Westinghouse Calculation Note Cover Sheet

CALC NO: V-EC-1606	REV: 0

TITLE: VERIFICATION OF PRESSURE LOCKING ANALYSIS PROGRAM PRESLOK

PROJECT: WOG	SHOP ORDER: 220
PURPOSE: (see page(s)) 5	RESULTS: (see page(s)) 5, 6

IS THERE MICROFILM ASSOCIATED WITH THIS CALCULATION? ___ YES ✓ NO

AUTHOR(S): NAME (Print or Type)	SIGNATURE	DATE
WILLIAM E. MOORE	William E. Moore	2/8/96

VERIFIER(S): NAME (Print or Type)	SIGNATURE	DATE
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Method of Verification Used: Indepent Review

MANAGER NAME (Print or Type)	SIGNATURE	DATE
L. I. WALKER	[signature]	2/8/96

CALCULATION NOTE METHODOLOGY CHECKLIST

CALC-NOTE NUMBER: V-EC-1606 REV. 0

CHECKLIST TO BE COMPLETED BY AUTHOR(S). (CHECK APPROPRIATE RESPONSE)

1. Is the Subject and/or the Purpose of the Design Analysis Clearly Stated ? .... Yes ✓ No ___
2. Are the Required Inputs and Their Sources Provided ? .... Yes ✓ No ___ N/A ___
3. Are the Assumptions Clearly Identified and Justified ? .... Yes ✓ No ___ N/A ___
4. Are the Methods and Units Clearly Identified ? .... Yes ✓ No ___ N/A ___
5. Have the Limits of Applicability Been Identified ? .... Yes ✓ No ___ N/A ___
6. Are the Results of Literature Searches, if Conducted, or Other Background Data Provided ? .... Yes ___ No ___ N/A ✓
7. Are all the Pages Sequentially Numbered and Identified by the Calculation Note Number ? .... Yes ✓ No ___
8. Is the Project or Shop Order Clearly Identified ? .... Yes ✓ No ___
9. Has the Required Computer Calculation Information Been Provided ? .... Yes ___ No ___ N/A ✓
10. Were the Computer Codes Used Under Configuration Control ? .... Yes ___ No ___ N/A ✓
11. Were the Computer Code(s) Used Applicable for Modeling the Physical and/or Computational Problems Identified ? .... Yes ___ No ___ N/A ✓
12. Are the Results and Conclusions Clearly Stated ? .... Yes ✓ No ___
13. Are Open Items Properly Identified ? .... Yes ___ No ___ N/A ✓
14. Were Approved Design Control Practices Followed Without Exception ? .... Yes ✓ No ___

NOTE:

- If no to any of the above, page number containing justification: ________

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1. The information in this calc note has been determined by the author(s) or appropriate Westinghouse personnel to be;

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   GENERALLY APPLICABLE TO FLEXIBLE WEDGE TYPE GATE VALVES

Note that prior to release, this calc note must be accompanied by a cover sheet which includes the appropriate proprietary information markings and disclosure clauses as specified in WCAP-7211, Rev. 3. Note also that prior to release, all pages of this calc note must be marked with the appropriate proprietary class designation.

TABLE OF CONTENTS

PURPOSE.

The purpose of this calculation is to provide verification that the MATHCAD program PRESLOK, which was developed for the Westinghouse Owner's Group to perform pressure locking analysis of flexible wedge type gate valves using the Commonwealth Edison method, accurately performs the required calculations. This verification will apply to Version 1 of the program (preslok1.mcd), which accepts closing valve factor as an input, and also to Version 2 (preslok2.mcd), which accepts the coefficient of friction between the disk and the seat as an input.

CONCLUSIONS

The conclusion of this report is that both Version 1 and Version 2 of the program PRESLOK, as described in Rev. 1 to the User's Manual, correctly perform the calculations necessary to analyze flexible wedge type gate valves for pressure locking using the Commonwealth Edison methodology.

METHODOLOGY

The PRESLOK User's Manual is attached to this calculation as Appendix A and is part of this calculation. The remainder of the calculation consists of a problem which is worked out by hand and compared to the PRESLOK Version 1 calculation results to verify that the MATHCAD instructions accurately reflect the analysis methods being used. We have also computed the answers for this problem using the PRESLOK Version 2 program by entering the co-efficient of friction corresponding to the valve factor used in the test problem. The PRESLOK Version 1 and PRESLOK Version 2 outputs for the test problem are attached to this calculation as Appendices B and C.

REFERENCES

1. Letter MSE-AEE-11448, January 19, 1996. This letter transmits the minutes of the WOG Subgroup on Pressure Locking and Thermal Binding meeting on 1/4-1/5/96.

2. USER'S GUIDE FOR PRESLOK, A GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL, REVISION 1, February 7, 1996. This revision of the manual

incorporates changes requested at the WOG Subgroup on Pressure Locking and Thermal Binding meeting on 1/4-1/5/96, as well as changes identified during the verification process. This document is Appendix A of this calculation.

3. Roark, Raymond J., and Young, Warren C., *Formulas for Stress and Strain*, 5th Edition, McGraw-Hill Book Company, 1975.

COMPARISON OF RESULTS

A line by line comparison of the results was performed, looking at as many significant figures in the MATHCAD output as were calculated in the hand calculations. The only result where the difference between the hand calculation and the MATHCAD calculations exceed one digit in the sixth significant figure is in the seat load. The difference in this result is

Hand Calculation	MATHCAD Calculation
$F_S = 82848.644$ lb.	$F_S = 82848.814$ lb.

$$\%\text{-}difference = \frac{82{,}848.814 - 82{,}848.644}{82{,}848.644} \times 100 = 0.0002\%$$

This amount of error is attributable to round off error, since the computer carries more significant digits than the hand calculation. The programs PRESLOK Version 1 and PRESLOK Version 2 are considered verified.

WESTINGHOUSE CALCULATION SHEET

PROPRIETARY Class 2C

TITLE Verification of Pressure Locking Analysis Program PRESLOK			PAGE 7 OF 12
PROJECT WOG	AUTHOR W. S. Moore DATE 2/5/96	CHK'D. BY DATE	VERIFIED BY DATE
S.O. 220	CALC. NO. V-EC-1606	FILE NO.	GROUP AEE

Sample Problem

Inputs:
$P_{bonnet} = 1300$ psi
$P_{up} = 200$ psi
$P_{down} = 500$ psi
$t = 1.7$ inches
$a = 7$ inches
$b = 1.1$ inches
$\theta = 9$ degrees
$\nu = 0.31$
$E = 29{,}000{,}000$ psi
$F_{po} = 23000.$ lb
$VF = 0.47$
$D_{stem} = 1.9$ inches
$Hub_{Length} = 0.6$ inches

$$\mu = VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)} = 0.47 \cdot \frac{\cos 9}{1 + 0.47 \sin 9}$$

$$\mu = 0.4324202$$

$$DP_{avg} = P_{bonnet} - \frac{P_{up} + P_{down}}{2} = 1300 - \frac{200 + 500}{2}$$

$$DP_{avg} = 950 \text{ psi}$$

$$D = \frac{E\,t^3}{12(1-\nu^2)} = \frac{29000000(1.7)^3}{12(1-0.31^2)} = 13{,}135{,}395 \text{ in-lb.}$$

$$G = \frac{E}{2(1+\nu)} = \frac{29{,}000{,}000}{2(1+0.31)} = 11{,}068{,}702 \text{ psi}$$

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

PROPRIETARY CLASS 2C

TITLE			PAGE
Verification of Pressure Locking Analysis Program PRESLOK			8 OF 12
PROJECT: WOG	AUTHOR: W.E. Moore DATE: 2/5/96	CHK'D. BY DATE	VERIFIED BY DATE
S.O.: 220	CALC. NO.: V-EC-1606	FILE NO.	GROUP: AEE

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

$$C_2 = \frac{1}{4}\left[1-\left(\frac{1.1}{7}\right)^2\left(1+2\ln\left(\frac{7}{1.1}\right)\right)\right] = 0.2209773$$

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

$$C_3 = \frac{1.1}{4(7)}\left\{\left[\left(\frac{1.1}{7}\right)^2+1\right]\ln\left(\frac{7}{1.1}\right)+\left(\frac{1.1}{7}\right)^2-1\right\} = 0.0361818$$

$$C_8 = \frac{1}{2}\left[1+\nu+(1-\nu)\left(\frac{b}{a}\right)^2\right]$$

$$C_8 = \frac{1}{2}\left[1+0.31+(1-0.31)\left(\frac{1.1}{7}\right)^2\right] = 0.6635194$$

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

$$C_9 = \frac{1.1}{7}\left\{\frac{1+0.31}{2}\ln\left(\frac{7}{1.1}\right)+\frac{1-0.31}{4}\left[1-\left(\frac{1.1}{7}\right)^2\right]\right\} = 0.2169174$$

$$L_{11} = \frac{1}{64}\left\{1+4\left(\frac{r_o}{a}\right)^2-5\left(\frac{r_o}{a}\right)^4-4\left(\frac{r_o}{a}\right)^2\left[2+\left(\frac{r_o}{a}\right)^2\right]\ln\left(\frac{a}{r_o}\right)\right\}$$

$r_o = b$ for Case I L, Tables 24 & 25, Ref 3

$$L_{11} = \frac{1}{64}\left\{1+4\left(\frac{1.1}{7}\right)^2-5\left(\frac{1.1}{7}\right)^4-4\left(\frac{1.1}{7}\right)^2\left[2+\left(\frac{1.1}{7}\right)^2\right]\ln\left(\frac{7}{1.1}\right)\right\}$$

$$L_{11} = 0.0113379$$

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

PROPRIETARY CLASS 2C

TITLE Verification of Pressure Locking Analysis Program PRESLOK			PAGE 9 OF 12
PROJECT WOG	AUTHOR W. E. Moore DATE 2/5/96	CHK'D. BY DATE	VERIFIED BY DATE
S.O. 220	CALC. NO. V-EC-1606	FILE NO.	GROUP AEE

$$L_{17} = \frac{1}{4}\left\{1 - \frac{1-\nu}{4}\left[1 - \left(\frac{r_o}{a}\right)^4\right] - \left(\frac{r_o}{a}\right)^2\left[1 + (1+\nu)\ln\frac{a}{r_o}\right]\right\}$$

$r_o = b$ for CASE 2L, Tables 24 & 25, Ref: 3

$$L_{17} = \frac{1}{4}\left\{1 - \frac{1-0.31}{4}\left[1 - \left(\frac{1.1}{7}\right)^4\right] - \left(\frac{1.1}{7}\right)^2\left[1 + (1+0.31)\ln\left(\frac{7}{1.1}\right)\right]\right\}$$

$$L_{17} = 0.1857616$$

$$M_{rb} = \frac{-DP_{avg}\cdot a^2}{C_8}\left[\frac{C_9}{2ab}\left(a^2 - r_o^2\right) - L_{17}\right]$$

$$M_{rb} = \frac{-950\cdot 7^2}{0.6635194}\left[\frac{0.2169174}{2(1.1)(7)}\left(7^2 - 1.1^2\right) - 0.1857616\right]$$

$$M_{rb} = -34193.193 \text{ in-lb/in.}$$

$$Q_b = \frac{DP_{avg}}{2b}\left(a^2 - r_o^2\right) = \frac{950}{2(1.1)}\left(7^2 - 1.1^2\right) = 20636.591 \ \frac{\text{lb}}{\text{IN}}$$

$$y_{bq} = M_{rb}\frac{a^2}{D}C_2 + Q_b\frac{a^3}{D}C_3 - \frac{DP_{avg}\cdot a^4}{D}L_{11}$$

$$y_{bq} = -34193.193\ \frac{7^2(0.2209773)}{13{,}135{,}395} + 20636.591\ \frac{7^3\,(0.0361818)}{13{,}135{,}395}$$

$$-\ \frac{(950)\ 7^4}{13{,}135{,}395}\,(0.0113379) = -0.0106578 \text{ inches.}$$

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

PROPRIETARY CLASS 2C

TITLE Verification of Pressure Locking Analysis Program PRESLOK			PAGE 10 OF 12
PROJECT WOG	AUTHOR W. T. Moore DATE 2/5/96	CHK'D. BY DATE	VERIFIED BY DATE
S.O. 220	CALC. NO. V-EC-1606	FILE NO.	GROUP AEE

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

since $r_o = b$, and $\ln(1) = 0$, $1 - 2\ln\left(\frac{r_o}{b}\right) = 1$

$$K_{sa} = -0.3\left[2\cdot\ln\left(\frac{7}{1.1}\right) - 1 + \left(\frac{1.1}{7}\right)^2\right] = -0.8177681$$

$$y_{sq} = \frac{K_{sa}\cdot DP_{avg}\cdot a^2}{t\cdot G} = \frac{-0.8177681\cdot 950\cdot 7^2}{(1.7)\cdot(11{,}068{,}702)}$$

$$y_{sq} = -0.002023 \text{ inches}$$

$$P_{force} = \pi(a^2-b^2)\cdot DP_{avg} = \pi(7^2-1.1^2)\,950 = 142{,}629.88 \text{ lb}$$

$$y_{stretch} = \frac{-P_{force}}{\pi b^2}\cdot\frac{\text{Hub length}}{2\cdot E}$$

$$y_{stretch} = \frac{-142629.88}{\pi(1.1)^2}\cdot\frac{0.6}{2\cdot 29000000} = -0.0003881 \text{ inches}$$

$$y_g = y_{bg} + y_{sg} + y_{stretch}$$

$$y_g = -0.0106578 - 0.002023 - 0.0003881 = -0.0130689 \text{ in}$$

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

PROPRIETARY CLASS 2C

TITLE			PAGE
Verification of Pressure Locking Analysis Program PRESLOK			11 OF 12
PROJECT: WOG	AUTHOR / DATE: W.E. Moore 2/5/96	CHK'D. BY / DATE:	VERIFIED BY / DATE:
S.O.: 220	CALC. NO.: V-EC-1606	FILE NO.:	GROUP: AEE

$L_3 = 0$

$L_9 = 0$

$$y_{bw} = -\frac{a^3}{D}\left[\frac{C_2}{C_8}\left(\frac{r_o C_9}{b} - L_9\right) - \frac{r_o C_3}{b} + L_3\right]$$

$r_o = a$ for Case 1L, Tables 24 & 25, Ref. 3

$$y_{bw} = -\frac{7^4}{13{,}135{,}395}\left[\frac{0.2209773}{0.6635194}\,\frac{0.2169174}{1.1} - \frac{0.0361818}{1.1}\right]$$

$$y_{bw} = -5.9921379 \times 10^{-6} \text{ inches}/\frac{lbf}{IN.}$$

$$K_{sa} = -1.2\,\frac{r_o}{a}\ln\frac{r_o}{b}$$

$r_o = a$ for Case 1L, Tables 24 & 25, Ref. 3

$$K_{sa} = -1.2\,(1)\ln\frac{7}{1.1} = -2.22072$$

$$y_{sw} = K_{sa}\frac{a}{t\,G_e} = -2.22072\,\frac{7}{(1.7)(11{,}068{,}702)} = -826.12587\times 10^{-9}$$

$$y_{compr} = -\frac{2\pi a}{\pi b^2}\left(\frac{\text{Hub length}}{2E}\right) = \frac{-2a}{b^2}\left(\frac{\text{Hub length}}{2E}\right)$$

$$y_{compr} = \frac{-(2)\cdot(7)}{1.1^2}\left(\frac{0.6}{2(29{,}000{,}000)}\right) = -119.69222 \times 10^{-9}\ \frac{IN}{lb/IN.}$$

REV. NO.	REV. DATE	AUTHOR / DATE	CHK'D. BY / DATE	VERIFIED BY / DATE

WESTINGHOUSE CALCULATION SHEET

TITLE Verification of Pressure Locking Analysis Program PRESLOK			PAGE 12 OF 12
PROJECT WOG	AUTHOR W. T. Moore DATE 2/5/96	CHK'D. BY DATE	VERIFIED BY DATE
S.O. 220	CALC. NO. V-EC-1606	FILE NO.	GROUP AEE

$y_w = y_{bw} + y_{sw} + y_{compr}$

$y_w = (-5.9921379 - 0.82612587 - 0.1196922) \times 10^{-6}$

$y_w = -6.937956 \times 10^{-6}$ inches / lbf/in.

Load per seat $= 2\pi a (y_\delta / y_w) = 2(\pi)(7)\dfrac{-0.0130689}{-6.937956 \times 10^{-6}}$

Load per seat = 82,848.644 lbs.

$F_{piston} = \frac{\pi}{4} D_{stem}^2 \cdot P_{bonnet} = \frac{\pi}{4}(1.9)^2(1300)$

$F_{piston} = 3685.8736$ lbs Note: This considers P_{atm} is zero and P_{bonnet} is psig.

$F_{vert} = \pi a^2 \sin\theta (2 \cdot P_{bonnet} - P_{up} - P_{down})$

$F_{vert} = \pi \cdot 7^2 \sin(9)(2 \cdot 1300 - 200 - 500) = 45754.309$ lbs

$F_{preslock} = (\text{Load per seat})(\mu\cos\theta - \sin\theta)(2)$

$F_{preslock} = (82848.644)(0.4324202 \cos 9 - \sin 9)(2)$

$F_{preslock} = 44847.947$ lbs.

$F_{total} = F_{po} - F_{piston} + F_{vert} + F_{preslock}$

$F_{total} = 23000 - 3685.8736 + 45754.309 + 44847.947 = 109,916.38$ lbs

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

USER'S GUIDE FOR PRESLOK, A GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

REVISION 1

February 7, 1996

USER'S GUIDE FOR PRESLOK GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

RECORD OF REVISION PAGE

Rev. 0	Original Issue	January 2, 1996
Rev. 1	Corrected various typographical errors that had no effect on the content. Removed erroneous negative sign from the equation for Q_b on page 16. Corrected the equation for K_{sa} and added a note after the equation for K_{sa} on page 16. Subscript corrected from y_{bw} to y_{sw} in the calculation of shear deflection due to seat load, page 17. The section concerning the calculation of the equilibrium contact load and the load per seat was rewritten, page 18. Minor spelling and English corrections were made to the section discussing "Determining the Disk to Seat Friction Coefficient," page 18. The calculation of the stem force component required to overcome the pressure locking seat load was put into standard equation format, page 18. Clarified that the Static Unseating Force is a program input, page 18. (F_{vert}) was removed from the subheading title "Reverse Piston Effect," page 19. The figures on pages 14 and 19 were redrawn. An equation for the total force required to overcome pressure locking force was added, page 19. The final paragraph, which discussed acceptance criteria, was deleted, page 19. Table numbers were added to the case numbers given next to equations which were taken from Roark, various pages.	February 7, 1996

USER'S GUIDE FOR PRESLOK GATE VALVE PRESSURE LOCKING ANALYSIS PROGRAM USING THE COMMONWEALTH EDISON MODEL

TABLE OF CONTENTS

USER'S GUIDE FOR PRESLOK

INTRODUCTION

Pressure locking is a phenomenon which can cause the unseating thrust for a gate valve to increase dramatically from its typical static unseating thrust. This can possibly result in the valve failing to open due to the actuator having insufficient thrust capability. Pressure locking can also result in valve damage in cases where the actuator thrust capability exceeds the valve structural capacity. For these reasons, a proper understanding of the conditions which may cause pressure locking, as well as a methodology for predicting the increase in unseating thrust for a pressure locked valve, are necessary.

A method of analyzing gate valves to predict the increase in unseating thrust for a pressure locked valve has been developed by Commonwealth Edison, and has been presented by Mr. Brian Bunte (Ref. 1). The Westinghouse Owner's Group, in the Pressure Locking/Thermal Binding Task Team meeting on November 13 and 14, 1995, authorized the preparation of a MATHCAD program and accompanying user's manual to allow the uniform use of the Commonwealth Edison pressure locking analysis methodology. This manual is the result of that authorization.

This manual and the program file for performing the analysis are available from the Westinghouse Owner's Group and may be obtained by contacting L. I. Ezekoye at (412) 374-6643 or W. E. Moore at (412) 374-6351. Please indicate whether the program is to be supplied on 3.5 inch diskettes or 5.25 inch diskettes.

USER'S GUIDE FOR PRESLOK

HARDWARE/SOFTWARE REQUIREMENTS

The program has been written using the MATHCAD 5.0 for Windows program. This program is available from

MathSoft, Inc.
101 Main Street
Cambridge, MA 02142
1-800-628-4223 or
617-577-1017
Fax: 617-577-8829

The program is also widely available from software vendors.

The following hardware and software requirements for running the MATHCAD 5.0 for Windows program are extracted from the User's Guide which is supplied with the MATHCAD program:

- An 80386 or higher IBM® or compatible computer. A math coprocessor is not required, but its presence will significantly improve performance.
- Microsoft® Windows™ Version 3.1 or later or Windows NT.
- At least 4MB of RAM. All memory above 640K should be configured as extended memory.
- At least 14MB of free hard disk space for MATHCAD files.
- An additional 1MB on the hard disk where MATHCAD is installed.
- At least 8MB of virtual memory. See the Windows user manual for how to specify virtual memory.
- A monitor and graphics card compatible with Windows.
- A mouse supported by Windows.
- Any printer supported by Windows.

The User's Guide supplied with the MATHCAD program should be followed for installation of the MATHCAD program onto your computer. The scope of this manual is to explain the usage of the PRESLOK analysis using the MATHCAD program.

USER'S GUIDE FOR PRESLOK

GETTING STARTED

The PRESLOK files are supplied to you on either a 3.5 inch or a 5.25 inch diskette, per your request. It is recommended that the first step to use the files is to copy a "working version" of the files to your hard disk so that the diskette can be retained as a record copy. The files which are included are as follows:

preslok1.mcd	MATHCAD program using the closing valve factor as an input.
preslok2.mcd	MATHCAD program using the coefficient of friction between disk and seat as an input.
plinput1.dat	ASCII file of input data required by version 1 of the PRESLOK program.
plinput2.dat	ASCII file of input data required by version 2 of the PRESLOK program.

The next step to use the program is to create a data file to transfer the input values for the variables to the PRESLOK analysis program. The PRESLOK program is expecting these variables to appear in text file in plain ASCII format with the name "plinput1.dat" for use with version 1 or "plinput2.dat" for use with version 2. The various numbers in the "plinput1.dat" or "plinput2.dat" file can be separated by spaces, commas, or carriage returns, and may appear as integers, floating point numbers, or as E-format numbers such as 2.35E-2 . An ASCII text file can be created using the Windows utility Notepad, or by numerous other methods. This file should be located in the same directory as the PRESLOK file, since when the PRESLOK file is loaded, that directory will become the MATHCAD default directory. The user is also referred to the chapter on "Data Files" in the MATHCAD User's Guide if further explanation of the use of the ".dat" file is needed.

Sample data files are included in the program diskette which can be used simply by changing the input values to the proper values for your analysis. Alternately, other file names can be used for the input data by changing the input file name on the page 1 of the PRESLOK program to the file name desired.

USER'S GUIDE FOR PRESLOK

RUNNING THE PRESLOK ANALYSIS

At this point it is assumed that the user has the MATHCAD 5.0 program loaded onto his computer, and that the PRESLOK Version 1 or PRESLOK Version 2 file and the "plinput1.dat" or "plinput2.dat" file are available to the computer in the same directory. To run the PRESLOK analysis, the user should perform the following steps:

1. Double click on the MATHCAD 5.0 icon to start the MATHCAD program.

2. Go to the File pulldown menu and click on Open (or click on the Open File icon on the Tool Bar.)

3. In the Open dialogue box, select the directory containing the preslok1.mcd or preslok2.mcd file and select the desired version of the program. Then click on OK.

4. The PRESLOK program will pick up the input values from the plinput1.dat or plinput2.dat file and perform the analysis if the program is in the automatic mode (Automatic Mode has a check mark next to it in the Math pulldown menu.) If the MATHCAD program is not in the automatic mode, it can be forced to perform the calculation by clicking on the Calculate Document function in the Math pulldown menu. Results may be inspected by using the scroll bar on the right hand side of the display to scroll through the display as desired.

5. To change the inputs, open the Windows utility Notepad and open the plinput1.dat or plinput2.dat file. Make the desired changes to the file and then save it. To have MATHCAD re-perform the analysis with the new input values, open the Math pulldown menu and click on Calculate Document. This alternate use of Notepad and the MATHCAD function Calculate Document should be repeated until the analysis is correct.

6 The output may be printed using the Print command in the pulldown menu under File or using the print icon in the Tool Bar. The user is referred to the MATHCAD User's Guide if any changes are desired to the Page Setup or the Printer Setup.

Note that valve identifiers or other identifying titles may be added to the output by using the MATHCAD text entry methods given in the MATHCAD User's Guide. If the user desires to add the identifier/title to each page, the use of a header is recommended. The header can be defined through the Headers/Footers command in the Edit pulldown menu or through the Header

USER'S GUIDE FOR PRESLOK

RUNNING THE PRESLOK ANALYSIS (continued)

command in the Page Setup dialogue box. See the Documents and Windows section of the MATHCAD User's Guide for further information about Headers.

7. The program may be exited using the Exit command in the File pulldown menu.

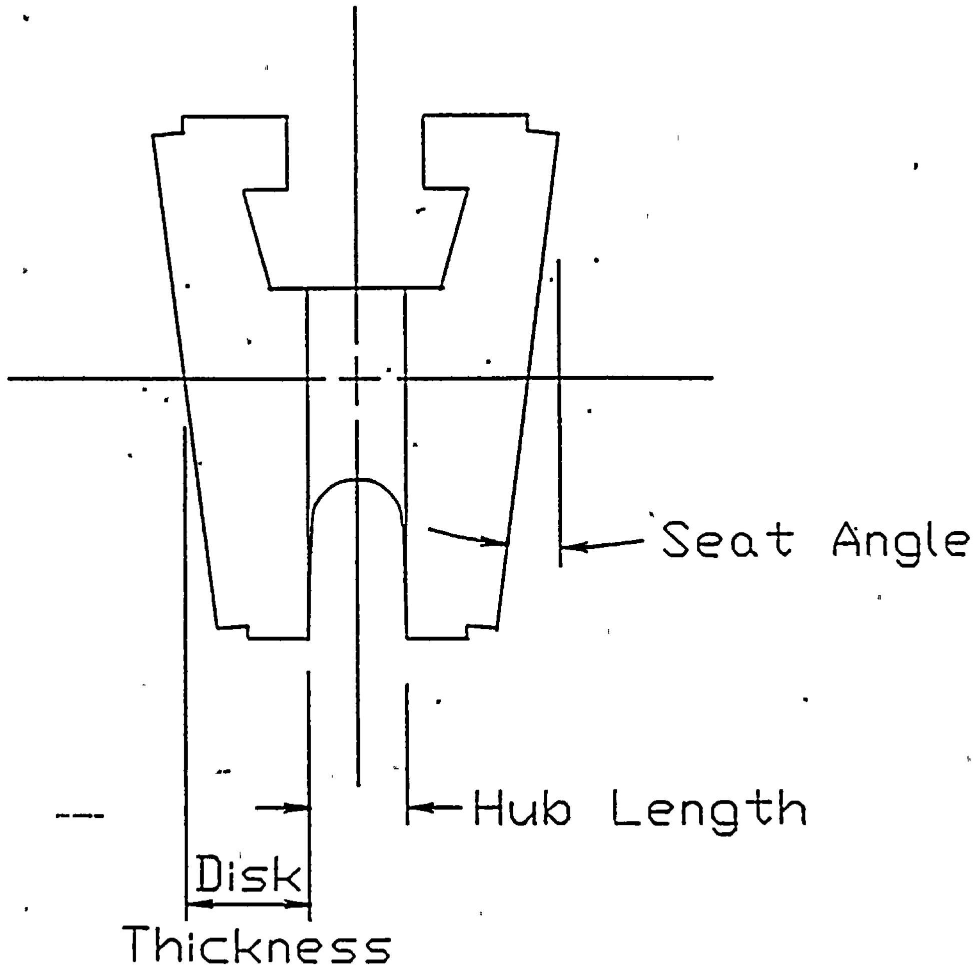


FIGURE 1 Disk Geometry

USER'S GUIDE FOR PRESLOK

INPUT PREPARATION

The following inputs are required for the use of the PRESLOK analysis using version 1 of the program:

- Pressure Conditions at the time of the pressure locking event. This includes the upstream, downstream, and bonnet pressure.

Bonnet Pressure:	P_{bonnet}	psi
Upstream Pressure:	P_{up}	psi
Downstream Pressure:	P_{down}	psi

- Valve Disk Geometry. This includes the hub radius, hub length, mean seat radius, average disk thickness, and seat angle.

Disk Thickness:	t	inches
Seat Radius:	a	inches
Hub Radius:	b	inches
Hub Length:	Hub_{length}	inches
Seat Angle:	θ	degrees

The disk thickness recommended for use in these calculations is the thickness at the centerline of the disk vertically. See Figure 1. This will normally be a value which is intermediate between the minimum and maximum thickness of the disk, and this is the thickness which has been used in the comparisons of test measurements which Commonwealth Edison is making with the analytical results. It is noted that the magnitude of the pressure locking force increases with the thickness of the disk, so that use of the maximum disk thickness would yield conservative results. The pressure locking forces predicted by using the maximum value of disk thickness are likely to be unreasonably high though.

The seat radius used in these calculations is the mean seat radius which corresponds to the radius at which one half of the seat area would be outside the mean seat radius and one half of the seat area would be inside the mean radius. Thus, given the inner and outer seat diameters, the mean seat radius is

$$a := \sqrt{\frac{OD_{seat}^2 + ID_{seat}^2}{8}}$$

USER'S GUIDE FOR PRESLOK

When the hub cross-section is not reasonably circular (e.g. many Westinghouse gate valve designs), then an effective hub radius is used which corresponds to a circle of equal area to the hub cross-sectional area.

$$b = \sqrt{\frac{\textit{Hub Area}}{\pi}}$$

The hub length is the distance from the inside face of the hub to the inside face of the hub at the hub radius, as shown on Figure 1. The seat angle is as shown on Figure 1.

- Valve Disk Material Properties. This includes the modulus of elasticity and the Poisson's ratio for the disk base material, at the temperature being considered.

Poisson's Ratio:	ν	dimensionless
Modulus of Elasticity:	E	psi

- Valve Stem Diameter

Stem Diameter:	D_{stem}	inches

This is the stem diameter in the region of the stem which is inside the packing.

- Static Unseating Thrust

Static Pullout Force:	F_{po}	pounds

This is the static pullout force obtained from testing of the valve for which the calculation is being performed.

- Closing Valve Factor

Valve Factor:	VF	dimensionless

It is suggested that this valve factor be the factor obtained from test measurements of closing the valve being considered in a DP test, if possible.

To use version 2 of the program instead of version 1, the closing valve factor VF is replaced by the co-efficient of friction to be considered between the disk and the seat; and the input data file is named plinput2.dat. All other inputs remain the same as for version 1. The different input value is

- Coefficient of Friction between Disk and Seat

Seat to Disk Coefficient of Friction:	μ.	dimensionless

USER'S GUIDE FOR PRESLOK

THEORY

ASSUMPTIONS

1. The valve disk is assumed to act as two ideal disks connected by a hub. That is, the disks are assumed to be round, of uniform thickness, and perpendicular to a cylindrical, concentric hub. A line perpendicular to the hub centerline and at the middle of the hub length is an axis of symmetry for the wedge. The equations in reference 2 for this idealized structure are assumed to conservatively model the actual load due to pressure forces. This assumption is considered conservative since inspection of the disk drawings show large fillets between the disk hub and seats which should make the valve disk stiffer than assumed in the reference 2 equations.

2. The coefficient of friction between the valve seat and disk is assumed to be the same under pressure locking conditions as it is under DP conditions. This assumption is considered to be justified based on bench marking of the calculations against ComEd and EPRI pressure locking test data for similar flex-wedge gate valves.

3. The upstream, downstream, and bonnet pressure values are considered to be known.

DESIGN INPUTS

The following design inputs are used in calculating the force required to unseat a pressure locked MOV:

- Pressure Conditions at the time of the pressure locking event. This includes the upstream, downstream, and bonnet pressure.

Bonnet Pressure:	P_{bonnet}	psi
Upstream Pressure:	P_{up}	psi
Downstream Pressure:	P_{down}	psi

- Valve Disk Geometry. This includes the hub radius, hub length, mean seat radius, and average disk thickness.

Disk Thickness:	t	inches
Seat Radius:	a	inches

USER'S GUIDE FOR PRESLOK

Hub Radius:	b	inches
Hub Length:	Hub_{length}	inches
Seat Angle:	θ	degrees

The disk thickness recommended for use in these calculations is the thickness at the centerline of the disk vertically. See Figure 1. This will normally be a value which is intermediate between the minimum and maximum thickness of the disk, and this is the thickness which has been used in the comparisons of test measurements which Commonwealth Edison is making with the analytical results. It is noted that the magnitude of the pressure locking force increases with the thickness of the disk, so that use of the maximum disk thickness would yield conservative results. The pressure locking forces predicted by using the maximum value of disk thickness are likely to be unreasonably high though.

The seat radius used in these calculations is the mean seat radius which corresponds to the radius at which one half of the seat area would be outside the mean seat radius and one half of the seat area would be inside the mean radius. Thus, given the inner and outer seat diameters, the mean seat radius is

$$a = \sqrt{\frac{OD_{seat}^2 + ID_{seat}^2}{8}}$$

When the hub cross-section is not reasonably circular (e.g. many Westinghouse gate valve designs), then an effective hub radius is used which corresponds to a circle of equal area to the hub cross-sectional area.

$$b = \sqrt{\frac{Hub\ Area}{\pi}}$$

The hub length is the distance from the inside face of the hub to the inside face of the hub at the hub radius, as shown on Figure 1. The seat angle is as shown on Figure 1.

- Valve Disk Material Properties. This includes the modulus of elasticity and the Poisson's ratio for the disk base material.

Poisson's Ratio:	ν	dimensionless
Modulus of Elasticity:	E	psi

USER'S GUIDE FOR PRESLOK

- Valve Stem Diameter

  Stem Diameter: D_{stem} inches

  This is the stem diameter in the region of the stem which is inside the packing.

- Static Unseating Thrust

  Static Pullout Force: F_{po} pounds

  This is the static pullout force obtained from testing of the valve for which the calculation is being performed.

- Coefficient of Friction between Disk and Seat

  Seat to Disk Coefficient of Friction: μ dimensionless

The analysis program is presented in two versions, one of which requires that the coefficient of friction to be used between the disk and the seat be input directly, and the other which allows the input of the closing valve factor instead. For the version which allows the input of the closing valve factor, the coefficient of friction is calculated as follows:

$$\mu = VF \cdot \frac{\cos\theta}{1 + VF \cdot \sin\theta}$$

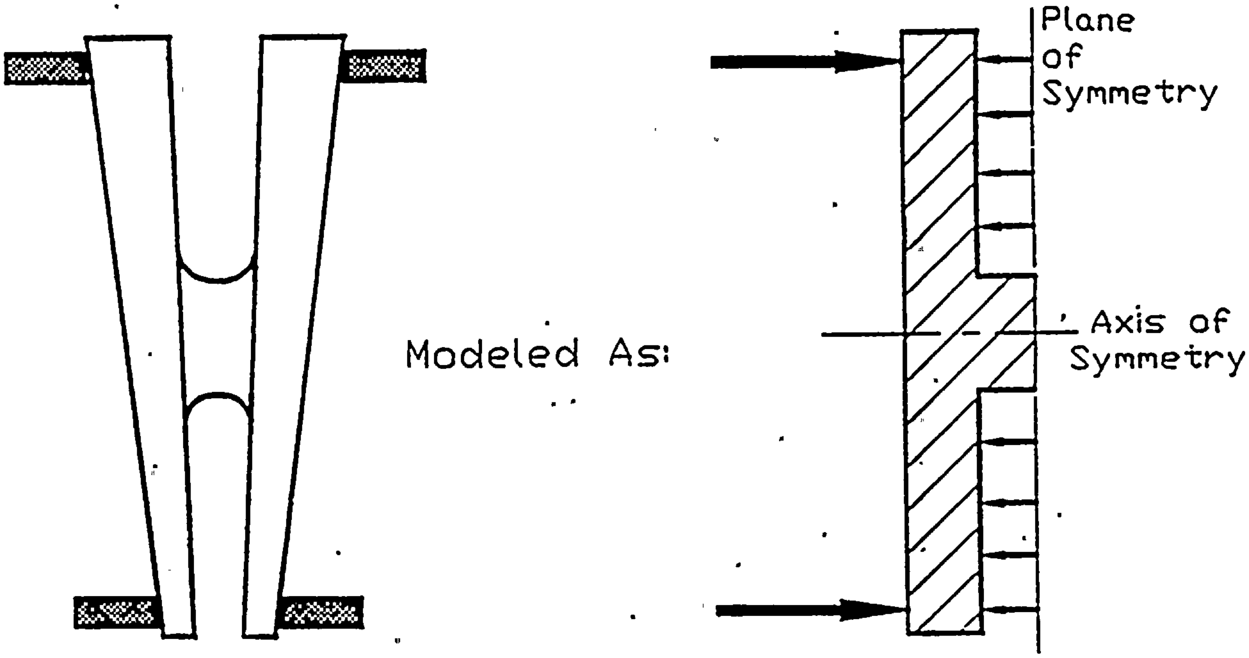
<u>CALCULATIONS</u>

The methodology for calculating the thrust required to open the MOVs under the pressure locking scenario is based on the Reference 2 (Roark's) engineering handbook. The methodology determines the total force required to open the valve under a pressure locking scenario by solving for the four components to this force. The four components of the force are the pressure locking component, the static unseating component, the piston effect component, and the "reverse piston effect" component. These magnitudes of these components are determined using the following steps:

USER'S GUIDE FOR PRESLOK

Pressure Locking Component of Force Required to Open the Valve

The valve disk is modeled as two plates attached at the center by a hub which is concentric with the valve disk. A plane of symmetry is assumed between the valve disks. This plane of symmetry is considered fixed in the analysis.



Based on this geometry, the following constants are calculated using the reference 2 equations:

Average DP Across Disk

$$DP_{avg} = P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$

Disk Stiffness Constants

$$D = \frac{E \cdot t^3}{12 \cdot (1 - \nu^2)}$$

$$G = \frac{E}{2 \cdot (1 + \nu)}$$

USER'S GUIDE FOR PRESLOK

Geometry Factors

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

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

$$C_8 = \frac{1}{2}\left[1+\nu+(1-\nu)\left(\frac{b}{a}\right)^2\right]$$

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

Deflection Due To Pressure Force

The pressure force is assumed to act uniformly upon the inner surface of the disk between the hub diameter and the outer disk diameter. The outer edge of the disk is assumed to be unimpeded and allowed to deflect away from the pressure force. In addition, the disk hub is allowed to stretch. The total displacement at the outer edge of the valve disk due to shear and bending and due to hub stretch are calculated using the reference 2 equations.

Corresponding Equations

Additional Geometry Factors (r_0 = b for Table 24, Case 2L)

$$L_{11} = \frac{1}{64}\left\{1+4\cdot\left(\frac{r_0}{a}\right)^2-5\cdot\left(\frac{r_0}{a}\right)^4-4\cdot\left(\frac{r_0}{a}\right)^2\left[2+\left(\frac{r_0}{a}\right)^2\right]\ln\left(\frac{a}{r_0}\right)\right\}$$

$$L_{17} = \frac{1}{4}\left\{1-\frac{1-\nu}{4}\left[1-\left(\frac{r_0}{a}\right)^4\right]-\left(\frac{r_0}{a}\right)^2\left[1+(1+\nu)\ln\left(\frac{a}{r_0}\right)\right]\right\}$$

USER'S GUIDE FOR PRESLOK

Moment Factors (r_0 = b for Table 24. Case 2L)

$$M_{rb} = \frac{-DP_{avg} \cdot a^2}{C_8}\left[\frac{C_9}{2 \cdot a \cdot b}\left(a^2 - r_0^2\right) - L_{17}\right]$$

$$Q_b = \frac{DP_{avg}}{2 \cdot b}\left(a^2 - r_0^2\right)$$

Bending Deflection due to Pressure

$$y_{bq} = M_{rb}\frac{a^2}{D}C_2 + Q_b\frac{a^3}{D}C_3 - \frac{DP_{avg} \cdot a^4}{D}L_{11}$$

Shear Deflection due to Pressure (r_0 = b for Table 25, Case 2L)

$$K_{sa} = -0.3 \cdot \left\{2 \cdot \ln\left(\frac{a}{b}\right) - 1 + \left(\frac{r_0}{a}\right)^2\left[1 - 2 \cdot \ln\left(\frac{r_0}{b}\right)\right]\right\}$$

Note: Since $r_0 = b$, $\left[1 - 2 \cdot \ln\left(\frac{r_0}{b}\right)\right] = 1$

$$y_{sq} = \frac{K_{sa} \cdot DP_{avg} \cdot a^2}{t \cdot G}$$

Deflection from Hub Stretch due to Pressure

$$P_{force} = \pi\left(a^2 - b^2\right) \cdot DP_{avg}$$

$$y_{stretch} = -\frac{P_{force}}{\pi \cdot b^2}\frac{Hub_{length}}{2E}$$

Total Deflection due to Pressure

$$y_q = y_{bq} + y_{sq} + y_{stretch}$$

An evenly distributed force is assumed to act between the valve seat and the outer edge of the valve disk. This force acts to deflect the outer diameter of the valve disk inward and to compress the disk hub. The pressure force is reacted to by an increase

USER'S GUIDE FOR PRESLOK

in this contact force between the valve disk and seats. The valve body seats are conservatively assumed to be fixed. Therefore, the deflection due to the known pressure load must be balanced by the deflection due to the unknown seat load. The deflection due to the pressure force was previously calculated. Now, the reference 2 equations are used to determine the contact force between the seat and disk which results in a deflection which is equal and opposite to the deflection due to the pressure force. This is done by first calculating the amount deflection created by a unit load of seat contact force (w = 1 lb/in). The equilibrium contact load is then determined by dividing the deflection caused by the unit contact load into the previously calculated deflection due to the pressure force. The equations are provided below:

Additional Geometry Factors (For Table 24, Case 1L, $r_0 = a$, $\therefore L_3 = L_9 = 0$

$$L_3 = \frac{r_0}{4a}\left\{\left[\left(\frac{r_0}{a}\right)^2 + 1\right]\cdot\ln\left(\frac{a}{r_0}\right) + \left(\frac{r_0}{a}\right)^2 - 1\right\}$$

$$L_9 = \frac{r_0}{a}\left\{\frac{1+\nu}{2}\cdot\ln\left(\frac{a}{r_0}\right) + \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{r_0}{a}\right)^2\right]\right\}$$

Bending Deflection due to Seat Load ($r_0 = a$ for Table 24, Case 1L)

$$y_{bw} = -\frac{a^3}{D}\cdot\left[\frac{C_2}{C_8}\cdot\left(\frac{r_0\cdot C_9}{b} - L_9\right) - \frac{r_0\cdot C_3}{b} + L_3\right]$$

Shear Deflection due to Seat Load ($r_0 = a$ for Table 25, Case 1L)

$$K_{sa} = -1.2\frac{r_0}{a}\ln\left(\frac{r_0}{b}\right)$$

$$y_{sw} = K_{sa}\frac{a}{t\cdot G}$$

Deflection from Hub Compression Due to Seat Load
(w = 1, $\therefore$Compressive force = $2\pi a$)

$$y_{compr} = -\frac{2\pi a}{\pi b^2}\left(\frac{Hub_{length}}{2E}\right)$$

Total Deflection from Unit Seat Load (w = 1)

$$y_w = y_{bw} + y_{sw} + y_{compr}$$

USER'S GUIDE FOR PRESLOK

Therefore, the equilibrium contact load distribution, in pounds per inch, and the corresponding load applied to each seat is calculated using the relationships below:

$$w_{equilibrium} = \frac{y_q}{y_w}$$ where y_w is calculated for w = 1.

Note that the sign of the equilibrium contact load is positive. This is because the sign conventions of Reference 2 have been maintained for all of the calculations, resulting in both the pressure load analysis and the line load analysis giving negative deflections, even though the loads and defections for the line load case are phyically in the opposite direction from the loads and deflection for the pressure load case.

The load per seat is then given by

$$F_S = 2\pi a\left(\frac{y_q}{y_w}\right)$$

Determining The Disk To Seat Friction Coefficient

Several methods can be used to determine an appropriate seat to disk friction coefficient. The coefficient of friction between the seat and disk is perhaps best determined based on the opening valve factor from a DP test. However, due to the difficulty sometimes encountered in obtaining a good, consistent value of the opening valve factor from testing, the PRESLOK program is written to accept either a closing valve factor or a co-efficient of friction directly. The equation used to calculate the coefficient of friction from the closing valve factor is given in the Design Inputs section of this User's Manual.

The stem force required to overcome the contact load between the seat and disk which opposes the pressure force is equal to the following, considering two disk faces:

$$F_{preslock} = 2 \cdot F_S \cdot (\mu \cdot \cos\theta - \sin\theta)$$

Static Unseating Force

The static unseating force represents the opening packing load and the pullout force due to wedging of the valve disk during closure. These loads are superimposed on the loads due to the pressure forces which occur during pressure locking. The value for this force is based on static test data for the MOVs, and is one of the inputs to the program (F_{po}).

USER'S GUIDE FOR PRESLOK

Piston Effect

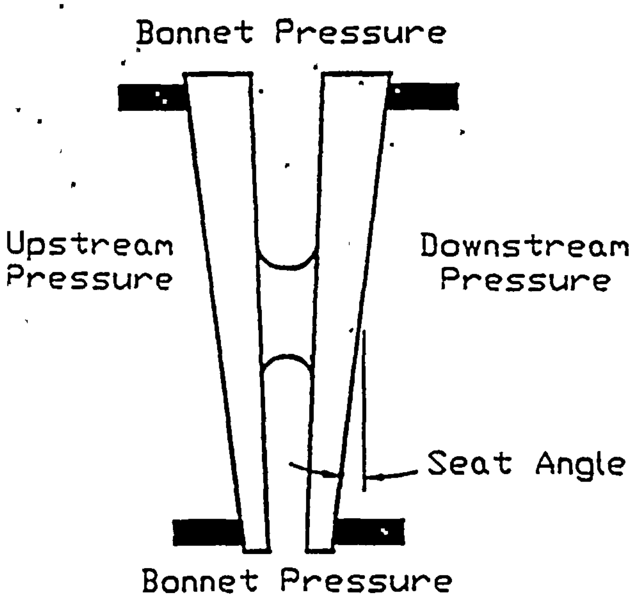
The piston effect due to valve internal pressure exceeding outside pressure is calculated using the standard industry equation. This force assists movement of the valve stem in the open direction.

$$F_{piston\ effect} = \frac{\pi}{4} D_{stem}^2 \left(P_{bonnet} - P_{atm}\right)$$

Reverse Piston Effect

The reverse piston effect is the term used in this calculation to refer to the pressure force acting downward against the valve disk. This force is equal to the differential pressure across the valve disk times the area of the valve disk times the sine of the seat angle times 2 (for two disk faces).

$$F_{vert} = \pi \cdot a^2 \cdot \sin\theta \cdot \left(2 \cdot P_{bonnet} - P_{up} - P_{down}\right)$$



Total Force Required to Overcome Pressure Locking

As mentioned previously, the total stem force (tension) required to overcome pressure locking is the sum of the four components discussed above. All of the terms are positive with the exception of the piston effect component.

$$F_{total} = F_{preslock} + F_{po} - F_{piston\ effect} + F_{vert}$$

USER'S GUIDE FOR PRESLOK

EXAMPLE OF AN ANALYSIS PERFORMED WITH PRESLOK, VERSION 1

The following is an image of the input file plinput1.dat used to run an example problem on version 1 of the PRESLOK analysis program:

```
1005    380     350     2       4.36    1.25    0.5     5
0.3     27.6E6  1.875   15409   0.52
```

The input file corresponds to input values as shown:

Bonnet Pressure:	P_{bonnet} = 1005 psi	
Upstream Pressure:	P_{up} = 380 psi	
Downstream Pressure:	P_{down} = 350 psi	
Disk Thickness:	t = 2.00 inches	
Seat Radius:	a = 4.36 inches	
Hub Radius:	b = 1.25 inches	
Hub Length:	L = 0.50 inches	
Seat Angle:	θ = 5 degrees	
Poisson's Ratio:	ν = 0.3	(dimensionless)
Modulus of Elasticity:	E = 27,600,000 psi	
Stem Diameter:	D_{stem} = 1.875 inches	
Static Pullout Force:	F_{po} = 15,409 pounds	
Valve Factor:	VF = 0.52	(dimensionless)

The next five pages contain the output of the PRESLOK program, Version 1, using the above input.

USER'S GUIDE TO PRESLOK

Program PRESLOK, Version 1
Revision 0
December 22, 1995

This Mathcad Program is designed to calculate the estimated opening force under pressure locking scenarios for flex-wedge gate valves using a calculational methodology that accounts for wedge stiffness resisting pressure locking forces. This program was prepared by the Westinghouse Owner's Group based upon the calculational methods developed by Commonwealth Edison.

While this information is presented in good faith and believed to be accurate, the Westinghouse Owner's Group does not guarantee satisfactory results from reliance upon such information. Nothing contained herein is to be construed as a warranty, express or implied, regarding the performance, merchantability, fitness or any other matter with respect to the product, nor as a recommendation to use any product or process in conflict with any patent. The Westinghouse Owner's Group reserves the right, without notice, to alter or improve the methods described herein.

This section of the program reads the thirteen items of input data from the plinput1.dat file.

$i := 0 .. 12$

$input_i := READ(plinput1)$

$P_{bonnet} := input_0 \cdot psi$

$P_{up} := input_1 \cdot psi$

$P_{down} := input_2 \cdot psi$

$t := input_3 \cdot in$

$a := input_4 \cdot in$

$b := input_5 \cdot in$

$Hub_{length} := input_6 \cdot in$

$\theta := input_7 \cdot deg$

$\nu := input_8$

$E := input_9 \cdot psi$

$D_{stem} := input_{10} \cdot in$

$F_{po} := input_{11} \cdot lbf$

$VF := input_{12}$

USER'S GUIDE TO PRESLOK

Program PRESLOK, Version 1

INPUTS:

Bonnet Pressure	$P_{bonnet} = 1005 \cdot psi$
Upstream Pressure	$P_{up} = 380 \cdot psi$
Downstream Pressure	$P_{down} = 350 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 2 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 4.36 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.25 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$v = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.76 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 15409 \cdot lbf$
Close Valve Factor	$VF = 0.52$
Stem Diameter	$D_{stem} = 1.875 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.5 \cdot in$

USER'S GUIDE TO PRESLOK

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)} \qquad \mu = 0.496$$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2} \qquad DPavg = 640 \cdot psi$$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot (1 - \nu^2)} \qquad D = 2.022 \cdot 10^7 \cdot lbf \cdot in$$

$$G := \frac{E}{2 \cdot (1 + \nu)} \qquad G = 1.062 \cdot 10^7 \cdot psi$$

Geometry Factors:

$$C_2 := \frac{1}{4}\left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right] \qquad C_2 = 0.1781$$

$$C_3 := \frac{b}{4 \cdot a}\left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right] \qquad C_3 = 0.0311$$

$$C_8 := \frac{1}{2}\left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right] \qquad C_8 = 0.6788$$

$$C_9 := \frac{b}{a}\left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4}\left[1 - \left(\frac{b}{a}\right)^2\right]\right] \qquad C_9 = 0.2789$$

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

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

USER'S GUIDE TO PRESLOK

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0069$$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.1526$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot(a^2 - b^2) - L_{17}\right] \qquad M_{rb} = -5265\cdot\text{lbf}$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot(a^2 - b^2) \qquad Q_b = 4466.5\cdot\frac{\text{lbf}}{\text{in}}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -3.9041\cdot 10^{-4}\cdot\text{in}$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.4743$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -2.7177\cdot 10^{-4}\cdot\text{in}$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot(a^2 - b^2)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 6.4731\cdot 10^{-5}\cdot\text{in}$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -7.2691\cdot 10^{-4}\cdot\text{in}$$

USER'S GUIDE TO PRESLOK

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right]\cdot \qquad y_{sw} = -3.079\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right)-L_9\right]-\left[\left(\frac{a}{b}\right)\cdot C_3\right]+L_3\right] \qquad y_{bw} = -6.012\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -5.055\cdot 10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -9.597\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 20750.5\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}{}^2\cdot P_{bonnet} \qquad F_{piston} = 2775\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 6662.4\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 16871\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 15409\cdot lbf$$

$$F_{total} = 36167.4\cdot lbf$$

USER'S GUIDE FOR PRESLOK

EXAMPLE OF AN ANALYSIS PERFORMED WITH PRESLOK, VERSION 2

The following is an image of the input file plinput2.dat used to run an example problem on version 2 of the PRESLOK analysis program:

1005	380	350	2.	4.36	1.25	0.5	5
0.3	27.6E6	1.875	15409	0.496			

The input file corresponds to input values as shown:

Bonnet Pressure:	P_{bonnet} = 1005 psi	
Upstream Pressure:	P_{up} = 380 psi	
Downstream Pressure:	P_{down} = 350 psi	
Disk Thickness:	t = 2.00 inches	
Seat Radius:	a = 4.36 inches	
Hub Radius:	b = 1.25 inches	
Hub Length:	L = 0.50 inches	
Seat Angle:	θ = 5 degrees	
Poisson's Ratio:	ν = 0.3	(dimensionless)
Modulus of Elasticity:	E = 27,600,000 psi	
Stem Diameter:	D_{stem} = 1.875 inches	
Static Pullout Force:	F_{po} = 15,409 pounds	
Seat to Disk Coefficient of Friction:	μ = 0.496	(dimensionless)

The next five pages contain the output of the PRESLOK program, Version 2, using the above input.

USER'S GUIDE FOR PRESLOCK

Program PRESLOK, Version 2
Revision 0
December 22, 1995

This Mathcad Program is designed to calculate the estimated opening force under pressure locking scenarios for flex-wedge gate valves using a calculational methodology that accounts for wedge stiffness resisting pressure locking forces. This program was prepared by the Westinghouse Owner's Group based upon the calculational methods developed by Commonwealth Edison.

While this information is presented in good faith and believed to be accurate, the Westinghouse Owner's Group does not guarantee satisfactory results from reliance upon such information. Nothing contained herein is to be construed as a warranty, express or implied, regarding the performance, merchantability, fitness or any other matter with respect to the product, nor as a recommendation to use any product or process in conflict with any patent. The Westinghouse Owner's Group reserves the right, without notice, to alter or improve the methods described herein.

This section of the program reads the thirteen items of input data from the plinput2.dat file.

$i := 0..12$

$input_i := READ(plinput2)$

$P_{bonnet} := input_0 \cdot psi$

$P_{up} := input_1 \cdot psi$

$P_{down} := input_2 \cdot psi$

$t := input_3 \cdot in$

$a := input_4 \cdot in$

$b := input_5 \cdot in$

$Hub_{length} := input_6 \cdot in$

$\theta := input_7 \cdot deg$

$v := input_8$

$E := input_9 \cdot psi$

$D_{stem} := input_{10} \cdot in$

$F_{po} := input_{11} \cdot lbf$

$\mu := input_{12}$

USER'S GUIDE FOR PRESLOCK

Program PRESLOK, Version 2

INPUTS:

Bonnet Pressure	$P_{bonnet} = 1005 \cdot psi$
Upstream Pressure	$P_{up} = 380 \cdot psi$
Downstream Pressure	$P_{down} = 350 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 2 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 4.36 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.25 \cdot in$
Seat Angle	$\theta = 5 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.3$
Modulus of Elasticity (disk material at temperature)	$E = 2.76 \cdot 10^7 \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 15409 \cdot lbf$
Coefficient of Friction between disk and seat:	$\mu = 0.496$
Stem Diameter	$D_{stem} = 1.875 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.5 \cdot in$

USER'S GUIDE FOR PRESLOCK

Program PRESLOK, Version 2.

PRESSURE FORCE CALCULATIONS

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2} \qquad DPavg = 640 \cdot psi$$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot (1 - \nu^2)} \qquad D = 2.022 \cdot 10^7 \cdot lbf \cdot in$$

$$G := \frac{E}{2 \cdot (1 + \nu)} \qquad G = 1.062 \cdot 10^7 \cdot psi$$

Geometry Factors:

$$C_2 := \frac{1}{4}\left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right] \qquad C_2 = 0.1781$$

$$C_3 := \frac{b}{4 \cdot a}\left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right] \qquad C_3 = 0.0311$$

$$C_8 := \frac{1}{2}\left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right] \qquad C_8 = 0.6788$$

$$C_9 := \frac{b}{a}\left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4}\left[1 - \left(\frac{b}{a}\right)^2\right]\right] \qquad C_9 = 0.2789$$

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

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

USER'S GUIDE FOR PRESLOCK

Program PRESLOK, Version 2

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\left[1 + 4\left(\frac{b}{a}\right)^2 - 5\left(\frac{b}{a}\right)^4 - 4\left(\frac{b}{a}\right)^2\left[2 + \left(\frac{b}{a}\right)^2\right]\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0069$$

$$L_{17} := \frac{1}{4}\left[1 - \frac{1-v}{4}\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\left[1 + (1+v)\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.1526$$

Moment

$$M_{rb} := \frac{-DPavg \cdot a^2}{C_8}\left[\frac{C_9}{2 \cdot a \cdot b}(a^2 - b^2) - L_{17}\right] \qquad M_{rb} = -5265 \cdot lbf$$

$$Q_b := \frac{DPavg}{2 \cdot b}(a^2 - b^2) \qquad Q_b = 4466.5 \cdot \frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb} \cdot \frac{a^2}{D} \cdot C_2 + Q_b \cdot \frac{a^3}{D} \cdot C_3 - \frac{DPavg \cdot a^4}{D} \cdot L_{11} \qquad y_{bq} = -3.9041 \cdot 10^{-4} \cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3 \cdot \left[2 \cdot \ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.4743$$

$$y_{sq} := \frac{K_{sa} \cdot DPavg \cdot a^2}{t \cdot G} \qquad y_{sq} = -2.7177 \cdot 10^{-4} \cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi \cdot (a^2 - b^2) \cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi \cdot b^2} \cdot \frac{Hub_{length}}{(2 \cdot E)} \qquad y_{stretch} = 6.4731 \cdot 10^{-5} \cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -7.2691 \cdot 10^{-4} \cdot in$$

USER'S GUIDE FOR PRESLOCK

Program PRESLOK, Version 2

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right]$$ $$y_{sw} = -3.079\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right]$$ $$y_{bw} = -6.012\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right)$$ $$y_{cmpr} = -5.055\cdot10^{-8}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr}$$ $$y_w = -9.597\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w}$$ $$F_s = 20750.5\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}^{2}\cdot P_{bonnet}$$ $$F_{piston} = 2775\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right)$$ $$F_{vert} = 6662.4\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta))$$ $$F_{preslock} = 16889.1\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po}$$ $$F_{po} = 15409\cdot lbf$$

$$F_{total} = 36185.5\cdot lbf$$

USER'S GUIDE FOR PRESLOK

REFERENCES

1. Bunte, Brian, "ComEd Pressure Locking Methodology and Test Program," presented at the NRC Region 3 Workshop on Pressure Locking and Thermal Binding, November 7, 1995.

2. Roark, Raymond J., and Young, Warren C., *Formulas for Stress and Strain, Fifth Edition*, McGraw-Hill Book Company, 1975.

3. Liberal use has also been made of a draft of a report being prepared by Mr. Brian Bunte of Commonwealth Edison Company, tentatively titled "Pressure Locking /Thermal Binding Report."

Program PRESLOK, Version 1
Revision 0
December 22, 1995

This Mathcad Program is designed to calculate the estimated opening force under pressure locking scenarios for flex-wedge gate valves using a calculational methodology that accounts for wedge stiffness resisting pressure locking forces. This program was prepared by the Westinghouse Owner's Group based upon the calculational methods developed by Commonwealth Edison.

This section of the program reads the thirteen items of input data from the plinput1.dat file.

$i := 0..12$

$input_i := READ(plinput1)$

$P_{bonnet} := input_0 \cdot psi$

$P_{up} := input_1 \cdot psi$

$P_{down} := input_2 \cdot psi$

$t := input_3 \cdot in$

$a := input_4 \cdot in$

$b := input_5 \cdot in$

$Hub_{length} := input_6 \cdot in$

$\theta := input_7 \cdot deg$

$\nu := input_8$

$E := input_9 \cdot psi$

$D_{stem} := input_{10} \cdot in$

$F_{po} := input_{11} \cdot lbf$

$VF := input_{12}$

Program PRESLOK, Version 1

INPUTS:

Bonnet Pressure	$P_{bonnet} = 1300 \cdot psi$
Upstream Pressure	$P_{up} = 200 \cdot psi$
Downstream Pressure	$P_{down} = 500 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 1.7 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 7 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.1 \cdot in$
Seat Angle	$\theta = 9 \cdot deg$
Poisson's Ratio (disk material at temperature)	$v = 0.31$
Modulus of Elasticity (disk material at temperature)	$E = 2.9 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 23000 \cdot lbf$
Close Valve Factor	$VF = 0.47$
Stem Diameter	$D_{stem} = 1.9 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.6 \cdot in$

Program PRESLOK, Version 1

PRESSURE FORCE CALCULATIONS

Coefficient of friction between disk and seat:

$$\mu := VF \cdot \frac{\cos(\theta)}{1 + VF \cdot \sin(\theta)}$$ $\mu = 0.432$

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2}$$ $DPavg = 950 \cdot psi$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot (1 - \nu^2)}$$ $D = 1.314 \cdot 10^7 \cdot lbf \cdot in$

$$G := \frac{E}{2 \cdot (1 + \nu)}$$ $G = 1.107 \cdot 10^7 \cdot psi$

Geometry Factors:

$$C_2 := \frac{1}{4} \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right) \right]$$ $C_2 = 0.221$

$$C_3 := \frac{b}{4 \cdot a} \left[\left[\left(\frac{b}{a}\right)^2 + 1 \right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1 \right]$$ $C_3 = 0.0362$

$$C_8 := \frac{1}{2} \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2 \right]$$ $C_8 = 0.6635$

$$C_9 := \frac{b}{a} \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \right] \right]$$ $C_9 = 0.2169$

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

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

Program PRESLOK, Version 1

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\left[1+4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2.+\left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0113$$

$$L_{17} := \frac{1}{4}\left[1-\frac{1-v}{4}\cdot\left[1-\left(\frac{b}{a}\right)^4\right]-\left(\frac{b}{a}\right)^2\cdot\left[1+(1+v)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.1858$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot(a^2-b^2)-L_{17}\right] \qquad M_{rb} = -34193.2\cdot lbf$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot(a^2-b^2) \qquad Q_b = 20636.6\cdot\frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -0.0107\cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right)-1+\left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.8178$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -0.002\cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot(a^2-b^2)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 3.8815\cdot 10^{-4}\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -0.0131\cdot in$$

Program PRESLOK, Version 1

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -8.261\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -5.992\cdot 10^{-6}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -1.197\cdot 10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -6.938\cdot 10^{-6}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 82848.8\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}{}^2\cdot P_{bonnet} \qquad F_{piston} = 3685.9\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 45754.3\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 44848\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 23000\cdot lbf$$

$$F_{total} = 109916.5\cdot lbf$$

This page has been added to present the PRESLOK1 outputs for verification. The only change is to display more significant digits of the calcualted numbers.

$\mu = 0.4324202$

$DPavg = 950 \cdot psi$

$D = 1.314 \cdot 10^{7} \cdot lbf \cdot in$

$G = 1.107 \cdot 10^{7} \cdot psi$

$C_2 = 0.2209773$

$C_3 = 0.0361818$

$C_8 = 0.6635194$

$C_9 = 0.2169174$

$L_3 = 0$

$L_9 = 0$

$L_{11} = 0.0113379$

$L_{17} = 0.1857616$

$M_{rb} = -34193.18999 \cdot lbf$

$Q_b = 20636.591 \cdot \frac{lbf}{in}$

$y_{bq} = -0.01065772 \cdot in$

$K_{sa} = -0.8177681$

$y_{sq} = -0.002023039 \cdot in$

$y_{stretch} = 3.8814905 \cdot 10^{-4} \cdot in$

$y_q = -0.01306891 \cdot in$

$y_{sw} = -8.261 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$y_{bw} = -5.992 \cdot 10^{-6} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$y_{cmpr} = -1.196922 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$y_w = -6.938 \cdot 10^{-6} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$F_s = 82848.814 \cdot lbf$

$F_{piston} = 3685.87 \cdot lbf$

$F_{vert} = 45754.31 \cdot lbf$

$F_{preslock} = 44848.03 \cdot lbf$

$F_{po} = 23000 \cdot lbf$

$F_{total} = 109916.47 \cdot lbf$

Program PRESLOK, Version 2.
Revision 0
December 22, 1995

This Mathcad Program is designed to calculate the estimated opening force under pressure locking scenarios for flex-wedge gate valves using a calculational methodology that accounts for wedge stiffness resisting pressure locking forces. This program was prepared by the Westinghouse Owner's Group based upon the calculational methods developed by Commonwealth Edison.

This section of the program reads the thirteen items of input data from the plinput2.dat file.

$i := 0..12$

$input_i := READ(plinput2)$

$P_{bonnet} := input_0 \cdot psi$

$P_{up} := input_1 \cdot psi$

$P_{down} := input_2 \cdot psi$

$t := input_3 \cdot in$

$a := input_4 \cdot in$

$b := input_5 \cdot in$

$Hub_{length} := input_6 \cdot in$

$\theta := input_7 \cdot deg$

$\nu := input_8$

$E := input_9 \cdot psi$

$D_{stem} := input_{10} \cdot in$

$F_{po} := input_{11} \cdot lbf$

$\mu := input_{12}$

Program PRESLOK, Version 2.

INPUTS:

Bonnet Pressure	$P_{bonnet} = 1300 \cdot psi$
Upstream Pressure	$P_{up} = 200 \cdot psi$
Downstream Pressure	$P_{down} = 500 \cdot psi$
Disk Thickness (taken at centerline of the hub vertically)	$t = 1.7 \cdot in$
Seat Radius (corresponding to mean seat diameter)	$a = 7 \cdot in$
Hub Radius (taken at plane of symmetry, perpendicular to the hub, radius of circle of equivalent area for non-circular hubs)	$b = 1.1 \cdot in$
Seat Angle	$\theta = 9 \cdot deg$
Poisson's Ratio (disk material at temperature)	$\nu = 0.31$
Modulus of Elasticity (disk material at temperature)	$E = 2.9 \cdot 10^{7} \cdot psi$
Static Pullout Force (measured value from diagnostic test)	$F_{po} = 23000 \cdot lbf$
Coefficient of Friction between disk and seat:	$\mu = 0.432$
Stem Diameter	$D_{stem} = 1.9 \cdot in$
Hub Length (from inside face of disk to inside face of disk)	$Hub_{length} = 0.6 \cdot in$

Program PRESLOK, Version 2.

PRESSURE FORCE CALCULATIONS

Average DP across disks:

$$DPavg := P_{bonnet} - \frac{P_{up} + P_{down}}{2} \qquad DPavg = 950 \cdot psi$$

Disk Stiffness Constants

$$D := \frac{E \cdot (t)^3}{12 \cdot (1 - \nu^2)} \qquad D = 1.314 \cdot 10^7 \cdot lbf \cdot in$$

$$G := \frac{E}{2 \cdot (1 + \nu)} \qquad G = 1.107 \cdot 10^7 \cdot psi$$

Geometry Factors:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right] \qquad C_2 = 0.221$$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right] \qquad C_3 = 0.0362$$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right] \qquad C_8 = 0.6635$$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right] \qquad C_9 = 0.2169$$

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

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

Program PRESLOK, Version 2

Geometry Factors: (continued)

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{b}{a}\right)^2 - 5\cdot\left(\frac{b}{a}\right)^4 - 4\cdot\left(\frac{b}{a}\right)^2\cdot\left[2 + \left(\frac{b}{a}\right)^2\right]\cdot\ln\left(\frac{a}{b}\right)\right] \qquad L_{11} = 0.0113$$

$$L_{17} := \frac{1}{4}\cdot\left[1 - \frac{1-\nu}{4}\cdot\left[1 - \left(\frac{b}{a}\right)^4\right] - \left(\frac{b}{a}\right)^2\cdot\left[1 + (1+\nu)\cdot\ln\left(\frac{a}{b}\right)\right]\right] \qquad L_{17} = 0.1858$$

Moment

$$M_{rb} := \frac{-DPavg\cdot a^2}{C_8}\cdot\left[\frac{C_9}{2\cdot a\cdot b}\cdot(a^2 - b^2) - L_{17}\right] \qquad M_{rb} = -34193.2\cdot lbf$$

$$Q_b := \frac{DPavg}{2\cdot b}\cdot(a^2 - b^2) \qquad Q_b = 20636.6\cdot\frac{lbf}{in}$$

Deflection due to pressure and bending:

$$y_{bq} := M_{rb}\cdot\frac{a^2}{D}\cdot C_2 + Q_b\cdot\frac{a^3}{D}\cdot C_3 - \frac{DPavg\cdot a^4}{D}\cdot L_{11} \qquad y_{bq} = -0.0107\cdot in$$

Deflection due to pressure and shear stress:

$$K_{sa} := -0.3\cdot\left[2\cdot\ln\left(\frac{a}{b}\right) - 1 + \left(\frac{b}{a}\right)^2\right] \qquad K_{sa} = -0.8178$$

$$y_{sq} := \frac{K_{sa}\cdot DPavg\cdot a^2}{t\cdot G} \qquad y_{sq} = -0.002\cdot in$$

Deflection due to hub stretch:

$$P_{force} := \pi\cdot(a^2 - b^2)\cdot DPavg$$

$$y_{stretch} := \frac{P_{force}}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{(2\cdot E)} \qquad y_{stretch} = 3.8815\cdot 10^{-4}\cdot in$$

Total Deflection due to pressure forces:

$$y_q := y_{bq} + y_{sq} - y_{stretch} \qquad y_q = -0.0131\cdot in$$

Program PRESLOK, Version 2

Deflection due to seat contact force and shear stress (per lbf/in.):

$$y_{sw} := -\left[\frac{1.2\cdot\left(\frac{a}{a}\right)\cdot\ln\left(\frac{a}{b}\right)\cdot a}{t\cdot G}\right] \qquad y_{sw} = -8.261\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to seat contact force and bending (per lbf/in.):

$$y_{bw} := -\left(\frac{a^3}{D}\right)\cdot\left[\left(\frac{C_2}{C_8}\right)\cdot\left[\left(\frac{a\cdot C_9}{b}\right) - L_9\right] - \left[\left(\frac{a}{b}\right)\cdot C_3\right] + L_3\right] \qquad y_{bw} = -5.992\cdot10^{-6}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Deflection due to hub compression:

$$y_{cmpr} := -\left(\frac{2\cdot\pi\cdot a}{\pi\cdot b^2}\cdot\frac{Hub_{length}}{2\cdot E}\right) \qquad y_{cmpr} = -1.197\cdot10^{-7}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Total deflection due to seat contact force (per lbf/in.):

$$y_w := y_{bw} + y_{sw} + y_{cmpr} \qquad y_w = -6.938\cdot10^{-6}\cdot\frac{in}{\left(\frac{lbf}{in}\right)}$$

Seat Contact Force for which deflection is equal to previously calculated deflection from pressure forces:

$$F_s := 2\cdot\pi\cdot a\cdot\frac{y_q}{y_w} \qquad F_s = 82848.8\cdot lbf$$

UNSEATING FORCES

$F_{packing}$ is included in measured static pullout Force

$$F_{piston} := \frac{\pi}{4}\cdot D_{stem}^{2}\cdot P_{bonnet} \qquad F_{piston} = 3685.9\cdot lbf$$

$$F_{vert} := \pi\cdot a^2\cdot\sin(\theta)\cdot\left(2\cdot P_{bonnet} - P_{up} - P_{down}\right) \qquad F_{vert} = 45754.3\cdot lbf$$

$$F_{preslock} := 2\cdot F_s\cdot(\mu\cdot\cos(\theta) - \sin(\theta)) \qquad F_{preslock} = 44848\cdot lbf$$

$$F_{total} := -F_{piston} + F_{vert} + F_{preslock} + F_{po} \qquad F_{po} = 23000\cdot lbf$$

$$F_{total} = 109916.5\cdot lbf$$

This page has been added to present the PRESLOK2 outputs for verification. The only change is to display more significant digits of the calcualted numbers.

$\mu = 0.4324202$

$DPavg = 950 \cdot psi$

$D = 1.314 \cdot 10^{7} \cdot lbf \cdot in$

$G = 1.107 \cdot 10^{7} \cdot psi$

$C_2 = 0.2209773$

$C_3 = 0.0361818$

$C_8 = 0.6635194$

$C_9 = 0.2169174$

$L_3 = 0$

$L_9 = 0$

$L_{11} = 0.0113379$

$L_{17} = 0.1857616$

$M_{rb} = -34193.18999 \cdot lbf$

$Q_b = 20636.591 \cdot \frac{lbf}{in}$

$y_{bq} = -0.01065772 \cdot in$

$K_{sa} = -0.8177681$

$y_{sq} = -0.002023039 \cdot in$

$y_{stretch} = 3.8814905 \cdot 10^{-4} \cdot in$

$y_q = -0.01306891 \cdot in$

$y_{sw} = -8.261 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$y_{bw} = -5.992 \cdot 10^{-6} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$y_{cmpr} = -1.196922 \cdot 10^{-7} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$y_w = -6.938 \cdot 10^{-6} \cdot \frac{in}{\left(\frac{lbf}{in}\right)}$

$F_s = 82848.814 \cdot lbf$

$F_{piston} = 3685.87 \cdot lbf$

$F_{vert} = 45754.31 \cdot lbf$

$F_{preslock} = 44848.04 \cdot lbf$

$F_{po} = 23000 \cdot lbf$

$F_{total} = 109916.47 \cdot lbf$

ATTACHMENT B

DA-ME-96-076

REV. Ø2 D2m

SHT. 1 OF 1

Input	TEST	V852A	V852B	NOTES
P-bonnet	1005	2250	2250	Bonnet pressure (psi)
P-up	380	30	30	Upstream pressure (psi)
P-down	350	0	0	Downstream pressure (psi)
t	2	1.536	1.536	Disk Thickness (in)
a	4.36	2.789	2.789	Seat radius (in)
b	1.25	1.5	1.5	Hub Radius (in)
b/a	0.286697248	0.537827178	0.537827178	Seat to Hub Radius Ratio
l-hub	0.5	0.4375	0.4375	Hub lenght (in)
theta	5	5	5	Seat angle (deg)
rheta-rad	0.087266461	0.087266461	0.087266461	rad
poison	0.3	0.3	0.3	Poisson' Ratio (disc material)
e	27600000	29000000	29000000	Modulus of Elasticity (psi)
dstem	1.875	1.75	1.75	Steam Diameter (in)
Fpo	15409	11000	11000	Static Pollout Force (lbs)
Vf	0.52	0.66	0.66	Valve factor
mu	0.49556189	0.621725137	0.621725137	Coeff. of Friction between disk & seat
dpavg	640	2235	2235	Average DP Across Disk (psi)
D	20219780.22	9623853.574	9623853.574	Disk Stiffness Constant
G	10615384.62	11153846.15	11153846.15	Disk Stiffness Constant
C2	0.178106699	0.08798395	0.08798395	Geometry Factors. Roark, Table 24
C3	0.031121901	0.011950404	0.011950404	Geometry Factors. Roark, Table 24

Input	TEST	V852A	V852B	NOTES
P-bonnet	1005	2250	2250	Bonnet pressure (psi)
P-up	380	30	30	Upstream pressure (psi)
P-down	350	0	0	Downstream pressure (psi)
t	2	1.536	1.536	Disk Thickness (in)
a	4.36	2.789	2.789	Seat radius (in)
b	1.25	1.5	1.5	Hub Radius (in)
b/a	0.286697248	0.537827178	0.537827178	Seat to Hub Radius Ratio
l-hub	0.5	0.4375	0.4375	Hub lenght (in)
theta	5	5	5	Seat angle (deg)
rheta-rad	0.087266461	0.087266461	0.087266461	rad
poison	0.3	0.3	0.3	Poisson' Ratio (disc material)
e	27600000	29000000	29000000	Modulus of Elasticity (psi)
dstem	1.875	1.75	1.75	Steam Diameter (in)
Fpo	15409	11000	11000	Static Pollout Force (lbs)
Vf	0.52	0.66	0.66	Valve factor
mu	0.49556189	0.621725137	0.621725137	Coeff. of Friction between disk & seat
dpavg	640	2235	2235	Average DP Across Disk (psi)
D	20219780.22	9623853.574	9623853.574	Disk Stiffness Constant
G	10615384.62	11153846.15	11153846.15	Disk Stiffness Constant
C2	0.178106699	0.08798395	0.08798395	Geometry Factors. Roark, Table 24
C3	0.031121901	0.011950404	0.011950404	Geometry Factors. Roark, Table 24
C8	0.678768359	0.751240326	0.751240326	Geometry Factors. Roark, Table 24
C9	0.278864492	0.28371542	0.28371542	Geometry Factors. Roark, Table 24
L3	0	0	0	Loading Constant, Roark, Table 24, Case 1L
L9	0	0	0	Loading Constant, Roark, Table 24, Case 1L
L11	0.006870736	0.001498148	0.001498148	Loading Constant, Roark, Table 24, Case 2L
L17	0.152622843	0.079290058	0.079290058	Loading Constant, Roark, Table 24, Case 2L
Mrb	-5264.98814	-2503.37374	-2503.37374	Moment Facto, Roark, Table 24
Qb	4466.4576	4118.748145	4118.748145	Unit Shear Force, Roark, Table 24
yb	-0.00039041	-8.8120E-05	-8.8120E-05	Bending Deflection due to pressure (in)
Ksa	-0.4742557	-0.15890822	-0.15890822	Shear deflection, Roark Table 25, case 2l
ysq	-0.00027177	-0.00016125	-0.00016125	Shear Deflection due to pressure (in)
Pforce	35079.47536	38818.28608	38818.28608	Force acting on Hub (lbs)
ystretch	0.000064731	0.000041424	0.000041424	Hub Deflection due to Hub Force (in)
yq	-0.00072691	-0.0002908	-0.0002908	Toal deflection due to Pressure Forces (in)
ysw	-3.0788E-07	-1.2116E-07	-1.2116E-07	Deflection due to seat cont. force and shear stress (per lbf/in)
ybw	-6.0123E-07	-8.9183E-08	-8.9183E-08	deflection due to bend. (per lbf/in)
y-cmpr	-5.0551E-08	-1.8700E-08	-1.8700E-08	Deflection due to Hun Compression (per lbf/in)
yw	-9.5966E-07	-2.2904E-07	-2.2904E-07	Toal deflection due to contact Force (per lbf/in)
Fs	20750.5253	22248.507	22248.507	Seat Contact Force (lbs)
F-piston	2774.971198	5411.884127	5411.884127	Piston Force (lbs)
F-vert	6662.37102	9520.295264	9520.295264	Reverse Piston Force (lbs)
F-prlock	16871.02311	23681.46854	23681.46854	Pressure Lock Force (lbs)
F-total	36167.42294	38789.87968	38789.87968	Total Unseated Force (lbs)

ATTACHMENT C
DA-ME-96-076
REV. 2
SHT. 1 OF 1

Input	TEST	V852A	V852B	NOTES
P-bonnet	1005	2250	2250	Bonnet pressure (psi)
P-up	380	30	30	Upstream pressure (psi)
P-down	350	0	0	Downstream pressure (psi)
t	2	1.536	1.536	Disk Thickness (in)
[illegible]	4.36	2.789	2.789	Seat radius (in)
[illegible]	1.25	1.5	1.5	Hub Radius (in)
[illegible]	0.286697248	0.537827178	0.537827178	Seat to Hub Radius Ratio
l-hub	0.5	0.4375	0.4375	Hub lenght (in)
theta	5	5	5	Seat angle (deg)
rheta-rad	0.087266461	0.087266461	0.087266461	rad
poison	0.3	0.3	0.3	Poisson' Ratio (disc material)
e	27600000	29000000	29000000	Modulus of Elasticity (psi)
dstem	1.875	1.75	1.75	Steam Diameter (in)
Fpo	15409	7816	7386	Static Pollout Force (lbs)
Vf	0.52	0.66	0.66	Valve factor
mu	0.49556189	0.621725137	0.621725137	Coeff. of Friction between disk & seat
dpavg	640	2235	2235	Average DP Across Disk (psi)
D	20219780.22	9623853.574	9623853.574	Disk Stiffness Constant
G	10615384.62	11153846.15	11153846.15	Disk Stiffness Constant
C2	0.178106699	0.08798395	0.08798395	Geometry Factors. Roark, Table 24
C3	0.031121901	0.011950404	0.011950404	Geometry Factors. Roark, Table 24

Input	TEST	V852A	V852B	NOTES
P-bonnet	1005	2250	2250	Bonnet pressure (psi)
P-up	380	30	30	Upstream pressure (psi)
P-down	350	0	0	Downstream pressure (psi)
t	2	1.536	1.536	Disk Thickness (in)
a	4.36	2.789	2.789	Seat radius (in)
b	1.25	1.5	1.5	Hub Radius (in)
b/a	0.286697248	0.537827178	0.537827178	Seat to Hub Radius Ratio
l-hub	0.5	0.4375	0.4375	Hub lenght (in)
theta	5	5	5	Seat angle (deg)
rheta-rad	0.087266461	0.087266461	0.087266461	rad
poison	0.3	0.3	0.3	Poisson' Ratio (disc material)
[illegible]	27600000	29000000	29000000	Modulus of Elasticity (psi)
[illegible]	1.875	1.75	1.75	Steam Diameter (in)
Fp[illegible]	15409	7816	7386	Static Pollout Force (lbs)
Vf	0.52	0.66	0.66	Valve factor
mu	0.49556189	0.621725137	0.621725137	Coeff. of Friction between disk & seat
dpavg	640	2235	2235	Average DP Across Disk (psi)
D	20219780.22	9623853.574	9623853.574	Disk Stiffness Constant
G	10615384.62	11153846.15	11153846.15	Disk Stiffness Constant
C2	0.178106699	0.08798395	0.08798395	Geometry Factors. Roark, Table 24
C3	0.031121901	0.011950404	0.011950404	Geometry Factors. Roark, Table 24
C8	0.678768359	0.751240326	0.751240326	Geometry Factors. Roark, Table 24
C9	0.278864492	0.28371542	0.28371542	Geometry Factors. Roark, Table 24
L3	0	0	0	Loading Constant, Roark, Table 24, Case 1L
L9	0	0	0	Loading Constant, Roark, Table 24, Case 1L
L11	0.006870736	0.001498148	0.001498148	Loading Constant, Roark, Table 24, Case 2L
L17	0.152622843	0.079290058	0.079290058	Loading Constant, Roark, Table 24, Case 2L
Mrb	-5264.98814	-2503.37374	-2503.37374	Moment Facto, Roark, Table 24
Qb	4466.4576	4118.748145	4118.748145	Unit Shear Force, Roark, Table 24
yb	-0.00039041	-8.8120E-05	-8.8120E-05	Bending Deflection due to pressure (in)
Ksa	-0.4742557	-0.15890822	-0.15890822	Shear deflection, Roark Table 25, case 2l
ysq	-0.00027177	-0.00016125	-0.00016125	Shear Deflection due to pressure (in)
Pforce	35079.47536	38818.28608	38818.28608	Force acting on Hub (lbs)
ystretch	0.000064731	0.000041424	0.000041424	Hub Deflection due to Hub Force (in)
yq	-0.00072691	-0.0002908	-0.0002908	Toal deflection due to Pressure Forces (in)
ysw	-3.0788E-07	-1.2116E-07	-1.2116E-07	Deflection due to seat cont. force and shear stress (per lbf/in)
ybw	-6.0123E-07	-8.9183E-08	-8.9183E-08	deflection due to bend. (per lbf/in)
y-cmpr	-5.0551E-08	-1.8700E-08	-1.8700E-08	Deflection due to Hun Compression (per lbf/in)
[illegible]	-9.5966E-07	-2.2904E-07	-2.2904E-07	Toal deflection due to contact Force (per lbf/in)
[illegible]	20750.5253	22248.507	22248.507	Seat Contact Force (lbs)
F-piston	2774.971198	5411.884127	5411.884127	Piston Force (lbs)
F-vert	6662.37102	9520.295264	9520.295264	Reverse Piston Force (lbs)
F-prlock	16871.02311	23681.46854	23681.46854	Pressure Lock Force (lbs)
F-total	36167.42294	35605.87968	35175.87968	Total Unseated Force (lbs)

Rochester Gas and Electric

Ginna Station Gate Valve PL/TB Investigation

Valve No. 0720 Description: RHR PMP DISCH TO LP B System: RHR EIN: 0720

Safety Class: 1 Size: 10 Valve Disc Type: FLEX Op Type MOV

Reference P&ID: 1247 Coordinate: I-2 Normal Position: CLOSE

Building Location: RC Elevation: 235 Room: CC03

System Design Temperature: 400 System Design Pressure: 600

Normal Ambient Temperature: 120 Accident Ambient Temperature: 286

Valve Function:

Hot Leg B RHR return. (Ref. EWR 2512 isometric 354-03)

Initial Screening

1) Is valve 0720 a member of the ASME XI IST program?	Yes
2) Is valve 0720 a member of the GL 89-10 program?	Yes
3) Does valve 0720 have an active safety function to open based upon the IST program?	Yes
4) Does valve 0720 provide a non safety function to open which is important to plant operation?	Yes
If yes explain: Required for cool-down.	
5) Does valve 0720 requires further PL/TB screening?	Yes

PL/TB screening

6) Is rapid depressurization of adjacent piping possible?	Yes
If yes explain: Assume Valve 721 leaks. LOCA.	
7) Is valve 0720 susceptible to heating from adjacent system fluid?	No
If yes explain:	
8) Is valve 0720 susceptible to heating from the ambient environment?	Yes
If yes explain: High LOCA temperature.	

Results

Valve 0720 is susceptible to pressure locking:	Yes
Valve 0720 is susceptible to thermal binding:	Yes

Evaluation Summary:

This valve's safety function is to provide containment isolation. The only time it is opened is to perform a normal cooldown during which time the conditions required to produce PL/TB are not present. Rapid depressurization and elevated ambient temperatures are a result of a LOCA. Prior to a normal, cooldown system heat from the RCL will unlikely reach this valve because it is isolated from the RCL by valve 0721. Historically there have been no problems in operating this valve.

9) Is further corrective action required?	No

Rochester Gas and Electric

Ginna Station Gate Valve PL/TB Investigation

Valve No. 0721 Description: RHR PMP DISCH TO LP B System: RHR EIN: 0721

Safety Class: 1 Size: 10 Valve Disc Type: FLEX Op Type MOV

Reference P&ID: ·1247 Coordinate: I-1 Normal Position: CLOSE

Building Location: RC Elevation: 235 Room: CC03

System Design Temperature: 650 System Design Pressure: 2485

Normal Ambient Temperature: 120 Accident Ambient Temperature: 286

Valve Function:

Hot Leg B RHR return. Valve cannot open above 410 psig via RC pressure interlock.(Ref. 2512 isometric 354-03)

Initial Screening

1) Is valve 0721 a member of the ASME XI IST program?	Yes
2) Is valve 0721 a member of the GL 89-10 program?	Yes
3) Does valve 0721 have an active safety function to open based upon the IST program?	Yes
4) Does valve 0721 provide a non safety function to open which is important to plant operation?	Yes
If yes explain: Required for cool-down.	
5) Does valve 0721 requires further PL/TB screening?	Yes

PL/TB screening

6) Is rapid depressurization of adjacent piping possible?	Yes
If yes explain: LOCA	
7) Is valve 0721 susceptible to heating from adjacent system fluid?	No
If yes explain:	
8) Is valve 0721 susceptible to heating from the ambient environment?	Yes
If yes explain: High LOCA temperature.	

Results

Valve 0721 is susceptible to pressure locking:	Yes
Valve 0721 is susceptible to thermal binding:	Yes

Evaluation Summary:

This valve's safety function is to provide containment isolation. The only time it is opened is to perform a normal cooldown during which time the conditions required to produce PL/TB are not present. Rapid depressurization and elevated ambient temperatures are a result of a LOCA. Prior to a normal, cooldown system heat from the RCL will unlikely reach this valve because it is located more than 20 feet away and below from the RCL. Historically there have been no problems in operating this valve.

9) Is further corrective action required?	No

re-opening DP less than the DP occurring initially.

Re-closing after Inadvertent Opening

Since the valves are not required to close, re-closing is not required.

Valve Reduced Voltage

MOV 1815 A/B Opening Valve receives signal to open on SI. Therefore, opening voltage is associated with operation during load sequencing due to SI.

MOV 1815 A/B Closing

Valve may close during SI sequence if a SI pump fails to start. Therefore, closing voltage is associated with operation during load sequencing due to SI.

Pressure Locking and Thermal Binding

These motor-operated gate valves have double discs and, therefore, are not susceptible to thermal binding.

These valves serve as suction to SI Pump C from the RWST. The only pressure available to these valves is the static head from the RWST, therefore, these valves are not susceptible to pressure locking.

6.2.5 MOV 878 A/B/C/D 878 A/C are SI pump discharge to hot legs. They are normally closed with AC power removed. 878 B/D are SI pump discharge to cold legs. They are normally open with AC power removed.

Since 878 B/D are in their safety-related position (open) with AC power removed, the valves can not be inadvertently closed from the control room. Should the valves become mispositioned as a result of some test, status lights in the control room and valve alignment check would prevent this condition from going unnoticed for extended periods of time. Therefore, 878 B & D will not be included in the GL 89-10 Program.

Since 878 A & C are in their safety-related position (closed) with AC power removed, the valves can not be inadvertently opened. These valves are also not required to be open for a transient. RV nozzles are relied upon to prevent boron precipitation. Status lights and valve alignment checks prevent extended periods of operation with mispositioned valves due to testing. Therefore, 878 A & C will not be included in the GL 89-10 Program.