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ISOLATION VALVE ASSESSMENT USER'S MANUAL

IVA

SOFTWARE

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TECHNICAL REPORT

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GETTING STARTED

The Isolation Valve Assessment (IVA) software is a package of tools for evaluating operator sizing criteria for 5° flexwedge motor–operated gate valves in the closing direction utilizing Limitorque operators. Gate valves of the flexwedge design are typically the most common design installed in systems where flow isolation capability is desired.

IVA software increases the user's efficiency by providing the following features:

- easy–to–use data entry screens
- automatic calculation of intermediate variables
- valve stem thrust estimates using both the standard industry equation and the INEL equation and comparisons with operator capabilities
- assessment of low flow, low differential pressure valve testing
- graphical displays of valve performance estimates relative to either operator capabilities or INEL test results.

Chapter 1

INTRODUCTION

The general data entry screen is the first screen that the user encounters upon starting up the IVA program. On this screen, the user enters valve parameters, operator characteristics, and operator motor information. The user also uses this screen to select one of two possible assessment modes. The first mode estimates the maximum stem thrust and assesses the capability of the equipment. The second mode assesses low flow, low differential pressure diagnostic test results. The general data entry screen is the first screen for both modes. The first mode contains three additional data entry screens for valve specific data and operator specific mechanical and electrical data. The second mode contains one additional data entry screen for diagnostic test specific data. The data from both modes is in the same data base such that the user can easily toggle from one mode to the other.

Each mode contains a results screen that summarizes the various calculations and displays the results. The results screen for the first mode displays estimated values for stem thrust, operator torque, and motor torque calculated using the industry and INEL equations. The motor torque, operator torque, and stem thrust which can be developed by the operator are also displayed. The results screen for the second mode displays an evaluation for validating and extrapolating results from low flow diagnostic tests. The results of that assessment determine whether extrapolation of low flow test results is possible.

Various graphs can be displayed in either mode. The first mode displays four graphs. The first graph is a plot of required stem thrust versus available stem thrust as a function of stem factor for nominal and degraded voltage conditions. The second graph provides the same information as a function of stem to stem nut coefficient of friction. The third plot displays the conversion of operator torque to stem thrust for a number of stem to stem nut coefficients of friction. The fourth plot relates the stem thrust to torque switch settings for a number of stem to stem nut coefficients of frictions. The second mode displays a single graph relating an evaluation of the low flow diagnostic test results, compared to the valves tested by the INEL, for possible extrapolation to high flow conditions.

Chapter 1

INTRODUCTION

1.1 SOFTWARE NOTICE

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights. The views expressed in this report are not necessarily those of the U.S. Nuclear Regulatory commission.

1.2 SOFTWARE DEVELOPMENT

This software was been developed by the Idaho National Engineering Laboratory under contract to the Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission. Any comments pertaining to the software should be directed to one of the following:

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Chapter 2

INSTALLATION

2.1 SYSTEM REQUIREMENTS

IVA was developed to operate on an IBM personal computer or compatible. PC/MS–DOS 3.1, or newer, and an 80 column display should be used. In order to display the various plots, the system also requires graphics capabilities. Best results are obtained with systems that have VGA color capabilities. However, the software has been successfully operated on systems with EGA or CGA screen modes, on systems with Hercules graphics cards, or with VGA monochrome capabilities.

2.2 INSTALLING THE PROGRAM

You can run IVA from either a floppy disk or a hard drive, but performance is better with a hard drive. To install the program on a hard drive, perform the following steps:

1. Create a subdirectory for the program's execution files. This is done by typing **MD\xxxx** where **xxxx** is a 1 to 8 character name for the new subdirectory.

2. Copy the IVA execution files to the new subdirectory:

   - insert the IVA disk into either a 51/4" or 31/2" floppy drive, depending on the size of your IVA program disk.

   - shift to the drive the IVA program disk was inserted into by typing **X:** where **X** is the letter designation of the floppy drive containing the IVA program.

   - Type **COPY *.* C:\xxxx**

If you want to be able to start IVA from any hard disk subdirectory, add the name of the subdirectory that was created for IVA to the DOS PATH command string that exists in your AUTOEXEC.BAT file and reboot the PC.

STARTING IVA

To run IVA from a hard disk:

1. Shift to the hard drive by typing **C:**.
2. If the subdirectory that IVA was copied to does not exist in the DOS PATH, change to the subdirectory containing the IVA executable files by typing **CD\XXXX**.
3. Type **IVA**.

To run IVA from a floppy disk:

1. Ensure that the DOS commands can be executed from a floppy drive by verifying that the complete subdirectory name (drive and subdirectory) containing the DOS commands is contained in the PATH command string that exists in your AUTOEXEC.BAT file. If the complete subdirectory name is not present, add it and reboot the machine.
2. Shift to the floppy drive containing the IVA executable files.
3. Type **IVA**.

When the program successfully loads, it creates a blank, unnamed data file, and the general data entry screen appears. Instructions for the use of the entry screens, along with procedures for loading and saving data files, are provided in the following sections of this manual.

Chapter 4

USING IVA

When IVA is started, the general data entry screen is the first screen that the user encounters. Two data entry modes can be selected from this screen. The default selection when the general data entry screen first appears is Mode 1, which is used to estimate the maximum stem thrust of a valve and assess the capability of a MOV. Mode 1 consists of three data entry screens in addition to the general data entry screen. The second mode (Mode 2) consists of one data entry screen (in addition to the general data entry screen) and is used to validate and extrapolate the results of low flow diagnostic test data. All the information needed to complete the IVA MOV calculations are input through these data entry screens. Operating the IVA program is very direct:

- Enter the data required per the current mode or press **F3** to retrieve a previously saved data file. The upper left corner of each data screen identifies the use of the data field the cursor currently resides in or whether the data field is optional.
- Press **F5** to view the estimated response for the mode selected. The extent of data displayed will depend on the amount of data input to the program.
- Press **F6** to select and view the various plots for the mode selected. The availability of plots will depend on the amount of data input to the program.
- Press **F4** to print out a hard copy of the current MOV data and calculations for the mode selected.
- Press **F8** to save the current data and, if desired, exit the program.

4.1 CURSOR MOVEMENT

You can move through the various data entry screens using the **PAGE–DOWN** and **PAGE–UP** keys. Entering **PAGE–DOWN** at the last data entry screen brings up the general data entry screen. Likewise, entering **PAGE–UP** at the general data entry screen brings up the last screen for whichever mode has been selected.

You can move from field to field in any of the data entry screens using the **UP–ARROW** or **DOWN–ARROW** keys.

You can move within a field using the **LEFT–ARROW, RIGHT–ARROW, HOME, END,** and **BACKSPACE** keys. Data within a field can be edited using the **INSERT** and **DELETE** keys.

Some data entry fields are bracketed by < > characters. This indicates that for that field, you can a toggle through a series of preset values. With the cursor in a toggle field, you can view and select using the **LEFT–ARROW** and **RIGHT–ARROW** keys. Note that several of the toggle fields have been included for future expansion of the program. As such, these fields contain a single option and do not appear to function. The valve type (Gate) on the general data sheet is one example of a toggle field which does not appear to function.

4.2 FUNCTION KEYS

F1 Help Information

This function displays context sensitive help information. If the help screen contains more information than will fit on a single screen, the bottom row of the screen will state that the additional information can be viewed using the **UP–ARROW, DOWN–ARROW, PAGE–UP** and **PAGE–DOWN** keys. If no context sensitive help information is available for the current cursor location, or if you press **F1** while the help information is being displayed, the Function Key Definition help screen appears. (Thus, pressing F1 either once or twice will bring up the screen that defines the function keys.) Pressing any other key will return you to the data entry screen you were in when you pressed F1.

Function Key Definitions Activate from any data entry screen

F1	EQUATIONS Help Information	Color/Graphics Mode	F2
F3	CHANGE DIRECTORY File Menu	Print Active Data	F4
F5	Estimated Response	Graphics Menu	F6
F7	Save File	Save/Clear/Exit	F8
F9	Table Up (Ctrl ↑)	Table Down (Ctrl ↓)	F10

Legend: UPPER CASE – SHIFT + FUNCTION KEY
lower case – Function Key only

Shift–F1 Equations

This function displays a series of 17 text screens that provide the user with the underlying formulas used by IVA. To view each equation, use the **PAGE–UP** and **PAGE–DOWN** keys. See the MOV Equation section of this manual to review these equations as they appear on screen.

F2 Colors/Graphics Mode

This function lets you select and save default screen colors for text screens and graphs. You can select various color combinations for the foreground, background, and window displays by moving the cursor to the desired item using the **UP–ARROW** and **DOWN–ARROW** keys, and then using the **LEFT–ARROW** and **RIGHT–ARROW** keys to make the selection. Examples of the current color combinations are shown next to the current settings. Colors for the various graphics can be set in the same manner. In addition, the graphics mode can be selected, subject to the capabilities of the system. When finished, press **Esc** to save the settings.

F3 File Menu

This function displays a listing of the available MOV data files in the current directory and provides four file management options at the bottom of the screen. Use the **LEFT–ARROW, RIGHT–ARROW, UP–ARROW,** and **DOWN–ARROW** keys to highlight the desired data file and then select the number of one of the following file management options. To unload a file or clear the current data being edited so that new data can be entered into the program, see the discussion under section F8, Save/Clear/Exit.

1. Load — Loads the data in the highlighted file into the current data entry screens.
2. Delete — Deletes the highlighted file after the user confirms the desired action.
3. Rename — Allows the user to enter a new name for the highlighted file. If a file exists with the same name, the user is prompted on whether the existing files should be overwritten or not.
4. Copy — Allows the user to copy the information in the highlighted file to a different file. If a file exists with the same name, the user is prompted on whether the the existing file should be overwritten or not.

Shift–F3 Change Directory

This function allows you to enter the name of an alternate data subdirectory. If the requested subdirectory does not exist, IVA will prompt the user on whether to create it or not. Subsequent file actions will occur within this subdirectory. All subdirectories created by IVA will exist under the directory that contains the IVA executable files.

F4 Print Active Data

Use this function to print out the input and results data for the current MOV being assessed. The actual output will depend on which mode is currently active, as selected on the general data entry screen. The following three pages provide examples of the output that is available. The first two pages present output when Mode 1 is active, the third page when Mode 2 is active. Note that a Hewlett Packard LaserJet or compatible printer is required.

IVA-3.10 Motor Operated Valve Capability Estimates Date:______
Time:______
Page: 1 of 2

Plant/Unit:______
System:______
Number:______ P&ID Coord:______
Valve Make:______ Type:______ Size:______
Oper. Make:______ Model:______ Number:______

Comments:______

Design Basis Conditions
Pressure (psig):______ DP (psid):______ Packing (lbf):______
Disk Factor:______ Subcooling:______

Valve Data
Orif Dia (in):______ Stem Dia (in):______ Seat ID (in):______
Orif Area(in²):______ Stem Area(in²):______ Seat OD (in):______
Seat Angle (deg):______ Seat MD (in):______

Operator Mechanical Data
Stem Thds/in:______ Lead Desc.:______ Pitch:______ Lead:______
Stem Friction:______ Stem Factor:______ Oper Ratio:______
Stroke Length (in):______ Time (sec):______ Speed (in/min):______

Operator Electrical Data

Motor Rated
Speed (RPM):______
Torque (ft-lbf):______
Voltage (volts):______
Stall Torque (ft-lbf):______
Stall Current (amps):______

Source Voltage
Nominal:______
Minimum:______
Maximum:______
Power:______
Containment Temperature (°F):______

Pullout Eff:______
App Factor:______
Stall Eff:______

Valve/Operator/Motor Requirements		
INEL Estimate	Industry Estimate	
		Disk Load (lbf) Rejection Loads (lbf) Packing - Weight Loads (lbf) Req'd Stem Thrust (lbf) Req'd Operator Torque (ft-lbf) Req'd Motor Torque (ft-lbf)

Unit Capabilities			Unit Requirements		
Available at Max. Voltage	Available at Nom. Voltage	Available at Min. Voltage	INEL Estimate	Industry Estimate	
					Stem Thrust Operator Torque Motor Torque Voltage Drop Torque Switch

Mode 1 Printed Output, Page 1 of 2

IVA-3.10 Motor Operated Valve Capability Estimates

Date:____
Time:____
Page: 2 of 2

Plant/Unit:____
System:____
Number:____ P&ID Coord:____
Valve Make:____ Type:____ Size:____
Oper. Make:____ Model:____ Number:____

Data Number	Torque Switch Setting	Operator Torque	Data Number	Torque Switch Setting	Operator Torque
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Data Number	Cable Type	Length (ft)	Wire Size	
			AWG	Cir Mils
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Mode 1 Printed Output, Page 2 of 2

```
IVA-3.10          Motor Operated Valve Test Assessment          Date:________
                                                                Time:________
                                                                Page: 1 of 1

Plant/Unit:_________________________________________________________
    System:______________________________
    Number:______________________________         P&ID Coord:_______________
Valve Make:_________________________   Type:__________   Size:___________
Oper. Make:________   Model:__________   Number:____________

    Valve Data

Seat Angle (deg):__    Stem Dia  (in):________    Seat ID (in):________
                       Stem Area(in²):________    Seat OD (in):________
                                                  Seat MD (in):________

    Recorded Test Conditions

  Pressure (psig):________   DP (psid):________   Packing (lbf):________
Stem Thrust (lbf):________   Fluid Subcooling:________________

    INEL Estimated Valve Response

            Total Disk Load                       Normalized Force
    Vertical (lbs):_______                  Normal (lbs):_______
  Horizontal (lbs):_______                 Sliding (lbs):_______

      Sliding Force Within Limits of INEL Data (______ to ______):____

      Is the test valve typical of valves tested by the INEL:____
```

Mode 2 Printed Output, Page 1 of 1

F5 Estimated Response

This function displays the estimated response screen, showing the results of IVA program calculations, depending on which mode is active. These results screens will be explained later in this manual.

F6 Graphics Menu

This function displays a mode–specific menu from which you can select one of several plots. All lines are color coded, and the colors can be changed using the F2 Color/Graphics Mode function, subject to the capabilities of the system.

Mode 1, Graph 1: Required and Available Thrust vs Stem Factor

The two horizontal lines identify the thrust required to close the valve, as estimated using the industry and the INEL equations. The vertical line identifies the estimated stem factor for the operator as it appears on Data Screen 3. The curved lines identify the thrust available from the operator under nominal and degraded voltage conditions, including the effects of voltage losses in the cables from the power source to the MOV.

Mode 1, Graph 2: Required and Available Thrust vs Stem Nut Friction

This option is identical to Graph 1, except that the various thrusts are plotted against the stem to stem nut coefficient of friction, which appears on Data Screen 3, instead of the stem factor.

Mode 1, Graph 3: Conversion of Operator Torque to Thrust

The two horizontal lines identify the thrust required to close the valve as estimated using the industry and the INEL equations. The vertical line identifies the maximum available operator torque at degraded voltage conditions, including the effect of voltage losses in the cables from the power source to the MOV. The various sloping lines represent the conversion of operator torque to thrust assuming several stem to stem nut coefficients of friction.

Mode 1, Graph 4: Relationship of Torque Switch Setting to Thrust

The two horizontal lines identify the thrust needed to close the valve as estimated using the industry and the INEL equations. The vertical line represents the maximum allowable torque switch setting at degraded voltage conditions, including the effect of voltage losses in the cables from the power source to the MOV. The various sloping lines represent the available thrust versus torque switch setting for several stem to stem nut coefficients of friction.

Mode 2, Graph 1: Relationship between Sliding and Normal Forces

A solid sloping line represents the best estimate relationship between sliding and normal forces acting on a disk. The two sloping dashed lines represent the limits observed in the INEL test data. The circle represents the estimated sliding and normal loads acting on the disk during a test.

F7
Save File

This function lets you save the current data file. A window prompts you as to whether the current file should be saved. If the response is Yes, a second window opens and identifies the current file name, if one exists. You can either use the same file name or change the file name prior to saving the file. If a file exists with the same name, a third window opens and prompts you on whether the existing file should be overwritten or not. Answering Yes will complete the save operation.

F8 Save/Clear/Exit

This function lets you save the current data file and exit the program. A window prompts you as to whether the current file should be saved as discussed under F7, Save File. A final window then opens and prompts you on whether to exit the program or not. A No response at this point will clear the current data file and start a new file.

If you want to exit the program without saving the current file, answer No to the Save File window and Yes to exit the program.

If you want to clear the current file without saving the data and without exiting the program, answer No to the Save File window and No to the Exit Program window.

F9/F10 Table Up/ Table Down

Use these functions to move through the multiple rows of the data tables to enter data in either the torque switch calibration table or the cable description table on Data Screens 3 and 4 of Mode 1.

On some machines, the **CTRL UP–ARROW** and **CTRL DOWN–ARROW** keys can also be used to move through the tables to enter data. This capability is machine dependent and is left for the user to determine if this capability is available on a given machine.

Chapter 5

DATA ENTRY SCREENS

5.1 Modes 1 and 2, Data Screen 1

The first data entry screen records general data associated with the MOV. This data plays no part in the actual calculations. This screen is common to both modes, and it is from this screen that you select either Mode 1 (capability assessment) or Mode 2 (validate and extrapolate). Such items as the plant and system the MOV is located in, the MOV number, the grid location on P&IDs and general valve and operator information can also be documented. A comment field is also provided.

```
File:                                          General Data (Sheet 1 of 4)
Variable Use:

Plant/Unit:
    System:
    Number:                                   P&ID coord:

     Valve Manufacturer:
                  Type:<          >   Size:

   Operator Manufacturer:<        >
                 Model:            Number:

                                       Mode:<                   >

Comments:

F1-Help              F5-Valve Response            PgUp/PgDn-new data sheet
```

Mode

Determines what type of input will be entered, calculated, printed and graphically displayed.

Available options are

- Capability Assessment (Mode 1)
- Validate & Extrapolate (Mode 2)

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

5. DATA ENTRY SCREENS

5.2 Mode 1, Data Screen 2

The second data entry screen in Mode 1 is used to record specific valve data and system conditions needed for design basis stem thrust calculations. Critical parameters include the maximum system pressure and valve differential pressure, disk factor, packing load, orifice and stem areas/diameters, the stroke length, the valve seat inside/outside/mean diameters and the subcooling of the fluid at design basis conditions.

You need not enter both the area and the diameter of the orifice and the stem. If you enter a diameter, then the computer calculates the corresponding area. Likewise, if you enter an area, then the computer calculates the corresponding diameter.

```
File:                                                  Valve Data (Sheet 2 of 4)
Variable Use:

              Pressure (psig):                               Disk factor:
 Differential Pressure (psid):                         Packing Load (lbf):

Orifice Diameter (in):                                 Stem Diameter (in):
         Area (sq in):                                       Area (sq in):

   Stroke Length (in):

         Seat ID (in):
         Seat OD (in):
   Mean Seat Dia (in):
     Seat Angle (deg):<  >

     Fluid Subcooling:<              >



F1-Help                 F5-Valve Response              PgUp/PgDn-new data sheet
```

Pressure (psig)
The maximum upstream pressure that the valve must close against as specified in the design basis documents.

Differential Pressure (psid)
The maximum differential pressure that the valve must close against as specified in the design basis documents. If this value is not specified, enter the maximum upstream pressure again as the maximum differential pressure.

Disk Factor
A factor that is dependent on the valve design.

The following[1] are typical values of disk factors being used by the industry:

0.2	for parallel seat double disk gate valves
0.3 to 0.5	for wedge gate valves

Packing Load (lb_f)

The maximum packing drag as specified in the design basis documents. The packing drag depends on the packing design, gland nut torque, and direction of operation.

The following[1] are maximum packing drag estimates being used by the industry based on the size of the stem:

	Packing Drag (lb_f)	
Stem Diameter	Asbestos	Flexible Graphite
Up to 1" inclusive	1000	700 — 1200
Greater than 1" to 1" inclusive	1500	1000 — 1800
Greater than 1" to 2" inclusive	2500	1600 — 3000
Greater than 2" to 4" inclusive	4000	3500 — 6000
Greater than 4"	5000	4000 — 7000

Note: The validity of these values for a specific application must be verified with the valve and/or packing manufacturer.

Orifice Diameter (inch)

The cross-sectional diameter of the valve port. Use the actual port diameter of the valve as a minimum. Larger port diameters introduce conservatism into the final estimated stem thrust.

The computer will calculate the valve port diameter if you enter the valve port area.

Orifice Area ($inch^2$)

The cross-sectional area of the valve port. Use the actual port area of the valve as a minimum. Larger port areas introduce conservatism into the final estimated stem thrust.

The computer will calculate the valve port area if you enter the valve port diameter.

Stem Diameter (inch)

The cross-sectional diameter of the valve stem. Use the stem diameter as supplied by the valve manufacturer.

The computer will calculate the stem diameter if you enter the stem area.

Stem Area (inch²)

The cross-sectional area of the valve stem. Use the stem area as supplied by the valve manufacturer.

The computer will calculate the stem area if you enter the stem diameter.

Stroke Length (inch)

The distance the valve disk travels from the fully open to the fully closed position. Use the valve stroke length supplied by the valve manufacturer. The computer will calculate the stroke length if you enter the valve stroke speed and the stroke time.

If the above information is not available, you can estimate the stroke length as 110% of the valve orifice diameter.

Seat ID (inch)

The inside diameter of the valve seating surfaces. The seat inner diameter should be measured in the plane perpendicular to the valve stem. If the seat inner diameter is not available, you can use the valve orifice diameter as an approximation.

Seat OD (inch)

The outside diameter of the valve seating surfaces. The seat outer diameter should be measured in the plane perpendicular to the valve stem. If the seat outer diameter is not available, you can use the valve orifice diameter plus two times the seat width as an approximation.

The following seat widths were observed for the flexwedge gate valves tested by the INEL. These measurements may be of some assistance in estimating the seat width of similar valves.

	Seat Width (inch)	
Valve Size	900 lb_f valve	600 lb_f valve
6 inch	0.125	0.135
	0.377	
10 inch	0.126	0.500
	0.545	

Mean Seat Diameter (inch) The average of the inside and outside diameters of the valve seating surfaces. The computer will calculate the mean seat diameter if you enter the seat inner diameter and the seat outer diameter.

Seat Angle (degrees) The angle of the valve seating surface relative to the valve stem. The seat angle for a majority of flexwedge gate valves is nominally 5 degrees. Currently, IVA is written to use this value only.

Fluid Subcooling Fluid subcooling is the difference between the actual temperature of a liquid and the saturation temperature of the liquid at the design basis pressure.

Two options are available:

- Less than 70°F subcooled (fluid near or at the steam temperature), and
- 70°F or greater subcooled (colder fluid).

If the actual fluid subcooling is unknown or is close to 70°F, or if additional conservatism is needed in the estimated stem thrust, use a subcooling of 70°F or greater.

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

5.3 Mode 1, Data Screen 3

The third data entry screen in Mode 1 is used to record specific mechanical data for the operator, such as the stem pitch and lead, stem to stem nut coefficient of friction and stem factor, stroke time and speed, and the overall operator ratio.

If you enter a threads/inch value and a lead description, the computer will automatically calculate the stem pitch and stem lead. If you directly enter a stem pitch or lead, the threads/inch and the lead description fields will go blank. If you enter a stem to stem nut coefficient of friction, the computer will calculate the stem factor, and vice versa.

```
File:                                                   Operator Data (Sheet 3 of 4)
Variable Use:

    Threads/inch:<    >                                 Close Limit:<       >
Lead Description:<    >
      Stem Pitch:                                 Stem Nut Friction:
       Stem Lead:                                       Stem Factor:

                         Stroke Time (sec):
                      Stroke Speed (in/min):

                     Over All Operator Ratio:

Data Set      Torque Switch      Operator
 Number          Setting          Torque




F1-Help                F5-Valve Response                PgUp/PgDn-new data sheet
```

Threads/inch (TPI)

The number of threads that occur in one inch of the valve stem.

Twenty–two options are available:

- Blank (No entry),
- 1 to 6 threads per inch in thread increments, and
- 6 to 16 threads per inch in 1 thread increments.

The threads per inch is the reciprocal of the stem pitch. If you enter the stem pitch or lead, this field will go blank.

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

Lead Description

The stem lead description describes the number of independent threads cut into the stem. This can also be expressed as the number of apparent stem threads advanced for each revolution of the stem.

Four options are available:

- Blank (No entry),
- Single,
- Double, or
- Triple.

If you enter the stem pitch or lead, this field will go blank.

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

Stem/Pitch (inch/thread)

The distance from the peak of one thread to the peak of an adjacent thread.

The stem pitch is the reciprocal of the stem threads per inch. If you enter the stem threads per inch, the computer will calculate the stem pitch. If you enter the stem pitch, the stem threads per inch field and the lead description field will go blank.

Stem Lead (inch/stem revolution)

The distance the stem travels in one revolution of the stem–nut.

The stem lead is the product of the stem pitch times

- 1 for single lead threads,
- 2 for double lead threads, or
- 3 for triple lead threads.

The computer will calculate the stem lead if you enter the stem pitch and the stem lead description. If you enter the stem lead, the stem threads per inch field and the lead description field will go blank.

Close Limit

An entry stating whether the valve closure is controlled by a torque switch or by a stem position switch.

Available options are

- Torque, or
- Position.

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

Stem Nut Friction

A coefficient of friction between the stem and the stem–nut that depends on the material, the surface finish, and the lubrication between the stem and the stem–nut.

The design basis stem to stem nut coefficient of friction will typically range from 0.15 to 0.20[2]. Conservatively, 0.2 is used to take into account the possibility of poor maintenance of the stem threads. However, lower and higher values have been calculated from the results of valve tests.

The computer will calculate the stem to stem nut coefficient of friction if you enter the stem pitch, the stem lead, the stem diameter, and the stem factor.

Stem Factor

A factor reflecting the conversion of operator torque to stem thrust. This factor varies with stem diameter, pitch, lead, and the stem to stem nut coefficient of friction.

The computer will calculate the stem factor if you enter the stem pitch, the stem lead, the stem diameter, and the stem to stem nut coefficient of friction.

Stroke Time (sec)

Use the valve stroke time specified in the technical specifications or as sized by the operator manufacturer. The computer will calculate the stroke time if you enter the valve stroke length and the stroke speed.

Stroke Speed (inch/minute)

Use the valve stroke time supplied by the technical specifications or as sized by the operator manufacturer. The computer will calculate the stem speed if you enter the stroke length and the stroke time.

Overall Operator Ratio

The number of electric motor turns to stem nut turns. This is often listed as the "RAT" number on the unit.

The computer will calculate the overall operator ratio if you enter the electric motor rated speed (next screen), the stem lead, and the stroke speed.

Torque Switch Information

Use the torque spring calibration data supplied by Limitorque or data from separate testing. If this information is available, enter the torque switch calibration data as a

- torque switch setting
- corresponding operator torque (ft–lb_f).

This information is used to estimate torque switch settings. If this information is not included, this feature of the program will not be available.

5.4 Mode 1, Data Screen 4

The final data entry screen in Mode 1 is used to record specific electrical data for the operator, such as the power source, the source nominal, minimum and maximum voltages, the motor rated speed, torque and voltage, the motor stall torque and current, stall and pullout efficiencies, application factor, and the temperature of the containment as design basis conditions.

The cable description fields allow information on the cable used to connect the motor to its electrical source to be entered. IVA uses the data entered in the length and cir mils fields to estimate the voltage drop caused by the connecting cables.

```
File:                                        Electrical Data (Sheet 4 of 4)
Variable Use:

  Power Source:<      >          Motor Rated                  Motor Stall
Source Voltage:             Speed (RPM):           Torque (ft-lbf):
     % Minimum:          Torque (ft-lbf):          Current (amps):
     % Maximum:          Voltage (volts):
                                                        Efficiency:
   Containment                App. Fact:
     Temp (°F):              Pullout Eff:

Data Set                                          Length     Wire Size
 Number     Cable Description                      (ft)      AWG    cir mils






F1-Help              F5-Valve Response              PgUp/PgDn-new data sheet
```

Power Source

The type of electrical power being supplied to the operator motor.

Available options are:

- AC-3Φ,
- AC-1Φ, or
- DC.

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

Source Voltage (volts)

The nominal voltage of the power source that supplies power to the operator motor.

Minimum Voltage (%)

The minimum voltage supplied to the operator motor under degraded voltage conditions.

Express as a percentage (0 to 100%) of the source voltage.

Maximum Voltage (%)

The maximum voltage supplied to the operator motor under maximum voltage conditions.

Express as a percentage (100% or higher) of the source voltage.

Containment Temperature (°F)

The maximum containment or power cable temperature expected during a design basis event.

Motor Rated Speed (RPM)

The rated speed of the operator motor.

Values suggested by Limitorque[1] include

850 RPM for 900 RPM, 3 phase 60 cycle service ac motors
1700 RPM for 1800 RPM, 3 phase 60 cycle service ac motors
3400 RPM for 3600 RPM, 3 phase 60 cycle service ac motors
700 RPM for 750 RPM, 3 phase 50 cycle service ac motors
1425 RPM for 1500 RPM, 3 phase 50 cycle service ac motors
2800 RPM for 3000 RPM, 3 phase 50 cycle service ac motors

1425 RPM for 1500 RPM, 3 phase 25 cycle service ac motors
2100 RPM for Modutronic motors
1700 RPM for 1800 RPM, 1 phase 60 cycle service ac motors
1900 RPM for dc motors

Note: Dc and 1 phase motors are load sensitive, so the design speeds are only approximate. Dc and 1 phase motors subjected to little or no running torque (e.g., high gear ratios and corresponding long operating times) may run at speeds 50 to 100% higher than indicated above.

Motor Rated Torque (ft–lb$_f$)

The rated torque for the operator motor at nominal voltage conditions. Use the electric motor rated specifications subject to the following caution from Limitorque[3]:

> As the ambient temperature increases, a dc motor's maximum output torque decreases. Limitorque's dc operator qualification (Report B0009) requires the operator to perform at 340°F. At this temperature, some of the dc motors cannot produce their rated starting torque. When sizing a nuclear qualified dc operator, the calculated motor torque must be less than the maximum available starting torque shown in the table below.

Rated Torque With dc Motors

Nominal motor starting torque (ft–lb$_f$)	Maximum available starting torque (ft–lb$_f$) at qualified starting temperature (340°F)	
	125 volt rating	250 volt rating
5	5	5
10	10	10
15	15	15
25	25	25
40	39	36
60	54	51
80	79	68
100	70	76
150	150	150
200	200	200

5. DATA ENTRY SCREENS

Motor Rated Voltage (volts)

The nominal voltage for which the operator motor is rated. This is also the voltage at which the operator motor rated speed and torque are specified.

Application Factor

The operator motor service factor required for a particular application.

Values suggested by Limitorque[4] include

0.90 — Standard
0.80 — 900 RPM motors
0.80 — High temperature applications using "SB"
0.80 — Compound motor gear applications
0.80 — Air motors
0.75 — Modutronic motors
0.75 — Hi-Lo applications
0.70 — Non rising stem where operator takes thrust
0.50 — Non rising stem where valve takes thrust

If two or more application factors are required, (e.g., 900 RPM motor with compound gearing and a Hi-Lo) use as follows:

$$\frac{0.8\ \text{(900 RPM motor)} \times 0.8\ \text{(Comp. Gear)} \times 0.75\ \text{(Hi-Lo)}}{0.9\ \text{(Standard)} \times 0.9\ \text{(Standard)}}$$

If two factors are required, divide by one standard factor.

If three factors are required, divide by two standard factors.

Chapter 5

DATA ENTRY SCREENS

Pull Out Efficiency

The efficiency of the gearing in the operator during pullout[5] (zero speed). Use the appropriate value from the following table.

Unit Size	Ratio Range	1500/1800 RPM motors	3000/3600 RPM motors
SMB–000	12.50 — 30.60	0.60	0.60
	33.50 — 100.00	0.40	0.40
	102.00 — 136.00	0.35	0.35
SMB–00	9.70 — 22.04	0.60	0.65
	23.00 — 41.00	0.40	0.45
	43.60 — 109.99	0.40	0.40
	114.00 — 183.90	0.35	0.35
SMB–0	11.80 — 17.50	0.65	0.65
	18.50 — 26.10	0.60	0.65
	26.42 — 41.33	0.40	0.45
	43.69 — 96.20	0.40	0.40
	102.60 — 150.80	0.35	0.40
	158.30 — 247.00	0.30	0.35
SMB–1	11.60 — 17.12	0.60	0.65
	18.13 — 25.65	0.60	0.65
	27.20 — 40.15	0.40	0.45
	42.50 — 88.40	0.40	0.40
	92.40 — 171.60	0.35	0.35
	191.70 — 234.00	0.30	0.35
SMB–2	10.60 — 17.77	0.60	0.65
	18.85 — 25.55	0.60	0.60
	26.24 — 41.51	0.40	0.45
	43.99 — 82.50	0.40	0.40
	84.84 — 150.00	0.35	0.35
	153.00 — 212.50	0.30	0.35
SMB–3	11.05 — 24.11	0.65	0.70
	25.76 — 37.28	0.60	0.65
	43.87 — 57.40	0.40	0.45
	61.50 — 95.53	0.40	0.40
	98.61 — 132.81	0.38	0.38
	138.40 — 186.40	0.33	0.35

Chapter 5

DATA ENTRY SCREENS

Unit Size	Ratio Range	1500/1800 RPM motors	3000/3600 RPM motors
SMB–4	10.13 — 32.30	0.65	0.70
	33.60 — 48.45	0.60	0.65
	51.79 — 124.95	0.40	0.40
	131.78 — 147.90	0.35	0.38
	152.13 — 219.30	0.33	0.35
SMB–5	61.42 — 96.40	0.40	0.45
	101.12 — 230.17	0.40	0.40

Motor Stall Torque (ft–lb$_f$)

The maximum torque available from the operator motor under nominal voltage stall conditions.

Use the electric motor stall torque specification. If this information is not available, you can estimate the stall torque as 110% of the electric motor rated torque.

Motor Stall Current (amps)

The maximum current the operator motor is likely to use under nominal voltage conditions. This will typically be the stall current at nominal voltage, but may be some other value for a particular application.

For guidance, the following table represents typical stall currents at nominal voltage conditions for operator motors in the Limitorque catalog. If motor-specific information is available, it should be used.

Rated	1700 RPM		3400 RPM		1900 RPM	
Torque	230V	460V	230V	460V	125V	250V
(ft–lb$_f$)	AC–3Φ	AC–3Φ	AC–3Φ	AC–3Φ	DC	DC
2	6	—	10	—	15	—
5	11	—	21/25	—	23	11
7.5	—	—	20	—	32	16
10	24	—	32	—	39	20
15	32	—	52	—	76	38
25	51	—	72	—	82	42
40	76	—	—	73	115	51
60	96	60	—	94	172	105

Rated Torque (ft–lb$_f$)	1700 RPM 230V AC–3Φ	1700 RPM 460V AC–3Φ	3400 RPM 230V AC–3Φ	3400 RPM 460V AC–3Φ	1900 RPM 125V DC	1900 RPM 250V DC
80	—	60	—	116	253	130
100	—	84	—	143	253	146
150	—	130	—	195	—	425
200	—	164	—	332	1050	530
250	—	183	—	391	—	—
300	—	234	—	468	—	—
350	—	280	—	—	—	—
400	—	—	—	629	—	—

Motor Stall Efficiency

An efficiency factor for operator motors during stall conditions.[5] Use the appropriate value from the following table.

Unit Size	Ratio Range	1500/1800 RPM motors	3000/3600 RPM motors
SMB-000	12.50 — 30.60	0.80	0.80
	33.50 — 100.00	0.50	0.55
	102.00 — 136.00	0.45	0.50
SMB-00	9.70 — 22.04	0.80	0.90
	23.00 — 41.00	0.60	0.65
	43.60 — 109.99	0.50	0.60
	114.00 — 183.90	0.45	0.50
SMB-0	11.80 — 17.50	0.85	0.95
	18.50 — 26.10	0.80	0.90
	26.42 — 41.33	0.55	0.60
	43.69 — 96.20	0.50	0.55
	102.60 — 150.80	0.45	0.50
	158.30 — 247.00	0.40	0.45

Unit Size	Ratio Range	1500/1800 RPM motors	3000/3600 RPM motors
SMB–1	11.60 — 17.12	0.85	0.95
	18.13 — 25.65	0.85	0.90
	27.20 — 40.15	0.55	0.60
	42.50 — 88.40	0.50	0.55
	92.40 — 171.60	0.45	0.50
	191.70 — 234.00	0.40	0.45
SMB–2	10.60 — 17.77	0.85	0.95
	18.85 — 25.55	0.85	0.90
	26.24 — 41.51	0.55	0.60
	43.99 — 82.50	0.50	0.55
	84.84 — 150.00	0.45	0.50
	153.00 — 212.50	0.40	0.45
SMB–3	11.05 — 24.11	0.90	0.95
	25.76 — 37.28	0.90	0.95
	43.87 — 57.40	0.55	0.60
	61.50 — 95.53	0.50	0.55
	98.61 — 132.81	0.50	0.50
	138.40 — 186.40	0.45	0.50
SMB–4	10.13 — 32.30	0.90	0.95
	33.60 — 48.45	0.90	0.95
	51.79 — 124.95	0.55	0.60
	131.78 — 147.90	0.50	0.55
	152.13 — 219.30	0.45	0.50
SMB–5	61.42 — 96.40	0.60	0.65
	101.12 — 230.17	0.60	0.65

Cable Description A description of the power cabling from the power source to the operator motor.

Cable Length (ft) The length of the power cable from the power source to the operator motor. Do not enter the length of the return cable.

Chapter 5

DATA ENTRY SCREENS

Cable Size (cir mils) The cross sectional area of the power cabling,[6] expressed either as an AWG (American Wire Gage) size or in circular mils. Entering one of the following AWG sizes will cause the corresponding value to appear in the cross sectional area (cir mils) column. Entering the actual cross sectional area in cir mils will cause the AWG column to go blank. The following information on the diameter of the power cabling is presented to assist in identifying the actual cable.

Gage Number (AWG)	Dia. (mils)	Area (cir mils)
0000	460.0	212,000
000	410.0	168,000
00	365.0	133,000
0	325.0	106,000
1	289.0	83,700
2	258.0	66,400
3	229.0	52,600
4	204.0	41,700
5	182.0	33,100
6	162.0	26,300
7	144.0	20,800
8	128.0	16,500
9	114.0	13,100
10	102.0	10,400
11	91.0	8,230
12	81.0	6,530
13	72.0	5,180
14	64.0	4,110

Chapter 5

DATA ENTRY SCREENS

5.5 Mode 2, Data Screen 2

The first data entry screen in Mode 2 is the same screen as the first screen in Mode 1 (see Section 5.1). The second data entry screen in Mode 2 is used to record specific information relative to a low flow diagnostic test of the MOV, such as the test stem thrust, pressure, differential pressure, packing load, and fluid subcooling.

If the other information called for on this screen (stem diameter, etc.) has not already been entered on Screen 2 of the Mode 1 data base (see Section 5.2), it can be entered here. If it has already been entered in the Mode 1 data base, it need not be entered again here.

```
File:                                              Test Data (Sheet 2 of 2)
Variable Use:

    Stem Diameter (in):
          Seat ID (in):
          Seat OD (in):
    Mean Seat Dia (in):
      Seat Angle (deg):<  >

                                  TEST                DESIGN
              Stem Thrust (lbf):
                Pressure (psig):
 Differential Pressure (psid):
             Packing Load (lbf):
               Fluid Subcooling:<              >  <                >



F1-Help                 F5-Valve Response          PgUp/PgDn-new data sheet
```

Test Stem Thrust (lb_f)

The maximum valve stem thrust measured during a test while the disk was riding on the valve body seat, but prior to wedging of the disk.

Test Pressure (psig)

The maximum pressure measured during a test while the disk was riding on the valve body seat, but prior to wedging of the disk.

Test Differential Pressure (psid)

The maximum differential pressure measured during a test while the disk was riding on the valve body seat, but prior to wedging of the disk.

Chapter 5

DATA ENTRY SCREENS

Test Packing Load (lb_f)

The packing drag measured during a pretest valve closure while the valve was nearly closed, but prior to wedging of the disk.

Test Fluid Subcooling

Fluid subcooling is the difference between the actual temperature of a liquid and the saturation temperature of the liquid at the test pressure.

Available options are

- Less than 70°F subcooled (fluid near or at the steam temperature), or
- 70°F or greater subcooled (colder fluid).

Use the **LEFT–ARROW** and **RIGHT–ARROW** keys to set this value.

The other parameters called for on this screen (stem diameter, etc.) are the same as those discussed in section 5.2 (Mode 1, Data Screen 2).

Chapter 6

ESTIMATED RESPONSE SCREEN

6.1 Mode 1, Results Screen

This screen is used to summarize the results of the design basis calculations. You can access this screen from any Mode 1 data entry screen by pressing **F5**. The upper left corner of the screen summarizes the results of the industry and the INEL estimates of disk load, rejection loads, packing minus weight loads, required stem thrust, required operator torque, and required motor torque. The required stem thrust, operator torque, and motor torque are duplicated in the lower right corner to allow easy comparison with Unit Capabilities.

The available stem thrust, operator torque, and motor torque at stall, nominal, and degraded voltage conditions, calculated considering the effect of voltage losses from the power source to the operator motor, are displayed under the heading "Unit capabilities." If torque switch calibration data was entered on Data Screen 3, then estimated torque switch settings are also displayed.

Mode 1: Capability Assessment

Valve/Operator/Motor Requirements		File:
INEL Estimate	Industry Estimate	
		Disk Load (lbf) μ=0.000, Rejection Loads (lbf) Packing - Weight Loads (lbf) Req'd Stem Thrust (lbf) Req'd Operator Torque (ft-lbf) Req'd Motor Torque (ft-lbf)

Unit Capabilities			Unit Requirements		
Available at Max. Voltage	Available at Nom. Voltage	Available at Min. Voltage	INEL Estimate	Industry Estimate	
					Stem Thrust Operator Torque Motor Torque Voltage Drop Torque Switch

Press any key to continue

Chapter 6

ESTIMATED RESPONSE SCREEN

6.2 Mode 2, Results Screen

This screen is used to summarize the results of the test validation and extrapolation calculations. You can access this screen from either Mode 2 data entry screen by pressing **F5**. The upper part of the screen summarizes an evaluation of the test results and an assessment as to whether the test valve was typical of the valves tested by the INEL. The lower part of the screen summarizes the results of design basis calculations using the INEL equation, assuming the test valve will be typical of the valves tested by the INEL.

```
+----------------+---- Mode 2: Validate & Extrapolate ------------+
| INEL Estimated | File:                                           |
| Valve Response |                                                 |
+----------------+                                                 |
|                | Test Condition Estimates:                       |
|                |    Stem Thrust (lbs)         Subcooling:        |
|                |    Packing - Weight Loads (lbs)                 |
|                |    Rejection Loads (lbs)                        |
|                |    Total Vertical Disk Loads (lbs)              |
|                |    Total Horizontal Disk Loads (lbs)            |
|                |                                                 |
|                |    Normalized Normal Disk Force (lbs)           |
|                |    Normalized Sliding Disk Force (lbs)          |
|                |    Sliding Disk Force Within Limits of INEL Data|
|                |         (        ) to (        )                |
+----------------+                                                 |
|                | Design Basis Estimates:                         |
|                |    Disk Load (lbs)           Subcooling:        |
|                |    Rejection Loads (lbs)                        |
|                |    Packing - Weight Loads (lbs)                 |
|                |    Req'd Stem Thrust (lbf)                      |
|                |                                                 |
+------ Press any key to continue ---------------------------------+
```

Chapter 7

MOV EQUATIONS

The following equations are used in IVA and are presented here as they appear on the various help screens.

Required Capability

(Equation 1 of 17)

RS.Thr = estimated using either the:

- Industry stem thrust equation
- INEL stem thrust equation.

RO.Tor = RS.Thr * SF

$$RM.Tor = \frac{RO.tor}{PO * AF * OAR}$$

where,

RS.Thr = Required Stem Thrust (lb_f)

RO.Tor = Required Operator Torque[1] (ft–lbf)

RM.Tor = Required Motor Torque[1] (ft–lbf)

and,

SF = Stem Factor

PO = Pull Out Efficiency

AF = Application Factor

OAR = Overall Operator Ratio

Chapter 7

MOV EQUATIONS

Available Capability at Rated Voltage

(Equation 2 of 17)

$$\text{Nom M.Tor} = \text{Motor Rated Torque} * \left[\frac{\text{NomV} - \text{VDrop}}{\text{RatedV}}\right]^{\text{Power}}$$

$$\text{Nom O.Tor} = \text{Nom M.Tor} * \text{PO} * \text{AF} * \text{OAR}$$

$$\text{Nom S.Thr} = \frac{\text{Nom O.Tor}}{\text{SF}}$$

where,

Nom M.Tor = Nominal Available Motor Torque[1] (ft–lbf)

Nom O.Tor = Nominal Available Operator Torque[1] (ft–lbf)

Nom S.Thr = Nominal Available Stem Thrust[1] (lbf)

and,

SF = Stem Factor

PO = Pullout Efficiency

AF = Application Factor

OAR = Overall Operator Ratio

NomV = Nominal Supply Voltage (volts)

VDrop = Cable Voltage Loss (volts)

RatedV = Motor Rated Voltage (volts)

Power = 1 for DC, 2 for AC

Chapter 7

MOV EQUATIONS

Available Capability at Minimum Voltage

(Equation 3 of 17)

$$\text{Min M.Tor} = \text{Motor Rated Torque} * \left[\frac{\text{MinV} - \text{VDrop}}{\text{RatedV}}\right]^{\text{Power}}$$

$$\text{Min O.Tor} = \text{Min M.Tor} * \text{PO} * \text{AF} * \text{OAR}$$

$$\text{Min S.Thr} = \frac{\text{Min O.Tor}}{\text{SF}}$$

where,

Min M.Tor	=	Minimum Available Motor Torque[1] (ft–lbf)
Min O.Tor	=	Minimum Available Operator Torque[1] (ft–lbf)
Min S.Thr	=	Minimum Available Stem Thrust[1] (lbf)

and,

SF	=	Stem Factor
PO	=	Pullout Efficiency
AF	=	Application Factor
OAR	=	Overall Operator Ratio
MinV	=	Minimum Supply Voltage (volts)
VDrop	=	Cable Voltage Loss (volts)
RatedV	=	Motor Rated Voltage (volts)
Power	=	1 for DC, 2 for AC

Chapter 7

MOV EQUATIONS

Available Capability at Maximum Voltage

(Equation 4 of 17)

$$\text{Max M.Tor} = \text{Motor Stall Torque} * \left[\frac{\text{MaxV} - \text{VDrop}}{\text{RatedV}} \right]^{\text{Power}}$$

$$\text{Max O.Tor} = \text{Max M.Tor} * \text{SE} * \text{OAR}$$

$$\text{Max S.Thr} = \frac{\text{Max O.Tor}}{\text{SF}}$$

where,

Max M.Tor	=	Maximum Available Motor Stall Torque[1] (ft–lbf)
Max O.Tor	=	Maximum Available Operator Torque[7] (ft–lbf)
Max S.Thr	=	Maximum Available Stem Thrust[1] (lbf)

and,

SF	=	Stem Factor
SE	=	Stall Efficiency
OAR	=	Overall Operator Ratio
MaxV	=	Maximum Supply Voltage (volts)
VDrop	=	Cable Voltage Loss (volts)
RatedV	=	Motor Rated Voltage (volts)
Power	=	1 for DC, 2 for AC

Chapter 7

MOV EQUATIONS

Cable Voltage Loss Calculation

(Equation 5 of 17)

$$\mathrm{VDrop} = \Sigma \frac{\mathrm{C2} * \mathrm{Ohms} * \mathrm{Length} * \mathrm{Amps}}{\mathrm{Mils}}$$

where,

VDrop = Cable Voltage Loss[6] (volts)

and,

Ohms = Cable Resistance (ohms-circular mils/ft)

Length = Cable Length (ft)

Mils = Cable Size (circular mils)

Amps = Voltage Adjusted Motor Stall Current (amps)

C2 = 2 for DC and AC–1Φ, √3 for AC–3Φ

Chapter 7

MOV EQUATIONS

Voltage Adjusted Motor Stall Current

(Equation 6 of 17)

$$Min.Amps = R.Amps \frac{MinS.Volt}{R.Volt}$$

$$Nom.Amps = R.Amps \frac{NomS.Volt}{R.Volt}$$

$$Max.Amps = R.Amps \frac{MaxS.Volt}{R.Volt}$$

where,

Min.Amps	=	Motor Current at Minimum Voltage (amps)
Nom.Amps	=	Motor Current at Nominal Voltage (amps)
Max.Amps	=	Motor Current at Maximum Voltage (amps)

and,

R.Amps	=	Stall Current at Rated Voltage (amps)
R.Volt	=	Motor Rated Voltage (volts)
MinS.Volt	=	Minimum Power Source Voltage (volts)
NomS.Volt	=	Nominal Power Source Voltage (volts)
MaxS.Volt	=	Maximum Power Source Voltage (volts)

Chapter 7

MOV EQUATIONS

Cable Resistance (Copper)

(Equation 7 of 17)

$$\text{Ohms} = 10.371 * \left[1 + \frac{\text{Temp} - 20}{234.5 + \text{Temp}} \right]$$

where,

Ohms = Cable Resistance[6] (ohms-circular mils/ft)

and,

Temp = Cable Temperature (°C–Note that this value is input on the data entry screen as °F but used in this equation as °C)

Chapter 7

MOV EQUATIONS

Industry Gate Valve Stem Thrust Equation

(Equation 8 of 17)

RS.Thr = F.disk $\pm$ F.rejection + F.packing
(+ for closure)

where,

RS.Thr	=	Required Stem Thrust[1] (lbf)

and,

F.disk	=	Disk Factor * Orifice Area * DP (lbf)
F.rejection	=	Upstream Pressure * Stem Area (lbf)
F.Packing	=	Packing Drag (lbf)
DP	=	The maximum pressure drop across the valve (psid)
Orifice Area	=	$1/4\ \pi$ (Orifice Dia)^2 (inch^2)
Stem Area	=	$1/4\ \pi$ (Stem Dia)^2 (inch^2)

Chapter 7

MOV EQUATIONS

INEL Gate Valve Stem Thrust Equation

(Equation 9 of 17)

RS.Thr = F.disk + F.rejection + F.packing

where,

RS.Thr = Required Stem Thrust[8] (lbf)

and,

$$F.disk = \frac{[f * \cos\alpha + \sin\alpha]\ F.H + [C * \text{Seat Area}]}{\cos\alpha - f * \sin\alpha} \text{(lbf)}$$

F.rejection	=	F.stem_rej–F.top + F.bottom (lbf)
F.packing	=	packing drag–disk and stem weight (lbf)
F.up	=	Upstream Pressure * Seat Area (lbf)
F.down	=	Downstream Pressure * Seat Area (lbf)
F.top	=	Upstream Pressure * Seat Area * tan α (lbf)
F.bottom	=	Downstream Pressure * Seat Area * tan α (lbf)
F.stem_rej	=	Upstream Pressure * Stem Area (lbf)
F.H	=	F.up–F.down
Seat Dia	=	1/2 (Seat ID + Seat OD) (inch)
Seat Area	=	1/4 π (Seat Dia)^2 (inch^2)
Stem Area	=	1/4 π (Stem Dia)^2 (inch^2)
f	=	0.400 for less than 70°F subcooled water 0.500 for 70°F or greater subcooled water
C	=	0 lb_f/in^2 for a best estimate calculation 50 lb_f/in^2 for a conservative calculation

Chapter 7

MOV EQUATIONS

Stem Factor Calculation

(Equation 10 of 17)

$$SF = \frac{d * [0.96815 * \tan \beta + \mu]}{24 * [0.96815 - \mu * \tan \beta]}$$

where,

SF = Stem factor[9]

and,

μ = Stem to stem nut coefficient of friction

d = Stem diameter– 1/2 Pitch (inch)

Lead = Stem Lead (inch/stem revolution)

$$\tan \beta = \frac{Lead}{\pi * d}$$

Chapter 7

MOV EQUATIONS

Stem To Stem Nut Coefficient of Friction Calculation

(Equation 11 of 17)

$$\mu = \frac{0.96815\ [24 * SF - d * \tan \beta]}{d + 24 * SF * \tan \beta}$$

where,

μ = Stem to stem nut coefficient of friction[9]

and,

SF = Stem factor

d = Stem diameter– Pitch (inch)

Lead = Stem Lead (inch/stem revolution)

$$\tan \beta = \frac{\text{Lead}}{\pi * d}$$

Chapter 7

MOV EQUATIONS

Overall Operator Ratio Calculation

(Equation 12 of 17)

$$OAR = \frac{Motor\ Speed * Lead}{Stem\ Speed}$$

where,

OAR	=	Overall Operator Ratio[1]

and,

Motor Speed	=	Rated Motor Speed (RPM)
Lead	=	Stem Lead (inch/stem revolution)
Stem Speed	=	MOV stem speed (inch/min)

Chapter 7

MOV EQUATIONS

Motor Rated Speed Calculation

(Equation 13 of 17)

$$\text{Motor Speed} = \frac{\text{OAR} * \text{Stem Speed}}{\text{Lead}}$$

where,

Motor Speed	=	Motor Rated Speed[1] (RPM)

and,

OAR	=	Overall Operator Ratio
Lead	=	Stem Lead (inch/stem revolution)
Stem Speed	=	MOV stem speed (inch/min)

7. MOV EQUATIONS

Chapter 7

MOV EQUATIONS

Valve Stroke Time

(Equation 14 of 17)

$$\text{Time} = \frac{\text{Length} \ * \ 60}{\text{Stem Speed}}$$

where,

Time	=	Valve Stroke Time[7] (sec)

and,

Length	=	Valve Stroke Length (inch)
Stem Speed	=	MOV Stem Speed (inch/min)

Chapter 7

MOV EQUATIONS

Sliding Force Limits

(Equation 15 of 17)

Is $(f * Fn - C) \leq Fs \leq (f * Fn + C)$?

where,

Fs	=	Normalized Sliding Force[8] (lbf)

and,

Fn	=	Normalized Normal Force[8] (lbf)
f	=	0.400 for less than 70°F subcooled water 0.500 for 70°F or greater subcooled water
C	=	50 lbf/in^2

Chapter 7

MOV EQUATIONS

Normalized Forces

(Equation 16 of 17)

$$Fn = \frac{H * \cos \alpha + V * \sin \alpha}{\text{Seat Area}}$$

$$Fs = \frac{H * \sin \alpha - V * \cos \alpha}{\text{Seat Area}}$$

where,

Fn	=	Normalized Normal Force[8] (lbf)
Fs	=	Normalized Sliding Force[8] (lbf)

and,

H	=	Total Horizontal Disk Forces (lbf)
V	=	Total Vertical Disk Forces (lbf)
α	=	Valve Seat Angle (degrees)
Seat Area	=	$1/4\ \pi\ (\text{Seat Dia})^2\ (\text{inch}^2)$

Chapter 7

MOV EQUATIONS

Total Disk Loads

(Equation 17 of 17)

H = F.up–F.down

V = F.stem–F.pack–F.stem_rej + F.top–F.bottom

where,

H	=	Total Horizontal Disk Load[8] (lbf)
V	=	Total Vertical Disk Load[8] (lbf)

and,

F.up	=	Upstream Pressure * Seat Area (lbf)
F.down	=	Downstream Pressure * Seat Area (lbf)
F.stem	=	Stem Thrust (lbf)
F.pack	=	Packing Drag (lbf)
F.stem_rej	=	Upstream Pressure * Stem Area (lbf)
F.top	=	Upstream Pressure * Seat Area * tan α (lbf)
F.bottom	=	Downstream Pressure * Seat Area * tan α (lbf)
Seat Dia	=	1/2 (Seat ID + Seat OD) (inch)
Seat Area	=	1/4 π (Seat Dia)^2 (inch^2)
Stem Area	=	1/4 π (Stem Dia)^2 (inch^2)

Chapter 8

LIMITORQUE OPERATOR RATINGS[10]

Model–Size	Ratio Range	Operator Rated Torque (ft–lb$_f$)	Operator Rated Thrust (lb$_f$)	Max. Threaded Stem Diameter 2 piece nut (inch)	Max. Threaded Stem Diameter 1 piece nut (inch)
SMB–000	12.5 — 30.6	90	8,000	1 3/8	1 1/2
	33.5 — 100.0	90			
	102.0 — 136.0	90			
SMB–00	9.7 — 22.0	250	14,000	1 3/4	2
	23.0 — 109.0	250			
	114.0 — 183.9	190			
SMB–0	11.8 — 26.1	500	24,000	2 3/8	2 3/4
	26.4 — 96.2	500			
	102.6 — 150.8	500			
	158.3 — 247.0	340			
SMB–1	11.6 — 25.7	850	45,000	2 7/8	3 1/4
	27.2 — 88.4	850			
	92.4 — 171.6	780			
	191.7 — 234.0	625			
SMB–2	10.6 — 25.6	1,800	70,000	3 1/2	3 7/8
	26.2 — 82.5	1,800			
	84.8 — 150.0	1,250			
	153.0 — 212.5	950			
SMB–3	11.0 — 24.1	3,700	140,000	5	5 3/4
	25.8 — 34.6	3,700			
	35.9 — 95.5	4,200			
	98.6 — 132.8	3,300			
	138.4 — 186.4	2,800			
SMB–4	10.1 — 32.3	7,500	250,000	5	6 3/4
	33.6 — 48.4	7,500			
	51.8 — 125.0	7,500			
	131.9 — 147.9	5,100			
	152.1 — 219.3	3,900			
SMB–5	59.3 — 96.4	20,000	500,000	6 1/4	8
	103.9 — 229.9	20,000			

Chapter 9

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7. Limitorque Outline of Sizing Procedure

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9. Limitorque 900–00003 and 900–00004, dated March 1988.

10. Limitorque Selection Procedure SEL–9, dated June 2, 1975.