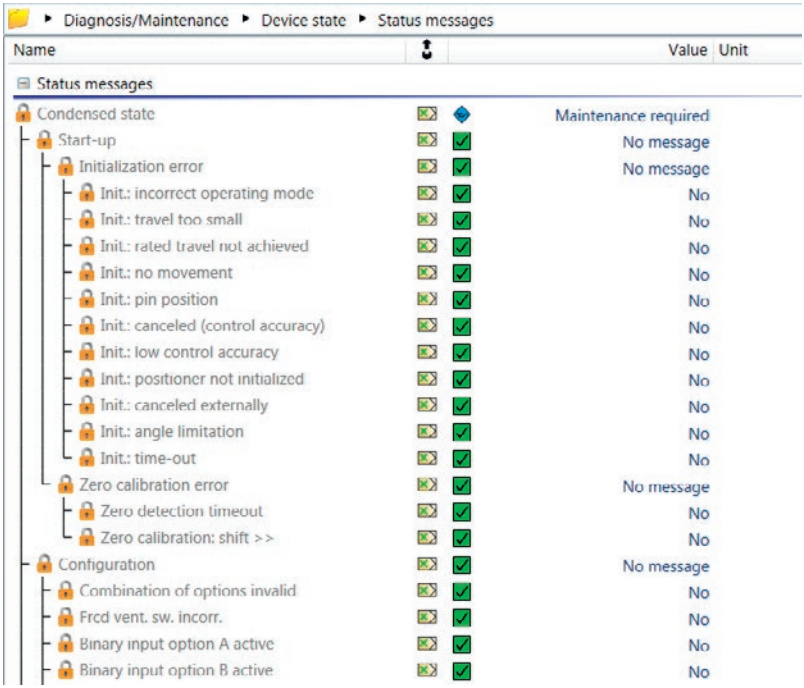
OPERATING INSTRUCTIONS

# EB 8389-3 EN

**Translation of original instructions**




## EXPERTplus Valve Diagnostics

TROVIS 3730-3 Electropneumatic Positioner

Firmware version 2.00.xx

Edition January 2019

**Note on these operating instructions**

These operating instructions assist you in operating the device safely. The instructions are binding for handling SAMSON devices.

➔ For the safe and proper use of these instructions, read them carefully and keep them for later reference.

➔ If you have any questions about these instructions, contact SAMSON's After-sales Service Department (aftersalesservice@samson.de).

The operating instructions for the devices are included in the scope of delivery. The latest documentation is available on our website at ***www.samson.de > Service & Support > Downloads > Documentation***.

**Definition of signal words**

**⚠ DANGER**

*Hazardous situations which, if not avoided, will result in death or serious injury*

**⚠ WARNING**

*Hazardous situations which, if not avoided, could result in death or serious injury*

***NOTICE***

*Property damage message or malfunction*

***Note***

*Additional information*

***Tip***

*Recommended action*

# 1 Safety instructions and measures

**Intended use**

EXPERTplus is a diagnostic firmware integrated into the positioner which allows the predictive, status-oriented maintenance of valves with pneumatic actuators.

EXPERTplus records the valve condition while the process is running (in automatic mode) and generates messages on the required maintenance work. In addition, numerous tests can be performed in manual mode to pinpoint emerging faults.

The diagnostic functions of EXPERTplus are completely integrated into the positioner. Diagnostic data are compiled, saved and analyzed in the positioner itself. Classified status messages on the state of the valve are generated from the analysis.

**Reasonably foreseeable misuse**

While the tests are being performed, the valve does not follow the set point. Instead, it is moved according to the test specifications. Therefore, the tests can only be started when the conditions in the plant allow it.

**Qualifications of operating personnel**

The devices are to be configured and set by trained and experienced personnel only. According to these operating instructions, trained personnel refers to individuals who are able to judge the work they are assigned to and recognize possible hazards due to their specialized training, their knowledge and experience as well as their knowledge of the applicable standards.

**Personal protective equipment**

No personal protective equipment is required.

**Revisions and other modifications**

Revisions or other modifications of the product are not authorized by SAMSON. They are performed at the user's own risk and may lead to safety hazards, for example. Furthermore, the product may no longer meet the requirements for its intended use.

**Safety features**

The software in offline mode has no influence on the connected device.

### Warning against residual hazards

The software in online mode has a direct influence on the connected device and, as a result, on the valve. To avoid personal injury or property damage, plant operators and operating personnel must prevent hazards that could be caused in the control valve by the process medium, the operating pressure, the signal pressure or by moving parts by taking appropriate precautions. They must observe all hazard statements, warning and caution notes in the referenced documents.

### Responsibilities of the operator

The operator is responsible for proper operation and compliance with the safety regulations. The operator is obliged to provide these operating instructions as well as the referenced documents to the operating personnel and to instruct them in proper operation. Furthermore, the operator must ensure that operating personnel or third persons are not exposed to any danger.

### Responsibilities of operating personnel

Operating personnel must read and understand these operating instructions as well as the referenced documents and observe the specified hazard statements, warnings and caution notes. Furthermore, the operating personnel must be familiar with the applicable health, safety and accident prevention regulations and comply with them.

### Referenced standards and regulations

None

### Referenced documentation

The following documents apply in addition to these operating instructions:

– Mounting and operating instructions (EB), safety manual (SH) and configuration manual (KH) for mounted device:
  ▶ EB 8484-3 and ▶ KH 8384-3
– Mounting and operating instructions for the associated control valve (actuator, valve and other valve accessories)

## 1.1 Notes on possible property damage

***NOTICE***

**Valve malfunction due to a configuration that does not meet the requirements of the application.**

Settings for the EXPERTplus valve diagnostics can be made in the TROVIS-VIEW software. In online mode of this software, the configuration and parameter settings take effect immediately in the connected positioner and affect the control valve as a result.

➔ Only activate the online mode when configurations, parameter settings and measured values are to be transferred from or to the device.

# 2 Operation

**Operation using TROVIS-VIEW/DD/DTM/eDD**

EXPERTplus allows the parameters to be viewed or changed using the TROVIS-VIEW software or DD/DTM/eDD.

– **TROVIS-VIEW** · SAMSON user interface used to configure various SAMSON devices
– **DTM** · Device type manager to describe the device and communication properties
– **DD/eDD** · Device description/enhanced device description

***Note***

*All parameter settings and configurations must also be downloaded onto the positioner to allow them to become effective.*

## 2.1 On-site operation

Some parameters can be changed at the positioner as well as over the user interface. Refer to the mounting and operating instructions of the TROVIS 3730-3 Positioner (▶ EB 8484-3) for a list of all parameters that can be changed at the positioner.

## 2.2 Operation using TROVIS-VIEW

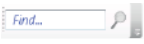
Operation using TROVIS-VIEW is described in these operating instructions. The following applies in this case:

– The default settings of parameters are written in square brackets [ ].
– Operation applies to the 'Diagnosis' user level.

**Note**

*The installation and operation of the TROVIS-VIEW software is explained in detail in the Operating Instructions ▶ EB 6661. These instructions are available on the Internet and in the [?] menu in TROVIS-VIEW.*

**Tip**

*The [Find...] function in the menu bar can be used to look for parameters:* 


# 3 Start-up

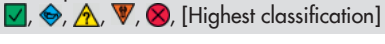
The positioner must be initialized to use the full scope of the valve diagnostics. During initialization the positioner adapts itself optimally to the friction conditions and the signal pressure required by the control valve. The positioner can be initialized using one of the following initialization modes: MAX, NOM or MAN. All functions of EXPERTplus cannot be used when a positioner has been initialized in the SUB mode.

1. Connect the positioner with the configuration and operating software.
   ➔ The TROVIS-VIEW software on a computer can be connected to the positioner using an isolated USB interface adapter (order no. 1400-9740).
2. Put the positioner into operation as described in the Mounting and Operating Instructions ▶ EB 8484-3.

   When initialization fails, the positioner generates a status message with the assigned status classification. See section 4.

   If a status message is generated during initialization, the group status 'Start-up' and 'Initialization' are also generated with the assigned status classification. See section 4.

**> Diagnosis/maintenance > Device state > Status classification**

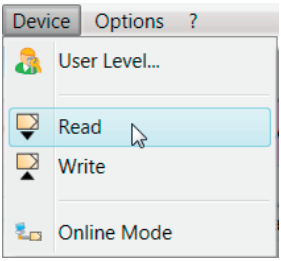
– Start-up:
 , [Highest classification]

– Initialization: ☑, ◈, ⚠, ▼, ⊗, [Highest classification]
– Init: incorrect operating mode: [☑], ◈, ⚠, ▼, ⊗
– Init: travel too small: ☑, [◈], ⚠, ▼, ⊗
– Init: rated travel not achieved: ☑, [◈], ⚠, ▼, ⊗
– Init: pin position: ☑, [◈], ⚠, ▼, ⊗
– Init: no movement: ☑, [◈], ⚠, ▼, ⊗
– Init: canceled (control accuracy): ☑, ◈, ⚠, ▼, ⊗, [highest classification]
– Init: low control accuracy: ☑, ◈, ⚠, ▼, ⊗, [highest classification]
– Positioner not initialized: ☑, ◈, [⚠], ▼, ⊗
– Init: canceled externally: ☑, [◈], ⚠, ▼, ⊗
– Init: angle limitation: ☑, ◈, ⚠, ▼, ⊗, [highest classification]
– Init: timeout: ☑, ◈, ⚠, ▼, ⊗, [highest classification]

**> Diagnosis/maintenance > Device state > Status messages**

– Start-up
– Initialization error
– Init: incorrect operating mode
– Init: travel too small
– Init: rated travel not achieved
– Init: no movement
– Init: pin position
– Init: canceled (control accuracy)
– Init: low control accuracy
– Init: positioner not initialized
– Init: canceled externally
– Init: angle limitation
– Init: timeout

3. Read out positioner data.
   ➔ In TROVIS-VIEW: select menu [Device > Read].




# 4 Device state

## 4.1 Information parameters and limits

[> Diagnosis/maintenance > Device state] contains information parameters on the positioner state and the limits used to generate status messages.

### Stress factor

The stress factor range is directly linked to the load cycle histogram. See section 5.1.4.

The load on the bellows and/or packing can be read from the 'Dynamic stress factor' parameter.

– 'Dynamic stress factor'
– 'Stem seal'

**> Diagnosis/maintenance > Device state**

– Stem seal: Self-adjusting, Adjustable, Bellows, Other, [Not selected]

**Total valve travel**

– 'Total valve travel': totaled full valve travel cycle
– 'Total valve travel limit': the 'Total valve travel' status message is generated when the total valve travel exceeds the limit.

**> Diagnosis/maintenance > Device state**

– Total valve travel:
1000 to 90,000,000, [1,000,000]

**Set point deviation**

– 'Lag time for set point deviation': the lag time is determined during initialization. It is the reset criterion for the 'Set point deviation' status message.
A transit time of less than 180 s determined during initialization causes the 'Lag time of set point deviation' to be set to 30 s. A transit time of 180 s or more determined during initialization causes the 'Lag time of set point deviation' to be set to six times the transit time.
– 'Tolerance band for set point deviation +/-': a set point deviation is recognized as a system deviation when the valve position deviates from the set point by the value adjusted in this parameter.

**Temperature**

– See section 4.5 for [Temperature] folder.

**Time**

– 'Operating hours counter'
– 'Device switched on since last initialization'
– 'Device in closed-loop operation'
– 'Device in closed-loop operation since last initialization'

**Counter**

– 'Number of initializations'
– 'Number of zero calibrations'

**Save**

– 'Diagnostic data': the diagnostic data are saved in a non-volatile memory (EEPROM).

### 4.1.1 Reset

➔ Refer to Table 1

| **Table 1:** *Reset in [> Diagnosis/maintenance > Device state]* | 'Reset diagnosis' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|
| Reset information parameters without operating hours counter | NO | YES | YES | NO | NO |
| Reset operating hours counter | NO | NO | NO | NO | NO |
| Reset limits | NO | YES | YES | NO | NO |

1) Reset depending on limit

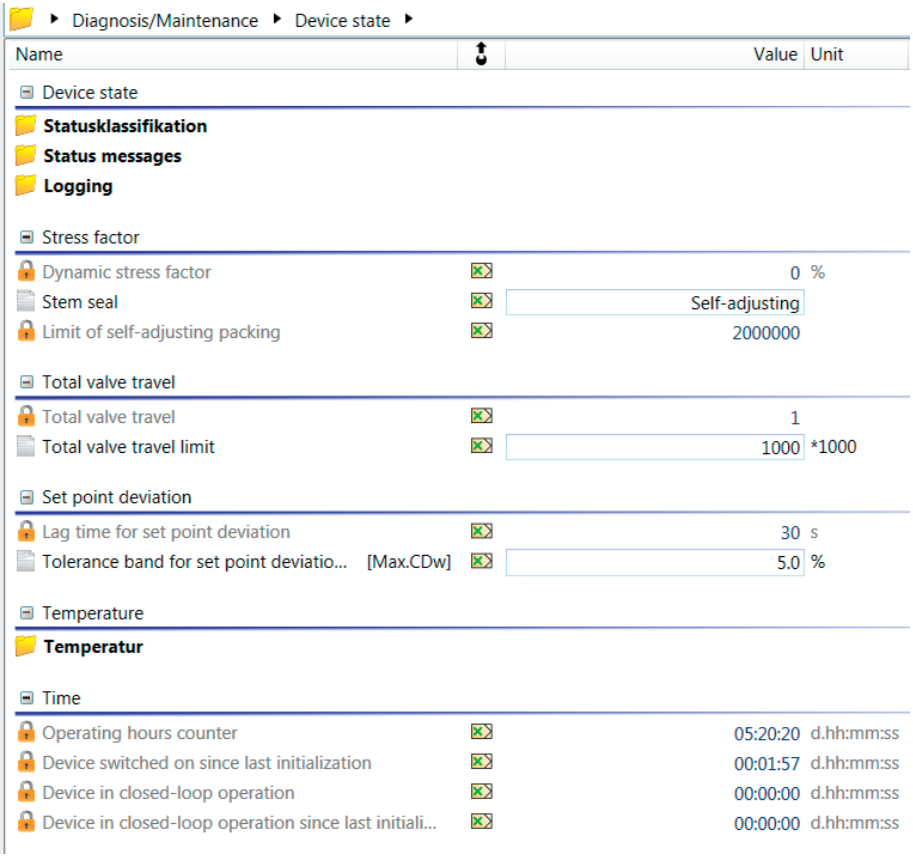



**Fig. 1:** *> Diagnosis/maintenance > Device state*

## 4.2 Status classification

A status classification is assigned to the status messages of the EXPERTplus valve diagnostics. This assigned status appears when a status message is generated.

The following classifications are possible:

Priority

- **No message**
  If an event is classified as 'No message', this event does not have any affect on the condensed state.
- **Maintenance required**
  The positioner still performs its control task (with restrictions). A maintenance demand 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.
- **Out of specification**
  The positioner is running outside the specified operating conditions or has not yet been initialized.
- **Function check**
  Test or calibration procedures are performed in the positioner. The positioner is temporarily unable to perform its control task as long as the procedure is taking place.
- **Failure**
  The positioner cannot perform its control task due to a functional fault in the positioner itself or in one of its peripherals.
- **Highest classification**
  Status classification of a group status (see section 4.3.1). The group status depends on the status classification assigned to the status messages: the status message with the highest classification determines the group status.

**Note**

*In the 'On-site: write' TROVIS-VIEW user level, the active status messages are visible. In some cases, only the active group status is visible without the assigned status messages.*

The status classification is predetermined in [> Diagnosis/maintenance > Device state > Status classification]. All status messages are assigned to a status by default.

**Note**

*The 'Out of specification' status is assigned to a positioner that has not yet been initialized.*

### 4.2.1 Reset

➔ Refer to Table 2

| **Table 2:** *Reset in [> Diagnosis/maintenance > Device state > Status classification]* | 'Reset diagnosis' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|
| Reset status classification | NO | NO | YES | NO | NO |

## 4.3 Status messages

The valve diagnostics integrated into the positioner generates classified status messages. All status messages with their assigned status are listed in [> Diagnosis/maintenance > Device state > Status classification].

**i** ***Note***

*The '☑ No message' status is generated when:*

- *The conditions to generate a status message are not fulfilled.*
- *The conditions to generate a status message are fulfilled, but the status message is assigned the 'No message' status.*

➔ We recommend following the instructions listed in the Appendix when a status message occurs.

### 4.3.1 Group and condensed states

To provide a better overview on the individual status messages, various status messages are summarized in a **group status**. If a status message assigned to a group is active, the group status is generated according to the predefined status classification.

The **condensed state** is summary of all status messages. To provide a better overview on the condition of the valve, all status messages are summarized in a condensed state which is made up from a summary of all classified messages in the positioner. The status message with the highest priority determines which condensed state is set. The status message with the highest priority determines the condensed state.

***Tip***

*The condensed state is indicated on the right-hand corner of the status bar in TROVIS-VIEW.*

## 4.4 Logging

EXPERTplus can log up to 400 events. They are listed in [> Diagnosis/maintenance > Device state > Logging] together with additional information on the event and the time it occurred.

Logging starts automatically. It does not need to be activated by the user.

For example, the following events are logged:

– The positioner was started up.
– The positioner was successfully initialized.
– EXPERTplus generates a status message.
– A generated status message has been canceled.
– A test was successfully completed.

**Tip**

*Use [Find...] function to find a certain event:*


**Note**

*When the 'Log 'No message' (NAMUR classification)' parameter is activated, events are also logged even when their status classification is set to 'No message'. The activation does not affect the issuing of status messages.*

### 4.4.1 Reset

➔ Refer to Table 3

## 4.5 Temperature

The temperature inside the device is displayed:

– 'Temperature inside device': current temperature inside the device
– 'Min. temperature inside device': the lowest temperature inside the device while in service
– 'Max. temperature inside device': the highest temperature inside the device while in service
– 'Minimum temperature limit': the 'Temperature inside device below min. limit' status message is generated with the assigned status classification when the temperature inside the device falls below the limit. The status message is canceled as soon as the temperature rises above the limit again.
– 'Maximum temperature limit': the 'Temperature inside device above max. limit' status message is generated with the assigned status classification when the temperature inside the device exceeds the limit. The status message is canceled as soon as the temperature falls below the limit again.

**Note**

*The 'Minimum temperature limit' and 'Maximum temperature limit' parameters are set to –60 °C and 80 °C respectively by default. These settings can only be changed in the 'Customer expert' user level.*

### 4.5.1 Reset

➔ Refer to Table 4

| **Table 3:** *Reset in [> Diagnosis/maintenance > Device state > Logging]* | 'Reset logging' | 'Reset diagnosis' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|---|
| Reset logging | YES | NO | YES | YES | NO | NO |

| **Table 4:** *Reset in [> Diagnosis/maintenance > Device state > Temperature]* | 'Reset diagnosis' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|
| Reset temperature values | NO | NO | [1] | NO | NO |

[1] YES = 'Minimum temperature limit' and 'Maximum temperature limit'
NO = 'Temperature inside device', 'Min. temperature inside device' und 'Max. temperature inside device'

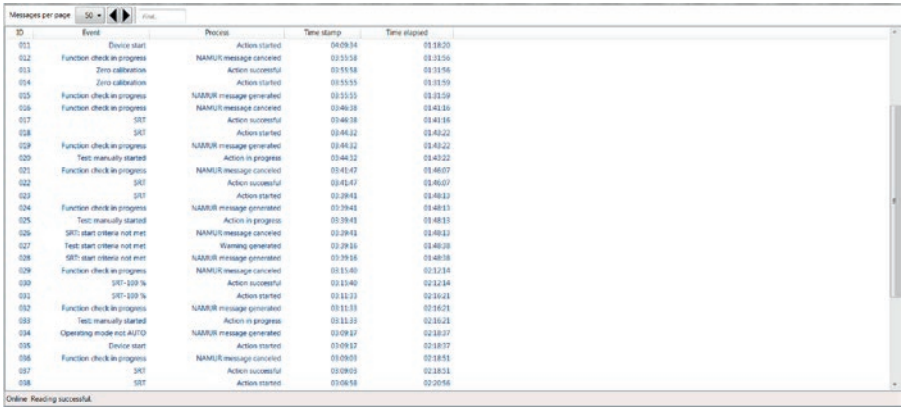



**Fig. 2:** *> Diagnosis/maintenance > Device state > Logging*

# 5 Monitoring

Monitoring compiles data while the process is running without disrupting the process. The data are saved and analyzed in the positioner, i.e. the positioner follows the set point to position the valve. A classified status message is generated when the positioner detects an event.

## 5.1 Histograms

Histograms are statistical analysis which are performed by the positioner in the AUTO and SAFE modes. For this purpose, data are logged every second and saved in a non-volatile memory every 24 hours.

Data logging and analysis do **not** need to be activated.

EXPERTplus has histograms on the following topics:

– Valve position (see section 5.1.2)
– Set point deviation (see section 5.1.3)
– Load cycle (see section 5.1.4)

The histograms can be displayed for different monitoring periods. The monitoring periods are defined in the drop-down menu and using the slider at the bottom of the histogram:


– Drop-down menu: [Service life], Days, Weeks, Months, Years
– Slider:

  Days: [Today], Yesterday, Day before yesterday, Three days ago, …, Six days ago

  Weeks: [This week], Last week, Week before last, Three weeks ago

  Months: [This month], Last month, Month before last, Three months ago, …, Eleven weeks ago

  Years: [This year], Last year, Year before last, Three years ago, …, Five years ago

### 5.1.1 Reset

The valve position, set point deviation and load cycle histograms are all reset. It is not possible to reset single histograms.

➔ Refer to Table 5

**Table 5:** *Reset the valve position, set point deviation and load cycle histograms.*

| | 'Reset histograms' | 'Reset diagnosis' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|---|
| Reset measured data | YES | YES | YES | YES | NO | NO |

## 5.1.2 Valve position

The valve position histogram provides information about the range in which valve mainly works during its service life and whether the operating range is possibly shifting.

The positioner records the valve position every second and assigns the data into predefined valve position classes. The distribution showing how often the sound level occurred within a valve position class is shown in a bar graph.

**Analysis and monitoring**

The first and last class indicate how often the 'End position w ≤' and 'End position w ≥' functions have been triggered.

– The 'End position w ≤' function causes the valve to move to the closed position when the valve position reaches an adjustable set point.
– The 'End position w ≥' function causes the valve to move to the open position when the valve position reaches an adjustable set point.

The functions can be adjusted in [> Configuration > Set point processing].

A valve position that is mainly located close to the closed or open position pinpoint to a valve that is too large or too small.

➔ We recommend checking the valve sizing.

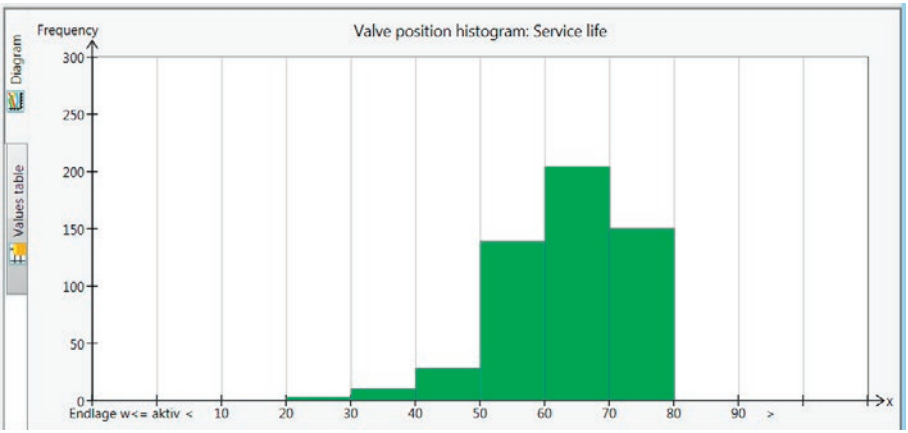



**Fig. 3:** *> Diagnosis/maintenance > Monitoring > Histograms > Valve position*

### 5.1.3 Set point deviation

The set point deviation histogram provides information on to which extent a set point deviation has occurred and whether faults may occur due to a restricted working range.

The positioner records the set point deviation every second and assigns the data into predefined classes. The distribution showing how often the set point deviation remained within a class is shown in a bar graph.

**Analysis and monitoring**

Ideally, the set point deviation should be as close to 0 % as possible.

Set point deviations greater than 1 % following in quick succession pinpoint to a limitation of the upper working range.

➔ We recommend checking the attachment. Set point deviations smaller than 1 % following in quick succession pinpoint to a limitation of the lower working range or to seat leakage.

➔ We recommend checking the attachment as well as the seat and plug for wear.

If almost all set point deviations during the short-term monitoring are greater than 1 % or smaller than –1 %, this may indicated that the actuator or valve stem is jammed.

➔ We recommend checking the plug stem for external influences that could be blocking it.

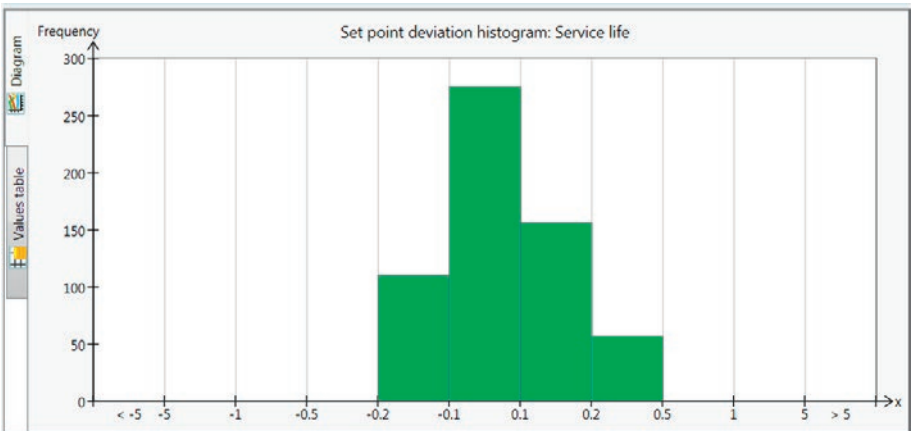



**Fig. 4:** *> Diagnosis/maintenance > Monitoring > Histograms > Set point deviation*

## 5.1.4 Load cycle

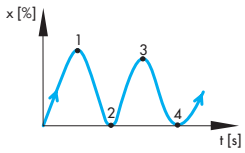
The load cycle histogram provides a statistical analysis of the cycles that the valve has moved through. As a result, the cycle counter also provides information on the dynamic stress of a bellows seal and/or packing.

The positioner records the height of the cycles that the valve has moved through taking the selected stem seal into account.

The cycles are assigned to classes. The distribution showing how often the cycle occurred within a class is shown in a bar graph.

**Note**

*A valve cycle span starts at the point where the valve stroke changes direction until the point where it changes direction again.*




**> Diagnosis/maintenance > Device state**

– Stem seal: [Not selected], Self-adjusting, Adjustable, Bellows, Other

**NOTICE**

*No analysis of 'Dynamic stress factor' with 'Stem seal' = 'Not selected' (= default setting).*
*Set 'Stem seal' parameter to allow an analysis of the load cycle histogram to be performed.*

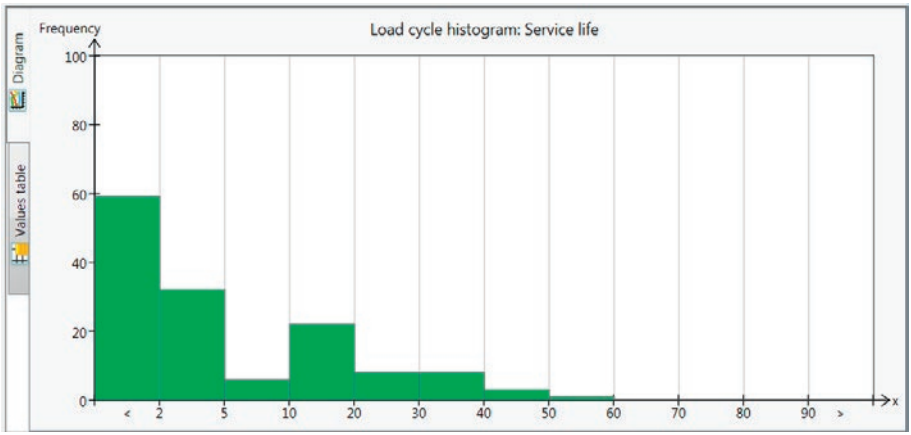



**Fig. 5:** *> Diagnosis/maintenance > Monitoring > Histograms > Load cycle*

### Analysis and monitoring

The load on the bellows and/or packing can be read from the 'Dynamic stress factor' parameter. The value is determined from the cycle spans or cycle heights and takes into account the type of packing used in the valve.

A 'Dynamic stress factor exceeded' status message is generated with the assigned status classification whenever:

– The number of measured cycle spans exceeds 2,000,000 when 'Self-adjusting' is selected as the stem seal.
– The number of measured cycle spans exceeds 800,000 when 'Adjustable' is selected as the stem seal.
– The number of measured cycle spans exceeds 90 % of the 'Max. cycle count' when 'Other' is selected as the stem seal.
– The number of measured cycle heights exceeds 8473930 when 'Bellows' is selected as the stem seal.

*Tip*

*The level of stress that the packing is exposed to depends on other factors besides load cycles, e.g. on the process medium and the operating conditions. Therefore, in the 'Customer expert' user level, it is possible to adapt the limits to trigger the 'Dynamic stress factor exceeded' status message as required.*

**> Diagnosis/maintenance > Device state**

– Dynamic stress factor

**> Diagnosis/maintenance > Device state > Status classification**

– Dynamic stress factor exceeded: ☑, [◈], ⚠, ▼, ⊗

**> Diagnosis/maintenance > Device state > Status messages**

– Dynamic stress factor exceeded

➔ We recommend checking the condition of the packing when the status message is generated to prevent external leakage.

## 5.2 Course of end position

Data are recorded in the background regardless of the operating mode selected when the conditions for logging data are fulfilled (see sections 5.2.1 and 5.2.2). Data logging does not need to be activated.

The course of end position function records the measured data when the valve moves to the end position:

– Valve position
– Temperature
– Time stamp of operating hours counter

The new recorded end position is compared to the last saved end position. If the valve position deviates by 0.3 % from the last value, the data of the new end position are saved.

A graph of the recorded end positions is plotted over time.

The positioner saves the valve positions in a circular buffer, which holds 30 measured values at one time.

**Analysis and monitoring**

The 'Course of lower end position' and 'Course of upper end position' status messages are generated with the assigned status classification whenever a new recorded end position deviates from the reference value by the 'Threshold for end position shift'. The reference value is determined during initialization (see sections 5.2.1 and 5.2.2). It is shown as a straight line in the graph.

**> Diagnosis/maintenance > Monitoring > Course of end position**

– Threshold for end position shift:
  0.3 to 100.0 %, [5.0 %]

**i** ***Note***

*When temperature fluctuations occur and with valves with a long insulating section, the 'Course of lower end position' and 'Course of upper end position' status messages may be generated at an early stage.*

### 5.2.1 Course of lower end position

To record data for the course of lower end position (behavior during tight closing), the following conditions must exist:

– The positioner was initialized in the MAX or NOM mode.
– The tight-closing function is active ('Lower end position' parameter = 'Activated').

**> Configuration > Set point processing**

– Lower end position: **[Activated]**

**i** ***Note***

*When the end position function is active, the valve shuts off tightly as soon as the set point is lower or equal to the value entered in 'End position w <='.*

The reference value for the course of the lower end position is reference zero. This is de-

termined during a MAX or NOM initialization and during a zero calibration.

**> Diagnosis/maintenance > Device state > Status classification**

– Lower end position shifted:


**> Diagnosis/maintenance > Device state > Status messages**

– Lower end position shifted

The generation of the 'Lower end position shifted' status message in combination with a shift of the course of the end position downward pinpoints to signs of wear between seat and plug in metal-seated valves.

➔ We recommend checking the seat and plug for wear.

**Note**

*The 'Lower end position shifted' status message is generated briefly after the initialization of soft-seated valves for design reasons. The soft seal settles after a few load cycles causing zero to be shifted. In these valves, a repeated generation of the status message after a long time service first indicates signs of wear.*

The generation of the 'Lower end position shifted' status message in combination with a shift of the course of the end position upward pinpoints to a blockage of the plug stem, e.g. due to dirt particles.

➔ We recommend checking the plug stem for mechanical blockage.

### 5.2.1.1 Reset

➔ Refer to Table 6

**Table 6:** *Reset the course of end position*

| | | Zero calibration | 'Reset course of end position' | 'Reset diagnosis' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|---|---|---|
| Reset reference value | Lower end position | YES | NO | NO | YES | YES | NO | YES |
| | Upper end position | NO | NO | NO | YES | YES | NO | YES |
| Reset measured data | Lower end position | NO | YES | YES | YES | YES | NO | YES |
| | Upper end position | NO | YES | YES | YES | YES | NO | YES |
| Reset status message | Lower end position | YES | NO | YES | YES | YES | NO | NO |
| | Upper end position | NO | NO | YES | YES | YES | NO | NO |

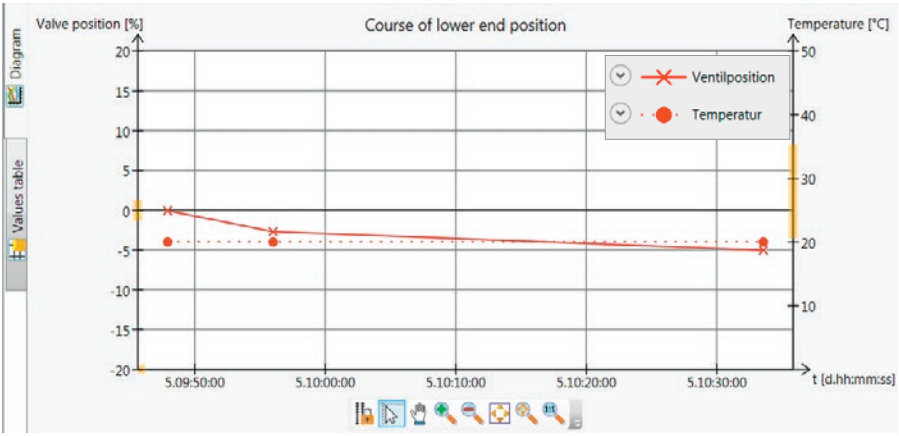



**Fig. 6:** *> Diagnosis/maintenance > Monitoring > Course of lower end position*

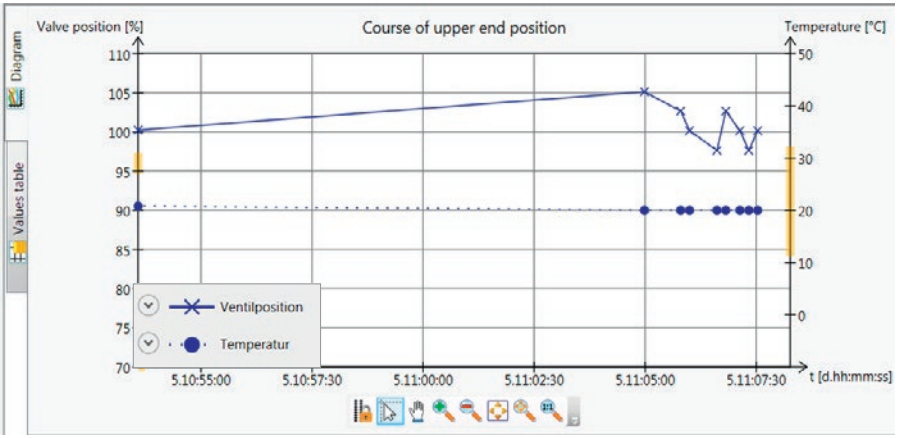



**Fig. 7:** *> Diagnosis/maintenance > Monitoring > Course of upper end position*

### 5.2.2 Course of upper end position

The positioner must be initialized in the MAX mode to allow course of end position data to be recorded.

The reference value for the course of the top zero point is the travel at the open valve position. It is determined only in the MAX initialization mode.

**Analysis and monitoring**

If the analysis of course of the upper end position pinpoints a fault, the positioner generates the 'Upper end position shifted' status message with the assigned status classification.

| **> Diagnosis/maintenance > Device state > Status classification** |
|---|
| – Upper end position shifted: ✓, [◆], ⚠, ▼, ⊗ |

| **> Diagnosis/maintenance > Device state > Status messages** |
|---|
| – Upper end position shifted |

➔ We recommend checking the plug stem for mechanical blockage when the status message is generated.

#### 5.2.2.1 Reset

➔ Refer to Table 6

## 6 Tests

Similar to the monitoring, data are compiled, saved and analyzed in the positioner for the tests. **However, in this case, the valve position is not determined by the set point, but by the active test.** The tests 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 step response test (PST), can only be performed in the MAN mode.

**i** ***Note***

*An active test is stopped and the positioner changes to the fail-safe position when the electrical signal falls below a certain level or when the forced venting function is triggered.*

### 6.1 Step response test (PST)

**i** ***Note***

*Depending on the software version, the terms "Step response test (SRT)", "step response (PST)" or "partial stroke test (PST)" are used. They all refer to the same test.*

The step response test (PST) 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 it may be possible to extend maintenance intervals. A shut-off valve normally in its end position can be prevented from seizing up or getting

jammed. The initial breakaway torque must first be overcome after the valve starts to move from its end position. The initial breakaway torque depends on the plug/seat seal, deposits on the plug, the process medium and friction at the valve trim. After the initial breakaway torque has been overcome, it can be assumed that the valve is able to close completely. The recording of the test results additionally allows an analysis of the dynamic control response.

During the step response test, the valve moves from its current operating point by the defined change in travel and back to the initial position again. The change in travel is calculated from the 'Start value' and 'Step height'.

The change in travel can be performed either in steps or in a ramp function (Fig. 8). The test is performed with the ramp function when the ramp times ('Ramp 1' and 'Ramp 2') are set to ≠ 0 s.

The test starts after reaching the 'Start value' and the 'Waiting time' has elapsed. Starting from the 'Start value', the valve moves through the 'Step height' in the 'Test direction'. The valve remains in this position for the time defined in 'Waiting time' before performing a second step change in the opposite direction to the operating point. The 'Sampling time' defines the time interval between which the measured values are recorded during the test.

**> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration**

– Start value: –20 to 120 %, [100 %]
– Step height: 2 to 100 %, [10 %]
– Test direction: [Minus], Plus
– Ramp 1: 0 to 9999 s, [60 s]
– Ramp 2: 0 to 9999 s, [6 s]
– Waiting time: can only be selected in the 'Customer expert' user level
– Sampling rate (not write-enabled)

## 6.1.1 Test cancelation criteria

Various test cancelation conditions provide additional protection against the valve slamming shut or moving further than step height. The positioner cancels the step response test when one of the following cancelation conditions is fulfilled:

**Time**

– 'Canceled: max. test duration': the test is canceled when the maximum permissible test duration is reached.

  **> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration**

  – Canceled: max. test duration (not write-enabled)

– 'Canceled: max. dead time': the test is canceled when the adjusted 'Waiting time' has elapsed without the valve having moved by the value 'Dead time limit determined'.

  This cancelation criterion only takes effect when 'Dead time limit determined' is set to ≠ 0 %.

**> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration**

– Canceled: max. dead time (not write-enabled)
– Dead time limit determined: can only be selected in the 'Customer expert' user level

### Tolerance bands

– 'Start value of tolerance band +/–': the test is not started when the operating point is outside the range: 'Start value' ± 'Start value of tolerance band +/–'.

**> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration**

– Start value of tolerance band +/–: 1 to 100 %, [3 %]

– 'Canceled: tolerance band (ramp) +/–', 'Canceled: tolerance band (step) +/–': The test is canceled as soon as the deviation of the valve position (in relation to the theoretical step end value, calculated from the 'Start value' and 'Step height') exceeds the adjusted value.

This cancelation criterion only takes effect when 'Canceled: tolerance band (ramp) +/–' or 'Canceled: tolerance band (step) +/–' is set to ≠ 0 %.

**> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration**

– Canceled: tolerance band (step) +/–: can only be selected in the "Customer expert" user level
– Canceled: tolerance band (ramp) +/–: 1 to 100 %, [5 %]

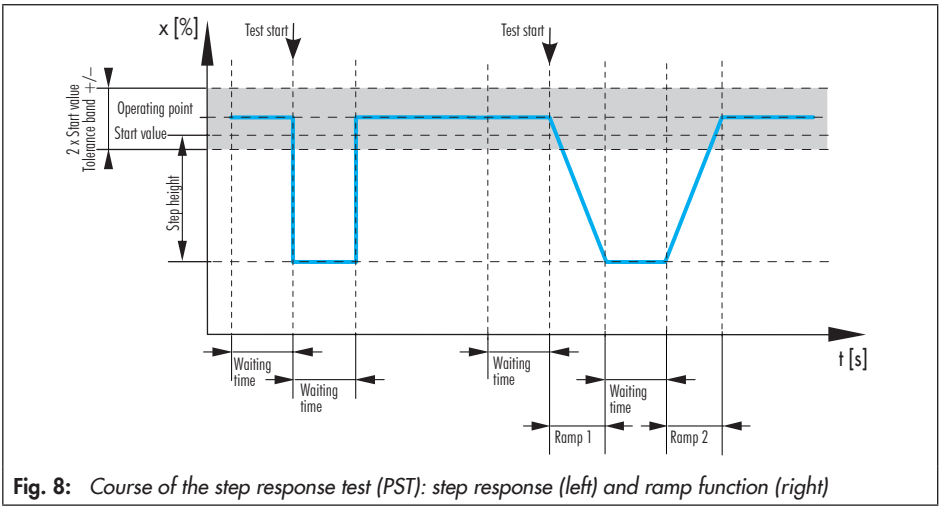



**Fig. 8:** *Course of the step response test (PST): step response (left) and ramp function (right)*

**Valve position**

– 'Canceled: x monitoring': the test is canceled when 'Minus' is selected as the 'Test direction' as soon as the valve position falls below the adjusted value. The test is canceled when 'Plus' is selected as the 'Test direction' as soon as the valve position exceeds the adjusted value.

  This cancelation criterion only takes effect when 'Canceled: x monitoring' is set to ≠ 0 %.

**> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration**

– Canceled: x monitoring: –20 to 120 %, [ATO: 85 %; ATC: 15 %]

***Notes on cancelation criteria***

– *The step response test must only be performed with the cancelation conditions (time or valve position) for valves with double-acting actuator and pneumatic booster as well as for valves that have been initialized using the SUB mode.*
– *Excessive overshooting may occur in valves fitted with volume boosters. In this case, the test cancelation criteria 'Canceled: x monitoring' and 'Canceled: tolerance band (ramp) +/–' or 'Canceled: tolerance band (step) +/–' must be increased accordingly.*

The reason why the test was canceled can be read in the 'Results of last test' parameter. Besides cancelation due to the adjusted test cancelation criteria, further events lead to the test being canceled, for example:

– The internal forced venting function is triggered.
– The current is lower than 3.8 mA.
– The test is manually canceled:
  ➔ On site by pressing the rotary push-button
  ➔ By software with the 'Stop test' parameter
– The positioner switches to the SAFE mode.
– At the start of the step response test triggered by the binary input, the edge control changes again to the state which starts the step response test.
– In AUTO mode, the edge control changes to the state in which the valve moves to a fixed value which is outs the range: 'Start value' ± 'Start value of tolerance band +/–'.

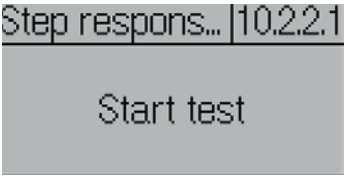
## 6.1.2 Test start

**Table 7:** *Start conditions of step response test (PST)*

| Operating mode | See section 6.1.2.1 for manual start (on site or using software) | Automatic start after 'Test interval' has elapsed (see section 6.1.2.2) | Start triggered by the binary input (see section 6.1.2.3) |
|---|---|---|---|
| AUTO | YES | YES | YES |
| MAN | YES | NO | YES |

### 6.1.2.1 Manual start

**On-site operation**




➔ Use the rotary pushbutton to go to the 'Step response test (PST)' command (menu item: [10 Diagnosis/maintenance > Tests]). See ▶ EB 8484-3.

➔ Press ⊛ to start test.

**i Note**

*A test can be canceled manually by pressing the rotary pushbutton again.*

**Software command via TROVIS-VIEW/ integration**

| **> Diagnosis/maintenance > Tests > Step response test (PST)** |
|---|
| ! Start PST |

**i Note**

*The test can be manually canceled by selecting the 'Stop test' command.*

### 6.1.2.2 Automatic start after 'Test interval' has elapsed

The step response test (PST) is started in AUTO mode regularly after the time entered in 'Test interval' has elapsed when the function is activated. The 'Delay time interval' parameter allows the test to be postponed once.

**i Note**

*The time until the next regular test can be adapted in the 'Time until next test' information parameter.*

| **> Diagnosis/maintenance > Tests > Step response test (PST) > Configuration** |
|---|
| – Test interval: 1 to 365 d, [7 d] |
| – Activate test interval: [Not active], Active |
| – Delay test interval: [0] to 2160 h |

| **> Diagnosis/maintenance > Tests > Step response test (PST)** |
|---|
| – Time until next test (not write-enabled) |

### 6.1.2.3 Start triggered by the binary input

Function only when positioners have the optional binary input (option A or B).

| **> Configuration > Options** |
|---|
| – Action upon active binary input: **start PST** |
| – Edge control: [Active = switch closed], Active = switch open |

## 6.1.3 Analysis and monitoring

The analyses of the last fifty step response tests (PST) are saved with a time stamp in [> Diagnosis/maintenance > Tests > Step response test (PST) > Reports and diagrams]. The last seven graphs at the maximum are shown.

The result of the last test can be read in [> Diagnosis/maintenance > Tests > Step response test (PST).

**Note**

*In total, seven step response tests (PST plus FST) with report and diagram can be displayed.*

### Test completed successfully

The following analysis parameters are shown after a completed step response test (PST).

Two test reports can be shown at one time for comparison. The comparison test can be selected as required.

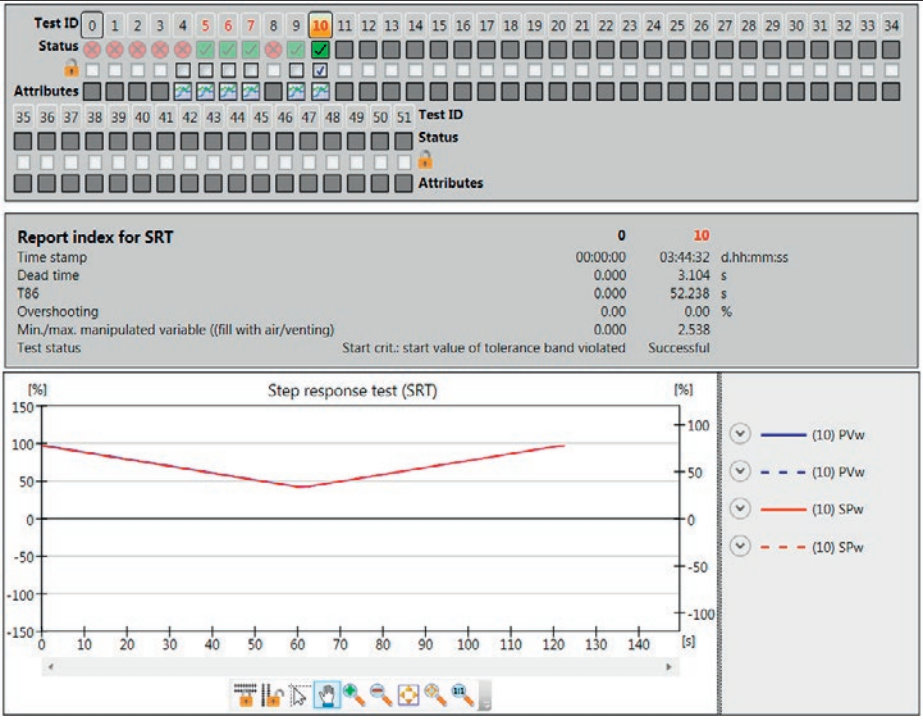



**Fig. 9:** *> Diagnosis/maintenance > Tests > Step response test (PST) > Reports and diagrams*

**> Diagnosis/maintenance > Tests > Step response test (PST) > Reports and diagrams**

– Time stamp (not write-enabled)
– Dead time (not write-enabled)
– T86 (not write-enabled)
– Overshooting (not write-enabled)
– Min./max. manipulated variable (fill with air/venting)
– Test status (not write-enabled)

The results of the first step response test performed with the current configuration are used as a reference test and are write-protected. All other step response tests can be write-protected manually:

➔ Check box.

**Test not completed**

If the test is canceled and no results are produced which activate the fail-safe position, the positioner changes to the 'Target operating mode'.

The fail-safe position can be activated, for example when the forced venting is triggered and when the current is lower than 3.8 mA.

A test cancelation causes the 'PST: cancelation criteria met' status message to be generated with the assigned status classification.

If the test cannot be started, the 'PST: start criteria not met' status message with the assigned status classification is generated.

*Note*

*No graph is plotted when a test cannot be started.*

**> Diagnosis/maintenance > Device state > Status classification**

– PST: cancelation criteria met:
– PST: start criteria not met:

**> Diagnosis/maintenance > Device state > Status messages**

– PST: cancelation criteria met
– PST: start criteria not met

➔ Recommended action when the test is canceled (see Table 8)

**Statistical analysis**

Every time a step response test is started, one of the following counters counts this event depending on the test status.

**> Diagnosis/maintenance > Tests > Step response test (PST)**

– Number of successful tests (not write-enabled)
– Number of canceled tests (not write-enabled)
– Number of failed start criteria (not write-enabled)

## 6.1.4 Reset

➔ Refer to Table 9

**Table 8:** *Recommended action when the status message is generated*

| | **Test result** | **We recommend:** |
|---|---|---|
| **PST: cancelation criteria met** | Current | ➔ Check input signal |
| | Internal error | ➔ Restart test |
| | Timeout | ➔ Check seat and plug for deposits or foreign particles |
| | No movement possible | |
| **PST: start criteria not met** | Start criteria | ➔ Check test configuration |
| | Function active | ➔ Wait for the active test to finish and restart test. |
| | Incorrect operating mode | ➔ Set operating mode corresponding to Table 7 and restart test. |

**Table 9:** *Reset step response test*

| | 'Reset diagnosis' | Reset PST configuration | 'Clear reports' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|---|---|
| Reset configuration | NO | YES | NO | YES | YES | NO | YES |
| Clear reports | YES | YES | YES | YES | YES | NO | NO |
| Reset histograms | YES | YES | YES | YES | YES | NO | NO |
| Reset reference test | YES | YES | NO | YES | YES | NO | YES |
| Reset status messages | YES | YES | NO | YES | YES | NO | NO |

## 6.2 Step response test (FST)

**Note**

*Depending on the software version, the terms "Step response test (SRT-100 %)", "step response (FST)" or "full stroke test (FST)" are used. They all refer to the same test.*

The dynamic valve performance can be evaluated by performing the test. During the step response test (FST), the valve moves through its entire working range.

The valve can move through the working range either in steps or with a ramp function (Fig. 10). The test is performed with the ramp function when the ramp time ('Ramp') is set to ≠ 0 s.

The test starts after the 'Waiting time' has elapsed. This ensures that the valve has reached the open position.

Starting from the open position, the valve moves to the closed position. The valve remains in this position for the time defined by the 'Waiting time' before performing a second step change in the opposite direction from the closed position to the open position. The 'Sampling time' defines the time interval between which the measured values are recorded during the test.

**> Diagnosis/maintenance > Tests > Step response test (FST) > Configuration**

– Ramp 1: 0 to 9999 s, [60 s]

– Waiting time: can only be selected in the 'Customer expert' user level

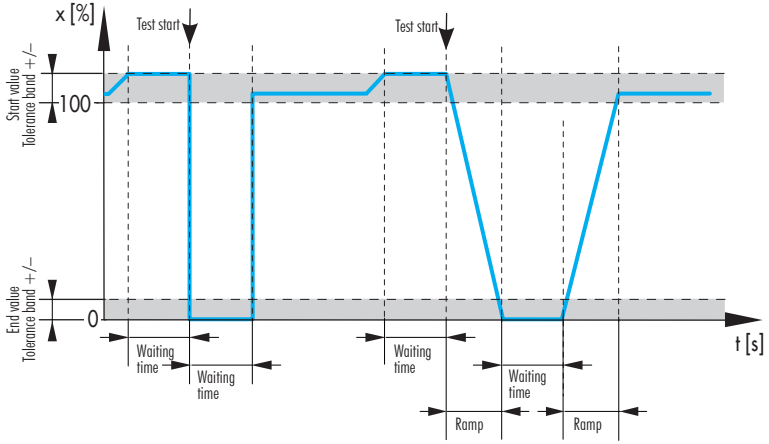



**Fig. 10:** *Course of the step response test (FST): step response (left) and ramp function (right)*

### 6.2.1 Test cancelation criteria

The positioner cancels the step response test (FST) when one of the following cancelation conditions is fulfilled:

**Time**

– 'Canceled: max. test duration': the test is canceled when the maximum permissible test duration is reached.

> **> Diagnosis/maintenance > Tests > Step response test (FST) > Configuration**
>
> – Canceled: max. test duration (not write-enabled)

**Tolerance bands**

– 'Start value of tolerance band +/–': the test is not started when the operating point is outside the range: open position – 'Start value of tolerance band'.

> **> Diagnosis/maintenance > Tests > Step response test (FST) > Configuration**
>
> – Start value of tolerance band +/–: 1 to 100 %, [3 %]

– 'End value of tolerance band +/–': the test is not started when the valve position after the first step does not reach the range: closed position + 'End value of tolerance band +/–'.

> **> Diagnosis/maintenance > Tests > Step response test (FST) > Configuration**
>
> – End value of tolerance band +/–: 1 to 100 %, [3 %]

Additionally, the step response test (FST) is canceled when one of the following events arises:

– The internal forced venting function is triggered.
– The current is lower than 3.8 mA.
– The test is manually canceled:
  ➔ On site by pressing the rotary push-button
  ➔ By software with the 'Stop test' parameter
– The positioner switches to the SAFE mode.
– At the start of the step response test triggered by the binary input, the edge control changes again to the state which starts the step response test (FST).

### 6.2.2 Test start

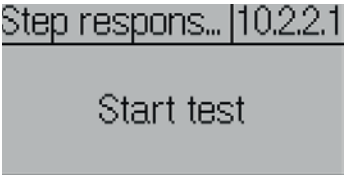
**Table 10:** *Start conditions of step response test (FST)*

| Operating mode | See section 6.2.2.1 for manual start (on site or using software) | Start triggered by the binary input (see section 6.2.2.2) |
|---|---|---|
| AUTO | NO [1] | NO [1] |
| MAN | YES | YES |

[1] Default setting
By activating the 'Allow start in AUTO mode' parameter in the "Customer expert" user level, the test can also be started in AUTO mode.

### 6.2.2.1 Manual start

**On-site operation**




➔ Use the rotary pushbutton to go to the 'Step response test (FST)' command (menu item: [10 Diagnosis/maintenance > Tests]). See ▶ EB 8484-3.

➔ Press ⊛ to start test.

**i Note**

*A test can be canceled manually by pressing the rotary pushbutton again.*

**Software command via TROVIS-VIEW/ integration**

| **> Diagnosis/maintenance > Tests > Step response test (FST)** |
|---|
| ! Start FST |

**i Note**

*The test can be manually canceled by selecting the 'Stop test' command.*

### 6.2.2.2 Start triggered by the binary input

Function only when positioners have the optional binary input (option A or B).

| **> Configuration > Options** |
|---|
| – Action upon active binary input: **start FST** |
| – Edge control: [Active = switch closed], Active = switch open |

## 6.2.3 Analysis and monitoring

The analyses of the last six step response tests (FST) at the maximum and graphs are saved with a time stamp in [> Diagnosis/ maintenance > Tests > Step response test (FST) > Reports and diagrams].

The result of the last test can be read in [> Diagnosis/maintenance > Tests > Step response test (FST).

**i Note**

*In total, seven step response tests (PST plus FST) with report and diagram can be displayed.*

**Test completed successfully**

The following analysis parameters are shown during a completed step response test (FST).

Two test reports can be shown at one time for comparison. The comparison test can be selected as required.

**> Diagnosis/maintenance > Tests > Step response test (FST) > Reports and diagrams**

– Time stamp (not write-enabled)
– Dead time (rising) (not write-enabled)
– Dead time (falling) (not write-enabled)
– T86 (rising) (not write-enabled)
– T86 (falling) (not write-enabled)
– T98 (rising) (not write-enabled)
– T98 (falling) (not write-enabled)
– Test status (not write-enabled)

The results of the first step response test (FST) performed with the current configuration are used as a reference test and are write-protected. All other step response tests can be write-protected manually:

➔ Check box.

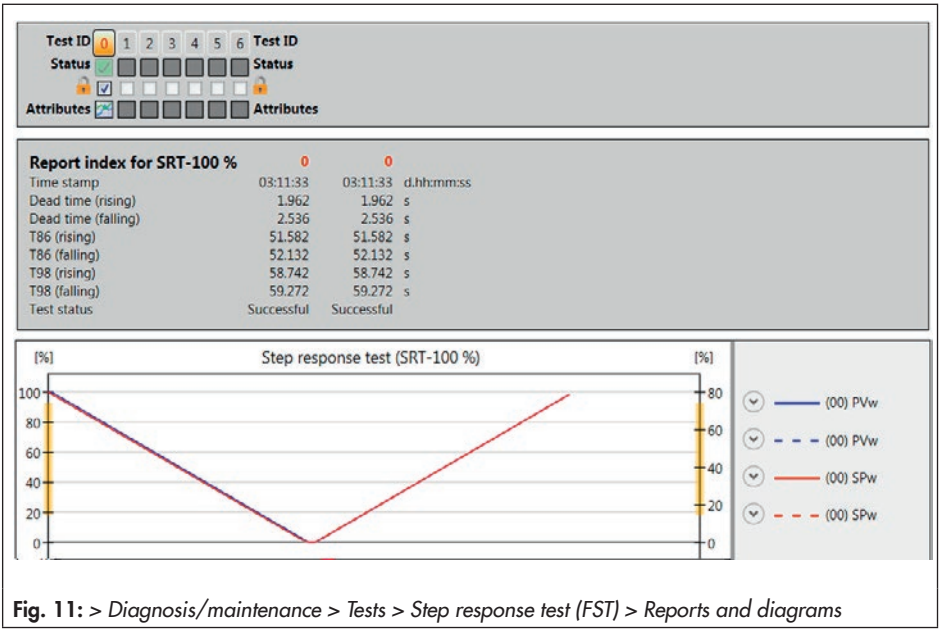



**Fig. 11:** *> Diagnosis/maintenance > Tests > Step response test (FST) > Reports and diagrams*

**Test not completed**

If the test is canceled and no results are produced which activate the fail-safe position, the positioner changes to the 'Target operating mode'.

The fail-safe position is activated when the forced venting is triggered and when the current is lower than 3.8 mA.

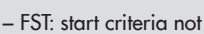
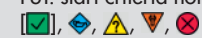
A test cancelation causes the 'FST: cancelation criteria met' to be generated status message with the assigned status classification.

If the test cannot be started, the 'FST': start criteria not met' status message with the assigned status classification is generated.

*Note*

*No graph is plotted when a test cannot be started.*

**> Diagnosis/maintenance > Device state > Status classification**

– FST: cancelation criteria met:

– FST: start criteria not met:


**> Diagnosis/maintenance > Device state > Status messages**

– FST: cancelation criteria met

– FST: start criteria not met

➔ Recommended action when the test is canceled (see Table 11)

**Statistical analysis**

Every time a step response test is started, one of the following counters counts this event depending on the test status.

**> Diagnosis/maintenance > Tests > Step response test (FST)**

– Number of successful tests (not write-enabled)

– Number of canceled tests (not write-enabled)

– Number of failed start criteria (not write-enabled)

## 6.2.4 Reset

➔ Refer to Table 12

**Table 11:** *Recommended action when the status message is generated*

| | **Test result** | **We recommend:** |
|---|---|---|
| **FST: cancellation criteria met** | Current | ➔ Check input signal |
| | Internal error | ➔ Restart test |
| | Timeout | ➔ Check seat and plug for deposits or foreign particles |
| | No movement possible | |
| **FST: start criteria not met** | Start criteria | ➔ Check test configuration |
| | Function active | ➔ Wait for the active test to finish and restart test. |
| | Incorrect operating mode | ➔ Set operating mode corresponding to Table 10 and restart test. |

**Table 12:** *Reset step response test*

| | 'Reset diagnosis' | 'Reset FST configuration' | 'Clear reports' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|---|---|
| Reset configuration | NO | YES | NO | YES | YES | NO | YES |
| Clear reports | YES | YES | YES | YES | YES | NO | NO |
| Reset histograms | YES | YES | YES | YES | YES | NO | NO |
| Reset reference test | YES | YES | NO | YES | YES | NO | YES |
| Reset status messages | YES | YES | NO | YES | YES | NO | NO |

## 6.3 Dead band

The difference in *set point w* that causes a minimal change in the *valve position x* is termed 'dead band'.

The valve dead band is affected by the friction hysteresis and the elastic processes in the valve stem packing.

The test is started in the manual mode.

During the dead band test, the positioner moves the valve in small steps through the range of 'Start set point' ±½ 'Span'. After every step the positioner records the response of the *valve position x*.

The test starts at the 'Start set point' and ends at position 1.

– 'Start set point' – ½ 'Span' in 'Start direction' = 'Minus' or
– 'Start set point' + ½ 'Span' in 'Start direction' = 'Plus'

After the 'Delay time after set point change' elapses, the valve moves from position 1 to position 2:

– 'Start set point' + ½ 'Span' in 'Start direction' = 'Minus' or
– 'Start set point' – ½ 'Span' in 'Start direction' = 'Plus'

After the 'Delay time after set point change' elapses, the positioner defines a further set point change, which starts in position 2 and ends at the 'Start set point'.

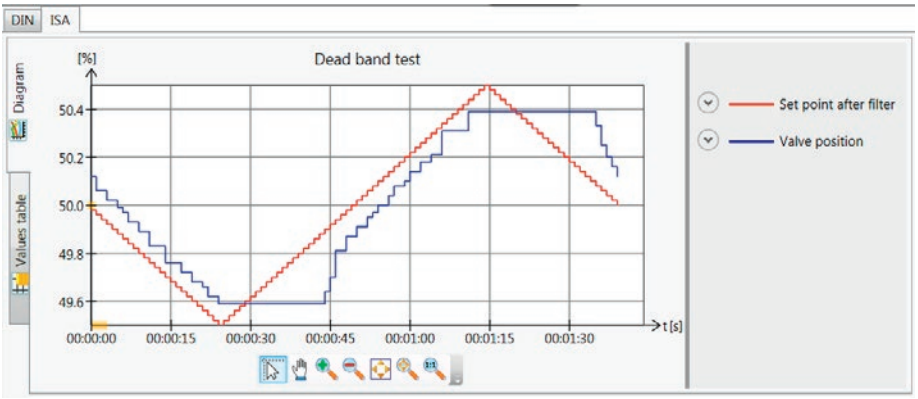



**Fig. 12:** > *Diagnosis/maintenance* > *Tests* > *Dead band* > *ISA*

**Analysis and monitoring**

The dead band test provides statements on the minimum, maximum and average dead band:

– 'Min. dead band': minimum change in set point that causes a minimal change in the valve position.
– 'Max. dead band': maximum change in set point that causes a minimal change in the valve position.
– 'Average dead band': average change in set point that causes a minimal change in the valve position.

A plotted diagram is generated after the test is successfully completed. Two different types of diagrams are available:

– DIN: valve position [%] plotted against the set point after filter [%]
– ISA: valve position [%] and the set point after filter [%] plotted over time [s]

**Defining parameters**

1. Switch to manual mode (Code 0 = MAN).
2. Select test parameters.
3. Start test.

The 'Test status' generates an 'Active' message.
'Function check' is activated as the condensed state.

**> TROVIS 3730-3**

1. – Desired operating mode: MAN

**> Diagnosis/maintenance > Tests > Dead band**

2. – Start set point: 0.0 to 100.0 %, [50.0 %]
   – Start direction: Minus, [Plus]
   – Span: 1 to 50 %, [1 %]
   – Delay time after set point change: 0.2 to 25.0 s, [1.0 s]
3. – Start test

***Note***

*Cancel the test by right-clicking 'Stop test' and selecting 'Execute' or by pressing the rotary pushbutton at the positioner. After the test has been canceled, the positioner remains in manual mode.*

## 6.4 Reset

Refer to Table 13

**Table 13:** *Resetting the dead band test*

| | 'Reset diagnosis' | 'Reset dead band test' | 'Reset (standard)' | 'Reset (advanced)' | Restart | Reset initialization |
|---|---|---|---|---|---|---|
| Reset measured data and diagram | YES | YES | YES | YES | NO | NO |

# 7 Error messages and recommended corrective action

| Message | Recommended action | Status classification |
|---|---|---|
| > Diagnosis/maintenance > Device state > Status classification | | |
| PST: cancelation criteria met | See section 6.1. | YES [] |
| PST: start criteria not met | See section 6.1. | YES [] |
| FST: cancelation criteria met | See section 6.2. | YES [  ] |
| FST: start criteria not met | See section 6.2. | YES [] |
| AMR signal outside range | ➔ Check attachment. | YES [  ] |
| Hardware error | ➔ Confirm error and select AUTO operating mode.<br>➔ Re-initialize positioner. | YES [highest classification] |
| Limit for total valve travel exceeded | ➔ Check valve and attachment for signs of wear. | YES [] |
| Lower end position shifted | See section 5.2. | YES [] |
| Upper end position shifted | See section 5.2. | YES [] |
| Dynamic stress factor exceeded | See section 5.1.4. | YES [] |
| Set point deviation | ➔ Check attachment.<br>➔ Check air supply.<br>➔ Check air lines/connections. | YES [  ] |
| Brownout | ➔ Check input signal. | YES [] |
| Current too low | ➔ Check input signal. | YES [] |
| IP shutdown | ➔ Check input signal. | YES [] |
| Current too high | ➔ Check input signal. | YES [  ] |
| Temperature inside device below min. limit | ➔ Check operating conditions. | YES [] |
| Temperature inside device above max. limit | ➔ Check operating conditions. | YES [] |
| Angle limitation | ➔ Check attachment. | YES [highest classification] |
| Logging suspended | The positioner is not impaired. The message no longer appears as soon as the positioner starts logging again. | YES [  ] |

| Message | Recommended action | Status classification |
|---|---|---|
| Operating range in CLOSED position | ➔ Check attachment.<br>➔ Check whether another valve can be used. | YES [  ] |
| Operating range in max. OPEN position | ➔ Check attachment.<br>➔ Check whether another valve can be used. | YES [  ] |
| Operating range shifting towards CLOSED position | ➔ Rethink the working range. | YES [] |
| Operating range shifting towards max. OPEN position | ➔ Rethink the working range. | YES [  ] |
| Limited working range: lower range | ➔ Check that pneumatic installations and connections are tight.<br>➔ Check supply pressure.<br>➔ Check plug stem for external influences that could be blocking it. | YES [  ] |
| Limited working range: upper range | ➔ Check that pneumatic installations and connections are tight.<br>➔ Check supply pressure.<br>➔ Check plug stem for external influences that could be blocking it. | YES [  ] |

**EB 8389-3 EN**

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