Series 373x
Electropneumatic Positioner
Type 373x-5
EXPERT+

SAMSON

with FOUNDATION™ fieldbus communication
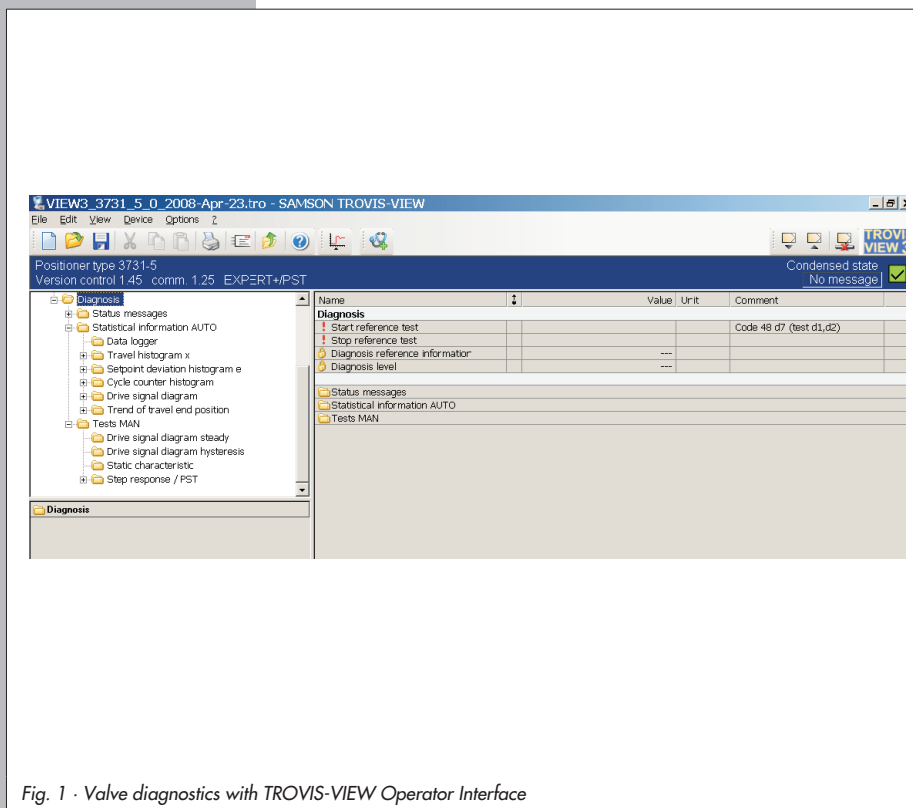

Fig. 1 · Valve diagnostics with TROVIS-VIEW Operator Interface

Operating Instructions

EB 8388-5 EN

Firmware version R 1.4x/K 1.2x

Edition August 2008

Contents

Note: These Operating Instructions **EB 8388-5 EN** are valid for:
Type 3730-5 Positioners with firmware version **R 1.44/K 1.24** and higher
Type 3731-5 Positioners with firmware version **R 1.45/K 1.25** and higher.

Note: The screen shots in these instructions are used to illustrate the appearance of TROVIS-VIEW. Certain details on screen may differ.

1 Description

1.1 General

The **Type 373x-5** Positioner in the EXPERT[+] version with partial stroke testing (PST) is based on the Type 373x-5 Positioner with FOUNDATION™ fieldbus communication. These instructions EB 8388-5 EN supplement the Mounting and Operating Instructions EB 8384-5 EN and EB 8387-5 EN.

Technical data, installation, electrical connection as well as operation and standard valve diagnostics are described in the Mounting and Operating Instructions:

Type 3730-5 → EB 8384-5 EN
Type 3731-5 → EB 8387-5 EN

Differences from standard positioner

EXPERT[+] provides predictive, status-oriented maintenance of pneumatic control valves. If EXPERT[+] is not activated, refer to section 1.3 on how to activate it.

EXPERT[+] upgrades the standard EXPERT diagnostics firmware incorporated in the positioner. The upgraded version provides extended functions to pinpoint valve parameters that have worsened, allowing the user to plan predictive maintenance and service work before malfunctions can affect the process and may cause unscheduled plant shutdowns.

Basics of EXPERT+

EXPERT[+] records the valve faults in automatic mode while the process is running and issues alarms on the required maintenance work. In addition, numerous tests can be performed in manual mode to pinpoint emerging faults.

The EXPERT[+] diagnostics are completely integrated in the positioner. Data required for diagnostics are automatically compiled and saved in the positioner. These data are analyzed by the positioner, which generates classified status alarms, providing information on the condition of the valve.

The diagnostics data, results and status alarms are available over **DD** (Device Description).

Apart from the basic settings at the positioner using the rotary pushbutton ⊛, the **TROVIS-VIEW3** software allow the parameters to be viewed and set conveniently.

Note: All the parameter settings that are changed over the operator interface must also be downloaded onto the positioner to allow them to become effective.

1.2 Diagnostic functions

There are two main groups of diagnostic functions available.

Statistical information AUTO
(in-service monitoring)

- Data logger
- Histograms
- Drive signal diagram
- Drive signal diagram steady-state
- Drive signal diagram hysteresis
- End position trending

These tests are performed while the process is running (automatic mode) without disrupting the process.

Activated tests are automatically performed when they are triggered by their start condition (e.g. data logger and drive signal diagram hysteresis).
Other tests are already performed in the background without being activated (e.g. histograms, cycle counter, drive signal diagram steady-state and end position trending).

Tests MAN
(out-of-service diagnostics)

- Drive signal diagram steady-state
- Drive signal diagram hysteresis
- Static characteristic
- Partial stroke test (PST)
- Additionally, the data logger from statistical information AUTO can be started in the manual mode.

These MAN tests must not be performed in closed-loop operation as the positioner can-

not follow the reference variable while performing these tests.
The valve is moved to a certain position defined by the test settings and the valve may move through its full working range.

1.3 Activating EXPERT+

The extended EXPERT+ diagnostics can be activated later at the positioner when EXPERT+ is not already activated on delivery of the positioner. The required activation code or an EXPERT+ USB dongle can be purchased to activate EXPERT+.

1.3.1 Activation with activation code

The activation code can be ordered (order number 1400-9318) from SAMSON. On ordering this option, specify the serial number of the positioner.

EXPERT+ is activated directly at the positioner.

Activation of EXPERT+

Enable configuration at the positioner:

Turn ⊗ → Code **3**, press ⊗,

turn ⊗ → **ON**, press ⊗.

After enabling configuration:

Turn ⊗ → Code **48**, press ⊗

Code **48** blinks.
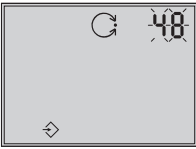
Turn ⊗ to select *d*, press ⊗,

turn ⊗ to select *d8*, press ⊗.

d8 blinks.
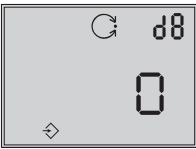
Turn ⊗ and set the activation code **XXXX**.

Press ⊗ to confirm the entered code.
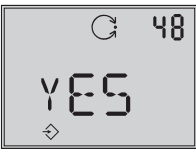
After the activation has been successfully completed, *yES* appears on the display.

Note: On entering the wrong activation code, the display returns to Code 0. The activation of EXPERT+ has been unsuccessful. After an incorrect activation code has been entered three times, Err *appears on the display after selecting Code 48 and d8. An activation code can only be entered again after the positioner has been reset to its default settings (Code 36).*

1.3.2 Activation with USB dongle

Fig. 2 · EXPERT+ USB dongle (order no. 1400-9555)

The EXPERT+ USB dongle can be ordered for the required number of activations (order no. 1400-9555).

To activate EXPERT+, the TROVIS-VIEW3 software (firmware 3.30 and higher) is required for the positioner:

Type 3730-5 → Order no. 6661-1058
Type 3731-5 → Order no. 6661-1065

Activation of EXPERT+

1. Switch on the computer.
2. Insert the EXPERT+ USB dongle into a free USB port of the computer.
3. Connect the positioner to the computer over the serial interface adapter.
4. Start TROVIS-VIEW for Type 373x-3 Positioner.
5. In offline mode, select *EXPERT+ activation* from the *Device* menu and follow the prompts.

1.4 Actuator and valve specification data

To correctly analyze the diagnostic data, several actuator and valve specifications need to be entered for the EXPERT+ diagnostics.

Enter the required data in the *Identification* folder (> *Positioner (AO, TRD)* > *Actuator*) as well as (> *Positioner (AO, TRD)* > *Valve*). Download the data to the positioner.

The *Model* and *Booster* parameters in the *Actuator* folder and *Stuffing box* parameter in the *Valve* folder need to be entered.

The default settings of these parameters are:

▸ *Model* = Single-acting

▸ *Booster* = Not present

▸ *Stuffing box* = Self-adjusting

These parameters do not need to be changed if the control valve also has these default settings.

1.5 Start the reference test

After EXPERT+ has been activated properly, the reference graphs for future diagnostic purposes need to be plotted to allow the diagnostics to function in its full scope.

The reference graphs are plotted automatically after the positioner has been initialized when the EXPERT+ has been activated (e.g. supplied with EXPERT+ already activated). On activating EXPERT+ at later time, the reference graphs are plotted after the positioner is re-initialized.

If the reference graph plotting is to be started separately in an initialized positioner or replotted, proceed as follows:

Set the positioner to ⬈ manual mode:

Turn ⊗ → Code **0**, press ⊗,
Code **0** blinks.

Turn ⊗ → **MAN**, press ⊗, the positioner moves to manual mode.
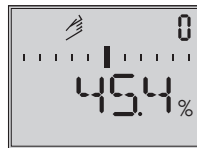
Manual operating mode

You can activate the reference test either by selecting the *Diagnosis* folder (> *Start reference test*) and right-click the parameter to select *Execute*, or, alternatively, start the reference test at the positioner itself by selecting Code **48** as follows:

Enable configuration at the positioner:

Turn ⊗ → Code **3**,

turn ⊗ → **ON**, press ⊗.

After enabling configuration:

Turn ⊗ → Code **48**, press ⊗,

Code **48** blinks.
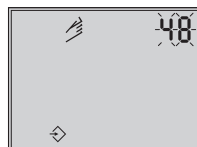
Turn ⊗ until **d** appears, press ⊗,

turn ✹ to select **d7**, press ✹.

d7 blinks.

```
  ⬎        d7


 YES
 ⬦
```
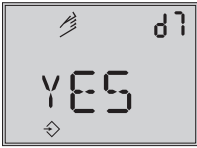
Turn ✹ → **yES**,

press ✹ to start the reference test.

CAUTION!
The control valve moves through its travel range during the reference test.

The tests **d1** (drive signal diagram steady-state) and **d2** (drive signal diagram hysteresis) are performed during the diagnostic reference test.
During the reference test, **tESt** and **d1** or **d2** appear in alternating sequence on the positioner display.
The measured data are used as reference data and any existing reference graphs are overwritten.
If the reference graphs could not be plotted correctly or are incomplete, this information is saved under Code **81** (which can be assigned to a classification, refer to section 4.5) in a non-volatile memory.

On canceling the reference test which was started in manual mode, the positioner remains in the manual mode.

On canceling a reference test automatically performed directly after initialization, the positioner changes to the automatic mode.

The positioner can also function properly after it has been initialized successfully without the reference data.

1.6 Range of functions

The following points need to be observed when the positioner is started up in the **SUB** mode (substitute calibration) or when a double-acting actuator and/or booster is used:

Start-up of the positioner in SUB mode (substitute calibration), without initialization:

▸ A reference test cannot be started.
▸ The start of all tests (Tests MAN) in one sweep is not possible.
▸ The *Drive signal diagram steady-state* and *Drive signal diagram hysteresis* for both Statistical information and Tests cannot be started.
▸ Activating the partial stroke testing with cancelation conditions is not recommended.

Double-acting actuator with reversing amplifier:

▸ A reference test cannot be started.
▸ The *Drive signal diagram steady-state* and *Drive signal diagram hysteresis* for both Statistical information and Tests cannot be started.
▸ Activating the partial stroke testing with cancelation conditions is not recommended.

Booster:

▷ The *Drive signal diagram steady-state* and *Drive signal diagram hysteresis* for Statistical information are not performed nor analyzed.

▷ Depending on the hystersis of the booster, the reference graph of *Drive signal diagram hysteresis* (d2) (Test) cannot be plotted.

▷ During the partial stroke test, larger overshoots can occur if a booster is used. As a result, the default settings of the *x control value* and *PST tolerance band* parameters must be changed correspondingly.

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*Note: Code **81** is set if the reference graphs could not be plotted or are incomplete.*

1.7 Activation, analysis and presentation of diagnostic data

All diagnostic functions which do not compile data automatically in the background (data logger, drive signal diagram hysteresis, tests MAN) must be activated to start them.

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*Note: To activate the tests MAN in manual mode, the positioner must be first set over Code **0** to ⌀ manual mode.*

Canceling diagnostic functions

There are two ways to cancel an active test:

▷ In the TROVIS-VIEW operator interface, select *Stop test* in the corresponding folder to cancel the test. The positioner then moves to the previously set operating mode and to the travel value previously set (manual mode) or returns to the reference variable (automatic mode).

▷ Press the rotary pushbutton once to cancel the tests MAN
d1 (drive signal diagram steady-state)
d2 (drive signal diagram hysteresis)
d3 (static characteristic)
d4 (partial stroke test)
and the test in statistical information AUTO
d5 (drive signal diagram hysteresis)
as well as the reference test in Code **48**.

On canceling a test (d1 to d4), the positioner moves to the operating mode previously set. The positioner goes into automatic mode on canceling test **d5** from statistical information AUTO.
The reference graphs must be plotted before the tests for drive signal diagrams steady-state and hysteresis in the manual mode can be analyzed.

Note: The analysis of raw data in automatic mode is started after the positioner has been in closed-loop operation for over one hour (after initialization).
This does not apply to the end position trend test and the dynamic stress factor in the cycle counter histogram as their analysis starts directly after closed-loop operation begins.

Alarms generated from the tests MAN are marked **TEST**.

If the electrical auxiliary power is too low, the test being performed is ended and the positioner moves to the operating mode previously set.

Upon failure of the auxiliary power, tests in tests MAN and statistical information AUTO must be restarted due reasons of safety. However, the drive signal diagram hysteresis test from statistical information AUTO and the partial stroke test (PST) remain activated.
In the event that the solenoid valve is triggered (Type 3730-5) or the forced venting is activated (Type 3731-5), active tests are stopped and the positioner changes to the fail-safe position.

1.7.1 Printing the diagnostic log

The *Print* command allows you to print out a diagnostic log of individual tests or the entire diagnosis.

The diagnostic log includes a title page and a list of all the data points including all their values and properties.

The title page contains all key information for clear identification of the printed log (device type, file name, time and date of creation, time and date of the last change and TROVIS-VIEW version).

Select *Print* in the *File* menu to add further information.

1. In the *File* menu, select *Print Options* to choose the scope of the diagnostic log. After installing/updating the TROVIS-VIEW software, customer data
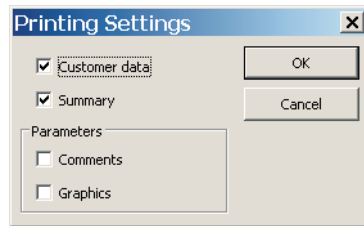
(*Customer data* in the *Edit* menu) and summary (table of contents) are listed in the diagnostic log by default.
Check the check boxes for the *Comments* and *Graphics* options to add these options to the diagnostic log.

2. Right-click the *Diagnosis* folder or the required subfolder and select *Print* from the context-sensitive menu to print the diagnostic log.
The printout contains the contents of the folder and its subfolders.

1.8 Exporting measured data

You can export the measured data compiled from tests and statistical information in a file (csv, xml or xls).

1. Open the *Tests* or *Statistical information* folder you require.
2. Click ▢ button located below the graph on the right-hand side to switch to a table of the measured data.
3. Click 🖳 button to export the data.
4. Save the data in a file, selecting the file type and name as required.
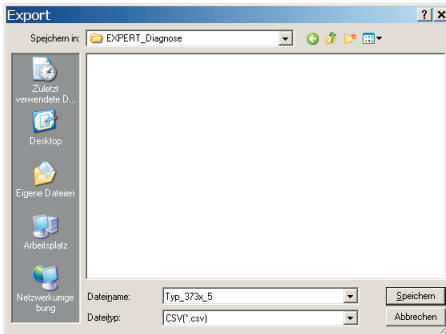
5. Click 📈 button to return the graph of the measured data.

2 Statistical information AUTO

The signals x, w and y need to be analyzed on a more precise basis to obtain advanced diagnostic information also over the valve, actuator and pneumatic air supply. The positioner compiles raw data for this purpose.

The signals are plotted, stored and analyzed while the process is running. In addition, an additional underlying hysteresis test detects any changes in friction.

2.1 Data logger

Fig. 3

The data logger allows the reference variable w, valve position x in relation to the operating range, drive signal y and setpoint deviation e to be plotted over time.
The measured data are saved in a FIFO memory with a capacity to save 100 data points in the positioner.

The data logger is completely integrated into the positioner. The software is only necessary for activation and to set the parameters.

The measured data can be viewed as a graph or in a list by selecting *Upload from Device* in the *Device* menu or by clicking 🖳 on the device toolbar.

Note: *Upon failure of the auxiliary power, the data logger is inactive and must be reactivated.*

Data logging

Data can be permanently logged or the logging can be automatically triggered when a start condition is fulfilled.

Right-click *Selection* parameter in *Data logger* folder to select *Permanent* or *Trigger* and set the *Scan rate* parameter. Right-click the *Start data logger* parameter and select *Execute* to start data logging.

Permanent data logging

The w, x, y and e variables are saved according to the adjusted scan rate in the FIFO memory which always stores the last 100 measured data points of each variable.

Note: You can read the data recorded over the last 24 hours in a graph in TROVIS-VIEW3 by leaving the Data logger *folder open and keeping the positioner online during this time.*

Triggered data logging

On selecting *Trigger* in the *Selection* parameter, the data logger records the measured data constantly in the background. A triggering event leads to the last 100 measured data points being stored together with the pretrigger time as well as the logging of the triggering condition.
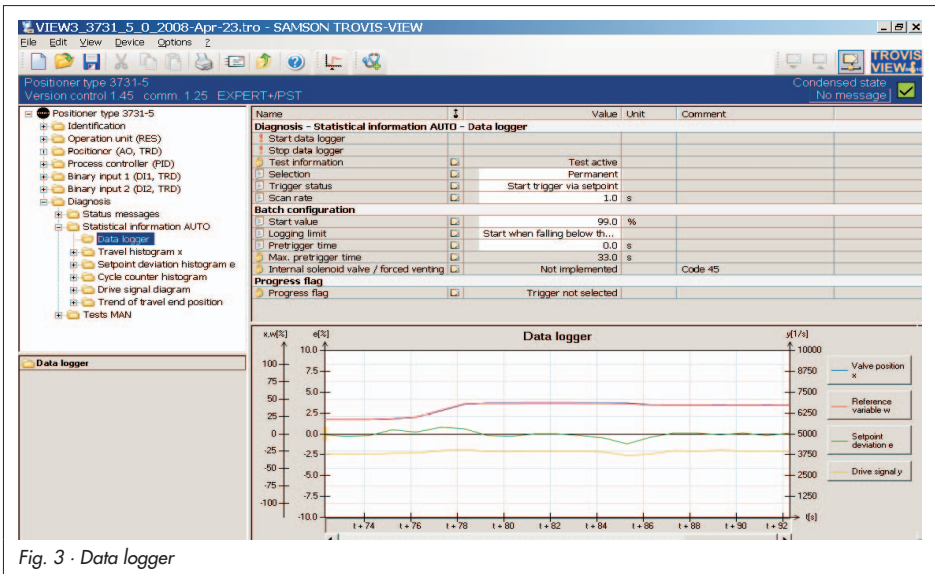
Fig. 3 · Data logger

The following conditions are available for triggering data logging:

▶ Setpoint

▶ Internal solenoid valve/forced venting

▶ Valve position

▶ Setpoint deviation

▶ Drive signal y

▶ Binary input

Setpoint, valve position, setpoint deviation, drive signal y

Right-click *Trigger status* parameter and select *Modify* from the context-sensitive menu to select the required trigger condition.

Activate data logging by selecting *Start data logger* parameter and select *Execute.*
The triggering event starts data logging when the start value exceeds or falls below an entered value.
Enter the required value at which data logging should be triggered in *Start value* parameter.
Select whether data logging should start when the entered value exceeds or falls below the start value in the *Logging limit* parameter.
After being triggered, the variables w, x, y and e are saved at the adjusted scan rate in the FIFO memory.

Additionally, there is a pretrigger time available to allow the variables to be stored that were logged before the triggered event. Enter the required pretrigger time by right-clicking the *Pretrigger time* parameter and selecting *Modify*. However, the pretrigger time entered may not be higher than the maximum pretrigger time determined by the positioner. This maximum

pretrigger time is shown in the *Max. pretrigger time* parameter. The data logging finishes automatically as soon as the maximum memory capacity of 100 measured data points for each variable including the pretrigger time is reached.

Internal solenoid valve/forced venting

Note: This function can only be used if the positioner is fitted with a solenoid valve (Type 3730-5) or the forced venting function (Type 3731-5).

Select *Trigger status* parameter and select *Start trigger via int. sol. valve/forced venting*. Activate data logging by selecting *Start data logger* and select *Execute* to start data logging as soon as the internal solenoid valve voltage drops (Type 3730-5) or the forced venting is activated (Type 3731-5). Similar to the travel condition, the variables w, x, e and y are saved at the adjusted scan rate in the FIFO memory on triggering.

Additionally, there is a pretrigger time available to allow the variables to be stored that were logged before the triggered event. Enter the required pretrigger time by right-clicking the *Pretrigger time* parameter and selecting *Modify*. However, the pretrigger time entered may not be higher than the maximum pretrigger time determined by the positioner. The data logging finishes automatically as soon as the maximum memory capacity of 100 measured data points for each variable including the pretrigger time is reached.

Setpoint or internal solenoid valve/forced venting

The triggering event starts as soon as one of the conditions (*Start trigger via setpoint* or *Start trigger via int. sol. valve/forced venting*) is fulfilled.

Binary input 1

Note: Triggering is started by the binary input (voltage input only). Set Selection binary input 1 *parameter in the* Binary input 1 (DI1, TRD) *folder to 5 – 30 V DC.*

Select *Trigger status* parameter and select *Start via binary input*. Activate data logging by selecting *Start data logger* parameter and select *Execute*. The triggering event starts data logging as soon as the state of the binary input is changed. On selecting *Start when falling below the initial value* in *Logging limit* parameter, the logging is started when the binary input is passive. By selecting *Start when exceeding the initial value*, the logging is started when the binary input is active.
After fulfilling the start condition, the variables w, x, e and y are saved at the adjusted scan rate in the FIFO memory.

The pretrigger time allows the variables to be stored that were logged before the triggered event. Enter the required pretrigger time by right-clicking the *Pretrigger time* parameter and selecting *Modify*. However, the pretrigger time entered may not be higher than the maximum pretrigger time determined by the positioner. This maximum pretrigger time is shown in the *Max. pretrigger time* parameter. The data logging

finishes automatically as soon as the maximum memory capacity of 100 measured data points for each variable including the pretrigger time is reached.

2.2 Travel histogram

Fig. 4

The valve travel histogram is a statistical analysis of the plotted valve travel.
The histogram provides information, for example, about where the valve mainly works during its service life and whether it shows a recent trend concerning changes in its operating range.

The valve travel is recorded and assigned to valve travel classes. The distribution showing how often the valve travel remains within a class is shown in per cent. The result is presented as a bar graph.

Long-term monitoring

The *Travel histogram* folder contains long-term data, i.e. measured data are updated cyclically (scan rate 1 s) over the entire positioner service life and stored every 24 hours in the positioner's non-volatile memory for long-term monitoring.
The *Number of measurement values* parameter shows the total amount of classified measured data points previously recorded. The *Average value x long* parameter contains the class in which the travel remained on average the most.

Short-term monitoring

In order to be able to recognize any short-term changes in valve travel properly, the last 100 measured data points are

stored at a scan rate (default: 1 s) in a FIFO memory.

The scan rate can be changed in the *Scan rate short-term histogram* parameter. On changing the scan rate, old data in the short-term histogram are deleted.

The *Average values x short* parameter contains the average class assignment for the last 100 measured data points stored in the FIFO memory.

Reset

Data can be reset to their default settings in the *Diagnosis* folder (> *Status messages* > *Reset*).

2.3 Setpoint deviation histogram

Fig. 5

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 positioner service life and whether it shows a recent trend concerning the setpoint deviation.
The setpoint deviation is recorded and assigned to predetermined level classes. The percentages showing how often the setpoint deviation remains within a class is presented as a bar graph. Ideally, the setpoint deviation should be as small as possible.

Long-term monitoring

Similar to the travel histogram, the *Setpoint deviation histogram* folder contains long-term data, i.e. measured data are updated cyclically (scan rate 1 s) over the en-

Fig. 4 · Travel histogram

tire positioner service life and stored every 24 hours in the positioner's non-volatile memory for long-term monitoring. Additional information determined from this long-term histogram are shown in Fig. 5. The *Min. setpoint deviation* and *Max. setpoint deviation* are also indicated as drag indicators.

Short-term monitoring

In order to obtain a summary of recent setpoint deviations, the last 100 setpoint deviations are saved at an adjustable scan rate (default: 1 s) in a FIFO memory. The scan rate can be changed in the *Scan rate short-term histogram* parameter. On changing the scan rate, old data in the short-term histogram are deleted. The *Average values e short* parameter indicates the class in which the last 100 measured setpoint deviations were stored on average in the FIFO memory.

Reset

Data can be reset to their default settings in the *Diagnosis* folder (> *Status messages > Reset*).
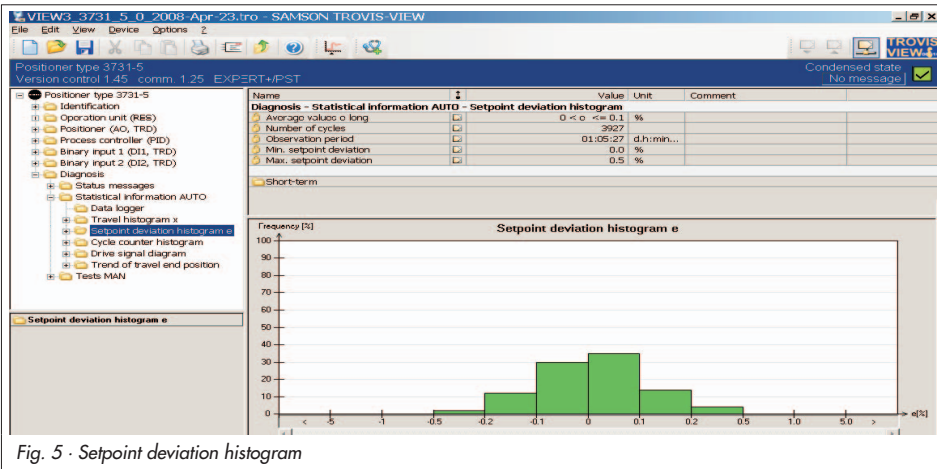
Fig. 5 · Setpoint deviation histogram

2.4 Cycle counter histogram

Fig. 6

The histogram shows the span of cycles the valve has moved through and the frequency of the cycles.

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.

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.

The *Dynamic stress factor* parameter is specified as a percentage reflecting the stress of the packing. An alarm is issued if the dynamic stress factor exceeds 90 %.

The *Dynamic stress factor* is determined from the cycle span and how often the cycle spans occurred (frequency) depending on which packing has been selected (see section 1.4) self-adjusting, adjustable or bellows seal.

To ensure this factor is correctly determined, make sure the correct packing is selected in the *Stuffing box* parameter in the *Identification* folder (> *Positioner (AO, TRD) > Valve*). The number of cycles to determine the dynamic stress factor is limited to 1 000 000 if the *Others* is selected.

The cycle counter records the number of cycles and the cycle spans which are assigned to cycle classes.

The calculated percentages on how often a cycle occurs within a class are shown as a bar graph.

Long-term monitoring

The *Cycle counter histogram* folder contains long-term data, i.e. measured data points are updated cyclically over the entire
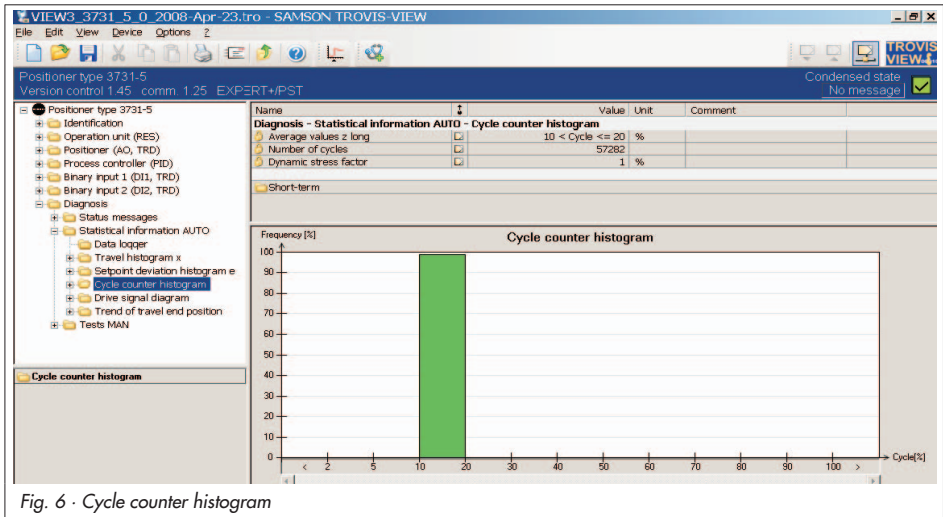
Fig. 6 · Cycle counter histogram
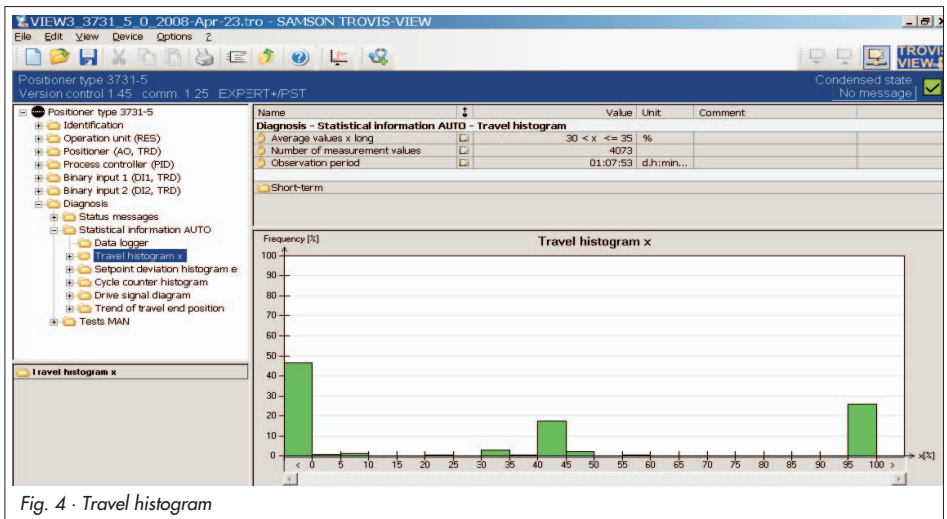
positioner service life and stored every 24 hours in the positioner's non-volatile memory for long-term monitoring.
The *Average value z long* parameter contains the cycle class in which the average cycle spans were found.

The *Counter of all measured values* parameter contains the total of classified measured data points previously recorded.

Short-term monitoring

In order to obtain a summary of recent cycles, the last 100 cycles measured are stored in a FIFO memory.
The *Short-term* folder contains this additional cycle counter histogram.
The *Average value z short* parameter contains the average cycle class for the last 100 measured data points stored in the FIFO memory.

Reset

Data can be reset to their default settings in the *Diagnosis* folder (> *Status messages* > *Reset*).

2.5   Drive signal diagram

2.5.1 Steady-state drive signal

Fig. 7

The signature diagram plotting drive signal versus valve position is based upon the drive signal y being the internal control signal of the i/p converter.
In relation to the valve position, this signal runs directly proportional to the signal pressure in the pneumatic actuator.
This graph is plotted after initialization and is stored as a reference in the positioner.
A pressure drop across the valve while the process is running causes the signal pressure in the actuator to change by the same amount as the valve travel because the flow forces have an affect on the equilibrium of forces at the valve stem.
A similar effect arises when the actuator springs loose their compression due to one or more springs failing. As a result, a change in the correlation between the internal drive signal y and the valve travel also pinpoints to one of these events having occurred.
A reduced spring force or a control valve with the fail-safe position "Fail-to-close" leads to the drive signal y shifting downwards with an ever smaller gradient.
In contrast, the pressure drop across the valve while the process is running does cause the drive signal y to drop, but the gradient rises irrelevant of the valve travel.
If significant leakage in the pneumatics arises due to screw fittings that are not tightened properly or due to a tear in the diaphragm, the drive signal even starts to rise steadily at a certain valve opening com-

pared to the reference graph.

The drive signal y starts to rise almost unsteadily at the restricted valve position if the positioner supply pressure is insufficient.

The steady-state drive signal diagram contains recent data to allow recent changes to be recognized. Furthermore, long-term data are also analyzed to be able to detect problems due to supply pressure changes or air leaks in the pneumatics before they have an impact on the process.

The measured data allows the following problems to be detected and the associated alarms to be issued:

▸ Air leakage in the pneumatics

▸ Spring force reduced

▸ Changes in supply pressure

The valve position and its associated drive signal y are measured after the pressure conditions have settled (steady-state). Each pair of measured data points recorded is

assigned to a valve position class. The average drive signal y is calculated for each class. The stored data can be read. The reference data required are plotted and stored after initialization.

Long-term monitoring

The long-term monitoring involves the average drive signal y for each valve position class being determined from all measured data points per valve position class. The average drive signal y is plotted against the valve position x.

Short-term monitoring

The short-term monitoring involves the average drive signal y determined from the last measured data points per valve position class. This allows short-term changes in actuator pressure to be pinpointed at various valve positions.
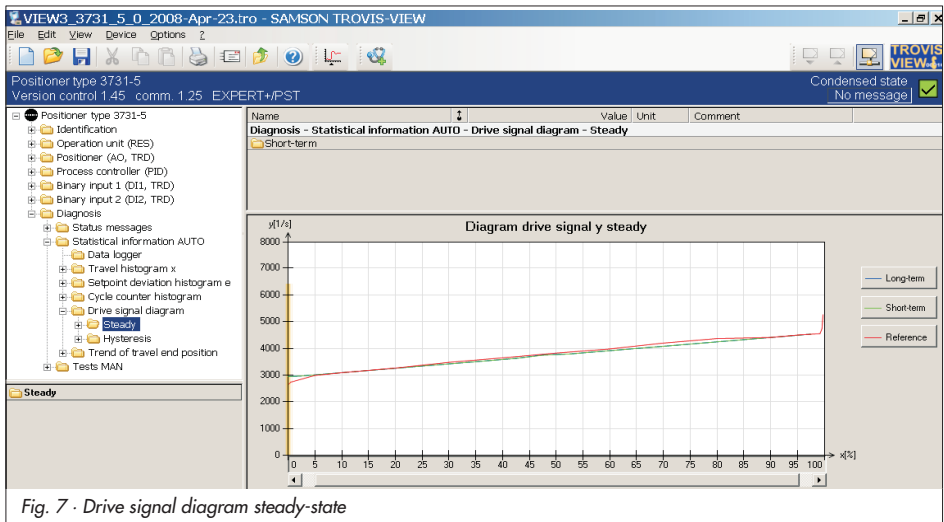
Fig. 7 · Drive signal diagram steady-state

The *Drive signal y* and *Valve position x* folders contain a table of the last ten measured data points.

Graphs

The *Steady-state* folder contains a common graph for long-term, short-term and reference data. The graph plotted using the reference data covers the full working range of the valve.
The data for long-term and short-term monitoring are recorded online while the process is running, and therefore, the graphs do not necessarily cover the full working range of the valve.

Reference values are used in cases where no data could be compiled for valve positions x as the valve did not move to those positions or a steady-state could not be reached.

The diagram allows changes in drive signal y at the corresponding valve positions to be easily recognized. Changes in pressure are also evident as the drive signal y is proportional to the actuator pressure.

Test requirements

A successfully plotted reference graph is necessary to record and analyze the data. Refer to section 1.6 in case a double-acting actuator with reversing amplifier or a booster is used or start-up was performed in the SUB mode (substitute calibration).

Reset

Data can be reset to their default settings in the *Diagnosis* folder (> *Status messages > Reset*).

Note: The valve can be moved through its travel range in manual mode, during plant shutdown or when the process allows it by selecting Drive signal diagram steady-state *in* Test MAN *to check the results or statements determined in automatic mode in the* Diagnosis *folder (>* Status message > Extended).

2.5.2 Hysteresis test (d5)

Fig. 8

The hysteresis test allows changes in friction to be analyzed and an alarm is issued when a significant change in friction is detected.

If the diagnostic test d5 is activated and the condition for the *Minimum time distance from test* parameter is met and the pressure conditions have settled, the test is performed with a change in travel < 1 % to find Δy. *tESt* and *d5* appear on the positioner display in alternating sequence and ✍ for manual mode appears while the test is running.

The test is immediately canceled and the positioner returns to closed-loop operation during this test phase if the valve position leaves the entered *Tolerance band of hysteresis* or a change in the reference variable occurs which is greater than the *Tolerance band of hysteresis.*

If the test was interrupted due to a change in the reference variable, the test is started again after waiting 30 seconds using the new operating point.
If the test is canceled again at this point due to a change in the reference variable Δw, the test is started again after waiting 60 seconds with the new operating point.
This can happen ten times, during which the time between tests is increased by 30 seconds each time (30 s x Number of tests repeated).
After the test is canceled for the tenth time (due to Δw), the time entered in *Minimum time distance from test* parameter is kept again.

The hysteresis test is deactivated by default. We recommend activating the test after you have entered *Minimum time distance from test* by selecting *Start test*.
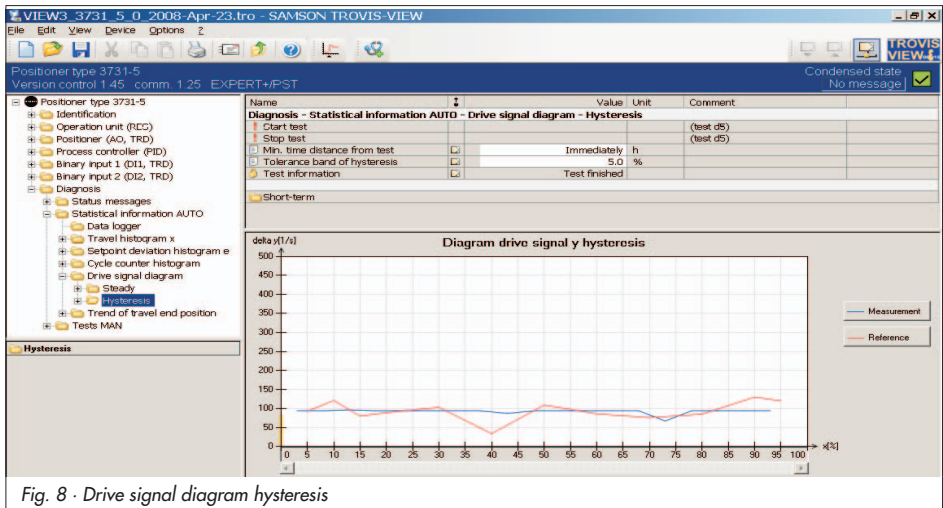
Fig. 8 · Drive signal diagram hysteresis

The *Minimum time distance from test* and the control parameters are stored in the non-volatile memory of the positioner.

Long-term monitoring

The measured results Δy are classified according to the valve position x in the valve position classes. The average value Δy per valve position class is determined from all the measured data

Short-term monitoring

To provide a short-term trend, the last ten valve positions x and the associated Δy values are saved in the *Short-term* folder (> *Valve position x* and *Difference signal drive*).

Graphs

The *Hysteresis* folder contains a graph with two lines plotted. The *Measurement* line shows the measured data recorded for long-term monitoring and the *Reference* line shows the reference data recorded after initialization.
The graph plotted using the reference data covers the full working range of the valve.

The data for long-term monitoring are recorded online while the process is running, and therefore, the graphs do not necessarily cover the full working range of the valve.

A straight line from the average reference data is shown in cases where no data could be compiled for valve working ranges which were not covered by the long-term monitoring.

The diagram allows changes in Δy with the corresponding valve positions to be recognized.
Changes in friction are highlighted as Δy is proportional to the actuator pressure which, in turn, is a measurement for friction. A change in friction leads to an alarm being issued.

Test requirements:

▷ A successfully plotted reference graph is necessary to analyze the friction.

▷ The characteristic type (Code *20*) must be set to *Linear* in order to record the data.

▷ Refer to section 1.6 in case a double-acting actuator with reversing amplifier or a booster is used or start-up was performed in the SUB mode (substitute calibration).

Note: *The valve can be moved through its travel range in manual mode, during plant shutdown or when the process allows it by selecting* Drive signal diagram hysteresis *in* Test MAN *to check the results or statements determined in automatic mode in the* Diagnosis *folder (*> Status message > Extended).

The following parameters are changed correspondingly during hysteresis test (d5) from statistical information AUTO:

- ▷ Lower x-range value (Code 8): 0 %
- ▷ Upper x-range value (Code 9): 100 %
- ▷ Lower/upper x-limit (Code 10/11): OFF
- ▷ Setpoint cutoff w decrease/increase (Code 14/15): OFF
- ▷ Pressure limit (Code 16): Active pressure limit is raised one stage higher
- ▷ W-ramp OPEN/CLOSED (Code 21/22): Variable

Reset

Data can be reset to their default settings in the *Diagnosis* folder (> *Status messages* > *Reset*).

2.6   End position trend

Fig. 9

The end position trend is used to detect a creeping zero point shift due to seat and plug wear or dirt between the seat and plug. A fluctuating zero point also causes an alarm to be issued.

To accomplish this function, the valve position x and the drive signal y are automatically logged and time-stamped by the operating hours counter in automatic mode when the valve moves to the lower end position. The measured data are stored in a FIFO memory that always stores 30 measured data points plus reference data. Measured data are first recorded in the FIFO memory when the valve position x deviates from the previously recorded value by the threshold value (0.25 %).

To allow the test to run automatically in the background, activate the tight-closing function (over Code 14 or in the *Positioner (AO, TRD)* folder (> *Reference variable > Setpoint cutoff decrease*) and make sure the positioner is in the AUTO operating mode.

In cases where a reference test has not been performed, the first zero point that the valve moved to in closed loop operation serves as the reference. The reference value is stored in a non-volatile memory independently from the FIFO memory.

An alarm is generated after a change in zero point or when a zero point shift outside of the zero point limit is detected.
Enter the zero point limit in the *Positioner* folder (> *Error control > Zero point limit*) or over Code 48 in the positioner, selecting d5 (default setting 5 %).
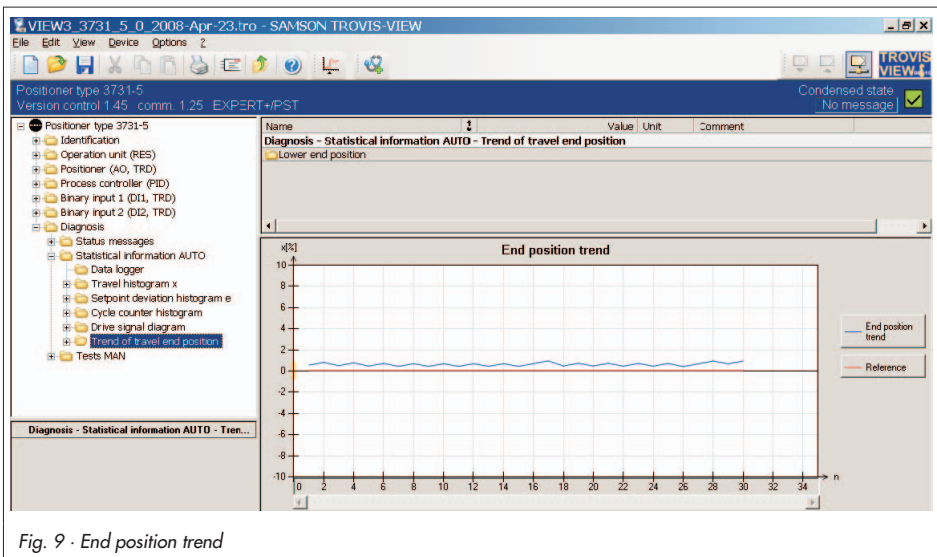
Fig. 9 · End position trend

Note: *The valve end position is also logged when the valve moves to the fail-safe position over the forced venting option and with an actuator with AIR TO OPEN.*

Graph versions

Select *Trend of valve end position* folder to view a graph of the recorded end positions. The reference value is represented by a straight line in the graph.

The graph highlights a trend and a change in the end position.

The *Lower end position* folder contains a table of the measured data (valve position x, drive signal y) with time stamp.

Reset

Data and the reference value can be reset to their default settings in the *Diagnosis* folder (> *Status messages* > *Reset*).

3   Tests in manual mode

Select the *Start all tests* parameter to auto-matically start the tests one after the other (refer to sections 3.1 and 3.2).

3.1   Tests MAN (d1 to d3)

These tests are not performed in closed-loop operation. The positioner does not follow its reference variable.

CAUTION!
In the tests d1 (drive signal diagram steady-state), d2 (drive signal diagram hys-teresis) and d3 (static characteristic), the control valve moves through its full working range after the test starts.
As a result, it is important to make sure be-fore starting the test whether the conditions (in the plant or process) allow the valve to move.

In contrast to the tests in statistical informa-tion AUTO, the corresponding test MAN covers the full working range of the valve and also serves to detect errors within the travel range.

The tests MAN provide a trend showing the current control valve state, any possible ex-isting malfunctions and help to pinpoint faults and to schedule predictive mainte-nance work.

For reasons of safety, the tests MAN can only be started when the positioner is in ✎ manual operating mode.

Select the operating mode over Code **0** on the positioner or in *Positioner (AO, TRD)* folder (> *Operating mode*).

The following list of parameters are changed while the tests MAN (d1 to d3) are being performed:

▸ Lower x-range value (Code 8): 0 %
▸ Upper x-range value (Code 9): 100 %
▸ Lower/upper x-limit (Code 10/11): OFF
▸ Setpoint cutoff w decrease/increase (Code 14/15): OFF
▸ Pressure limit (Code 16): Active pressure limit is raised one stage higher
▸ Characteristic (Code 20): Linear
▸ W-ramp OPEN/CLOSED (Code 21/22): Variable

Note: *The tests MAN can only be activated in the manual operating mode.*

3.1.1 Drive signal diagram steady-state (d1)

Fig. 10

As described in detail in section 2.5 on the drive signal diagram, the drive signal y plotted versus valve position x allows the following changes at the control valve to be recognized (and an alarm issued):

▸ Air leakage in the pneumatics
▸ Spring force reduced
▸ Changes in the supply pressure

This test (d1) causes the valve to move through the travel range to allow the results and alarms issued in automatic mode to be accurately checked.
After starting the test, the valve is moved to various fixed valve positions x distributed over the full working range of the valve. The drive signal y is measured for each valve position x and stored in the positioner memory. The necessary data set for the reference graph is automatically plotted and stored directly after initialization. The start time for the reference graph is stored with the *Reference time stamp* in the positioner's non-volatile memory.
Any further measurement is stored as a repeated measurement. Previously recorded repeated measurements stored in the positioner are overwritten. However, note that you can upload previous repeated measurements to a computer before starting a new test.
While the test is active, **d1** and **tESt** appear on the positioner display in alternating sequence and ✍ indicates manual operating mode.
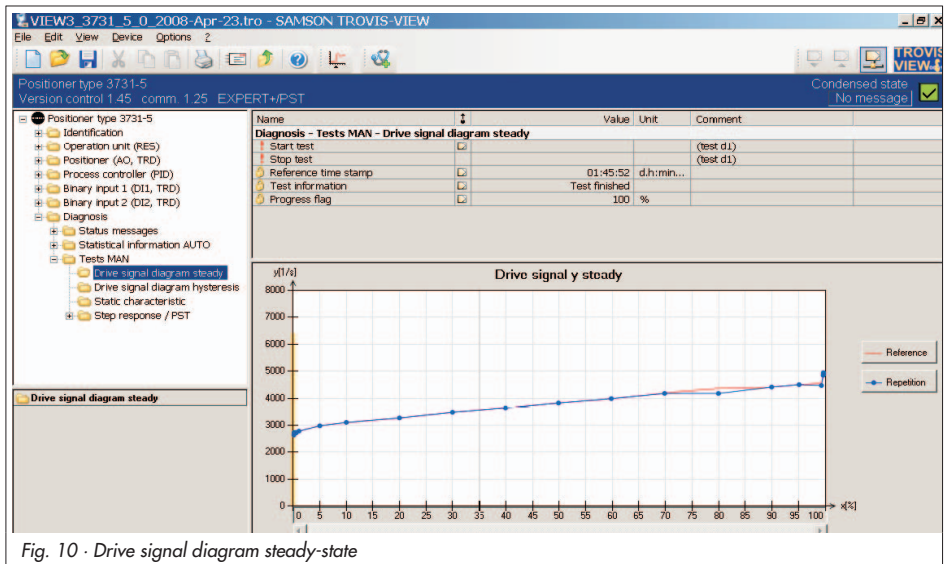
Fig. 10 · Drive signal diagram steady-state

Viewing the recorded parameters:

The *Drive signal diagram steady-state* folder contains the reference and repeated measurements in a table and in a graph plotting the drive signal versus the valve position.

Test requirements:

▶ A successfully plotted reference graph and repetition lines are necessary in order to analyze the data.
If a reference graph still has not been plotted on starting the test, this test is adopted as the reference.

▶ Refer to section 1.6 in case a double-acting actuator with reversing amplifier or a booster is used or start-up was performed in the SUB mode (substitute calibration).

3.1.2 Drive signal diagram hysteresis (d2)

Fig. 11

Similar to the corresponding test in statistical information AUTO, this test (d2) is used to analyze the change in friction forces. However, unlike the test in statistical information AUTO, this test causes the valve to move to defined valve positions over the travel range, and determines Δy for each valve position.

The valve is made to move to fixed nodes of the valve position x and the valve position is ramped up (< 1 %) correspondingly.

The drive signal y and the change in valve opening are analyzed during this test concerning changes in Δy for changes in direction to precisely check the results or any alarms issued in automatic mode.

If the valve cannot move to a certain valve position node or the setpoint leaves the *Tolerance band of hysteresis* during the test, a message is generated in *Test information* and the test is canceled.

The necessary data set for the reference graph is automatically plotted and stored directly after initialization. The start time for the reference graph is stored with the *Reference time stamp* in the non-volatile memory of the positioner. Any further measurement is stored as a repeated measurement.

Previously recorded repeated measurements stored in the positioner are overwritten. However, you can upload previous repeated measurements to a computer before you start a new test.

While the test is active, **d2** and **tESt** appear on the positioner display in alternating sequence. ⌀ indicates manual operating mode.
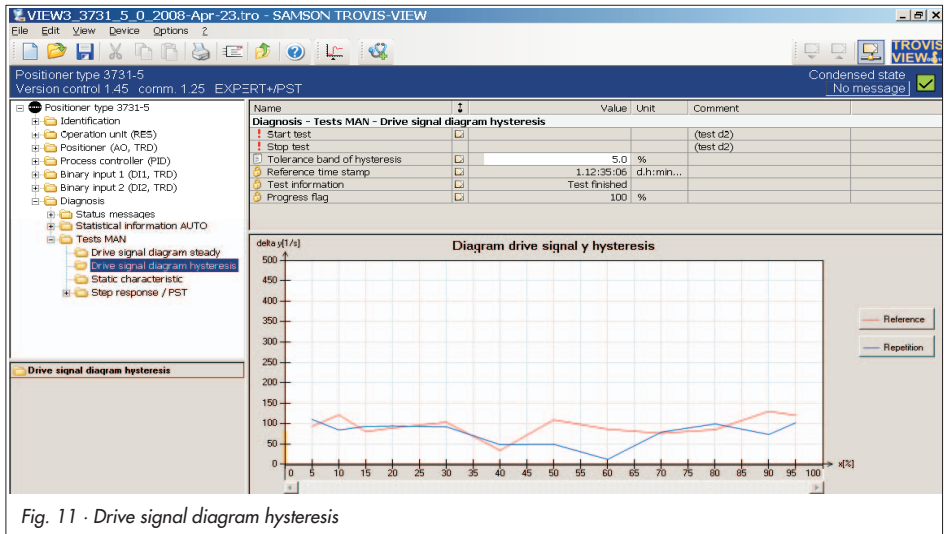

Fig. 11 · Drive signal diagram hysteresis

Viewing the recorded parameters:

The *Drive signal diagram hysteresis* folder contains a table or graph with reference measurements and the last repeated measurement performed plotting the change in drive signal Δy versus the valve position x.

Test requirements:

▶ A successfully plotted reference graph and repeated measurements are necessary in order to analyze the data.
If a reference graph still has not been plotted on starting the test, this test is adopted as the reference.

▶ Refer to section 1.6 in case a double-acting actuator with reversing amplifier or a booster is used or start-up was performed in the SUB mode (substitute calibration).

3.1.3 Static characteristic (d3)

Fig. 12

The static performance of the control valve is affected by the friction hysteresis and the elastic processes in the valve stem packing. The static characteristic is plotted to check the static performance. An analysis of the control loop is performed using the analysis parameters: *Min. dead band, Max. dead band* and *Average dead band*.

To accomplish this, the reference variable w is commanded in small steps and the response of the valve position x is plotted after waiting a predetermined period of time. This test (d3) allows the full working range of the valve to be recorded in manual mode.

It is also possible to define a test range by selecting the *Start* and *End* parameters. The ascendent and descendent are plotted within the test range. 100 measured points are plotted at the maximum, i.e. max. 50 measured points are available for the ascendent and the descendent.

The step height and the number of measuring points are determined automatically by the adjusted test range. The dead band is analyzed by a step height smaller than 0.2 %.

The setpoint difference that causes a minimal change in the valve position x is termed dead band. It is recorded and analyzed in the positioner for each step.

While the test is active, **d3** and **tESt** appear on the positioner display in alternating sequence. ✍ indicates manual operating mode.
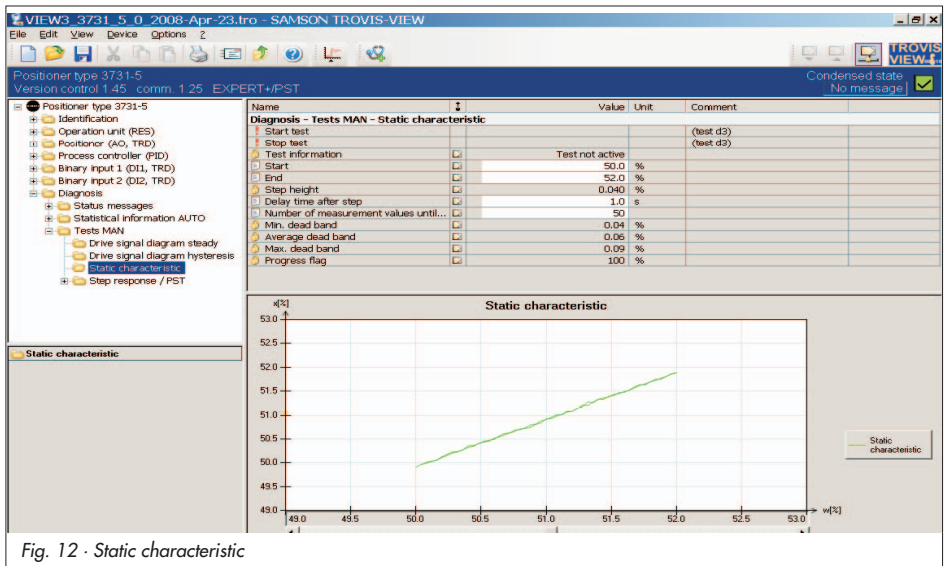

Fig. 12 · Static characteristic

Viewing the recorded parameters

The *Static characteristic* folder contains a table and a graph of the measured points, plotting the valve position x versus the reference variable w.
The *Measured data* subfolder (>*Valve position x*) and (> *Reference variable w*) contain a table of the individual corresponding measured points.

Data can be reset the *Diagnosis* folder (> *Status messages* > *Reset*).

Test requirements

The starting point must be smaller than the final point.
The dead band is analyzed if the step height is smaller than 0.2 %.

Reset

Data can be reset to their default settings in the *Diagnosis* folder (> *Status messages* > *Reset*).

3.2 Partial stroke test – PST (d4)

Fig. 13

The partial stroke test *(d4)* is particularly suitable for the status-oriented detection of malfunctions in pneumatic shut-off valves. As a result, the probability of failure on demand (PFD) can be reduced and maintenance intervals may possibly be extended.

The partial stroke test can prevent a valve normally in its end position from seizing up or getting jammed. Recording the test additionally allows an analysis of the dynamic control response.

During the partial stroke test, the valve is moved from a defined start value, e.g. the operating point (end position), either in steps or in a ramp function until it reaches a defined final value. Then, the valve is moved back again to its initial position.

The partial stroke test can be performed, for example between 5 and 10 % based on the start value while the plant is running, yet without disrupting plant operation. The start and final values for the partial stroke test can be configured by the user.

The various test cancelation conditions provide additional protection against the valve slamming shut and moving past the final value. The increasing and decreasing characteristic are analyzed separately.

Partial stroke tests can be started and canceled either manually at any time (on site or using an engineering tool) or automatically according to a certain time schedule.

A test status is determined at the end of a partial stroke test, which allows operators to directly see whether the test has been completed successfully or not. When the test has not been completed successfully, possible reasons why the test was canceled are given. The test status and the reason for the
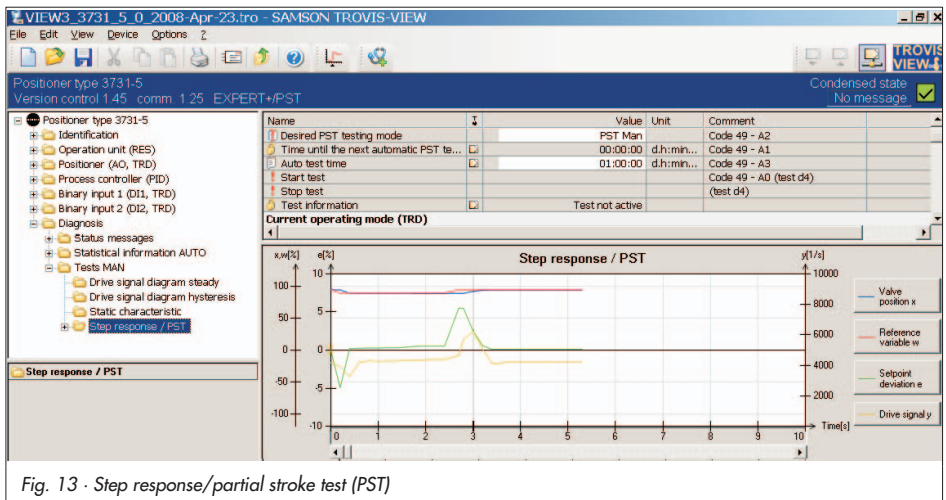

Fig. 13 · Step response/partial stroke test (PST)

cancelation are indicated on the positioner's display and in the engineering tool used.

Upon failure of the auxiliary power, the automatic activation of the partial stroke test remains active. The time counter in *Auto test time* is reset to 0 again.
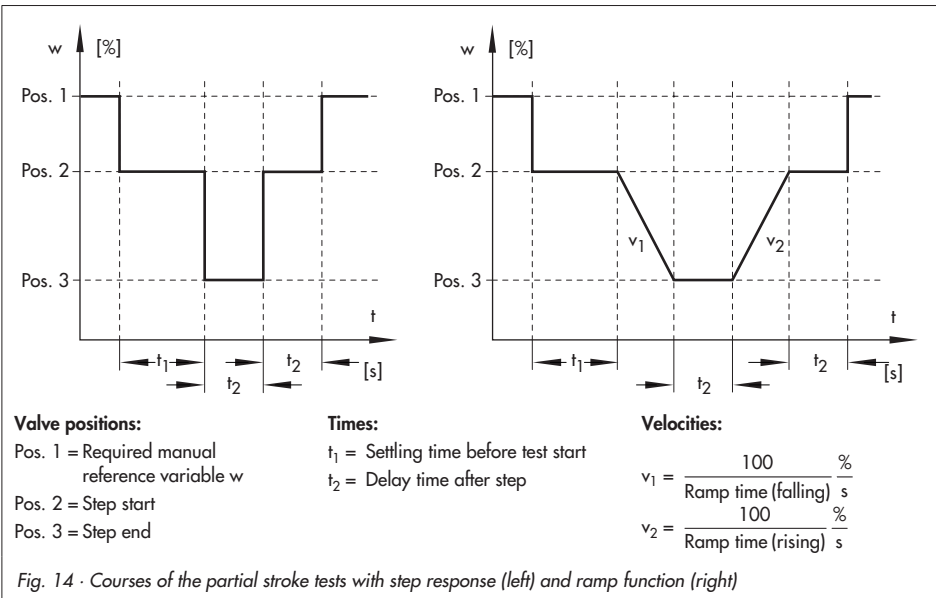
The hysteresis test d5 from statistical information AUTO as well as the setpoint deviation histogram and cycle counter histogram are also available in manual mode if the partial stroke test is automatically started (PST Auto) (refer to section on starting the partial stroke test).
Changes to the parameters are possible regardless of the operating mode when the *PST Man* is set in the *PST testing mode* parameter.

Note: *You can configure the partial stroke test either over the operator interface or directly at the positioner by selecting Code 49. These instructions contain a supplement to the code list in EB 838x-5 EN listing Code 49 (section 9 on page 53).*

Depending on the parameter settings, the partial stroke test is conducted either in steps or in a ramp function of the valve position (see Fig. 14).

After being activated, the test does not start until the *Settling time before test start* (t_1) has elapsed. This waiting period ensures that the valve has reached the position defined by the *Step start* parameter (pos. 2) before the test starts.

Valve positions:
Pos. 1 = Required manual reference variable w
Pos. 2 = Step start
Pos. 3 = Step end

Times:
t_1 = Settling time before test start
t_2 = Delay time after step

Velocities:
$$v_1 = \frac{100}{\text{Ramp time (falling)}} \frac{\%}{\text{s}}$$
$$v_2 = \frac{100}{\text{Ramp time (rising)}} \frac{\%}{\text{s}}$$

Fig. 14 · Courses of the partial stroke tests with step response (left) and ramp function (right)

Starting from the *Step start* position (pos. 2), the valve moves to the defined end position (*Step end* parameter, pos. 3). The valve remains in this position for the time defined by the *Delay time after step* (t_2) before performing a second step change in the opposite direction from *Step end* (pos. 3) to *Step start* (pos. 2). After the *Delay time after step* (t_2) has elapsed, the valve is moved back to its initial position (= *Required manual reference variable w*, pos. 1).

The *Step tolerance limit* sets the permissible tolerance limit for the step's start and end values.

The *Scan rate* defines the interval at which the measured values are recorded during the test.

The positioner stores a maximum of 100 measured values per measured variable (valve position x, reference variable w, setpoint deviation e, drive signal y and the time when they were recorded).
The *Min. recommended scan time,* which should not be shorter, if at all possible, is calculated from the *Duration of the test.*

After 100 measured values per measured variable have been stored, the logging is stopped. However, the test is still completed. The *Measured data storage out of memory* alarm is generated if the test is not ended with data logging.

The **Display** section in TROVIS-VIEW3 shows the *Progress flag* in percent.

1. Step response function, Fig. 14 left
The step response function is activated when the *Activation of the ramp function* parameter is set to "No".
The valve is moved in steps to the *Step end* position (pos. 3) during the first half of the test and to the *Step start* position (pos. 2) during the second half of the test.

2. Ramp function, Fig. 14 right
The ramp function is active when the *Activation of the ramp function* parameter is set to "Yes" (default).
A step before the partial stroke test can be prevented when the *Step start* parameter is consistent with the operating point of the positioner.
The valve is moved to the *Step end* (pos. 3) and *Step start* (pos. 2) positions with fixed velocities (v_1 and v_2) set by the *Ramp time (falling)* and *Ramp time (rising)* parameters. The ramp time specifies the time required by the valve to move through the travel range 100 to 0 % (falling) and 0 to 100 % (rising).

Note: Times for the Ramp time (falling/rising) *are determined during initialization of the positioner. Do not set the times in these parameters below these limits for the partial stroke test with ramp function.*

Cancelation conditions

The positioner cancels the partial stroke test when one of the following activated cancelation conditions is fulfilled. This cancelation causes a classified status alarm to be generated.

Definable cancelation conditions include:

▸ *Max. test duration*: 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.
The condition is only active when *Activation x control* is set to "Yes".

▸ *delta y-monitoring value*: The test is canceled when the control signal y falls below the predetermined comparison value. This comparison value is made up from *delta y-monitoring reference value* parameter and the set safety factor *delta y-monitoring value.*
The *delta y control value* is set in % and is based on the entire control signal range (10 000 1/s).
The cancelation condition is active when *Activation delta y-monitoring* is set to "Yes".
Monitoring the delta y only makes sense when the partial stroke test is performed as a ramp function.
The results of the first partial stroke test are used as reference values.

▸ *PST tolerance band*: The test is canceled as soon as the deviation of the valve position (in relation to the step height) exceeds the adjusted value. The condition is only active when *Activation PST tolerance band control* is set to "Yes".

Note: Changes to the parameters listed below cause the delta y-monitoring *to change as well as the* Scan time *and* Max. test duration *parameters. As a result, new reference values need to be saved.*
– Step start
– Step end
– Activation of the ramp function
– Ramp time (falling)
– Ramp time (rising)
– Delay time after step

Starting the partial stroke test

The partial stroke test can be started manually or automatically according to a time schedule.

▸ **Manual start of the partial stroke test (AO Transducer Block)**
The test can be started and canceled using the ENHANCED_ DIAG_CMD parameter in the AO Transducer Block (see page 40). The test is started in the *PST Man* testing mode. The AO Transducer Block must be in the Local Override mode (display of on-site operation: ✍) or in the manual mode (display ✍ and ↻). Refer to section 8 on page 52.
In the manual mode, the reference variable can be determined by the FINAL_VALUE parameter of the AO Transducer Block.

▸ **Manual start of the partial stroke test using DI2 Function Block**
To start the partial stroke test and evaluate the condensed status, the DI2 Function Block can be used. It can be activated by selecting the "Condensed status and PST" option of the SELECT_

BINARY_ INPUT2 parameter in the Resource Block. The partial stroke test is started when the simulation is locked by writing the discrete value 7 on the SIMULATION_ VALUE with a status greater than "uncertain".
The condensed status is issued at the discrete output OUT_D for analysis purposes.
The DI2 Function Block allows the test to be started manually from any operating mode with either *PST Man* and *PST Auto*. Refer to section 8 on page 52.

Note: *On enabling the simulation, the partial stroke test of the DI2 Function Block is deactivated.*

▶ **Automatic starting of the test according to a predetermined time schedule (Auto test time)**
An automatic test according to a time schedule is only performed when the *Auto test time* parameter is set to ≠ 0. The testing mode also needs to be switched over to *PST Auto*. The first test is started when the interval has elapsed for the first time.
The *Time until the next automatic PS Test takes place* parameter indicates the time that remains until the next test is started.

tEst d4 appears on the positioner display during the test.

The following listed parameters are changed correspondingly during a partial stroke test:

▶ Lower x-range value (Code 8): 0 %
▶ Upper x-range value (Code 9): 100 %

▶ w-ramp OPEN/CLOSED (Codes 21/22): variable

A successfully performed partial stroke test is logged. The cancelation messages created by the partial stroke test are recorded in the logging. Should the same fault occur again at a later point in time, this message is relogged.
The results of the first partial stroke test are used as reference values.

Measured data analysis

Analyses of the last three partial stroke tests completed are saved in the positioner with a time stamp and a statement about how the test was started (manually or automatically). If the test has not been completed successfully, the reason why the test was canceled is indicated under "Maintenance alarm".

Possible reasons for cancelation depending on the defined cancelation conditions are:

▶ *x cancelation*: The valve position fell below the *x control value*.
▶ *y cancelation*: The drive signal fell below the predefined comparison value (see description on page 36).
▶ *Tolerance band exceeded*: The deviation of the valve position exceeded the *PST tolerance band*.
▶ *Max. test time exceeded*: The test was not completed within the specified period of time.

Further error messages include:

▶ *No text available*
▶ *Test man. canceled:* The test has been manually canceled.
▶ *Measured data storage out of memory*: The scan rate has been selected too low.

After 100 measured data per measured variable have been recorded, the logging stops. However, the test is continued.

▶ *Int. sol. valve/forced venting*: The test was canceled because the internal solenoid valve has been triggered (Type 3730-5) or the forced venting has been activated (Type 3731-5).

▶ *Supply pressure/friction*: An insufficient supply pressure or excessive friction occurred during the test.

When a partial stroke test has been completed successfully, analyzed parameters are also displayed separately for the increasing and the decreasing characteristic.

Parameters for a partial stroke test (step response):

▶ *Overshoot (relative to the step height) [%]*
▶ *Dead time* [s]
▶ *T63* [s]
▶ *T98* [s]
▶ *Rise time* [s]
▶ *Settling time* [s]
▶ *Minimum value for y control (y_Min) [1/s]*

Parameters for a partial stroke test (ramp):

▶ *Overshoot (relative to the step height) [%]*
▶ *Minimum value for y control (y_Min) [1/s]*

If the test has not been completed successfully, this is indicated under Code 82. The influence on the condensed state is determined in the *Partial Stroke Test - Status active* parameter (default: Maintenance requested).

Reset

Using the *Reset PST* parameter, the parameters of the partial stroke test are reset to their default values.
Any recorded measured values and error messages are deleted. Logging messages are not changed.
Resetting the start-up parameters over Code 36 also resets the PST parameters.

3.2.1 Step reponse

The dynamic performance of the control valve can be tested by plotting its step response.

The step response of the valve is plotted with the PST function by sudden changes in the valve position. To proceed, the *Activation of the ramp function* parameter needs to be set to *"No"* (see Fig. 14, left). In addition, the following settings are recommended:

▸ Deactivate all cancelation conditions of the partial stroke test (see page 35).

▸ Start the partial stroke test manually (PST Man).

After the test is completed, the data are automatically analyzed in the positioner and the *Overshoot*, *Dead time*, *T63*, *T98*, *Rise time*, *Settling time* and *Minimum value for y control* parameters are determined separately for both step responses.

Viewing the recorded parameters:

The *PST* folder contains a graph plotted over time of the parameters required for an analysis of the step response such as the reference variable w, valve position x, setpoint deviation e and drive signal y.

3.3 Data logger

The data logger from the statistical information AUTO can also be started in the manual mode (refer to section 2.1) and, as a result, is available in the *PST Auto* and *PST Man* testing modes. Changes can only be made when *PST Man* is set.

Accessible functions of ENHANCED_DIAG_CMD parameter:

0   No function
1   Start data logger
2   Abort data logger
3   Start hysteresis online test
4   Abort hysteresis online test
5   Start partial stroke test/step response
6   Abort partial stroke test /step response
7   Start test in turn
8   Abort test in turn
9   Start drive signal diagram steady
10 Abort drive signal diagram steady
11 Start drive signal diagram hysteresis
12 Abort drive signal diagram hysteresis
14 Abort static characteristic
15 Start reference test
16 Abort reference test
17 Reset event logger
21 Reset 'X – long term histogram'
22 Reset 'Cycle counter histogram – long term'
23 Reset 'E long term setpoint deviation'
24 Reset 'Y - X long term'
25 Reset 'Y - X short term'
26 Reset 'Hysteresis long term'
27 Reset 'Lower end position'
28 Reset 'Lower end position – ref. values'
29 Reset 'X – short term histogram'
30 Reset 'E – short term setpoint deviation'
31 Reset 'Cycle counter histogram – short term'
32 Reset 'Hysteresis short term'
37 Reset 'Step response/partial stroke test'
38 Reset 'Y - X measured values
39 Reset 'Hysteresis measured values'

4 Diagnosis – Status alarms

4.1 Standard EXPERT alarms

The standard EXPERT diagnostics provides information about positioner states such as operating hours counter, process monitoring, number of zero calibrations and initializations, total valve travel, temperature, initialization diagnostics, zero/control loop errors, etc.

In addition, the standard EXPERT diagnostics generates messages and status alarms which allow faults to be pinpointed quickly when a fault occurs. The messages and status alarms generated by EXPERT appear on the positioner display and can also be viewed on the TROVIS-VIEW interface in the *Diagnosis* folder (> *Status messages*).

Alarms and messages are classified in the following main groups:

▷ Status
▷ Operation
▷ Hardware
▷ Initialization
▷ Data memory
▷ Temperature

Further information on the positioner status (e.g. tight-closing function) and the parameters (e.g. characteristics) are displayed in the *Positioner (AO/TRD)* folder.

The following folders contain particularly informative data for valve diagnostics:

▷ *Positioner (AO/TRD)* folder (> Process data)
  Information on the current process variables, condensed state, state of the Transducer Block and temperature.
  The Trend Viewer function (activate *Trend Viewer* in the *View* menu) allows process variables to be shown in one or more graphs.
  To proceed, drag and drop the required process variable into the graph.

▷ *Positioner (AO/TRD)* folder (> *Error control*)
  Information on total travel with a freely defined limit

▷ *Positioner (AO/TRD)* folder (> *Error control > Classification report*)
  Classification of individual events/alarms with a status

▷ *Positioner (AO/TRD)* folder (> *Start-up > Initialization*)
  List of initialization errors which can also be found in the *Diagnosis* folder (> *Status messages*).

▷ Diagnosis folder (> *Status messages > Logger*)
  Alarms recorded that have been sent by the positioner.

4.2 Extended EXPERT[+] alarms

Further status alarms are generated from the extensive information gained in the diagnostic functions of EXPERT[+] and the partial stroke test which provide the user with information covering the whole control valve. These status alarms can be viewed in the *Diagnosis* folder (> *Status messages* > *Extended*).

An active alarm generated by EXPERT[+] or by the partial stroke test appears on the positioner display over Code *79*.

A partial stroke test that has not been successfully completed is also registered in *Code 82*.

4.3 Logging

The last thirty alarms (EXPERT/ EXPERT[+]) are stored in the positioner with a time-stamp (logged by the operating hours counter).

The alarms stored can be viewed in the *Status message* folder > *Logger*.
Entries can be reset in the *Reset* folder.

4.4 Condensed state

To provide a better overview, the state of the positioner is summarized in a condensed state which is made up from a summary of all classified alarms generated by the positioner.

Note: If an event is classified as "No message", this event does not have any affect on the condensed state of the positioner.

The condensed state is displayed in the engineering tool (TROVIS-VIEW/DTM) as well as on the positioner display as in the table below.

Additionally, the condensed state can be read from the CONDENSED_STATE parameter in the Resource Block and from the OUT_D parameter in the DI Function Blocks.

Note: The condensed state and status alarms are marked with ☐ in TROVIS-VIEW3 until they have been read out.

Condensed state	TROVIS-VIEW/DTM	Positioner display
Maintenance alarm	❌ red	▮▮
Maintenance required/ Maintenance requested	◆ blue	🔧
Function check	▽ orange	Text
No message	✅ green	

4.5 Classification of the status alarms

A status is assigned to every event or alarm.

The following states listed in the table below are possible.

Select *Positioner (AO, TRD)* folder (> *Error control* > *Classification report*) to modify the classification of standard alarms generated by EXPERT.

Select *Positioner* (AO, TRD) folder (> *Error control* > *Classification report* > Extended) to modify the classification of alarms generated by EXPERT[+].

All additional alarms generated by EXPERT[+] have the status "No message" by default, except for the status alarms for the partial stroke test (PST). The status alarm for the partial stroke test has the "Maintenance required" as its default setting.

On resetting the positioner parameters to their default settings (Code 36), the status classification is also reset to the default setting.

Note: If modifications that have already been made should be kept, we recommend uploading them on a computer before performing a reset and then downloading them onto the positioner again afterwards.

The following classifications are possible:

▷ **Maintenance alarm**
The positioner cannot perform its control task due to a functional fault in the device or in one of its peripherals or an initialization has not yet been successfully completed.

▷ **Maintenance required/requested**
The positioner still performs its control task (with restrictions). A maintenance requirement or above average wear has been determined. The wear tolerance will soon be exhausted or is reducing at a faster rate than expected. Maintenance is necessary in the medium term.

▷ **Function check**
Test or calibration procedures are being performed. The positioner is temporarily unable to perform its control task until this procedure is completed.

Status classification of individual alarms	TROVIS-VIEW3/DTM
Maintenance alarm	red
Maintenance required/ Maintenance requested	blue
Function check	orange
No message	white

Status classification over FOUNDATION™ fieldbus

The CONDENSED_ STATE is created by summarizing all classified status alarms from the positioner and is available in the Resource Block. In addition, the CONDENSED_STATE is shown in the OUT_D parameter of the DI Function Blocks and appears on the positioner display. The status of individual alarms can be assigned as required using the ERROR_OPTS parameter.

The following classifications of the states are possible:

▶ Maintenance required
▶ Maintenance requested
▶ Maintenance alarm
▶ Function check
▶ No message

In addition to the condensed state, the messages of **Block Error** (Resource and AO Transducer Block) can also be assigned to the events:

▶ No message
▶ Device needs maintenance soon
▶ Device needs maintenance now

5   Resetting diagnosis parameters

When an alarm is issued, the source of the error should be first located and the error remedied.

In the case of an EXPERT alarm, we recommend reading the recommended action in the error code list (refer to EB 8384-5 EN or EB 8387-5 EN).

Recommended action on EXPERT$^+$ alarms are listed in the table in section 7.

Standard EXPERT diagnostics

Alarms generated by EXPERT, which are indicated on the positioner display by an error code, can be confirmed by pressing the rotary pushbutton after selecting the corresponding error code.

Resetting error codes as well as resetting options such as logging or the total valve travel can be performed using an engineering tool, for example, TROVIS-VIEW3 software (see Fig. 15).

Extended EXPERT$^+$ diagnostics

Extended alarms generated by EXPERT$^+$ are based upon the tests in statistical information AUTO and tests MAN. An active EXPERT$^+$ alarm is indicated by Code *79* in the positioner. A partial stroke test that has not been successfully completed is also registered in *Code 82.*

Select *Diagnosis* folder (> *Status messages > Reset*) to reset data from statistical information AUTO and tests MAN (see Fig. 15). Note that the corresponding short-term histogram/short-term monitoring is also reset on resetting long-term histogram/long-term monitoring. The data of the partial stroke test are directly reset in the *Diagnosis* folder (> *Tests MAN > Step response/Partial stroke test > Reset - PST*).

On performing the tests MAN, the measuring data of the last measurement as well as the reference measurements (for d1 and d2) are stored in the positioner.

Fig. 15 · Resetting diagnostic parameters

On restarting a test MAN, the existing data are updated by the repeated measurement data and stored in the positioner.
In addition, the repeated measurements of the tests MAN such as drive signal diagram steady-state and drive signal diagram hysteresis can be reset by selecting the *Diagnosis* folder (> *Status messages* > *Reset*).

Resetting the measured data does not cause the reference graphs to be reset:

▹ Drive signal diagram steady-state
▹ Drive signal diagram hysteresis
▹ Reference value for the end position trend

However, the existing data set is replaced by the new reference data when the reference graphs for steady-state and hysteresis graphs (see section 1.5) are replotted. The data sets from already existing measurements of steady-state and hysteresis graphs recorded in both statistical information AUTO and tests MAN are reset when both reference graphs are updated.

Initialization

After an initialization has been successfully completed, new reference measurements are automatically plotted and the existing reference data are overwritten. The new reference data and the optimized control parameters cause the following statistical information AUTO and MAN tests to be reset:

▹ Drive signal diagram steady-state (statistical information AUTO and tests MAN)
▹ Drive signal diagram hysteresis (statistical information AUTO and tests MAN)

▹ Setpoint deviation histogram (long-term and short-term)
▹ End position trend
▹ Partial stroke test
A reference measurement needs to be performed due to the new ramp times (see note on page 35).

Resetting over Code 36 (EXPERT/EXPERT⁺)

Activate Code 36 or select *Operation unit* folder (> *Start with default settings*) to reset the positioner parameters to their default settings (see code list in EB 8384-5 EN or EB 8387-5 EN).
The following diagnostic functions of EXPERT/EXPERT⁺ diagnostics are reset:

▹ Settings and activated tests from statistical information AUTO and tests MAN in EXPERT+
▹ Operating hours counter: (> *Device switched on since initialization*) and (> *Device since initialization in control loop*) (EXPERT)
▹ Total valve travel (EXPERT)
▹ All short-term histograms (EXPERT+) Drive signal diagram steady-state and diagram hysteresis from statistical information AUTO and tests MAN (EXPERT+)
▹ Static characteristic and partial stroke test (EXPERT+)
▹ End position trend (EXPERT+)

Additionally, the status classification is reset. If the same status classification is to be used in future, you can upload the settings onto a computer over, for example, TROVIS-VIEW software.

Mounting the positioner onto another control valve

As the EXPERT+ extended diagnostics provides statements about the entire control valve, the data from statistical information AUTO and tests MAN need to be reset when the positioner is attached to a different control valve.

After mounting the positioner on the new control valve, perform a reset over Code 36 and re-initialize the positioner. This leads to the most of the diagnostic functions being reset.

We recommend additionally to manually reset the long-term travel histogram and the long-term cycle counter histogram as well as the logging by selecting the *Diagnosis* folder (> *Status messages* > *Reset*).

6 Diagnostic parameters saved in non-volatile memory

	Data saved if a parameter change is detected	Cyclic saving (24 h)
Data logger	Data logging, scan rate, start value, logging limit, trigger status	
Travel histogram	Scan rate of short-term monitoring	Data for long-term histogram
Setpoint deviation histogram		
Cycle counter histogram		
Drive signal histogram (steady-state)		Data for short-term and long-term histograms
Drive signal histogram (hysteresis) (d5)	Minimum time between tests, start test	Data for long-term monitoring
End position trend	Measured values when end position changes	
Drive signal diagram (steady-state) (d1)	Reference test, reference time stamp	
Drive signal diagram (hysteresis) (d2)		
Static characteristic (d3)		
Partial stroke test (d4)	Delta y-monitoring reference value, Activation delta y-monitoring, Delta y-monitoring value, Step start, Step end, Activation of the ramp function, Ramp time (falling), Ramp time (rising), Settling time before test start, Delay time after step, Scan rate, Activation x control, x control value, Activation PST tolerance band control, PST tolerance band, Maximum test duration, parameters for analysis, Number of steps, Step tolerance limit	
Actuator and valve data	Yes	
Logging	Save when a new alarm is issued	
Classification of status alarms	Yes	

7 Troubleshooting

Fault category	Alarm	Recommended action	Resetting alarm
Supply pressure	Possibly changed (TEST)[1]	Check supply pressure. Refer to the section on supply pressure in EB 8384-5 EN or EB 8387-5 EN.	Reset y-x signature measured data
	Possibly at full capacity (TEST)[1]		
	Possibly insufficient		Reset over Code 57. Reset y-x long-term and short-term monitoring
Trend concerning working range of valve	Working range shift CLOSED position	Check the valve working range.	Reset x long-term and short-term histograms
	Working range shift max. OPEN		
Air leakage in the pneumatics	Possibly exists (TEST)[1]	Check pneumatic actuator and connections for leakage.	Reset y-x signature measured data
	Possibly too much (TEST)[1]		
	Possibly too much		Reset y-x long-term and short-term monitoring Reset over Code 57.
	Possibly exists		
Restriction of full range of valve	Downwards	Check pneumatic accessories and connections for leakage.	Reset over Code 57.
	Upwards		
	No change possible (terminals)	Check supply pressure and increase it, if necessary. Refer to the section on supply pressure in EB 8384-5 EN or EB 8387-5 EN. Check plug stem for problems caused by an external source.	Reset e short-term histogram

Reset e long-term histogram |
| End position trend | Zero point shift downwards monotonic | Check plug and seat | Reset lower end position trend |
| | Average value above the reference line | | |

End position trend (continued)	Zero point shift upwards monotonic Average value above the reference line	Check plug and seat	Reset lower end position trend
	Zero point fluctuates Average value above the reference line		
	Zero point shift downwards monotonic Average value below the reference line		
	Zero point shift upwards monotonic Average value below the reference line		
	Zero point fluctuates Average value below the reference line		
Mechanical connection linking positioner/ control valve	Possible restriction of the full range of valve	Check attachment	Reset e short-term histogram
Full range of valve	Mainly near to CLOSED position	Reconsider whether the working range is suitable	Reset x long-term histogram
	Mainly near to max. OPEN		
	Mainly CLOSED position		
	Mainly max. OPEN		
Friction	Much higher over the full range of valve	Check packing	Reset hysteresis long-term and short-term monitoring
	Much lower over the full range of valve		
	Much higher over part of the range		
	Much lower over part of the range		

Friction (continued)	Much higher/lower over the full range of valve (TEST)[1]	Check packing	Reset hysteresis measured data
	Much higher/lower over part of the range (TEST)[1]		
Actuator springs	Spring rigidness possible reduced (spring failure) (TEST)[1]	Check springs in the actuator	Reset y-x signature measured data
	Compression possible reduced (TEST)[1]		
Seat leakage	Possibly different	Check plug and seat	Reset y-x signature measured data
			Reset e short-term histogram
Leakage to the atmosphere	Maybe to be expected soon	Check packing	Reset hysteresis long-term and short-term monitoring
			Reset hysteresis measured data
			Reset z long-term histogram
Dynamic stress factor [2]	Percentage as information on packing load Leakage to the atmosphere alarm active when greater than 90 %	Check packing	Reset z long-term histogram
Partial stroke test	PST status set	Check cancelation conditions (p. 35) and measured data analysis (p. 37) Check valve for malfunction (e.g. blockage).	Restart test after correcting

[1] Generated by tests MAN
[2] This value is included in the Cycle counter histogram in statistical information AUTO

8   Starting partial stroke test manually

Operating mode (on-site display)	PST testing mode	Partial stroke test start manually (see page 36)		PST configuration possible
		AO Transducer Block	DI2 Function Block	
⟋ (AO Transducer Block in Local Override mode)	PST Man	Yes	Yes	Yes
	PST Auto	No	Yes	*PST testing mode* and *Auto test time* only
↻	PST Man	No	Yes	Yes
	PST Auto	No	Yes	*PST testing mode* and *Auto test time* only
⟋ and ↻ (AO Transducer Block in MAN mode)	PST Man	Yes	Yes	Yes
	PST Auto	No	Yes	*PST testing mode* and *Auto test time* only

9   Code 49 in parameter list

Supplement to code list in section 15.1 of EB 8384-5 EN or EB 8387-5 EN

Code no.	Parameters – display, Values [default settings]	Description
Note!		Code 49 must be enabled for configuration first over Code 3. Refer to EB 8384-5 EN or EB 8387-5 EN. The PST parameters (except for A2 and A3) can only be changed in the *PST Man* testing mode.
49	**PST parameters**	
	A0 d4 - Start test	
	A1 Time until the next automatic PST test Display only	Time remaining until the next partial stroke test is started (only applies in manual mode).
	A2 Activation of auto test time Auto - Man, [Man]	Activates or deactivates the automatic partial stroke test according to time
	A3 Auto test time 1 to 56280 h, [1 h]	Required time for repeating a partial stroke test
	A4 Status classification of Partial Stroke Test - Status active OK · C · CR · b, [C]	The following status classification are possible for a partial stroke test that has not been completed successfully: OK No message C Maintenance required CR Maintenance requested b Maintenance alarm
	A5 Recommended minimum scan rate Display only	The scan rate parameter (d9) should be configured to this value at least.
	A6 y_Min Display only	Display of minimum y value from the last performed partial stroke test.
	A7 delta y-monitoring reference value Display only	Predetermined limit for y cancelation. Automatically determined during the test.
	A8 Activation of delta y-monitor. Yes - No, [Yes]	Activates or deactivates the delta y-monitoring.
	A9 delta y-monitoring value 0.0 to 100 % [10 %]	Safety factor added to the reference value.

Code no.	Parameters – display, Values [default settings]	Description
49	d0 – Unassigned –	
	d1 – Unassigned –	
	d2 Step start 0.0 to 100.0 %, [100.0 %]	Start value for step response test
	d3 Step end 0.0 to 100.0 %, [90.0 %]	End value for step response test
	d4 Activation of the ramp function Yes – No, [Yes]	Activates or deactivates the ramp function.
	d5 Ramp time (rising) 0 to 9999 s, [value determined during initialization, minimum value: 15 s]	Ramp time for 0 to 100 % (rising) of the ramp function. A suitable value is determined during initialization; if possible, make sure the ramp time does not fall below this value.
	d6 Ramp time (falling) 0 to 9999 s, [value determined during initialization, minimum value: 15 s]	Ramp time for 100 to 0 % (falling) of the ramp function. A suitable value is determined during initialization; if possible, make sure the ramp time does not fall below this value.
	d7 Settling time before test start 1 to 240 s, [10 s]	Delay time before test is started to ensure that the valve can be moved to the step start position safely (t_1, Fig. 14).
	d8 Delay time after step 2.0 to 240 s, [2.0 s]	Delay time between the first and the second step change (t_2, Fig. 14).
	d9 Scan rate 0.2 to 250 s, [0.2 s]	Scan rate of step response measurement
	E0 Activation x control Yes – No, [No]	Activates or deactivates x monitoring
	E1 x control value −10.0 to 110.0 %, [0.0 %]	The test is canceled when the valve position falls below this value.
	E2 – Unassigned –	
	E3 – Unassigned –	
	E4 – Unassigned –	
	E5 Activation PST tolerance band control Yes – No, [Yes]	Activates or deactivates PST tolerance band monitoring

Code no.	Parameters – display, Values [default settings]		Description
49	E6	PST tolerance band 0.1 to 100.0 %, [5.0 %]	The test is canceled when the deviation of the valve position exceeds this percentage.
49	E7	Max. test duration 30.0 to 25000.0 s, [30.0 s]	Maximum test duration; the test is canceled in any case when this period has elapsed.
	E8	– Unassigned –	
	E9	Reset PST	All PST parameters are reset to their default values. All measured data are deleted.
PST error codes (display only)			
	F0	No test available	No test available or test canceled manually
	F1	Test OK	
	F2	x cancelation	Test canceled by the x cancelation function
	F3	y cancelation	Test canceled by the y cancelation function
	F4	Tolerance band exceeded	The test has been canceled. x values outside the tolerance band occurred
	F5	Max. test time exceeded	Test not completed within the maximum test duration and therefore canceled
	F6	Test manually canceled	Test canceled by the user
	F7	Measured data storage out of memory	Storage for measured values out of memory. After 100 measured values per measured variable, the logging is stopped. However, the test is still continued.
	F8	Int. solenoid valve/forced venting	**Type 3730-5:** Test canceled because the solenoid valve has been triggered **Type 3731-5:** Test canceled because the forced venting has been activated
	F9	Supply pressure/ friction	Test canceled due to insufficient supply pressure or excessive friction