7.3 SOFTWARE TOOLS

We have developed two software packages that are useful in helping the analyst evaluate a motor-operated valve's operability. This chapter first discusses IVA (Isolation Valve Assessment), then MISTA (MOV In Situ Test Assessment). The IVA software is currently available to the public; however, MISTA is not publicly available, because it contains proprietary information from the diagnostic vendors.

IVA software. The IVA software is a package of tools for:

- Evaluating the capability of motor-operated gate and globe valves (powered by Limitorque actuators) to close or open against specified loads
- Analyzing the results of either a no-load seating test (closing with no flow or pressure) or a dynamic closing or opening test (with flow and differential pressure).

The IVA software consists of two modes: the *Capability Assessment Mode* and the *Test Data Assessment Mode*. Each mode provides the user an opportunity to input data and presents a *results screen* that summarizes and displays the results of various calculations. Several analysis tools and graphical outputs are included.

The *Capability Assessment Mode* estimates the design basis stem thrust and assesses the capability of the equipment to operate against the load, considering the torque switch setting, the output of the electric motor, and other parameters. The analyst provides input values for pressure, disc friction, stem friction, rated motor torque, motor voltage, motor temperature, and other parameters, and IVA performs the calculation and displays the results. IVA makes it easy for the analyst to perform various *What if?* calculations.

The r*esults screen* in the Capability Assessment Mode summarizes the results of the design basis calculations (see Figure 7-7). You can access this screen from any data entry screen in the *Capability Assessment Mode*. The results screen displays motor torque, actuator torque, and stem thrust capabilities of the actuator, for comparison with calculations of required values. For these comparisons, estimated values for required stem thrust, required actuator torque, and required motor torque using both the INEEL correlation (gate valve only) and the industry equation are displayed.

The screen is divided into two parts, the Capabilities part and the Requirements part.

The Capabilities part of the screen summarizes

- The available stem thrust, actuator torque, and motor torque at maximum, nominal, and minimum voltage conditions
- Effects of voltage losses from the power source to the actuator motor
- An estimated maximum torque switch setting, if torque switch calibration data were entered.

```
Capability Assessment Mode
File:

| CAPABILITIES                          | REQUIREMENTS                | Current Operator Settings
|                                       |                             |   Torque Switch:
| Available | Available | Available | INEL | Industry |                |   Output Torque:
| at Max.   | at Nom.   | at Min.   | Estimate | Estimate |                |   Output Thrust:
| Voltage   | Voltage   | Voltage   | f=   | μ=       |
|           |           |           |      |          | Stem Thrust
|           |           |           |      |          |    Margin
|           |           |           |      |          |    Percent Margin
|           |           |           |      |          | Operator Torque
|           |           |           |      |          |    Margin
|           |           |           |      |          |    Percent Margin
|           |           |           |      |          | Motor Torque
|           |           |           |      |          | Voltage @ MOV
|           |           |           |      |          | Source Voltage
|           | Reference | Maximum   | Minimum | Minimum |
|                                                     | Torque Switch Setting
Press any key to continue
```

Figure 7-7 IVA results screen, Capability Assessment Mode

For gate valves, the Requirements part of the screen displays two sets of requirements estimates, one based on the INEEL correlation, and the other based on the standard industry equation. For globe valves, the Requirements part of the screen displays requirements estimates based on he standard industry equation for globe valves. The estimates displayed are

- The required stem thrust, actuator torque, and motor torque
- The estimated minimum torque switch settings, if torque switch calibration data were entered.

The *capabilities* assessment at nominal voltage begins with the source voltage (usually the voltage at the motor control center) and estimates the voltage at the motor terminals using the cable size and length, temperature, and thermal overload and/or starting resistances.

Once the motor terminal voltage has been specified, IVA estimates the motor torque one of two ways. If you specified the 10% null voltage motor assessment method, the motor torque will be based on the motor terminal voltage relative to the motor rated voltage (percent voltage squared for ac power) times the motor rated or motor stall torque and the application factor, provided the motor terminal voltage is not within 10% of the motor rated voltage. If the motor terminal voltage is within 10% of the motor rated voltage, the motor torque will be based on the application factor times the motor rated or motor stall torque. If you

specified the full voltage range motor assessment method, the motor torque will be based on the motor terminal voltage relative to the motor rated voltage (squared for ac power) times the motor rated or motor stall torque and the application factor.

IVA estimates the available actuator torque from the motor torque, the overall gear ratio of the actuator gearbox, and the gearbox efficiency. IVA then uses either the stem friction and stem characteristics data or the stem factor (input by you) to convert this actuator torque to stem thrust. IVA uses a linear curve fit of the spring pack calibration data to estimate a torque switch setting that corresponds with the estimated available actuator torque. Using this process, IVA produces two estimates of the torque switch setting, based on available torque: one for nominal voltage conditions and one for minimum voltage conditions. However, IVA considers the torque switch setting at minimum voltage to be a maximum setting, because if the torque switch is set higher, it is possible that the motor will be unable to develop sufficient torque to trip the torque switch, in which case the motor would stall and likely burn out.

The *requirements* assessment first estimates the stem thrust required by the valve to perform its design basis function. For globe valves, this estimate is based on the standard industry equation. For gate valves, IVA calculates two estimates, one based on the standard industry equation, and one based on the INEEL correlation. Using the estimate of the required stem thrust along with the stem factor, IVA then estimates the required actuator torque. The margin and percent margin consist of the difference between the available actuator torque at degraded voltage conditions and the actuator torque required at design basis loads.

IVA determines the appropriate torque switch setting from the required actuator torque. IVA considers the estimate of the required actuator torque to be a minimum, because a lower torque switch setting will cause the torque switch to trip before the actuator produces enough torque to develop the corresponding thrust necessary to isolate flow and completely close the valve at design basis conditions. IVA also estimates the required motor torque according to the method selected earlier by you. If any of the required actuator torque or thrust requirements exceed the limits of the unit, or if the resultant margin is less than zero, IVA prints such results on the screen in a nonstandard color to draw your attention to them.

IVA also can display various mode-specific graphs. The Capability Assessment Mode can display the following seven graphs, subject to user input:

- The required stem thrust versus available stem thrust as a function of stem factor for nominal and degraded voltage conditions (functional margin).
- The required stem thrust versus available stem thrust as a function of stem friction for nominal and degraded voltage conditions (functional margin).
- The required actuator torque versus available actuator torque as a function of stem factor for nominal and degraded voltage conditions (functional margin).
- The required actuator torque versus available actuator torque as a function of stem friction for nominal and degraded voltage conditions (functional margin).

- The conversion of actuator torque to stem thrust based on several different values for the stem friction.
- The relationship of stem thrust to torque switch setting based on several different values for the stem friction.
- The torque switch calibration data and the linear fit of the data.

The *Test Data Assessment Mode* assesses the results of an in-plant or laboratory test. The analyst provides input values for test parameters, the valve hardware features and dimensions, and the measured stem thrust and actuator torque (or stem torque), and IVA performs the calculations for the disc friction, stem friction, and other parameters.

The *results screen* in the Test Data Assessment Mode summarizes the results of calculations IVA performs using test data you have input. You can access this screen from any data entry screen in the Test Data Assessment Mode. The results screen displays an assessment of a dynamic closing or opening valve test (with flow and differential pressure) or a no-load seating test (no flow or pressure). The results of a dynamic test determine the applicability of the INEEL correlations (and associated disc friction values) for estimating the design basis requirements of a valve. Those results also provide data for using the INEEL Threshold Method to estimate design basis stem friction parameters. The results of a seating test provide data for using the INEEL Fold Line Method to estimate design basis stem friction parameters.

In the Test Data Assessment Mode, one of four different screens will appear, depending on your input on the data entry screens:

- Two screen for a gate valve (one for closing and one for opening)
- Two screens for a globe valve (one for closing and one for opening).

The gate valve closing test data screen and parameters are included here for illustration purposes (Figure 7-8). The other three screens are similar.

During the evaluation of a dynamic test (with flow and differential pressure) closing or opening a gate valve, IVA uses the test results you have input to determine whether the valve is typical of valves tested by the INEEL. (This confirms that the INEEL correlation is applicable). For either a gate valve or a globe valve, IVA also uses the results to estimate the design basis stem friction and the corresponding stem factor using the INEEL Threshold Method. In the evaluation of the seating test for either a gate valve or a globe valve, IVA uses the results to estimate the design basis stem friction and the corresponding stem factor using the INEEL Fold Line Method.

During the evaluation of a set of test results, IVA calculates an estimate of the gate valve's response to the test conditions, including the following parameters:

- INEEL friction factor - based on the INEEL correlation.
- Disc factor - based on the standard industry equation.

```
Test Data Assessment Mode - Estimated Response

ESTIMATED GATE VALVE RESPONSE DURING A CLOSING TEST:
   Total horizontal disc load
   Total vertical disc load
   Normalized normal disc force
   Normalized sliding disc force: (      0.) to (      0.)

   INEL friction factor
   Disc factor
   Hooking factor

THRESHOLD METHOD | FOLD LINE METHOD | ESTIMATED DESIGN BASIS STEM/STEM-NUT RESPONSE BASED
                                     ON A SINGLE CLOSING TEST:
                                        Minimum correlation thread pressure
                                        Minimum test thread pressure

                                        Stem/stem-nut coefficient of friction
                                        Stem factor

                                     ESTIMATED DESIGN BASIS STEM/STEM-NUT RESPONSE BASED
                                     ON ALL CLOSING TESTS:
                                        Stem/stem-nut coefficient of friction
                                        Stem factor

Press any key to return
```

Figure 7-8 IVA results screen, Test Data Assessment Mode

- Hooking factor - based on the INEEL hooking equation for those gate valves that exhibit hooking in the stem thrust during closing and do not exhibit other nonpredictable characteristics, such as disc-to-guide damage or disc-to-seat damage.
- Minimum correlation thread pressure - the minimum thread pressure required to demonstrate applicability of the stem/stem-nut response using either the INEEL Threshold Method or the INEEL Fold Line Method.
- Minimum thread pressure - an estimate of the stem thrust transmitted between the stem and the stem-nut by a nominal area based on one stem-thread revolution for either the INEEL Threshold Method or the INEEL Fold Line Method. Use of this nominal thread area is consistent with standard practices in thread stress calculations.
- Stem friction (stem/stem-nut coefficient of friction) - based on the stem thrust, actuator torque, stem diameter at the stem-nut, and stem pitch and lead, for use in conjunction with either the INEEL Threshold Method or the INEEL Fold Line Method.
- Stem factor - based on the actuator torque and the stem thrust, for use in conjunction with either the INEEL Threshold Method or the INEEL Fold Line Method.
- Design basis stem friction

(stem/stem-nut coefficient of friction) - based on all the stem thrust and actuator torque test data in the program's database for either the INEEL Threshold Method or the INEEL Fold Line Method.

- Design basis stem factor - based on all the stem thrust and actuator torque test data in the programs, database for either the INEEL Threshold Method or the INEEL Fold Line Method.

To perform these calculations, IVA first estimates the net horizontal and net vertical loads acting on the disc. Next, IVA transforms these loads into normalized normal loads and normalized sliding loads by accounting for the seat angle of the valve and the size of the disc. IVA displays the result of that calculation on the left side of the results data screen; the normalized sliding load limits of the INEEL correlation are displayed on the right.

- If the results *do not* fall within the limits of the INEEL correlation, the INEEL correlation might not be applicable to that valve. IVA prints such results on the screen in a nonstandard color to draw your attention to them.
- If the results *do* fall within the limits of the INEEL correlation, you can assume that the response of the test valve is similar to the response of the valves tested by the INEEL and used to develop the correlation. This is the criterion that determines that the INEEL correlation is applicable to the test valve. This evidence of similarity provides confidence that your use of the INEEL correlation to estimate the design basis response of the valve will provide results that are conservative and reasonably accurate. You can perform that calculation in IVA's Capability Assessment Mode.

When assessing the response of globe valve testing, only the disc factor used in the industry equation is estimated. For either type of valve, both the test-specific conversion of actuator torque to stem thrust is estimated, along with an estimate of the design basis conversion, depending on the extent of input data, using either the INEEL Threshold Method or the INEEL Fold Line Method.

The Test Data Assessment Mode can display selected graphics, depending on the type of valve selected, the type of test performed, and extent of user input:

- An assessment of a single dynamic closing or opening gate valve test in comparison with the results of gate valve testing by the INEEL.
- An assessment of multiple high-subcooling, dynamic-closing gate valve tests in comparison with the results of high-subcooling gate valve testing by the INEEL.

- An assessment of multiple low-subcooling, dynamic-closing gate valve tests in comparison with the results of low-subcooling gate valve testing by the INEEL.
- An assessment of the stem factor versus stem-thread pressure results from one or more dynamic tests, evaluated against the INEEL Threshold Method.
- An assessment of the stem friction versus stem-thread pressure results from one or more dynamic tests, evaluated against the INEEL Threshold Method.
- An assessment of the stem factor versus stem-thread pressure from on or more seating tests, evaluated against the INEEL Fold Line Method.
- An assessment of the stem friction versus stem-thread pressure from one or more seating tests, evaluated against the INEEL Fold Line Method.

MISTA software. The MOV In Situ Test Assessment (MISTA) software is a package of tools for reviewing the results of in situ test data to assess pertinent motor-operated valve response parameters, such as the design-basis disc-to-seat coefficient of friction (or disc factor), stem/stem-nut coefficient of friction, and the design-basis stem factor. The MISTA software package includes a feature for assessing the response of a Limitorque dc-powered motor-operated gate valve and determining whether it will slow down excessively under design-basis conditions, such as to fail to achieve either flow isolation and/or the required stroke time.

To ensure MOV operability under design-basis conditions, the U.S. NRC has requested the capability to independently evaluate in situ diagnostic test data. In situ test data, however, are subject to individual interpretation, and many of the calculations necessary to evaluate the response of a motor-operated valve are not performed by the various diagnostic test systems. To compound the issue, the in situ test data are difficult (if not impossible) to use outside the diagnostic test system environment, because of the proprietary data formats. Even if the data were available, large volumes of information need to be processed, and many of the calculations necessary to arrive at design-basis performance estimates rely on assessment methodologies that are difficult for either utility personnel or U.S. NRC inspectors to implement.

Fortunately, this test assessment capability can be achieved by cross-linking proprietary diagnostic test system software and a commercial graphical analysis software package with software developed at the INEEL. Two of the largest diagnostic test system manufacturers, Liberty Technologies and ITI MOVATS, have agreed to cooperate by providing either the software or the information to translate their proprietary data formats to a more universal format that can be recognized by the data analysis and display software (DADiSP). The data from the other diagnostic vendors are already in a format that is recognized by DADiSP.

The integrated software, called MISTA, is a complete in situ diagnostic test assessment program capable of independently evaluating the response of a gate or globe valve during in situ testing using methodologies available to the industry, including those developed at the INEEL. MISTA functions as an interface between DADiSP (which performs calculations and contains mathematical routines and custom macros), the VOTES, MOVATS 3000, MOVATS 3500, and MOVATS UDS software (which collects real-time data from operating valves in the field), and the Isolation Valve Assessment (IVA) software (which may contain previously entered MOV characteristic data). It brings the IVA characteristic data into the appropriate MISTA submenus, loads the previously collected MOVATS or VOTES data into DADiSP, and performs calculations from predefined routines selected from the MISTA menu. If characteristic data are entered manually, these data may be saved through MISTA for later use.

The software results can be viewed on-screen, and selected data can be printed in hardcopy. Menu-driven data input and assessment information is also included. MISTA software consists of two modes: the *MOV Test Assessment Mode* and the *DC Motor Assessment Mode*.

The *MOV Test Assessment Mode* assesses diagnostic test data to estimate MOV response parameters needed to determine design-basis thrust requirements. To support these assessments, the program performs the following types of calculations:

- An estimate of the closing disc factor of a gate valve or globe valve, calculated using in situ test data as input to standard industry equations.
- An estimate of the closing or opening disc-to-seat coefficient of friction, normalized normal load, or the normalized sliding load of a gate valve, calculated using in situ test data as input to methodologies developed at the INEEL.
- An estimate of the closing hooking factor of a gate valve, calculated using in situ test data as input to methodologies developed at the INEEL.
- An estimate of the closing or opening stem/stem-nut coefficient of friction, the stem factor, or the stem thread pressure of a gate or globe valve, using in situ test data as input to methodologies developed at the INEEL.
- An estimate of the closing or opening actuator torque of a gate or globe valve, using in situ test data along with measurements of either the spring pack displacement or the spring pack force.

The available test assessments for the MOV Test Assessment Mode are:

- Industry equation disc factor (for close and open directions)
- Friction factor (for close and open directions)
- Normalized normal force (for close and open directions)
- Normalized sliding force (for close and open directions)
- Hooking factor
- Stem/stem-nut coefficient of friction
- Stem factor
- Stem thread pressure

- Stem speed based on motor speed
- Actuator torque from spring pack displacement
- Actuator torque from spring pack force
- Spring pack force from spring pack displacement
- Motor speed from stem speed.

The *DC Motor Assessment Mode* assesses the ability of a dc MOV to achieve flow isolation and to meet its stroke time requirements when called upon to function under design-basis loads and degraded voltage conditions. Among other functions, it uses in situ test data to calculate (a) the closing or opening stem speed from the electric motor speed or (b) the closing or opening electric motor speed from the stem speed.

The available test assessments for the DC Motor Assessment Mode are:

- Motor performance curves versus motor torque
- Disc position versus stem position
- System upstream, valve differential, and downstream pressure versus stem position
- Normalized upstream and valve differential pressure versus stem position
- Motor speed and motor current versus motor torque
- Disc area versus stem position
- Calculated or input valve thrust versus stem position
- Actuator torque versus stem position
- Motor torque versus stem position
- Time versus stem position
- Stem speed and motor speed versus stem position
- Motor current and motor voltage versus stem position
- Stem position versus time
- Stem speed and motor speed versus time
- Motor current and motor voltage versus time.