Understanding Valve Actuator Diagnostics

Electric motor-operated valve actuators can tell you a lot about their condition if you take advantage of sophisticated diagnostics available from current designs combined with networking protocols. This tutorial can help you put those capabilities to work.

Constant diagnostic evaluation of electric motor-operated valves (MOVs) has become an important tool for asset management, predictive maintenance programs, troubleshooting, and scheduled periodic maintenance. Predictive functionality allows your maintenance personnel to be proactive in servicing MOVs, while limiting costly failures and unscheduled plant process shutdowns. During scheduled downtime, maintenance personnel are given the information they need to prioritize valve and actuator maintenance to make best use of scarce opportunities.

Improvements in diagnostics
Diagnostic testing of electrically actuated valves began nearly 30 years ago to validate the operability of safety-related MOVs in the nuclear power industry. Since this periodic, manually-initiated form of diagnostic testing could identify problems in both the valve and actuator, it became not only a tool to verify MOV operation, but also for troubleshooting and preventive maintenance.

In recent years, innovations within electronic smart actuation devices created a highly sophisticated but labor-intensive troubleshooting effort for plant personnel. To overcome the labor intensity, built-in-self-test (BIST) features, developed in conjunction with customer requirements, have removed the manual initiation and transformed the historical periodic diagnostic testing into a continuous process, performed integrally within the electric actuator, as shown in the diagnostic system dashboard graphic.

Today, electric valve actuators served by digital communication networks are commonplace among new plant installations. This is partly due to recent advances in electric actuators that allow them to process more diagnostic information than comparable pneumatic models. Much of the current innovation effort of electric actuators is aimed at providing more diagnostic information to the end user.

Using FDT and EDDL
While advantages resulting from networking actuators are numerous, the main objective for maintenance and asset managers is to receive detailed diagnostic data in a clear, precise, and timely manner so they can take appropriate actions in order to avoid plant shutdown conditions. Due to the depth of device knowledge required for diagnostic development, the device manufacturer should perform precise packaging of the data for proper transmission across a digital communication network for display in the plant’s diagnostic software. Due to the unique characteristics and failure modes of the different units that make up modern process systems,
the device manufacturer is able to design
diagnostic strategies able to evaluate each
unit specifically, rather than using gener-
ic scripts based on equipment types that
could be misleading.

The packaging of device-specific diag-
nostic information for network commu-
nications should be developed to operate
on two complementary device integra-
tion platforms: Field Device Tool/Device
Type Manager (FDT/DTM) and Electronic
Device Description Language (EDDL). Both
of these can use fieldbus networks, such as
Foundation Fieldbus or Profibus, to trans-
port data from the field to the end user.

FDT/DTM allows data exchange between
primary control systems or engineering/asset management
tools [FDTs] and device-specific software components [DTMs].
Actuators and valves can be operated, configured, monitored,
and diagnosed through the DTMs integrated in the FDT frame.
The graphical user interface [GUI] supports advanced views
through an FDT-compliant interface.

EDDL allows data exchange between host control sys-
tems or engineering/asset management tools and device-spe-
cific software components known as Device Description (DD)
files. The DD file is provided in a plain-text format that can be
opened with word-processing applications. This file is integrat-
ed into the host control system for operation, configuration,
monitoring, and diagnosing the field unit.

Both platforms offer many benefits, including a GUI for
alarms, histograms, charts and graphs, and other relevant data
when integrated into a MOV digital network. Device manu-
ufacturers support both technologies and will likely continue to
do so. A given end user will typically choose one or the other

platform based on preferences related to larger
control system suppliers, fieldbus architectures,
and instrumentation conventions. Some tech-
nologies are closely aligned and tend to be used
together.

Using prepackaged data
Regardless of the platform utilized by a given
plant, the critical component for successful diag-
nostic deployments lies with the device manu-
facturer’s software development techniques. One of
these techniques is to prepackage the data prior
to passing it along via one of the device integra-
tion platforms operating on a fieldbus network.

Building a diagnostic engine software com-
ponent, with prepackaged diagnostic analy-
sis capabilities within the electric actuator, permits you to
access multiple types of valve and actuator diagnostic infor-
mation visually that is meaningful to different departments
within your organization. By following the NAMUR NE-107
standard, a Foundation Fieldbus diagnostic specification
based on guidelines established by the NAMUR Working
Group 2.6, during development an end user is able to classify
each valve and actuator alert, alarm, and diagnostic con-
dition as a failure, off-specification, maintenance, or check
function. The data is then routed to the appropriate plant
personnel.

Some modern electric actuator systems allow access to
condition data and alarms on a local display or on Bluetooth-
enabled devices. This provides easy access to valve and actu-
tor data as the software used on the Bluetooth device provides
access to the most often used functions of the full FDT/DTM
or EDDL interface. The graphic on P3 shows an example of a
mobile device interface.
Valve diagnostic parameters

Valve-specific diagnostics allow you to monitor the health of all valves and actuators in a plant or process. By gathering, analyzing, and packaging results inside the electric actuator, you can monitor a valve’s health. A valve warning prior to a critical failure gives your maintenance personnel time to repair the valve without unscheduled shutdowns and loss of productivity.

Many operating parameters can serve as indicators of a valve’s health, including:
- The actuator’s torque trend during valve travel;
- Capturing the valve cycle count; and
- Monitoring the valve’s span of travel.

When evaluating the actuator’s torque trend, a nominal baseline is established and then an ongoing comparative analysis is performed.

A low-torque condition will prompt warnings and/or alarms normally associated with a broken valve stem or plug, seat leaking, flashing, packing wear, sheared key, or damaged stem-to-stem nut interface.

A high-torque situation reveals valve issues such as seat wear, obstruction, gumming, extreme vibration, inadequate stem lubrication, excessively tightened packing, or other mechanical issues.

Capturing the valve cycle or operation count allows maintenance to assess usage, while prompting a service reminder after a user-assigned count set point has been reached. This quickly helps the maintenance engineer determine if excessive wear conditions exist and service is required.

Diagnosing the span of valve travel over a period of time validates important attributes associated with the valve, including correct sizing and range of performance. For optimum modulating performance, the majority of valve operation should be positioned near 50% open. Naturally, open/close valve applications should reveal a normal distribution between 0% and 100% open. Skewed data in one direction or the other suggests a valve that may not be optimally sized for the application. Typical flow conditions are as important as pipe size for valve selection.

Actuator diagnostics

Actuator-specific data gathered within the device should include information on standard key components, such as the electric motor, mechanical gearing, position encoder, torque sensor, and motor controller/contactor. The actuator’s BIST feature analyzes component-related data in order to determine overall actuator health.

By gathering the motor supply voltage, current, winding temperature, and runtime, you will be able to see the electric motor performance measures clearly. Individual user-configurable thresholds provide direction for generating motor warnings and alarms. For example, a high-motor-current condition can signal impending issues such as motor failure, loss of mechanical-gear efficiency, and low-line voltage.

Encoders are typically used in electric actuators to enable precise valve positioning, so it is extremely important to integrate encoder diagnostics into the actuator. These components are either absolute or incremental rotary-style encoders using optical or mechanical sensing technologies. Optical encoders
typically use LEDs beamed onto photodiodes through slits in a disc. Mechanical encoders typically employ strips of magnetized material placed on a rotating disc interacting with a Hall-effect sensor.

Redundancy in encoder/sensor design allows the BIST feature to discern if a specific electronic component failure merits only a warning or an alarm plus safe shutdown of the actuator. For motor control, most electric actuators use either a mechanical-reversing contactor or a solid-state motor controller. There are more diagnostic capabilities when the solid-state device is included, because its microprocessor-based software can monitor detailed performance characteristics associated with the motor-driver insulated-gate bipolar transistor (IGBT), internal RAM and bus communications.

Innovative design techniques have been developed to ensure actuator mechanical-reversing contactors have diagnostics and safeguards to protect against erroneous operation. By continually analyzing dedicated signal lines associated with the motor reversing contactor relay drive transistor, the actuator can eliminate unexpected erroneous actuation caused by internal electronic failures and erratic external command signals, as well as report current status, alarms, and the actuator’s health.

**Saving time, money**

There are countless diagnostic-testing techniques that can be performed for MOVs, including partial stroke and emergency shutdown tests. Valves and actuators should be equipped with the core requirements for continuous embedded-device testing while installed in industrial applications.

As plant asset management systems continue to expand, an electric actuator that monitors MOV health indicators and communicates the results in a user-friendly fashion is just as essential as actuating the valve. This information helps you and your maintenance staff minimize unplanned downtime and prioritize maintenance during scheduled outages to increase the profitability of your facility.

*B. Scott Wilkerson is senior product manager for Flowserve Flow Control Division.*