MOVATS® USERS TECHNICAL NOTICE 88-01

August 1988

SUBJECT: DIFFERENTIAL PRESSURE THRUST CALCULATIONS

DISCUSSION:

Recently, MOVATS Incorporated learned that at least two utilities were still using the original MOVATS® equations published in Union Electric Company's IEB 85-03 response to calculate the thrust required to overcome differential pressure for motor-operated valves (MOV's). A letter indicating that these equations could no longer be supported by our data base was mailed on January 19, 1988. In some cases, the equations generate thrust values that are overly conservative, and in other cases the equations were based on less than 20 data points (as stated in the Union Electric IEB 85-03 response) and are not conservative based on the current data base. Our present statistical method for performing thrust calculations was adopted to more accurately reflect the continual addition of new data.

MOVATS Incorporated began compiling results from field tests of MOVs under differential pressure (DP) conditions in 1986 and subsequently began using the data to calculate DP thrust requirements for valves. Since that time, the data base has changed in many ways. New data is continually being added, a Quality Assurance program has been implemented, an improved statistical methodology adopted, and the way the data is grouped has changed for some valve types. Due to these changes, the calculated DP thrust requirements have also changed. When MOVATS Incorporated performs calculations, they are based on the data base as of the date the calculations are performed. Even though this is stated in E.R.-1.0, "MOVATS Incorporated Differential Pressure Thrust Calculation Methodology", which is sent with each calculation performed, we felt there may be a need to emphasize this point.

MOVATS Incorporated uses the DP test data base to statistically predict DP thrust requirements for a valve. This is done using data points for valves of the same type from the data base. Linear regression is performed on the data points to find the equation for the "best-fit" line through the data. After a thrust value is predicted for the valve using the "best-fit" equation, a 90% confidence band, or tolerance, is added to the predicted thrust to obtain the calculated thrust required by the valve to overcome differential pressure.

For some valve types, the statistically calculated DP thrust requirements have not changed significantly with changes to the data base. For other valve types, such as globe valves, the thrust values have increased because the data was split to account for differences caused by direction of flow through the valve. This type of data base refinement is expected to continue as we identify outlying classes of valves or applications. The MOVATS Incorporated Users Group is expected to provide advice on managing changes to the data base.

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It should be noted that the need for a data base to help predict DP thrust requirements was identified by MOVATS Incorporated when it became apparent that standard equations used for calculating thrust generally are not conservative. We feel that the statistical approach to determining thrust requirements is providing the industry with data tnat is more reliable than any other available source. The changes to the data base and the calculational methodology over the last two years are a direct result of our efforts to strengthen the data base. We intend to continue our efforts to provide the best calculations possible.

RECOMMENDATIONS:

If you have any questions on our data base, or on past calculations provided to you, please contact our Engineering Department.

PLANNED ACTION:

The MOVATS Incorporated Users Group Subcommittee on Thrust Calculations will be reviewing our data base methodology and offering suggestions for improvement, as well as studying new ways to group the test data.

MOVATS® USERS TECHNICAL NOTICE 88-02

August 1988

SUBJECT: SPRING PACK RESPONSE TO STEM LOADS

DISCUSSION:

This notice has been developed to address several issues related to using actuator spring pack compression as an indicator of motor-operated valve stem thrust. The MOVATS® Thrust Measuring Device (TMD) uses a linear variable differential transformer (LVDT) to very accurately measure spring pack compression as a motor-operated valve is stroked. While the issues have been focused on the performance of the TMD, they actually reflect directly on the response of the spring pack. Since the torque switch is controlled by spring pack movement, its performance is also affected.

Using the TMD to monitor spring pack compression identifies a number of degradations that cannot be found with any other type of test equipment. In fact, there is no single device that can monitor all the parameters that impact motor-operated valve performance. MOVATS Incorporated's efforts have focused on developing a combination of devices that can be used to diagnose valve/actuator problems.

Measuring Loads Below Preload:

Preload is defined as the amount of stem thrust required to start spring pack movement. Preload exists because the spring pack is permanently compressed a fixed amount during actuator assembly. Because of this, spring pack compression cannot be used to measure that portion of stem load that is less than preload. Therefore, spring pack compression must be supplemented with other methods in order to measure total stem thrust. MOVATS Incorporated uses spring pack compression calibrated to a load cell to measure stem thrust above actuator running load. Running load can then be measured using motor load or stem strain devices to determine total stem thrust. As a result, the inability to use spring pack compression to measure stem loads below preload is overcome by using more than one measuring device.

False Preload:

False preload is a term currently being used by MOVATS Incorporated to describe a condition resulting from an apparent delay in spring pack response to a load on the stem. The exact cause of the delay has not been determined, although several hypotheses are being investigated. The effect can be seen on an actuator that has a running load greater than spring pack preload. Even though the spring pack has already started to compress due to the running load, a delay in spring pack compression is seen when the stem contacts the load cell. This delay appears the same as a preload, resulting in the term "false preload". Its magnitude appears to be directly related to the stem loading characteristics. The same effect can be expected in a valve where preload is greater than running load; however, there is no way to separate the false preload effect from the actual preload.

The primary concern is whether this delay in spring pack response could affect the torque switch trip point as well as the results obtained with a TMD. For example, if closing thrust measurements are obtained under static conditions using any type of diagnostic equipment and used to set the torque switch, the thrust at torque switch trip under differential pressure conditions may be lower than under static conditions. The lower thrust might result because the delay in spring pack response is less when the valve seats against differential pressure. The differential pressure causes the stem forces to build more gradually than when the valve is closed under static conditions.

However, testing at MOVATS Incorporated has indicated that the spring pack "catches up" during the loading. This "catching up" has led to the conclusion that thrust values at torque switch trip and maximum differential pressure are not significantly affected. Testing is currently in progress to determine the validity of this conclusion and to quantify the potential error. We are also examining the methods used to analyze signatures to determine whether some of them may be more susceptible to error from this condition than others.

Open vs. Close Response:

The assumption that equal spring pack displacements in the open and closed direction correspond to equal amounts of torque is an implicit part of the Limitorque actuator design. The stem factors used to convert this torque into stem thrust have also been assumed to be equal in both directions. The degree to which these assumptions can be supported has recently been questioned by many in the industry, including MOVATS Incorporated. Testing has been and is being performed to determine the cause and magnitude of differences in thrust resulting from equal spring pack displacements in opposite directions.

Early testing by MOVATS Incorporated indicated that differences between thrust measurements for equal spring pack displacements were small. However, some recent testing on one actuator has shown differences between open and closed thrusts for equal spring pack displacements of approximately 20% for much of the stroke with much higher differences during the initial loading. The testing showed lower delivered thrust in the closed direction. The first postulated cause was differences in wear of the stem nut, so a new stem nut was obtained. The stem was lubricated and the new stem nut installed. This resulted in the differences dropping below 10% for most of the loading and, as a result, it appeared that stem nut wear was the primary cause.

Subsequently, the stem was relubricated and the original stem nut installed. When the testing was repeated, the results matched those obtained with the new stem nut. Additional testing was performed varying the degree of lubrication, and for the actuator being tested, it was demonstrated that degradation of stem lubrication was the dominant cause of the differences between open and closed thrust. Differences less than 5% were consistently obtained with a clean, well-lubricated stem. Additional testing to verify these results using other actuators is planned in the future.

Stem Lubrication:

While degradation of stem lubrication has always been known to affect actuator performance, it may not have been obvious to everyone that it degrades performance by affecting the relationship between spring pack compression and output thrust (K-factor). Changes exceeding 20% have been seen in testing.

While some in the industry have discussed the influence of stem lubrication on the K-factor measured by the TMD, the type of diagnostic equipment used to set the torque switch makes little difference. The simple fact is, that if stem lubrication changes after the torque switch is set, the thrust delivered will also change. If the lubrication degrades, the valve may not have enough thrust to operate. If the switch is set with a poorly lubricated stem and the stem is subsequently lubricated, the delivered thrust may exceed the valve/actuator's rating, increasing the potential for damage.

The testing currently in progress will demonstrate the effects of change in stem lubrication. However, the present solution to the problem is to ensure that the valve stem is well lubricated prior to diagnostic testing and that the lubrication is maintained. Using motor load to monitor actuator performance periodically should provide an early indicator of degrading stem lubrication.

MOVATS® USERS TECHNICAL NOTICE 88-03

September 1988

SUBJECT: USE OF THE A.C. MOTOR LOAD UNIT

INTRODUCTION:

The A.C. Motor Load Unit (AC-MLU) was developed to provide a simple maintenance tool for periodically monitoring the performance capability of motor-operated valves (MOVs). By monitoring motor input current and voltage, the motor load unit generates an output signal that is directly proportional to stem thrust. The motor load unit can accurately measure steady-state loads, which makes it effective for monitoring actuator running load. Changes in running load are a direct indicator of changes in the actuator's capability to perform under maximum differential pressure conditions.

RANGE AND COMPENSATION SETTING:

The range setting on the motor load unit scales the input current to make it compatable with the electronics. The correct range setting is determined from a table in the MOVATS® Generic Procedure that lists the settings based on motor full-load current. This is a straightforward process that has not caused significant problems.

The compensation setting adjusts the gain of the motor load circuitry that corrects the output to account for motor inefficiencies. This adjustment also ensures that the unit's output is not affected by line voltage fluctuations of ± 10%. Compensation settings are provided in the same table as the range settings. The values listed were obtained by performing no-load tests on a variety of AC motors. One compensation setting is specified for each motor size. However, recent no-load testing has shown that identical motors sometimes require different compensation settings. The differences may result from motor age, variations in the manufacturing process, variations in winding or insulation resistance, clearance differences between windings and metal structures of the motor, or any number of other factors. Testing performed during the development of the motor load unit indicated that having the exact compensation setting was not critical, particularly if the same setting was used for subsequent testing of the same valve. However, the potential error resulting from incorrect settings was not quantified. Testing is ongoing to define the degree of error that can result from incorrect compensation settings. This testing will determine if it is necessary to perform no-load testing on each motor to identify the correct compensation setting.

AC-MLU WARM-UP:

As with most electronic equipment, some amount of warm-up time is required before the motor load unit will provide a usable output. The unit was originally designed to be powered from the same power being supplied to the actuator motor. If the unit was used at the motor control center and connected to the power side of the contactor, there would be adequate warm-up time before the unit was used to record data. On the other hand, if the unit was connected to the motor side of the contactor, either at the motor control center or at the MOV, the unit would only be energized while the motor was running. This did not allow adequate warm-up time and could result in inaccurate data from the unit.

During the spring of 1988, a modification was made to the motor load unit so that it would be powered from the same 120-volt wall plug that was supplying the panel indication circuit. As a result, the unit is always energized as long as it is plugged in and turned on with the switch on the back panel. This modification also has been added to all motor load units that have been returned to MOVATS Incorporated for calibration since March 1988.

The exact nature and extent of potential inaccuracies due to inadequate warm-up are not presently known. MOVATS Incorporated has initiated a test program to define these inaccuracies. In the meantime, any AC-MLUs that have not been calibrated since March 1988 should be returned for modification and calibration.

MOTOR LOAD VS. STEM THRUST:

While motor load output has proven to be an excellent tool for detecting actuator and valve degradations, the ultimate purpose has been to use it to quantify stem thrust. To do this, a method for calibrating motor load to stem thrust is required.

Early in the development of the motor load unit, it was determined that motor load output does not change immediately when the stem is loaded. Attempts to quantify the delay and correct for it met with limited success, and as a result, motor load is not currently being used to quantify transient loads on the stem. On the other hand, steady-state values of motor load are very repeatable and can be correlated with stem thrust. The most accurate method for determining this correlation or M-factor is to induce a step change in stem running load and compare the change in steady-state motor load with the magnitude of change measured by the load cell. The step change in running load is induced using a hydraulic cylinder mounted between the load cell plate and the load cell.

In an effort to simplify the field application of this technique, the mechanical dynamic load simulator (MDLS) was developed. This device consists of a stack of Belleville washers mounted between the load cell plate and the load cell to slow down the loading of the stem. Since a step change in running load is not achieved, the accuracy of the M-factor obtained using this method is somewhat less than that obtained with a hydraulic cylinder. Testing indicated that the M-factor obtained using the MDLS is approximately 15% higher than that obtained using a hydraulic cylinder. This higher M-factor results in a conservative measurement of running load. Subsequent testing using a broader range of actuators and gear ratios has shown that the conservatism is often even more that 15%. Motor load analysis takes no credit for this conservatism. The degree of conservatism is affected by the length of compression and the stiffness of the washers. Testing to determine the optimum MDLS characteristics for different actuator sizes and speeds is currently in progress.

INFORMATION CONTACT:

Stan Hale (404) 424-6343

MOVATS® USERS TECHNICAL NOTICE 88-04

November 1988

SUBJECT: 2151 MAINFRAME

DISCUSSION:

The 2151 Mainframe was introduced by MOVATS Incorporated in the spring of 1988 as an upgrade to the 2150 Mainframe. This upgrade incorporates several improvements that increase the versatility and convenience of the mainframe.

One such improvement is the addition of a 99-position thumbwheel switch that allows direct spanning of almost any load cell or other strain gauge device. This eliminates the need for using external amplifier boxes with any of the load cells.

An improved circuit for sensing the position of actuator control switches also has been incorporated into the 2151 Mainframe. This switch sensing circuit provides more effective isolation from control circuit voltage spikes. It specifically eliminates the need for an external isolation box when testing actuators that have high-voltage DC control power.

Another feature of the 2151 Mainframe is the multiplexing of the switch sensing circuit output onto channel "B" of the mainframe oscilloscope. This allows switch position plus two other parameters, e.g., TMD and load cell outputs, to be monitored simultaneously on the two-channel oscilloscope.

Other improvements include field-changeable circuit protection fuses that have been located on the rear panel of the mainframe penthouse and a modification to the current monitoring circuit to eliminate high-voltage spikes on the input.

SWITCH SENSING CIRCUIT

Since the release of the 2151 Mainframe, some users have experienced stray data points and chatter (sometimes manifested as a double trace) on switch sensing signatures. This occurs on standard and multiplexed switch sensing traces.

The switch sensing circuit was designed to monitor the position of powered and unpowered control switches. In the case of unpowered switches in the open position, various levels of induced noise voltage often exist across the contacts. If this noise voltage level falls within a certain small range, it will be perceived by the switch sensing circuit as a series of momentary switch actuations or chatter. The potential for this condition was recognized during development of the 2151 Mainframe, but it was judged to be an improbable occurrence. However, subsequent field usage has shown the condition to be more common than expected.

A precision rectifier circuit has been developed to correct this switch sensing circuit problem. Testing at MOVATS Incorporated and at plants that have experienced the problem has demonstrated that 2151 Mainframes modified with the new rectifier circuit are no longer susceptible to the noise condition.

The switch sensing circuit modification can be easily installed and does not affect the mainframe calibration nor the circuit time response. All 2151 Mainframes shipped after mid-September, 1988, have the circuit modification installed.

AUTOMATED ANALYSIS SOFTWARE

The automated signature analysis software presently offered by MOVATS Incorporated was not designed to operate on the multiplexed signatures produced by the 2151 Mainframe. Work is underway to determine the feasibility of developing automated software for use on the multiplexed signatures or some modified version of these signatures.

In the interim, users desiring to generate non-multiplexed signatures that can be analyzed with the existing automated analysis software can do so by disabling the multiplexing feature on the 2151 Mainframe. This disabling is a simple procedure that will be provided by MOVATS Incorporated upon request.

INFORMATION CONTACT:

Kelly Eslinger or Bill Lavallee at (404) 424-6343.

first class

MOVATS INCORPORATED
R.W. CARR
200 Chastain Center Blvd.
Suite 250
Kennesaw, Georgia 30144
(404) 424-6343

TO:

MR. OWEN ROTHBERG

U.S. N.R.C.

WASHINGTON, DC 20555

first class