Rochester Gas & Electric Corporation
Ginna Station

Motor-Operated Valve Qualification Program Plan

Calculation Assumption Verification Criteria

EWR 5111

ATTACHMENT K

Revision 1

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1. Introduction

NRC Generic Letter 89-10, "Safety-Related Motor Operated Valve Testing and Surveillance" requires that the correct switch settings be established and maintained for all Safety-Related MOVs at each nuclear plant. In establishing the correct switch settings, the NRC staff expects licensees to validate their assumptions for determining thrust and torque requirements. Validation of assumptions should be based on the best available MOV test data. The NRC considers the best available MOV test data (in order of reliability) to be:

Valve-specific data
Plant-specific data
EPRI test data
Industry test data

The NRC has also recommended that each MOV be demonstrated to be operable by testing it at the design basis conditions if practicable. Where it is not practicable to test a MOV under sufficient dynamic conditions to demonstrate design-basis capability, engineering or statistical methods to determine appropriate assumptions for such parameters as valve and stem friction, and load sensitive behavior from other MOVs, where justified, could be used.

The importance of adequately justifying the methods to demonstrate MOV operability was reiterated in NRC Information Notice 97-07, "Problems Identified During Generic Letter 89-10 Closeout Inspections".

2. Purpose

The purpose of this document is to determine and justify interim and long term valve factors used to calculate the minimum required thrust to open and close each Ginna Station Generic Letter (GL) 89-10 Motor-Operated Gate and Globe Valve under design basis conditions. In addition, bounding values to account for Load Sensitive Behavior (Rate Of Loading) Effect and Stem Coefficient of Friction are determined and justified in this attachment.

This document will also discuss methods for evaluating measured packing load data.

3. Analysis of Valve Factors and Required Thrust Methodology

Per reference 1, the forces that the actuator must over come to open or close a gate or unbalanced disc globe valve under design basis conditions are:

DP Thrust - this force due to the effect of differential pressure across the valve. It includes direct fluid forces acting on the disc, and friction forces developed in the valve internals.

Piston Effect Thrust - the force due to internal line pressure acting on the valve stem. This force opposes stem movement in the close direction and assists stem movement in the open direction.

Packing Friction - the force needed to slide the stem through the packing.

Deadweight - weight of the valve stem and disc (typically negligible).

Torque Arm Friction - the torque in the stem is reacted in the valve by surfaces which engage and slide. This torque reaction causes a friction load which opposes stem motion.

With the exception of the DP Thrust, these forces can be conservatively predicted with a high degree of confidence. Unfortunately, the DP thrust is typically the dominant contributor to the required thrust. In addition to the design basis DP, valve internal geometry and friction between the internal components significantly affect the DP thrust.

In order to accurately determine the DP thrust component a MOV test under DP conditions with highly accurate measuring equipment has to be performed. Due to operating and safety constraints, it is not practical to test all Safety-Related MOVs under DP conditions. Therefore, an analytical method is used to conservatively predict the force due to DP. For consistency and to encompass the possibility of degradation in valve performance due to aging, the analytical method is used for all 89-10 MOVs. There are two generally accepted analytical methods to calculate required thrust, the "standard industry equation", and the EPRI Performance Prediction Methodology (EPRI PPM).

Standard Industry Equation (Valve Factor Methodology)

Historically, the required thrust to open or close a Motor-Operated Gate or Globe Valve was calculated by use of the "standard industry equation" and a valve factor as shown below.

Required Thrust = DP Thrust + Piston Effect Thrust + Packing Friction

where

DP Thrust = (Valve Factor)(Differential Pressure)(Orifice Area)

Since the contributions of the deadweight and torque arm friction are typically small in comparison to the other forces, these are neglected in the "standard industry equation." As stated previously, the DP Thrust is significantly affected by variables such as valve internal geometry and friction between the internal components. In the "standard industry equation", the valve factor is used to account for variations in friction and internal tolerances.

Some of the advantages of using the "standard industry equation" to calculate required thrust are:

- ease of use
- familiarity
- small number of design inputs which are readily available

Some of the disadvantages of using the "standard industry equation" to calculate required thrust are:

- Valve factors have been found to vary significantly from valve to valve.
- It is difficult to ensure a conservative valve factor is selected without an adequate amount of test data.
- The effect of age related degradation on the valve factor is not widely known at this time.

EPRI Performance Prediction Methodology (EPRI PPM)

More recently, the Electric Power Research Institute (EPRI) has developed improved methods for predicting the performance of gate and globe valves under dynamic conditions. EPRI performed numerous valve tests to provide data for model development and validation. EPRI integrated the individual models and methods into an overall methodology including a computer model for most gate and globe valves and hand calculation models for certain gate valves.

The NRC staff issued a Safety Evaluation approving the EPRI PPM for predicting the thrust requirements with respect to the EPRI computer and hand-calculation models for gate and globe valves provided they are developed in accordance with the conditions and limitations contained in the NRC Safety Evaluation.

Some of the advantages of using the EPRI PPM to calculate required thrust are:

- Determines a bounding value of required thrust.
- Considers the effect of flow and internal valve configuration.
- Bounding prediction encompasses future degradation.

Some of the disadvantages of using the EPRI PPM to calculate required thrust are:

- Requires a large number of design inputs which are typically not readily available.
- The required thrust prediction often seems excessively conservative for low temperature pumped flow valves when compared to plant test data.
- The user must be trained in use of EPRI computer software and consider limitations in the NRC SER.

Applicability to RG&E MOV Qualification Program

The purpose of the RG&E MOV Qualification Program is to ensure the reliable operation of MOVs in safety-related systems at Ginna Station. Therefore, it is essential that the methodology used to calculate required thrust provide a high level of confidence that safety-related MOVs will perform their intended functions.

Due to its ease of use and familiarity, the standard industry equation remains the preferred method to determine required thrust for GL 89-10 gate and globe MOVs. However, if the available Ginna test data is not sufficient to provide a high level of confidence that the valve factor for any particular valve is conservative, additional dynamic test data should be obtained at the earliest practicable opportunity (i.e. Refueling Outage, work window, etc.). If dynamic testing can not be performed or is not desirable, efforts should be initiated to obtain valve factor data from similar valves under similar operating conditions, or procure the PPM design inputs and perform the PPM calculation at the earliest practicable opportunity.

Whether or not a valve factor can be considered sufficient for "long term" use will be determined based on the following criteria:

The valve factor is based on satisfactory Ginna dynamic testing of the subject valve and includes a provision for future degradation.

The valve factor for a non-dynamic tested valve is based on satisfactory Ginna dynamic testing of at least 2 or 30% of the total number of identical valves with similar operating conditions and includes a provision for future degradation.

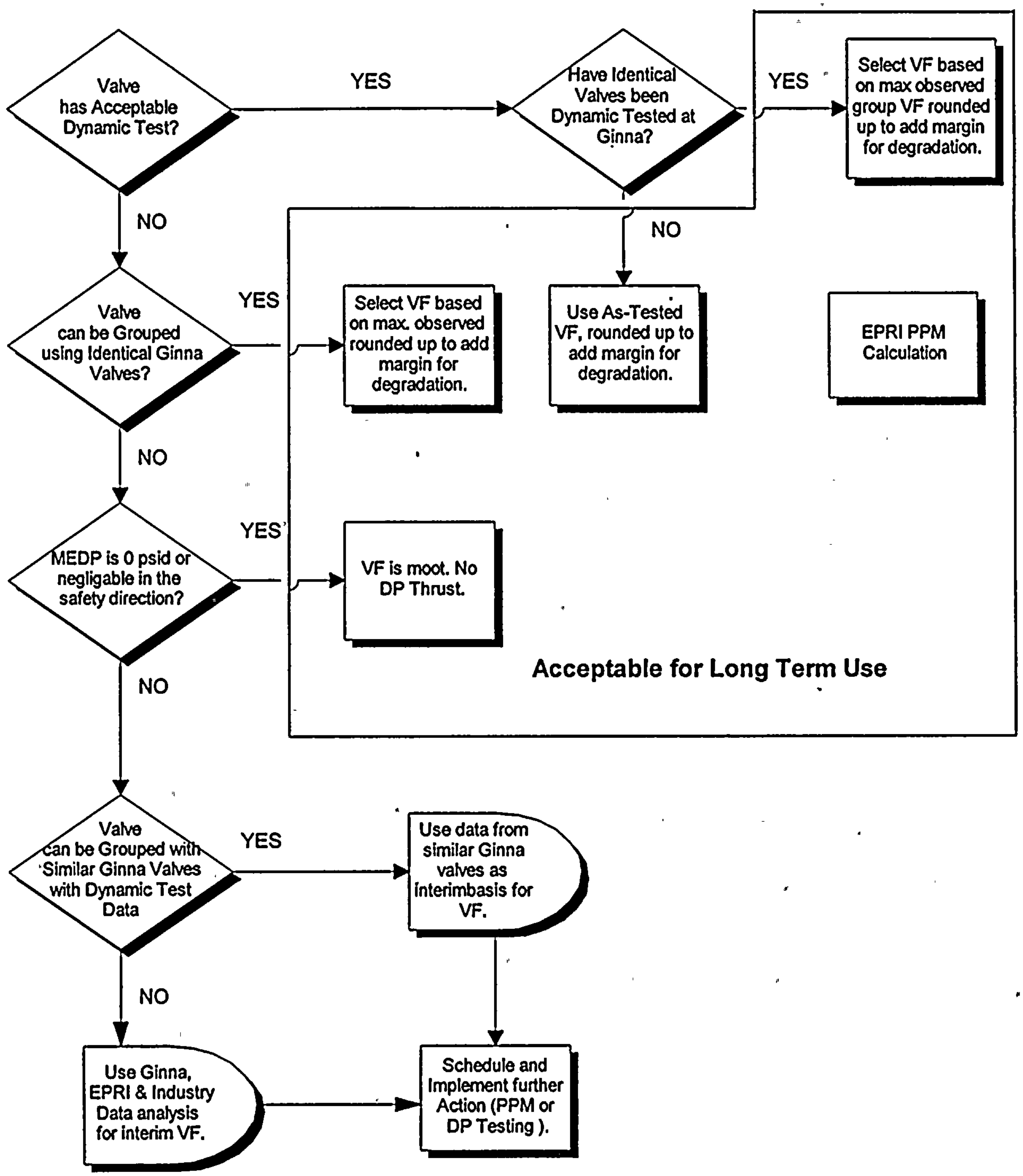
The design basis DP in the safety direction is 0 psid or negligible, in which case the differential pressure thrust is 0 and the value of the applied valve factor is moot.

The process to determine acceptable long term and interim valve factors is shown in figure 1. If one of the above conditions is not met, only an interim valve factor may be assigned, and additional action (further testing or the EPRI PPM) will be required. It should be noted that the design basis system conditions must be similar (i.e. system fluid, flow rate, DP's) in order apply the results of Ginna dynamic test data of identical valves to non-dynamic tested valves. In addition, close valve factors are determined based on achieving flow isolation in certain cases and hardseating in other cases as appropriate based on the leakage requirements for the subject valve.

Margin for future degradation is incorporated in selected long term valve factors that are based on Ginna test data by rounding the maximum adjusted valve factor to the next highest 0.05 value (as a minimum). This method of accounting for valve factor degradation will be confirmed or refined when results of the Joint Owner's Group (JOG) Program on MOV Periodic Verification methodology become available. *For* *the purposes of MOV operability assessments, it is considered acceptable to use the as-tested valve factor for a MOV which has been DP tested, provided the effect of measurement uncertainties on the as-tested valve factor are accounted for.*

Since a significant amount of time is required to implement the dynamic testing, data evaluations, or EPRI PPM calculations, an interim position is needed. For the near term, MOV design basis will be based on the "standard industry equation" and conservative valve factors based on an analysis of Ginna, EPRI and industry test results on identical and similar valves. Valve similarity is based on a comparison of manufacturer, seating surface materials, operating conditions, pressure class, and valve size. Slight variations in size, pressure class, and operating conditions were considered to be acceptable when applying the test results of similar valves to justify interim valve factors.

It should be noted that less conservative valve factor values and other means are available to demonstrate short-term operability of MOVs in this category. The interim valve factors are considered to be conservative, and it is expected that additional dynamic testing or PPM calculations will demonstrate this. Hence, the interim values could become the long term values when sufficient test data is obtained to further justify the values.



NOTES:

1) In no instance will a Valve Factor less than 0.30 be used in Thrust Calculations.
2) The maximum as-tested valve facors will be rounded up to provide margin for degradation.

Figure 1: Process to Determine Long Term and Interim Valve Factors

Acceptability of Ginna DP Tests

The available dynamic test data traces were reviewed in reference 24 to determine if adequate DP thrust was measured to accurately determine a valve factor. Based on the review in reference 24 and Attachment K-2, acceptable test data for calculating valve factors was available on 15 gate valves and 3 globe valves.

In addition, reference 4 provides guidelines for evaluating the acceptability of in-situ DP tests. Figures 8-1 through 8-5 provides a minimum acceptable DP based on the valve pressure class, test DP, and mean seat area. In addition, the test DP should be greater than 33% of the design basis DP. The minimum acceptable test graphs (from reference 4) with the Ginna DP test data are shown in Figures 4-7 below.

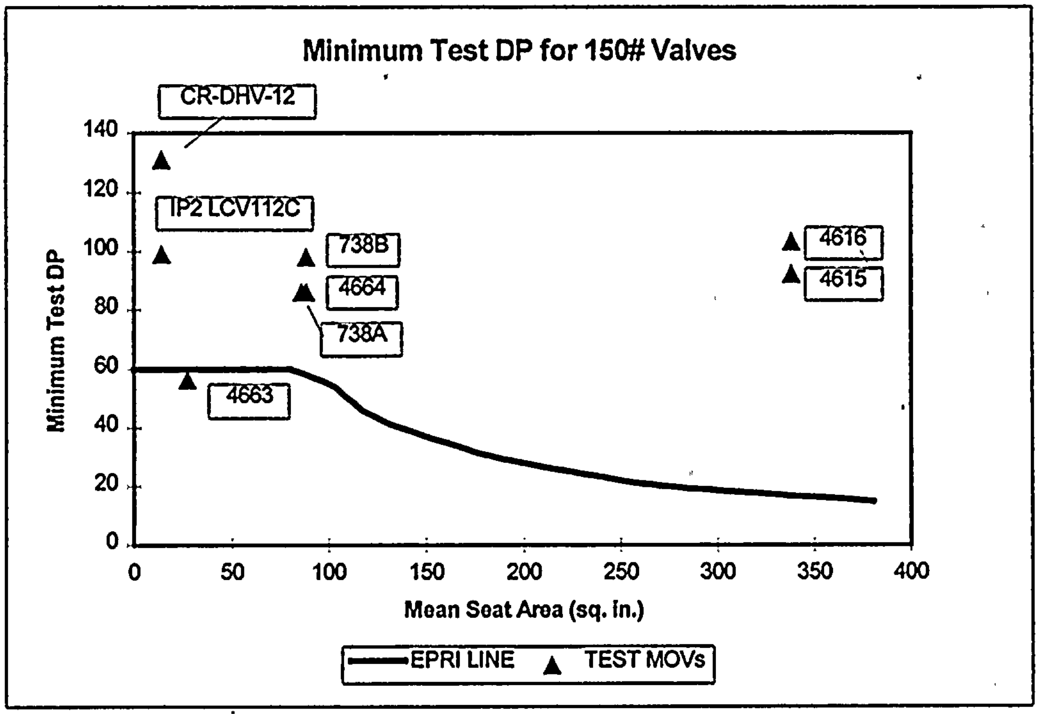


Figure 2: 150# Class Valve DP Tests

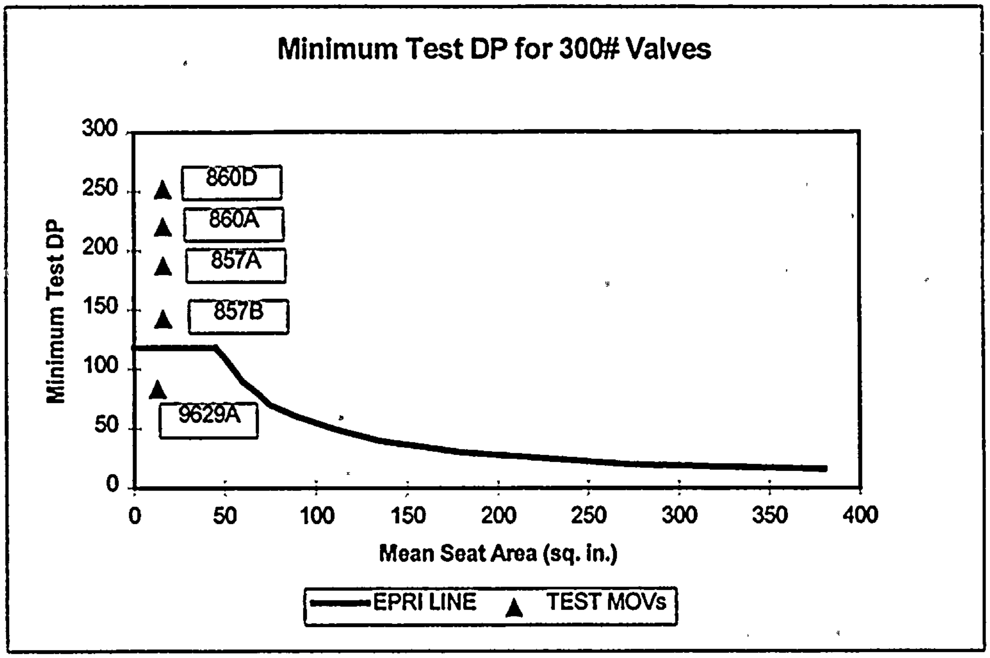


Figure 3: 300# Class Valve DP Tests

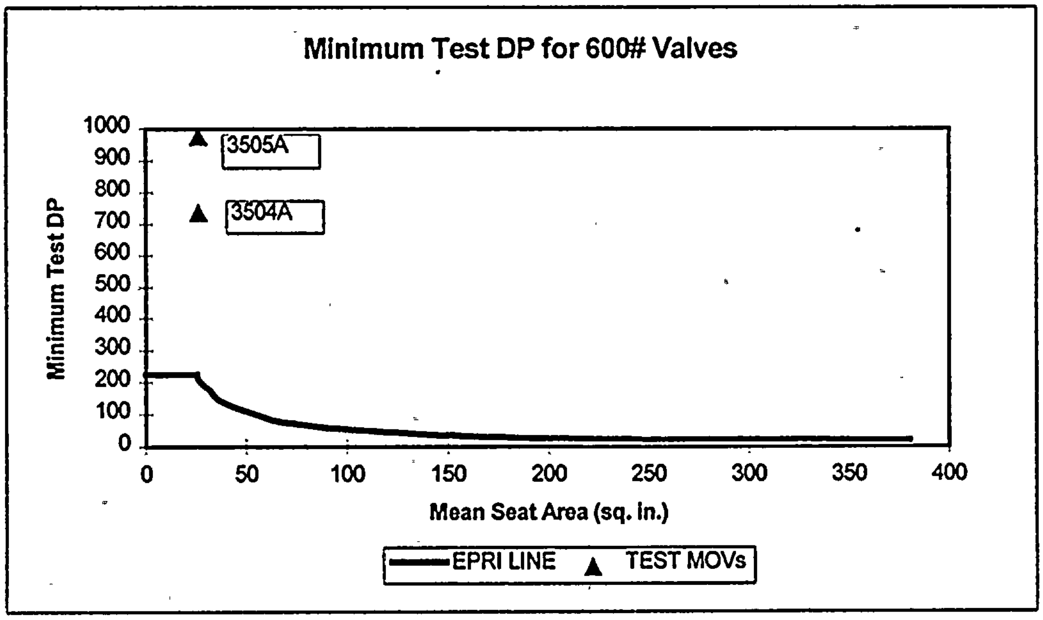


Figure 4: 600# Class Valve DP Tests

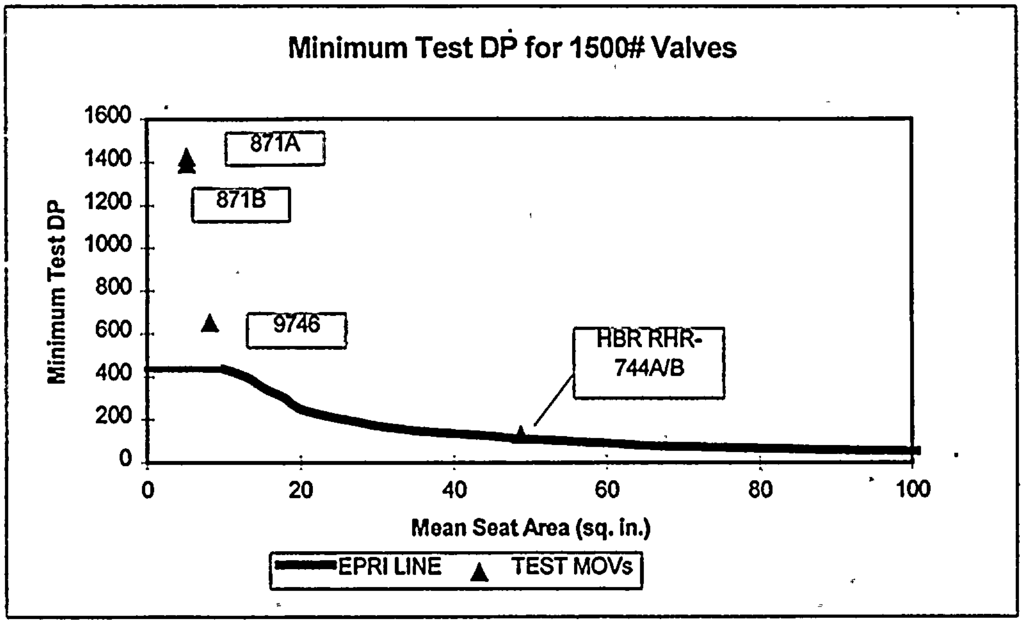


Figure 5: 1500# Class Valve DP Tests

From figures 4 through 7, the DP tests of 4663, and 9629A did not meet the EPRI minimum acceptable test DP. Valve 4663 was tested at 56 psid (59% of the design basis DP). The minimum EPRI test pressure for 150# class valves is 60 psid, which is a mere 4 psi more than the test pressure for 4663. Since the design basis DP for 4663 is only 95 psid and the test was performed by use of a system alignment similar to the design basis condition, the 56 psid DP test is considered to be acceptable for use on 4663. However, the results will not be used to assess the performance of other valves.

Valve 9629A was tested at 87% of the design basis DP, however, the EPRI acceptance criteria was not met. A review of figure 5 indicates that the design basis condition of 95 psid is also below the minimum EPRI criteria. Therefore, the test results for this valve are considered to be acceptable, since it reasonably approximated the design basis condition.

All other Ginna DP tests deemed acceptable in reference 24 were performed at greater than 33% of the design basis DP and met the minimum EPRI test DP criteria.

Analysis of Ginna Valve Factor Test Data

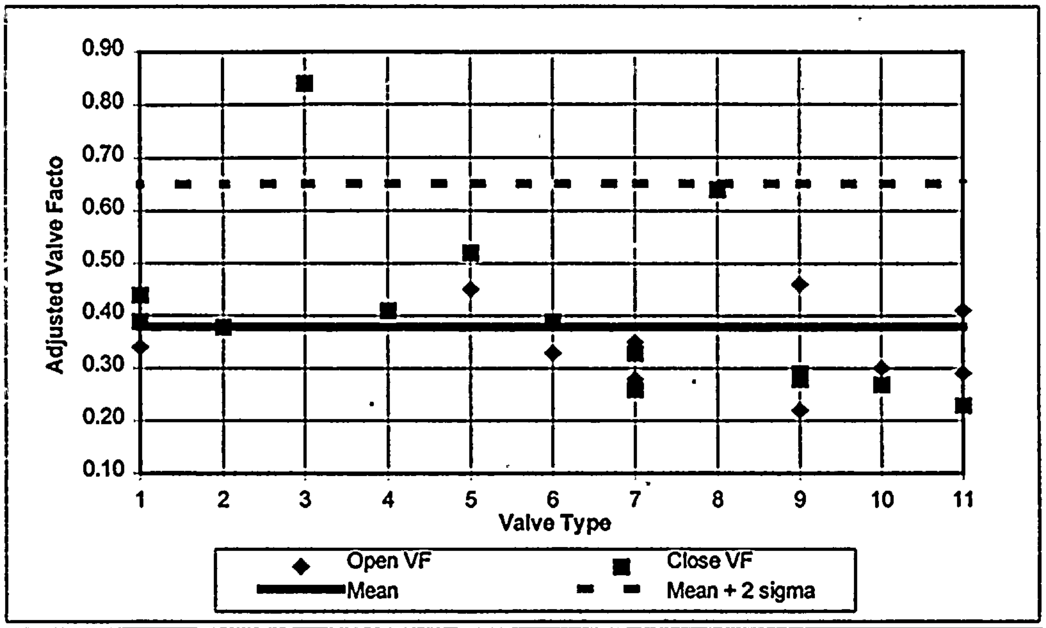
Reliable DP test thrust data for calculating valve factors was available on 15 gate MOVs (two of which were a DD gate). With the exception of MOVs 3504A/3505A, all tests were performed with low temperature water in the system. DP test data was also available for the Fisher, balanced disc globe valves (9701A/B) and Rockwell Stop Check Valves (3976/3977). Table 1 and Figure 2 summarize the available Ginna open and close valve factor test data for gate valves. The mean and mean + 2 sample standard deviations (mean + 2 sigma) values were calculated for the available Ginna gate valve factor data. The results of the analysis and the distribution of the Ginna Valve Factor data is shown in figure 3.

MOV	Valve Manufacturer	Valve Pressure Class, Size & Type	Open Valve Factor	Close Valve Factor
857A	Anchor/Darling	300#, 6x4x6" DD Gate	0.34	0.44
857B	Anchor/Darling	300#, 6x4x6" DD Gate	0.39*	0.39*
814	Crane	150#, 6" FW Gate	N/A	0.84
4663	Crane	150#, 6" FW Gate	N/A	0.41
4615	Crane	150#, 20" FW Gate	0.45	0.52
4616	Raimondi	150#, 20" FW Gate	0.33	0.39
4664	Crane	150#, 10" SW Gate	N/A	0.64
738A	Crane	150#, 10" SW Gate	0.28	0.26
738B	Crane	150#, 10" SW Gate	0.35	0.23
871A	Velan	1500#, 3" FW Gate	0.22	0.29
871B	Velan	1500#, 3" FW Gate	0.46	0.28
9746	Westinghouse	2035# 3" FW Gate	0.38	N/A
3504A	Anchor/Darling	600#, 6" FW Gate	0.29*	0.23*
3505A	Anchor/Darling	600#, 6" FW Gate	0.41	N/A
9629A	Borg-Warner	300#, 4" FW Gate	0.30*	0.27*

Valve Factor values are from Attachment K-1, with the exception of those with an asterisk (*).

Values with an asterisk (*) are from Ginna DP test evaluation Data Sheet for the subject MOV. All thrust values were obtained from the same data trace, and these values have not been adjusted for measurement error.

Table 1: Ginna Gate Valve Factor Test Data



Valve Type Key			
1	300#, 6"x4"x6" A/D DDG	7	150#, 10" Crane SWG
2	2035#, 3" West. FWG	8	150#, 10" Crane SWG
3	150#, 6" Crane FWG (All Stellite)	9	1500#, 3" Velan FWG
4	150#, 6" Crane-Chapman FWG	10	300#, 4" Borg-Warner FWG
5	150#, 20" Crane FWG	11	600#, 6" A/D FWG
6	150#, 20" Raimondi FWG		

Figure 6 : Ginna Valve Factor Test Data for All Gate Valves (Various Manufacturers)

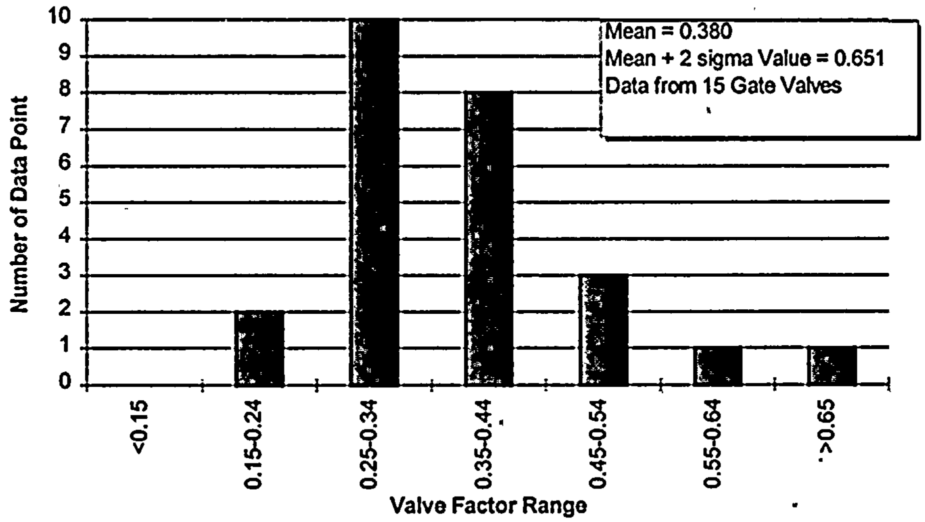


Figure 7: Distribution of Ginna Gate Valve Factor Test Data (All Data Points)

Based on the available test data, the mean valve factor for a Ginna Gate valve was 0.380 , and the Overall Mean + 2 sigma valve factor was 0.651. Figure 3 and the statistical values are provided for comparison to figure E-25 in reference 5 only. The maximum observed valve factor was 0.84 for 814 in the close direction.

Analysis of EPRI and Industry Data

Review of EPRI MOV Performance Prediction Program Test Results

Some of the more important findings identified during the EPRI MOV Performance Prediction Program were (summarized from reference 5):

EPRI Gate Valve Findings:

- In ambient water, apparent disc friction coefficients (similar to valve factor) increase with stroking under DP conditions until a plateau was reached. The amount of rise and the number of strokes required to achieve stabilization vary considerably from valve to valve. Initial disc friction coefficients ranged from 0.1 to 0.3 and stabilized friction coefficients ranged from 0.1 to 0.6. The number of strokes required until stabilization was achieved ranged from less than 50 to 900. The largest variation in stabilized friction coefficient occurred with small (less than 6"), low pressure class (150# and 300# class) valves.
- For pumped flow conditions, apparent disc friction coefficients decrease as temperature increases.
- Apparent disc friction coefficients decrease as differential pressure increases.
- For pumped flow conditions, deformations of cantilevered guide rails can occur at high flows (greater than 30 fps).
- The required opening thrust for a gate valve can be increased by the Bernoulli effect, which is due to reduced pressure under the disc near the closed position when the fluid velocity is relatively high.
- Under cold water pumped flow conditions, the apparent disc friction coefficients to fully open or reach initial wedging during closing range from 0.1 to 0.7 with the following exceptions for valve types in use at Ginna:

    Mechanisms associated with the internal disc wedge for Anchor/Darling double disc valves can result in apparent disc friction coefficients greater than 0.7 for opening and greater than 0.9 for closing at low DP. The highest apparent open valve factor for a double disc gate valve was 0.80 and the highest close value at hard seat was >1.05 and 0.50 at flow isolation (from reference 6).

    For Borg-Warner valves, parasitic thrust effects can result in apparent disc friction coefficients between 0.7 and 0.9 at low DP.

The maximum EPRI apparent disc friction coefficient of 0.70 exceeded the bounding stellite 6 to stellite 6 coefficient of friction for flat on flat contact of 0.61 in reference 4. This was due to disc orientations other than flat against the seat. Possible orientations include tipped on the guides, tipped on the guides and downstream seat, tipped on the guides and upstream seat, and tipped on both seats. If one of these other orientations were encountered during the test, the apparent disc friction coefficient could be greater than 0.61 based on the contact load and edge sharpness.

The EPRI PPM hand calculation methodologies for Anchor/Darling Double disc and Aloyco Split Wedge Gate Valves were developed and validated based on the test results of only one valve of each type in the flow loop test program.

[illegible]

EPRI Globe Valve Findings:

- Depending upon the details of the valve design, the load from the DP across the valve applies either to the seat area or the guide area. If a valve factor based on the seat area is used for a valve in which the guide area is the key area, the thrust required can be significantly underestimated (i.e. by as much as a factor of two).
- If the appropriate area (seat or guide) is used in determination of valve factors, valve factors for incompressible flow are in the range from 0.9 to 1.1.
- For hot water blowdown with two-phase, flashing flow through the valve, side loading on the globe plug can result in increased thrust requirements; the corresponding guide-based valve factor can exceed 1.4.

Review of Commonwealth Edison Valve Factor Analysis

A review of the Valve Factor "White Papers" prepared by Commonwealth Edison (references 11 through 14) was also performed. The ComEd analysis included data from both the EPRI test program and in-situ data from ComEd, and other utilities. The analysis excluded MOVs with low DP loads (< 4000 Lbs) on the basis of large measurement uncertainty. The primary grouping criteria used by ComEd was that valves from the same manufacturer with the same disc design can be analyzed together. The analysis of data to the grouping criteria did not consider effects such as valve orientation, service condition, and material condition. The ComEd Analysis also concluded that the valve factor decreased as valve size increased. The ComEd "nominal" valve factor was based on a best-fit straight line of the test data. The ComEd "bounding" valve factor line was based a two sigma confidence bound on individual valve factors for all valves within the group. In addition, ComEd determined a "conservative group" valve factor line which excluded the valve to valve variability due to unusually low values.

For valves at ComEd which were not DP tested, a valve factor approximately 0.10 greater than the nominal valve factor was used in MOV thrust calculations. ComEd uses a bias and random method to calculate MOV thrust requirements, and the use of this method equates approximately to adjusting the nominal valve factor values by 0.10 in the standard equation.

The results of the ComEd analysis for valve types in the Ginna GL 89-10 MOV Program are summarized below:

Anchor/Darling Double Disc Gate Valves (reference 11)

The nominal "wedge bottoming" (flow isolation) valve factors for Anchor/Darling Double Disc Gate Valves in cold water applications ranged from 0.48 for 3" valves to 0.35 for 12" valves. The conservative group "wedge bottoming" (flow isolation) valve factors in cold water applications ranged from 0.72 for 3" valves to 0.59 for 12" valves.

The ComEd analysis determined that the hard seat valve factor could be as much as 1.6 times greater than the flow isolation valve factor if the valve is installed with the upper wedge on the high pressure side (preferred orientation) and 2.05 times greater if the valve is installed with the upper wedge on the low pressure side.

A nominal "wedge bottoming" valve factor for high temperature applications was 0.35 and the bounding valve factor was 0.45. For hard seating (which ComEd referred to as disc spreading) with the upper wedge upstream, the nominal valve factor for high temperature applications was 0.45 and the bounding valve factor was 0.55. For hard seating with the upper wedge downstream, the nominal valve factor for high temperature applications was 0.60 and the bounding valve factor was 0.70.

Crane Wedge Gate Valves (reference 12)

For 150# and 300# class Crane Flex Wedge Gate Valves in cold water applications the nominal valve factors ranged from 0.75 for 3" valves to 0.38 for 20" valves. The conservative group valve factors ranged from 0.96 for 3" valves to 0.60 for 20" valves.

Borg-Warner 300# class Flex Wedge Gate Valves (reference 13)

- ComEd test data was not available, therefore, data from EPRI and the Perry Station was reviewed.

The nominal valve factors ranged from 0.42 for 3" valves to 0.46 for 20" valves. Due to an insufficient amount of data, the bounding ComEd valve factor was 0.65 based on the maximum EPRI disc to seat coefficient of friction of 0.61 adjusted for a 5 ^{o} wedge angle. This method was not considered acceptable for use at Ginna.

Velan 1500# Flex Wedge Gate Valves (reference 14)

For 1500# class Velan Flex Wedge Gate Valves, the nominal valve factor was 0.595 and the bounding valve factor was 1.067. It should be noted that a sufficient number of data points were not available to generate regression curves for the high pressure Velan valves.

Review of TU Electric (Comanche Peak) Borg-Warner Valve Factor Test Data

Valve factor data from Comanche Peak in reference 15 was also reviewed. Comanche Peak tested 3 groups (total of 16 valves) of 4" Borg-Warner Flex Wedge Gate valves under DP ranging from 95 to 2878 psid. The valves were 150#, 900#, and 1500# pressure class. The maximum statistical valve factor for any 4" Borg-Warner Flex Wedge Gate valve group (based on mean + 2 sigma) was 0.64 and the highest observed valve factor was 0.62.

Evaluation of Ginna GL 89-10 Program Gate and Globe MOVs

In accordance with the methodology in Figure 1, identical gate and globe valves in the Ginna GL 89-10 program with similar design basis system conditions were grouped together to ensure that a bounding valve factor for a given valve type was selected. The final values are shown in Attachment K-6. A discussion of each of these valve types is given in the following sections of this report.

Anchor/Darling Double Disc Gate Valves

6"x 4"x 6" 300# Class Anchor/Darling Double Disc Gate Valves (Group AD1)

There are seven valves of this type (shown on drawing 11497) in the GL 89-10 program. The wedges, and seating surfaces are all hardfaced with Stellite. Per reference 16, valves 857A/B/C are not required to be leak tight, and flow isolation was the functional requirement in the close direction. Valves 860A/B/C/D have a defined leakage criteria, and hard seating was the functional requirement in the close direction.

Per EWR-5080 R/8, the 857A/B/C valves are required to open against 225 and 251 psid. The 860A/B/C/D MOVs are required to open against 283 psid and close against 98 psid. The design basis flow rates for these MOVs was <15 fps.

Six of the valves were DP tested in the open direction, two of which (857A/B) had measured DP thrust values high enough to accurately calculate valve factors. Four of the valves were DP tested in the close direction, two of which (857A/B) could be used to calculate valve factors. Therefore, sufficient Ginna test data was not available to formulate a long term valve factor basis for all of the MOVs.

Based on the maximum observed valve factor for 857A&B, a conservative value of 0.50 should be used as the long-term valve factor for 857A&B.

The low DP load during the close DP tests of 860A&D was most likely the result of low flow through the ¾" containment spray test return line. The opening tests for these MOVs was performed with approximately 220 psid across the disc when the valves were closed. This DP should have been sufficient to produce a DP load similar to the design basis opening DP of 283 psid, regardless of the flow rate. The shape of the open DP thrust traces for these MOVs indicates that the valves were effected by DP and line pressure, but the magnitude of the DP load was not much greater than the static opening loads. In fact the response to opening against DP for 860A and D was nearly identical as shown in Attachment K-2. Since the opening DP thrust for 860A/D were very low, and the test should have produced a DP load similar to the design basis, the use of a 0.50 interim valve factor based on the maximum observed valve factor for 857A&B is considered to be acceptable. In order to further justify the 0.50 value, MOVs 857C , and 860A-D should be DP tested at the next practicable opportunity. Due to restraints of the containment spray system, only the open DP test of 860A-D is expected to produce a measurable DP effect.

10"x 8"x10" 300# Class Anchor/Darling Double Disc Gate Valves (Group AD2)

There are two valves (704A/B) of this type (shown on drawing 11500) in the GL 89-10 program. The wedges, and seating surfaces are all hardfaced with Stellite. Per reference 16, none of the valves are required to be leak tight, and flow isolation was the functional requirement in the close direction.

The required closing MEDP for these MOVs was only 33 psi at low flow rates (50 gpm and <15 fps).

Ginna station DP test data was not available on identical valves. The smaller A/D DD Gate valves tested at Ginna yielded a maximum valve factor of 0.46. The size differential between these valves and the 6"x 4"x6"

valves was too great to consider the valves to be similar. Therefore, an EPRI PPM calculation should be performed to determine the required thrust for these MOVs.

10" 300# Class Anchor/Darling Double Disc Gate Valves (Group AD3)

There are three valves of this type (shown on drawing 11502) in the GL 89-10 program. The wedges, and seating surfaces are all hardfaced with Stellite. Per reference 16, none of the valves (850A/B, and 856) are not required to be leak tight, and flow isolation was the functional requirement in the close direction.

Per EWR-5080 R/8, the 850A/B valves are required to close against ~30 psid and open against 225 psid. The 856 MOV is only required to close against ~ 6 psid, which is considered to be negligible. The design basis flow rates for these MOVs were 50 gpm and <15 fps.

Valve 850B was DP tested against 42 psi in both directions, and no significant DP effects were evident in the data. The design basis close DP condition was not considered to be much more severe than static conditions. The size differential between these valves and the 6"x4"x6" valves was too great for the valves to be thought of as similar.

Since the 850A/B MOVs have to open against a significant DP, an EPRI PPM calculation should be performed to determine the required thrust for these MOVs.

The closing DP under design basis conditions was negligible for 856 and there is no safety-related function to open. Therefore, a valve factor is not needed to calculate the required thrust for the valve to perform its safety related function.

10"x 8"x10" 1500# class, Anchor Darling Double Disc Gate Valves (Group AD4)

There are two valves of this type (shown on drawing 11663) in the GL 89-10 program. The wedges, and seating surfaces are all hardfaced with Stellite. Per reference 16, none of the valves in this group (841 and 865) are required to be leak tight, and flow isolation was the functional requirement in the close direction.

Ginna station DP test data was not available to form a basis for the valve factor. These valves are the SI Accumulator Tank Shutoff Valves. Per EWR-5080 R/8, the MOVs are normally open with the power removed during plant operation and are required to close for recovery from a SGTR. Under this scenario, the required closing DP is negligible with a line pressure of 700 psi. The DP for opening and closing these MOVs was conservatively selected as 33 psi based on the minimum threshold value in EWR-5080 R/8.

Since the closing DP under design basis conditions was negligible and their is no safety-related function to open these valves, the opening and closing valve factor are not considered to be of critical importance. Therefore, a valve factor is not needed to calculate the required thrust for the valve to perform their safety related function, and any reasonable value is acceptable for use in thrust calculations.

3" 1513# class, Anchor Darling Double Disc Gate Valves (Group AD5)

There are two valves of this type (shown on drawing W-882777) in the GL 89-10 program. They are the PORV Block Valves and are subjected to high temperature, steam service. The seating surfaces are hardfaced with Stellite, and the wedge contact surfaces are stainless steel without hardfacing. Ginna station DP test data was not available to form a basis for the valve factor.

The valves in this group (515 and 516) have a leakage limit of 10 gpm. Per reference 26, this can be achieved at flow isolation. The difference in pressure class and operating conditions between these valves and the 6"x4"x6" valves was too great for the valves to be similar. A preliminary EPRI PPM calculation has been performed for these MOVs. Since these valves can not be DP tested, this EPRI PPM calculation should be reviewed, approved, and used as the long term required thrust methodology for these MOVs.

Anchor Darling Flex Wedge Gate Valves

6" 600# Anchor Darling Flex Wedge Gate Valves (Group AD6)

There are two valves (3504A and 3505A) of this type (shown on drawing W-7820110B) in the GL 89-10 program. They are the Steam Admission to the SDAFWP Valves and are subjected to high temperature, steam service. The seating surfaces are hardfaced with Stellite. Per reference 16, none of the valves in this group are required to be leak tight, and flow isolation was the functional requirement in the close direction.

Both of the valves were DP tested in both directions. With the exception of the close stroke for 3505A, the test data could be used to calculate valve factor. Therefore, sufficient Ginna test data was available to formulate a valve factor basis that is acceptable for long term use. It is recommended that a close DP test be performed on 3505A to verify the adequacy of the value selected in Attachment K-6.

Aloyco Split Wedge Gate Valves

3" 150# class, Aloyco Split Wedge Gate Valves (Group A1)

There is one valve (313) of this type (shown on drawing E-45216) in the GL 89-10 program. The seating surfaces are hard faced with stellite. Per reference 16, valve 313 has a defined leakage limit, and therefore, hard seating was the functional requirement in the close direction.

MOV 313 was DP tested against 62% of the MEDP (93 psid) in the close direction, and no significant DP effects were evident in the data. The adjusted close valve factor was 0.14. However, per reference 24, the measured DP load was too low to calculate a reliable valve factor. The MEDP for opening these MOVs is 33 psi based on the minimum threshold value in EWR-5080 R/8. A review of EWR-5080 R/8 indicated that the MOV is normally open and is not required to stroke to the open position during a design basis event. Hence, there is no design basis safety function to open, and the opening valve factor was not considered to be of critical importance. The valve is required to close against an MEDP of 150 psid.

A preliminary EPRI PPM calculation has been performed for this MOV. It is important to note that the hand calculation model for Aloyco Split Wedge Gate Valves was validated based on testing of a single 4"150 Lb. Class Valve under several DP conditions. A review of Table 4-3 in Reference 7 indicated that the ratio of the measured thrust to hard seat and the PPM predicted thrust to hard seat (using the default friction coefficients) ranged from 0.09 to 0.21. In other words, the PPM calculation of thrust to hardseat overestimated the actual measured thrust from 4.76 to 11.1 times. This is considered to be an excessively conservative prediction, especially when compared to the test results for 313. Therefore, the EPRI PPM prediction for hardseating was not considered to provide a reasonable prediction of the true thrust to hardseat MOV 313.

Additional analysis to determine thrust requirements for flow isolation and disc hard-seating was performed by Kalsi Engineering (reference 26). The intent of the analysis was to review the excessive conservatisms applied by the EPRI methodology and incorporate realistic conditions of MOV 313 thus providing a more accurate diagnosis of required thrust values needed for hard seating. A total of nine different load cases were analyzed for various conditions. Conclusions yielded that MOV 313 will close and achieve a hard-seating condition under the present torque switch setting. Seat coefficient of friction of .35 is a reasonable bounding value.

The open and closed valve factors were calculated for the EPRI MOV by use of the test data in Attachment 2 of reference 7 and the equations in Attachment K-3 of this report. Per the Attachment K-3 calculations, the EPRI open valve factors ranged from 0.17 to 0.26 and the close valve factors based on the thrust to hard seat ranged from 0.17 to 0.66. The high valve factors to hard seat (0.45 to 0.66) were all encountered when the valve was stroked against approximately 275 psid. Of the EPRI tests performed at 180 psid, the maximum valve factor to hard seat was 0.30.

In addition to the EPRI valve, dynamic test data was available on 4"150 Lb. Class Aloyco Split Wedge Gates from Indian Point Unit 2 and Crystal River (references 18 and 19). The Indian Point 2 MOV was tested at 92.8 psid and the hard seating valve factor (adjusted for measurement uncertainty) was 0.41. The Crystal River MOV was tested at 128 psid and the hard seating valve factor (adjusted for measurement uncertainty) was 0.32. The valve factors for the Indian Point and Crystal River valves were calculated in Attachment K-4.

Based on the 313 test results, Kalsi Engineering analysis, IP2 data, and Crystal River data, a valve factor of 0.50 in the standard industry equation to establish the minimum thrust requirement is acceptable for hard-seating of the valve under design basis conditions.

10"x 8"x10" 150# class, Aloyco Split Wedge Gate Valves (Group A2)

There are two valves (896A/B) of this type (shown on drawing E-43540) in the GL 89-10 program. The seating surfaces are hard faced with stellite. Per reference 16, 896A/B are not required to be leak tight, and flow isolation was the functional requirement in the close direction for that MOV.

The MEDP for opening these MOVs is 33 psi based on the minimum threshold value in EWR-5080 R/8. A review of EWR-5080 R/8 indicated that both MOVs are normally open and are not required to stroke to the open position during a design basis event. Hence, there is no design basis safety function to open the MOVs, and the opening valve factor was not considered to be of critical importance.

Per EWR-5080 R/8 896A/B are required to be closed via a manual remote signal during switch over to recirculation after all pumps have been stopped. The closing pressure across the valve under this scenario is negligible, and the closing valve factor was also not considered to be of critical importance for these MOVs. Therefore, a valve factor is not needed to calculate the required thrust for the valves to perform their safety related function, and any reasonable value is acceptable for use in thrust calculations.

Westinghouse Flex Wedge Gate Valves

3" 2035# class Westinghouse Flex Wedge Gate Valve (Group W1)

There is one valve (9746) of this type (shown on drawing 1168378D38) in the GL 89-10 program. The seating surfaces and disc guides are hard faced with Stellite. Per reference 16, this valve (9746) does not have a defined leakage limit, and flow isolation was the functional requirement in the close direction.

Per EWR-5080 Rev. 8, MOV 9746 is required to close to isolate the "D" train SBAFW discharge piping and divert flow through the cross-connect. The pump is stopped prior to closing the valve, and the DP and line pressure will essentially be 0. The minimum threshold value of 33 psi was specified as the MEDP in EWR-5080. Therefore, a valve factor is not needed to calculate the required thrust for the valve to perform its safety related function, and any reasonable value is acceptable for use in thrust calculations.

Crane Flex Wedge Gate Valves

3" 150# class Crane Flex Wedge Gate Valves (Group C1)

There are two valves (759A/B) of this type (shown on drawing K-6298) in the GL 89-10 program. The seating surfaces are hardfaced with Stellite and the guide rails are carbon steel. Per reference 16, valves 759A/B are required to be leak tight. Therefore, hardseating was the functional requirement in the close direction.

Per EWR-5080 Rev. 8, the MOVs are required to close on receipt of a containment isolation signal against 140 psid. MOV 759B was successfully DP against approximately 70 psid in both directions, however, reference 24 concluded that the DP loads were too low (less than 1000 Lbs) to accurately calculate a valve factor. MOV 759A was also tested against DP in the close direction, but direct thrust measurements were not obtained, and a valve factor could not be determined.

These valves are the same model as the 6", 813/814 valves and are shown on the same valve drawing. Since the 813/814 and 759A/B valves and service conditions are similar, a valve factor of 0.90 based on the dynamic test of 814 should be used as the interim open and close valve factor for 759A/B. Since the dynamic test of these MOVs does not produce enough DP load to calculate a valve factor, a PPM calculation should be performed in the long term

The 0.90 value agrees well with the ComEd nominal valve factor for 3" Crane valves of 0.75 plus the adjustment of 0.10 and is slightly less than the conservative group valve factor of 0.95.

6" 150# class Crane Flex Wedge Gate Valves (All Stellite Seating Surfaces) (Group C2)

There are two valves (813/814) of this type (shown on drawing K-6298) in the GL 89-10 program. The seating surfaces are hardfaced with Stellite and the guide rails are carbon steel.

Per reference 16, valves 813, and 814 are required to be leak tight. Therefore, hardseating was the functional requirement in the close direction. Per EWR-5080 R/8 813/814 are required to close against a design basis DP of 100 psid and are not required to open in response to a design basis event.

Both 813 and 814 were tested against DP, but a valve factor could only be calculated for the 814 valve. The as-tested, adjusted close valve factor for 814 was 0.84.

Since the 813/814 valves and service conditions are identical, a valve factor of 0.90 based on the dynamic test of 814 should be used as the interim open and close valve factor for 813 until additional dynamic testing of the 813 MOV is performed.

The 0.90 value is significantly greater than the ComEd nominal valve factor for 6" Crane valves of 0.68 plus the adjustment of 0.10 and is equal to the conservative group valve factor .

6" 150# class Crane Flex Wedge Gate Valves (Disc Not Hardfaced) (Group C3)

There is 1 valve (4663) of this type (shown on drawing C-3151991-A) in the GL 89-10 program. The disc seating surface is A217 Gr. CA15 and is not hardfaced. The body seat rings are hardfaced with Stellite. Due to the different disc hardfacing materials, the 4663 valve was not considered to be identical to the 813/814 valves.

Per reference 16, 4663 does not have to provide a leak tight seal. Therefore, flow isolation was the functional requirement in the close direction. Per EWR-5080 R/8 4663 is required to close against a design basis DP of 95 psid and is not required to open in response to a design basis event.

MOV 4663 was DP tested in the close direction at 59% of the design basis DP and the adjusted valve factor was 0.41. However, from figure 4, the minimum EPRI test DP was not achieved.. The minimum EPRI test pressure for 150# class valves is 60 psid, which is a mere 4 psi more than the test pressure for 4663. Since the design basis DP for 4663 is only 95 psid and test was performed by use of a system alignment similar to the design basis condition, the 56 psid DP test and as-tested valve factor is considered to be acceptable for use on 4663.

10" 150# class Crane Flex Wedge Gate Valves (Disc Not Hardfaced) (Group C4)

There is 1 valve (4670) of this type (shown on drawing C-3151560 Rev. C) in the GL 89-10 program. The disc seating surface is A217 Gr. CA15 and it is not hardfaced. The body seat rings are hardfaced with Stellite. The valve is not required to be leak tight (per reference 16), and flow isolation was the functional requirement in the close direction.

Per EWR-5080 R/8 4670 is required to close against a design basis DP of 95 psid, and is not required to open in response to a design basis event. MOV 4670 was tested against DP, but direct thrust measurements were not obtained, and a valve factor could not be determined. This valve is the same model (47 ½ XU-F) as the 4663 6"valve.

A valve factor of 0.90 is significantly greater than the ComEd nominal valve factor for 10" Crane valves of 0.60 plus the adjustment of 0.10 and the conservative group valve factor of 0.80. Therefore, a value of 0.90 should be used as the interim open and close valve factor for 4670 until additional dynamic testing or a PPM Calculation can be performed.

Crane Solid Wedge Gate Valves

10" 150# class Crane Solid Wedge Gate Valves (All Stellite Seating Surfaces) (Group C5)

There are two valves (738A/B) of this type (shown on drawing K6299) in the GL 89-10 program. Both the seating surfaces are hardfaced with Stellite for the 738A/B valves. These valves are not required to be leak tight (per reference 16), and flow isolation was the functional requirement in the close direction.

Both 738A/B were DP tested in the open and close direction. Therefore, sufficient Ginna test data was available to formulate a long term valve factor basis.

10" 150# class Crane Solid Wedge Gate Valves (Stellite on Stainless Steel Seating Surfaces) (Group C6)

There is 1 valve (4664) of this type (shown on drawing K-1055) in the GL 89-10 program. The disc is hardfaced with stellite and the body seat ring is "Exelloy" (410 SS) for 4664. Due to the different disc hardfacing materials, the 4664 valve was not considered to be identical to the 738A/B valves.

This valve is not required to be leak tight (per reference 16), and flow isolation was the functional requirement in the close direction.

Per EWR-5080 R/8 4664 is required to close against a design basis DP of 95 psid, and is not required to open in response to a design basis event. MOV 4664 was successfully DP tested in the close direction and the adjusted close valve factor was 0.64. Therefore, sufficient Ginna test data was available to formulate a long term valve factor basis for this MOV.

20" 150# class Crane Solid Wedge Gate Valves (Group C7)

There is 1 valve (4615) of this type (shown on drawings PB-137988 and AA-FA-VAA-A) in the GL 89-10 program. The seating surfaces are hardfaced with 410 SS (14% chrome). The seat ring is not hardfaced. This valve is not required to be leak tight (per reference 16), and flow isolation was the functional requirement in the close direction.

The valve was DP tested in the open and close direction. Therefore, sufficient Ginna test data was available to formulate a long term valve factor basis.

20" 150# class Raimondi Solid Wedge Gate Valves (Group R1)

There is 1 valve (4616) of this type (shown on drawing AA-FA-VAA-A) in the GL 89-10 program. The seating surfaces are hardfaced with 410 SS (14% chrome) and the seat ring is hardfaced with Stellite. The valve is not required to be leak tight (per reference 16), and flow isolation was the functional requirement in the close direction.

The valve was DP tested in the open and close direction. Therefore, sufficient Ginna test data was available to formulate a long term valve factor basis.

Velan Flex Wedge Gate Valves

3" 1500# class Velan Flex Wedge Gate Valves (Group V1)

There are two valves (871A/B) of this type (shown on drawing 88405-4) in the GL 89-10 program. The seating surfaces are hard faced with Stellite No. 6 and the guide rails are stainless steel with 4 stellited pads. Per reference 16, valves 871A/B do not have to be leak tight, and flow isolation was the functional requirement in the close direction.

Both of the valves were DP tested in both directions, and the data could be used to calculate valve factors. Therefore, sufficient Ginna test data was available to formulate a long term valve factor basis.

6" 1500# class Velan Flex Wedge Gate Valves (Group V2)

There are two valves (852A/B) of this type (shown on drawing 88405-5) in the GL 89-10 program. The seating surfaces are hard faced with Stellite No. 6 and the guide rails are stainless steel with 4 stellited pads. Per reference 16, valves 852A/B are required to be leak tight, and therefore, hard seating was the functional requirement in the close direction.

The design basis opening scenario for 852A/B is against 2250 psi due to check valve leakage with a negligible flow rate. 852A/B are not required to close during a design basis event. The similar 871A/B (3") valves were DP tested against approximately 1500 psi.

Upon comparison of the valve drawings for the 6" and 3" valves, the parts and materials appear to be identical. Therefore, application of the 871A/B data to the non-tested 6" valves for short term use was justified based on the similarity of the valves, the EPRI finding that valve friction factors typically decrease with increasing DP and the ComEd finding that valve factors typically decrease with valve size. Hence, the valve factor for the 6" valves would be expected to be less than the lower DP 3" valves.

Per EWR-5080 Rev. 8, the flow rate under design basis conditions the MOVs is 0 gpm. Therefore, the possibility of guide rail bending due to the Velan design is considered to be remote. In addition, these valves have been tested under static conditions, and any indication of guide rail bending due to previous strokes was not apparent in the static test data.

Per reference 23, these valves are susceptible to pressure locking. The pressure locking scenario is significantly more severe than opening the valve with DP across the disc. Therefore, the design basis pressure locking calculation should be used to establish the minimum required opening thrust. The valves do not have a closing design basis function, and the close valve factor value was not considered to be of critical importance.

10" 1500# class Velan Flex Wedge Gate Valves (Group V3)

There are two valves (700/701) of this type (shown on drawing 88904-1) in the GL 89-10 program. The seating surfaces are hard faced with Stellite No. 6 and the guide rails are stainless steel with 4 stellited pads. Per reference 16, both of these valves are required to be leak tight, and therefore, hard seating was the functional requirement in the close direction.

Per EWR-5080 R/8 700/701 these valves do not meet the general requirements of GL 89-10, but are considered to be "high risk." They are required to open and close against a design basis DP of 410 psid.

The 3" 1500# class Velan Gate valves tested at Ginna yielded a maximum adjusted valve factor of 0.46. The size differential between these valves and the 3" valves was too great to regard the valves as similar.

EPRI tested a 10" 1500# class Velan gate valve under steam blow down conditions as part of its flow loop test program. Since the 700/701 MOVs are not subjected to steam blow down , the EPRI tests were not considered to be applicable. Dynamic test data on two identical valves was obtained at Carolina Power & Light's H.B. Robinson Unit 2. The adjusted open and close valve factors were calculated by use of the H.B. Robinson test data (References 21 and 22) and the equations in Attachment K-4. From Attachment K-4, the maximum adjusted open and close valve factors were 0.69 and 0.67. Per figure 7, the Robinson data meets the minimum EPRI criteria, but is only 32% of the design basis DP for the Ginna 700/701 valves. Nevertheless, the Robinson data was the best available. Since these valves do not meet the general requirements of GL 89-10 a valve factor of 0.70 based on the Robinson data should be used as the long term valve factor for these MOVs.

The 0.70 valve factor agrees well with the ComEd nominal valve factor for 10" 1500# Velan valves of 0.595 plus the adjustment of 0.10.

Borg-Warner Flex Wedge Gate Valves

4" 300# class Borg-Warner Flex Wedge Gate Valves (Group BW1)

There are two valves (9629A/B) of this type (shown on drawing 73480) in the GL 89-10 program. The seating surfaces are hardfaced with stellite and the guide rails are heat treated stainless steel. The valves are not required to be leak tight (per reference 16), and flow isolation was the functional requirement in the close direction. Per EWR-5080 R/8 9629A/B are required to open and close against a design basis DP of 95 psid.

MOV 9629A was tested against DP, and the measured valve factors were 0.27 (close) and 0.30 (open). From figure 5, the minimum EPRI test DP was not achieved, however, the design basis condition of 95 psid does not meet the minimum EPRI criteria either. The test was performed at 83% of the design basis DP, and the Ginna test data should be used to formulate a long term valve factor basis for 9629A.

The most similar valve in the EPRI test program was a 6" 150# class Borg-Warner flex wedge gate valve. The maximum open disc friction coefficient was 0.872 and the maximum close value was 0.879. The bounding ComEd valve factor for Borg-Warner gate valves was 0.65 based on the maximum EPRI disc to seat coefficient of friction of 0.61 adjusted for a 5 $^{\circ}$ wedge angle. This method was not considered acceptable for use at Ginna. Data from Comanche Peak in Reference 15 was also reviewed. Comanche Peak tested 16, 4" Borg-Warner valves under a wide range of DP and flow conditions. The maximum valve factor for 4" Borg-Warner valves at Comanche Peak was 0.62.

During the EPRI test program, Borg-Warner valves exhibited higher than expected apparent disc friction coefficients at low DP due to parasitic thrust effects. In addition, NRC IN 89-61, "Failure of Borg-Warner Gate Valves To Close Against Differential Pressure," discussed higher than expected valve factor (ranging from 0.38 to 0.74) for 4" 1500# class Borg-Warner gate valves at Catawba.

Due to the poor performance of Borg-Warner valves in the EPRI program, a valve factor of 0.90 should be used as the interim open and close valve factor for 9629B until dynamic testing of 9629B is performed. This value is very conservative when compared to the results of the 9629A DP test. It should also be noted that based on the present configuration and switch settings, both valves are capable of opening and closing at valve factors much greater than 0.90.

GL 89-10 Globe Valves

With the exception of the Fisher, balanced disc globe valves (9701A/B), Ginna station valve factor test data was not available to form a basis for the valve factor for globe valves.

Without available site specific test data, the valve factors for Ginna globe valves were determined based on the EPRI finding that if the appropriate area (seat or guide) is used, valve factors for incompressible flow are in the range from 0.9 to 1.1. Each Ginna globe valve types was compared to the globes in reference 4 to determine if they were seat or guide based. The appropriate area was then used in the thrust/torque calculation along with a valve factor of 1.1.

Evaluation of Globe Valve Design Basis Flow Conditions

Fisher Balanced Disc Globe Valves (Group F1)

Valves 9701A/B are Fisher, balanced disc globe valves, which have been DP tested. The manufacturer supplied the methodology used in the required thrust calculation. These MOVs were DP tested and the calculated requirements agreed well with the dynamic test results. It should be noted that the Fisher methodology is comparable to using a valve factor of 1.0.

2" 1500# class Velan Globe Valves (Group V4)

The design basis flow rate for valves 897/898 is 0 gpm at a temperature of 80^{O}F. The valves are 2" Velan globes, and a review of the valve drawing (E-73-0545) indicated that they are seat based. Since the design basis flow and temperature are low, the use of a 1.1 valve factor with the appropriate area was acceptable based on the EPRI test results.

3" 900# class Rockwell/Edwards Globe Valves (Group RE1)

The design basis flow rate for valves 4007/4008 is 230 gpm at a temperature of 100^{O}F. The valves are 3" Rockwell globes, and a review of the valve drawing (P-447997) indicated that they are seat based. Since the design basis flow and temperature are low, the use of a 1.1 valve factor with the appropriate area was acceptable based on the EPRI test results.

3" 1500# class Rockwell/Edwards Globe Valves (Group RE2)

The design basis flow rate for valves 9703A/B is 200 gpm at a temperature of 100°F. The valves are 3" Rockwell globes, and a review of the valve drawing (ACD-31602215) indicated that they are guide based. Since the design basis flow and temperature are low, the use of a 1.1 valve factor with the appropriate area was acceptable based on the EPRI test results.

3" 900# class Rockwell/Edwards Globe Valves (Group RE3)

The design basis flow rate for valves 9704A/B is 200 gpm at a temperature of 100°F and DP of 1461 psi. The valves are 3" Rockwell stop checks, and a review of the valve drawing (ACD-31602220) indicated that they are guide based. These valves are in the Stand By Auxiliary Feed Water System, and since the design basis flow rate and temperature are low use of a 1.1 valve factor with the appropriate area was acceptable based on the EPRI test results.

14" 900# class Rockwell/Edwards Stop Check Valves (Group RE4)

The design basis flow rate for valves 3976/3977 is 0 gpm at a temperature of 345°F and DP of 400 psi. The valves are 14" Rockwell stop checks, and a review of the valve drawing (P-447073) indicated that they are seat based. These valves are in the Main Feed Water System, and since the design basis flow rate is 0 gpm, they will not be subjected to a blowdown condition. Therefore, the design basis fluid is expected to be liquid water, and the use of a 1.1 valve factor with the appropriate area was acceptable based on the EPRI test results. These valves were both DP tested, and the test results supported the use of a 1.1 valve factor.

Valve Factor and Required Thrust Conclusions

Based on the process in Figure 1, each gate valve in the Ginna GL 89-10 program was evaluated to determine:

- if a long term valve factor could be justified
- the value of long term and interim valve factors
- a recommended required thrust methodology and action for long term resolution based on the feasibility of dynamic testing the valve.

The recommended required thrust methodology and action required for long term resolution are summarized in Attachment K-5 for each gate valve in the Ginna GL 89-10 program. The long term and interim valve factor values and basis for the values (as discussed previously) are summarized in Attachment K-6.

The present valve factor of 1.10 and standard industry equation used for unbalanced disc globe valves in the Ginna GL 89-10 program is considered adequate at this time based on EPRI and Ginna globe valve test data. Further justification of this value should be obtained as part of the MOV Periodic Verification Program, by performing a representative sample of dynamic tests or obtaining and evaluating industry test data on similar globe valves.

It should be noted that as additional dynamic test data is obtained, this evaluation will need to be revised to incorporate and evaluate the results of those tests and account for the reasonable and expected variation in valve factors based on the data scatter. In addition, the method used to account for valve factor degradation should be confirmed or refined when results of the Joint Owner's Group (JOG) Program on MOV Periodic Verification methodology become available. The margins that have been applied to the as-tested valve factors are shown in Attachment K-7. This Attachment is provided for future comparison to the results of the JOG Program on MOV Periodic Verification.

4. Analysis of Load Sensitive Behavior and Stem Coefficient of Friction

Load Sensitive Behavior

EPRI and industry test data has demonstrated that MOV output thrust at close control switch trip can be significantly lower under dynamic (differential pressure) conditions than the output thrust under static conditions. This phenomenon has been called the "rate-of-loading" effect or "load-sensitive behavior".

EPRI testing has shown that the thrust change from static to dynamic conditions was due mainly to changes in the coefficient of friction (μ) at the stem to stem nut interface. The change in μ was found to be caused by a "squeeze film" effect. Under static conditions the load between the stem and stem nut increases rapidly when the valve disc impacts the seat. This rapid loading does not allow enough time for the lubricant to flow out of the stem/stem nut interface. Under these circumstances, the parts can be supported on a thin film of pressurized lubricant which is a mixture of boundary and hydrodynamic lubrication.

Under dynamic conditions, the load increases slowly due to the build up of differential pressure forces. Under this loading, there is enough time for the lubricant to be squeezed from between the parts resulting in higher coefficients of friction associated with boundary lubrication. The precise extent to which the phenomenon occurred for a particular stem, stem nut, and lubricant combination was found to be unpredictable.

Close torque switch settings are verified by measuring the thrust at control switch trip (CST) under static test conditions. Where practical, DP testing should be performed to verify proper switch settings under design basis flow and pressure. However, since it is not possible to DP test all 89-10 MOVs, the potential decrease in thrust under dynamic conditions must be accounted for when establishing the minimum close thrust at CST criteria for MOVs which were only tested under static conditions.

Load sensitive behavior uncertainty is accounted for in the Target Thrust/Torque Calculations. The required minimum acceptable thrust at CST for static testing is increased by appropriate factors to ensure that the combined effect of all uncertainties will not result in insufficient thrust at CST to close the valve under dynamic conditions.

The potential differences in the thrust at CST under dynamic versus static conditions may be accounted for by use of a load sensitive behavior correction factor (LSB). The value of the correction factor can be calculated for MOVs which have adequate close DP test thrust data by use of Equation (1).

$$LSB\% = [(S.\ Th@TST - D.\ Th@TST) / S.\ Th@TST] * 100 \qquad \text{Eq. (1)}$$

where

S.Th@TST = Static Closing Thrust at Control Switch Trip

D.Th.@TST = Dynamic Closing Thrust at Control Switch Trip

The correction factor is used to adjust the target closing thrust value determined in the target thrust/torque calculations as follows:

$$\text{Req'd Thrust Under Static Conditions} = \text{Req'd Thrust Under Design Basis DP Conditions}\ (1 + LSB) \qquad \text{Eq. (2)}$$

where,

LSB = LSB Correction Factor.

Stem Coefficient of Friction (μ-Stem)

The stem coefficient of friction is calculated from the measured stem factor and physical dimensions of the stem threads. The stem factor is the ratio of the closing torque at CST to closing thrust at CST. The torque and thrust are not adjusted for instrument error. The stem coefficient of friction is calculated using Equation (3).

$$\mu = \frac{\cos \phi_2 \, [24\,(Tq.@TST/Th.@TST) - d_s \tan \phi_1]}{24\,(Tq.@TST/Th.@TST)\,(\tan \phi_1) + d_s} \qquad \text{Equation (3)}$$

where:

ϕ_2 = stem thread tooth pressure angle (from Table 1)
ϕ_1 = stem thread lead angle
= $\tan^{-1}$ (stem thread lead/πd_s)
d_s = stem thread pitch diameter = $d_{nominal} - h$
$d_{nominal}$ = stem thread major (outside) diameter
h = stem thread height

Tq.@TST =Closing Torque at Torque Switch Trip from Static or DP test

Th.@TST = Closing Thrust at Torque Switch Trip from Static or DP test

ACME Screw Thread Type	ϕ_2 (degrees)	h (in.)
Standard	14.5	0.5
Stub	14.5	0.3

Table 2: ACME Power Screw Dimensions

Application of Ginna LSB and Stem Coefficient of Friction Test Results

As discussed in the Introduction, the two best sources of test data for validating assumptions are valve specific data and plant specific data. Actual dynamic testing is not practicable for many valves. Other valves may have been tested in the past only to have subsequent industry experience and improvements in testing technology cast doubts on the data which was obtained. As a result, the possibility exists for a significant number of valves to be lacking in reliable, supporting test data; therefore, the need to apply plant specific test data becomes increasingly important.

Industry experience has shown that when applying measured test data to non-tested valves, the load sensitive behavior and stem coefficient of friction tend to be a function of plant specific maintenance practices such that measured test results can generally be applied to all valves at a particular facility. Values of load sensitive behavior, and stem coefficient of can be calculated from the measured data using equations 1 and 3. Because of the uncertainty associated with the measured values, some type of statistical method should be employed prior to the application of the calculated results.

The following is an acceptable method for statistical analysis.

$$\text{Mean} = \Sigma x / n$$

$$\text{Sample Standard Deviation} = [(n\Sigma x^2 - (\Sigma x)^2) / n(n-1)]^{1/2}$$

By calculating the mean and the standard deviation, a 97% confidence value can be determined as the mean plus 2 standard deviations. This value represents a generally acceptable, conservative bounding value for the value in question.

Evaluation of LSB & μ-Stem Test Data

The available DP test data packages were reviewed to determine the measured values of thrust at CST (static & dynamic), and μ -Stem (static & dynamic).

The data that was extracted to evaluate LSB is presented in Table 3 for the reliable DP tests as determined in section 3 of this evaluation. The evaluation was based on a statistical analysis of load-sensitive-behavior (LSB), and stem coefficient of friction (μ-Stem). The entire population of available data was used for the analysis of LSB and μ-Stem since these factors are generally independent of valve type and application.

The percent LSB for each valve was derived from the thrust at CST (static and dynamic) by use of equation (1). The calculated values are recorded in Table 3. The values of μ-Stem were taken directly from the DP test data packages. Static test μ-Stem values are shown in Table 4 and the dynamic μ-Stem values are shown in Table 5.

Valve ID	Work Order	Test Date	D. Th@TST	S. Th@TST	LSB
738A	19221443	22-Mar-94	7305	7490	2.47%
738B	19221441	20-Mar-94	10202	N/A	N/A
814	19221433	20-Mar-94	3619	3594	-0.70%
857A	19604163	09-Nov-96	4637	5095	8.99%
857B	19702113	04-Nov-97	4487	4542	1.21%
871A	19404023	06-Oct-94	3423	N/A	N/A
871B	19221428	02-Apr-93	7447	8290	10.17%
3504A	19703805	03-Dec-97	12848	13098	1.91%
3505A	19604599	11-Nov-96	18547	20068	7.58%
4615	19402962	19-Apr-95	19546	21071	7.24%
4616	19221506	02-Apr-94	20471	20116	-1.76%
4663	19400660	01-Mar-94	3208	3299	2.76%
4664	19504253	08-Apr-96	6424	7419.3	13.42%
9629A	19702111	17-Feb-97	7929	7468	-6.17%
9746	19400530	24-Feb-94	5427	5562	2.43%
				Mean	3.92%
				Sample Standard Deviation (σ)	5.64%
				Mean + 2σ	15.20%
				Maximum	13.42%

Table 3 : LSB Test Data

Valve ID	Test Type*	Test Date	μ-STEM
1813B	Static	30-Mar-94	0.045
313	Static	22-May-96	0.134
3504A	Static	07-May-96	0.142
3505A	Static	11-Nov-96	0.119
4615	Static	06-May-96	0.069
4616	Static	05-Nov-96	0.086
4663	Static	09-May-96	0.131
4664	Static	08-Apr-96	0.072
515	Static	17-Apr-95	0.101
516	Static	18-Apr-95	0.097
700	Static	16-Mar-94	0.072
701	Static	15-Mar-94	0.070
738A	Static	22-Mar-94	0.192
738B	Static	15-Apr-96	0.115
749B	Static	26-Mar-94	0.126
759A	Static	26-Mar-94	0.116
759B	Static	23-Oct-97	0.114
813	Static	01-May-96	0.148
814	Static	20-Mar-94	0.108
852A	Static	08-Sep-96	0.075
852B	Static	09-Sep-96	0.095
856	Static	22-Mar-94	0.114
857A	Static	09-Nov-96	0.115
857B	Static	04-Nov-97	0.104
857C	Static	03-Nov-96	0.091
865	Static	11-Mar-94	0.091
896B	Static	17-Apr-96	0.038
9629A	Static	01-Nov-97	0.037
9701A	Static	14-Apr-95	0.120
9701B	Static	13-Apr-95	0.117
		Mean	**0.102**
		Sample Standard Deviation (σ)	**0.034**
		Mean + 2σ	**0.169**
		Maximum	**0.192**

Table 4 : Static Test μ-Stem Data

Valve ID	Work Order	Test Type	Test Date	μ-STEM
3504A	19703805	DP	03-Dec-97	0.106
3505A	19604599	DP	11-Nov-96	0.051
4615	19402962	DP	19-Apr-95	0.056
4616	19221506	DP	02-Apr-94	0.129
4663	19400660	DP	01-Mar-94	0.138
4664	19504253	DP	08-Apr-96	0.091
738A	19221443	DP	22-Mar-94	0.213
738B	19221441	DP	20-Mar-94	0.127
814	19221433	DP	20-Mar-94	0.138
857A	19604163	DP	09-Nov-96	0.108
857B	19702113	DP	04-Nov-97	0.113
871A	19404023	DP	06-Oct-94	0.123
871B	19221428	DP	02-Apr-93	0.204
9629A	19702111	DP	17-Feb-97	0.044
9701A	19402945	DP	14-Apr-95	0.117
9701B	19221941	DP	21-Apr-93	0.124
			Mean	0.118
			Sample Standard Deviation (σ)	0.046
			Mean + 2σ	0.210
			Maximum	0.213

Table 5 : Dynamic Test μ-Stem Data

The statistical analysis of LSB and μ-Stem shows that using a 97% confidence value of "mean plus 2 sigma" results in:

%LSB	**= 15.72**
μ-Stem (static)	**= 0.19**
μ -Stem (dynamic)	**= 0.21**

These are bounding values and are in good agreement with accepted industry experience.

Load Sensitive Behavior Conclusions

Based on the 97% confidence LSB value of 15.20%, an LSB "bias" term of 15% was selected for use in thrust/torque calculations for Ginna GL 89-10 MOVs. The 15% value bounded 13 of the 13 available data points.

Another acceptable method to address LSB is by use of a "bias" (direct multiplier) and "random" (combined by the square root of the sum of the squares (SRSS) technique with other uncertainties such as measurement error and torque switch repeatability factor). This will be referred to as the "SRSS' method. If the "SRSS" method were used, a bias value of 3.92% and random value (equal to 2 standard deviations) of 11.28% would be used to account for LSB based on the statistical LSB results in Table 4.

The use of the "SRSS" type methodology removes excessive conservatism in the application of the LSB, measurement error, and torque switch repeatability factors. While the benefits of using this methodology are desirable, it can become difficult to implement. Therefore, for simplicity, it was decided that a single "bias" term would be used to account for LSB. In order to demonstrate the conservatism of the 15% value selected to account for LSB at Ginna, an evaluation of the combined effect of LSB, measurement uncertainty, and torque switch repeatability factors was performed.

SRSS method

The overall required thrust multiplier using the SRSS method can be calculated by use of the following equation:

Required Thrust Multiplier = (1 + LSBbias) (1 + (LSBrandom ^{2} + eI ^{2} + TSrep ^{2}) $^{1/2}$)

where:

LSBbias = LSB bias term = 0.0392 from Table 4

LSBrandom = LSB random uncertainty term = 2 standard deviations = 0.1128 from Table 4.

eI = test equipment measurement uncertainty assumed to equal best possible value of 0.05.

TSrep = torque switch repeatability assumed to equal best possible value of 0.05.

Required Thrust Multiplier = (1 + 0.0392) * (1+ (0.1128 ^{2} + 0.05 ^{2} + 0.05 ^{2}) $^{1/2}$)

Required Thrust Multiplier = 1.178 by SRSS method

LSB Bias Method

The overall required thrust multiplier using the LSB Bias method can be calculated by use of the following equation:

Required Thrust Multiplier = (1 + LSB) (1 + (eI ^{2} + TSrep ^{2}) $^{1/2}$)

where:

LSB = 0.15, which was selected to account for LSB effects at Ginna.

eI = test equipment measurement uncertainty assumed to equal best possible value of 0.05.

TSrep = torque switch repeatability assumed to equal best possible value of 0.05.

Required Thrust Multiplier = (1 + 0.15) * (1+ (0.05 ^{2} + 0.05 ^{2}) $^{1/2}$)

Required Thrust Multiplier = 1.23 by LSB Bias method

When compared to the SRSS method, the use of an LSB value of 0.15 results in an additional conservatism of approximately 4%, [(1.23-1.178)/1.178].

By calculating LSB in accordance with equation (1) and applying the 15% LSB factor in accordance with equation (2), the resulting Required Thrust Under Static Conditions is approximately 2.3% lower than if the Required Thrust Under Design Basis DP Conditions were divided by (1-LSB). This was offset by the conservatism of the LSB Bias method used in the calculations.

Based on a comparison of the 2 methods, a value of 0.15 can be used as the LSB correction factor. The resulting required thrust multiplier for the SRSS and Bias methods have been compared using various combinations of eI and TSrep values, and the bias method was found to produce a larger multiplier in all cases with an LSB value equal to 0.15. Based on the evaluation of the SRSS and bias methods the use of a 0.15 LSB value will produce conservative and appropriate adjustment of the required thrust in the thrust/torque calculations.

The values/methods to account for LSB in RG&E MOV calculations, which are used for both the open and close directions, were determined by use of the following criteria:

1) For MOVs which have been adequately tested under DP Conditions

A) The "as-tested" %LSB value calculated in Table 3 may be used in the thrust/torque calculation for the subject MOV.

B) IF additional conservatism is desired, the LSB correction factor of 15 % based on the preceding analysis data may be used in the thrust/torque calculation for the subject MOV.

C) An acceptable alternative method to account for LSB in test and margin calculations setup for open and limit switch close MOVs is to convert the minimum required thrust to overcome design basis DP and available thrust capability to corresponding torque values by use of the as-tested dynamic stem factor or a dynamic stem factor based on a coefficient of friction of 0.20. The 0.20 value is justified based on the statistical analysis of the dynamic stem coefficient of friction data .

2) For MOVs which have NOT been adequately tested under DP Conditions

A) The LSB correction factor of 15 % based on the statistical analysis of Ginna test data may be used in the thrust/torque calculation for the subject MOV.

B) An acceptable alternative method to account for LSB in test setup and margin calculations is to convert the minimum required thrust to overcome design basis DP and available thrust capability to corresponding torque values by use of a stem factor based on a coefficient of friction of 0.20. The 0.20 value is justified based on the statistical analysis of the dynamic stem coefficient of friction data

It should be noted that as additional dynamic test data is obtained, this evaluation will need to be revised to incorporate and evaluate the results of those tests.

Stem Coefficient of Friction Conclusions

The 97% confidence values of μ-Stem (static) and μ-Stem (dynamic) of 0.20 and 0.21 are in good agreement with accepted industry experience and the results of the EPRI MOV Performance Prediction Test Program. Therefore, a stem coefficient of friction of 0.20 was a maximum value under both static and dynamic conditions. A lower value of μ-Stem may be used in the setup calculations, as required, and where properly justified by available test data.

The stem coefficient of friction is constantly verified to be less than 0.20 during periodic MOV testing. It should be noted that as additional dynamic test data is obtained, this evaluation may need to be revised to incorporate and evaluate the results of those tests.

5. Analysis of Packing Load

Packing load is a value which is obtained directly through static testing. An analysis of available test data may be used to develop a window of margin that can be used to justify not re-testing a valve following packing adjustments (assuming the packing gland nuts are torqued to the same value). This type of analysis could be performed using a population based analysis or a group based analysis.

Population Based Analysis - a population based analysis would evaluate the available data from the entire valve population. Each measured data point should first be evaluated for validity. If the data for a valve is not considered valid, the data should be removed from the analysis and the valve eliminated as a candidate for relaxed testing requirements. For the valves which pass this initial screening, a bounding, assumed packing load should be established based on EPRI recommendations, as follows:

Stem Diameter	Assumed Packing Load
Up to 1 inch	1000 lb.
1 to 1.5 inch	1500 lb.
1.5 to 2.5 inch	2500 lb.
2.5 to 4 inch	4000 lb.

Once the bounding EPRI number is established, each measured valve packing load (segregated into open and close directions) is divided by the bounding EPRI number to establish a packing load ratio. The mean value and the standard deviation (see section 2.5 below) are then calculated for the entire population of packing load ratios (again segregated into open and close directions). From the calculated mean and standard deviation, the performance of Ginna Station valve packing loads relative to the bounding EPRI values can be assessed with the intent to establish a packing load margin which can be used to justify relaxing test requirements

Group Based Analysis - A group based packing analysis uses a different approach than that described above. The intent of a group based analysis would be to segregate valves into groups based on similar packing performance characteristics (i.e packing type, stem diameter, stem material, valve type & service conditions, etc.). Then measured packing load data would be obtained for valves within each group. The measured data should include corresponding pairs of "as-found" and "as-left" packing loads for the same valve. This data could then be statistically analyzed to establish the expected packing load range for the group. The "as-found" and "as-left" data pairs could be used to determine the anticipated change in packing load which results from re-torquing the gland nuts. This type of analysis would be most useful for valves which do not have large thrust margins. If it can be demonstrated, for a particular group of valves, that the packing load is significantly less than the bounding EPRI value, then the thrust/torque calculations could be based on the smaller, measured test values while still maintaining sufficient margin to justify relaxing the testing requirements.

Initial inspection of available test data showed that there was insufficient data available to support a group based analysis, therefore, a population based analysis was performed. The original scope of the analysis was to include gate and globe valves only, however, after reviewing the test data it was determined that there was insufficient valid globe valve data, therefore, the analysis was limited to gate valves only. The analysis was performed using the values for measure running load in the open and close direction taken from the static test data packages. Once the raw test data was collected, each data point was reviewed to establish its validity. Data points were excluded for the following reasons:

- The recorded value exactly equaled the bounding EPRI number. In these instances it appears that an actual measured value could not be determined and the EPRI number was recorded instead.

- The measured values exceeded the bounding EPRI number. This is considered to be indicative of some type of packing problem and these valves and the associated data were excluded from consideration.

The remaining valves, not excluded for the reasons listed above, were included in the analysis and are considered candidates for relaxed testing requirement. Attachment K-8 presents the valves included in the analysis along with the associated measured packing loads.

Each measured data point listed in Attachment K-8 was divided by the associated, bounding EPRI value to establish a packing load ratio. The results are recorded in Attachment K-9.

A statistical analysis (refer to section 4) was performed for the calculated ratios as documented at the end of Attachment K-9. The results of the analysis show that the average packing load is approximately 40% of the bounding EPRI value with a standard deviation of about 20%. A 97% confidence, "2 sigma" value of the packing load ratio is about 80%. Thus the available data indicates that the maximum expected packing load of Ginna station MOVs is about 80% of the bounding EPRI number. Since the packing torque typically was not known prior to performance of the static test, it is assumed that the statistical results encompass the expected range of packing torque values at Ginna. In other words, the test data scatter should be indicative of the packing loads at both the nominal torque values and the loads at reduced gland torque values. Therefore, retorquing the packing to the nominal torque value is also expected to be encompassed by the 80% bounding value.

Packing Load Conclusions

On the basis of this analysis, it is reasonable to establish a margin limit at 80% of the bounding EPRI value determined as discussed previously. Based on the statistical results, there is a high level of confidence that the packing load for any given gate valve is less than 80% of the assumed design packing torque. Therefore, the margin limit can then be used as a criteria for judging whether the re-test requirements for a given valve may be relaxed. The requirement to re-test a valve following packing adjustment may be waived if all of the following conditions are met:

- The valve must be a gate valve.
- Valid static test data must be available for each valve (grouping is not supported by this analysis) which demonstrates that the measured packing load in the open and close directions is less than 80% of the bounding EPRI value.
- The scope of the packing adjustment must be limited to re-tightening the gland nuts, in accordance with controlled procedures, to the torque value which was established prior to obtaining the test data discussed above.
- The packing load value used to determine target thrust/torque values to establish switch setting limits must be equal to or greater than the bounding EPRI value.

6. Attachments

Attachment K-1 - Calculation of Valve Factor From Ginna Test Data
Attachment K-2 -. Open DP Thrust Traces for MOVs 860A and 860D
Attachment K-3 - Calculation of Valve Factor From EPRI Test Data for Aloyco Split Wedge Gate Valves.
Attachment K-4 - Calculation of Valve Factor From Indian Point 2 and Crystal River Test Data for 4", 150# class Aloyco Split Wedge Gate Valves and 10" 1500# Velan Flex Wedge Gate Valve from H.B. Robinson
Attachment K-5- Recommended Required Thrust Methodology and Actions Required for Long Term Resolution.
Attachment K-6- Long Term and Interim Gate Valve Factors.
Attachment K-7 - Margin For Valve Factor Degradation (in Safety-Direction) for MOVs with Long Term Valve Factors
Attachment K-8 – Packing Load Analysis – Test Data
Attachment K-9 – Packing Load Analysis

7. References

1. NMAC Report NP-6660-D, "Application Guide for Motor Operated Valves in Nuclear Power Plants", Final Report, March 1990.

2. Deleted

3. EWR-5080 Rev. 9, "RG&E Design Analysis NSL-5080-002"

4. EPRI Topical Report -TR-103237 Rev. 2- "EPRI MOV Performance Prediction Program (PPM): Implementation Guide Revision 1," Electric Power Research Institute, Palo Alto, CA, October 1996.

5. EPRI Topical Report -TR-103244 Rev. 1- "EPRI MOV Performance Prediction Program (PPM): Topical Report - Revision 2," Electric Power Research Institute, Palo Alto, CA, April 1997.

6. EPRI Topical Report -TR-103232- "EPRI MOV Performance Prediction Program (PPM): Engineering Analysis Report for Anchor/Darling Double Disk Gate Valves," Electric Power Research Institute, Palo Alto, CA, November 1994.

7. EPRI Topical Report -TR-103235- "EPRI MOV Performance Prediction Program (PPM): Engineering Analysis Report for Aloyco Split Wedge Gate Valves," Electric Power Research Institute, Palo Alto, CA, August 1996.

8. EPRI Topical Report -TR-103229- "EPRI MOV Performance Prediction Program (PPM): Gate Valve Model Description Report," Electric Power Research Institute, Palo Alto, CA, November 1994.

9. EPRI Topical Report -TR-103233- "EPRI MOV Performance Prediction Program (PPM): Engineering Analysis Report for Westinghouse Flex Wedge Gate Valves," Electric Power Research Institute, Palo Alto, CA, November 1995.

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15. Bill R. Black, TU Electric- Comanche Peak Steam Electric Station, "Results of the Motor Operated Valve Engineering and Testing Program", Proceedings of the Third NRC/ASME Symposium on Pump and Valve Testing, NUREG/CP-0137, Vol. 1, July 1994.

16. RG&E Inservice Test Program, Rev. 0

17. NRC Information Notice, IN 89-61, "Failure of Borg-Warner Gate Valves To Close Against Differential Pressure"

18. Consolidated Edison, Indian Point 2, SE-SQ-12.314, MOV Dynamic Test Evaluation for Valve LCV-112C. Test date: 3/8/93.

19. New York Power Authority, Indian Point 3 IP3-RPT-MULT-01345, R/1, Attachment 2, "Evaluation of Valve CH-LCV-112B" dated 1-13-98. (Includes evaluation of Crystal River DP Testing of DHV-12).

20. Crane-MOVATS ER-5.0 Rev. 10 Addendum 0.

21. H.B. Robinson Calculation RNP-M/MECH-1471 Rev. 2, "Evaluation of Static and Dynamic Test Data for RHR-744A"

22. H.B. Robinson Calculation RNP-M/MECH-1472 Rev. 2, "Evaluation of Static and Dynamic Test Data for RHR-744B"

23. Altran Technical Report 94108-TR-01, Pressure Locking and Thermal Binding Evaluation.

24. Duke Engineering and Services Report, Ginna Station MOV DP Test Review, Generic Letter 89-10 Closure, dated February 18-20, 1998

25. Duke Engineering and Services Report, Ginna Station MOV Assessment Generic Letter 89-10 MOV Program Closure

26. Kalsi Engineering Document # 2029C Rev. 0.

Calculation of Valve Factor From Ginna Test Data

CLOSE VALVE FACTORS

Valve ID			Press Class	Adjusted Thrust to overcome DP (M1) (Clsd)	Measured Static PL (Clsd)	Stem Diameter	Corrected Upstream Pressure (A) (Clsd)	Corrected DP (Closed)	Orifice Area	Close Valve Factor
0857A	6x4x6	A/D DD	300	1864	293	1.375	170	187	15.904	0.44
814	6"	Crane FW	150	2304	186	0.875	106	91	26.970	0.84
4663	6"	Crane-Ch FW	150	1795	1123	1.125	56	56	26.970	0.41
4615	20"	Crane FW	150	17090	374	2.250	95.2	92.2	338.163	0.52
4616	20"	Crane FW	150	14821	740	2.000	107.2	103.2	338.163	0.39
4664	10"	Crane FW	150	5454	546	1.625	86	86	85.932	0.64
0738A	10"	Crane SW	150	3320	816	1.625	113.5	98.1	88.247	0.26
0738B	10"	Crane SW	150	3049	993	1.625	104.5	89.1	88.247	0.23
0871A	3"	Velan FW	1500	4214	604	1.125	1480	1420	5.157	0.29
0871B	3"	Velan FW	1500	4558	1101	1.125	1460	1390	5.157	0.28

Closed VF = (M1-Measured PL-Stem Area*Upstream Pressure)/(DP*Orifice Area)

Test data from M-64.1.6 Data Sheets for Each MOV except for 857A which is from Attachment 2 adjusted by 1.414% read. +117 Lbs..

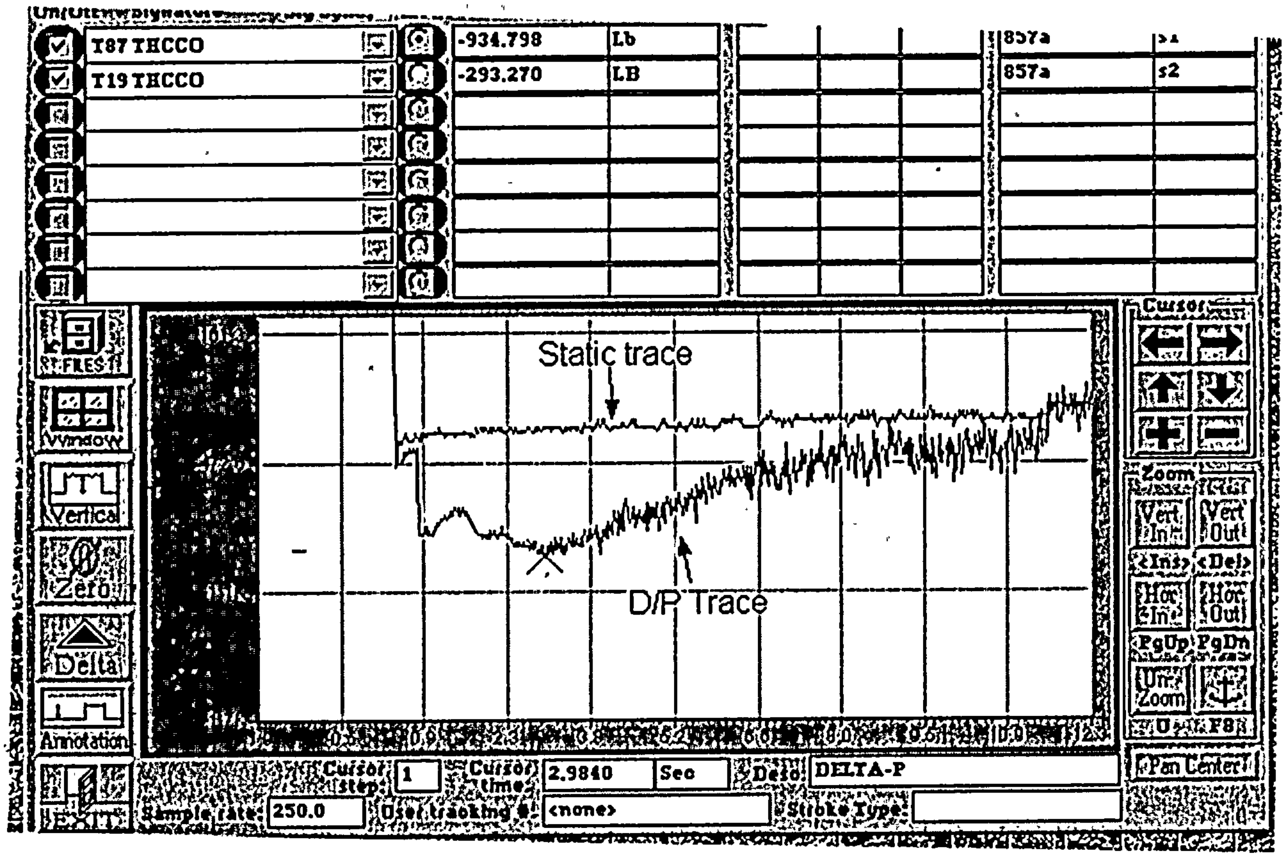
OPEN VALVE FACTORS

Valve ID			Press Class	Adjusted Thrust to overcome DP (M1) (Opn)	Measured Static PL (Opn)	Stem Diameter	Corrected Upstream Pressure (A) (Opn)	Corrected DP (Open)	Orifice Area	Open Valve Factor
0857A	6x4x6	A/D DD	300	1065	293	1.375	170	187	15.904	0.34
9746	3"	W FW	1500	1273	620	1.125	1360	650	8.143	0.38
4615	20"	Crane FW	150	15079	1405	2.250	95.2	92.2	338.163	0.45
4616	20"	Crane FW	150	12550	1296	2.000	107.2	103.2	338.163	0.33
0738A	10"	Crane SW	150	3131	982	1.625	112.5	96.1	88.247	0.28
0738B	10"	Crane SW	150	3389	846	1.625	104.5	88.1	88.247	0.35
0871A	3"	Velan FW	1500	2335	2169	1.125	1480	1420	5.157	0.22
0871B	3"	Velan FW	1500	3026	1192	1.125	1460	1390	5.157	0.46
3505A	6"	A/D FW	600	9864	810	1.375	990	975	26.239	0.41

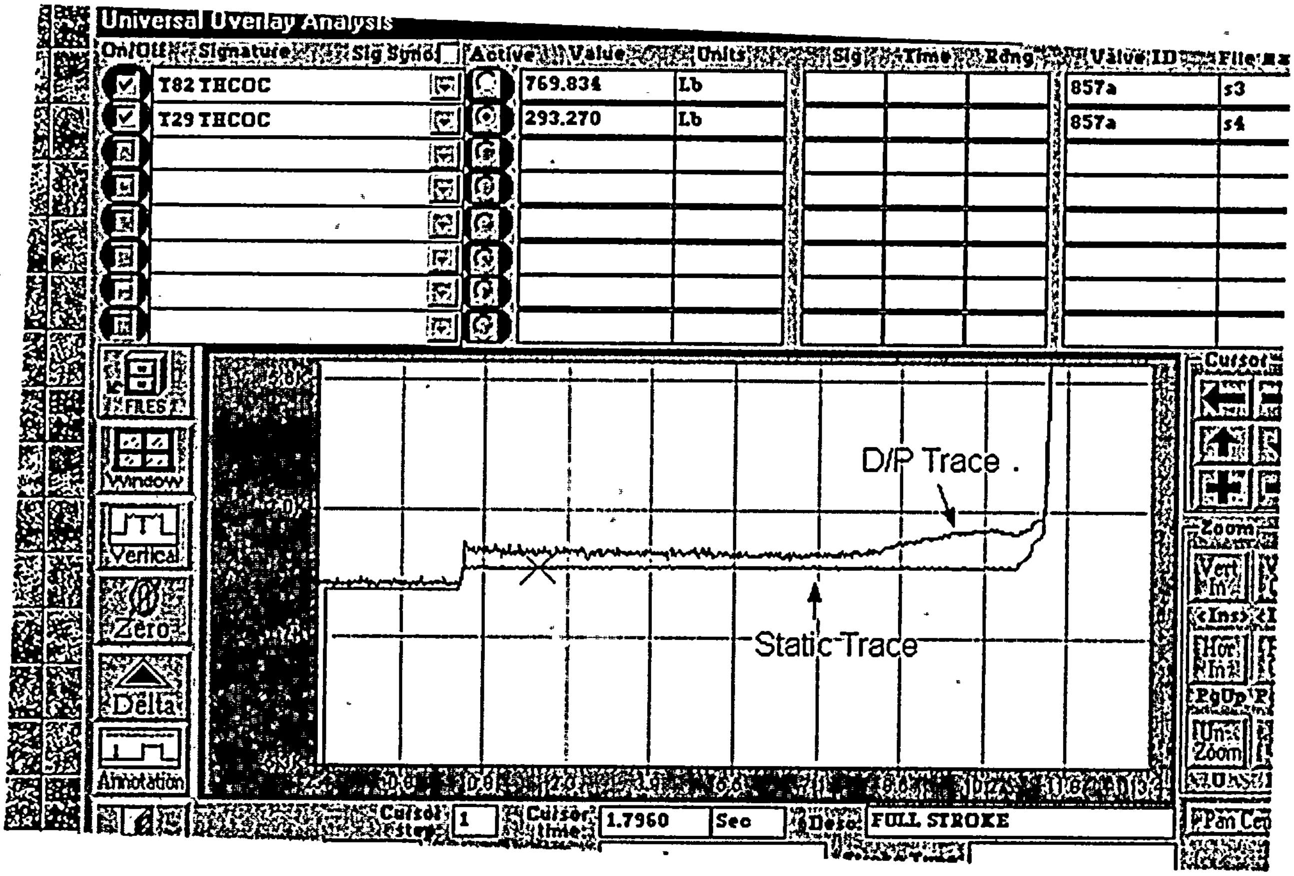
Open VF = (M1-Measured PL+Stem Area*Upstream Pressure)/(DP*Orifice Area)

DP Thrust Traces for MOVs 857A, 860A and 860D

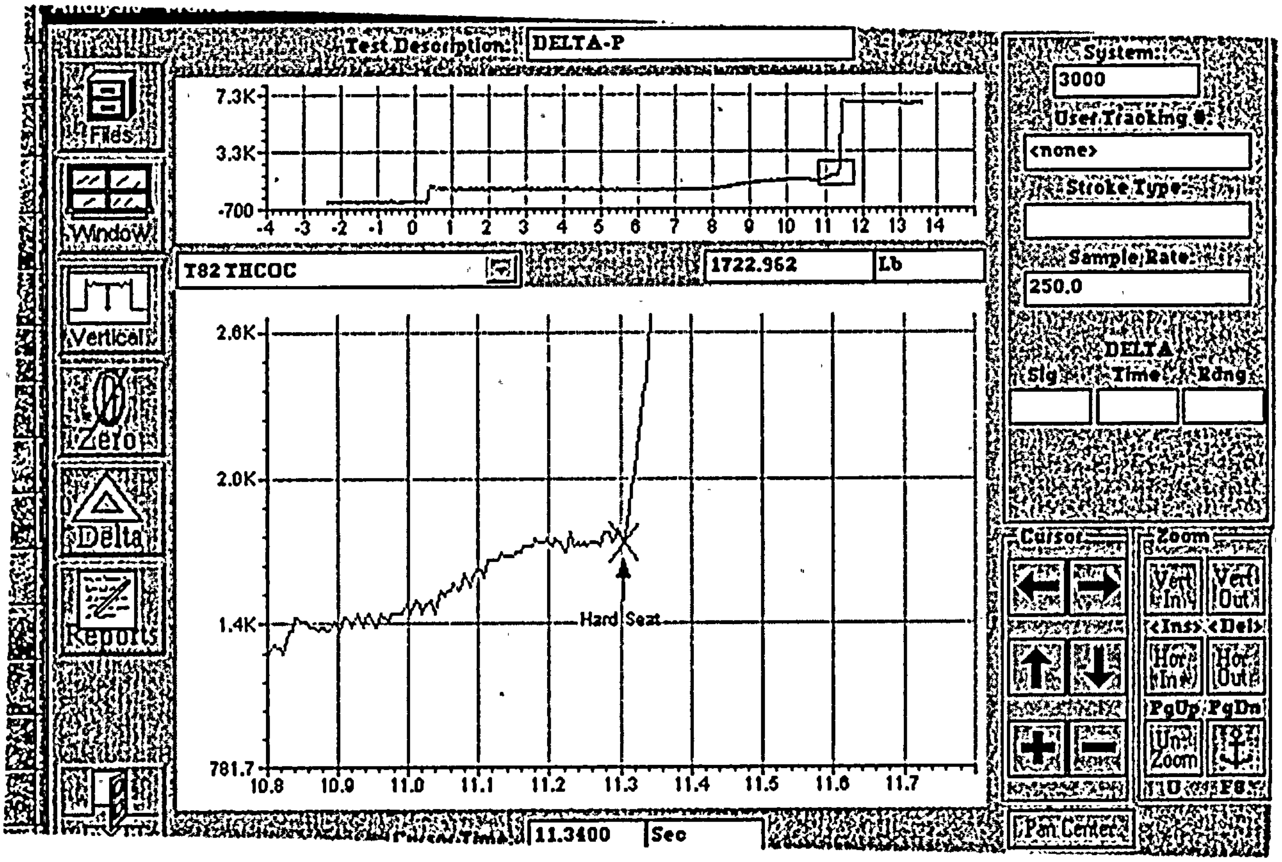
MOV 857A Open Static and DP Thrust



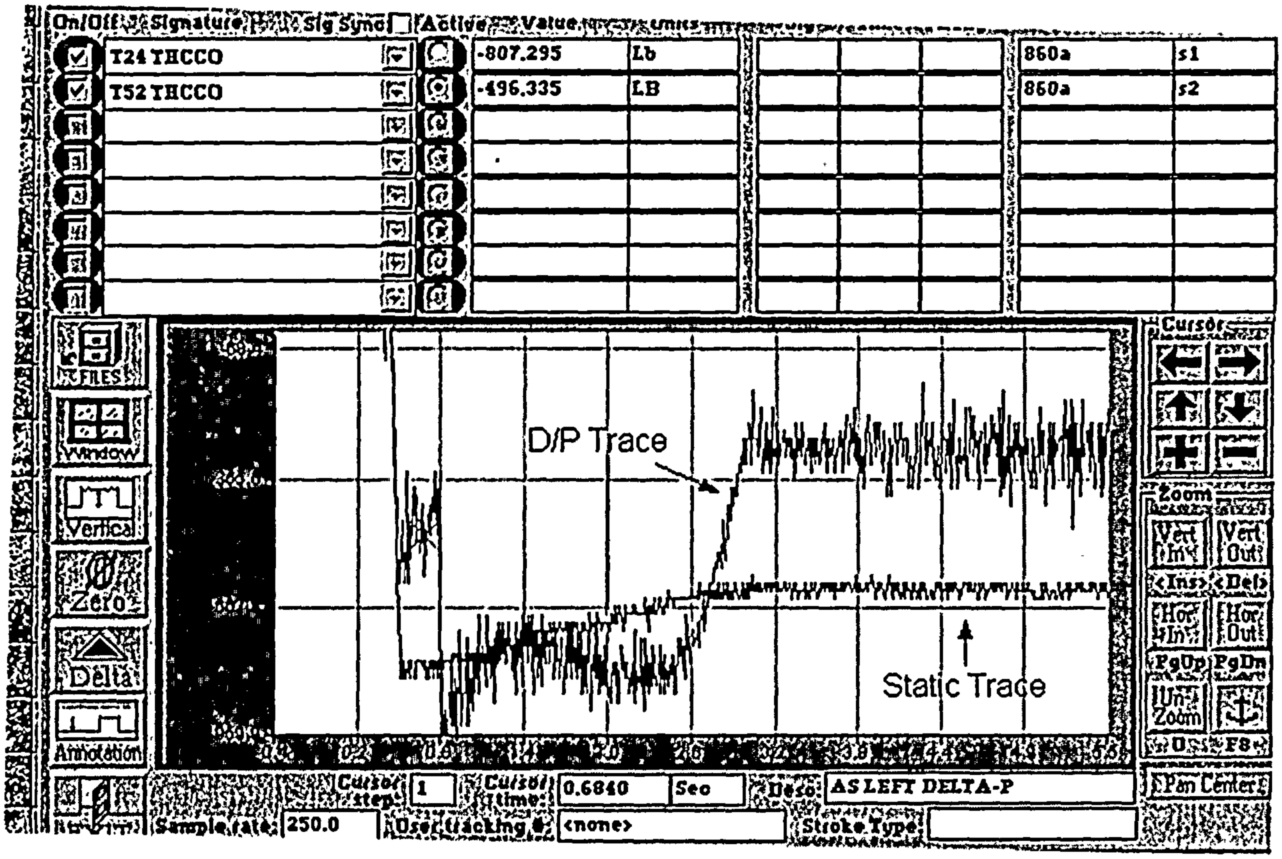
MOV 857A Close and DP Thrust



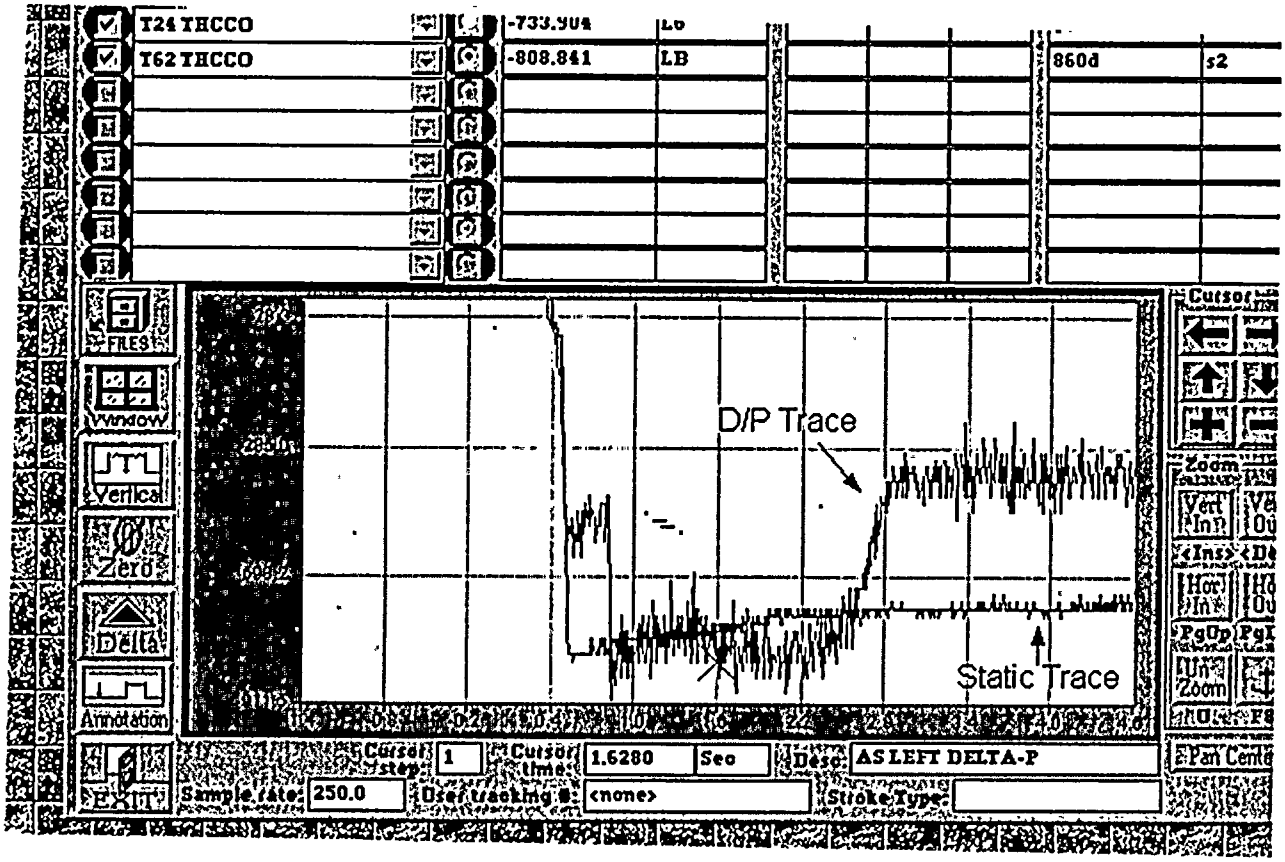
MOV 857A Expanded View of Static and DP Thrust at Hard Seat



MOV 860A Open Static and DP Thrust



MOV 860D Open Static and DP Thrust



Calculation of Open & Close Valve Factors From EPRI Test Data for the Aloyco Split Wedge Gate Valve (Wyle Valve #15)

EPRI Test	Stem A	Disc A	Open DP	Open LP	Open Thrust	Open PL	Open VF	Apparent Disc μ
232	0.785	13.98	89	96.56	423	236	0.21	N/A
234	0.785	13.98	183	191.69	542	236	0.18	N/A
236	0.785	13.98	275	283.4	705	236	0.18	N/A
240	0.785	13.98	280	275.6	669	236	0.17	N/A
242	0.785	13.98	278	268.9	759	236	0.19	N/A
244	0.785	13.98	181	190.6	600	236	0.20	N/A
246	0.785	13.98	93.2	99.3	492	236	0.26	N/A
250	0.785	13.98	245.7	250.98	696	236	0.19	N/A

Stem Diameter = 1.000 in.
Mean Seat Diameter =4.219 in.

$$\text{Open VF} = \frac{\text{Open DP Thrust} - \text{Open PL} + \text{StemA} * \text{Open LP}}{\text{Disc A} * \text{Open DP}}$$

Notes: EPRI did not calculate apparent disc μ values in the open direction.

Valve, pressure, and thrust data obtained from Attachment 3 of EPRI Technical Report -TR-103235- MOV Performance Prediction Program (PPM): Engineering Analysis Report for Aloyco Split Wedge Valves," Electric Power Research Institute, Palo Alto, CA, August 1996.

EPRI Test	Stem A	Disc A	Close DP	Close LP	Close Thrust	Close PL	Close VF	Apparent Disc μ
231	0.785	13.98	87	94.4	590	308	0.17	0.11
233	0.785	13.98	180	187.34	912	330	0.17	0.13
235	0.785	13.98	274	282.89	2782	352	0.58	0.13
239	0.785	13.98	260	286.8	2250	374	0.45	0.19
241	0.785	13.98	275.6	286.2	3175	396	0.66	0.18
243	0.785	13.98	181.8	185.5	1333	418	0.30	0.21
245	0.785	13.98	93.9	98.31	862	440	0.26	0.18

Stem Diameter = 1.000 in.
Mean Seat Diameter =4.219 in.

$$\text{Close VF} = \frac{\text{Close DP Thrust} - \text{Close PL} - \text{StemA} * \text{Close LP}}{\text{Disc A} * \text{Close DP}}$$

Notes: Apparent Disc μ is based on Flow Isolation. Valve Factor calculated at hard

Valve, pressure, and thrust data obtained from Attachment 2 of EPRI Technical Report -TR-103235- MOV Performance Prediction Program (PPM): Engineering Analysis Report for Aloyco Split Wedge Valves," Electric Power Research Institute, Palo Alto, CA, August 1996.

Attachment K-4

Calculation of Valve Factor From Indian Point 2 and Crystal River Test Data for 4" 150# Class Aloyco Split Wedge Gate Valves and 10" 1500# Velan Flex Wedge Gate Valve from H.B. Robinson

Indian Point 2 and Crystal River 150# Aloyco Split Wedge Gate Valves

Valve ID	Valve Size	Valve Type	Press Class	Adjusted Thrust to reach Hard Seat	Measured Static PL	Stem Diameter	Corrected Upstream Pressure (A)	Corrected DP	Orifice Area	Hard Seat Valve Factor
Indian Point 2 LCV-112C	4"	Aloyco SPW	150	796	190	1.000	98.9	92.8	13.980	0.41
Crystal River CR-DHV-12	4"	Aloyco SPW	150	1277	609	1.000	131	128	13.980	0.32

Hard Seat VF = (Adj. Hard Seat Thrust-Measured PL-Stem Area*Upstream Pressure)/(DP*Orifice Area)

Indian Point 2 Test Data from Reference 18

Crystal River Test Data from Reference 19

Thrust Error Adjustments in accordance with reference 20.

H.B. Robinson 1500# Velan Flex Wedge Gate Valves

Valve ID	Valve Size	Valve Type	Press Class	Adjusted Thrust to reach Hard Seat	Measured Static PL	Stem Diameter	Corrected Upstream Pressure (A)	Corrected DP	Orifice Area	Close Valve Factor
RHR-744A	10"	Velan FWG	1500	6206	1282	2.500	141.4	130.3	48.710	0.67
RHR-744B	10"	Velan FWG	1500	4428	779	2.500	141.4	130.3	48.710	0.47
				Adjusted Open DP Thrust	Measured Static PL	Stem Diameter	Corrected Upstream Pressure (A)	Corrected DP	Orifice Area	Open Valve Factor
RHR-744A	10"	Velan FWG	1500	4765	1516	2.500	141.4	130.3	48.710	0.62
RHR-744B	10"	Velan FWG	1500	4562	861	2.500	141.4	130.3	48.710	0.69

Close VF = (Adj. Hard Seat Thrust-Measured PL-Stem Area*Upstream Pressure)/(DP*Orifice Area)
Open VF = (Adj. Open DP Thrust-Measured PL+Stem Area*Upstream Pressure)/(DP*Orifice Area)

Test Data and Error Values from References 21 and 22

Attachment K-5

Recommended Required Thrust Methodology and Actions Required for Long Term Resolution.
Page 1 of 1

Valve Number	Valve Size	Valve Type	ANSI Press. Class	Valve Vendor	Recommended Calculation Methodology	Action Required for Long Term Resolution
313	3	SPW GATE	150	Aloyco	Standard	None
515	3	DD GATE	1513	Anchor Darling	EPRI PPM	Perform PPM
516	3	DD GATE	1513	Anchor Darling	EPRI PPM	Perform PPM
700	10	GATE	1500	VELAN	Standard	None
701	10	GATE	1500	VELAN	Standard	None
704A	10"x8"x10"	DD GATE	300	Anchor Darling	EPRI PPM	Perform PPM
704B	10"x8"x10"	DD GATE	300	Anchor Darling	EPRI PPM	Perform PPM
738A	10	GATE	150	CRANE	Standard	None
738B	10	GATE	150	CRANE	Standard	None
759A	3	GATE	150	CRANE	EPRI PPM	Perform PPM
759B	3	GATE	150	CRANE	EPRI PPM	Perform PPM
813	6	GATE	150	CRANE	Standard	DP Test
814	6	GATE	150	CRANE	Standard	None
841	10"x8"x10"	DD GATE	1500	Anchor Darling	Standard	None
850A	10	DD GATE	300	Anchor Darling	EPRI PPM	Perform PPM
850B	10	DD GATE	300	Anchor Darling	EPRI PPM	Perform PPM
852A	6	GATE	1500	VELAN	EPRI PPM	Perform PPM
852B	6	GATE	1500	VELAN	EPRI PPM	Perform PPM
856	10	DD GATE	300	Anchor Darling	Standard	None
857A	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	None
857B	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	None
857C	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	DP Test
860A	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	Open DP Test
860B	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	Open DP Test
860C	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	Open DP Test
860D	6"x4"x6"	DD GATE	300	Anchor Darling	Standard	Open DP Test
865	10"x8"x10"	DD GATE	1500	Anchor Darling	Standard	None
871A	3	GATE	1500	VELAN	Standard	None
871B	3	GATE	1500	VELAN	Standard	None
896A	10"x8"x10"	SPW GATE	150	Alyoco	Standard	None
896B	10"x8"x10"	SPW GATE	150	Alyoco	Standard	None
3504A	6	GATE	600	Anchor Darling	Standard	None
3505A	6	GATE	600	Anchor Darling	Standard	Close DP Test
4615	20	GATE	150	CRANE	Standard	None
4616	20	GATE	150	Raimondi	Standard	None
4663	6	GATE	150	CRANE	Standard	None
4664	10	GATE	150	CRANE	Standard	None
4670	10	GATE	150	CRANE	Standard	DP Test
9629A	4	GATE	300	Borg Warner	Standard	None
9629B	4	GATE	300	BorgWarner	Standard	DP Test
9746	3	GATE	2035	Westinghouse	Standard	None

Attachment K-6

Long Term and Interim Gate Valve Factors.
Page 1 of 1

Valve Number	Valve Size	Valve Type	ANSI Press. Class	Valve Vendor	OPEN Valve Factor	CLOSE Valve Factor	For Interim or Long Term Use?	Basis for Valve Factor
313	3	SPW GATE	150	Aloyco	0.50	0.50	Long Term	1, 11
515	3	DD GATE	1513	Anchor Darling	EPRI PPM	EPRI PPM	Long Term	N/A
516	3	DD GATE	1513	Anchor Darling	EPRI PPM	EPRI PPM	Long Term	N/A
700	10	GATE	1500	VELAN	0.70	0.70	Long Term	4, 8, 10
701	10	GATE	1500	VELAN	0.70	0.70	Long Term	4, 8, 10
704A	10"x8"x10"	DD GATE	300	Anchor Darling	EPRI PPM	EPRI PPM	Long Term	6
704B	10"x8"x10"	DD GATE	300	Anchor Darling	EPRI PPM	EPRI PPM	Long Term	6
738A	10	GATE	150	CRANE	0.40	0.30	Long Term	1,2
738B	10	GATE	150	CRANE	0.40	0.30	Long Term	1,2
759A	3	GATE	150	CRANE	0.90	0.90	Interim	5
759B	3	GATE	150	CRANE	0.90	0.90	Interim	1,5
813	6	GATE	150	CRANE	0.90	0.90	Interim	5
814	6	GATE	150	CRANE	0.90	0.90	Long Term	1
841	10"x8"x10"	DD GATE	1500	Anchor Darling	N/A	N/A	Long Term	3
850A	10	DD GATE	300	Anchor Darling	EPRI PPM	EPRI PPM	Long Term	6
850B	10	DD GATE	300	Anchor Darling	EPRI PPM	EPRI PPM	Long Term	6
852A	6	GATE	1500	VELAN	FROM PL/TB CALC		Long Term	9
852B	6	GATE	1500	VELAN	FROM PL/TB CALC		Long Term	9
856	10	DD GATE	300	Anchor Darling	N/A	N/A	Long Term	3
857A	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Long Term	1
857B	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Long Term	1
857C	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Interim	2
860A	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Interim	1,2
860B	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Interim	2
860C	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Interim	2
860D	6"x4"x6"	DD GATE	300	Anchor Darling	0.50	0.50	Interim	1,2
865	10"x8"x10"	DD GATE	1500	Anchor Darling	N/A	N/A	Long Term	3
871A	3	GATE	1500	VELAN	0.55	0.35	Long Term	1,2
871B	3	GATE	1500	VELAN	0.55	0.35	Long Term	1,2
896A	10"x8"x10"	SPW GATE	150	Alyoco	N/A	N/A	Long Term	3
896B	10"x8"x10"	SPW GATE	150	Alyoco	N/A	N/A	Long Term	3
3504A	6	GATE	600	Anchor Darling	0.50	0.50	Long Term	1, 2
3505A	6	GATE	600	Anchor Darling	0.50	0.50	Interim	1, 2
4615	20	GATE	150	CRANE	0.60	0.60	Long Term	1,2
4616	20	GATE	150	Raimondi	0.50	0.50	Long Term	1,2
4663	6	GATE	150	CRANE	0.50	0.50	Long Term	1
4664	10	GATE	150	CRANE	0.70	0.70	Long Term	1
4670	10	GATE	150	CRANE	0.70	0.70	Interim	5, 6
9629A	4	GATE	300	Borg Warner	0.50	0.50	Long Term	1
9629B	4	GATE	300	BorgWarner	0.90	0.90	Interim	7
9746	3	GATE	2035	Westinghouse	N/A	N/A	Long Term	3

Valve Factor Basis Key

1 Dynamic Test of Subject MOV
2 Maximum Adjusted Valve Factor for group of identical valves.
3 0 psid or negligible MEDP in safety direction.
4 Maximum Adjusted Valve Factor for group of similar valves.
5 As-Tested Valve Factor for similar or identical Valve.
6 ComEd Valve Factor Data
7 Comanche Peak Valve Factor Data
8 Not a TRUE GL 89-10 MOV, included in program due to risk significance.
9 MOV has open safety function. Min. requirement is due to PL/TB.
10 IP2 and Crystal River or Robinson Valve Factor Test Data

Attachment K-7

Margin For Valve Factor Degradation (in Safety-Direction) for MOVs with Long Term Valve Factors

OPEN SAFETY FUNCTION VALVES

Valve	As-Tested Open Valve Factor	Long Term Open Valve Factor	Open VF Margin	%
857B	0.34	0.50	0.16	47%
857B	0.39	0.50	0.11	28%
4615	0.45	0.60	0.15	33%
4616	0.33	0.50	0.17	52%
738A	0.28	0.40	0.12	43%
738B	0.35	0.40	0.05	14%
3504A	0.29	0.50	0.21	72%
3505A	0.41	0.50	0.09	22%
9629A	0.30	0.50	0.20	67%

CLOSE SAFETY FUNCTION VALVES

Valve	As-Tested Close Valve Factor	Long Term Close Valve Factor	Close VF Margin	%
4615	0.52	0.60	0.08	15%
4616	0.39	0.50	0.11	28%
4664	0.64	0.70	0.06	9%
814	0.84	0.90	0.06	7%
871A	0.29	0.35	0.06	21%
871B	0.28	0.35	0.07	25%
3504A	0.23	0.50	0.27	117%
9629A	0.27	0.50	0.23	85%

Attachment K-8
Packing Load Analysis - Test Data

Valve ID	Work Order	Type	Disc	Stem Dia.	EPRI Packing Load	Smartbook Packing Load	Close Test Packing Load	Open Test Packing Load
0313	19601738	GATE	SP	0.875	1000	878	627	547
0515	19402869	GATE	DD	0.75	1000	1000	532	568
0516	19402867	GATE	DD	0.75	1000	1000	514	513
0704B	19221563	GATE	DD	1.375	1500	1500	815	1086
0738A	19221443	GATE	SW	1.625	2500	2500	816	982
0738B	19504231	GATE	SW	1.625	2500	2500	843	935
0738B	19221441	GATE	SW	1.625	2500	2500	993	846
0749B	19321381	GATE	FW	0.625	1000	1000	206	195
0759A	19321386	GATE	FW	0.625	1000	1000	23	23
0759B	19321389	GATE	FW	0.625	1000	1000	46	57
0813	19601477	GATE	FW	0.875	1000	1000	194	319
0814	19221433	GATE	FW	0.875	1000	1000	186	240
0850A	19321364	GATE	DD	1.5	1500	1500	702	1170
0856	19521366	GATE	DD	1.5	1500	1500	528	455
0857A	19504238	GATE	DD	1.375	1500	1500	439	247

Attachment K-8
Packing Load Analysis - Test Data

Valve ID	Work Order	Type	Disc	Stem Dia.	EPRI Packing Load	Smartbook Packing Load	Close Test Packing Load	Open Test Packing Load
0857A	19604163	GATE	DD	1.375	1500	1500	726	637
0857B	19504240	GATE	DD	1.375	1500	1500	458	498
0857B	19604162	GATE	DD	1.375	1500	1500	568	469
0857C	19604161	GATE	DD	1.375	1500	1500	440	330
0857C	19504242	GATE	DD	1.375	1500	1500	421	513
0860A	19221439	GATE	DD	1.375	1500	772	706	700
0860A	19400531	GATE	DD	1.375	1500	772	772	699
0860B	19221438	GATE	DD	1.375	1500	924	924	804
0860C	19221437	GATE	DD	1.375	1500	634	634	605
0860D	19400532	GATE	DD	1.375	1500	806	806	709
0865	19321368	GATE	DD	2.125	2500	2500	620	810
0871B	19221428	GATE	FW	1.125	1500	1500	1101	1192
0896A	19240743	GATE	SP	1.25	1500	1500	1173	1173
0896B	19504243	GATE	SP	1.25	1500	1500	403	459
1815B	19241158	GATE	SP	1	1000	1000	569	628

Attachment K-8
Packing Load Analysis - Test Data

Valve ID	Work Order	Type	Disc	Stem Dia.	EPRI Packing Load	Smartbook Packing Load	Close Test Packing Load	Open Test Packing Load
3505A	19600234	GATE	FW	1.375	1500	1500	1445	1445
3505A	19604599	GATE	FW	1.375	1500	1500	304	810
4615	19504250	GATE	SW	2.25	2500	2500	374	1405
4616	19602930	GATE	FW	2	2500	2500	1593	1817
4616	19221506	GATE	FW	2	2500	2500	740	1296
4663	19400660	GATE	FW	1.12	1500	1200	1123	1200
4663	19504251	GATE	FW	1.12	1500	1200	741	718
4664	19221519	GATE	FW	1.625	2500	2500	1350	1350
4664	19504253	GATE	FW	1.625	2500	2500	546	
4670	19502206	GATE	FW	1.375	1500	1500	344	
9629A	19504257	GATE	FW	1	1000	1000	623	477
9629A	19221943	GATE	FW	1	1000	1000	642	605
9629B	19221944	GATE	FW	1	1000	1000	369	220
9746	19400530	GATE	FW	1.125	1500	1500	609	620
9746	19241156	GATE	FW	1.125	1500	1500	609	620

Attachment K-9
Packing Load Analysis

Valve ID	EPRI Packing Load	Tested Close Packing Load	Tested Open Packing Load	[Close / EPRI] PL Ratio	[Open / EPRI] PL Ratio
0313	1000	627	547	0.627	0.547
0515	1000	532	568	0.532	0.568
0516	1000	514	513	0.514	0.513
0704B	1500	815	1086	0.543	0.724
0738A	2500	816	982	0.326	0.393
0738B	2500	843	935	0.337	0.374
0738B	2500	993	846	0.397	0.338
0749B	1000	206	195	0.206	0.195
0759A	1000	23	23	0.023	0.023
0759B	1000	46	57	0.046	0.057
0813	1000	194	319	0.194	0.319
0814	1000	186	240	0.186	0.240
0850A	1500	702	1170	0.468	0.780
0856	1500	528	455	0.352	0.303
0857A	1500	439	247	0.293	0.165
0857A	1500	726	637	0.484	0.425
0857B	1500	458	498	0.305	0.332

Attachment K-9
Packing Load Analysis

Valve ID	EPRI Packing Load	Tested Close Packing Load	Tested Open Packing Load	[Close / EPRI] PL Ratio	[Open / EPRI] PL Ratio
0857B	1500	568	469	0.379	0.313
0857C	1500	440	330	0.293	0.220
0857C	1500	421	513	0.281	0.342
0860A	1500	706	700	0.471	0.467
0860A	1500	772	699	0.515	0.466
0860B	1500	924	804	0.616	0.536
0860C	1500	634	605	0.423	0.403
0860D	1500	806	709	0.537	0.473
0865	2500	620	810	0.248	0.324
0871B	1500	1101	1192	0.734	0.795
0896A	1500	1173	1173	0.782	0.782
0896B	1500	403	459	0.269	0.306
1815B	1000	569	628	0.569	0.628
3505A	1500	1445	1445	0.963	0.963
3505A	1500	304	810	0.203	0.540
4615	2500	374	1405	0.150	0.562
4616	2500	1593	1817	0.637	0.727

Attachment K-9
Packing Load Analysis

Valve ID	EPRI Packing Load	Tested Close Packing Load	Tested Open Packing Load	[Close / EPRI] PL Ratio	[Open / EPRI] PL Ratio
4616	2500	740	1296	0.296	0.518
4663	1500	1123	1200	0.749	0.800
4663	1500	741	718	0.494	0.479
4664	2500	1350	1350	0.540	0.540
4664	2500	546		0.218	
4670	1500	344		0.229	
9629A	1000	623	477	0.623	0.477
9629A	1000	642	605	0.642	0.605
9629B	1000	369	220	0.369	0.220
9746	1500	609	620	0.406	0.413
9746	1500	609	620	0.406	0.413

Statistical Analysis of Packing Load Ratios

Average of [Close / EPRI] PL Ratio	Standard Deviation of [Close / EPRI] PL Ratio	Average of [Open / EPRI] PL Ratio	Standard Deviation of [Open / EPRI] PL Ratio
0.419	0.200	0.456	0.206