Positioner Series 3730 and Series 3731
EXPERT/EXPERT+ Valve Diagnostics

Application
Positioner firmware for early detection of control valve faults giving maintenance recommendations

EXPERT and EXPERT+ are enhanced firmwares designed for predictive, status-oriented maintenance on control valves with pneumatic actuators. All diagnostic functions are completely integrated into the positioner.

EXPERT and EXPERT+ enable operators to conveniently view and edit data in the TROVIS-VIEW and FDT/DTM engineering tools, which makes operation easy to learn. Integration into other engineering tools is made possible by DD/eDD.

TROVIS-VIEW: graphical user interface for configuration and parameterization of various SAMSON devices

FDT: Field Device Tool; for manufacturer-independent integration of field devices

DTM: Device Type Manager; contains the device and communication properties

DD/eDD: Device Description/enhanced Device Description

Special features
- Diagnostic tests performed on control valves without requiring additional sensors
- Raw diagnostic data are permanently collected and analyzed online in the positioner and status alarms are generated
- Automatic plotting of reference graphs during initialization
- Cyclical refresh of diagnostic data, multiplexing capability
- Monitoring and test functions for predictive maintenance to pinpoint critical conditions before faults occur
- Display of the minimum and maximum temperatures with details on how long the limits have been exceeded
- Automatic start of test functions
- Display of service and maintenance recommendations
- Display of classified status and fault alarms
- Status classification and condensed state based on NAMUR recommendation NE 107
- Status alarms and condensed states also displayed on the positioner's LCD as well as issued to the fault alarm contact*
- Plotting of y-x signature (drive signal) for fault detection
- Test functions to determine friction changes
- Operating hours counter allows data and test results to be sorted by time
- Diagnostic data and test results saved and analyzed in the positioner

Fig. 1 · Type 3241-1 Control Valve and Type 3730-3 Positioner with HART® communication

Fig. 2 · Type 3731 Ex d Positioner

TROVIS-VIEW Data Sheet **T 6661 EN**
Type 3730-x Positioner **T 8384-x EN**
Type 3731-x Positioner **T 8387-x EN**

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Data Sheet **T 8388 EN**

Scope of functions

The diagnostic functions can be applied to any valve fitted with a pneumatic actuator.

Integrated into the positioner	Firmware version or higher
Type 3730-2 and Type 373x-3	1.30
Type 3730-4	K 1.0 / R 1.43
Type 373x-5	K 1.21/ R 1.41

EXPERT+ is available as an option.

Table 1 · Available functions

Test function	See section	Description	On-line	Off-line
Initialization diagnostics	1.1	Positioner self-test, mechanical attachment, valve travel range, initialization time OK?, opening and closing times	•	
Operating parameters, current process variables	1.2.1 1.2.2	Process variables w, x, e, y; operating hours counter, number of zero calibrations and initializations, temperature, total valve travel, self-monitoring of positioner	•	
Status alarms, classification	1.2.3 2.4 3.1	Display and logging of classified status alarms and condensed states	•	•
Data logger	2.1.1	Plotting and saving of process variables w, x, y and e with trigger function	•	
Valve end position trends	2.1.2	Automatic closed position logging, detection of end position shift due to wear and dirt on the seat and plug, alternation of closing position	•	
Cycle counter	2.1.3	Dynamic stress acting on packing and metal bellows	•	
Histograms	2.1.4	Display of x, e and the cycle counter; overview of working range and control response	•	
y-x signature	2.2.1	Information on spring force, pneumatics, supply air, mechanical attachment	•	•
Hysteresis test	2.2.2	Detection of friction changes	•	•
Static characteristic	2.3.1	Analysis of the control loop, e.g. dead band of control valve		•
Step response	2.3.2	Analysis of the dynamic control response (dead time, transit time, overshooting, rise time and settling time)		•
Display and parameterization over software	3	Display of all collected data and analysis results using a suitable software tool, simple parameterization	•	•

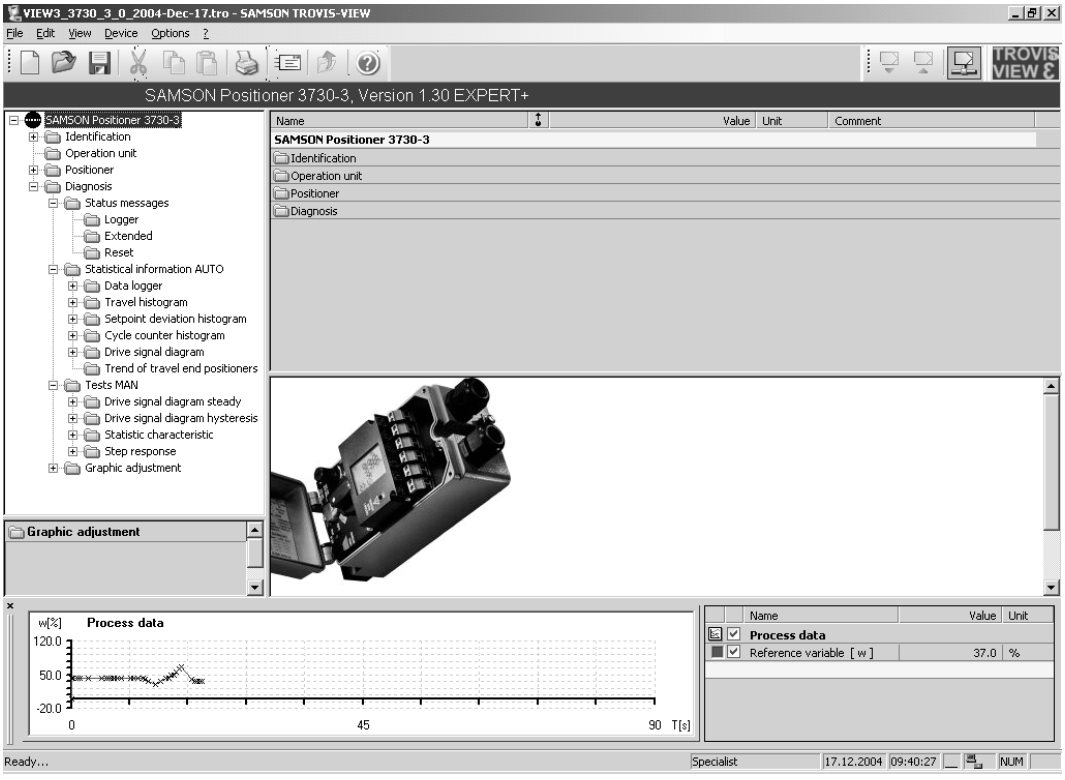

Fig. 3 · TROVIS-VIEW, graphical user interface with Type 3730-3 Positioner

1 EXPERT

1.1 Initialization diagnostics

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

1.2 Online monitoring

1.2.1 Display of the current process variables

EXPERT provides the process variables collected by the positioner (e.g. the reference variable w, controlled variable x, error e and manipulated variable y) and analyzes the diagnostic data.

1.2.2 Important operating parameters (Fig. 4)

EXPERT provides an overview of the valve status as well as the following operating parameters, which enable the operator to analyze the current valve condition and perform predictive maintenance:

- Operating hours counter, distinction between overall operating time and operating time in active control (since the first start-up and the last initialization routine)
- Number of zero calibrations performed
- Number of initializations performed
- Display of the current temperature as well as saving of the maximum and minimum temperatures, including alarm function when a limit is exceeded
- Total valve travel, including customizable limit

1.2.3 Direct detection of fault sources

The alarms and status alarms generated by EXPERT enable quick fault detection in case an error occurred. The last 30 alarms are logged in a FIFO (first in, first out) memory together with the operating hour they were generated in.

Possible fault categories are:

Operating errors, e.g.:

- Control loop error (excessive error, e.g. blocked actuator, insufficient supply pressure etc.)
- Zero point shift

Hardware and data memory faults are also indicated.

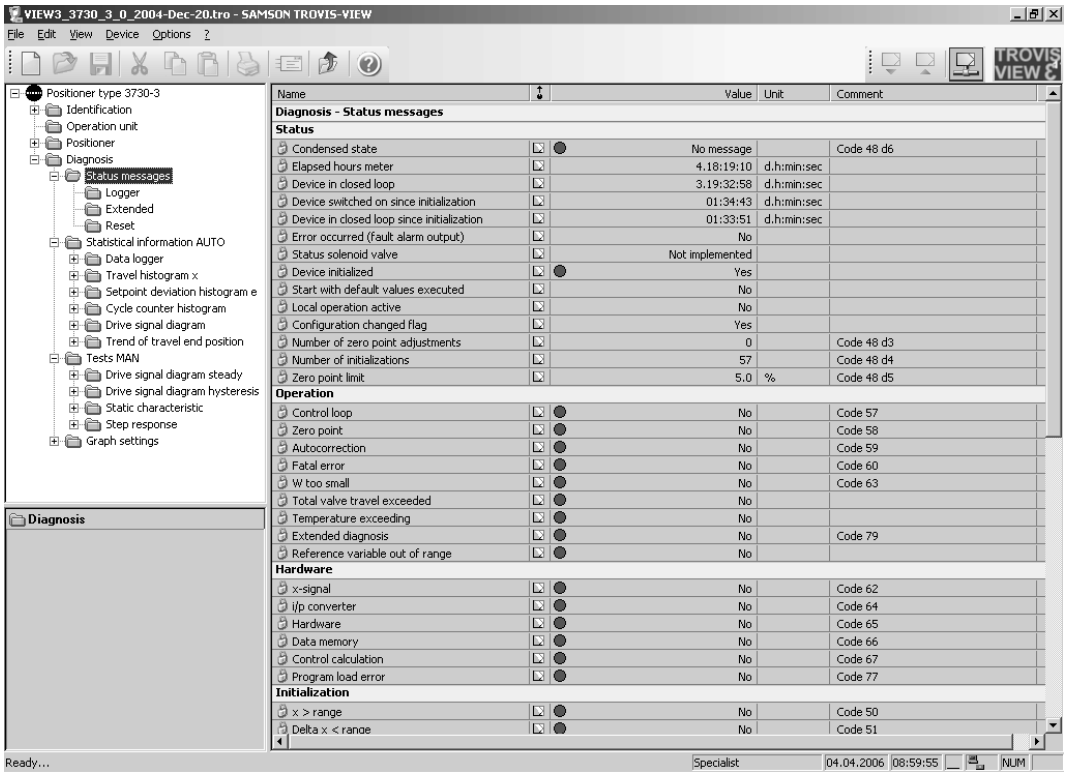

Fig. 4 · TROVIS-VIEW with status for Type 3730-3 Positioner

2 EXPERT+

2.1 Process monitoring

By permanently recording raw diagnostic data (w, x, y and e) in the positioner, the user can gather information about how the control valve behaves under process conditions.

Signal logging enables an analysis of the current measuring scope as well as of the positioner's entire service life.

The following statements can be made:

– Valve position range OK

– Valve mainly operates in the upper or the lower end position

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

2.1.1 Data logger

The variables reference variable w, valve position x, setpoint deviation e, drive signal y and the operating hours counter are recorded and saved in a FIFO memory. The interval between the individual measuring points can be customized.

Apart from permanent sampling, the data can also be collected online while the process is running, provided a certain trigger condition is met.

The trigger condition can be defined by the user as certain thresholds (valve travel (setpoint) or solenoid valve condition/forced venting).

Additionally, a pretrigger time is available which allows data to be displayed also before the trigger conditions are met. The memory size can be selected as required.

2.1.2 Valve end positions

This test serves to detect wear or dirt on the valve trim and is run automatically while the process is running. The valve position is recorded when the lower end position is reached and any changes logged together with the drive signal y and a time stamp.

The first measured value is used as a reference.

Further measured values showing a greater deviation from the last recorded value are logged.

2.1.3 Cycle counter

The dynamic stress that the valve packing and possibly a metal bellows are exposed to can be analyzed by counting cycle frequency and assigning the travel performed in the cycle to a determined valve travel class. The results are displayed as a long-term histogram and a short-term histogram. Based on the diagnostic data, a dynamic stress factor [%] with an alarm limit is generated.

2.1.4 Histograms (Fig. 5)

The variables valve position x and setpoint deviation e are sampled at determined intervals. They are classified and, similar to the cycle counter, displayed as long-term and short-term histograms. The scan rate of the short-term histograms for x and e can be adjusted. Additionally, the number of measurement values, the observation period, the average value as well as e_{min} and e_{max} are displayed.

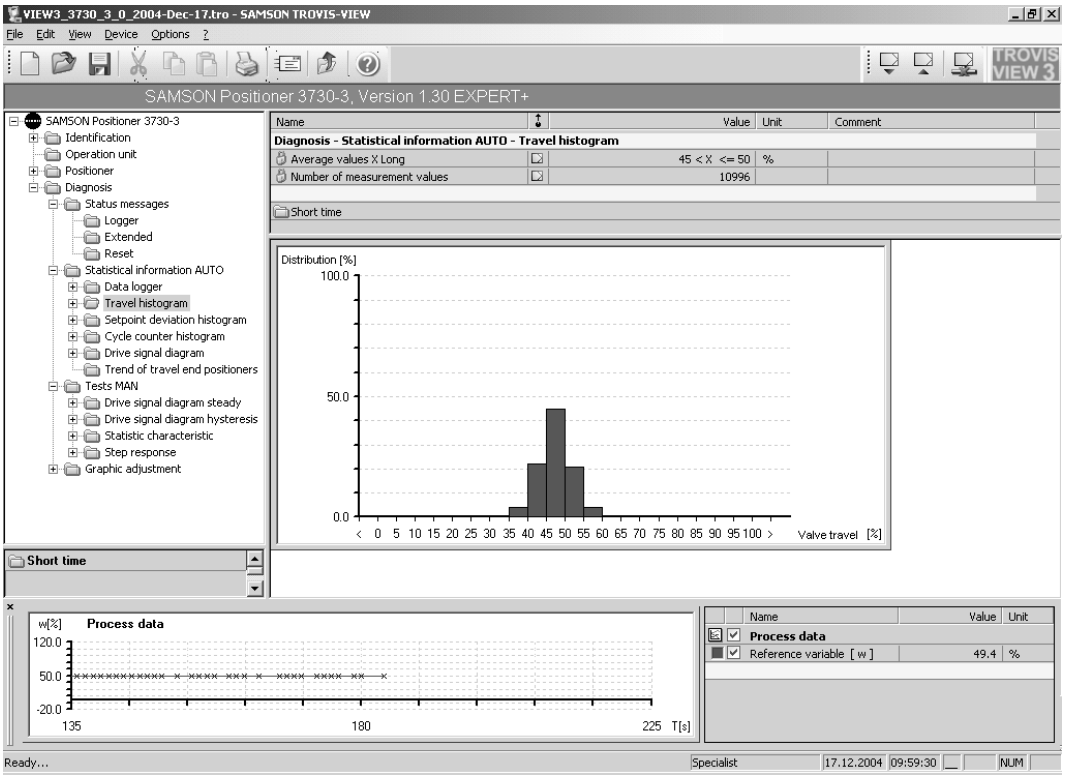

Fig. 5 · Valve travel histogram

2.2 Internal drive signal y versus valve position x

2.2.1 y-x signature (Fig. 6)

While the process is running, the internal drive signal y is automatically recorded, averaged and assigned to a valve travel class once the valve has reached a steady state.

The test function is also available in the manual mode. During which, the valve is moved to certain predefined travel positions x over the travel range and the associated y signal is recorded when the valve reaches a steady state.

The reference graph required for this analysis is automatically plotted during initialization.

Statements can be made on the spring force, the pneumatic system, the air supply and the mechanical attachment. Corresponding alarms are generated.

2.2.2 Hysteresis test

This test serves to detect friction changes (hysteresis).

It is started automatically while the process is running as soon as a configurable time between tests has elapsed and the valve has reached a steady state.

The results are saved, averaged and analyzed according to valve position classes.

For this test, a minimal change of the valve opening over a certain period of time is preset with a determined tolerance band. The test is automatically canceled when this tolerance is exceeded or the reference variable changes and the positioner returns to standard control operation. The analysis is based on Δy.

The test can also be started in the manual mode. In this case, the test is performed at certain valve travel positions x within the travel range.

The reference graph required for this analysis is automatically plotted during initialization.

2.3 Tests for targeted early fault detection

2.3.1 Static characteristic (checking the static control response)

The static control response of the control valve is checked by varying the reference variable in steps of, for example, 0.1 %. The response of the controlled variable is recorded after a customized delay has elapsed (travel position when the valve has reached a steady state).

The control loop is analyzed with the help of the minimum, mean and maximum dead band of the control valve.

In manual mode, the entire valve travel range is recorded.

2.3.2 Step response (checking the dynamic control response, Fig. 7)

The dynamic control response of the control valve is checked by changing the reference variable in steps of defined height in both travel directions (step response).

The course of the controlled variable x, reference variable w, drive signal y and setpoint deviation e is recorded at a determined scan rate until the valve has reached a steady state again. The dead time, T_{63}, T_{98}, overshooting as well as rise time and settling time are indicated separately for increasing and decreasing characteristic.

This test can be carried out in manual mode over the entire valve travel range.

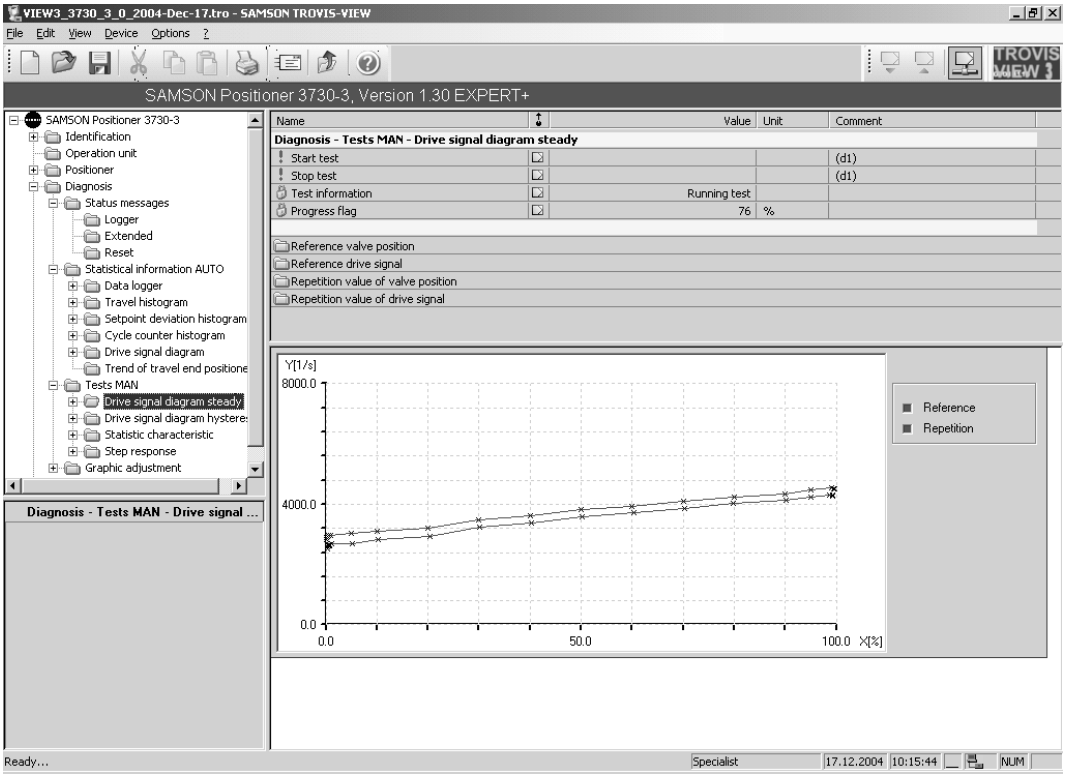

Fig. 6 · y-x signature (drive signal) as indicated in TROVIS-VIEW

2.4 **Plain text diagnostics** (Fig. 8)

EXPERT+ automatically generates other additional status alarms from the collected diagnostic data, e.g.:

– Pneumatic leakage
– Friction changed

As with EXPERT, the status alarms are logged with the operating hour they were generated in.

3 Visualization and parameterization of EXPERT and EXPERT+ diagnostics

The TROVIS-VIEW software or the DTM tool generate graphs from the data, test results and status alarms collected by the diagnostics firmware in the positioner.

In addition, the diagnostics data can also be made accessible to other engineering tools using the DD (Device Description) or eDD (enhanced DD), which enables the data to be displayed in graph form, e.g. using Siemens PDM.

How the data are displayed depends on the applied tool.

3.1 Classification and marking of status alarms

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

Status alarm (event)	**Engineering tool** TROVIS-VIEW/DTM
Inactive	
Active · Classified as "No message"	
Active · Classified as "Maintenance required"/"Maintenance demanded"	
Active · Classified as "Function check"	
Active · Classified as "Maintenance alarm"	

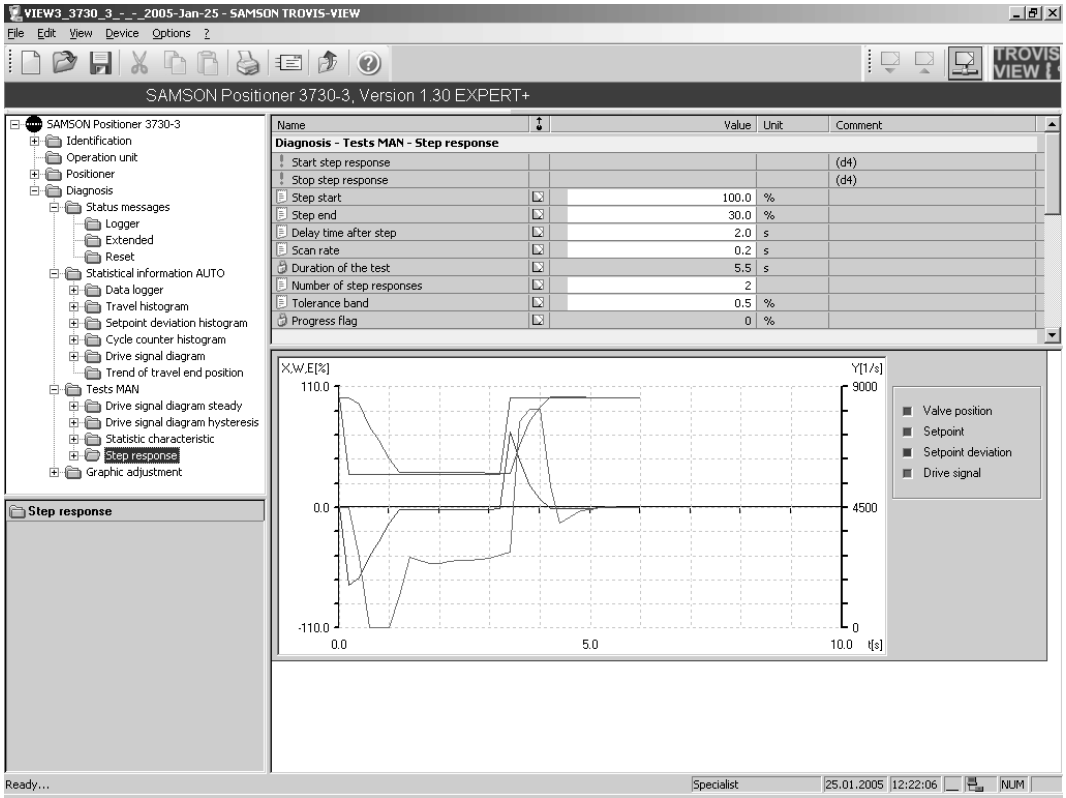

Fig. 7 · Testing the dynamic control response, step response

The classification can be assigned by the user. The classified status alarms (events) are summarized in a condensed state.

Condensed status	Engineering tool TROVIS-VIEW/DTM	Positioner display
Maintenance alarm		
Maintenance required Maintenance demanded		
Function check		Text
No message		

The condensed status is indicated on the positioner display and can be read using the communication features. In addition, the condensed state can be issued to the optional fault alarm contact*.

Type 3730-4: The status classification is consistent with the Profibus Profile 3.01 with condensed status and diagnostic message extension. The process-related fault status is classified.

Type 373x-5: The condensed state is listed in the Resource Block and can also be issued to the discrete output of either the Function Block DI1 or DI2. In addition to the condensed state, a block error for the Resource Block and AO Transducer Block can be formed from the classified alarms (events).

In this case, the following assigned states are possible:

– No message
– Maintenance soon
– Maintenance now

* Fault alarm contact in Types 3730-2 and 3730-3, optional in Type 3731-3

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

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

– Current process variables
– y-x signature
– Hysteresis test
– Static characteristic
– Step response
– Valve end position trending

The long-term and short-term histograms described in section 2.1.4 are displayed as bar graphs.

A difference is made between long-term and short-term in the y-x signature and the histograms.

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

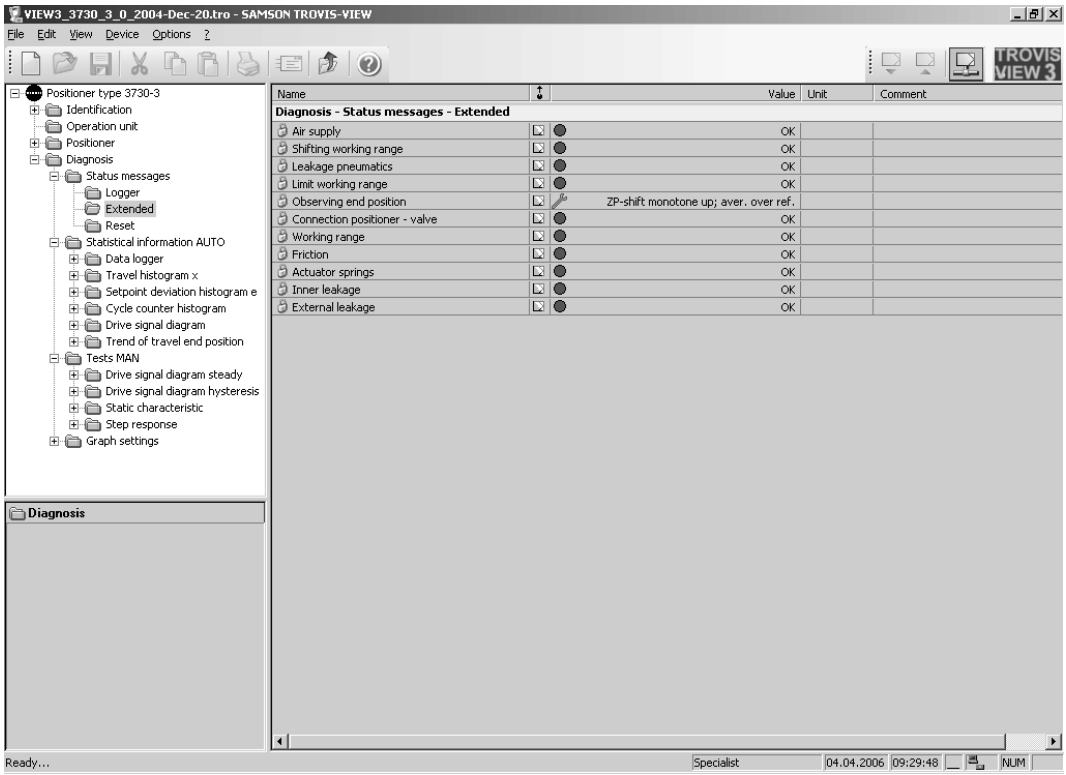

Fig. 8 · Extended status alarms

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