 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
106	2SI-693 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188
107	3SI-693 (10")/Modification	0.0963	0.0136	0.7422	0.2887	0.00181	0.0863	0.5218	445	-188

	A	AU	AV	AX	AY	AZ	BA	BB
1	Peter G. Knaggs							
2	Joe Daza	PRESSURE LOCKING CALCULATION						
3								
4		**Disk**	**Hub**	**Residual Closing**	**Vertical Load**	**Stem piston**	**Total Stem Thrust Req'd to Overcome**	**Total Torque Req'd to Overcome**
5	**Valve Tag (size)**	**Load**	**Load**	**Load at Cracking**	**On Disks**	**Load**	**Press Locking**	**Pressure Locking**
6		w/DPavg	Pup-Pdown	Residual Load	Fvert	Fpiston	Ftotal	Required Torque
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(ft-lbf)
85								
86	1SI-685 (10")/Modification	6,310	4,090	14,997	3,330	809	27,917	476
87	2SI-685 (10")/Modification	6,310	4,090	14,997	3,330	809	27,917	476
88	3SI-685 (10")/Modification	6,310	4,090	14,997	3,330	809	27,917	476
89	1SI-694 (10")/Modification	6,310	4,090	14,997	3,330	809	27,917	476
90	2SI-694 (10")/Modification	6,310	4,090	14,997	3,330	809	27,917	476
91	3SI-694 (10")/Modification	6,310	4,090	14,997	3,330	809	27,917	476
92								
93								
94	1SI-686 (20")/Modification	20,140	14,072	21,152	10,932	1,624	64,671	1,243
95	2SI-686 (20")/Modification	20,140	14,072	21,152	10,932	1,624	64,671	1,243
96	3SI-686 (20")/Modification	20,140	14,072	21,152	10,932	1,624	64,671	1,243
97	1SI-696 (20")/Modification	20,140	14,072	21,152	10,932	1,624	64,671	1,243
98	2SI-696 (20")/Modification	20,140	14,072	21,152	10,932	1,624	64,671	1,243
99	3SI-696 (20")/Modification	20,140	14,072	21,152	10,932	1,624	64,671	1,243
100								
101								
102	1SI-688 (10")/Modification	6,310	4,090	15,759	3,330	809	28,680	489
103	2SI-688 (10")/Modification	6,310	4,090	15,759	3,330	809	28,680	489
104	3SI-688 (10")/Modification	6,310	4,090	15,759	3,330	809	28,680	489
105	1SI-693 (10")/Modification	6,310	4,090	15,759	3,330	809	28,680	489
106	2SI-693 (10")/Modification	6,310	4,090	15,759	3,330	809	28,680	489
107	3SI-693 (10")/Modification	6,310	4,090	15,759	3,330	809	28,680	489

	A	BC	BG	BH	BI	BJ	BK
1	Peter G. Knaggs						
2	Joe Daza	**MOV Min Avail Thrust due to Structural Limit or Motor Torque Limit** Limiting Thrust (lbf)	**MARGIN** LIMITING THRUST subtract REQUIRED THRUST (lbf)	**MARGIN** DESIGN (%)	Suscept?	Additional PL Load "(PL Load -Res. Load)" (lbf)	**DIMEN. CORR.**
3							
4							
5	**Valve Tag (size)**						
6							
7							
85							
86	1SI-685 (10")/Modification	31,909	3,992	14.3	No	12,921	0.589
87	2SI-685 (10")/Modification	31,909	3,992	14.3	No	12,921	0.589
88	3SI-685 (10")/Modification	31,909	3,992	14.3	No	12,921	0.589
89	1SI-694 (10")/Modification	31,909	3,992	14.3	No	12,921	0.589
90	2SI-694 (10")/Modification	31,909	3,992	14.3	No	12,921	0.589
91	3SI-694 (10")/Modification	31,909	3,992	14.3	No	12,921	0.589
92							
93							
94	1SI-686 (20")/Modification	88,137	23,465	36.3	No	43,520	1.217
95	2SI-686 (20")/Modification	88,137	23,465	36.3	No	43,520	1.217
96	3SI-686 (20")/Modification	88,137	23,465	36.3	No	43,520	1.217
97	1SI-696 (20")/Modification	88,137	23,465	36.3	No	43,520	1.217
98	2SI-696 (20")/Modification	88,137	23,465	36.3	No	43,520	1.217
99	3SI-696 (20")/Modification	88,137	23,465	36.3	No	43,520	1.217
100							
101							
102	1SI-688 (10")/Modification	31,909	3,230	11.3	No	12,921	0.563
103	2SI-688 (10")/Modification	31,909	3,230	11.3	No	12,921	0.563
104	3SI-688 (10")/Modification	31,909	3,230	11.3	No	12,921	0.563
105	1SI-693 (10")/Modification	31,909	3,230	11.3	No	12,921	0.563
106	2SI-693 (10")/Modification	31,909	3,230	11.3	No	12,921	0.563
107	3SI-693 (10")/Modification	31,909	3,230	11.3	No	12,921	0.563

	A	BL	BM
1	Peter G. Knaggs		
2	Joe Daza		
3		**Residual % of Cracking**	**CHAPTER 15 EVENT RESULTING IN THE MAXIMUM INCREASE IN BONNET TEMPERATURE PRIOR TO REQ'D ACTIVE OPEN FUNCTION**
4			
5	**Valve Tag (size)**	**Load Limit**	
6			Reqd by GL 95-07
7			
85			
86	1SI-685 (10")/Modification	91.16%	ALL (Normal Conditions)
87	2SI-685 (10")/Modification	91.16%	ALL (Normal Conditions)
88	3SI-685 (10")/Modification	91.16%	ALL (Normal Conditions)
89	1SI-694 (10")/Modification	91.16%	ALL (Normal Conditions)
90	2SI-694 (10")/Modification	91.16%	ALL (Normal Conditions)
91	3SI-694 (10")/Modification	91.16%	ALL (Normal Conditions)
92			
93			
94	1SI-686 (20")/Modification	81.74%	ALL (Normal Conditions)
95	2SI-686 (20")/Modification	81.74%	ALL (Normal Conditions)
96	3SI-686 (20")/Modification	81.74%	ALL (Normal Conditions)
97	1SI-696 (20")/Modification	81.74%	ALL (Normal Conditions)
98	2SI-696 (20")/Modification	81.74%	ALL (Normal Conditions)
99	3SI-696 (20")/Modification	81.74%	ALL (Normal Conditions)
100			
101			
102	1SI-688 (10")/Modification	91.55%	ALL (Normal Conditions)
103	2SI-688 (10")/Modification	91.55%	ALL (Normal Conditions)
104	3SI-688 (10")/Modification	91.55%	ALL (Normal Conditions)
105	1SI-693 (10")/Modification	91.55%	ALL (Normal Conditions)
106	2SI-693 (10")/Modification	91.55%	ALL (Normal Conditions)
107	3SI-693 (10")/Modification	91.55%	ALL (Normal Conditions)

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)

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-evaluation of BW/IP weaklink analysis based on a revised Design Basis temperatur (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)

2) The valve structural limits for thrust and torque reflect the re-evaluation of BW/IP weaklink analysis based on a revised Design Basis temperatur (Valve Part No. 77850/13-N001-2101-94-8) is documented in Study 13-JS-A41.

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-201)

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)

13JSIBUV0671

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

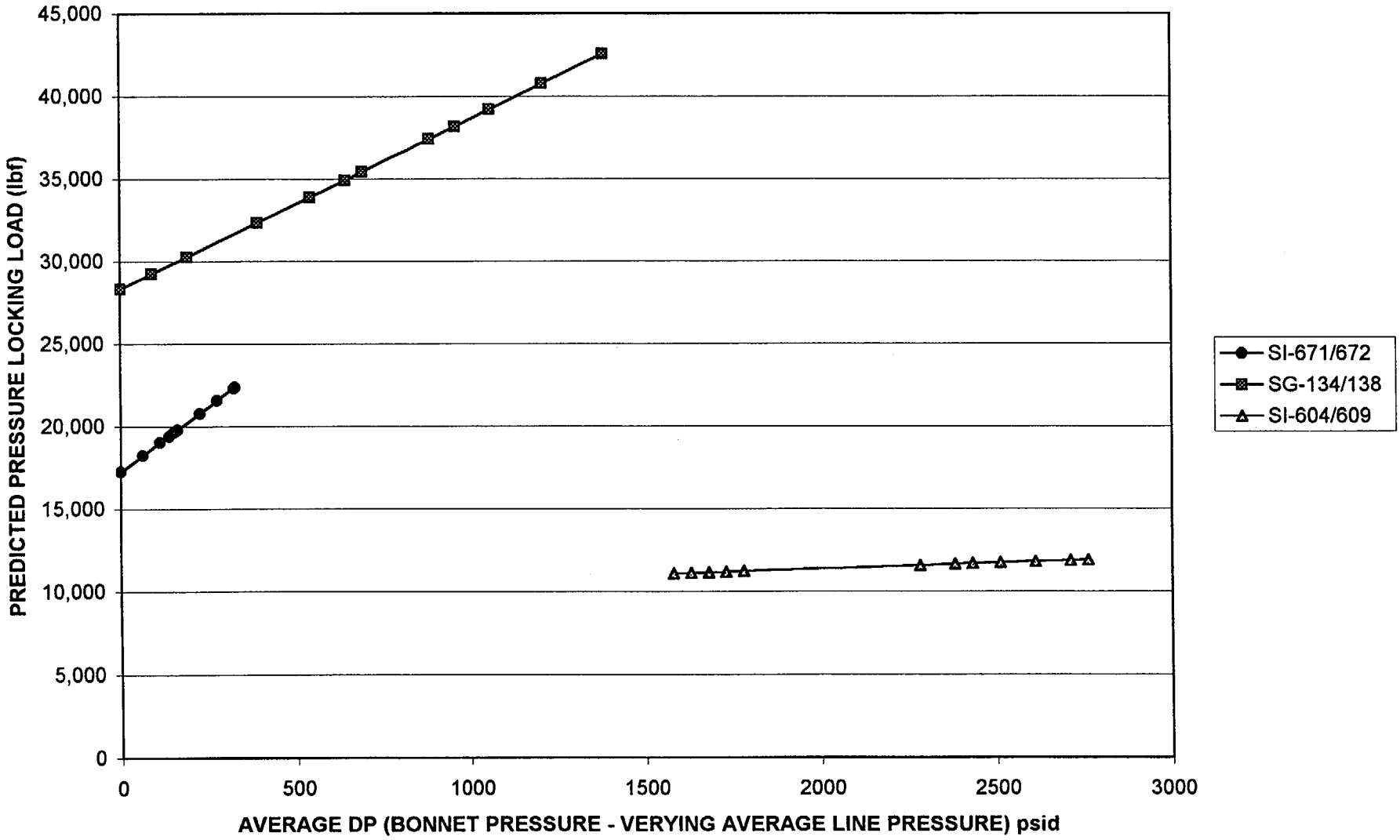
13JSIAUV0672

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 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.

13JSIA(B)HV686(696)

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

COMPARISON OF PRESSURE LOCKING LOAD WITH BONNET TO PIPING DP



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 Pressure Locking testing on a Borg Warner 10", 300# class flexible wedge gate valve. This testing was done to determine the stem thrust required in opening the flexible wedge gate valve with the fluid pressure in the valve bonnet greater than the fluid pressure in the upstream and downstream piping. Testing was performed at several different bonnet pressures with two different closed torque switch settings. The test methodology, instrumentation and final results are identified in Attachment 5 of 13-MC-ZZ-217.

A review and analysis of the Pressure Locking test VOTES data acquisition system strain gage thrust traces was performed to determine the appropriate valve factor (VF) for use in the validation of the PVNGS Pressure Locking model. Specific test values were obtained from the identified test points in a similar manner as the published test results. The maximum force after peak cracking (VOTES point O10), and the opening running force (VOTES points O13/O14) were determined. These values were used with the values for the valve seat area and the measured maximum line pressure to calculate the range of valve factors in accordance with standard methodology. The highest measured valve factor 0.44 was utilized based on the review of the test results (See attached B-W Pressure Locking Test Data, differential pressure valve strokes Test#59 & Test#100) and is consistent with APS' GL 89-10 program grouping methodology. The other inputs used in the PVNGS Pressure Locking model validation are provided in Attachment 5.

Analysis of the test data resulted in the development of an experimental dimensionless correlation factor to determine the percentage of residual load as a function of the bonnet pressure induced load. The correlation indicates that as the bonnet pressure increases the residual load percentage of the closing thrust is reduced. This correlation was established based on the test results in Attachment 5 and is represented in Chart 5 of this attachment. The plotted residual percentage of the closing load at opening is obtained by subtracting the calculated pressure locking load components from the total measured opening load divided by the maximum cracking limit.

The measured Pressure Locking opening thrust test data is compared to the PVNGS Model predicted values on Charts 1 & 2. Also, the measured data and predicted pullout thrust values are fit with linear regressions and plotted against the bonnet pressure on Charts 3 & 4 of this attachment. Charts 1 & 3 include selected tests with a measured bonnet pressure greater than 200 psig and prior closing thrust less than 17,000 lbs (Low closing Thrust). Charts 2 & 4 include selected tests with a measured bonnet pressure greater than 50 psig and prior closing thrust greater than 31,000 lbs (High closing Thrust). In general a good correlation between the linear regressions for the measured data and the predicted values is demonstrated by the similarity in slope between the plotted lines on Charts 3 & 4.

The margin between the measured data and predicted values (basic margin) presented in Chart 3 for the low closing thrust ranges from a high of 24.8 % (Borg-Warner test 52) to a minimum margin of 3.3 % (Borg-Warner test 56). The measured data presented in Chart 4 for the high closing thrust tracks the predicted values correctly with the basic margins ranging from a high of 12.4% (Borg-Warner test 43) to a minimum of 0.1% (Borg-Warner test 83). However, the basic margin for the high closing thrust does not include any allowance for the identified nonlinear anomalous test point (Borg-Warner test 80). The closing thrust for this data point is outside the range of values for 10" or smaller 300# class valves found in PVNGS applications. It should be noted that the test results for this data point are enveloped by the 10% margin, as shown on Chart 2, to ensure a level of conservatism to address any related uncertainties.

Therefore, for applications of PVNGS Pressure Locking model with postulated bonnet pressure of above 200 psig, a minimum of 10% margin is expected to be maintained between the MOV capability and the calculated required pressure locking load unless otherwise specified.

B-W PRESSURE LOCKING TEST DATA (Valve Factor Determination)

	A	C	D	E	F	G	I	J	K	N	O	P	Q	R	S	T	U	W
1		BORG WARNER 10" 300# TEST GATE VALVE TRACE DATA SUMMARY																
2																		
3		TEST PRESSURES					VALVE GEOMETRY							VALVE THRUST MEASUREMENTS				
4										Stem	Stem	Seat		Max Clos	Pullout	Max Force	Open Running	Open
5	TEST	Pinitial	Pup	Pdown	DP_line	DPavg	a	b	theta	Diamete	Area	Area		Load	Thrust	After PC	Thrust	VF (dyn)
6																		
7	Test #18	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68						
8	Test #19	0	100	0	100	-50	5.13	2.63	5	1.5	1.77	82.68						
9	Test #20	0	100	0	100	-50	5.13	2.63	5	1.5	1.77	82.68						
10	Test #21	0	200	0	200	-100	5.13	2.63	5	1.5	1.77	82.68		26,172	11,096	2,637	348	0.16
11	Test #22	0	450	0	450	-225	5.13	2.63	5	1.5	1.77	82.68		25,477	13,535	6,021	149	0.18
12	Test #23	0	730	0	730	-365	5.13	2.63	5	1.5	1.77	82.68		23,436	16,420	10,300	149	0.19
13	Test #24u	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68						
14	Test #24d	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68						
15	Test #25d	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68						
16	Test #25u	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68						
17																		
18																		
19	Test #28	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		26,959	13,330	14,723	348	
20	Test #29	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		28,945	18,799	14,025	398	
21	Test #30	0	540	0	540	-270	5.13	2.63	5	1.5	1.77	82.68		28,550	14,722	15,767	398	0.37
22	Test #31	0	245	0	245	-122.5	5.13	2.63	5	1.5	1.77	82.68		29,395	15,966	7,560	448	0.37
23	Test #32	0	285	0	285	-142.5	5.13	2.63	5	1.5	1.77	82.68		29,446	14,126	8,704	348	0.38
24	Test #33	0	455	0	455	-227.5	5.13	2.63	5	1.5	1.77	82.68		29,843	11,291	13,678	448	0.37
25	Test #34	0	475	0	475	-237.5	5.13	2.63	5	1.5	1.77	82.68		29,794	13,927	14,126	398	0.37
26	Test #35	0	450	0	450	225	5.13	2.63	5	1.5	1.77	82.68		29,794	13,778	14,126	398	0.39
27	Test #36	0	0	550	550	-275	5.13	2.63	5	1.5	1.77	82.68		29,344	10,494	7,112	348	0.17
28	Test #37	0	0	505	505	-252.5	5.13	2.63	5	1.5	1.77	82.68		29,344	9,102	10,096	249	0.26
29	Test #38	0	0	505	505	-252.5	5.13	2.63	5	1.5	1.77	82.68		28,996	9,549	14,871	298	0.37
30	Test #39	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		29,096	12,683	15,269	398	
31																		
32																		
33	Test #42	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,783	16,513		696	
34	Test #43	205	0	0	0	205	5.13	2.63	5	1.5	1.77	82.68		32,032	25,467	4,825	497	
35	Test #44	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,781	17,357		746	
36	Test #45	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,162	7,261		596	
37	Test #46	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,659	7,509		597	
38	Test #47	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,859	7,907		597	
39	Test #48	209	0	0	0	209	5.13	2.63	5	1.5	1.77	82.68		16,809	15,268	4,824	497	
40	Test #49	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,659	7,857		597	
41	Test #50	402	0	0	0	402	5.13	2.63	5	1.5	1.77	82.68		16,708	20,786	6,166	497	
42	Test #51	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,856	7,707		597	
43	Test #52	630	0	0	0	630	5.13	2.63	5	1.5	1.77	82.68		16,958	26,705	9,051	448	
44	Test #53	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,460	8,105		598	
45	Test #54	694	0	0	0	694	5.13	2.63	5	1.5	1.77	82.68		16,361	28,395	9,996	597	
46	Test #55	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		16,956	7,658		646	
47	Test #56	919	0	0	0	919	5.13	2.63	5	1.5	1.77	82.68		16,709	41,872	10,045	696	
48																		
49	Test #58	950	0	0	0	950	5.13	2.63	5	1.5	1.77	82.68		15,665	5,023		945	---
50	Test #59	0	0	510	510	-255	5.13	2.63	5	1.5	1.77	82.68		9,895	16,757	17,602	149	0.44
51																		
52																		
53	Test #66	0	0	208	208	-104	5.13	2.63	5	1.5	1.77	82.68		31,722	22,474	6,215	398	0.36
54	Test #67	0	0	198	198	-99	5.13	2.63	5	1.5	1.77	82.68		31,772	22,126	6,165	447	0.37
55	Test #68	0	0	370	370	-185	5.13	2.63	5	1.5	1.77	82.68		31,922	24,513	11,834	447	0.39
56	Test #69	0	0	413	413	-206.5	5.13	2.63	5	1.5	1.77	82.68		31,922	24,414	13,922	398	0.42
57	Test #70	0	0	600	600	-300	5.13	2.63	5	1.5	1.77	82.68		32,069	25,506	18,396	497	0.38
58	Test #71	0	0	610	610	-305	5.13	2.63	5	1.5	1.77	82.68		31,721	27,545	20,683	398	0.42
59	Test #72	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,571	16,705		696	
60	Test #73	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,670	17,202		696	
61	Test #74	208	0	0	0	208	5.13	2.63	5	1.5	1.77	82.68		31,720	27,643	3,729	596	
62	Test #75	213	0	0	0	213	5.13	2.63	5	1.5	1.77	82.68		31,920	28,241	4,425	597	
63	Test #76	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,822	17,751		696	
64	Test #77	391	0	0	0	391	5.13	2.63	5	1.5	1.77	82.68		32,017	33,906	6,612	646	
65	Test #78	402	0	0	0	402	5.13	2.63	5	1.5	1.77	82.68		32,168	34,604	6,513	646	
66	Test #79	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,671	17,949		696	
67	Test #80	467	0	0	0	467	5.13	2.63	5	1.5	1.77	82.68		31,818	40,121	6,911	547	
68	Test #81	219	0	0	0	219	5.13	2.63	5	1.5	1.77	82.68		32,020	28,540	4,027	746	
69	Test #82	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		32,467	17,700		646	
70	Test #83	110	0	0	0	110	5.13	2.63	5	1.5	1.77	82.68		32,318	25,457	1,641	646	
71	Test #84	54	0	0	0	54	5.13	2.63	5	1.5	1.77	82.68		31,820	22,871	1,342	646	
72	Test #85	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,771	17,352		646	
73	Test #86	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		32,464	20,980	994	646	
74	Test #87	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		32,463	18,494		696	
75	Test #88	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		32,317	18,197		746	
76																		
77																		
78	Test #92	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		31,951	17,541		745	
79	Test #93	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		17,442	8,000		745	
80	Test #94	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		17,244	8,996		795	
81	Test #95	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		17,443	11,132		894	
82	Test #96	557	0	0	0	557	5.13	2.63	5	1.5	1.77	82.68		17,394	27,035	5,914	696	
83	Test #97	504	0	0	0	504	5.13	2.63	5	1.5	1.77	82.68		17,691	26,189	5,814	795	
84	Test #98	0	0	0	0	0	5.13	2.63	5	1.5	1.77	82.68		17,443	8,547		795	
85	Test #99	0	0	610	610	-305	5.13	2.63	5	1.5	1.77	82.68		14,164	21,022	20,227	298	0.42
86	Test #100	0	0	578	578	-289	5.13	2.63	5	1.5	1.77	82.68		16,151	19,729	20,375	298	0.44

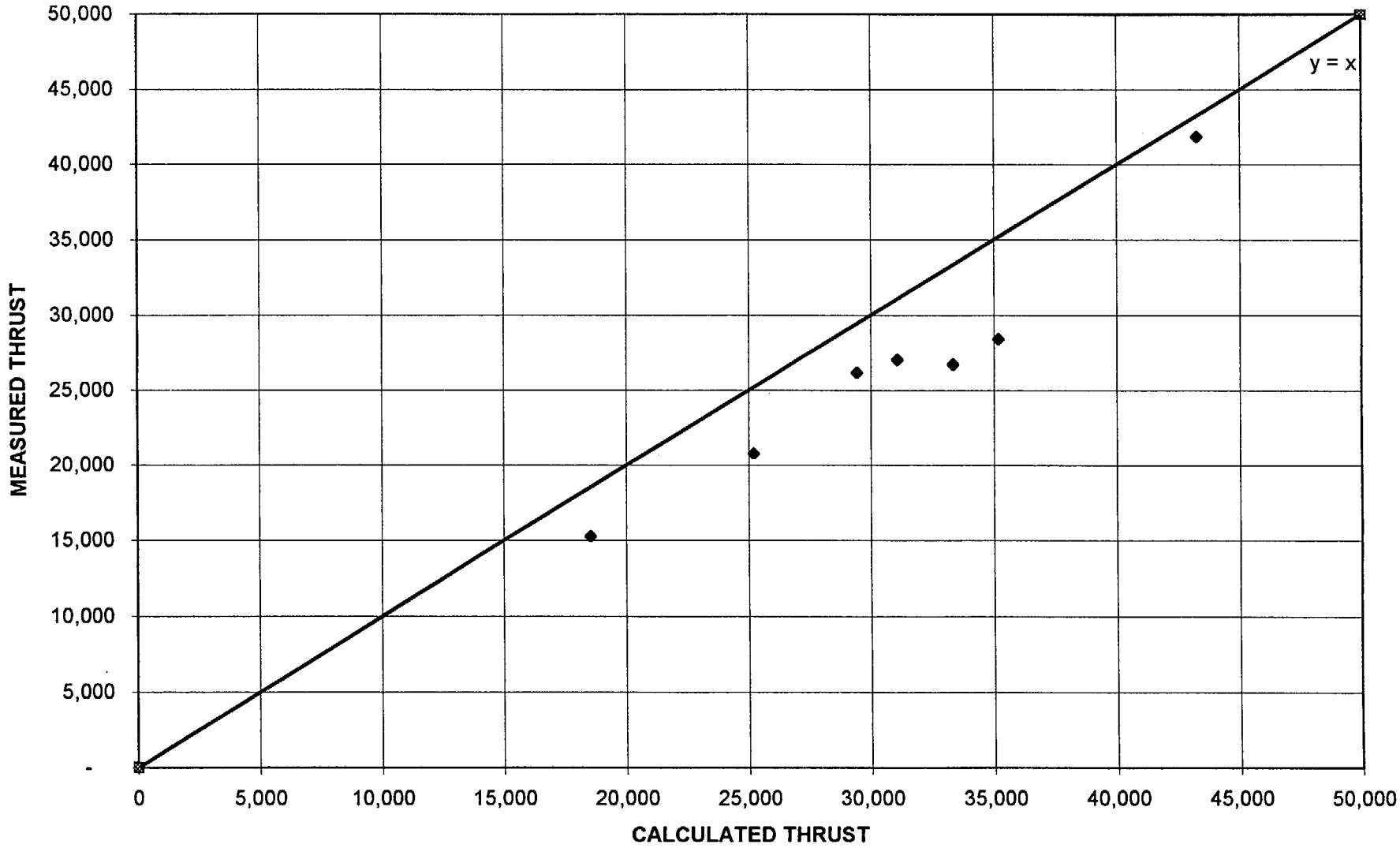
PRESSURE LOCKING TEST DATA/PVNGS MODEL VALIDATION

	A	B	C	D	E	G	H	I	J	K	L	N	O	Q	R	S	T	U	V	W	X	Y	Z
1		BORG WARNER 10" 300# TEST GATE VALVE																					
2												MOV MISC INPUTS											
3		TEST PRESSURES				VALVE INPUTS						Max Close	% Residual	Calculation of Disk Load Perpindicular to the Seat Using Roark Thin Plate Theory									
4	TEST#	Pinitial	Pup	Pdown	DPavg	a	b	theta	nu	VF	Dstem	Load	at Cracking	C2	C3	C8	C9	L11	L17	mu	Qb	Qa	Disk Load
6	**Test #43 - PL**	**205**	**0**	**0**	**205**	5.13	2.63	5	**0.3**	**0.44**	**1.5**	32,032	**65%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	**0.4558**	**415**	**-175**	**5,134**
11	Test #48 - PL	209	0	0	209	5.13	2.63	5	0.3	0.44	1.5	16,809	64%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	423	-178	5,234
13	Test #50 - PL	402	0	0	402	5.13	2.63	5	0.3	0.44	1.5	16,708	60%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	814	-343	10,068
15	Test #52 - PL	630	0	0	630	5.13	2.63	5	0.3	0.44	1.5	16,958	57%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	1,276	-537	15,778
17	Test #54 - PL	694	0	0	694	5.13	2.63	5	0.3	0.44	1.5	16,361	55%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	1,405	-592	17,381
19	Test #56 - PL	919	0	0	919	5.13	2.63	5	0.3	0.44	1.5	16,709	52%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	1,861	-784	23,016
26	**Test #74 - PL**	**208**	**0**	**0**	**208**	5.13	2.63	5	**0.3**	0.44	**1.5**	31,720	**65%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**421**	**-177**	**5,209**
27	**Test #75 - PL**	**213**	**0**	**0**	**213**	5.13	2.63	5	**0.3**	0.44	**1.5**	31,920	**65%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**431**	**-182**	**5,334**
29	**Test #77 - PL**	**391**	**0**	**0**	**391**	5.13	2.63	5	**0.3**	0.44	**1.5**	32,017	**64%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**792**	**-334**	**9,792**
30	**Test #78 - PL**	**402**	**0**	**0**	**402**	5.13	2.63	5	**0.3**	0.44	**1.5**	32,168	**64%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**814**	**-343**	**10,068**
32	**Test #80 - PL**	**467**	**0**	**0**	**467**	5.13	2.63	5	**0.3**	0.44	**1.5**	31,868	**63%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**946**	**-398**	**11,696**
33	**Test #81 - PL**	**219**	**0**	**0**	**219**	5.13	2.63	5	**0.3**	0.44	**1.5**	32,020	**65%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**443**	**-187**	**5,485**
35	**Test #83 - PL**	**110**	**0**	**0**	**110**	5.13	2.63	5	**0.3**	0.44	**1.5**	32,318	**66%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**223**	**-94**	**2,755**
36	**Test #84 - PL**	**54**	**0**	**0**	**54**	5.13	2.63	5	**0.3**	0.44	**1.5**	31,820	**67%**	**0.0967**	**0.0137**	**0.7418**	**0.2889**	**0.00183**	**0.0866**	0.4558	**109**	**-46**	**1,352**
46	Test #96 - PL	557	0	0	557	5.13	2.63	5	0.3	0.44	1.5	17,394	58%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	1,128	-475	13,950
47	Test #97 - PL	504	0	0	504	5.13	2.63	5	0.3	0.44	1.5	17,691	59%	0.0967	0.0137	0.7418	0.2889	0.00183	0.0866	0.4558	1,020	-430	12,622

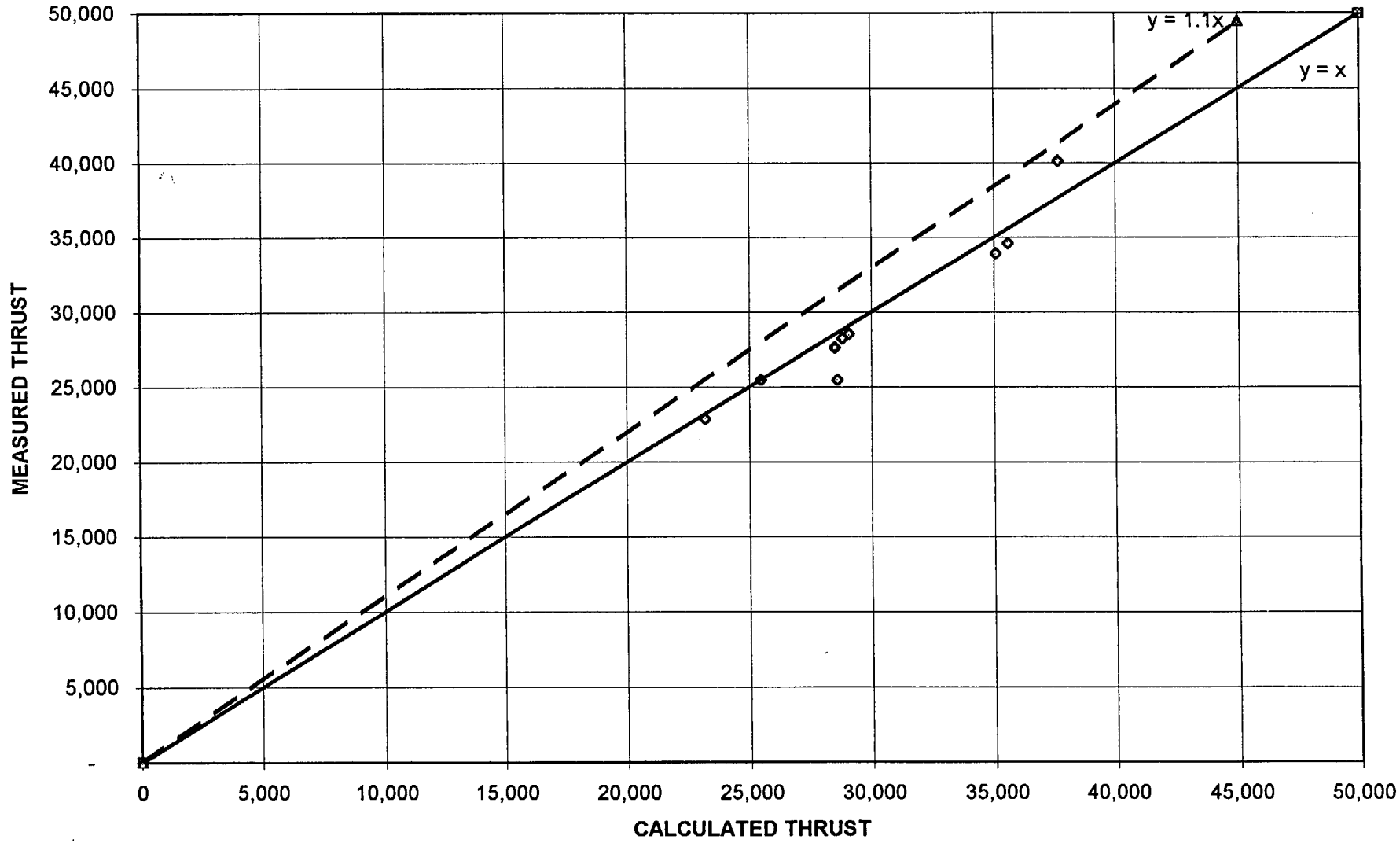
PRESSURE LOCKING TEST DATA/PVNGS MODEL VALIDATION

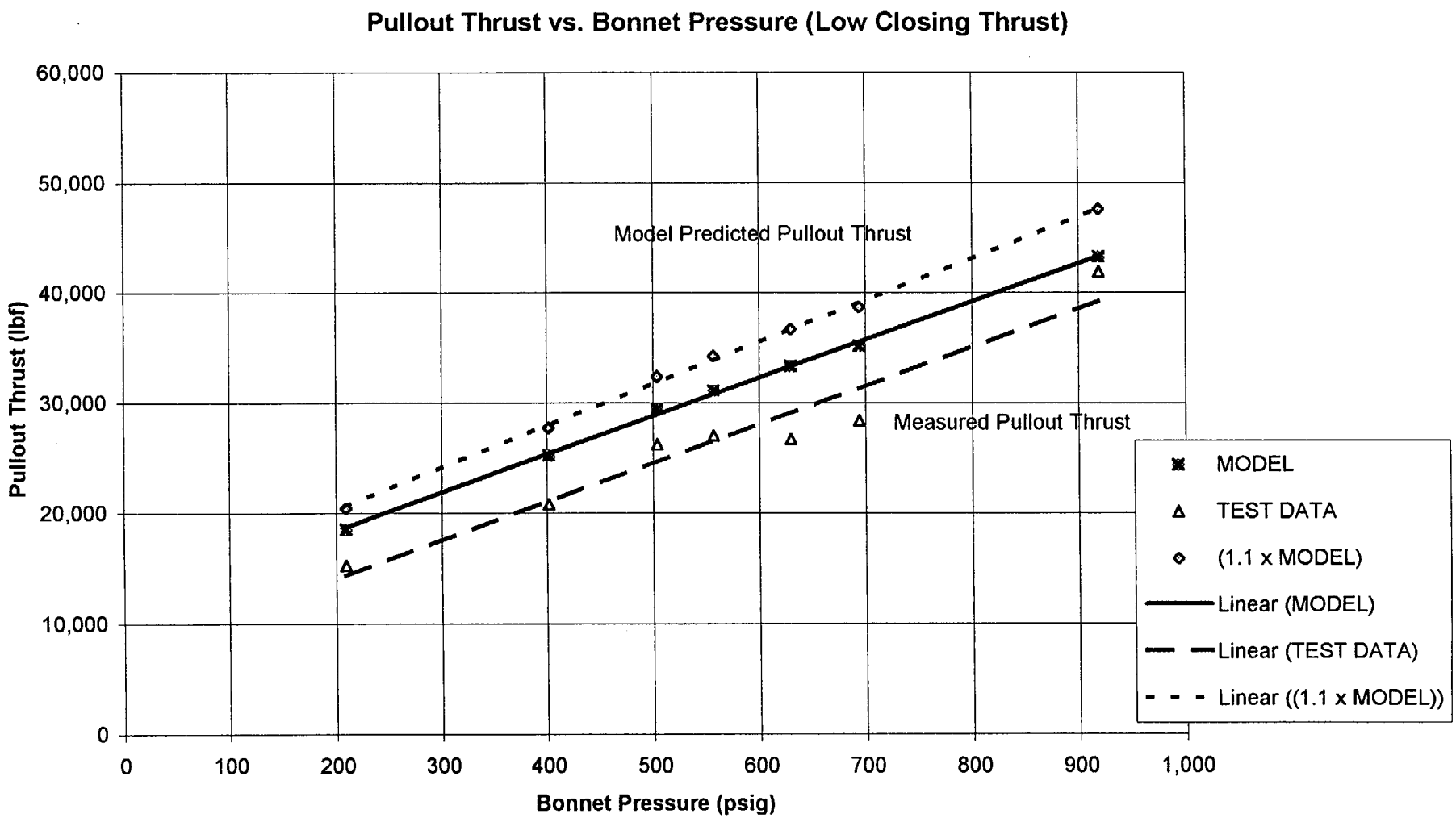
	A	AB	AC	AD	AF	AG	AH	AI	AJ	AL	AM	AN
1												
2		Residual Closing	Vertical Load	Stem Piston	Total Stem Thrust	Measured	Margin %		Residual Closing	Exp.Dimensional	Meas. Residual %	Residual % of
3		Load at Cracking	On Disks	Load	Req'd to Open	PL Load		Bonnet	Load at Opening	Corrolation	of Cracking	Cracking
4	TEST#	Residual Load	Fvert	Fpiston	Ftotal			Pressure	(Measured Load-PL Loads)	(BPxSAxmu/Closing)		Load Limit
6	**Test #43 - PL**	**20,892**	**2,949**	**362**	**28,612**	**25,467**	**12.4**	**205**	**17,747**	0.177	**82.69%**	**97%**
11	Test #48 - PL	10,681	3,006	369	18,553	15,268	21.5	209	7,397	0.344	**65.68%**	95%
13	Test #50 - PL	10,078	5,782	710	25,217	20,786	21.3	402	5,646	0.665	**50.44%**	90%
15	Test #52 - PL	9,612	9,062	1,113	33,338	26,705	24.8	630	2,979	1.027	**26.22%**	85%
17	Test #54 - PL	9,034	9,982	1,226	35,171	28,395	23.9	694	2,258	1.172	**20.60%**	82%
19	Test #56 - PL	8,642	13,218	1,624	43,253	41,872	3.3	919	7,262	1.520	**64.87%**	77%
26	**Test #74 - PL**	**20,675**	**2,992**	**368**	**28,508**	**27,643**	**3.1**	**208**	**19,810**	0.181	**93.21%**	**97%**
27	**Test #75 - PL**	**20,795**	**3,064**	**376**	**28,816**	**28,241**	**2.0**	**213**	**20,219**	0.184	**94.54%**	**97%**
29	**Test #77 - PL**	**20,365**	**5,624**	**691**	**35,091**	**33,906**	**3.5**	**391**	**19,181**	0.338	**89.41%**	**95%**
30	**Test #78 - PL**	**20,436**	**5,782**	**710**	**35,576**	**34,604**	**2.8**	**402**	**19,464**	0.345	**90.31%**	**95%**
32	**Test #80 - PL**	**20,054**	**6,717**	**825**	**37,642**	**40,121**	**-6.2**	**467**	**22,533**	0.405	**105.54%**	**94%**
33	**Test #81 - PL**	**20,845**	**3,150**	**387**	**29,093**	**28,540**	**1.9**	**219**	**20,292**	0.189	**94.59%**	**97%**
35	**Test #83 - PL**	**21,348**	**1,582**	**194**	**25,490**	**25,457**	**0.1**	**110**	**21,314**	0.094	**98.44%**	**99%**
36	**Test #84 - PL**	**21,169**	**777**	**95**	**23,203**	**22,871**	**1.5**	**54**	**20,837**	0.047	**97.74%**	**99%**
46	Test #96 - PL	10,107	8,012	984	31,084	27,035	15.0	557	6,058	0.885	**51.98%**	87%
47	Test #97 - PL	10,453	7,249	891	29,434	26,189	12.4	504	7,208	0.787	**60.81%**	88%

VALIDATION COMPARISON OF MEASURED COMED TEST DATA (LOW CLOSING THRUST) TO PVNGS PRESSURE LOCKING MODEL PREDICTED THRUST VALUES

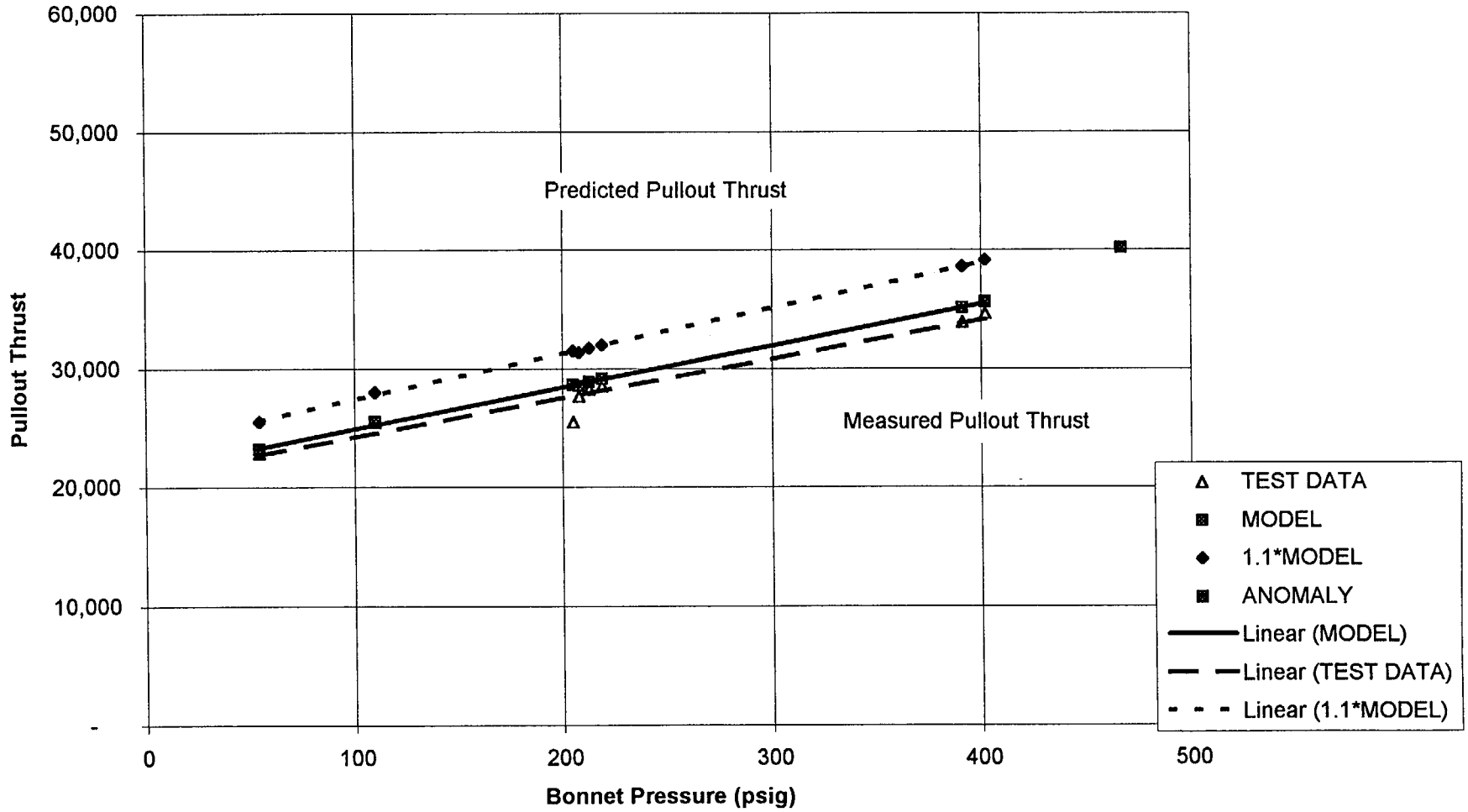


VALIDATION COMPARISON OF MEASURED COMED TEST DATA (HIGH CLOSING THRUST) TO PVNGS PRESSURE LOCKING MODEL PREDICTED THRUST VALUES

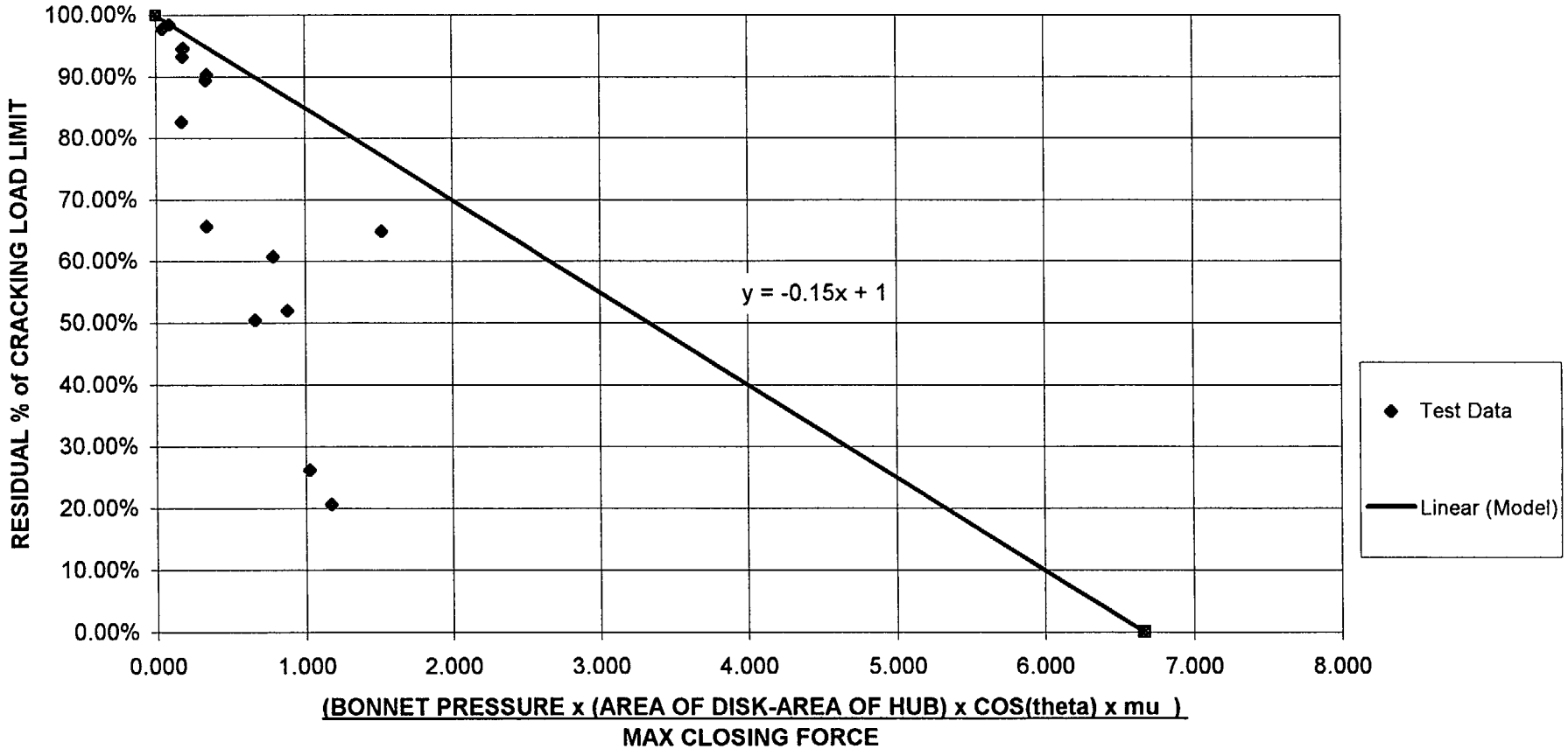



Pullout Thrust vs. Bonnet Pressure (Low Closing Thrust)
Pullout Thrust (lbf)
60,000
50,000
40,000
30,000
20,000
10,000
0
0
100
200
300
400
500
600
700
800
900
1,000
Bonnet Pressure (psig)
Model Predicted Pullout Thrust
Measured Pullout Thrust
MODEL
TEST DATA
(1.1 x MODEL)
Linear (MODEL)
Linear (TEST DATA)
Linear ((1.1 x MODEL))

Pullout Thrust vs. Bonnet Pressure (High Closing Thrust)



RESIDUAL LOAD / BONNET PRESSURE / CLOSING FORCE RELATIONSHIP



Peter G. Knaggs
Joe Daza

Attachment 6- PVNGS PL Model Comparison to Other Test Data

BACKGROUND

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 other selected Test Data in response to NRC Request for Additional Information (Generic Letter 95-07 RAI NRC Letter dated June 11, 1999). INEEL pressure locking test results were 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 an 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 results of this comparison are presented in the second part of this attachment (pages 13-20). In addition, Commonwealth Edison had also tested a Crane Valve under varying pressure locking conditions including line pressures. A summary of these test results was included in the Commonwealth Edison report in Attachment 5 of this Calculation. The results of this comparison are presented in the first part of this attachment (pages 4-12).

COMED 10" 900 LB. CRANE FLEX WEDGE PL TEST RESULTS

A follow-up discussions with the NRC based on APS Generic Letter 95-07 RAI Response Letter dated October 8, 1999 and an additional Generic Letter 95-07 RAI dated August 3, 2000 resulted in further PVNGS pressure locking model adjustment and a review and documentation of additional test results. These additional test results were needed to reflect the response of flexible wedge gate valves with relatively rigid gates, thicker disk and larger hub diameter dimensions, than the 6" 600 lb. Walworth, more comparable to the relatively rigid and stout PVNGS Borg-Warner and Anchor-Darling gates. In addition, a review and analysis of the Pressure Locking test VOTES data acquisition system strain gage thrust traces was performed to determine the appropriate valve factor (VF) for use in the validation of the PVNGS Pressure Locking model. The highest measured VF, 0.31, was utilized based on the review of the test traces (See attached Crane Pressure Locking Test Data, Differential Pressure valve stroke Test#27). The other inputs used in the model validation for the 10" 900 lb Crane flexible wedge gate valve is provided in Attachment 5. The additional Commonwealth Edison pressure locking test results for a 10" 900 lb Crane flexible wedge gate valve were reviewed and compared with the predicted PVNGS model pressure locking loads. The results from the 10" 900 lb Crane pressure locking test are presented in this Attachment.

The Crane opening thrust test data is compared to the PVNGS Model predicted values on Chart 1. This comparison indicates that the PVNGS PL Model is more conservative for the more rigid high-pressure class valves such as the PVNGS higher class Borg-Warner

valves evaluated in this Calculation. Also, the measured data and predicted pullout thrust values are fit with linear regressions and plotted against the bonnet pressure on Charts 2 & 3 of this Attachment. Chart 2 includes selected PL tests with a measured bonnet pressure greater than 200 psig and prior closing thrust less than 64,000 lbs (Lower closing thrust). Chart 3 includes selected PL tests with a measured bonnet pressure greater than 200 psig and prior closing thrust greater than 73,000 lbs. (Higher closing thrust). Comparison of the PVNGS predicted pressure-locking thrusts with the measured Crane test results indicate a higher level of conservatism. The PVNGS model enveloped all the Crane test cases. The model conservatively calculated higher loads than the associated measured pressure-locking load. The margin between the measured data and predicted values (basic margin) presented in Charts 2 & 3 range from a high of 76% (Crane test# 7) to a minimum margin of 11 % (Crane test# 43) for both the low and high closing thrusts. This analysis suggests that the PVNGS pressure locking model use should be restricted to the PVNGS Borg-Warner and Anchor-Darling Flexible Wedge gate valves since the model is sensitive to the relative gate dimensions and stiffness and may significantly over predict the required pullout results.

INEEL 6" 600 LB. WALWORTH FLEX WEDGE PL TEST RESULTS

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; along with the Maximum closing loads from Kalsi Document 1968FC were input into the PVNGS PL model. 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 test results to the PVNGS model predicted opening thrust for the 6" 600# Walworth flexible wedge gate valves is shown in Chart 4. In addition, Charts 5 & 6 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 net bonnet pressure.

Chart 5 of this Attachment shows the comparison of the PVNGS pressure locking model to the INEEL cold pressure locking test results (Tests 229 thru 232 and 343). All these test cases were identified as restricted to pressure locking at temperatures around 75 °F. In general the least square linear regression comparisons of the PVNGS pressure locking model with the INEEL pressure locking test results shown in Chart 5 indicate a close correlation. However, there were two data points, tests 229 and 230, where the PVNGS model under predicted the INEEL test results by a small magnitude (less than 3 %).

Chart 6 shows the comparison of the PVNGS pressure locking model to the INEEL thermal pressure locking test results (Tests 307, 316 and 329). These test cases were identified as occurring subsequent or during heating of the valve both internally and externally causing bonnet thermal pressurization. The final temperatures were recorded in the range 125 °F to 205 °F. In general the least square linear regression comparisons of the PVNGS pressure locking model with the INEEL pressure locking test results shown in Chart 6 indicate a conservative correlation. The PVNGS PL model did not under predict any of the INEEL thermal test results.

It appears that the PVNGS pressure locking model provides a reasonably good estimate of the INEEL measured pressure locking loads. This reanalysis is based on the measured closing forces being utilized that were not originally available.

CRANE PRESSURE LOCKING TEST DATA (Valve Factor and Max Close Determination)

	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			CRANE 10" 900# TEST GATE VALVE VOTES TRACE DATA SUMMARY																								
2																											
3			TEST PRESSURES						VALVE GEOMETRY										VALVE THRUST MEASUREMENTS								
4														Stem	Stem	Seat	BFSL	Max Close	Max Close	Pullout	Pullout	Max Dynamic	Max Force	Open Runnin	Open Running		Open
5	TEST	TYPE	Pinitial	Pup	Pdown	DP_line	DPavg		a	b	theta			Diamete	Area	Area	uv/v/lbF	uv/v	Load	uv/v	Thrust	mv/v	After PC	mv/v	Thrust		VF
6	Test #1	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.0204	1284.93	63,049	501.74	24,619		0	8.16	400		
7	Test #2	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.0204	1264.78	62,060	499.79	24,524		0	8.16	400		
8	Test #3	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.0204	1264.94	62,068	503.94	24,727		0	6.12	300		
9	Test #4	S	350	350	350	0	0		4.36	1.25	5			1.875	2.76	59.72	0.0204	1279.20	62,767	479.45	23,526		0	2.04	100		
10	Test #5	S	350	350	350	0	0		4.36	1.25	5			1.875	2.76	59.72	0.0204	1285.33	63,068	495.77	24,326		0	4.08	200		
11	Test #6	PL	650	350	355	5	298		4.36	1.25	5			1.875	2.76	59.72	0.0204	1299.57	63,767	612.04	30,031	89.77	4,405	2.04	100		
12	Test #7	PL	850	360	350	10	495		4.36	1.25	5			1.875	2.76	59.72	0.0204	1297.60	63,670	654.92	32,135	120.37	5,906	2.04	100		
13	Test #8	S	335	325	440	115	-48		4.36	1.25	5			1.875	2.76	59.72	0.0204	1293.50	63,469	514.14	25,228		0	2.04	100		
14	Test #9	PL	1,040	330	340	10	705		4.36	1.25	5			1.875	2.76	59.72	0.0204	1268.98	62,266	720.18	35,338	108.13	5,306	2.04	100		
15	Test #10	PL	1,040	330	340	10	705		4.36	1.25	5			1.875	2.76	59.72	0.0204	1277.05	62,662	730.33	35,836	159.12	7,808	4.08	200		
16	Test #11	PL	345	330	340	10	10		4.36	1.25	5			1.875	2.76	59.72	0.0204	1287.31	63,165	530.43	26,027	44.88	2,202	4.08	200		
17	Test #12	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.0204	1319.90	64,764	565.09	27,728		0	12.24	601		
18	Test #13	PL	1195	0	0	0	1195		4.36	1.25	5			1.875	2.76	59.72	0.0204	1207.66	59,257	964.91	47,346	136.68	6,707	28.56	1,401		
19	Test #14	PL	1375	0	0	0	1375		4.36	1.25	5			1.875	2.76	59.72	0.0204	1187.22	58,254	1,036.27	50,847	116.27	5,705	34.68	1,702		
20	Test #15	PL	1375	0	0	0	1375		4.36	1.25	5			1.875	2.76	59.72	0.0204	1176.06	57,707	1,039.38	51,000	129.54	6,356	27.54	1,351		
21	Test #16	DP	1425	1440	0	1440	705		4.36	1.25	5			1.875	2.76	59.72	0.0204	1238.35	60,763	681.34	33,432	418.19	20,520	16.32	801		0.28
22	Test #17	DP	1475	1470	0	1470	740		4.36	1.25	5			1.875	2.76	59.72	0.0204	1230.05	60,356	632.37	31,029	381.46	18,717	14.28	701		0.25
23	Test #18	DP	1000	1015	0	1015	493		4.36	1.25	5			1.875	2.76	59.72	0.02038	1213.73	59,555	611.97	30,028	291.70	14,313	20.40	1,001		0.27
24	Test #19	DP	995	980	0	980	505		4.36	1.25	5			1.875	2.76	59.72	0.02038	1230.01	60,354	628.26	30,827	293.73	14,413	20.40	1,001		0.28
25	Test #20	DP	1015	1030	0	1030	500		4.36	1.25	5			1.875	2.76	59.72	0.02038	1236.17	60,656	654.80	32,130	316.18	15,514	30.60	1,501		0.27
26	Test #21	DP	975	1,010	0	1010	470		4.36	1.25	5			1.875	2.76	59.72	0.02038	1242.28	60,956	644.60	31,629	312.10	15,314	20.40	1,001		0.28
27	Test #22	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1304.42	64,005	583.39	28,626		0	24.48	1,201		
28	Test #23	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1309.61	64,260	587.49	28,827		0	40.80	2,002		
29	Test #24	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1695.16	83,178	593.61	29,127		0	38.76	1,902		
30	Test #25	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1717.58	84,278	722.12	35,433		0	36.72	1,802		
31	Test #26	DP	995	1,010	0	1010	490		4.36	1.25	5			1.875	2.76	59.72	0.02038	1609.32	78,966	797.52	39,132	338.59	16,614	22.44	1,101		0.30
32	**Test #27**	**DP**	**965**	**960**	**0**	**960**	**485**		**4.36**	**1.25**	**5**			**1.875**	**2.76**	**59.72**	**0.02038**	**1584.97**	**77,771**	**795.54**	**39,035**	**330.46**	**16,215**	**22.44**	**1,101**		**0.31**
33	Test #28	DP	1,485	1,480	0	1480	745		4.36	1.25	5			1.875	2.76	59.72	0.02038	1574.68	77,266	828.13	40,634	460.98	22,619	20.40	1,001		0.29
34	Test #29	DP	1,465	1,490	0	1490	720		4.36	1.25	5			1.875	2.76	59.72	0.02038	1537.97	75,465	832.22	40,835	467.10	22,920	20.40	1,001		0.29
35	Test #30	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1709.29	83,871	797.53	39,133		0	28.56	1,401		
36	Test #31	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1737.83	85,271	748.57	36,731		0	6.12	300		
37	Test #32	S	345	335	340	5	8		4.36	1.25	5			1.875	2.76	59.72	0.02038	1729.69	84,872	756.74	37,132		0	6.12	300		
38	Test #33	S	335	360	340	20	-15		4.36	1.25	5			1.875	2.76	59.72	0.02038	1733.81	85,074	787.35	38,633		0	4.08	200		
39	Test #34	PL	655	330	350	20	315		4.36	1.25	5			1.875	2.76	59.72	0.02038	1694.90	83,165	899.46	44,134	120.34	5,905	6.12	300		
40	Test #35	PL	655	330	340	10	320		4.36	1.25	5			1.875	2.76	59.72	0.02038	1703.17	83,571	879.12	43,136	112.18	5,504	12.24	601		
41	Test #36	S	345	340	360	20	-5		4.36	1.25	5			1.875	2.76	59.72	0.02038	1715.33	84,167	748.54	36,729		0	6.12	300		
42	Test #37	S	315	330	340	10	-20		4.36	1.25	5			1.875	2.76	59.72	0.02038	1741.83	85,468	775.05	38,030		0	6.12	300		
43	Test #38	PL	1,055	350	370	20	695		4.36	1.25	5			1.875	2.76	59.72	0.02038	1696.94	83,265	1,032.03	50,639	173.37	8,507	2.04	100		
44	Test #39	PL	1,055	370	350	20	695		4.36	1.25	5			1.875	2.76	59.72	0.02038	1699.03	83,368	1,027.98	50,441	189.69	9,308	4.08	200		
45	Test #40	S	335	330	330	0	5		4.36	1.25	5			1.875	2.76	59.72	0.02038	1770.49	76,661	758.78	37,232		0	12.24	601		
46	Test #41	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1768.43	86,773	830.16	40,734		0	8.16	400		
47	Test #42	PL	1,365	0	0	0	1365		4.36	1.25	5			1.875	2.76	59.72	0.02038	1562.36	76,661	1,423.66	69,856	144.81	7,105	20.40	1,001		
48	Test #43	PL	1,165	0	0	0	1165		4.36	1.25	5			1.875	2.76	59.72	0.02038	1493.00	73,258	1,431.81	70,256	214.16	10,508	77.47	3,801		
49	Test #44	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1743.79	85,564	805.61	39,529		0	10.20	500		
50	Test #45	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1733.65	85,066	815.84	40,031		0	8.16	400		
51	Test #46	PL	1,575	0	0	0	1575		4.36	1.25	5			1.875	2.76	59.72	0.02038	1552.08	76,157	1,468.46	72,054	144.81	7,105	26.51	1,301		
52	Test #47	PL	1,575	0	0	0	1575		4.36	1.25	5			1.875	2.76	59.72	0.02038	1531.70	75,157	1,462.36	71,755	171.32	8,406	24.47	1,201		
53	Test #48	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1737.66	85,263	815.80	40,029		0	24.47	1,201		
54	Test #49	S	0	0	0	0	0		4.36	1.25	5			1.875	2.76	59.72	0.02038	1743.83	85,566	830.10	40,731		0	6.12	300		
55	Test #50	PL	1,775	0	0	0	1775		4.36	1.25	5			1.875	2.76	59.72	0.02038	1552.07	76,157	1,580.63	77,558	1,307.33	64,148	30.59	1,501		

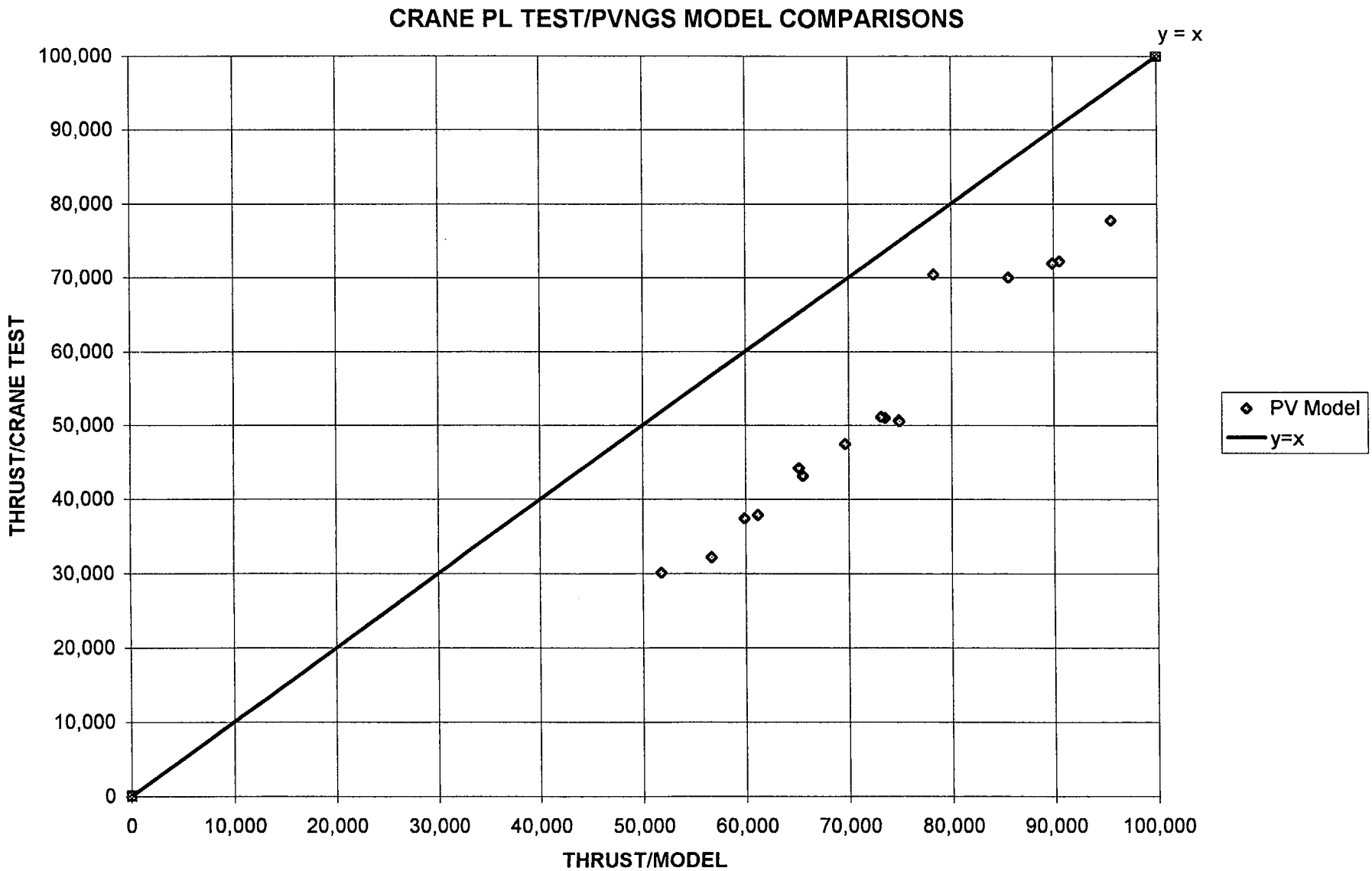
	A	D	E	F	G	H	I	J	K	L	AD	AE
3												
4		PRESSURE LOCKING CALCULATION										
5	**10"Crane 900 # Gate Valve**	SYSTEM INPUTS				VALVE INPUTS					MOV MISC INPUTS	
6		Pinitial (psig)	Pup (psig)	Pdown (psig)	Pini-Pav (psig)	a (in.)	b (in.)	theta (deg.)	nu	VF	Max Close Load (lbf)	% Residual Load at Cracking
7												
8	PRESSURE LOCKING TEST											
9	CRANE (10") test# 6	650	350	355	352.50	4.36	1.25	5	0.3	0.31	63,767	65%
10	CRANE (10") test# 7	850	360	350	355.00	4.36	1.25	5	0.3	0.31	63,670	65%
11	CRANE (10") test# 9	1,000	330	340	335.00	4.36	1.25	5	0.3	0.31	62,266	64%
12	CRANE (10") test# 10	1,040	330	340	335.00	4.36	1.25	5	0.3	0.31	62,662	64%
13	CRANE (10") test# 13	1,195	0	0	0.00	4.36	1.25	5	0.3	0.31	59,257	63%
14	CRANE (10") test# 14	1,375	0	0	0.00	4.36	1.25	5	0.3	0.31	58,254	63%
15	CRANE (10") test# 15	1,375	0	0	0.00	4.36	1.25	5	0.3	0.31	57,707	63%
16	CRANE (10") test# 34	655	330	350	340.00	4.36	1.25	5	0.3	0.31	83,165	66%
17	CRANE (10") test# 35	655	330	340	335.00	4.36	1.25	5	0.3	0.31	83,571	66%
18	CRANE (10") test# 38	1,055	350	370	360.00	4.36	1.25	5	0.3	0.31	83,265	65%
19	CRANE (10") test# 39	1,055	370	350	360.00	4.36	1.25	5	0.3	0.31	83,368	65%
20	CRANE (10") test# 42	1,365	0	0	0.00	4.36	1.25	5	0.3	0.31	76,661	64%
21	CRANE (10") test# 43	1,165	0	0	0.00	4.36	1.25	5	0.3	0.31	73,258	64%
22	CRANE (10") test# 46	1,575	0	0	0.00	4.36	1.25	5	0.3	0.31	76,157	63%
23	CRANE (10") test# 47	1,575	0	0	0.00	4.36	1.25	5	0.3	0.31	75,157	63%
24	CRANE (10") test# 50	1,775	0	0	0.00	4.36	1.25	5	0.3	0.31	76,157	63%

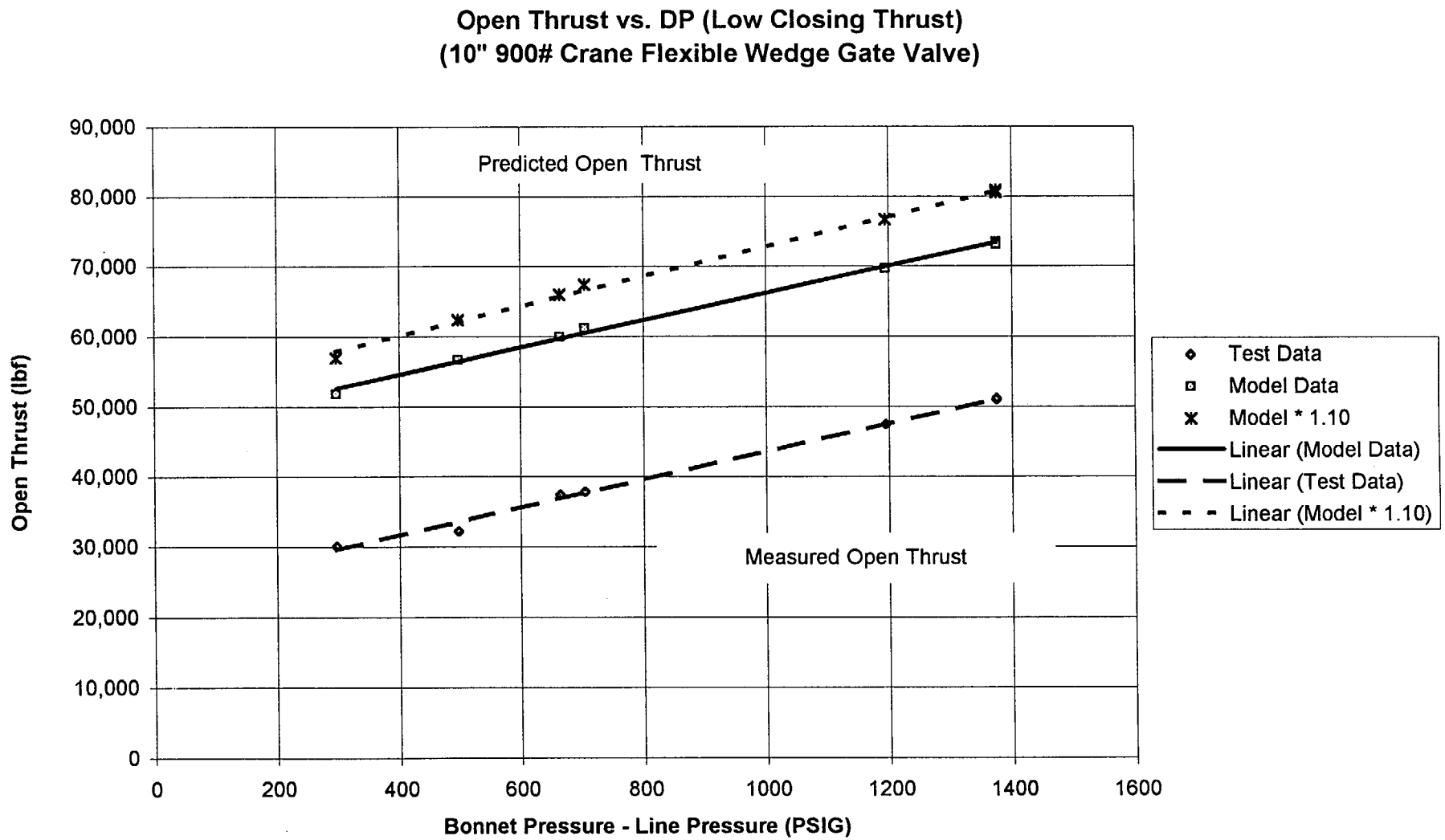
	A	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT
3												
4			**CALC**									
5	**10"Crane 900 # Gate Valve**		**DP X**	**Calculation of Disk Load Perpindicular to the Seat Using Roark Thin Plate Theory**								
6		Pfinal	**DISKS**	C2	C3	C8	C9	L11	L17	mu	Qb	Qa
7		(psig)	DPavg									
8	PRESSURE LOCKING TEST		(psig)									
9	CRANE (10") test# 6	650	298	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	1,023	-302
10	CRANE (10") test# 7	850	495	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	1,703	-502
11	CRANE (10") test# 9	1,000	665	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	2,288	-675
12	CRANE (10") test# 10	1,040	705	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	2,425	-715
13	CRANE (10") test# 13	1,195	1195	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	4,111	-1,212
14	CRANE (10") test# 14	1,375	1375	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	4,730	-1,395
15	CRANE (10") test# 15	1,375	1375	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	4,730	-1,395
16	CRANE (10") test# 34	655	315	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	1,084	-320
17	CRANE (10") test# 35	655	320	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	1,101	-325
18	CRANE (10") test# 38	1,055	695	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	2,391	-705
19	CRANE (10") test# 39	1,055	695	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	2,391	-705
20	CRANE (10") test# 42	1,365	1365	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	4,695	-1,385
21	CRANE (10") test# 43	1,165	1165	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	4,007	-1,182
22	CRANE (10") test# 46	1,575	1575	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	5,418	-1,598
23	CRANE (10") test# 47	1,575	1575	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	5,418	-1,598
24	CRANE (10") test# 50	1,775	1775	0.1781	0.0311	0.6788	0.2789	0.00687	0.1526	0.3174	6,106	-1,801

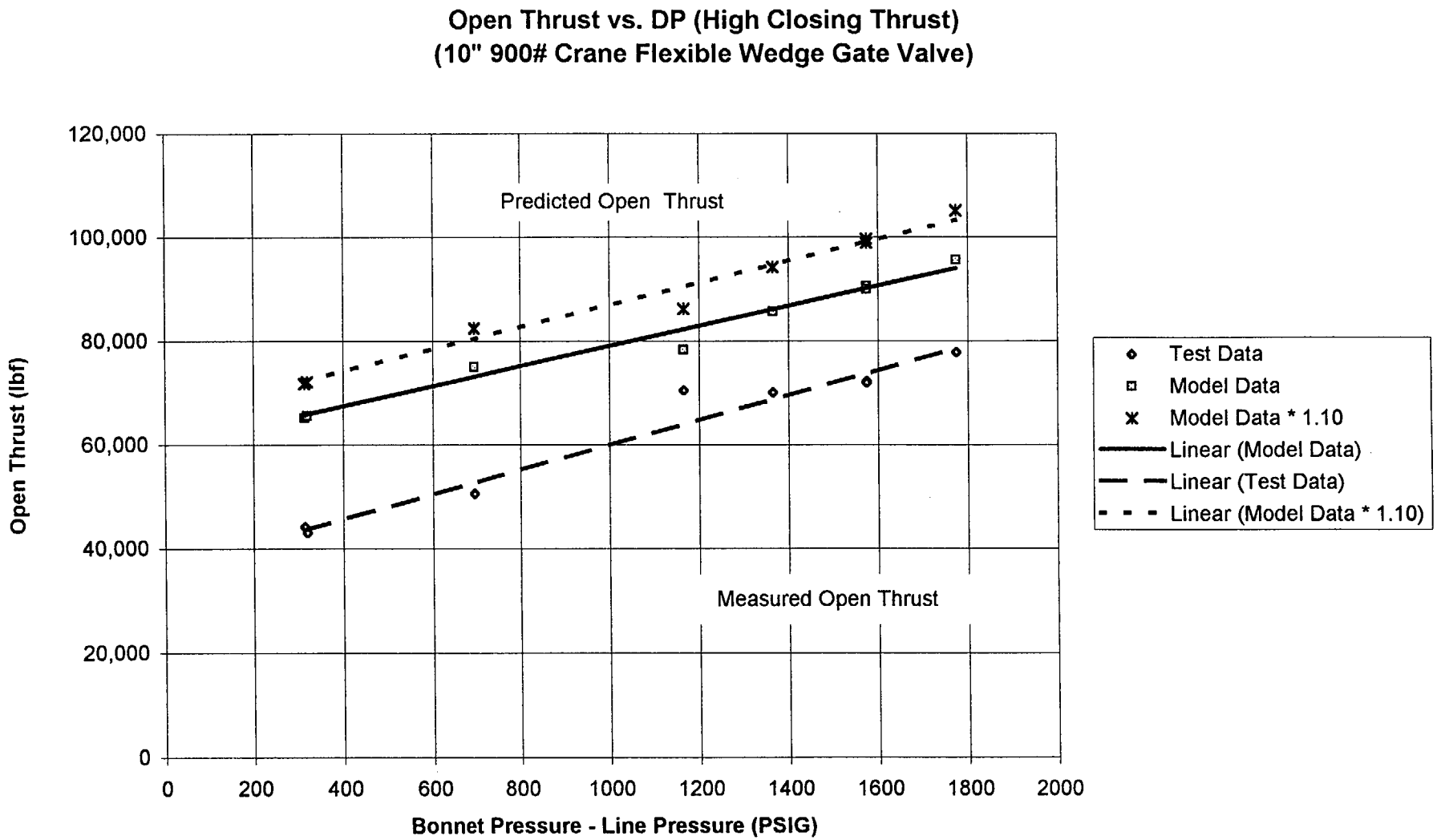
	A	AU	AV	AX	AY	AZ	BA
3		PRESSURE LOCKING CALCULATION					
4				**Residual Closing**	**Vertical Load**	**Stem piston**	**Total Stem Thrust**
5	**10"Crane 900 # Gate Valve**	**Disk Load**	**Hub Load**	**Load at Cracking**	**On Disks**	**Load**	**Req'd to Overcome**
6		w/DPavg	Pup-Pdown	Residual Load	Fvert	Fpiston	**Press Locking**
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	Ftotal
8	PRESSURE LOCKING TEST						(lbf)
9	CRANE (10") test# 6	5,249	2,673	41,592	3,097	798	51,813
10	CRANE (10") test# 7	8,734	2,692	41,178	5,153	1,043	56,714
11	CRANE (10") test# 9	11,733	2,540	39,976	6,923	1,227	59,945
12	CRANE (10") test# 10	12,439	2,540	40,172	7,339	1,276	61,214
13	CRANE (10") test# 13	21,084	-	37,621	12,440	1,466	69,679
14	CRANE (10") test# 14	24,260	-	36,635	14,314	1,687	73,522
15	CRANE (10") test# 15	24,260	-	36,269	14,314	1,687	73,156
16	CRANE (10") test# 34	5,558	2,578	54,580	3,279	804	65,191
17	CRANE (10") test# 35	5,646	2,540	54,852	3,331	804	65,565
18	CRANE (10") test# 38	12,263	2,730	53,950	7,235	1,295	74,882
19	CRANE (10") test# 39	12,263	2,730	54,019	7,235	1,295	74,951
20	CRANE (10") test# 42	24,084	-	48,985	14,210	1,675	85,604
21	CRANE (10") test# 43	20,555	-	47,054	12,128	1,430	78,307
22	CRANE (10") test# 46	27,789	-	48,282	16,396	1,933	90,534
23	CRANE (10") test# 47	27,789	-	47,612	16,396	1,933	89,864
24	CRANE (10") test# 50	31,318	-	47,934	18,478	2,178	95,551

	A	BB	BJ	BK
3				
4		**MEASURED**	**MARGIN**	**Residual Closing**
5	**10"Crane 900 # Gate Valve**	**Pressure**	**(P-M/M)x100**	**Load at Opening**
6		**Locking Load**	**%**	**(Measured Load-PL Loads)**
7		(lbf)		(lbf)
8	PRESSURE LOCKING TEST			
9	CRANE (10") test# 6	30,103	72.1	19,882
10	CRANE (10") test# 7	32,213	76.1	20,162
11	CRANE (10") test# 9	37,421	60.2	20,452
12	CRANE (10") test# 10	37,922	61.4	17,586
13	CRANE (10") test# 13	47,462	46.8	24,050
14	CRANE (10") test# 14	50,974	44.2	17,263
15	CRANE (10") test# 15	51,126	43.1	14,239
16	CRANE (10") test# 34	44,243	47.3	14,929
17	CRANE (10") test# 35	43,142	52.0	32,517
18	CRANE (10") test# 38	50,664	47.8	36,348
19	CRANE (10") test# 39	50,565	48.2	29,633
20	CRANE (10") test# 42	70,028	22.2	45,231
21	CRANE (10") test# 43	70,428	11.2	35,646
22	CRANE (10") test# 46	72,231	25.3	37,213
23	CRANE (10") test# 47	71,931	24.9	29,679
24	CRANE (10") test# 50	77,749	22.9	33,660

	A	BL	BM	BN
3				
4				
5	**10"Crane 900 # Gate Valve**	**Exp.Dimensional Corrolation** (BP*SA*mu/Closing)	**Meas. Residual % of Cracking**	**Residual % of Cracking** **Load Limit**
6				
7				
8	PRESSURE LOCKING TEST			
9	CRANE (10") test# 6	0.177	46.54%	97%
10	CRANE (10") test# 7	0.231	47.26%	97%
11	CRANE (10") test# 9	0.278	49.02%	96%
12	CRANE (10") test# 10	0.288	41.89%	96%
13	CRANE (10") test# 13	0.349	60.58%	95%
14	CRANE (10") test# 14	0.409	44.23%	94%
15	CRANE (10") test# 15	0.413	36.83%	94%
16	CRANE (10") test# 34	0.136	26.79%	98%
17	CRANE (10") test# 35	0.136	58.07%	98%
18	CRANE (10") test# 38	0.220	65.15%	97%
19	CRANE (10") test# 39	0.219	53.05%	97%
20	CRANE (10") test# 42	0.309	88.06%	95%
21	CRANE (10") test# 43	0.276	72.62%	96%
22	CRANE (10") test# 46	0.358	72.93%	95%
23	CRANE (10") test# 47	0.363	58.94%	95%
24	CRANE (10") test# 50	0.404	65.97%	94%


CRANE PL TEST/PVNGS MODEL COMPARISONS
y = x
THRUST/CRANE TEST
THRUST/MODEL
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
PV Model
y=x


Open Thrust vs. DP (Low Closing Thrust)
(10" 900# Crane Flexible Wedge Gate Valve)
Predicted Open Thrust
Measured Open Thrust
Open Thrust (lbf)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
200
400
600
800
1000
1200
1400
1600
Bonnet Pressure - Line Pressure (PSIG)
Test Data
Model Data
Model * 1.10
Linear (Model Data)
Linear (Test Data)
Linear (Model * 1.10)


Open Thrust vs. DP (High Closing Thrust)
(10" 900# Crane Flexible Wedge Gate Valve)
Predicted Open Thrust
Measured Open Thrust
Open Thrust (lbf)
120,000
100,000
80,000
60,000
40,000
20,000
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Bonnet Pressure - Line Pressure (PSIG)
Test Data
Model Data
Model Data * 1.10
Linear (Model Data)
Linear (Test Data)
Linear (Model Data * 1.10)

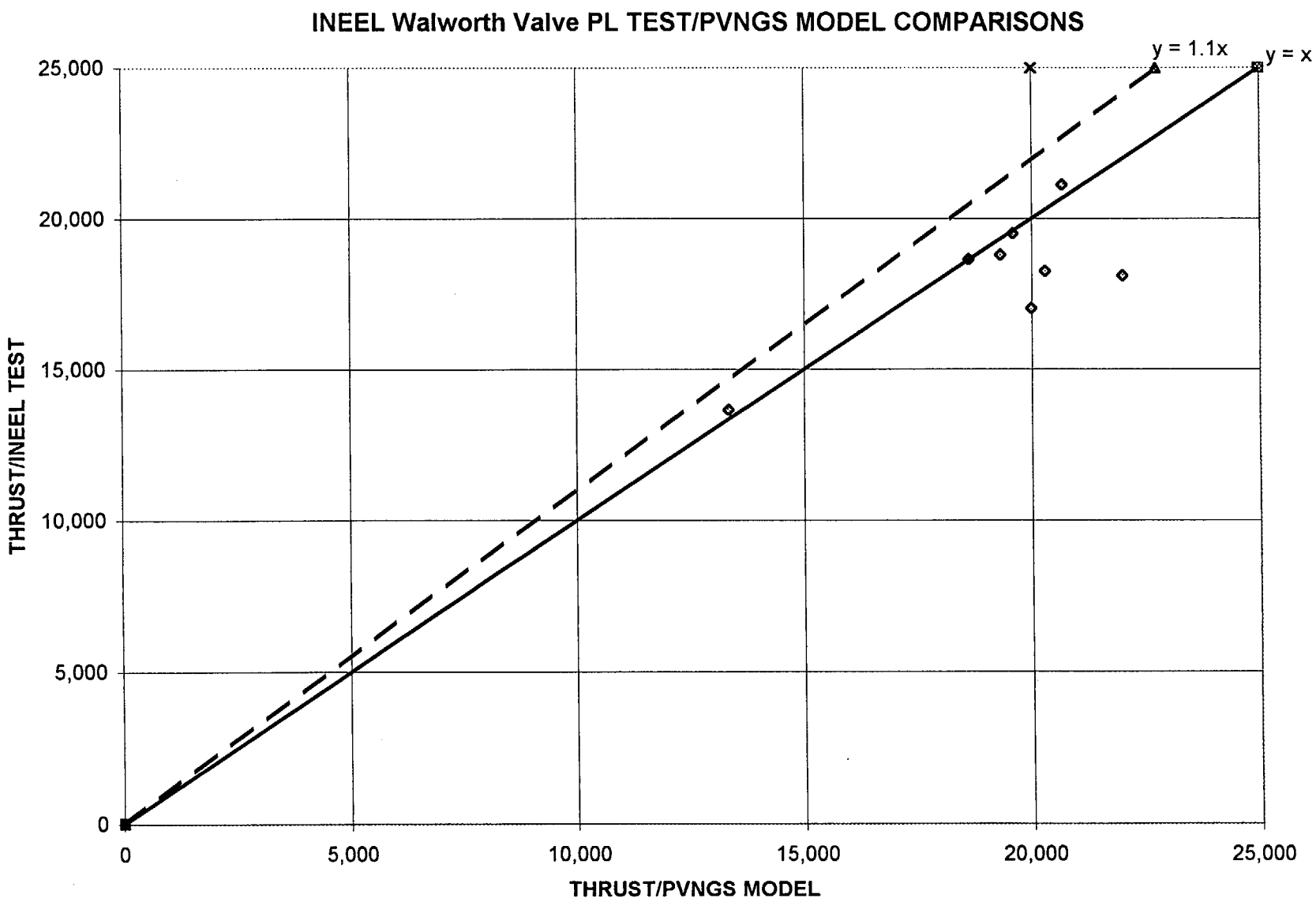
	A	B	C	D	E	F	G	H	I	J	K	AC	AD
2													
3													
4													
5	**Walworth 600 #**	**SYSTEM INPUTS**					**VALVE INPUTS**					**MOV MISC INPUTS**	
6	**Gate Valve**	Tinitial	Tfinal	Pinitial	Pup	Pdown	a	b	theta	nu	VF	Max Close	% Residual
7		(degf)	(degf)	(psig)	(psig)	(psig)	(in.)	(in.)	(deg.)			Load (lbf)	at Cracking
8	Test 226	74	74	3	1	1	2.7575	1.29	5	0.3	0.6	6,497	67%
9	Test 227	72	72	1075	1072	-4	2.7575	1.29	5	0.3	0.6	6,497	48%
10	Test 228	77	77	1039	-3	1031	2.7575	1.29	5	0.3	0.6	6,497	48%
11	**Test 229**	**73**	**73**	**495**	**-3**	**-1**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**10,537**	**61%**
12	**Test 230**	**69**	**69**	**1065**	**-3**	**-3**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**10,707**	**55%**
13	**Test 231**	**72**	**72**	**1127**	**-3**	**363**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**10,033**	**54%**
14	**Test 232**	**73**	**73**	**1056**	**318**	**-3**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**10,047**	**55%**
15	Test 233	70	70	1	-1	-2	2.7575	1.29	5	0.3	0.6	9,052	67%
16	Test 234	71	71	1012	1009	-2	2.7575	1.29	5	0.3	0.6	9,052	54%
17	Test 235	71	71	1041	-3	1034	2.7575	1.29	5	0.3	0.6	9,052	53%
18	Test 237	70	70	-2	-3	-4	2.7575	1.29	5	0.3	0.6	15,839	67%
20	**Test 307**	**203**	**203**	**1073**	**34**	**-2**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**10,299**	**55%**
21	Test 308	217	217	16	14	12	2.7575	1.29	5	0.3	0.6	9,484	67%
22	Test 309	190	190	1024	1022	-2	2.7575	1.29	5	0.3	0.6	9,484	54%
23	Test 310	187	187	922	0	916	2.7575	1.29	5	0.3	0.6	9,484	56%
24	Test 312	71	71	207	200	196	2.7575	1.29	5	0.3	0.6	8,755	64%
25	Test 313	69	69	1056	1053	5	2.7575	1.29	5	0.3	0.6	8,755	53%
26	Test 314	67	67	1062	6	1055	2.7575	1.29	5	0.3	0.6	8,755	53%
27	**Test 316**	**205**	**205**	**1141**	**-1**	**-3**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**11,289**	**55%**
28	Test 317	179	179	9	9	8	2.7575	1.29	5	0.3	0.6	9,558	67%
29	Test 318	181	181	1061	1059	-4	2.7575	1.29	5	0.3	0.6	9,558	54%
30	Test 319	182	182	1010	-3	1003	2.7575	1.29	5	0.3	0.6	9,558	55%
31	Test 322	69	69	44	41	57	2.7575	1.29	5	0.3	0.6	7,615	66%
32	Test 323	67	67	1007	1004	44	2.7575	1.29	5	0.3	0.6	7,615	51%
33	Test 324	76	76	1015	39	1009	2.7575	1.29	5	0.3	0.6	7,615	51%
34	Test 325	71	71	49	46	44	2.7575	1.29	5	0.3	0.6	5,887	66%
35	Test 326	66	66	1100	1097	-4	2.7575	1.29	5	0.3	0.6	5,887	45%
36	Test 327	70	70	1073	-3	1066	2.7575	1.29	5	0.3	0.6	5,887	46%
37	**Test 329**	**125**	**125**	**1105**	**35**	**-3**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**9,250**	**53%**
38	Test 330	148	148	42	67	55	2.7575	1.29	5	0.3	0.6	7,496	66%
39	Test 331	136	136	1083	1080	-4	2.7575	1.29	5	0.3	0.6	7,496	50%
40	Test 332	133	133	1047	-2	1040	2.7575	1.29	5	0.3	0.6	7,496	51%
41	Test 341	66	66	1119	-1	1114	2.7575	1.29	5	0.3	0.6	7,496	49%
42	Test 342	70	70	2	1	2	2.7575	1.29	5	0.3	0.6	8,842	67%
43	**Test 343**	**65**	**65**	**1050**	**2**	**3**	**2.7575**	**1.29**	**5**	**0.3**	**0.6**	**9,512**	**54%**

	A	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
2												
3												
4												
5	**Walworth 600 #**	**DP X DISKS**		**Calculation of Disk Load Perpindicular to the Seat Using Roark Thin Plate Theory**								
6	**Gate Valve**	Pfinal	DPavg	C2	C3	C8	C9	L11	L17	mu	Qb	Qa
7		(psig)	(psig)									
8	Test 226	3	2	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	2	-1
9	Test 227	1,075	541	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	671	-269
10	Test 228	1,039	525	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	652	-261
11	**Test 229**	**495**	**497**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**617**	**-247**
12	**Test 230**	**1,065**	**1068**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,325**	**-530**
13	**Test 231**	**1,127**	**947**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,175**	**-470**
14	**Test 232**	**1,056**	**899**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,115**	**-446**
15	Test 233	1	3	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	3	-1
16	Test 234	1,012	509	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	631	-252
17	Test 235	1,041	526	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	652	-261
18	Test 237	-2	2	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	2	-1
20	**Test 307**	**1,073**	**1057**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,312**	**-525**
21	Test 308	16	3	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	4	-1
22	Test 309	1,024	514	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	638	-255
23	Test 310	922	464	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	576	-230
24	Test 312	207	9	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	11	-4
25	Test 313	1,056	527	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	654	-262
26	Test 314	1,062	532	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	660	-264
27	**Test 316**	**1,141**	**1143**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,418**	**-567**
28	Test 317	9	1	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1	0
29	Test 318	1,061	534	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	662	-265
30	Test 319	1,010	510	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	633	-253
31	Test 322	44	-5	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	-6	2
32	Test 323	1,007	483	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	599	-240
33	Test 324	1,015	491	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	609	-244
34	Test 325	49	4	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	5	-2
35	Test 326	1,100	554	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	687	-275
36	Test 327	1,073	542	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	672	-269
37	**Test 329**	**1,105**	**1089**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,351**	**-541**
38	Test 330	42	-19	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	-24	9
39	Test 331	1,083	545	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	676	-271
40	Test 332	1,047	528	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	655	-262
41	Test 341	1,119	563	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	698	-279
42	Test 342	2	1	0.1122	0.0169	0.7266	0.2950	0.00251	0.0996	0.6307	1	0
43	**Test 343**	**1,050**	**1048**	**0.1122**	**0.0169**	**0.7266**	**0.2950**	**0.00251**	**0.0996**	**0.6307**	**1,300**	**-520**

	A	AT	AU	AW	AX	AY	AZ
2		PRESSURE LOCKING CALCULATION					
3							Total Stem Thrust
4				Residual Closing	Vertical Load	Stem piston	Req'd to Overcome
5	Walworth 600 #	Disk Load	Hub Load	Load at Cracking	On Disks	Load	Press Locking
6	Gate Valve	w/DPavg	Pup-Pdown	Residual Load	Fvert	Fpiston	Ftotal
7		(lbf)	(lbf)	(lbf)	(lbf)	(lbf)	(lbf)
8	Test 226	22	6	4,349	8	4	4,382
9	Test 227	5,870	3,218	3,086	2,253	1,319	13,108
10	Test 228	5,696	3,098	3,129	2,186	1,275	12,834
11	**Test 229**	**5,392**	**12**	**6,477**	**2,069**	**607**	**13,343**
12	**Test 230**	**11,588**	**18**	**5,919**	**4,447**	**1,307**	**20,665**
13	**Test 231**	**10,275**	**1,085**	**5,394**	**3,943**	**1,383**	**19,314**
14	**Test 232**	**9,749**	**949**	**5,487**	**3,741**	**1,296**	**18,631**
15	Test 233	27	9	6,064	10	1	6,109
16	Test 234	5,517	3,034	4,873	2,117	1,242	14,300
17	Test 235	5,702	3,107	4,838	2,188	1,277	14,557
18	Test 237	16	21	10,614	6	2	10,656
20	**Test 307**	**11,469**	**96**	**5,636**	**4,401**	**1,317**	**20,286**
21	Test 308	33	78	6,335	12	20	6,439
22	Test 309	5,577	3,073	5,147	2,140	1,257	14,682
23	Test 310	5,034	2,760	5,268	1,932	1,131	13,863
24	Test 312	98	1,193	5,622	37	254	6,696
25	Test 313	5,718	3,188	4,622	2,194	1,296	14,426
26	Test 314	5,767	3,197	4,615	2,213	1,303	14,488
27	**Test 316**	**12,402**	**12**	**6,219**	**4,759**	**1,400**	**21,992**
28	Test 317	5	51	6,393	2	11	6,441
29	Test 318	5,789	3,179	5,154	2,221	1,302	15,041
30	Test 319	5,534	3,013	5,214	2,124	1,239	14,645
31	Test 322	-54	295	5,050	21	54	5,258
32	Test 323	5,241	3,158	3,915	2,011	1,236	13,089
33	Test 324	5,327	3,158	3,906	2,045	1,246	13,190
34	Test 325	43	271	3,886	17	60	4,157
35	Test 326	6,006	3,293	2,648	2,305	1,350	12,902
36	Test 327	5,875	3,203	2,680	2,255	1,317	12,696
37	**Test 329**	**11,816**	**96**	**4,896**	**4,535**	**1,356**	**19,986**
38	Test 330	-206	368	4,973	79	52	5,162
39	Test 331	5,913	3,242	3,746	2,269	1,329	13,842
40	Test 332	5,729	3,128	3,788	2,199	1,285	13,559
41	Test 341	6,103	3,354	3,704	2,342	1,373	14,129
42	Test 342	5	9	5,922	2	2	5,936
43	**Test 343**	**11,365**	**15**	**5,136**	**4,362**	**1,289**	**19,590**

	A	BI	BJ	BK
2				
3		**MEASURED**	**MARGIN**	**Residual Closing**
4		**Pressure**	**(P-M/M)**	**Load at Opening**
5	**Walworth 600 #**	**Locking Load**	***100%**	**(Measured Load-PL Loads)**
6	**Gate Valve**	(lbf)		(lbf)
7				
8	Test 226	4,353	0.7	4,321
9	Test 227	14,590	-10.2	4,568
10	Test 228	14,612	-12.2	4,907
11	**Test 229**	**13,652**	**-2.3**	**6,785**
12	**Test 230**	**21,132**	**-2.2**	**6,386**
13	**Test 231**	**18,798**	**2.7**	**4,878**
14	**Test 232**	**18,634**	**0.0**	**5,491**
15	Test 233	6,065	0.7	6,020
16	Test 234	14,177	0.9	4,750
17	Test 235	14,778	-1.5	5,059
18	Test 237	10,612	0.4	10,571
20	**Test 307**	**18,251**	**11.1**	**3,601**
21	Test 308	6,354	1.3	6,250
22	Test 309	11,895	23.4	2,361
23	Test 310	10,429	32.9	1,834
24	Test 312	5,866	14.2	4,792
25	Test 313	11,226	28.5	1,421
26	Test 314	12,142	19.3	2,268
27	**Test 316**	**18,096**	**21.5**	**2,323**
28	Test 317	6,404	0.6	6,356
29	Test 318	12,108	24.2	2,221
30	Test 319	12,703	15.3	3,272
31	Test 322	5,102	3.1	4,894
32	Test 323	11,936	9.7	2,762
33	Test 324	12,636	4.4	3,352
34	Test 325	3,944	5.4	3,673
35	Test 326	14,801	-12.8	4,547
36	Test 327	15,256	-16.8	5,240
37	**Test 329**	**17,010**	**17.5**	**1,919**
38	Test 330	5,022	2.8	4,833
39	Test 331	14,893	-7.1	4,797
40	Test 332	15,242	-11.0	5,472
41	Test 341	15,742	-10.2	5,316
42	Test 342	5,924	0.2	5,910
43	**Test 343**	**19,501**	**0.5**	**5,047**

	A	BL	BM	BN	BO
2					
3		**Exp.Dimensional Corrolation**	**Meas. Residual % of Cracking**	**Residual % of Cracking**	**LOADING TYPE**
4		(BP*SA*mu/Closing)		**Load Limit**	
5	**Walworth 600 #**				
6	**Gate Valve**				
7					
8	Test 226	0.005	99.26%	100%	S
9	Test 227	1.940	104.95%	71%	HD
10	Test 228	1.875	112.73%	72%	HU
11	**Test 229**	**0.551**	**96.11%**	**92%**	**PL**
12	**Test 230**	**1.166**	**89.02%**	**83%**	**PL**
13	**Test 231**	**1.317**	**72.57%**	**80%**	**PL**
14	**Test 232**	**1.232**	**81.57%**	**82%**	**PL**
15	Test 233	0.001	99.25%	100%	S
16	Test 234	1.311	78.32%	80%	HD
17	Test 235	1.348	83.41%	80%	HU
18	Test 237	-0.001	99.61%	100%	S
20	**Test 307**	**1.221**	**52.19%**	**82%**	**PL**
21	Test 308	0.020	98.37%	100%	S
22	Test 309	1.266	37.16%	81%	HD
23	Test 310	1.140	28.86%	83%	HU
24	Test 312	0.277	81.69%	96%	S
25	Test 313	1.414	24.23%	79%	HD
26	Test 314	1.422	38.67%	79%	HU
27	**Test 316**	**1.185**	**30.71%**	**82%**	**PL**
28	Test 317	0.011	99.26%	100%	S
29	Test 318	1.301	34.68%	80%	HD
30	Test 319	1.239	51.09%	81%	HU
31	Test 322	0.068	95.93%	99%	S
32	Test 323	1.550	54.14%	77%	HD
33	Test 324	1.563	65.70%	77%	HU
34	Test 325	0.098	93.13%	99%	S
35	Test 326	2.191	115.29%	67%	HD
36	Test 327	2.137	132.85%	68%	HU
37	**Test 329**	**1.401**	**30.97%**	**79%**	**PL**
38	Test 330	0.066	96.24%	99%	S
39	Test 331	1.694	95.52%	75%	HD
40	Test 332	1.638	108.95%	75%	HU
41	Test 341	1.750	105.86%	74%	HU
42	Test 342	0.003	99.76%	100%	S
43	**Test 343**	**1.294**	**79.20%**	**81%**	**PL**


INEEL Walworth Valve PL TEST/PVNGS MODEL COMPARISONS
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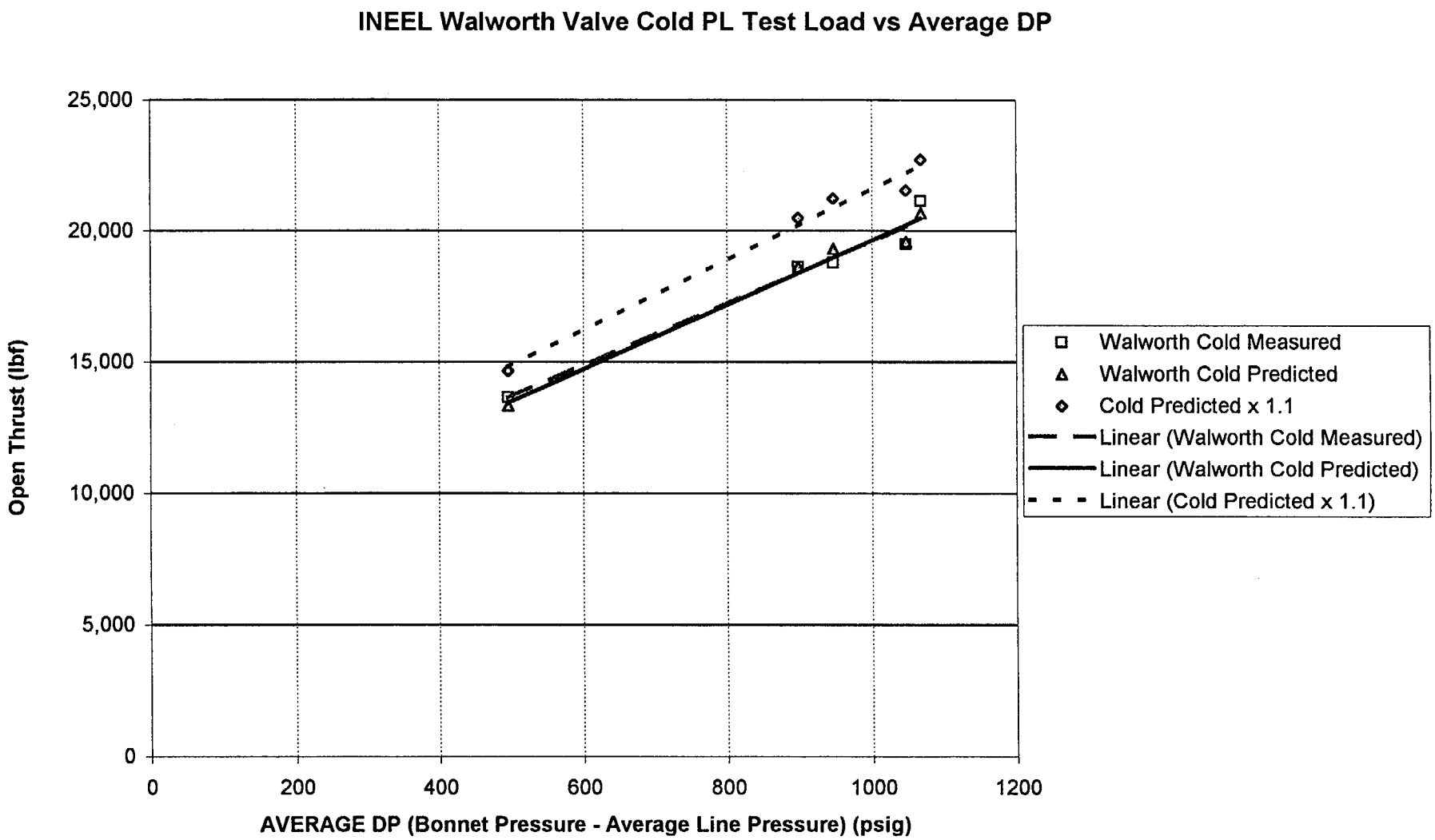
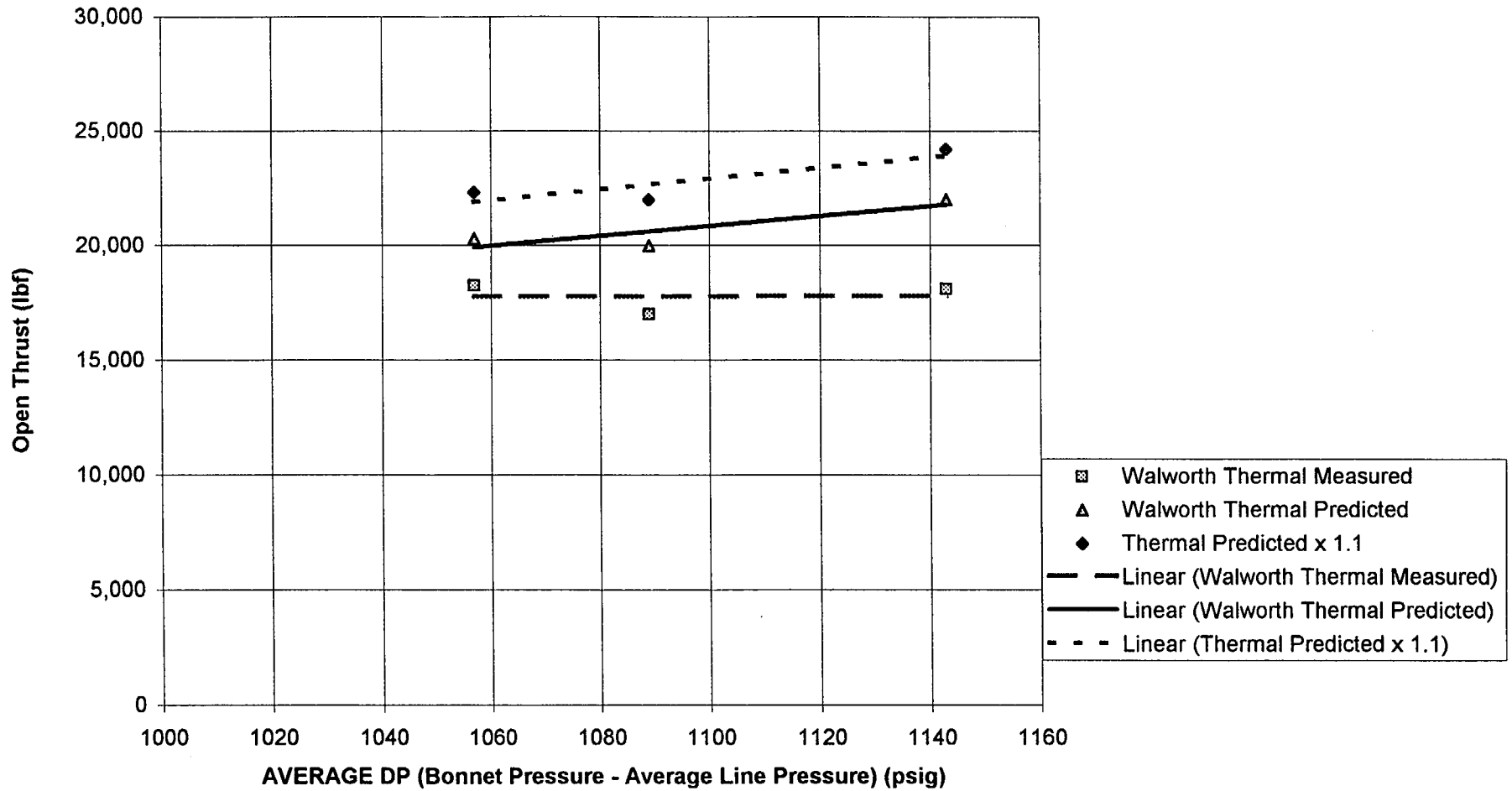
y = x
25,000
20,000
15,000
10,000
5,000
0
THRUST/INEEL TEST
0
5,000
10,000
15,000
20,000
25,000
THRUST/PVNGS MODEL


INEEL Walworth Valve Cold PL Test Load vs Average DP
Open Thrust (lbf)
25,000
20,000
15,000
10,000
5,000
0
0
200
400
600
800
1000
1200
AVERAGE DP (Bonnet Pressure - Average Line Pressure) (psig)
Walworth Cold Measured
Walworth Cold Predicted
Cold Predicted x 1.1
Linear (Walworth Cold Measured)
Linear (Walworth Cold Predicted)
Linear (Cold Predicted x 1.1)

INEEL Walworth Valve Thermal PL Test Load vs Average DP