Operating Manual

Oil Condition Sensors - LubCos Guard

SCSO 400-1000

Safety and operating instructions

Read safety and operating instructions before use

Note: Representations do not always correspond exactly to the original. No legal claims arise from information provided by us in error. Subject to change.

The indicated data only serve to describe the product. Information regarding the use of this product are only examples and suggestions. Catalog specifications are no guaranteed features.
The information given does not release the user from his / her own assessments and inspection.

Our products are subject to a process of natural wear and aging.

The picture on the title page shows a configuration example.
The delivered product may thus differ from the illustration.

Content

Content

1. Quick Start

The following section describes the steps for initial commissioning of the Oil Condition Sensor LubCos to be carried out at the PC. For this purpose, the following components are required:

1. PC / Laptop with RS232 connection, or alternatively, with a USB port, which serves as a measuring computer
2. Oil Condition Sensor LubCos
3. Sensor cable (order number: SCSO 100-5030)
4. Power supply incl. cold device plug (order number: SCSO 100-5080)
5. Software LubMon PC$_{light}$ or LubMon Config (www.argo-hytos.com)
6. In addition, when connected via USB: USB-RS232 converter with associated driver software (order number: SCSO 100-5040)

The software LubMon PC$_{light}$ and LubMon Config can be downloaded from the website www.argo-hytos.com.
The components are to be prepared as follows:

A) Software Installation LubMon PC$_{light}$

1. Unzip the file LubMon PClight.zip or LubMon Config.zip on your computer.

B) Software installation of the driver for the USB-RS232 converter with data acquisition via USB
(If you do not use a converter, please continue with point D)

2. Now connect your USB-RS232 converter to your PC / laptop.
3. If the USB-RS232 converter is not known by the PC, the corresponding driver must be installed.
   For this purpose, follow the installation instructions of the operating system or the supplied driver CD.

C) Sensor connection with data acquisition via USB

4. Connect the sensor cable to the M12 connector at the sensor.
5. Connect the 9-pin D-Sub connector of the cable to the appropriate serial port of the USB-RS232 converter.
6. Connect the USB connector of the USB-RS232 converter to the appropriate serial port of your PC / laptop.
7. Connect the power supply and the sensor cable.
8. Now properly connect your power supply via the cold device plug to the mains voltage. Your sensor is now ready for operation.

D) Sensor connection with data acquisition via RS232

9. Connect the sensor cable to the M12 connector at the sensor.
10. Connect the 9-pin D-Sub connector of the cable to the appropriate serial port of your PC / laptop.
11. Connect the power supply and the sensor cable.
12. Now properly connect your power supply via the cold device plug to the mains voltage. Your sensor is now ready for operation.

E) Starting the software

13. LubMon PClight or Lub Config can be started by double click onto the file LubMonPClight.exe or LubConfig.exe.
14. Select the serial port (COM), at which you have connected the sensor to the computer. If you do not use a USB-RS232 converter, this is usually COM 1.
15. When using a USB-RS232 converter, a new virtual COM port is created. Then choose this port.
    If necessary, you can check the assignment of the virtual COM port in the Windows Device Manager.
16. The incoming data and the identification of the sensor appear on the left side of the window. On the right side of the window, the data can be visualized in a graph.

Further important information and tips on using the full functionality of the sensor, see Chapter 6.

1.1. Checking the sensor function

The sensor is designed so that it can be exposed to specified loads over long periods of time. With fluids or applications where there is no experience base regarding the long-term stability of the sensor, the sensor should be checked in the laboratory every two years at the latest.

2.1 General

The LubCos Guard is an intelligent sensor for determining the status of hydraulic and lubrication systems. The sensor is designed as a screw-in sensor and is used for continuous monitoring of the oil condition and wear in gear applications. By detecting wear and damage at an early stage, you can plan maintenance activities and minimize downtime.

The sensor is provided with a G1 thread and can be integrated directly into the gearbox housing or the lubrication circuit.
From measured oil parameters, indications on status changes as e.g. oil aging, refreshment or water ingress can be derived. As a result, incipient damage can be detected at an early stage or completely avoided. This offers the possibility, to prevent serious machine faults by suitable measures as well as to prolong maintenance and oil change intervals. Information regarding a performed plant maintenance or the use of the prescribed lubricant can also be derived from the measured oil parameters and their property changes and then be documented.

The sensor detects the following parameters:

- temperature
- ferromagnetic particles
- ferromagnetic parts (“chunks”)
- relative humidity
- conductivity
- relative permittivity of the fluid
- filling level

Since the conductivity and the relative permittivity show a strong temperature dependence, the sensor offers the possibility to convert these parameters to a fixed reference temperature. For this conversion, the sensor continuously measures at different temperatures, and thereby determines the temperature gradient of the parameters.

To determine the temperature gradient, a few temperature cycles are required when starting up the sensor. During operation, the temperature gradient is continuously updated even with an oil change or oil aging.

The individual measured values as well as other sensor functions are described below in more detail:

2.2 Temperature measurement

For measuring the oil temperature, a PT1000 platinum resistance sensor is used. The measuring range extends from -20 °C to +120 °C. Since the resistance sensor is located directly in the oil, the conductivity of the surrounding medium should not exceed a value of 3 µs/m (-1).

2.3 Humidity measurement

The measurement of the relative humidity (symbol: φ) is effected by using a capacitive transducer. The capacitive humidity sensor detects the relative humidity in the measuring range between 0 % and 100 %. In case of free water or emulsions, the sensor indicates 100 %. Since the humidity sensor is located directly in the oil, the conductivity of the surrounding medium should not exceed a value of 3 µs/m (-1).

2.3.1 Relative humidity

Relative humidity φ is understood to be the ratio of the actually in the oil contained (ρ_w) to the maximum possible amount of dissolved water at the saturation limit ($\rho_{w,max}$).

$$\varphi = \frac{\rho_W}{\rho_{W\,max}} \cdot 100\ \% \qquad (3\text{-}1)$$

Since the saturation limit, i.e. the maximum absorbable absolute humidity $\rho_{w,max}$ is strongly temperature dependent, the relative humidity varies with the temperature, even when the absolute humidity remains constant. Usually, oils absorb more water with increasing temperature, before the saturation limit has been reached.

2.3.2 Absolute humidity

The absolute humidity is no physically measured value. It is determined by the relative humidity φ and the saturation limit $\rho_{w,max}$ according to the following formula (3-2).

$$\rho_W = \frac{\varphi \cdot \rho_{Wmax}}{100\ \%} \qquad (3\text{-}2)$$

The saturation limit $\rho_{w,max}$ depends on the oil type and the temperature and must be determined in the laboratory.
For more information, please contact the ARGO-HYTOS service team.

2.4 Conductivity measurement

Oils in the fresh state show a characteristic conductivity. Since the conductivity is oil specific in the context of manufacturing variations, it already constitutes a criterion for distinguishing oils. In order to distinguish oil based on the conductivity, the conductivity at a certain temperature or the change in the conductivity above this temperature must be significantly distinguishable.

Also an entry of foreign matter (solid / liquid) can be detected, so far as this results in a change in conductivity at certain temperature or of the conductivity above this temperature.

Oil change, oil mixtures and contaminations can thus be detected on the basis of conductivity under the given boundary conditions.

It should be considered that even batch variations and oil aging have an influence on the conductivity.

The conductivity may change due to various aging processes, so that by means of conductivity measurement also the aging course can be tracked. The measuring range of the conductivity extends from < 100 up to approx. 800,000 pS/m.

Since the conductivity is highly dependent on the temperature[1], the sensor performs an internal conversion to a reference temperature of 40 °C. An additional parameter results from this conversion: the temperature gradient of the characteristic size, which can also be used for the characterization of the oil - as described above.

2.5 Measuring the relative permittivity

The relative permittivity $\varepsilon_{Öl}$ of the fluid is an indicator for its polarity. Base oils and additive packages with different chemistry and from different manufacturers may differ in their polarity. The polarity and the course of the polarity of the fluid above the temperature are thus characteristics, which may be recognized under specific conditions, as e.g. under consideration of batch variations, oil confusions, oil mixing and refreshments.

Oils often change their polarity during the aging process. Should this lead to a significant change in the polarity, also the course of aging might be monitored. The measuring range of the relative permittivity is between 1...7.

Since the relative dielectric constant is dependent on the temperature, the sensor performs a conversion to a reference temperature of 40 °C. An additional parameter results from this conversion: the temperature gradient of the characteristic size, which can also be used for the characterization of the oil - as described above.

Note:
When used in highly conductive liquids, the measurement of the relative dielectric constant may be subject to a cross-interference, despite of the integrated compensation.

2.6 Measurement of the filling level

The sensor is provided with a capacitive filling level detection. The Guard's sensor measuring length is equal 32mm. The level is measured according to the same principle as the dielectric constant. As a reference for the measurement, the dielectric constant, detected by the sensor, is used. This method allows to detect the filling level capacitively, without having to specify the type of the fluid.

Note:
When used in highly conductive liquids, the measurement of the level may be subject to a cross-interference, despite of the integrated compensation.

[1] Higher conductivity of the oil has a negative effect on the accuracy of the measurement.

2.7 Measuring the particles

The sensor detects the amount of ferromagnetic particles that accumulate at the permanent magnet of the sensor head. Here, the sensor can distinguish between fine particles in the micrometer range and coarse ferromagnetic fragments ("chunks") in the millimeter area. On the basis of the output signal from 0 to 100%, the occupancy of the sensor surface with ferromagnetic particles or fragments can be read off.

2.8 Operating hours counter

The sensor has an integrated operating hours counter whose values are still present even after power failure. After interruption, the counter restarts counting at the last stored value before the interruption.

2.9 Data logger

The integrated operating hours counter, which operates as soon as the sensor has been connected to the power supply, makes it possible to assign hours of operation to the measured characteristics. The time stamp, the four measured values temperature, oil humidity, conductivity and relative permittivity and all other derived parameters are stored in the sensor ring memory (see Chapter 6.8). In total, more than 5460 data sets can be stored in the memory

2.10 Fine ferromagnetic particles

The detection of fine ferromagnetic particles is achieved steplessly and is output via a signal from 0 to 100%. 0% displays a particle-free surface, 100%, however, means that the sensor surface has reached its preset limit. When this limit has been reached, the oil should be filtered or the sensor should be screwed out and the particles should be cleared from the surface.

The parameter, output by the sensor, is called: OR_f = OccupancyRate_fine

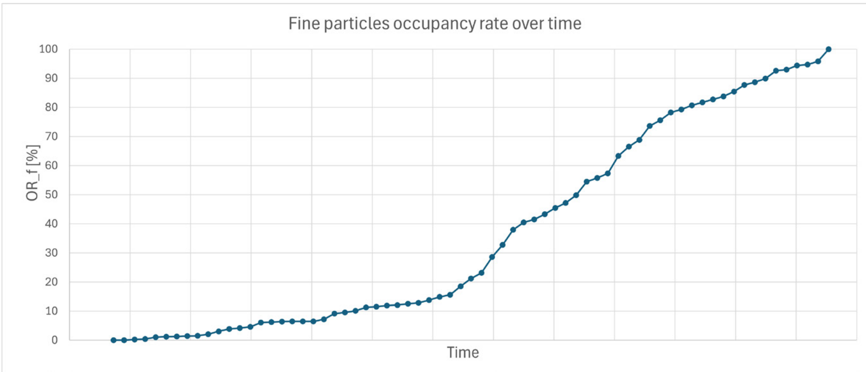


Figure 1: OccupancyRate_fine

Figure 2: Example for the detection of fine particles

2.10.1 Coarse ferromagnetic fragments (chunks)

The detection of coarse ferromagnetic fragments (chunks) is effected by default in steps of 10% and is output via a signal from 0 to 100%. 0% displays a chunk-free surface. 100%, however, means that the sensor surface has reached the set limit value (= 10 chunks). When this limit has been reached, the oil should be filtered or the sensor should be screwed out and the particles should be cleared from the surface.

The parameter, output by the sensor, is called: OR_c = OccupancyRate_chunk

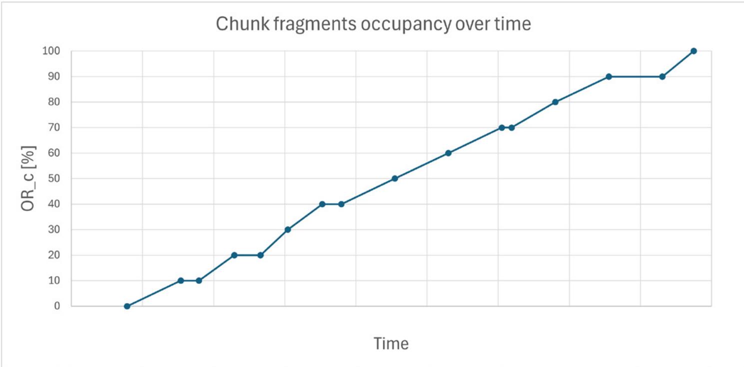


Figure 3: OccupancyRate_chunk

Figure 4: Example for the detection of chunks

2.10.2 Sum signal

In order to display both parameters at the same time, the sensor calculates the sum of the occupancy rate of fine particles and "chunks". 0% displays a free, uncontaminated sensor surface. 100%, however, mean that the sensor surface has reached the set limit (= 100% fine particles or 10 chunks or any combination of both).

The parameter, output by the sensor, is called: OR_s = OccupancyRate_sum

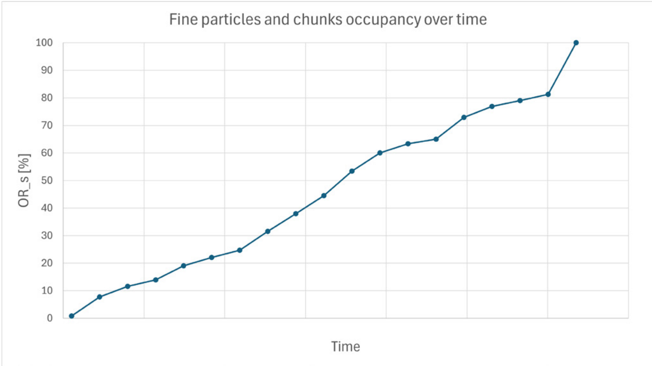


Figure 5: OccupancyRate_sum

Figure 6: Example for the output of the sum signal

2.11 Oil condition

Oil aging is generally understood to include all changes of parameters and properties of the oil during its lifetime.
The goal is, to detect significant aging processes of the oil, based on the changes in the parameters, measured by the sensor. The automatic oil condition analysis however goes beyond this. The aim here is to detect not only the aging, but also other status changes. Possible status changes are:

- Oil aging (e.g., oxidation of the oil)
- Contamination with foreign fluids
- Water ingress (e.g. high water content or free water)
- Oil change, also changing to the wrong oil type
- Oil refreshment
- Oil mixing

The aim of an automatic evaluation is to assist the user in interpreting the characteristics and to recognize various states and status changes comparing the current measurement data and saved history data. This recognition of states and state changes on the used rule base is however only reliable if the measured data and their quality basically allow this interpretation (see Chapter 2.1).

A detailed description of all recognizable state changes and their query, storage and parameterization can be found in the appendix.

2.12 Determination of the Remaining Useful Life Time (RUL)

In addition to the classification of different states or state changes, another sensor function, the Remaining Useful Lifetime (RUL), must be estimated on the basis of the available data. A distinction is made between two different approaches.
Figure 8 shows the exemplary course of an aging characteristic over the operating time.

After an oil change, the oil parameters do not change or do not significantly change over a long period of time. Only after the so-called incubation period (phase 1), when certain additives, the antioxidants are depleted, the accelerated aging of the oil begins, mostly running progressively (phase 2).
Phase II is characterized by an accelerated aging process and thus changing aging characteristics. Based on the signal trends of the various measured parameters, an extrapolation until a predetermined aging limit and thus the Remaining Useful Lifetime (RUL), can be calculated.

A standard parameterization of the aging limits is set at the factory. For specific information regarding the setting of aging limits, please contact the ARGO-HYTOS service team.

Note:
The limit values should be adjusted for specific applications. The determined residual life represents a reference value, which was determined by linear extrapolation. It is important to note that aging processes can also run non-linear.

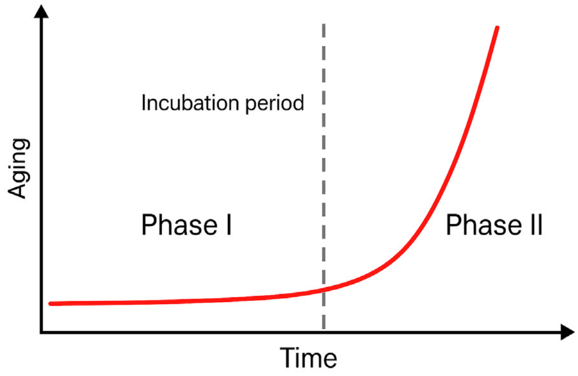


Figure 7: Theoretical aging process

2.13 Scope and conditions of the automatic status assessment and RUL calculation

For automatic state judging some constraints must be considered:

- State changes can only be detected if the information is included in the measured parameters. For example, based on the measured parameters usually no statements about the consumption of antioxidants are possible.
- Individual critical changes in the oil can be superimposed in the extreme case, so that the resulting overall change does not reflect this state.
- For the respective states or state changes there are limits of detectability, in which the underlying signal changes or gradients of change will not be recognized.
- The automatic status assessment can be disturbed by cross-influences.
- The calculation of the RUL is only a rough estimate. In open systems with uncontrollable introduction of contaminants and in systems with widely varying operating conditions, the uncertainty of the parameter statement increases. The parameterization also has strong influence on the results.
- Through a purely mathematical estimation of the RUL from measured stress parameters, spontaneous state changes cannot be predicted.

Overall - with a sufficient amount of data and targeted parameterization - you mostly can achieve a satisfying accuracy and prediction of the aging curve.

2.14 Derived characteristics

The following derived parameters are also calculated by the sensor and read out via the digital interface.

#	Parameter	Abbreviation	Unit	Statement
1	Operating hours	Time	h	Counts as soon as the power is turned on
2	Temperature	T	°C	Oil temperature
3	Relative permittivity (rel. DC)	P	-	Polarity of the liquid. Fresh oils differ in P and can thus be distinguished. Furthermore, P changes during the oil aging.
4	Conductivity	C	pS/m	Fresh oils differ in C and can thus be distinguished. Furthermore, C changes during the oil aging.
5	Rel. oil humidity	RH	%	Rel. humidity between 0 and 100 %
6	Filling level	L	%	Filling level between 0 and 100
7	Fine ferromagnetic particles	[OR_f]	%	Occupancy rate fine: occupancy rate of the sensor surface with fine particles
8	Coarse ferromagnetic fragments	[OR_c]	-	Occupancy rate chunk: occupancy rate with large particles (chunks) from 0 ... 100 % in 10 % steps (detection of max. 10 chunks)
9	Sum signal	[OR_s]	%	Occupancy rate sum: occupancy rate - sum of OR_f and OR_c

Table 1: Determined original characteristics

The parameters are dependent on the temperature which is compensated by the sensor. From this compensation two additional temperature gradients do arise, which are used for condition evaluation.

#	Original parameter	Derived characteristic Abbreviation	Unit	Statement
1	P	PTG	1/K	Rel. DC - temperature gradient
2	C	CTG	(pS/m)/K	Conductivity - temperature gradient
3	RH	HTG	%/K	Rel. oil humidity - temperature gradient

Table 2: Derived temperature gradients

From the original parameters P, C and RH and the determined temperature gradients PTG, CTG and HTG, the sensor calculates the temperature compensated parameters P40 and C40 and H20, H40 in the same unit as the respective original parameter.

Note:
The accuracy of detection of PTG, CTG and HTG as well as the quality of the temperature compensation are fluid dependent.

#	Original parameter	Derived characteristic Abbreviation	Statement
1	P	P40	Rel. DC at reference temperature of 40 °C
2	C	C40	Conductivity at reference temperature of 40 °C
3	RH	RH20[1]	Rel. oil humidity compensated to 20 °C oil temperature

Table 3: Temperature compensated characteristics

[1] Compensation of the relative humidity to 20 °C is strongly dependent on the fluid, temperature profile and other boundary conditions

The sensor in turn determines temporal gradients from the original parameters, the temperature gradients and the compensated characteristics. The temporal gradients, in particular, give an indication of the kind of change.

#	Original parameter	Derived characteristic Abbreviation	Unit	Statement
1	P40	LGP40	1/h	Long-term gradient of P40
2	P40	MGP40	1/h	P40 gradient over a medium term
3	P40	SGP40	1/h	Short-term gradient of P40
4	C40	LGC40	(pS/m)/h	Long-term gradient C40
5	C40	MGC40	(pS/m)/h	C40 gradient over a medium term
6	C40	SGC40	(pS/m)/h	Short-term gradient of C40
7	T	LGT	K/h	Long-term gradient of the oil temperature
8	T	SGT	K/h	Short-term gradient of the oil temperature
9	H20	SGH20	%/h	Short-term gradient of H_2O

Table 4: Temporal gradients

Rapid changes indicate e.g. topping up of oil, slow gradients might indicate - depending on the size - contamination with a foreign liquid or an oil aging. The sensors determine short-term gradients, where the averaging time takes a few hours and long-term gradients, where the averaging time takes a few hundred up to a few thousand hours.

An overview on all parameters used for the assessment is given in Chapter 13 "Appendix".
Figure 8 is a graphical overview of the interaction between the measured parameters and the algorithms in the sensor.

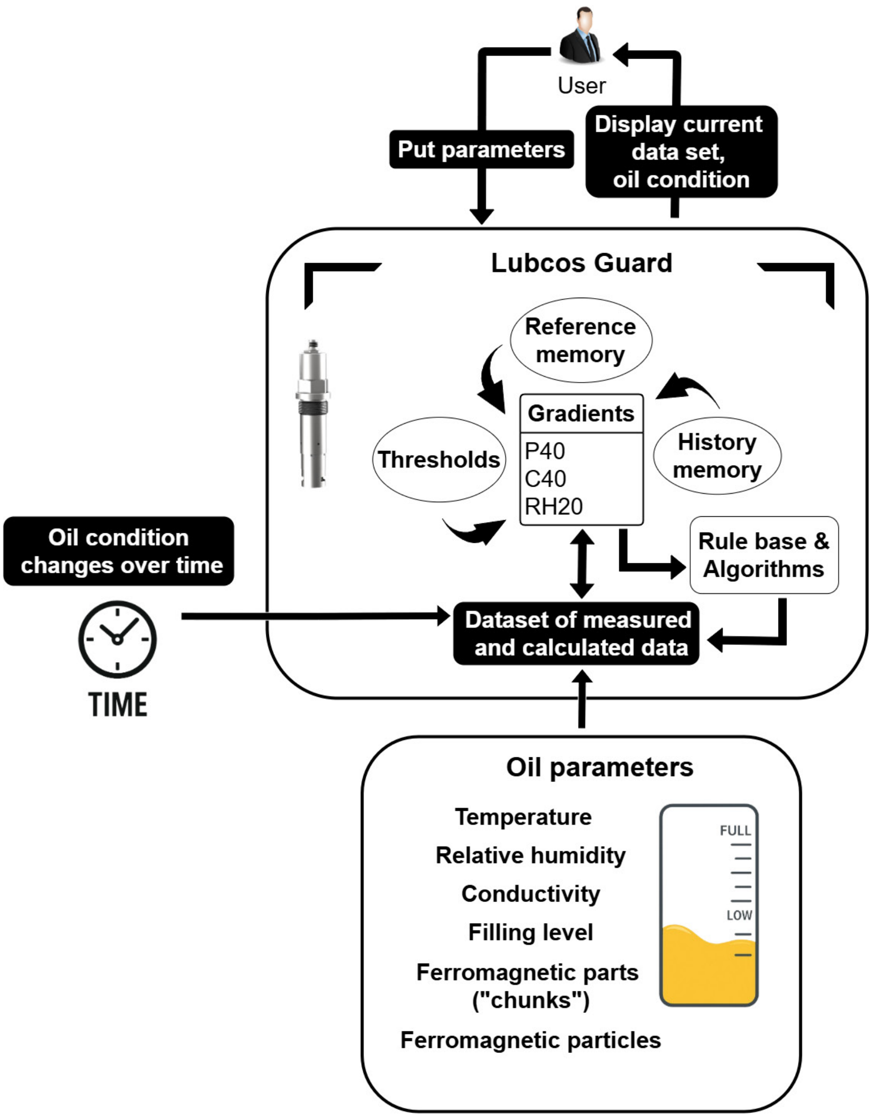


Figure 8:
Data processing and interaction between measured parameters and algorithms in the sensor

2.15 Cross-influences

The sensor signal is substantially free of cross-influences, as long as there are no interfering contours or (electro)-magnetic fields in the defined detection radius.

On first operation, a minimum offset (<5%) may occur in the measurement signal due to a cross-influence of the oil (sensor is - ex works - calibrated to air). This influence, however, is automatically compensated after the first cleaning process. One possibility for earlier compensation is by execution of the SONew command (see Chapter 6.1).

2.16 Overview on issued parameters for individual commands

The sensors support a series of commands to issue the measured, derived and calculated parameters of the oil. The responses to the individual commands are listed in the following tables. Depending on the version of the sensor firmware, the order or the content of the issues may differ.

#	Parameter name	Unit	Statement
1	Time	h	Operating hours counter of the sensor
2	T	°C	Temperature of the fluid
3	L	%	Height of the oil level referred to the measuring range (only with level sensors)
4	L_s	%	Oil level scaling
5	OR_s	%	Occupancy rate sum: occupancy rate - sum of OR_f and OR_c
6	OR_f	%	Occupancy rate fine: occupancy rate of the sensor surface with fine particles
7	OR_c	-	Occupancy rate chunk: occupancy rate with large particles (chunks) from 0 ... 100 % in 10 % steps (detection of max. 10 chunks)
8	P	-	Relative permittivity of the fluid
9	P40	-	Relative permittivity of the fluid compensated to 40 °C fluid temperature
10	C	pS/m	Conductivity of the fluid
11	C40	pS/m	Conductivity of the fluid compensated to 40 °C fluid temperature
12	rH	%	Relative humidity of the fluid
13	rH20	%	Relative humidity of the fluid compensated to 20 °C (room temperature) fluid temperature
14	OAge	h	Time since last manual reset ("SONew" command)
15	RUL	h	Summarized and weighted RUL
16	CRC:	-	Summary auto-recognized oil states

Table 5: Response to the command "RVal"

3.1 General data

Sensor data	Size	Unit
Max. operating pressure	50 (750)	bar (psi)
Operating conditions		
Temperature [1 4] Rel. humidity [1]	-20 ... +85 (-4 ... +185 0 ... 100	°C °F) % r.H. (non-condensing)
Compatible fluids excluding water-based types	mineral oils (H, HL, HLP, HLPD, HVLP), synthetic esters (HETG, HEPG, HEES, HEPR), polyalkylenglycols (PAG), zinc and ash-free oils (ZAF), polyalphaolefins (PAO)	
Wetted materials	aluminum, HNBR, polyurethane resin, epoxy resin, chemical nickel/gold (ENIG), soldering tin (Sn96,5Ag3Cu0,5NiGe), aluminum oxide, glass (DuPont QQ550) gold, silver-palladium	
Protection class [2]	IP67	
Power supply [3]	9 ... 33	V
Power input	max. 0.2	A
Output		
Interfaces	RS 232 [5]/ CANopen [6]/ (SAE J1939 on request)	-
Connections		
Threaded connection	G1	inch
Tightening torque of threaded connection	45 ±4.5	Nm
Electrical connection	M12 x 1, 8-pole	-
Tightening torque M12-connection	0.5	Nm
Measuring range		
Fine particles	0 ... 100	%
Coarse particles	0 ... 10	-
Rel. dielectric number	1 ... 7	-
Rel. humidity	0 ... 100	% r.H.
Conductivity	100 ... 800,000	pS/m
Temperature	-40 ... +125 (-40 ... +257	°C °F)
Fluid level [7]	32 (1.25)	mm (inch)
Measuring resolution		
Fine particles	0.1	%
Coarse particles	1	-
Rel. dielectric number	$1*10^{-4}$	-
Rel. humidity	0.1	% r.H.
Conductivity	1	pS/m
Temperature	0.1	K
Fluid level	0.1	%

Sensor data	Size	Unit
Measuring accuracy [8]		
Fine particles	5	%
Coarse particles	1	-
Rel. dielectric number [9]	±0.015	-
Rel. humidity (10 ... 90%) [10]	±3	% r.H.
Rel. humidity (<10%, >90%) [10]	±5	% r.H.
Conductivity (100 ... 2000 pS/m)	±200	pS/m
Conductivity (2000 ... 800,000 pS/m)	Typ. <±10	%
Temperature	±2	K
Fluid level	Typ. <±5	%
Response time (T90 [11]) humidity measurement	<1 (air) <5 (oil)	min
Weight	284	g

[1] Outside the specified measuring range, there are possibly no plausible measuring values to be expected
[2] With screwed on connector
[3] Automatic switch-off at U <8 V and U >36 V, with load-dump impulses over 50V an external protection must be provided
[4] Up to + 125 °C when working on CAN
[5] With 9600 baud rate speed
[6] With 50/100/125/250/500 kbit/s speed- CANopen or SAE J1939
[7] max 32mm TOP EDGE VENTS
[8] Works in calibration range +20 ... +85 °C (68 ... +185 °F)
[9] Calibrated to n-Pentan at 25 °C (77 °F)
[10] Calibrated to air at room temperature
[11] Time required for a sensor to reach 90% of the final value at the output in the event of an abrupt change

Table 6: Technical specifications

3.2 Dimensions

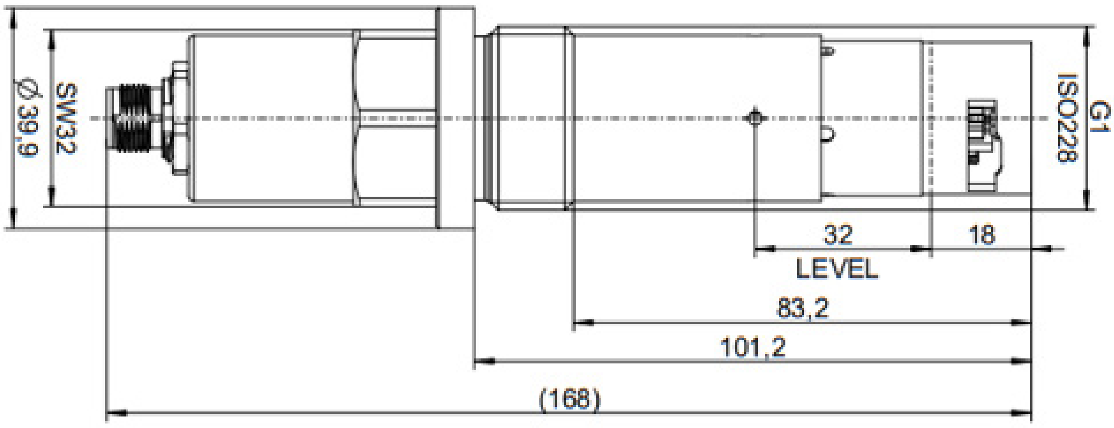


Figure 9: Dimensions LubCos Guard

3.3 Permissible mechanical loads

The permissible mechanical loads for the sensor are listed in the following table:

Load	Size	Unit
Max. vibration in longitudinal direction LubCos Guard Testing based on DIN EN 60068-2-6	f: 10 - 55 A: +/- 75mm f: 55 - 2000 a: 10	Hz mm Hz g
Shock test according to DIN EN 60068-2-27 LubCos Guard Testing based on DIN EN 60068-2-6	50 g for 6ms, half sine, 3 shocks each for both sensors in all three coordinate directions 100 g for 11 ms, half sine, 3 shocks each in all three coordinate directions	Hz mm Hz g

Table 7: Permissible mechanical loads

4. Mounting

The sensor is designed as a screw-in sensor with a G1 thread. To ensure the measuring function of the oil level, the sensor must be screwed vertically from above into the tank of the application.

The measuring head of the LubCos Guard should always be located in the oil.
According to gear application, the system must be stopped to avoid incorrect readings of the oil level parameters (e.g. air-bubbles).

Screw the sensor into a prepared position in the tank. The sealing to the oil side is provided by a profile sealing ring. In order to ensure a proper sealing, the sealing surface for inserting the sensor should be specially prepared and the maximum roughness should be R_{max} = 16. The tightening torque of the sensor is 45 Nm ± 4.5 Nm.

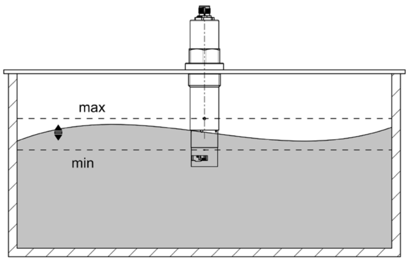


Figure 10: LubCos Guard installation recommendation

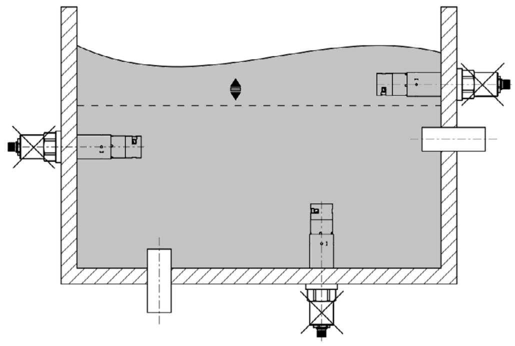


Figure 11: Installation examples of incorrect mounting of the sensor in an oil tank

To ensure proper operation, please respect the following guidelines and the mounting position and location of the sensor:

- Ensure that the sensor is completely covered with oil in operating situation of the system. Foam formation in the tank should be avoided.
- When installed in the return line or flushing line, it must be ensured that the flushing line is not running empty in any operating situation.
- To avoid thermal influences as far as possible, the sensor should not be installed in the immediate vicinity of hot parts and components (e.g. motor).
- In order to allow a calculation of the characteristic values to a reference temperature, varying oil temperatures are required. The greater the temperature changes are, the faster the temperature gradient can be determined.
- The measurement should always be taken at a point that is characteristic for the system being monitored.
- The sensor should be installed at a point where the medium is sufficiently mixed.

5.1 General information and safety note

The device must be installed by a qualified electrician. Follow the national and international regulations for the installation of electrical equipment.

Voltage supply according to EN 50178, SELV, PELV, VDE 0100-410 / A1.

M12x1, 8-pole, male connector

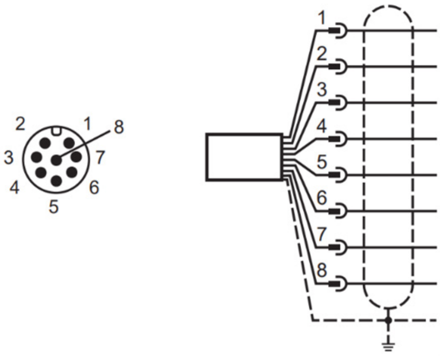


Figure 12: Pin assignment sensor plug

Pin no.	Signal	Description	Wire colors	
			DIN 47100	DIN EN 60947-5-2
1	L+	9…33 V DC	White	Brown
2	L-	0 V DC	Brown	White
3	TxD/ CAN L	RS232C / CANopen / J1939	Green	Blue
4	RxD/ CAN H	RS232C / CANopen / J1939	Yellow	Black
5	Not connected	-	Grey	Grey
6	Not connected	-	Pink	Pink
7	Not connected	-	Blue	Violet
8	SGND	Signal ground	Red	Orange
	Shield	Shield internally connected to L-		

Table 8: Pins description

The permissible operating voltage is between 9V and 33V DC. The sensor cable is to be shielded. In order to achieve the protection class IP67, only suitable plugs and cables may be used. The tightening torque for the plug is 0.5 Nm.

The communication with the sensor is carried out either via a serial RS232 interface or CAN (Open or J1939).

6.1 Serial interface (RS232)

The sensor is provided with a serial interface, via which it can be read and configured. For this purpose, a PC and an appropriate terminal program or a readout software is required. .

RS232 communication allows the user to easily configure and read sensor data. It is not currently the recommended standard for industrial applications, but it is ideal for initial configuration and getting to know the sensor's capabilities in a laboratory environment or test bench. In our free programs for configuration and communication with the sensor we also use this standard (link to the programs).

A detailed description of the available commands can be found in Appendix A to this document.

6.2 CANopen

The CAN (Controller Area Network) bus is a reliable, high-speed communication standard used in embedded systems for exchanging data between devices. A key element is the physical layer, which must comply with the guidelines set out in the CiA documents, guaranteeing correct terminations, wiring and signal compatibility. In combination with the CAN Open protocol, the LubCos Guard enables secure and fast communication in industrial and mobile applications.

A detailed description of the sensor communication over CAN Open can be found in Appendix B of this document, and an .eds file is available on the website (link here) for quick integration of the sensor into control systems.

In the following, the commissioning of the sensor is described in each case with the RS232 and CAN interface.

Check, if the device is properly installed and securely electrically connected. For proper functionality of the sensor, the conditions listed in Chapter 4 and Chapter 5 must be observed.

7.1 Commissioning with RS232 interface

After connecting the sensor to the power supply, the sensor automatically reports via RS 232 with its sensor identification number (see Appendix A).

The sensor is now ready for operation and can be read with the digital interface. An overview of the supported commands is given in Appendix A, Table 1 and Table 2. Please follow the instructions in Chapter 1 for quick setup.

7.2 Commissioning with CAN interface

The sensor is standardly supplied with activated RS232 and deactivated CAN interface. For permanent activation of the CAN interface, the sensor must be configured via RS232 interface (command "WCOEN", see Appendix A Chapter 1.1).

On delivery, the CANopen interface of the sensor is configured according to Table 10.

Standard configuration CANopen interface		
Parameter	**Set value**	**RS232 command**
Node-ID	0x64 (dez: 120)	WCOID
CAN Baud rate	250 kBit/s	WCOSpd
Heart Beat - Timer	1000 ms	WHBeat
TPDO1 ID	Node ID + 0x180 = 0x1E4 (dez: 484)	WTPDO1
TPDO2 ID	Node ID + 0x280 = 0x2E4 (dez: 740)	WTPDO2
TPDO3 ID	Node ID + 0x380 = 0x3E4 (dez: 996)	WTPDO3ID
TPDO4 ID	Node ID + 0x480 = 0x4E4 (dez: 1252)	WTPDO4ID
TPDO1 Type	255	WTPDO1Type
TPDO2 Type	255	WTPDO2Type
TPDO3 Type	255	WTPDO3Type
TPDO4 Type	255	WTPDO4Type
TPDO1 Timer	5000 ms	WTPDO1Timer
TPDO2 Timer	5000 ms	WTPDO2Timer
TPDO3 Timer	5000 ms	WTPDO3Timer
TPDO4 Timer	5000 ms	WTPDO4Timer
CAN activated	0	WCOEN

Table 9: CANopen standard configuration

After configuration of the CAN interface in accordance with the existing CANopen network, the CAN interface of the sensor can be activated and the sensor can be connected to the CANopen network (see Appendix B).

How to communicate with the sensor despite of the activated CAN communication via RS232 interface is described in Appendix A.

7.3 Range of functions depending on the configuration

Depending on the desired functionality, the sensor can be configured with additional information, to offer the respective functions. The table below provides an overview on the necessary configuration of the sensor to the respective functions. An information on the configuration of the sensor is given in Chapter 6.1.

In order to keep the device- and programming-related effort for the user low, the automatic evaluation of the sensor characteristics is carried out in the sensor itself. The collected data are stored event-, time- or command-triggered in the data and error memory. An "Event" is understood as a change in the status codes of the summarized states in Chapter 13, Table 15. The event-dependent storage can be set using the command "SETrig" (see Chapter 6.1).

Required configurations for receipt of functions	
Features / Scenario	**Necessary information on the system / configuration needs**
› Basic parameters: temperature, humidity, P, C, P40, C40 › Average temperature, load factor since commissioning of the sensor › Short-term gradients › Alarms on water content, „Low oil level“	› No further information on system necessary
› Alarms for exceedance of temperature	› Limits for maximum and average temperature must be adapted to the application
› Contamination detection with other oils / fluids › Long-term gradient › Aging progress of parameters (P40 and V40)	› Learning process must always be initiated with fresh oil
› Alarms for aging progress of limits	› Limit values for P40 and C40 must be configured (if default configuration is not enough)
› Alarm for ferromagnetic particles "chunks"	› Limit the amount of ferromagnetic particles "chunks" (if default configuration is not enough)
› Prediction for "Remaining Useful Lifetime" of the oil	› Learning process must always be initiated with fresh oil › Limit values for P40 and C40 must be configured (more information available than specified by standard configuration) › Load factor of the system (see Chapter 13.1) and associated service life of the oil must be known

Table 10: Range of functions depending on the configuration

Error: No sensor communication with Terminal Program	
Reason	**Measure**
› Cable is not properly connected	▶ First, please check the correct electrical connection of the sensor or the data and power cable. Please be aware of the prescribed connection assignment.
› Operating voltage is outside the prescribed range	▶ Please operate the sensor in the range between 9 V und 33 V DC.
› Interface configuration is faulty	▶ Check and possibly correct the settings of the interface parameters (9600, 8,1, N, N). Test the communication using a terminal program, if necessary by using an interface tester.
› Wrong communication port selected	▶ Check and correct the choice of the communication port (e.g. COM1).
› Incorrect spelling of sensor commands	▶ Check the spelling of the sensor commands. Note in particular the capitalization and lowercase. ▶ With invalid commands, the sensor returns the entered string with a prefixed question mark.
› Cable wrong or defective	▶ If possible, use ARGO-HYTOS data cables.
› RS232 interface is not activated	▶ Activate the RS232-interface either temporarily or permanently, using LubConfig or a terminal program, as described in Chapter 6.

Error: Measurement values are not plausible or vary	
Reason	**Measure**
› Sensor measures the air due to a heavily oscillating tank volume	▶ Check if the sensor is correctly installed in accordance with the installation instructions.
› Sensor measures air in the oil or polar deposits in the oil sump	▶ Check if the sensor is correctly installed in accordance with the installation instructions.
› The oil is strongly foamed	▶ Check if the sensor is correctly installed in accordance with the installation instructions. Foaming can be expected especially in transmissions and with unfavorable installation positions.
› Measured values are out of specification	▶ Observe the technical data and operate the sensor within the specified ranges.

Error: No sensor communication via CAN	
Reason	**Measure**
› Cable is not properly connected	▶ First, please check the correct electrical connection of the sensor or the data and power cable. Please be aware of the prescribed connection assignment.
› Operating voltage is outside the prescribed range	▶ Please operate the sensor in the range between 9 V und 33 V DC.
› Interface configuration is faulty	▶ Check and possibly correct the settings of the interface parameters. The setting to be selected depends on the configuration of the sensor.
› CAN interface is not activated	▶ Activate the CAN-interface with the help of the RS232-interface, with LubConfig or with a terminal program, as described in Chapter 6

Error: Incorrect measurement of the absolute humidity	
Reason	**Measure**
› Calibration parameter is set incorrectly	▶ The measuring range is oil-specific and must be programmed. Contact the ARGO-HYTOS service team.
› Measuring range is set incorrectly	▶ The measuring range is oil-specific and must be programmed. Contact the ARGO-HYTOS service team.

Table 11: Different types of errors

9. Application example

The oil condition is a factor, formed out of many parameters. Limits for specific oil parameters are dependent on the particular application, such as the components used and the materials. The type and speed of the oil parameter change is in turn dependent on the application, the specific system load as well as on the pressure or lubricating medium used.

It is thus not possible to define universally valid limits of individual parameters. Below, however, some characteristics for status changes of pressure and lubricants are exemplarily listed. The mentioned values are to be understood as guide values. For a system-specific adaptation of the guide values, laboratory tests are needed.

State / status change	Criteria
1. Oil refreshment / oil change	A refreshment of small amounts of oil is characterized by a change in sensor characteristics within a short period of time. Depending on the temperature, fluid viscosity, flow conditions and mixing in the system, the refilling of oil can be recognized within a few hours. The same applies for an oil change. With an oil change, in so far as the sensor is operated during the oil change, - at oil drain - an interim drop in the measured values on the respective air value can be recognized. Whether an oil refreshing can be detected, largely depends on the refilled oil quantity, the difference of the oil characteristics and the resolution of the sensor. **Relative permittivity (DC):** If an oil is filled up with a - compared to the currently existing medium in the system - higher or lower relative permittivity, the value rises or falls by homogeneous mixing. This state change occurs when a different type of oil is filled up or when the oil in the system already shows a change due to aging effects. If an oil with exactly the same relative permittivity as the oil in the system is filled up, this cannot be determined on the basis of this parameter. Nevertheless, the oil refreshment can be recognized by other parameters, which are described in the following.
2. Use of proper oil	The use of prescribed lubricants can be checked with the help of the conductivity and relative permittivity. For the fresh oils, the respective characteristics must be present. Then, the theoretically present and the currently measured values can be compared.
3. Oil aging	The oxidative aging of pressure and lubrication media usually results in polar aging products. Typically, there arise aldehydes and ketones and in the next sequence acid and high-molecular aging products. In analysis laboratories, the neutralization number NZ is often used as characteristic value for the determination of free acids in the oil. Since oils already have different neutralization numbers in the fresh oil condition, usually the trend history of the NZ is observed. A change in the NZ to 2 mg KOH/g is seen for example in hydraulic oils as an indicator for an oil change. **Relative permittivity (DC):** The increase of polar oil components can be traced with the sensor with the help of the relative DC. As with the observation of the NZ, the trend curve rather than the absolute parameter is crucial. Due to an oxidation, typically an increase in the relative DC is noted. In general, the change will be slow. If there is a change in the relative permittivity exceeding 10 to 20 % compared to the fresh oil value, the oil should be examined more closely. A closer examination is also then advised if the rate of change of the signal increases significantly and a progressive signal waveform is observed. **Conductivity:** In the course of aging, the conductivity as well as the relative DC are subject to changes. In many cases, the number of charge carriers in the oil and the conductivity increase. In the sensor, the fresh oil values of conductivity and relative DC are stored. Oil aging can thus be detected by comparing fresh oil values and current characteristics. The sensor records this evaluation independently and derives the corresponding aging progress (AP) out of this.

Table 12: Status of the sensor

Accessories	
Complete data cable set, M12x1, 8-pin, A-coded 5 m (16 ft) length	SCSO 100-5030
Data cable with open ends, M12x1, 8-pin, A-coded 5 m (16 ft) length	SCSO 100-5020
Female cable connector M12x1, 8-PIN, A-coded for connection of a data cable	SCSO 100-5010
USB adapter - RS 232 serial	PPCO 100-5420
Power supply	SCSO 100-5080
Ethernet - RS 232 gateway	SCSO 100-5100
Display and storage device LubMon Visu	SCSO 900-1000
LubMon Visu, Ethernet	SCSO 900-1010
LubMon Connect	SCSO 700-1000
LubMon PClight software	free download
LubMon Config software	free download
USB-C Sensor Adapter	SCSO 100-6000

Table 13: Accessories for LubCos Guard

11.1 Coding of error bits

Block	#	Bit	Type	Description	Recommended light status
1	0	0	Alarm	Low oil level summary	RED
1	1	1	Alarm	Sensor in air	RED
1	2	2	Alarm	Reserved	RED
1	3	3	Alarm	Sensor partially in air	RED
1	4	4	Alarm	Free water (RH > 95 %)	RED
1	5	5	Alarm	Extreme water content (RH > 75 %)	RED
1	6	6	Alarm	Current temperature exceeds limit	RED
1	7	7	Alarm	Average of temperature history exceeds limits	-
1	8	8	Alarm	Oil aging*, parameter exceed set limits	RED
1	9	9	Alarm	Reserved	-
1	10	10	Alarm	Reserved	-
1	11	11	Alarm	Reserved	-
1	12	12	Alarm	Oil change is recommended* ** (RUL<= 0h)	RED
1	13	13	Alarm	Reserved	-
1	14	14	Alarm	Forecast: free water at room temperature**	-
1	15	15	Alarm	Forecast: extreme water content at room temperature**	-
2	16	0	Info/warning	Reserved	-
2	17	1	Info/warning	Reserved	-
2	18	2	Info/warning	Reserved	-
2	19	3	Info/warning	Filling level above set limit (only with level sensors)	-
2	20	4	Info/warning	High water content (RH > 50 %)	YELLOW
2	21	5	Info/warning	Reserved	-
2	22	6	Info/warning	Reserved	-
2	23	7	Info/warning	Reserved	-
2	24	8	Info/warning	Reserved	-
2	25	9	Info/warning	Temperature: Measuring range exceeded	-
2	26	10	Info/warning	Humidity: Measuring range exceeded	-
2	27	11	Info/warning	Conductivity: Measuring range exceeded	-
2	28	12	Info/warning	rel. DC: Measuring range exceeded	-
2	29	13	Info/warning	Oil does not correspond to a pre-determined reference oil (the characteristics of the oil vary too much from the values of the learned fresh oil)	-
2	30	14	Info/warning	Other oil type detected than with previous filling / set reference oil* **	-
2	31	15	Info/warning	Reserved	-
2	32	0	Info/warning	Learning phase has not yet been completed, is set as fresh oil after designating of the current oil	-
3	33	1	Info/warning	Slow water ingress**	-
3	34	2	Info/warning	Modified reference value (reference values / limits were externally reset, remains active for about 15 seconds)	-
3	35	3	Info/warning	Reserved	-
3	36	4	Info/warning	Forecast: high relative humidity at room temperature**	-
3	37	5	Info/warning	Soon oil change advised* (RUL under 15 % of reference lifetime)	YELLOW
3	38	6	Info/warning	The counter for oil aging was stopped externally, will be deleted again at next sensor reboot or by command	-

Block	#	Bit	Type	Description	Recommended light status
3	39	7	Info/warning	PowerUp (Sensor has been rebooted, remains active for about 15s)	-
3	40	8	Info/warning	Reserved	-
3	41	9	Info/warning	Reserved	-
3	42	10	Info/warning	Reserved	-
3	43	11	Info/warning	Reserved	-
3 3	44 45	12 13	Info/warning	Oil type recognition** 44: HLP 45: HEPR 44+45: HEES/HETG	- -
3	46	14	Info/warning	Gradients not yet reliable	-
3	47	15	Info/warning	Event-depending memory deactivated	-
4	48	0	Error	Reserved	-
4	49	1	Error	Sensor defective (summary of the self-diagnosis, sensor partially failed or specified measuring range strongly exceeded)	-
4	50	2	Error	Forecast aging implausible* **	-
4	51	3	Error	Electronics temperature out of permissible range	-
4	52	4	Error	Humidity: Measured value out of permissible range	-
4	53	5	Error	Temperature: Measured value out of permissible range	-
4	54	6	Error	Conductivity: Measured value out of permissible range	-
4	55	7	Error	rel. DC: Measured value out of permissible range	-
4	56	8	Error	Reserved	-
4	57	9	Error	Reserved	-
4	58	10	Error	Reserved	-
4	59	11	Error	Reserved	-
4	60	12	Error	Reserved	-
4	61	13	Error	Reserved	-
4	62	14	Error	Reserved	-
4	63	15	Error	Reserved	-

Table 14: Detectable state changes and the associated bit encoding

* After an oil change, these parameters are only available after a completed learning phase, depending on the system after 10 to 250 operating hours and several load conditions, since the required gradients can only be determined with sufficient accuracy after some learning time.
** This state assessment is currently in the testing phase.

11.2 Load factor of a system

For the calculation of the load factor of a system, a typical temperature histogram or a temperature histogram at the measuring point of the sensor must be available. With the formula (15-1), the load factor can be calculated from a temperature histogram. H_n is the number of counts in the currently considered temperature class of the histogram, N is the total number of counts in the histogram, T_{class} is the average temperature of the currently considered class and T_{class} must be set to 95 °C.

$$fB = \sum_{n=0}^{n=N} \left[\frac{H_n}{N} \cdot 1{,}5^{\frac{T_{klasse} - T_{max}}{10}} \right] \qquad (15\text{-}1)$$

The sensor autonomously determines the load factor at site. Alternatively, this load factor can be used as a reference, if the machine can be viewed as a representative device with average load.

[1] www.argo-hytos.com

12.1 RS-232

The sensor is provided with a serial interface, via which it can be read and configured. For this purpose, a PC and an appropriate terminal program or a readout software is required. Both are described in more detail in the following chapters.
RS232 communication allows for easy configuration and reading of sensor data. It is currently not the recommended standard for industrial applications, but it is ideal for initial configuration and getting to know the capabilities of the sensor in a laboratory environment or test bench. In our free programs for configuration and communication with the sensor, we also use this standard.

12.2 Interface parameters

If the sensor is started in CAN mode, it must be reset to RS232 mode. After connecting the sensor to the current supply, the sensor recognizes online if it is connected to a serial interface (interface configuration see below) and if a defined character ("#") is sent, which must be present during the starting phase. If the character is not sent, the sensor jumps to CANopen mode. If it understands the transmitted character, it goes into communication mode via RS232. RS-232 mode can be permanently activated here using a command (see below). With a restart of the sensor, it automatically starts in RS232 mode and the above procedure can be omitted.

- Baud rate: 9600
- Data bits: 8
- Stop bits: 1
- Flow control: none
- Parity bits: none

12.3 Command list

Below, all interface commands for communication with the sensor are listed. These can be transferred to the sensor by using a terminal program such as e.g. HTerm.

12.3.1 Read commands

#	Instruction format	Meaning	Return format
1	RVal[CR]	Reading all measurements with subsequent checksum (CRC), see Chapter 14, Chapter 2.12	$ Time:x.xxx[h];T:xx.x[°C]; ....;CRC:x[CR][LF]
2	RID[CR]	Reading the identification and subsequent checksum (CRC)	$ARGO-HYTOS;LubCosGUARD; SN:xxxxx;...;CRC:x[CR][LF]
3	RCon[CR]	Reading the configuration parameters and CAN configuration with subsequent checksum (CRC)	$ Time:x.xxx[h];…; CRC:x[CR][LF]
4	RGrad[CR]	Reading the parameter gradients with subsequent checksum (CRC), see Chapter 14, Chapter 2.12	$Time:x.xxx[h]; PTG:x.xxx[1/K]; CTG:x. xxxx[pS/m/K];…; CRC:x[CR][LF]
5	RMemO[CR]	Reading the memory organization, parameter and unit of data is output	Time [h]; T [°C]; P [-];P40 [-];PTG [1/K];C [pS/m];… [CR][LF]
6	RMemS[CR]	Reading the number of storable records	MemS: xxxx[CR][LF]
7	RMemU[CR]	Reading the number of stored records	MemU: xxxx[CR][LF]
8	RMem[CR]	Reading the entire memory, incl. organization, records are separated by [CR] [LF], interruption by pressing either of the keys	Time [h]; T [°C]; P [-];P40 [-];PTG [1/K];… [CR][LF] x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… [CR][LF]
9	RMem-n[CR]	Reading the last n records in the memory with subsequent checksum (CRC) per record, separation of data with semicolon, separation of records with [CR] [LF], starting with the oldest record, interruption by pressing either of the keys	$x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… ;CRC:x[CR][LF] … $x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… ;CRC:x[CR][LF]
10	RMem-n;i[CR]	Reading i records in the memory, starting with the (current record) - (n records), followed by the checksum (CRC) per record, separation of data with semicolon, separation of records with [CR] [LF], starting with the oldest record , interruption by pressing either of the keys	$x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… ;CRC:x[CR][LF] … $x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… ;CRC:x[CR][LF]
11	RMemH-n[CR]	Reading the records of the last n hours in the memory with subsequent checksum (CRC) per record, separation of data with semicolon, separation of records with [CR] [LF], starting with the oldest record, interruption by pressing either of the keys	$x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… ;CRC:x[CR][LF] … $x.xxx;x.xxxx;x.xxxx;x.xxxx;x.xxxx;… ;CRC:x[CR][LF]
12	RORef[CR]	Reading stored reference values Ref Stn (status of the learning process: 255 not triggered, 30..1 learning process is running, 0 learning process completed), RefV40, RefP40, REFM, RefPTG	$RefStat:x[-];RefC40:x[pS/m];… ;CRC:x[CR][LF]
13	RLim[CR]	Reading set limits for alarm and calculation of the aging progress value and RUL Defaults: LimitP40%: 5.0% LimitC40%: 300% LimT: 85 °C LimTMean: 65 °C RULh: 5000h RULfB: 0.2000 - LMax: 90%[1] LMin: 20%[1] ChunkDetThr: 5.0% ChunkCntThr: 10 - Limp: 100.0 % Limf: -3.0 %	$ChunkDetThr:x.x[%];ChunkCnt- Thr:x[-];Limp:x.x[%];Lim- f:x.x[%];LimP40%:x.x[%];Lim- C40%:x[%];LimT:x.x[C];LimTMean:x.x[C];RUL- h:x[h];RULfB:x.x[-];LMax:x[%];L- Min:x[%];CRC:x[CR][LF]

Appendix A - Table 1: Serial communication - read commands

12.3.2 Write commands

#	Instruction format	Meaning	Return format
1	SONew[CR]	Stores the current state as fresh oil. All parameters are deleted (gradient, reference values, learned values), oil age is set to 0 h, learning process is triggered (duration: approx. 250 hours), data remain in memory	ok[CR][LF]
2	WMemInt*n*[CR]	Sets memory interval to n minutes Range n: 1..1440 minutes	MemInt:*n* [min] [CR][LF]
3	SMemD[CR]	Stores the currently available data in the memory as a new record	ok[CR][LF]
4	WCOSpdx[CR]	Sets the baud rate of the CAN interface x = Baud rate in kbit / s Supports the following baud rates (each in kbit / s): 10, 20, 50, 100, 125, 250, 500 Implementation with next restart	COSpd:x[CR][LF]
5	WCOIDx[CR]	Sets the node ID for CANopen mode. Range x: 0..127 COB-ID of the TPDO is automatically set to default values TPDO1 COB ID: 0x180 + Node-ID TPDO2 COB ID: 0x280 + Node-ID TPDO3 COB ID: 0x380 + Node-ID TPDO4 COB-ID: 0x480 + Node-ID Implementation with next restart	COID:xxx[CR][LF]
6	WCOHBeat*n*[CR]	Sets Heart Beat Time for CANopen mode. Range x: 0..10000ms, resolution: 50ms When n = 0, Heart Beat is turned off Corresponds to SDO entry index: 0x1017 Implementation with next restart	COHBeat:n[ms] [CR][LF]
7	WTPDOy*n*[CR]	Sets TPDOy-COB ID for CANopen mode. Range y: 1..4 Range n: 384..1279 (0x180..0x4FF) Corresponds to SDO entry index: 0x180y, Sub 1 Implementation with next restart	TPDOy:n[CR][LF]
8	WTPDOyTypes [CR]	Sets TPDOy-Type for CANopen mode. Range *y*: 1..4 Range *n*: 1..240, 254, 255 Corresponds to SDO entry index: 0x180y, Sub 2 Implementation with next restart	TPDOyType:n [CR][LF]
9	SChunkCnt-Thr[CR]	Limit value, how many chunks (large particles) may be counted in the system before OR_c reaches 100 % (default: 10)	ChunkCntThr:x[CR][LF]
10	SComModex[CR]	Sets the communication mode: x = 0: CANopen x = 2: RS232 (default) Implementation with next restart	ComMode:x[CR][LF]
11	WTPDOyTimer*n* [CR]	Sets TPDOy-Timer for CANopen-mode. Range *y*: 1..4 Range *n*: 0 .. 32500ms, resolution: 50ms When *n* = 0, heartbeat is turned off Corresponds to SDO entry index: 0x1017 Implementation with next restart	TPDOyTimer:n[ms] [CR][LF]
12	WLimP40%*n* [CR]	Sets limit for allowable change P40 compared to learned reference value in % When approaching and exceeding the current P40 deviation from this value, warnings and alerts are set Range *n*: 1,0..100,0% Default value *n*: 5%	LimP40%:*n*[%] [CR][LF]

#	Instruction format	Meaning	Return format
13	WLimC40%*n* [CR]	Sets limit for allowable change C40 compared to learned reference value in % When approaching and exceeding the current C40 deviation from this value, warnings and alerts are set Range *n*: 1,0..1000,0% Default value *n*: 300 %	LimC40%:*n*[%] [CR][LF]
14	WLimT*n* [CR]	Sets limit on maximum allowable temperature When exceeding the limit value, alarm is set Range n: 20,0..120,0 ° C Default value n: 80 ° C	LimT: *n.n*[°C][CR][LF]
15	WLimTmean*n* [CR]	Sets limit for allowable maximum average temperature When exceeding the limit value, alarm is set Range n: 20,0..120,0 °C Default value n: 60 °C	LimT:*n.nn*[°C][CR][LF]
16	SETrig*n* [CR]	Switches off event triggered storage of measurements (n = 0) or (n = 1) Range n: 0..1 Default value n: 0	MemETrig:*n*[CR][LF]
17	WRULh*n* [CR]	Enter the reference lifetime of the current oil for temperature-based RUL calculation (see Chapter 2.10)	RULh:*n*[CR][LF]
18	WRULfB*n* [CR]	Enter the reference load factor of the current oil for temperature-based RUL calculation (see Chapter 2.10)	RULfB:*n*[CR][LF]
19	STrAu*n*[CR]	Switches off automatic transmission of measured values (n = 0) or (n = 1..60), every n minutes, transfer corresponds to the response to command RVal Range *n*: 0..60 Default value *n*: 0	TrAu:*n*[min][CR][LF]
20	WLMax*n*[1]	Sets maximum allowable level in % When exceeding this limit, an alarm is set Range *n*: 0 ...100 % Default value *n*: 90 %	LMax: *n*[%] [CR][LF]
21	WLMin*n*[1]	Sets minimum allowable level in % When falling below this limit, an alarm is set Range n: 0...100 % Default value n: 20 %	LMin:*n*[%] [CR][LF]

Appendix A - Table 2: Serial communication - write commands

12.4 CRC calculation

Each character sent in the string (incl. Line Feed and Carriage Return) must be added up, based on a range of 8 bits (0→255). If the result is zero, there is no error.

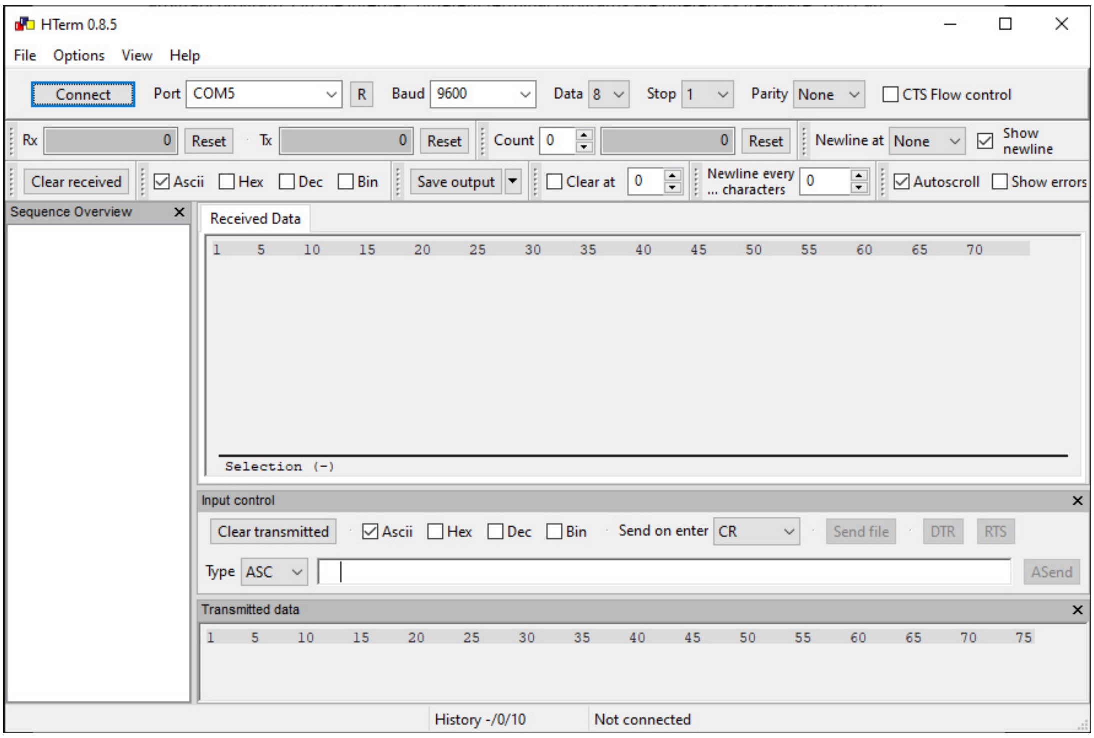
Example of a sent string: RH:31[%];CRC:Ù[CR][LF]

Character	Value
R	82
H	72
:	58
3	51
1	49
[	91
%	37
]	93
;	59
X	67
P	82
X	67
:	58
Ù	217
[CR]	13
[LF]	10
sum	0→OK

Appendix A - Table 3: Example of a checksum calculation (CRC)

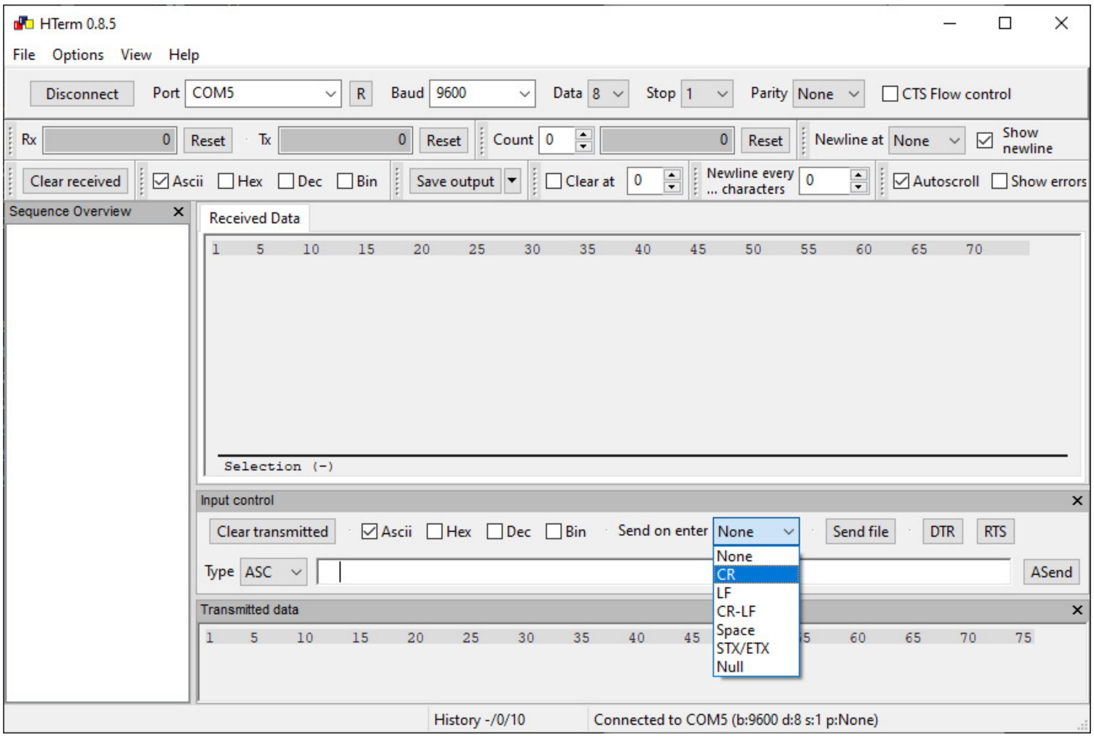
12.5 Communication with a terminal program

If the sensor is connected to a PC and drivers are installed, you may communicate with it, using an arbitrary program. On the internet, different terminal programs are offered as freeware.

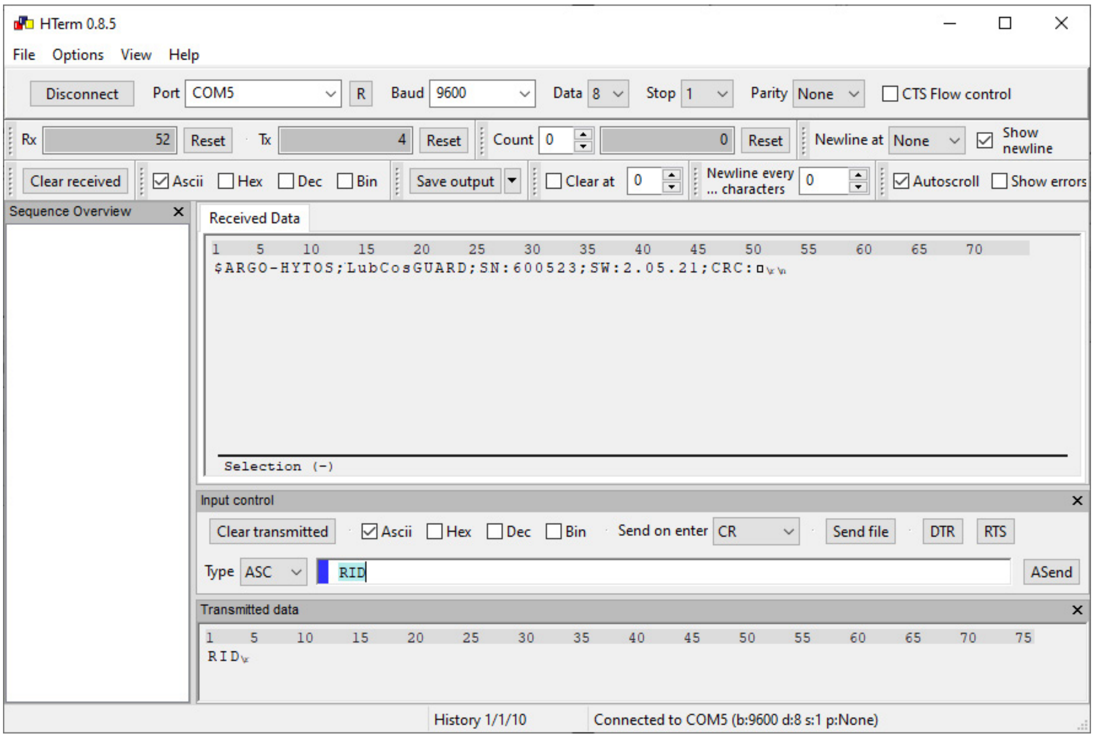


Appendix A - Figure 1: Hterm setting for proper connection

Then, mark "CR" in the Send on enter.



Appendix A - Figure 2: “CR” sign setting



Appendix A - Figure 3: “RID” command respond example

In the subsequent input window, the corresponding commands for reading or configuration can be entered. The command list is shown in Chapter 1.2.

12.6 TCP/IP connection

The Hyper Terminal alternatively offers the possibility to establish a TCP / IP connection. If sensors are remotely interrogated via this protocol, the conversion of the RS232 signal, using an Ethernet Gateway, is required. Matching gateways can be requested at ARGO-HYTOS.

12.7 Configuration for automatic status assessment

For automatic evaluation of the condition, the sensor is pre-configured with default values. If individual configuration values are changed, a procedure is recommended as shown in table below (example for standard configuration).

Step		Parameter
1	Setting of the memory interval to 20 minutes	WSaveInt20.0[ENTER]
2	Writing the aging limits	WLimP40 5.0[ENTER] WLimC40 300[ENTER]
3	Writing the temperature limits	WLimT80.0[ENTER] WLimTMean50.0[ENTER]
4	If known, setting of the reference lifetime of the oil	WRULhxxxx[ENTER]
5	If known, setting the reference load factor of the oil	WRULfBxxxx[ENTER]
6	Clear memory if required	CMem[ENTER]
7	Indicating the current oil as fresh oil	SONew[ENTER]
8	Limit value, how many chunks (large particles) may be counted in the system before OR_c reaches 100 % (default: 10)	ChunkCntThr[ENTER]

Appendix A - Table 4: Procedure for default configuration of the sensor

After an oil change, these steps have to be repeated with adapted parameters, in so far as the type of oil has changed. With the same type of oil as before the oil change, it is sufficient to perform step 7 (marking the current oil as fresh oil). The sensor resets internally learned values, gradients, oil age, etc. and initializes a new learning cycle which can take up to 250 hours.

12.8 Output trigger

The measured values can in principle be output via the RS232 interface in two different ways: time-triggered or command-triggered. The list of commands to query parameters is given in Chapter 6.1 and in the Appendix A. There are both, commands to query the current parameters as well as to query the characteristics from the recent past (time may vary depending on the selected setting).

13. Appendix B

13.1 CAN Communication

The CAN interface corresponds to the "CAN 2.0B Active Specification". The data packets correspond to the format shown in Figure 16. The picture is intended for illustration purposes only, the implementation corresponds to the CAN 2.0B specification.

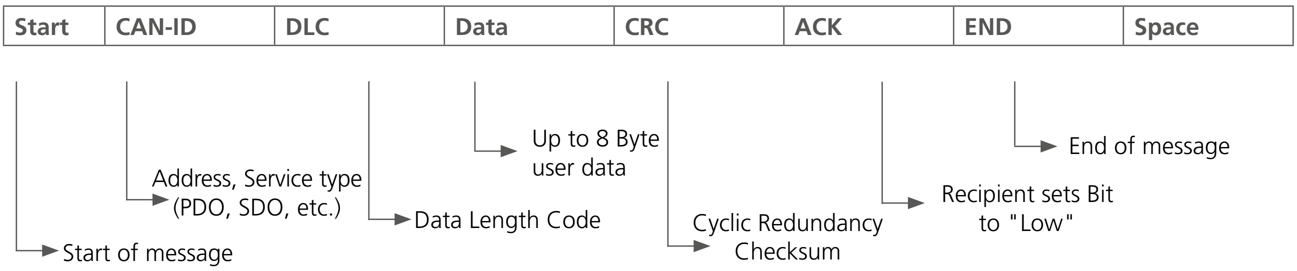
By CiA recommended and by the sensor supported data rates			
Data rate	**Supported**	**CiA Draft 301**	**Bus length (CiA Draft Standard 301)**
1 Mbit/s	no	yes	25 m
800 kbit/s	no	yes	50 m
500 kbit/s	yes	yes	100 m
250 kbit/s	yes	yes	250 m
125 kbit/s	yes	yes	500 m
100 kbit/s	yes	no	750 m
50 kbit/s	yes	yes	1000 m
20 kbit/s	yes	yes	2500 m
10 bkit/s	yes	yes	5000 m

Appendix B - Table 1: Supported bus speeds with CANopen communication and associated cable lengths

The electrical parameters of the CAN interface are listed in the table below:

Parameter	Size	Unit
Typ. response time to SDO requests	<10	ms
Max. response time to SDO requests	150	ms
Supply voltage CAN transceiver	3,3	V
Integrated scheduling	no	-

Appendix B - Table 2: Electrical parameters CAN interface



Appendix B - Figure 1: CAN message format

13.2 CANopen

CANopen defines "what" and not "how" something is described. With the implemented method, a spread control network is realized, which can connect very simple participants to very complex controls without causing communication problems between the participants.
The central concept of CANopen is the so-called Device Object Dictionary (OD), a concept as it is also used in other fieldbus systems. In the following chapter, there is detailed information, first on the Object Dictionary, then on the Communication Profile Area (CPA), and then on the CANopen communication process itself.

13.2.1 „CANopen Object Directory" in general

The CANopen Object Dictionary (OD) is an object dictionary in which each object can be addressed with a 16-bit index. Each object can consist of several data elements that can be addressed by an 8-bit sub-index.
The basic layout of a CANopen object directory is shown in the table below:

CANopen Object Dictionary		
Index (hex)		Object
0000		-
0001	- 001F	Static data types (Boolean, Integer)
0020	- 003F	Complex data types (consisting of standard data types)
0040	- 005F	Complex data types, manufacturer-specific
0060	- 007F	Static data types (device profile specific)
0080	- 009F	Complex data types (device profile specific)
00A0	- 0FFF	Reserved
1000	- 1FFF	Communication Profile Area (e.g. equipment type, fault register, supported PDOs, ..)
2000	- 5FFF	Communication Profile Area (manufacturer-specific)
6000	- 9FFF	Device profile area (e.g. "DSP-401 Device Profile for I / O Modules")
A000	- FFFF	Reserved

Appendix B - Table 3: General CANopen Object Dictionary Structure

13.2.2 CANopen communication objects

Communication objects, transmitted by CANopen, are described by services and protocols and are classified as follows:

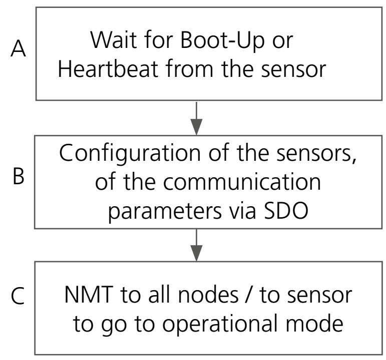
- Network Management (NMT) provides services and for bus initialization, error handling and node controller
- Process Data Objects (PDOs) are used to transfer process data in real time
- Service Data Objects (SDOs) enable read and write access to the object directory of a node
- Special Function Object Protocol allows application-specific network synchronization, time stamp transmission and emergency messages

Below, the initialization of the network with a CANopen master and a sensor is described as an example.

After application of the current, the sensor sends a Boot Up Message within 5 seconds and once the pre-operational state has been reached. In this state the sensor only sends the heartbeat messages, if configured accordingly (Point A in Appendix B - Figure 2).

Subsequently, the sensor can be configured via SDOs, in most cases this is not necessary, since the once set communication parameters are automatically stored by the sensor (see Point B in Appendix B - Figure 2).

In order to restore the sensor in the operational state, either an appropriate message can be send to all the CANopen participants or specifically to the sensor. In operational state, the sensor sends the supported PDOs according to its configuration either at periodic intervals or triggered to Synch messages (see Point C Appendix B - Figure 2).



Appendix B - Figure 2:
CANopen Bus initialization process

Depending on the state of the sensor, different services of the CANopen protocol are available (see table below).

Availability of services, depending on the sensor condition				
Com. Object	Initializing	Pre-Operational	Operational	Stopped
PDO			X	
SDO		X	X	
Synch		X	X	
BootUp	X			
NMT		X	X	X

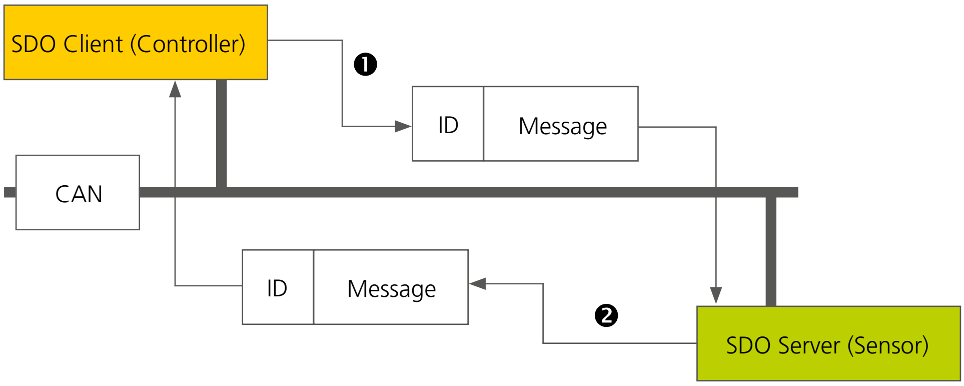
Appendix B - Table 4: Available CANopen services in different sensor states

13.2.3 Service Data Object (SDO)

Service Data Objects allow read and write access to the object directory of the sensor. The SDOs are acknowledged and the transmission always takes place only between two participants, a so-called client / server model (see Appendix B - Figure 3).

The sensor can only function as a server, thus only answers to SDO messages and does not send requests to other participants by itself. The SDO messages from the sensor to a client need the NodeID + 0x580 as ID. For inquiries from the client to the sensor (Server), the NodeID + 0x600 is expected as ID in the SDO message.

The standard protocol for SDO transfer requires 4 bytes to encode the transmit direction, the data type, the index and the sub-index. Thus, 4 bytes of the 8 bytes of a CAN data field remain for the data content. For objects whose data content is larger than 4 bytes, there are two other protocols for the so-called fragmented or segmented SDO transfer.



Appendix B - Figure 3: SDO client / server relationship

SDOs are intended to configure the sensor via access to the object directory, to request rarely used data or configuration values or to download large amounts of data. The SDO features at a glance:

- All the data in the object directory can be accessed
- Confirmed transfer
- Client / server relationship when communicating

The control and user data of a non-segmented SDO standard message spread across the CAN message as shown in Table 4. The user data of an SDO message are up to 4 bytes in size. Using the control data of an SDO message (Cmd, Index, Subindex), the access direction to the object directory and possibly the transmitted data type are determined. For exact specifications of the SDO protocol, the "CiA Draft Standard 301" should be consulted.

CAN	CAN-ID	DLC	User data CAN message							
			0	1	2	3	4	5	6	7
CANopen SDO	COB-ID 11 Bit	DLC	Cmd	Index		Subindex	User data CANopen SDO Message			

Appendix B - Table 5: Structure of an SDO message

An example of a SDO query of the serial number of the sensor from the object directory at index 0x1018, sub-index 4, with data length 32 bits is shown below. The client (controller) sends a read request to the sensor with the ID "NodeID" (see table below).

CAN	**CAN-ID**	**DLC**	**User data CAN Message**							
			0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
CANopen	**COB-ID 11 Bit**	**DLC**	**Cmd**	**Index**		**Subidx**	**User data SDO**			
				1	**0**	**0**	**3**	**2**	**1**	**0**
Message from client to sensor	0x600 + NodeID	0x08	0x40	0x18	0x10	0x04	dont care	dont care	dont care	dont care

Appendix B - Table 6: SDO Download request to the server by the client

The sensor responds with the appropriate SDO message (see table below) in which the data type, index, sub-index and the serial number of the sensor are encoded, here as an example serial number 200123 (0x30DBB).

CAN	CAN-ID	DLC	User data CAN message							
			0	1	2	3	4	5	6	7
CANopen	COB-ID 11 Bit	DLC	Cmd	Index		Subidx	User data SDO			
				1	0	0	3	2	1	0
Message from client to sensor	0x580 + NodeID	0x08	0x43	0x18	0x10	0x04	0xBB	0x0D	0x30	0x00

Appendix B - Table 7: SDO download response by the server to the client

An example for the upload of data (heartbeat time) via SDO in the object directory of the sensor at index 0x1017 with data length 16 bits is shown below. The client (controller) sends a write request to the sensor with the ID "NodeID" (see table below) in order to set the heartbeat time to 1000 ms (0x03E8).

CAN	CAN-ID	DLC	User data CAN message							
			0	1	2	3	4	5	6	7
CANopen	COB-ID 11 Bit	DLC	Cmd	Index		Subidx	User data SDO			
				1	0	0	3	2	1	0
Message from client to sensor	0x600 + NodeID	0x08	0x2B	0x17	0x10	0x00	0xE8	0x03	0	0

Appendix B - Table 8: SDO upload request to the server by the client

The sensor responds with an appropriate SDO message (see Table 8) in which is confirmed that the access was successful and the index and sub-index are encoded, to which access had been made.

CAN	CAN-ID	DLC	User data CAN message							
			0	1	2	3	4	5	6	7
CANopen	COB-ID 11 Bit	DLC	Cmd	Index		Subidx	User data SDO			
				1	0	0	3	2	1	0
Message from sensor to client	0x580 + NodeID	0x08	0x60	0x17	0x10	0x00	0x00	0x00	0x00	0x00

Appendix B - Table 9: SDO Upload response to the client by the server

13.2.4 Process Data Object (PDO)

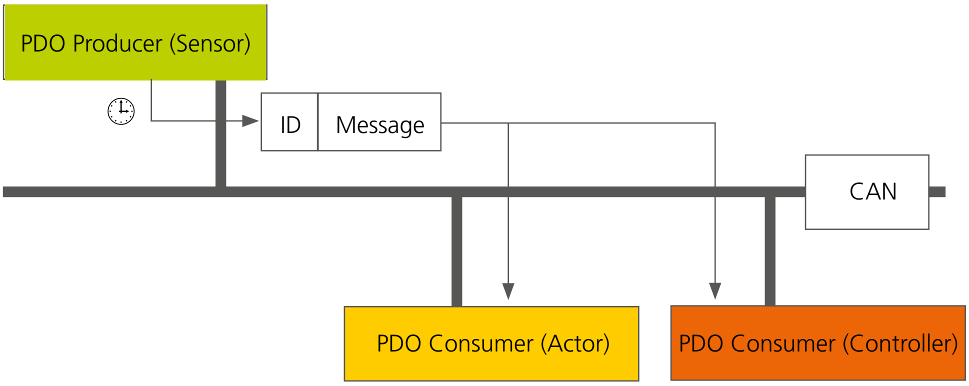
PDOs are one or more records, that are reflected from the object dictionary in the up to 8 bytes of a CAN message, to transfer data quickly and with the least possible expenditure of time from a "Producer" to one or more "Consumers" (see Figure 4). Each PDO has a unique COB-ID (Communication Object Identifier), is sent by a single node, but may be received from a plurality of nodes and does not need to be acknowledged / confirmed.

PDOs are ideally suited for the transfer of sensor data to the controller or from the controller to actuators. The PDO attributes of the sensor at a glance:

› The sensor supports four TPDOs, no RPDOs
› The mapping of the data in PDOs is fixed and cannot be changed
› COB-IDs for all TPDOs are freely selectable
› All TPDOs can be transmitted event- / timer-triggered or cyclically, SYNCH-triggered and can be set individually for each TPDO.

The sensor supports two different PDO transmission methods.

1. In the event or timer-triggered method, the transmission is initiated by a sensor internal timer or event.
2. In the SYNC-triggered method, the transfer takes place in response to a SYNC message (CAN message by a SYNC producer without user data). The answer with PDO is carried out either with each received synch or set to all n-received SYNC messages.



Appendix B - Figure 4: PDO consumer / producer relationship

13.2.5 PDO Mapping

The device supports three to four transmit PDOs (TPDO) to allow the most efficient operation of the CAN bus. The sensor does not support dynamic mapping of PDOs, the mapping parameters in the OD are therefore only readable but not writable.
Figure 6 shows the principle of the mapping of objects from the OD in a TPDO, it corresponds to the CiA DS-301, Chapter 8.5.4. Which objects are mapped in TPDO 1 to 4, can be found in the OD at Index 0x1A00 to 0x1A03. The structure of the PDO mapping entries is shown in Figure 5. Furthermore, each TPDO has a description of the communication parameters, i.e. transmission type, COB-ID and possibly Event Timer. The communication parameters for TPDO 1 to 4 are documented in the OD at index 0x1800 to 0x1803.

Byte: MSB LSB

Index (16 Bit)	Subindex (8 Bit)	Object length in Bit (8 Bit)

Appendix B - Figure 5: Basic structure of a PDO mapping entry

Complete OD, a.o. with map-enabled objects			
Index	Sub	Type	Object
...	...	...	...
2006	01	S16	Permittivity of the oil, multiplied by 1000
...	...	...	...
2007	02	U16	Compensated conduct
...	...	...	...
2006	02	U16	Compensated perm.
...	...	...	...
2008	01	U16	Conductivity of the oil, divided by 100
...	...	...	...

TPDO2 mapping parameters in OD, at index 0 x 1 A01		
Sub	Type	Value
00	U 8	04
01	U32	0x20060110
02	U32	0x20070110
03	U32	0x20060210
04	U32	0x20070210

TPDO2 communication parameters in OD, at index 0x1801		
Sub	Type	Object
00	U 8	Highest subindex
01	U 32	COB-ID
02	U 8	Transmission type
03	-	n. a.
04	-	n. a.
05	U 16	Event timer

TPD02	Permitivitty * 1000		Conductivity/ 100		Comp. P * 1000		Comp. C / 100	
Byte in CAN-Msg.	0	1	2	3	4	5	6	7

Appendix B - Figure 6: Principle of the mapping of multiple OD objects in a TPDO

The sensor supports certain types of the TPDO (see Table below), which can be entered for the respective communication parameters of the TPDOs (see Figure 6).

By sensor supported TPDO types					
Type	supported	cyclically	not cyclically	synchronous	asynchronous
0	yes		X	X	
1-240	yes	X		X	
241-253	no				
254	yes				X
255	yes				X

Appendix B - Table 10: Description of TPDO types

13.2.6 „CANopen Object Directory"

The complete object dictionary of the sensor is shown in Table 10 and Table 11. In Table 10, the communication-related part of the object directory is displayed. The here possible settings correspond, with a few exceptions, to the CANopen standard as described in DS 301. There are some restrictions regarding the communication due to the used hardware platform. The setting procedure for "Heartbeat Time" (Index 1017h), "TPDO1 event timer" (Index 1800h, Sub-index 5), "TPDO2 event timer" (Index 1801h, Sub-index 5), "TPDO3 event timer" (Index 1802h, Sub-index 5) are limited to 50 ms instead of the intended 1 ms. This means that these objects can be set, for example, to 0 ms, 50 ms, 250 ms, but not to 35 ms, 125 ms, etc.

Appropriate EDS files for the sensors are available on the website of ARGO-HYTOS.

Communication profile area						
Idx (hex)	**Sub**	**Name**	**Type**	**Attr.**	**Default**	**Notes**
1000h	0	Device type	unsigned 32	ro	194h	Sensor, see DS404
1001h	0	Error register	unsigned 8	ro	00h	Mandatory, see DS301
100Ah	0	Manufacturer software version	string	ro	"2.00"	
1017h	0	Producer heartbeat time	unsigned 16	rw	3E8h	Heartbeat time in ms, granularity of 10ms (instead of 1ms, e.g. can be set to 0, 10, 30, but not to 22) range: 0..10000
1018h		**Identity Object**	**Record**	**ro**		
	0	Number of entries	unsigned 8	ro	04h	largest sub index
	1	Vendor ID	unsigned 32	ro	000000E6h	Argo Hytos
	2	Product code	unsigned 32	ro	1400	LubCos GUARD
	3	Revision number	unsigned 32	ro	2000	
	4	Serial number	unsigned 32	ro		Device dependent
1800h		**Transmit PDO1 Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	180h+NodeID	COB-ID used by PDO, range: 181h..1FFh, can be changed while not operational
	2	Transmission type	unsigned 8	rw	1h	cyclic+synchronous, asynchronous values: 1-240, 254, 255
	5	Event timer	unsigned 16	rw	1000	event timer in ms for asynchronous TPDO1, value has to be a multiple of 50 and max 12700

Idx (hex)	Sub	Name	Type	Attr.	Default	Notes
1801h		**Transmit PDO2 Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	280h+NodeID	COB-ID used by PDO, range: 281h..2FFh, can be changed while not operational
	2	Transmission type	unsigned 8	rw	1h	cyclic+synchronous, asynchronous values: 1-240, 254, 255
	5	Event timer	unsigned 16	rw	1000	event timer in ms for asynchro-nous TPDO2, value has to be a multiple of 50 and max 12700
1802h		**Transmit PDO3 Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	380h+NodeID	COB-ID used by PDO, range: 381h..3FFh, can be changed while not operational
	2	Transmission type	unsigned 8	rw	1h	cyclic+synchronous, asynchronous values: 1-240, 254, 255
	5	Event timer	unsigned 16	rw	1000	event timer in ms for asynchro-nous TPDO, value has to be a multiple of 50 and max 12700
1803h		**Transmit PDO4 Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	480h+NodeID	COB-ID used by PDO, cannot be changed
	2	Transmission type	unsigned 8	rw	1h	COB-ID used by PDO, range: 481h..4FFh, can be changed while not operational
	5	Event timer	unsigned 16	rw	1000	event timer in ms for asynchro-nous TPDO, value has to be a multiple of 50 and max 12700
1A00h		**TPDO1 Mapping Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	07h	Largest sub index
	1	PDO Mapping for 1st app obj. to be mapped	unsigned 32	co	20040108h	OR_s * 2
	2	PDO Mapping for 2nd app obj. to be mapped	unsigned 32	co	20040208h	OR_f * 2
	3	PDO Mapping for 3rd app obj. to be mapped	unsigned 32	co	20040308h	OR_c *
	4	PDO Mapping for 4th app obj. to be mapped	unsigned 32	co	20090708h	Oil Temp
	5	PDO Mapping for 5th app obj. to be mapped	unsigned 32	co	200B0408h	Level * 2
	6	PDO Mapping for 6th app obj. to be mapped	unsigned 32	co	200B0108h	Level scaled * 2
	7	PDO Mapping for 7th app obj. to be mapped	unsigned 32	co	20080210h	rel. Humidity of the oil, multiplied by 10, Range: 0.0..100.0%

Idx (hex)	Sub	Name	Type	Attr.	Default	Notes
1A01h		**TPDO2 Mapping Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	04h	largest sub index
	1	PDO Mapping for 1st app obj. to be mapped	unsigned 32	co	20060110h	Permittivity *1000
	2	PDO Mapping for 2nd app obj. to be mapped	unsigned 32	co	20070110h	Conductivity /100
	3	PDO Mapping for 3rd app obj. to be mapped	unsigned 32	co	20060210h	Permittivity @ 40°C *1000
	4	PDO Mapping for 4th app obj. to be mapped	unsigned 32	co	20070210h	Conductivity @ 40°C /100
1A02h		**TPDO3 Mapping Parameter**	**Record**			
	0	Number of entries	unsigned 8	ro	04h	largest sub index
	1	PDO Mapping for 1st app obj. to be mapped	unsigned 32	co	20050510h	RUL+2000
	2	PDO Mapping for 2nd app obj. to be mapped	unsigned 32	co	20050210h	Oil Age
	3	PDO Mapping for 3rd app obj. to be mapped	unsigned 32	co	2009010h	Meantime * 100
	4	PDO Mapping for 4th app obj. to be mapped	unsigned 32	co	20090210h	T Sensor * 10
1A03h		**TPDO4 Mapping Parameter**	**Record**		**Only for Level sensors**	
	0	Number of entries	unsigned 8	ro	02h	largest sub index
	1	Sensor Operating Time in s	unsigned 32	co	20050120h	Sensor Operating Time in s
	2	PDO Mapping for 1st app obj. to be mapped	unsigned 32	co	10180420h	Sensor Serial Number

Appendix B - Table 11: "Communication Profile Area", communication related object directory

All oil and sensor related objects are placed in the object directory from Index 2004h onwards and shown in Table 11. This part of the object directory is sensor specific and reflects the by the sensor measured and derived parameters for the oil. Furthermore, some configuration options are supported, for example, for setting the values for maximum temperature or to make the necessary adjustments for the calculation of RUL (see Chapter 2.12, 2.13, 7.2).

Manufacturer-specific Profile Area						
Idx (hex)	**Sub**	**Name**	**Type**	**Attr.**	**Default**	**Notes**
2004h		**Condition Monitoring Bit Field**	**Record**			
	0	Number of entries	unsigned 8	ro	09h	largest sub index
	1	OR_s	unsigned 8	ro		Occupance Rate sum signal with particles in % multiplied by 2
	2	OR_f	unsigned 8	ro		Occupance Rate signal with fine particles in % multiplied by 2
	3	OR_c	unsigned 8	ro		Occupance Rate signal with chunk particles in % multiplied by 2
	4	d_f	signed	ro		Change of fine particle signal in % since last SONew multiplied by 100
	5	d_p	signed	ro		Change of prox signal in % since last SONew multiplied by 100
	6	Fine Particle Threshold	unsigned 8	rw	-300	Threshold for d_f which corres-ponds to 100% of OR_f in % multiplied by 100
	7	P Threshold	unsigned 8	rw	10000	Threshold for p signal in % multiplied by 100
	8	Chunk Counter Threshold	unsigned 8	rw	10	Amount of chunks which corres-ponds to 100% of OR_c in %
	9	Chunk Detection Threshold	unsigned 8	rw	15	Threshold for p-change needed to be counted as chunk in %
2005h		**Time related parameters**	**Record**			
	0	Number of entries	unsigned 8	ro	08h	largest sub index
	1	Sensor UpTime	unsigned 32	ro		Operating time in seconds
	2	Oil age	unsigned 16	ro		Time since last oil change in hours
	3	Save interval	unsigned 16	rw	20	Save interval in minutes 1..60
	4	Remaining Occupancy Time	unsigned 16	ro		Remainig time in hours until OR_s signal reaches 100%
	5	Remaining Useful Lifetime	unsigned 16	ro		Remaining Lifetime of the oil + 2000 in hours, see chapter Oil Lifetime for description
	6	Remaining Useful Lifetime (Temperature based)	unsigned 16	ro		Component for calculation of Remaining Lifetime of the oil in hours, see chapter Oil Lifetime for description
	7	Remaining Useful Lifetime (Gradients based)	unsigned 16	ro		Component for calculation of Remainig Lifetime of the oil in hours, see chapter Oil Lifetime for description
	8	Remaining Useful Life Time of Oil for Overwrite	unsigned 16	rw		Has to be written in case of replacement of sensor, but keeping the old oil. By writing with the RUL value of the previous sensor the new sensor initiates a countdown for RUL calculation. Genuine RUL calculation is inhibited while countdown running and a new Oil Life cycle is not initiated

Idx (hex)	Sub	Name	Type	Attr.	Default	
2006h		**Permittivity related parameters of the oil**	**Record**			
	0	Number of entries	unsigned 8	ro	06h	largest sub index
	1	Permittivity	unsigned 16	ro		Permittivity of the oil, multiplied by 1000
	2	Permittivity, temperature compensated	unsigned 16	ro		Permittivity of the oil, compensa-ted to 40°C, multiplied by 1000
	3					
	4	Threshold for Permittivity, deviation from fresh oil value in %	signed 16	rw		LimitP40%, threshold for deviation of P @ 40°C from teached value in %, multiplied by 100
	5	Aging Progress of Permittivity in %	unsigned 16	ro		P @ 40°C Aging Progress in %, multiplied by 10
	6	Permittivity fresh oil value	unsigned 16	rw		Permittivity of the oil, compensa-ted to 40°C, multiplied by 1000
2007h		**Conductivity related parameters of the oil**	**Record**			
	0	Number of entries	unsigned 8	ro	08h	largest sub index
	1	Conductivity	unsigned 16	ro		Conductivity of the oil, divided by 100, 0..1.000.000pS/m
	2	Conductivity, temperature compensated	unsigned 16	ro		Conductivity of the oil, compen-sated to 40°C, divided by 100, 0..1.000.000pS/m
	3					
	4	Threshold for Conductivity, deviation from fresh oil value in %	signed 16	rw		LimitC40%, threshold for deviation of C @ 40°C from teached value in %, multiplied by 100
	5	Aging Progress of Conductivity in %	unsigned 16	ro		C @ 40°C Aging Progress in %, multiplied by 10
	6	Conductivity fresh oil value	unsigned 16	rw		Conductivity of the oil, compen-sated to 40°C, divided by 100, 0..1.000.000pS/m
	7	log10(Conductivity)	unsigned 16	ro		log10(Conductivity), multiplied by 10000
	8	log10(C40)	unsigned 16	ro		log10(Conductivity compensated to 40°C), multiplied by 10000
2008h		**Humidity related parameters of the oil**	**Record**			
	0	Number of entries	unsigned 8	ro	05h	largest sub index
	1	rel. Humidity	unsigned 8	ro		rel. Humidity of the oil, multiplied by 2, Range: 0.0..100.0%
	2	rel. Humidity	unsigned 16	ro		rel. Humidity of the oil, multiplied by 10, Range: 0.0..100.0%
	3	rel. Humidity, temperature compensated to 20°C	unsigned 16	ro		rel. Humidity of the oil in % multiplied by 10, compensated to 20°C, range: 0.0..100.0%
	4	rel. Humidity, temperature compensated to 20°C	unsigned 16	ro		rel. Humidity of the oil in % multiplied by 10, compensated to 40°C, range: 0.0..100.0%
	5	Condensation temperature	unsigned 16	ro		Temperature where the water in Oil would condensate to free water, Value in °C, Range: 0..100°C

Idx (hex)	Sub	Name	Type	Attr.	Default	Notes
2009h		**Temperature related parameters of the oil**	**Record**			
	0	Number of entries	unsigned 8	ro	07h	largest sub index
	1	Current Oil Temperature	signed 16	ro		Oil temperature of the oil in °C, multiplied by 10
	2	Current Sensor Temperature	signed 16	ro		Sensor temperature of the oil in °C, multiplied by 10
	3	Mean Temperature	signed 16	ro		Mean Temperature of the oil since last oil change in °C multiplied by 100
	4	Threshold for max. oil temperature	unsigned 16	rw	85	Temperature where an alarm bit is set, range: 0..85 (multiplied by 10)
	5	Threshold for max. mean temperature	unsigned 16	rw	65	Temperature where an alarm bit is set, range: 0..85 (multiplied by 10)
	6	Current Temperature Load Factor since last SONew	unsigned 16	ro		Current calculated fB*1000
	7	Current Oil Temperature	signed 8	ro		Oil temperature of the oil in °C
200Ah		**Aging process**	**unsigned 8**	**ro**		**Aging Progress in % multiplied by 10**
200Bh		**Level related parameters**	**Record**			
	0	Number of entries	unsigned 8	ro	04h	largest sub index
	1	Current Oil Level Scaled	signed 8	ro		Oil Level in %
	2	Max Oil Level	unsigned 8	rw	0	Max Oil Level for scaling
	3	Min Oil Level	unsigned 8	rw	100	Min Oil Level for scaling
	4	Current Oil Level Full Scale	unsigned 8	ro		Oil Level in % *2
2020h		**Commandos/Settings**	**Record**			
	0	Number of entries	unsigned 8	ro	5h	largest sub index
	1	New Oil	unsigned 8	wo		new oil commandos 0x01 = new oil see chapter Commandos for more detailed description
	2	Communication Type	unsigned 8	rw		Type of communication enabled on nex boot up: 0 = CANopen 1 = CAN SAE J1939 2 = RS232
	3	CANopen Node-ID	unsigned 8	rw		Node-ID of the davice on next reboot
	4	Auto Operational on Startup enable	unsigned 8	rw	0	If value = 1 then the device goes to operational after boot process, if value is set to 0 device goes into preoperational mode after boot process
	5	Maximum PCB Temperature ever seen	signed 8	ro		Highest PCB Temperature recorded
2030h		**RUlfB and RULh settings**	**Record**			
	0	Number of entries	unsigned 8	ro	02h	largest sub index
	1	RUL Reference Load Factor fB * 1000	unsigned 16	rw		reference load factor fB multiplied by 1000
	2	RUL Reference Lifetime in Hours	unsigned 16	rw		0..30000 h, reference life time for this oil in this application

Appendix B - Table 12: “Manufacturer-specific Profile Area“, sensor related part of the CANopen communication profile

14. Contact address

ARGO-HYTOS Polska sp.z o.o.
Condition Monitoring & Electronics
Władysława Grabskiego 27
32-640 Zator, Poland

Phone: +48 33 873 16 52
Email: info.pl@argo-hytos.com

EU- Declaration of conformity

ARGO-HYTOS Polska sp. z o.o.
Władysława Grabskiego 27
32-640 Zator, Poland
+48 33 873 16 52
info.pl@argo-hytos.com
www.argo-hytos.com

herewith declares that the sensor described below:

LubCos Guard: SCSO 400-1000

Satisfies the following EU directive:

EMC Directive 2014/30/EU

Harmonized standards:

PN-EN 61000-6-2:2019

PN-EN 61000-6-4:2007/A1:2011

The evaluation and testing of the device was made by the EMC testing laboratory:

KRIWAN Testzentrum GmbH
Teslastraße 2
74670 Forchtenberg
Germany

A labeling requirement under the Pressure Equipment Directive G7/23/EC does not exist.
The assessment to this directive was made by the ARGO-HYTOS GmbH.

The declaration applies for all identical copies of the product that are manufactured according to the included development, design, and manufacturing drawings and descriptions, which are a component of this declaration.

Zator, 28.04.2025

Arkadiusz Noworyta
General Manager
ARGO-HYTOS Polska Sp. z o.o.

International

ARGO-HYTOS worldwide

Benelux	ARGO-HYTOS B.V.	info.benelux@argo-hytos.com
Brazil	ARGO-HYTOS Fluid Power Systems Ltda.	info.br@argo-hytos.com
China	ARGO-HYTOS Fluid Power Systems	info.cn@argo-hytos.com
Czech Republic	ARGO-HYTOS s.r.o	info.cz@argo-hytos.com
	ARGO-HYTOS Protech s.r.o	info.protech@argo-hytos.com
France	ARGO-HYTOS SAS	info.fr@argo-hytos.com
Germany	ARGO-HYTOS GMBH	info.de@argo-hytos.com
Great Britain	ARGO-HYTOS Ltd.	info.uk@argo-hytos.com
Hong Kong	ARGO-HYTOS Hong Kong Ltd.	info.hk@argo-hytos.com
India	ARGO-HYTOS PVT. LTD.	info.in@argo-hytos.com
Italy	ARGO-HYTOS S.r.l.	info.it@argo-hytos.com
Poland	ARGO-HYTOS Polska sp. z o.o.	info.pl@argo-hytos.com
Sweden	ARGO-HYTOS Nordic AB	info.se@argo-hytos.com
Turkey	ARGO-HYTOS Hidrolik Ekip. San. ve Tic. Ltd. Şti.	info.tr@argo-hytos.com
USA	ARGO-HYTOS Inc.	info.us@argo-hytos.com