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Manual
Moisture Analyser PCE-WIO 1

Contents

1 Detection of Water in Oils

The sensor NP330-F is designed for online measurement of the absolute water content in mineral oils and ester oils. It has, for years, proved successful in detecting water inrushes in oil coolers and in controlling oil drying systems.

Continuous monitoring of the absolute water content by the sensor is, in the following respects, superior to sampling determination of the water content through chemical methods:

- Rapid detection of any water inrush – e.g. caused by a leakage – considerably increases safety and helps avoiding secondary damages due to water in the system. This will result in a significant reduction of repair costs and down times.
- Oil drying systems can be controlled in a moisture-dependent way with the help of the sensor NP330-F, which will reduce energy and analysis costs as compared with systems without online measurement.
- Continuous measurement of the water content in hydraulic systems is an efficient method of quality control in production processes. It eliminates the risk of ignoring an increasing water content between two sampling measurements.

Figure 1: Sensor NP330-F with display

1.1 Description of Operation

To determine the water content, free water molecules in the oil are registered by a capacitive sensor element, and the oil temperature is measured. On the basis of these two measured quantities, and referring to stored calibration data, a micro-controller in the sensor calculates the absolute water content of the oil through numerical interpolation (see figure 2).

Figure 2: Signal-flow diagram

Feuchtefühler	moisture sensor
Temperaturfühler	temperature sensor
Kalibrierdaten	calibration data
Interpolation 3-dim.	3-dimensional interpolation
Datenaustausch	data exchange
Stromausgang	current output
Schaltausgang	switching output

The water content is put out linearly in ppm or in per cent by means of an analogue 4-20 mA signal and via the serial interface. The sensor NP330-F is optionally equipped with a programmable

switching output. The user can freely program the switching threshold as well as a switching hysteresis and a switching delay.

If an actual water content is above the programmed switching threshold, the connection between switching output and supply voltage is high-resistance, if it is below the switching threshold, the connection is low-resistance. The switching output can be loaded by a current of maximum 100 mA, at 24 V.

Usually, the measurement range goes from 10 ppm to the saturation limit of free water molecules in oil.

1.2 Structure

1.2.1 Sensor

The sensor head is made of high-quality steel, with a 5/8-18 UNF internal thread. The sensor elements for temperature and moisture are located at the sensor head. For measurement, the sensor head has to be placed into the oil flow. The sensor elements are protected against heavy flow by a sleeve. The sensor is dimensioned for media pressures up to 300 MPa. The electrical connection takes place via a 7-pole circular connector of type Binder 723.

Figure 4: Dimensions [mm]

1.2.2 Display Instrument

For indication of the measured value, a table display and a switchboard display are available as accessories (see figure 1). The table display provides the supply voltage for the sensor. The sensor can be operated by connecting it directly to the table display by means of the connection cable included in the consignment. There are no other cables necessary. The serial interface, the 4-20 mA signal and the switching output are accessible at the outer surface of the device, at respective plug connectors. Connection options are depicted in figure 3

Figure 3: Connections options

PC COM	PC COM
4-20 mA Schreiber / SLS	4-20 mA recording instrument / SLS
Alarm / SLS	Alarm / SLS
GfS Wassergehalt in ppm	GfS water content in ppm
Tischanzeige-Instrument	table display
Steckernetzteil	plug-in power supply unit

If the sensor is to be operated with a switchboard display, a DC supply current of 24 V has to be provided.

1.3 Calibration

The oil (2 litres) sent by the customer for calibration purposes is at first tested for its water content.

Subsequently, it is submitted to a drying process. A calibration curve is then established on the basis of successively added well-defined quantities of water in a closed oil cycle. Figure 5 shows a section of a calibration curve. It can be seen how the value measured by the moisture sensor follows the addition of certain amounts of water. To establish the dependence of the measured value on temperature, calibration is done at different oil temperatures.

Figure 5: Section of a calibration with Skydrol

Uhrzeit	time
Sensorsignal [Hz]	sensor signal [Hz]

1.4 Quality Control

During calibration, oil samples are taken and examined by the analytical laboratories of AVENTIS Research & Technologies. There, the water content of the oil is ascertained by means of Karl-Fischer titration. Karl-Fischer titration is one of the most important and acknowledged methods of water detection (ASTM Standard D1744). This ensures calibration of the sensor according to the actual water content of the oil in ppm. On customer request, a calibration certificate can be issued.

It is recommended to annually check the sensor and recalibrate it if need be.

Checking the sensor may as well be done by the customer, who has to make a comparative measurement by chemically analyzing an oil sample taken from the respective system. To avoid locally different water concentrations affecting the test result the user has to mind taking the oil sample in the close neighbourhood of the sensor.

1.5 Accessories

The sensor NP330-F is optionally equipped with a switching output. Additionally, the following accessories are available:

- table display including 230 V plug-in power supply unit and sensor connection cable
- switchboard display
- connecting cable to sensor (3m), other length on request
- ½-inch adapter for 5/8-18 UNF internal thread
- sensor chamber for laboratory applications

1.6 Order Numbers

Article	Order number
Sensor NP330-F	NP330.03-F
Sensor NP330-F with switching output	NP330.04-F
Sensor connection cable, length 3m other lengths on request	NP390
Table display including 230 V plug-in power supply unit and sensor connection cable, without externally accessible switching output: Indication scale (depending on measurement range): 0 to 1.999% H_2O 0 to 1999 ppm H_2O	 NP415.01.2 NP415.01.3
Table display including 230 V plug-in power supply unit and sensor connection cable with externally accessible switching output: Indication scale (depending on measurement range): 0 to 1.999% H_2O 0 to 1999 ppm H_2O	 NP415.02.2 NP415.02.3
Switchboard display Indication scale (depending on measurement range): 0 to 1.999% H_2O 0 to 1999 ppm H_2O	 NP369.01.2 NP369.01.3

1.7 Technical Data Sensor NP330-F

Measurement range water content	from about 10 to 10'000 ppm in oil, according to type
Measurement range temperature	-20º C – +60º C
Measurement accuracy	depending on calibration data, error less than 10% of limit of measurement range accessible
Operating pressure	from vacuum to 30 MPa
Operating temperature	-20º C – +60º C
Media compatibility	differs with aggressive substances and has to be established respectively
Operating supply	18 – 28 V DC, about 30 – 70 mA
Outputs	RS 232 data I/O for connection of a computer current output 4-20 mA switching output (optional) 24 V DC, max. 100 mA
Plug-and-socket connector	7-pin circular connector, type Binder 723
Protection type	IP 65
Sample connection thread	5/8 – 18 UNF, width across flats: 22 mm

Mounting depth	50 mm
Height of casing	115 mm
Diameter of casing	60 mm
Total length	176 mm
Weight	about 450 g
Recalibration	intervals depending on use. One annual check recommended

2 Installation and Starting-up

2.1 Installation into Media Flows

- The sensor should be installed at a place where the moisture content of the oil is most telling with regard to the respective issue. If, for instance, a cooler leakage is suspected as source of malfunction, the measurement site is to be located in the oil pipe closely behind the cooler outlet. If the quality of oil introduced into a system is to be monitored, the measurement site is to be located in the suction line of the pump.

  The sensor has to be installed at a threaded hole positioned in a way that the sensor element will be continuously bathed in the oil to be monitored, that no sedimentation can take place, and that the sensor element will not fall dry during stop of the system. The oil flow is to meet the protection sleeve of the sensor in radial – not in axial – direction, i.e. the sensor element is to be inserted into the pipe at right angles to the direction of the oil flow.

- The oil temperature at the measurement site is to be as close as possible to the operating temperature of the oil but not above 60ºC. If need be, a partial measurement flow with respective cooling has to be provided.

- The internal thread is of size 5/8-18 UNF, cylindrical, with even flange level. Included in the consignment is a Dowty-Seal sealing ring. The supporting surface for this sealing ring has to be of 26 mm in diameter. The tightening torque is uncritical, recommended are about 40-80 Nm. Of help will be an open-end wrench of 22 mm width across flats. The depth of immersion of the sensor element amounts to about 50 mm from flange level.

2.2 Deinstallation and Cleaning

- The sensor is deinstalled by means of an open-end wrench (22 mm width across flats), which has to be placed at the sensor head. If unscrewed by turning its casing, the sensor might be damaged!

- Once the sensor head has been in touch with the oil, it must not remain uncleaned in the open air for an extended period. Drying or resinifying of oil on the sensor head surface has to be absolutely

avoided through cleaning! Remains of some ester oils (e.g. Skydrol) on the sensor element may become aggressive when reacting with air humidity and will then damage the sensor element.

- For cleaning the sensor head, customary cleaner's naphtha may be used. The sensor head may be dipped into cleaner's naphtha up to the thread. Care should be taken to bathe the sensor element thoroughly in cleaner's naphtha. A wash-bottle might as well be used to rinse the sensor head. Attention should be paid, however, not to unscrew the sleeve sheathing the sensor element, since the sensor element is very sensitive to mechanical strain.

2.3 Electrical Connection

The sensor is equipped with a 7-pin circular connector of type BINDER 723. Two types of cables are offered: Cable NP 390 serves for normal use and establishes connections to all sensor functions. Cable 408 is a three-wire cable serving for power supply and transmission of the current signal 4-20 mA only. This cable is coated with a silicon hose to protect it against aggressive media.

- The pin assignment of the plug connector at the sensor is shown in table 1.
- The sensor is connected to supply unit and evaluating unit according to terminal connection diagram (see figure 6).
- For connection of table display or switchboard display, please see chapters 2.6 and 2.7

Figure 6: Terminal connection diagram

Ölstrom	oil flow
Kabel NP 390	cable NP 390
Steckerbelegung	connector pin assignment
Schirm (schwarz)	shield (black)
weiß	white
braun	brown
grün	green
gelb	yellow
grau	grey
rosa	pink
blau	blue
PC COM Anschluss	PC COM connection
DB 9 Steckverbinder	DB 9 plug connector
RS 232 Schnittstelle	RS 232 interface
Messwerte lesen, verarbeiten	reading, processing measured data
Schwellwert für Digitalausgang festlegen	defining threshold value for digital output
Kalibrierdaten verwalten	managing calibration data
24 V Relais oder Digitaleingang	24 V relay or digital input
zur Grenzwertbearbeitung, Alarmauslösung etc.	for processing limits, triggering alarms, etc.

4-20 mA Anzeigeinstrument	4-20 mA display instrument
oder SPS Stromeingang 4-20 mA	or SPS current input 4-20 mA
zum Messen, Steuern, Regeln	for measuring and controlling
24 V DC Stromversorgung	24 V DC power supply
Schutzleiter	protective conductor

Table 1: Pin assignment circular connector

Pin	Signal	Description
1	supply GND	supply connection earth
2	analogue out 4-20 mA	current signal output moisture content value 4-20 mA
3	supply +24 V DC	supply connection +24 V
4	RS 232 GND	data interface RS 232 earth connection
5	RS 232 TxD	data output RS 232
6	RS 232 RxD	data input RS 232
7	digital out 0 V or 24 V	switching output, open or connected to supply +24 V (connection optionally existing, type NP 330.04-F)

2.4 Serial Interface

For operation of and communication with the sensor NP330-F, the Windows standard programme **Hyper Terminal** is used. Preconditions:

- IBM-compatible PC with serial interface
- operating system Windows95, Windows98, or WindowsNT

Various terminal programmes (e.g. **Telix**) can be applied according to the configuration in table 2.

2.5 Configuration and Start of the Terminal Programme

1. Insert the provided floppy disk labelled "Hyper Terminal/NP330-F/G" into your disk drive.
2. Copy its contents onto your harddisk, into an arbitrarily chosen directory (Suggestion: C:\NP330*.*).
3. Open the subdirectory "Hyper Terminal" newly established on your harddisk.
4. Now you may choose between the two data files "HT_COM1.ht" and "HT_COM2.ht".

These two data files will configure Hyper Terminal as follows:

Table 2: Terminal configurations

baud rate	9600
parity	none

data bits	8
stop bits	1
protocol	none
character delay	100 ms

2.5.1 Connection of Sensor to PC

1. Connect the sensor to a serial interface of your PC. Pay attention as to which interface (COM1 or COM2) you use.
2. Supply sensor with operating voltage.

2.5.2 Programme Start

- If you have connected the sensor to the serial interface COM1, start the terminal programme by doubleclicking the data file "HT_COM1.ht".

OR:

- If you have connected the sensor to the serial interface COM2, start the terminal programme by doubleclicking the data file "HT_COM2.ht".
- Your screen will show the window represented in figure 7.
- Press Ctrl+C, the answer will be the input character $. The sensor is now prepared to receive commands.

Figure 7: Terminal programme "Hyper Terminal"

2.5.3 Output of Measured Data via Serial Interface

- Start of continuous output of measured data
  Input: ACO**ENTER**

Data are then put out at a rate of one second. Data output ist structured as follows:
Time, raw moisture [Hz], raw temperature [digit], moisture/water content [ppm], temperature [ºC]

- Interruption of data output
  Input: Ctrl+C
  Restart by ACO**ENTER**

2.5.4 Programmming of Trip Point

- Preparation for input by Ctrl+C

- Selection of trip point
  Input: HSC200**Enter** for trip point 200 ppm

- Selection of switching hysteresis
  Input: HYW10**Enter** for switching hysteresis +/-10 ppm

- Selection of switching delay
  Input: HYZ5**Enter** for switching delay of 5 seconds

- Storage of parameters
  Input: SAV**Enter**

After about 5 seconds, all current configurations will be stored, and the sensor will start continuous output of measured data.

- Looking at current sensor configurations for a check
  Input: DSP**Enter**

There will be an output of all current sensor configurations. This function will allow you to look at the programmed configurations for a check.

2.6 Table Display NP415 for Sensor NP330

2.6.1 Description

The table display instrument NP415 is a measurement instrument especially designed for the sensor NP330. It serves to visualize the 4-20 mA signal of the sensor and provides access to the serial interface, the switching output and the current loop of the sensor.

For application of the moisture sensors NP330-G and NP330-F, the table display NP415 is available with different indication scales. It is designed as a table device and conceived for 'stand-alone' use of the sensor NP330-F. Power supply for both table display NP415 and sensor NP330 is realized via the plug-in power supply unit provided.

Externally accessible plug connections are:
- connection cable to sensor NP330
- RS232 of sensor NP330 for communication with PC
- 4-20 mA current loop of sensor NP330 for an external recording instrument (measurement device)
- switching output of sensor NP330 (optional)

Data are displayed via a 3½-digit 7-segment indication (13 mm) and decimal point.

The state of the switching output of the sensor NP330.04 is indicated by an LED in the front panel.

2.6.2 Hints for Use

Hints and warnings listed in these operating instructions have to be respected to ensure riskless operation.

The device can be operated without impairment of its operational reliability within the range of acceptable environmental conditions described in section 2.6.10.

The table display NP415 can be used with the following sensors:

- moisture sensor NP330-G (gas applications)
- moisture sensor NP330-F (oil applications)

All connections have to be established by means of the cables and plug connectors included in the consignment.

The device is not equipped with an on/off-switch, which means that sensor and display instrument are activated by voltage supply.

There has to be a low-resistance connection between pick-off of current loop and display instrument. This may be realized by means of the short-circuiting plug provided or else by an external current measurement device or recording instrument. Without this low-resistance connection, the current loop is interrupted, and the display instrument shows the value corresponding with 0 mA according to its scale. Maximum apparent ohmic resistance of an external measurement device or recording instrument amounts to 750 Ω.

2.6.3 Terminal Connection Diagram NP415

Figure 8: Basic circuit

Tischanzeige-Instrument NP415	table display instrument NP415
GfS Wassergehalt in ppm	GfS water content in ppm
Kabel NP418	cable NP418
Steckernetzteil NP373	plug-in power supply unit NP373

Figure 9: Extended connection possibilities

PC COM	PC COM
4-20 mA Schreiber / SPS	4-20 mA recording instrument / SPS
Alarm optional	alarm, optional
Kabel NPxxx	cable NPxxx
GfS Wassergehalt in ppm	GfS water content in ppm
Tischanzeige-Instrument	table display instrument

Steckernetzteil NP373	plug-in power supply unit NP373

2.6.4 Representations of Table Display NP415

Figure 10: Table casing

Ansicht Frontpanel NP415	**view front panel NP415**
Anzeige-Wert	indication value
LED-Schaltausgang	LED switching output
Anzeige-Einheit	indication unit
Ansicht Rückwand NP415	**view backside NP415**
Sensoranschluss X2	sensor connection X2
Steckernetzteil X1	plug-in power supply unit X1
Sensor 4-20 mA Stromschleife X3	sensor 4-20 mA current loop X3
Sensor RS232 X4	sensor RS232 X4
Schaltausgang optional X5	switching output, optional, X5
4-20 mA Schreiber / Brücke	4-20 mA recording instrument / bridge
Seitenansicht NP415	**side view NP415**
Frontpanel	front panel
Klappfüße	collapsible feet
Rückwand	backside

2.6.5 Circuit Diagram – Supply Voltage

Figure 11: Circuit diagram supply voltage

Masse	earth
Anzeigegerät NP369	display instrument NP369

2.6.6 Circuit Diagram – 4-20 mA Signal

Figure 12: Circuit diagram 4-20 mA signal

Masse	earth
Ausgang 4-20 mA	output 4-20 mA
Brücke oder SPS	bridge or SPS
Anzeigegerät NP369	display instrument NP369

2.6.7 Circuit Diagram – Sensor RS232

Figure 13: Circuit diagram sensor RS232

Masse	earth

2.6.8 Circuit Diagram – Switching Output

Figure 14: Circuit diagram switching output

Masse	earth
Schaltausgang 24 V	switching output 24 V

2.6.9 Order Data

Article	Scale			Article number
	4 mA	20 mA	unit	
Table display Type NP415.01.1	-80.0	20.0	ºC TP	NP415.01.1
Table display Type NP415.01.2	0	1.999	% H_2O	NP415.01.2
Table display Type NP415.01.3	0	1999	ppm H_2O	NP415.01.3

2.6.10 Technical Data

Indication Display	**7-segment indication, 13 mm LED, red**		
Indication range	type NP415.01.1: type NP415.01.2: type NP415.01.3: max. +/- 1999 digit	-80.0 – 20.0 0 – 1.999 0 – 1999	ºC TP % H_2O ppm H_2O
Error message	"1" in case of exceeding upper limit of measurement range "-1" in case of exceeding lower limit of measurement range		
Measurement range	4 – 20 mA DC		
Measurement error	≤ +/- (1 digit + 0.15% of measured value)		
Temperature influence	≤ +/- 0.08 digit/K (related to 25 ºC)		
Measurement rate	about 2.5 measurements per second		
Adjusting time	less than 2 seconds with abrupt change		
Operating temperature	0 – +50 ºC, no thawing allowed		

Plug-in power supply unit	
Input voltage	230 V AC / 50 Hz 34.5 VA
Output voltage	22 V DC, metallically separated
Output current	max. 400 mA
Protection type	IP30
Casing Casing type	table casing with collapsible feet
Material of casing	ABS plastic, front panel aluminium-anodized
Protection type	IP 50
Dimensions	about 150 x 65 x 210 mm (width x height x length)
Weight	about 620 g

2.7 Switchboard Display NP369

2.7.1 Description

The switchboard display NP369 is a flush-mounting instrument to visualize 4-20 mA signals.

Data are indicated in a 3½-digit 7-segment indication (13 mm) and decimal point.

The flush-mounting instrument is designed to be mounted in a switchboard.

The display instrument NP369 is designed for use with moisture sensors NP330-G and NP330-F. Different indication scales are available (see section 2.7.5).

2.7.2 Hints for Use

Hints and warnings listed in these operating instructions have to be respected to ensure riskless operation.

The device can be operated without impairment of its operational reliability within the range of acceptable environmental conditions described in section 2.7.6.

Before a first start-up, the device has to be checked for damages due to inappropriate transportation or storage. If, due to potential damages, risky operation has to be suspected, the device must not be started up. If riskless operation does not seem warranted any more, the device has to be shut down and to be secured against unintended operation. In that case, power supply voltage to all poles has to be disconnected. If the device is interconnected with other instruments or equipment, the effects of a start-up or shut-down have to be considered in advance and appropriate measures have to be taken.

2.7.3 Installation

The display instrument NP369 is to be inserted into the designated cut-out.

The cut-out has to be of 90.5 x 43 mm in size (see figure 15).

Figure 15: Switchboard cut-out seen from front side

Fixation is realized by means of the fixation elements provided. The locking screws have to be tightened alternatingly until the device is fixed.

With respect to the location of the device, heat radiation of neighbouring devices has to be considered (admissible environmental temperature has to be taken into account!).

The electrical connection has to comply with the respective directives (e.g., in Germany, VDE100). The supply voltage is indicated on the type label and is to be connected to terminals 15 and 16.

The protective conductor serves exclusively for discharging line-side disturbances.

2.7.4 Terminal Connection Diagram

The terminal assignment of the display instrument NP369 is represented in table 3 (see also figure 16).

Table 3: Terminal assignment

Terminal number	Signals
01	+ input 4-20 mA
02	- input 4-20 mA
03 – 13	not used
14	protective conductor
15	+ 24 V DC supply
16	earth

2.7.5 Order Data for Switchboard Display NP 369

Article	Scale			Article number
	4 mA	20 mA	unit	
Display instrument Type NP369.01.1	-80.0	20.0	ºC TP	NP369.01.1
Display instrument	0	1.999	% H_2O	NP369.01.2

Type NP369.01.2				
Display instrument Type NP369.01.3	0	1999	ppm H_2O	NP369.01.3

Figure 16: Terminal connection diagram NP369

Com Anschluss DB 9	COM connection DB 9
Anzeigegerät NP369	display instrument NP369
Typ:	type:
Serien Nr.	serial number
Eingang	input
Versorgung	supply
Relais o.ä.	relay or similar device
Eingang 24 V max. 100 mA	input 24 V, max. 100 mA
schwarz	black
grün	green
blau	blue
weiß	white
braun	brown
rosa	pink
grau	grey
gelb	yellow
Versorgung	supply
GND	GND
Schutzleiter	protective conductor
Sensorkabel NP 390	sensor cable NP 390

2.7.6 Technical Data NP369

Display	**7-segment indication, 13 mm LED, red**			
Indication range	type NP369.01.1 type NP369.01.2 type NP369.01.3 max. +/- 1999 digit	-80.0 0 0	… 20.0 … 1.999 … 1999	ºC TP % H_2O ppm H_2O
Decimal point	firmly adjustable			
Error message	"1" in case of exceeding upper limit of measurement range "-1" in case of exceeding lower limit of measurement range			
Measurement range	4 – 20 mA DC			
Measurement error	≤ +/- (1 digit + 0.15% of measured value)			

Temperature influence	≤ +/- 0.08 digit/K (related to 25 ºC)
Measurement rate	about 2.5 measurements per second
Response time	less than 2 seconds with abrupt change
Operating temperature	0 – +50 ºC, no thawing allowed
Supply voltage	18 – 28 V DC, nominally 24 V, less than 7 VA max. residual ripple 100 mV_{ss}
Casing	plastic rack-mounting casing according to DIN 43700 with locking braces according to DIN 43835 removable front panel
Casing material	Noryl (glass-fibre reinforced), flame-resistant
Protection type	in front of the front panel IP 50 terminals IP 20 (DIN 40050, IEC 144)
Dimensions	about 96 x 48 x 135 mm (width x height x length)
Weight	about 450 g
Mounting depth	about 126 mm
Switchboard cut-out	90.5 mm x 43 mm
Switchboard thickness	max. 40 mm
Connection method	screw terminals with wire protection for max. 1.5 mm^2

2.7.7 Representations of Display Instrument NP369

Figure 17: Sketch of side view of display instrument NP369

Display-Frontrahmen	front panel of display
Sitz Befestigungselement	location of fixation element
Gehäuse	casing
Anschlussklemmen	terminals
Schalttafel	switchboard

Figure 18: Sketch of front view of display instrument NP369

Display-Frontrahmen	front panel of display
7-Segment-Anzeige	7-segment indication
GfS Wassergehalt in ppm	GfS water content in ppm
Beschriftungsfeld	inscription field

Figure 19: Location of fixation elements on display instrument NP369

Sitz Befestigungselement	location of fixation element
Spannschraube	locking screw
Befestigungselement	fixation element
Schalttafel	switchboard