Series 3730 and Series 3731

EXPERTplus Valve Diagnostics with Partial Stroke Test (PST)

Application

Positioner firmware for early detection of control valve faults giving maintenance recommendations. Valid for firmware version V 1.51 and higher.

**Note:** The EXPERTplus valve diagnostics for Type 3730-6 Positioner is described in a separate data sheet (T 8389-1 EN).

The EXPERTplus valve diagnostics can detect faults and provide predictive, status-oriented maintenance of pneumatic control valves. The full scope of diagnostic functions is completely integrated into the positioner. The numerous diagnostic functions allow faults to be pinpointed in control and safety-related on/off valves at an early stage. Functions include, for example, partial stroke testing and data logging.

The TROVIS-VIEW software, which allows the user to access, read and edit the diagnosis, is easy to learn. The integration options including eDD, eEDD, FDT/DTM allow the diagnostic functions to be also used in other engineering tools. Classified status alarms and the condensed state conforming to the NAMUR Recommendation NE 107 can also be read off at the on-site display of the positioner and can be issued over the fault alarm contact*.

**TROVIS-VIEW:** Operator interface to configure and parameterize various SAMSON devices

**FDT:** Field device tool for the manufacturer-independent integration of field devices

**DTM:** Device type manager to describe the device and communication properties

**DD/eDD:** Device description/enhanced device description

**Special features**

- Data required for diagnostics are constantly compiled, saved and analyzed in the positioner. Status alarms are automatically generated. Test data and their analysis are saved in the positioner.
- Cyclical polling of test data, multiplexer-capable
- Statistical information (in-service monitoring) and tests (out-of-service diagnostics) pinpoint critical states before malfunctions can affect the process, allowing the user to plan predictive maintenance and service work on control and on/off valves
- Minimum and maximum temperature readings with details on how long the limits have been exceeded
- Automatic start of diagnostic functions
- Display of service and maintenance recommendations
- Display of classified status and fault alarms

* Fault alarm contact of Type 3730-2 and Type 3730-3, option for Type 3731-3.

* Fault alarm contact of Type 3730-2 and Type 3730-3, option for Type 3731-3.

**Options**

- Leakage sensor to monitor the seat leakage
- Binary input, e.g. to start tests, connect an external solenoid valve or a leakage sensor, etc.

**Fig. 1:** Type 3241-1 Control Valve and Type 3730-3 Positioner with HART™ communication

**Fig. 2:** Flameproof Type 3731 Electropneumatic Positioner

**Special features**

- Status classification and condensed state based on NAMUR Recommendation NE 107
- Status alarms and condensed state can also be read off at the display or can be issued over the fault alarm contact*
- Plotting of y-x signature (valve signature) for fault detection
- Diagnostic function to pinpoint changes in friction
- Operating hours counter allows data and events to be sorted by time
- Diagnosis data and test analysis saved in the positioner
- Integrated partial stroke testing (PST) and full stroke testing (FST)

**Options**

- Leakage sensor to monitor the seat leakage
- Binary input, e.g. to start tests, connect an external solenoid valve or a leakage sensor, etc.

**Edition June 2012**

**Data Sheet**

T 8389 EN
Summary of diagnostic functions
There are two main groups of diagnostic functions available:

Statistical information (in-service monitoring)
Data are compiled, saved and analyzed by the positioner while the process is running without disrupting the process. The positioner follows the reference variable during this time. A classified status alarm or fault alarm is generated if the positioner detects an event.

Tests (out-of-service diagnostics)
Similar to the statistical information function, data are compiled, saved and analyzed by the positioner. However, in this case, the valve position is not determined by the reference variable, but the active test. The tests (PST, FST) can only be started when the conditions in the plant allow it (e.g. plant shutdown or service work in the workshop). For reasons of safety, these tests, except for partial stroke testing, can only be performed in the MAN operating mode.

Table 2 shows the individual diagnostic functions with their test analyses.

Application type: Control valve or on/off valve
The EXPERTplus valve diagnostics is used in combination with pneumatic control valves. The positioner works using the application types, control valve or on/off valve. Both application types allow positioner to run in both AUTO or MAN operating modes.

The table shows the correlation between the application type and operating mode:

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The discrete analysis of the reference variable with the application type, on/off valve and in AUTO mode allows the valve to be moved to the fail-safe position or a user-defined fixed value (e.g. 100 %) by entering the corresponding reference variable. In addition, the partial stroke test (PST) can be started by entering the corresponding reference variable w.

Type 3730-4 Positioner only works in the "control valve" application type.

![Fig. 3 · EXPERTplus valve diagnostics with TROVIS-VIEW 4 Operator Interface](image-url)
Table 2 · Summary of EXPERTplus functions

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1 EXPERTplus valve diagnostics

1.1 Start-up diagnostics
EXPERTplus monitors the control valve during automatic initialization to ensure trouble-free start-up. In addition, the opening and closing times are determined. The diagnosis also indicates faults concerning attachment and the entire valve travel range as well as hardware, data memory defects and the initialization time.

1.2 Process variables and operating parameters

1.2.1 Current process variables
EXPERTplus provides the key process variables collected by the positioner (reference variable w, valve position x, drive signal y, setpoint deviation e and temperature t) and analyzes the diagnostic data.

1.2.2 Key operating parameters/status alarms
To evaluate the current condition of the control valve and schedule maintenance routines, EXPERTplus provides the user with a status summary. The alarms for the operating parameters listed below are time-stamped:
- Operating hours counter, distinction between positioner switched on and positioner in closed-loop operation (since the first start-up and the last initialization routine)
- Number of zero calibrations performed
- Number of initializations performed
- Display of the current temperature as well as saving of the maximum and minimum temperatures, including alarm function when a limit is exceeded
- Total valve travel, including customizable limit

1.2.3 Direct detection of fault sources
EXPERTplus generates fault alarms and status alarms allowing quick fault detection in case an error has occurred. The last 30 alarms are logged in a FIFO (first in, first out) memory together with the operating hour they were generated in.

The following category of status alarms are available:
- Status
- Operational
- Hardware
- Initialization
- Data memory
- Temperature
- Extended status alarms
- Operational errors, for example:
  - Control loop error (excessive error, e.g. blocked actuator, insufficient supply pressure etc.)
  - Zero point shift
  - Hardware
  - Data memory
  - Temperature
  - Initialization
2 Diagnostic functions

2.1 Statistical information (in-service monitoring)

By permanently recording raw diagnostic data (w, x, y and e) in the positioner, the user can gather information about how the control valve behaves under process conditions. Signal logging enables an analysis of the current measuring scope as well as of the positioner’s entire service life. The following statements can be made, for example:

– Valve position range OK
– Valve mainly operates in the upper or the lower end position
– Dynamic stress factor

As a result, recommendations for predictive maintenance can be given. In addition, immediately required action is reported.

2.1.1 On/off diagnosis (not Type 3730-4)
The on/off diagnosis provides statements on the valve end position, i.e. the actual travel range and changes in transit time and breakaway times.

The on/off diagnosis runs for on/off valves in AUTO mode in the background. The monitoring does not need to be activated. While the plant is running, Breakaway time (rising/falling), Transit time (rising/falling) and Valve end position parameters are recorded. The first values recorded are used as a reference for further tests.

If the analysis detects an error, the positioner generates a corresponding alarm.

2.1.2 Data logger
The variables reference variable w, valve position x, setpoint deviation e, drive signal y and the operating hours counter are recorded and saved in a FIFO memory. The interval between the individual measuring points can be defined by the user. Apart from permanent sampling, the data can also be collected online while the process is running, provided a certain trigger condition is met. The trigger condition can be defined by the user as certain thresholds.

2.1.3 Travel histogram
The valve travel histogram is a statistical analysis of the plotted valve positions. The histogram provides information about where the valve mainly spends the majority of its time during its service life and whether it shows a recent trend concerning changes in its operating range.

Data are recorded in the background regardless of the operating mode selected. A short-term histogram and a long-term histogram are plotted.

The positioner generates an alarm if the analysis of the travel histogram detects an error in “Shifting working range” or “Working range”.

2.1.4 Setpoint deviation histogram
The setpoint deviation histogram contains a statistical analysis of any setpoint deviations recorded. This provides a summary of how often and to which level a setpoint deviation has occurred during the valve service life and whether it shows a recent trend concerning the setpoint deviation. Ideally, the setpoint deviation should be as small as possible.

Data are recorded in the background regardless of the operating mode selected.

Fig. 4 · Data logger
A short-term histogram and a long-term histogram are plotted. The positioner generates an alarm if the histogram detects an error in “Limiting working range”, “Inner leakage” or “Connection positioner/valve”.

2.1.5 Cycle counter histogram

The cycle counter histogram provides a statistical analysis of the cycles. As a result, the cycle counter also provides information on the dynamic stress of a bellows seal and/or packing. A valve cycle starts at the point where the valve stroke changes direction until the point where it changes direction again. The valve stroke between these two changes in direction is the cycle span. Data are recorded in the background regardless of the operating mode selected. A short-term histogram and a long-term histogram are plotted.

If the analysis detects an error, the positioner generates a corresponding alarm.

2.1.6 Drive signal diagram steady-state

Steady-state drive signal diagram allows changes in the supply pressure or leakage in the pneumatics to be detected. If the supply pressure is insufficient for the actuator to move through the entire bench range, this pinpoints to a fault in supply pressure or leakage in pneumatics. In this case, the positioner generates an alarm.

Data are recorded and analyzed in the background regardless of the operating mode selected when a reference graph exists. A short-term monitoring listing the measured data and a long-term monitoring in a graph are possible.

If the analysis detects an error, the positioner generates a corresponding alarm.

2.1.7 Drive signal diagram - Hysteresis test

The hysteresis test allows changes in friction to be analyzed. The positioner generates an alarm when the results of the hysteresis test pinpoint to “Friction” or “External leakage”. If a reference graph exists, the hysteresis test can be started in both AUTO or MAN operating modes. The test can be performed once or cyclically. A short-term monitoring listing measured data and a long-term monitoring in a graph provide an analysis of the measured data. If the analysis detects an error, the positioner generates a corresponding alarm.

2.1.8 Trend of travel end position

This test serves to detect wear or dirt on the valve trim and is run automatically while the process is running. The valve position is recorded when the lower end position is reached and any changes logged together with the drive signal y and a time stamp. The first measured value is used as a reference. Further measured values showing a greater deviation from the last recorded value are logged.

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Fig. 5 - Drive signal diagram steady-state
2.2 Tests (out-of-service diagnostics)

(2.2.1 to 2.2.3)

For reasons of safety, the tests (out-of-service diagnostics) can only be started when the positioner is in the MAN operating mode. The control valve moves through its working range after a test starts. Therefore, it is important to make sure before starting a test whether the conditions (in the plant or process) allow the valve to move.

The tests provide a trend showing the current control valve state, any possible existing malfunctions and help to pinpoint faults and to schedule predictive maintenance work.

2.2.1 Drive signal diagram steady-state

The drive signal diagram steady-state allows you to check the results of the steady-state drive signal diagram in Statistical information (in-service monitoring) more closely.

After starting the test, the valve moves to various fixed valve positions \( x \) distributed over the working range of the valve. The drive signal \( y \) is measured for each valve position \( x \) and compared with the reference graph. The statements on the following faults can be made:

- Supply pressure
- Leakage in the pneumatics
- Actuator springs

If the analysis detects an error, the positioner generates a corresponding alarm.

2.2.2 Drive signal diagram hysteresis

This test allows you to check the results of the drive signal diagram (hysteresis test) in Statistical information (in-service monitoring) more closely.

After starting the test, the valve moves to various fixed valve positions \( x \) distributed over the working range of the valve. After moving to the valve position, a ramp movement changing the valve travel is performed. The change in drive signal \( y \) is measured for each valve position \( x \) and compared with the reference data.

If the analysis of the drive signal detects an error concerning the friction or external leakage, the positioner generates a corresponding alarm.

2.2.3 Static characteristic

The static performance of the control valve is affected by the friction hysteresis and the elastic processes in the valve stem packing.

The positioner specifies the reference variable \( w \) in a defined test range (Start and End) in small steps and records the response of the valve position \( x \) after waiting a defined delay time. An analysis of the control loop is possible from the recording and detection of Min. dead band, Max. dead band and Average dead band.
2.3 Partial stroke test (PST)

In standard cases of application, a shut-off valve in a safety loop is fitted with a solenoid valve for emergency shutdown and limit switches for position feedback. Dedicated shut-off valves typically remain static for months or years in normal operating conditions.

The use of a positioner with integrated partial stroke testing provides an alternative. The positioner can be mounted on a valve to replace or supplement a solenoid valve.

The partial stroke test function prevents the valve from becoming stuck, for example, due to corrosion or material disintegration.

Recording the test results additionally allows an analysis of the dynamic control response. For this purpose, the valve is moved from a defined start value, e.g. operation point, either as step response or as a ramp function to a defined point and then moved back to its original position.

As a result, the probability of failure on demand (PFD) can be reduced and it may be possible to extend maintenance intervals.

Various cancelation conditions provide additional protection against the valve slamming shut or moving past the end position:

- The test is canceled when the maximum permissible test duration is exceeded.
- $x$ control value: The test is canceled when the value falls below the adjusted valve position.
- delta y-monitoring: The test is canceled when the drive signal y falls below the predetermined comparison value.
- The test is canceled as soon as the deviation of the valve position exceeds the adjusted PST tolerance band.

If a partial stroke test has not been completed, a classified status alarm is generated directly reporting the partial stroke test at the positioner display, the engineering tool used and over the fault alarm output*. This allows safety and test functions to be brought together and partial stroke testing for safety-related on/off valves to be performed.

![Partial stroke test diagram](image)

Fig. 7 - Partial stroke test
2.4 Full stroke test (FST)
The dynamic valve performance can be evaluated by performing a full stroke test. The valve moves through its entire working range during a full stroke test. The first step ends in the fail-safe position, meaning the second step starts from the fail-safe position. The change in travel can be performed either in steps or in a ramp function. For the test in a ramp function, additionally the velocities for the rising and falling ramps need to be defined. After being activated, the test does not start until the settling time before test start has elapsed. This waiting period ensures that the valve has reached its start position. For reasons of safety, this test can only be started in the MAN mode. The dynamic valve performance can be evaluated at the end of the full stroke test from the recorded test procedure. Any full stroke test performed is marked to indicate whether the test was completed successfully or not.

3 Visualization and parameterization of EXPERTplus diagnostics

The TROVIS-VIEW software or the DTM tool generate graphs from the data, test results and status alarms collected by the diagnostic firmware in the positioner. In addition, the diagnostic data can also be made accessible to other engineering tools using the DD (device description) or eDD (enhanced DD), which enables the data to be displayed in a graph, e.g. using Siemens PDM. How the data are displayed depends on the tool.

3.1 Classification and marking of status alarms

Based on NAMUR recommendation NE 107, the alarms (events) generated EXPERTplus are assigned a status (classified). The following states can be assigned to an alarm (event):

<table>
<thead>
<tr>
<th>Status alarm</th>
<th>TROVIS-VIEW/DTM</th>
<th>Positioner display</th>
</tr>
</thead>
<tbody>
<tr>
<td>No message, O.K.</td>
<td>✅ green</td>
<td>Text, e.g. tESting, tunE, tESt</td>
</tr>
<tr>
<td>Function check</td>
<td>✉ orange</td>
<td></td>
</tr>
<tr>
<td>Maintenance required/Maintenance demanded</td>
<td>💡 blue</td>
<td></td>
</tr>
<tr>
<td>Out of specification</td>
<td>⚠ yellow</td>
<td>Blinking</td>
</tr>
<tr>
<td>Maintenance alarm</td>
<td>✘ red</td>
<td></td>
</tr>
</tbody>
</table>

The condensed state is indicated on the positioner display and can be read over the communication. Additionally, the condensed state can be issued over the fault alarm contact*.

3.2 Diagrams in TROVIS-VIEW, DTM, eDD (e.g. Siemens PDM)

The software with trend viewing function allows the variables \((w, x, y, e)\) recorded by the data logger to be plotted over time. Similarly, the raw data and data collected in the various tests are plotted in graphs:

- Current process variables
- \(y-x\) signature
- Hysteresis test
- Static characteristic
- Step response
- Valve end position trending
- PST \((x, w, e, y)\) of the current test
- FST \((x, w, e, y)\) of the current test

The long-term and short-term histograms described in section 2.1.3 to 2.1.5 are displayed as bar graphs. A difference is made between long-term and short-term in the \(y-x\) signature and the histograms.

The plotted graphs visualize changes in control behavior and support predictive maintenance.

4 Binary input

The optional binary input (Types 3730-2, 3731-3 and 3731-3 Positioners) allows various actions to be performed which also affect the diagnostic functions. These actions are always logged by the positioner.

- **Transfer switching state**
  The switching state of the binary input is logged.

- **Set local operation write protection**
  Settings cannot be changed at the positioner while the binary input is active.

- **Start partial stroke test (PST)**
  The positioner starts a single partial stroke test.

- **Go to fail-safe reference value**
  An on/off valve moves to the entered fail-safe reference value when the positioner is in automatic mode.
  No action is started when the positioner is in manual mode (MAN) or fail-safe position.
  No action is started for a control valve.

- **Switch between AUTO/MAN**
  No action is started if the positioner is in the fail-safe position.
  The positioner changes from AUTO mode into MAN mode and vice versa.

- **Start data logger**
  The data logger is started when the binary input is active.
  Data are logged according to the settings.

- **External solenoid valve connected**
  The triggering of an external solenoid valve is recognized.

- **Leakage sensor**
  The “External leakage soon to be expected” error is set. The error is reset when the edge control is set to OFF. The alarm remains saved in the logging.

* Fault alarm contact of Type 3730-2 and Type 3730-3, option for Type 3731-3.