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Oil Performance Monitor LUBRICON

Continuous Oil Survey in Engines and Machines

- Manual -

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1 Components

The measuring system LUBRICON consists of the following components:

- Sensor head
- Sensor cable (7m)
- Electronic unit
- Power supply cable (2m)

The sensor cable is fixed by use of two couplings: 1 piece of Hirschmann CA6LD for the connection of the sensor head and 1 piece Amphenol-Tuchel C091A T3475 002 for the coupling to the electronic unit.
The power supply cable is fixed by 1 piece Amphenol-Tuchel C091A T 3476 002.

Remark:

The waterproof version „S“ comes along with special waterproof connectors produced by LUMBERG instead of Amphenol-Tuchel.

The plug-in connections are constructed in such a way that confusion is not possible.

The sensor head is the most important component in order to create correct measurement values while the electronic unit will not influence the behaviour of the sensor. For this reason the sensor head comes along with an integrated data memory chip where all the sensor relevant parameters are stored. This offers the advantage to combine any sensor with any electronic unit !
But you have to change the sensor in the power-off-status only !
If you start the system again, the electronic unit will detect the new sensor with the new parameter set which is different from the one stored inside the box. This will be indicated by the LED-display in the following way (further details as given in chapter 5):

- **New sensor head, parameter transfer successful**
  LED-red and LED-yellow are flashing with increasing frequency, LED-green and LED-red are dark.
- **New sensor head, parameter transfer failed**
  LED-green and LED-red (Error) are flashing with increasing frequency, LED-yellow and LED-red are dark.

If the parameter transfer has been successful and no push button has been pressed, the parameter set of the sensor will be transfered to the electronic unit and stored on its mother-board.
From now on, the new sensor head is adapted to the unit and the system will start with the correct parameter set of the sensor.

- **Enable parameter transfer**
  If you press the push button during the phase of LED-flashing as described above, the system is not allowed to transfer the parameter set of the sensor to the systems motherboard.
  In this case the system will use the parameter set which is stored on its motherboard.

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2 Installation

During transportation the sensor head is protected by means of a transportation cap.

- **Please remove the transportation cap of the sensor very carefully.**
- **Be very careful of the sensor head, especially during the installation process.**
- **Avoid mechanical forces to the oil survey sensor.**
- **Never use any tools with hard surfaces.**
- **The sensor is designed for oil applications only; never use the sensor for water or water-based liquids !**

The electronic unit should be placed in a dry space near the sensor head.
Please take care that the electronic unit is protected against high humidity and higher temperatures.
The electronic unit has to be connected to the sensor by use of the sensor cable.
Please use the power supply cable and pay attention to the correct DC-power supply.

Remark:

In standard version „D“ the system can be connected to a 10...30 VDC power supply.
The version „A“ (with integrated 4...20mA analog output signals) is available for

- 12 VDC **or**
- 24 VDC power supply.

All these systems have one thing in common: The **red** wire should be connected to the **plus** (+) pole of the VDC power supply, the **black** one to the **minus** (-) pole.

Nevertheless, any mistake will not be able to damage the instrument. Please wait a few minutes until the integrated thermal fuse will be cooled down. Then repeat the process correctly.

Instructions for a correct system installation:

a) First of all please install the sensor; pay attention to the general installation procedure as pointed out above.

b) Please install the sensor cable in order to connect the sensor with the electronic unit.
Do not install the sensor cable near any high voltage and / or high frequency cable.
Although the sensor cable is very well shielded, this may increase the danger of unwanted effects on the sensor signal.

c) Connect the sensor with one end of the cable and the electronic unit with the other.

d) Next please connect the electronic unit to the correct **DC-power supply**.

e) Please watch the status of the four LEDs in front of the electronic unit (cf. chapter 5).
In case of power-on to the electronic unit, all four LEDs will be switched on for a few seconds (status “M”).
Then the LED with the green light will be activated for a short moment indicating the systems version. This will be followed by another LED-status according to the preinstallation of the system.

f) If both the electronic box and the correctly connected sensor properly function, the red LED on the left side of the panel should **not be activated** and the other three LEDs (green, yellow and red) should be activated (status "A"). This means that the system is waiting for the command in order to start the fresh-oil calibrating procedure.

g) Now you can activate the continuous oil survey by use of the systems push button as described in the next chapter 3.
In case of a correctly started fresh oil calibrating procedure the three oil quality LEDs will change from status „A" to status „E" (details are given in chapter 5).
This means that the yellow LED will no longer be activated and that you can be sure that the fresh-oil calibrating procedure has been initiated.
Once the fresh-oil calibrating procedure has started, it will continue for several hours at least, depending on the preinstalled software of the system.
When the calibration process is finished, the red LED will turn off as well.
Only the green LED of the oil quality will then be activated, indicating the best possible quality of the fresh oil.

h) The system is then activated for the continuous oil survey without any error.
If the system is not in the status described above, a correct oil survey is not possible.
In this case, we suggest that you change the electronic unit; if the misfunction continues the problem is probably caused by the sensor, which has to be replaced.

i) You can disconnect the system from the DC power supply whenever you want, - even during the fresh oil calibration procedure.
The system will continue its work as soon as it is connected to the DC power supply again.
But of course the system cannot detect a correct oil quality without any power supply.

3 Programming (Fresh Oil Calibration and Adjustment)

Three different activities can be initiated by means of the push-button. The procedure is as follows:

1. Pressing the key for less than 0,2 seconds will be without any effect (to allow for errors).
2. Pressing the key for 1 to 2 seconds will interrupt any on-going process and the red LED on the left will indicate an error while the other 3 LEDs will remain dark.
3. A short time after that the green LED will lighten up for about 3 seconds, then go dark, and subsequently the yellow LED and then the red LED will do the same.
If during this phase the key is left untouched, the oil sensor will go back to the normal measuring process without any of the 3 alternative functions being started.
4. However, if the key is pressed again while one of the LEDs is lighting, this LED will start to flash for about 5 seconds, thus indicating that the corresponding function has been selected.
5. If no further pressing of the key occurs during these 5 seconds the oil sensor will return to the normal measuring procedure, which permits the correction of a wrong choice.

6. If , however, during this 5 seconds period the key is pressed again, the function corresponding to the flashing LED will definitely be selected; the LED will lighten up continuously for about 3 seconds and the corresponding function will actually be initiated.

The three LEDs correspond to the three different functions according to the following code:

LED colour	**Function**
green	start fresh oil calibration
yellow	adjustment/ quality upgrading
red	yet no function assigned

The function selected will then be indicated.
(Note: The red LED on the right is currently without a corresponding function).

- **Function: Fresh-oil calibration**

The command „fresh-oil calibration“ serves to initiate the oil-monitoring procedure of the system and should only be applied if the system has been filled with fresh oil and a new monitoring cycle is desired.
All data previously obtained and stored in the system during earlier cycles will be canceled and the reference (indicated) value of the fresh-oil will newly determined when the defined reference temperature has been reached.

Attention:
If temperature compensation has been activated in the system, the command for fresh-oil calibration should given only after operating temperature has been reached !

- **Function: Adjustment of indicated value of oil quality**

As decribed in chapter 6 this function serves to achieve a change of the indicated value of oil quality, i.e. an improvement of the oil quality.

4 System Application and Functions

There are two fundamental purposes for the measuring system LUBRICON: a **continuous measuring** of all the oil parameters with data output obtained at the digital USB interface (with additional analog interface output optionally avalaible), and the **monitoring of oil quality** according to the requirements determined by the user, who can enter his requirements as part of the programming into the system.

a) Continuous measurings and data output

The system provides the continuous measuring of the following four types of operational data:
- oil temperature
- viscosity
- relative dielectric constant (permittivity)
- specific electric conductivity.

The time needed for measuring these is about 30 seconds (response time).

If desired data output can also be transfered to the USB interface of the system, and data can also be recorded and evaluated by a connected computer. The software required for this purpose by a WINDOWS-operated computer is part of the system as delivered.

As communication of the system takes place through the defined ASCII-codes it is also possible to connect it by means of a digital interface to a computer operated by another than the WINDOWS-system (e.g. SPS).
If needed, an ASCII-code-chart can be provided by the flucon fluid control GmbH.

Note: The splashwater-proof version of the system (Version „S“) provides this interface only internally, i.e. there is no interface available on the outside of the system‘s case.

In the version „A“ of the basis system with analog interface the measuring system data obtained will be transfered to four pieces of 4....20mA electric output terminals, and or to 1...5V voltage terminals respectively.

b) Monitoring of oil quality

In addition to the continuous measuring of all relevant oil data as described above under a) LUBRICON can also provide monitoring of oil quality if certain prerequisites are fulfilled, as described here.
Further explanations concerning this can be found in chapter 7.
The monitoring of oil quality takes place on the basis of the specific condition of the fresh oil as well as the determination of certain limit values for the evaluation of oil quality.
Thus, on the basis of the fresh-oil quality, the system constantly measures the actual oil data and compares them to the data obtained from fresh-oil.
Three different levels of oil quality can be indicated by the system:

- good / very good quality (LED green)
- medium quality (LED yellow)
- bad quality (LED red).

As far as the definition of oil quality is concerned, fresh oil is assigned a value of 100 %; when oil quality reaches a value of ≤ 0 % the oil must by all means be exchanged (for further details cf. chapter 7).

After fresh-oil calibration has taken place the quality of the oil will be indicated by means of the three LEDs that are to be found side by side at the front of the evaluating electronic device.
For this purpose the following limit values of maximum oil strain have been defined

- limit value „Viscosity“ **[Red V]** in %
- limit value „Rel. Dielectric Constant“ **[Red E]** in %
- limit value „Specific Electric Conductivity“ **[Red C]** in % .

These limit values represent a deviation in percent on the basis of the fresh-oil under consideration; they are absolute values, i.e. they can denote values that are either higher or lower than the data obtained from the fresh oil.

Here is an example to illustrate the situation:

Red V = „30“ is selected as the limit values for viscosity in the system.

If the measured data of the viscosity deviates by more than 30 % from the fresh-oil value, the viscosity of the oil has reached its maximum strain value.
On the basis of the fresh-oil viscosity this will be valid for all viscosity values in the following range ($0.70 * \eta_{fresh} < \eta < 1.30 * \eta_{fresh}$).

This also implies to the other two oil parameters relative dielectric constant and specific electric conductivity.
Finally the three characteristic values of the oil , - each based on a comparison to the respective fresh-oil data -, will be combined by means of superposition to indicate **oil quality**.

If the three values (of viscosity, rel. dielectric constant and spec. electric conductivity) are equal, they will be equally weighted for the evaluation of the oil performance.
In order to further differentiate the sensitivity of the oil quality the parameter **Weight** is provided (weight V, weight E and weight C); these weight factors are within a range from zero to 1 (0...1):

In addition there are two further limit values in order to define the **oil performance**:

- limit value „Oil Quality Red“ **[Red Perf]** in % and
- limit value „Oil Quality Yellow“ **[Yellow Perf]** in % .

→ A decrease of the selected value of this parameter results in a slight delay of the time that elapses until the minimum value of the oil quality, - i.e. the 0 % value -, is reached.

→ An increase of the selected value results in an acceleration of this process.

Note:

- The value of the oil quality can be modified both by means of the predetermination of the limit values (Red V, Red E and Red C) and by the selection of the value for the oil quality „red“ (Red Perf).
- Furthermore the specific characteristic data can be assigned various degrees of significance for the evaluation of the resulting oil quality (Weight V, weight E and weight C).

So far it has been assumed for purposes of simplification that the actual oil data for viscosity, relative dielectric constant and specific electric conductivity can be directly compared to the reference data obtained from the fresh oil.
This, however, is hardly the case, due to variations of the oil temperature.
In order to cope with the effects of oil temperature on oil data and the process of oil ageing two procedures are possible:

- Monitoring of oil quality by measuring at a specific reference temperature (**Temperature compensation = OFF)**

  Evaluation in regard to oil ageing (that is LED green, yellow or red lighting up) takes place **only at one specified reference temperature** of the oil, usually at 70°C.

The advantage of this approach consists in the direct comparability of the oil data, as both the fresh oil and the used oil data are measured at the same temperature of the fluid. However, this method cannot be used in machines that are permanently operated, as there the specified reference temperature may reached only rarely or even not at all.

- Monitoring of oil quality by means of calculation of a defined reference temperature (**Temperature compensation = ON**)

  For machines whose oil cycles do not include phases of cooling-down the comparison of actual oil data with the respective fresh oil data must take place only after an adequate temperature compensation has been achieved by mathematical calculation.
  This is particularly necessary concerning viscosity, and also for the specific electric conductivity, whereas these is rather little effect of temperature on the relative dielectric constant.
  Therefore, when temperature compensation of the viscosity takes place, it is necessary to indicate not only the value of the fresh oil viscosity, - and, of course, the corresponding temperature -, but also the value for the so-called directional charateristic „m“ according to the „UBBELOHDE-WALTER-Equation“.
  This directional characteristic „m“ is determined in the system on the basis of the actually measured data for viscosity and temperature, with the parameter „m“ stored in the system serving as the starting value for iteration.

On the next page you will find all the relevant parameters of the measuring system LUBRICON which may be changed by use of a personal computer.

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Summary of relevant parameters of the measuring system LUBRICON:

Parameter	Comment	Preinstallation (standard)
Mode	**Measuring mode** Mode=1 : Temperature compensation OFF No quality control (no signals of LEDs) Mode=7 : Temperature compensation OFF Quality control with LED-function Mode=8 : Temperature compensation ON Quality control with LED-function	**1**
Interv/h	**Interval of time (10 minutes) for quality control [1/6 h]**	**1**
T ref	**Reference temperature [°C]** a) Reference temperature for oil quality control **or** b) Reference temperature for temp.-compensation	**70.0**
T band	**Deviation from the Reference temperature [°C]** if the temperature is not in the defined tolerance band (Tref-Tband) < Temp. > (Tref-Tband) the temperature compensation will be be stopped	**20.0**
M start	**Parameter for the temperature compensation**	**3.5**
Red Perf	**Limit „Oil Performance Red“ [%]**	**20**
Yellow Perf	**Limit „Oil Performance Yellow“ [%]**	**75**
Red V	**Limit „Viscosity“ [%]**	**30**
Red E	**Limit „Rel. Dielectric Constant“ [%]**	**50**
Red C	**Limit „Spec. Electr. Conductivity“ [%]**	**50**
Weight V	**Weight factor „Viscosity“**	**1**
Weight E	**Weight factor „Rel. Dielectric Constant“**	**1**
Weight C	**Weight factor „Spec. Electr. Conductivity“**	**1**
Scale V	**Scaling factor analog output interface „Viscosity“**	**1000.0**
Scale E	**Scaling factor analog output interface „Rel. Dielectric Constant“**	**10.0**
Scale C	**Scaling factor analog output interface „Spec. Electr. Conductivity“**	**500.0**
Scale T-	**Scaling factor analog output interface „Min.-Temp.“**	**-50.0**
Scale T+	**Scaling factor analog output interface „Max.-Temp.“**	**150.0**

→ **Further information for programming the system is available in the short version software instructions.**

→ **Further explanations concerning the general problem of oil monitoring are to be found in chapter 7.**

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5. LED-Display

The LEDs at the front of the electronic unit inform the user about the condition of the oil and possible misfunctions.

	(red/Error)	green	yellow	red	Comment
A	off	on	on	on	waiting for command „Fresh Oil Calibration“
B	off	on	off	off	oil ok (oil quality very good / good)
C	off	off	on	off	Warning (oil quality medium)
D	off	off	off	on	Alarm (oil quality bad, oil exchange absolutely necessary)
E	off	on	off	on	Ready for fresh-oil calibration
F	flashing	off	off	off	Error diagnostics
G	flashing	on	off	off	Error temperature sensor
H	flashing	off	on	off	Error quartz sensor
I	flashing	on	on	off	Error cable
J	flashing	off	off	on	Error search range
K	flashing	on	off	on	Error electrically conductive liquid
M	on	on	on	on	Programme start

The most important statuses of the LEDs as presented in the chart above were already explained in the instructions on how to start the system (cf. chapter 2, Installation).

- Immediately after connecting them to electricity all 4 LEDs will be ON for a few seconds (status „M“). The signal will then change according to what procedure will take place next.
- When the systems functions without any errors the red LED on the left will remain dark.
- When the system has been newly installed and the sensor has been correctly fitted the „status A“ will be activated, i.e. the system indicates „Ready for command fresh-oil calibration“ which is put into effect by pressing the key, as described in chapter 3.
- The LED signal will then change to green and red on (status „E“), thus indicating „Waiting for fresh-oil calibration“.
  How the system then proceeds depends on whether
  a) it works with a **constant reference temperature** or
  b) by means of **temperature compensation** applied to the viscosity data obtained by measuring.

  For version a) calibration takes place only when the reference temperature defined within the system (standard: 70°C) has been exeeded and / or when it is reached again.
  After that the LED signal changes to green, meaning „oil ok, oil quality very good / good“ (status „B“).
  For the version b) calibration takes place only after a sufficiently constant working temperature has been reached in the on-going process; then viscosity is calculated in relation to the reference temperature defined in the system (standard: 70°C); the LED signal then changes to green, indicating „oil ok, , oil quality very good / good“ (status „B“).
- When the system has been working for a larger period of time the LED signal may change to yellow (status „C“), indicating a warning, or eventually to red (status „D“=, indicating an alarm.
- **Malfunctioning of the system will be indicated by flashing of the red LED on the left.**

The system recognizes possible sources of malfunctioning and indicates them by specific combinations of LED-signals .

Occasional short flashing of the error LED may occur and should be tolerated.

If flashing of the error LED continues for 2 minutes or more this indicates a permanent malfunctioning of the system.

Note: In this situation oil monitoring is no longer effective !!

The most likely error signal is a combination of red LED flashing, green and yellow LEDs ON, which indicates that the sensor is not properly connected (status „I“).
Failure of the temperature sensor to operate is indicated by the combination of the red LED flashing with the green LED ON (status „G“). When there is a failure of the quartz sensor there will be the combination red LED flashing and yellow LED ON (status „H“).
If traces of water or any other electrically conductive liquid appear in the oil the signal will be: red LED flashing, green and red LEDs ON (status „K“, electrically conductive liquid). The same signal appears in the event of short circuit in the sensor cable at the quartz sensor.

6 Troubleshooting

When there is an error signal it is always helpful to record as precisely as possible what signals occur and under which conditions of operation they appear in the system; it is particularly important to note:

- the condition/status of the LEDs
- time and date of occurrence
- mileage (if the system is operated in a vehicle)
- time elapsed and mileage accumulated since the last fresh-oil calibration took place.

If a failure signal occurs while the system is on status „G“, „H“ or „I“ the pin- and socket connectors of the sensor and the electronic device should be checked.

Furthermore, it may prove immediately helpful to cut the system off from the power supply for about 30 seconds. All relevant data will remain available, and after reconnecting and turning the system on again the LEDs should be read again, their condition should once again be recorded.

If comparatively soon after fresh-oil calibration the system signals change from green (=oil quality very good / good) to yellow (=oil quality medium) and if this change appears highly implausible, the system can be subjected to an **adjustment** of the indicated value of oil quality.
This is achieved by pressing the key according to the instructions already given in chapter 3 above. The adjustment can be initiated while the yellow LED flashes.
This method allows the user to change the indicated oil quality towards a better level; in this way the signal can be changed from „yellow“ to „green“ or from „red“ to „yellow“.

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7 Important Remarks: The Problem of Oil Quality Detection

Oil ageing is subject to various influences. While the physical properties of an oil, such as temperature, viscosity, relative dielectric constant and specific electric conductivity can be measured by means of adequate sensors and can therefore be clearly defined, this is not true for oil quality.

Here matters vary according to the specific conditions in which the oil is used, and a final evaluation is made on the basis of changes in above-mentioned properties of the oil, with the data obtained from the fresh oil serving as point of reference. This excludes any claim to a general validity of the evaluation.

Therfore, while the LUBRICON system can achieve a precise measuring of the changes of the physical characteristic data, the resulting evaluation of oil quality that it provides must necessarily remain an approximated estimate.

This estimate is based on the following requirements:

a) the user must determin by himself the specific limit values of the maximum change in % allowed for the various parameters of the oil

b) each parameter of the oil must be weighted and assigned its measure of importance in the general evaluation of oil quality.

Limit values which express the maximum changes the oil may undergo compared to the properties of the fresh oil before it is considered no longer good, i.e. either of medium or even of bad quality, are very decisively influenced and thus determined by the circumstances of the individual application.

For example:

Experiences show that for the monitoring of lubricating oils in combustion engines the choice of the fuel that is used is of major importance. The definition of the limit values as described above will certainly vary widely depending on whether the engine is fuelled by diesel, petrol, gas or biogas.

The limit values for monitioring of oil in hydraulic machines will be quite specific and different again.

The LUBRICON system comes with a presetting that indicates oil quality in three levels: „green“ signals a very good to good quality, „yellow“ indicates the beginning of the oil ageing process and „red“ shows that the oil should no longer be used.

This presetting cannot cover every individual application adequately.

Therfore it is necessary that every user establishes the correspondence between the signal and the level of oil quality himself, as only the particulars of application can determine, which oil quality is unacceptable.
In other words: The user is responsible to tell the system at what point it should signal „red = oil quality bad“.

The general procedure is as follows:

→ After fresh oil has been fed into the system the command „fresh-oil calibration“ activates the LUBRICON system, which then records the changes of the four different measuring values and determines the oil quality by means of the preset specified limit values.

→ Right before the next change of oil this data can be read and then serve as the basis for individual reseting.

→ To facilitate practical application the programme „Lubricon.EXE“ is available with a short version description on CD.
After presetting has been achieved the LUBRICON system will indicate the three different levels of oil quality for the individual application.
flucon fluid control GmbH provides a maximum of support and guidance, enabling the user to do their own presetting according to their needs and requirements, and therefore the optimal monitoring of oil against premature ageing can be achieved.

8 Pin Connectors and Signals

The basic version of the LUBRICON system provides the following plug-in connections:

- 1 piece built-in panel jack „Sensor“ (7 polar)
- 1 piece built-in plug „Power supply“ (7 polar)

The cable of the measuring head (sensor) contains the corresponding device for the 7-polar built-in plug of the case:

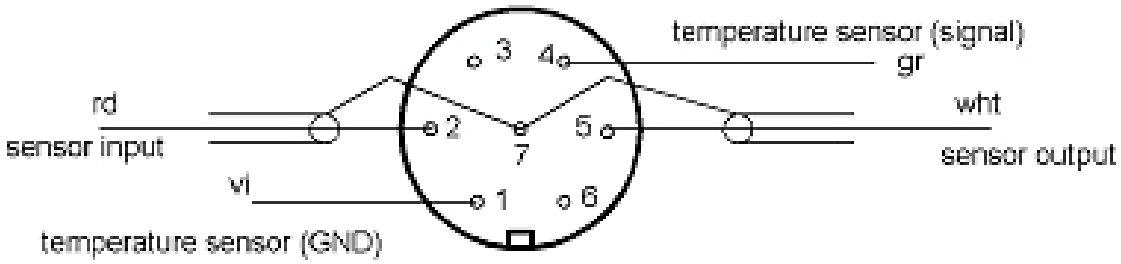
- 1 piece plug „Cable“ (7 polar)

The pin assignment for the built-in socket „Sensor“ is identical in all versions of the LUBRICON system.

The pin assignment for the cable-socket „Power Supply“, however, varies in the different versions of the LUBRICON system.

a) The built-in socket „Sensor“ in the case

Sensor
Built-in socket in the case (view at the solder side)

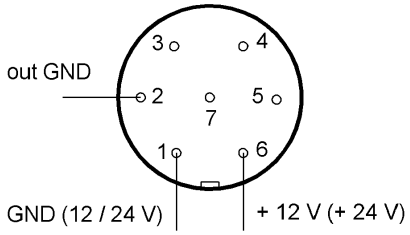


Built-in socket „Sensor“ at the case:

Pin-No.	Comment
1	Temperature sensor GND
2	Quartz sensor-Input (shielded)
3	Memory-chip (optional)
4	Temperature sensor Signal
5	Quartz sensor-Output (shielded)
6	Memory-chip (optional)
7	Temperature sensor GND

b) Socket „Power Supply“ on the cable

Power Supply
Socket on the cable (view on solder side)



Socket on cable „Power Supply“:

Pin-No.	Version „D“	Version „A“	Version „S“
1	GND (Power Supply)	GND (Power Supply)	GND (Power Supply)
2	GND (Digital I/O)	GND (4...20mA resp. 1...5V & I/O)	GND (4...20mA resp. 1...5V & I/O)
3	Digital-IN 1	4...20mA resp. 1...5V spec.el. Cond.	4...20mA resp. 1...5V spec.el. Cond.
4	Digital-OUT 1	4...20mA resp. 1...5V rel. DK	4...20mA resp. 1...5V rel. DK
5	Digital-OUT 2	4...20mA resp. 1...5V Viscosity	4...20mA resp. 1...5V Viscosity
6	+ VDC (Power Supply) +10...+30VDC	+ VDC (Power Supply) **A12**: **+12VDC** (±10%) **A24**: **+24VDC** (±10%)	+ VDC (Power Supply) **S12**: **+12VDC** (±10%) **S24**: **+24VDC** (±10%)
7		4...20mA resp. 1...5V Temp. **or** 4...20mA resp. 1...5V Oil Quality	4...20mA resp. 1...5V Temp. **or** 4...20mA resp. 1...5V Oil Quality

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Control conduits:

As is already visible in the pin assignment presented above, the control conduits in the LUBRICON system vary according to the different versions of the system.
The pin assignment depicted in the chart above demonstrates which of the control conduits described below is available in each specific version of the system.

Digitale In- and Output Terminals

There is a maximum of two digital output terminals and one digital input terminal available in the system.
These three digital conduits are optocouplers and are decoupled from operating voltage by means of plating.
The **Input** terminal (digital-IN 1) has a protective resistor of 560 Ohm and can be operated at a voltage of 5 volt (approx. 6 mA). For operation at higher voltages adequate protective resistors are necessary:

R = ((Usignal – 1,3) / 6mA) – 560 Ohm
R(12 V) = approx. 1, 2 kOhm
R(24 V) = approx. 3,3 kOhm

By means of a defined sequence of signals this input-conduit permits a remote-control execution of these functions of the system that have been described above in chapter 3.

Time-based coding permits three functions to be carried out on the **digital input** conduit in the following manner:
A signal on the digital input conduit starts a time interval of 4 seconds, within which 1 to 3 impulses can be received, the start being counted as the first signal; each pulse and the breaks between pulses should last about 250ms. If more than three pulses occur within the 4-second interval the system returns to the normal operating mode.

Number of pulses	Function
1	Fresh-oil calibration
2	Quality improvement
3	currently without any function
>3	no function

The red LED normally indicating errors is here used to indicate the arrival of input signals. When this is the case all LED lights go out and then the red error LED flashes once for every impulse coming in. At the end of the 4-second interval the old signal status will reappear.

The two **digital output** terminals (Digital-OUT 1 u. OUT 2) can be operated at a maximum of 20 mA. Their normal conditions correspond to the LED signal combinations indicated at the front of the housing as follows:

Digital-OUT 1	**Digital-OUT 2**	**Function**
OFF	OFF	Error signal
ON	OFF	Oil condition very good / good (green)
OFF	ON	Oil condition medium (yellow)
ON	ON	Oil condition bad (red)

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Analog Output Terminals

If the system is supplied with an analog interface there will be a total of 4 analog output terminals available, which are wired as active current loop output terminals for 4....20mA or 1....5V voltage and which are decoupled from the operating voltage by means of plating.

Note: The configuration of the analog interface varies according to the measuring mode (mode).

- **Mode = 1 (oil monitoring OFF)**

Scaling for the 4...20mA-**current output** is as follows:

Rel. Dielectric Constant	4 mA correspond to 0,	20 mA correspond to 10
Temperature	**4 mA correspond to –50°C,**	**20 mA correspond to 150°C**
Viscosity	4 mA correspond to 0 mPas,	20 mA correspond to 1500 mPas
Spec. Electr. Conductivity	4 mA correspond to 0 nS/m,	20 mA correspond to 500 nS/m

In case of error all four analog output terminals will have a current of 2 mA.

For the event of 1...5V-**Voltage output** the presetting is as follows:

Rel. Dielectric Constant	1 V correspond to 0,	5 V correspond to 10
Temperature	**1 V correspond to –50°C,**	**5 V correspond to 150°C**
Viscosity	1 V correspond to 0 mPas,	5 V correspond to 1500 mPas
Spec. Electr. Conductivity	1 V correspond to 0 nS/m,	5 V correspond to 500 nS/m

- **Mode ≠ 1 (oil monitoring ON)**

Scaling for the 4...20mA-**current output** is as follows:

Rel. Dielectric Constant	4 mA correspond to 0,	20 mA correspond to 10
Oil Performance	**4 mA correspond to –30 %,**	**20 mA correspond to 100 %**
Viscosity	4 mA correspond to 0 mPas,	20 mA correspond to 1500 mPas
Spec. Electr. Conductivity	4 mA correspond to 0 nS/m,	20 mA correspond to 500 nS/m

In case of error all four analog output terminals will have a current of 2 mA.

For the event of 1...5V-**Voltage output** the presetting is as follows:

Rel. Dielectric Constant	1 V correspond to 0,	5 V correspond to 10
Oil Performance	**1 V correspond to –30 %,**	**5 V correspond to 100 %**
Viscosity	1 V correspond to 0 mPas,	5 V correspond to 1500 mPas
Spec. Electr. Conductivity	1 V correspond to 0 nS/m,	5 V correspond to 500 nS/m

The scaling factor for **viscosity** can be determined by means of the software programme Lubricon.EXE), as described above in chapter 4.
The scaling for the other three measuring values (rel. dielectric constant, spec. electric conductivity and temperature / oil performance) is preset in the system with the above-mentioned reference values.

Further instructions concerning the basic parameter presetting of the system are available in the short-version of software manual.

9 Technical Specifications

A. Electronic Unit:

Measuring values:	Viscosity, Temperature, Permittivity and Conductivity
Display:	3 pieces LED (green/yellow/red) for the oil quality (perfect/acceptable/bad)
Error display:	1 piece LED (red) for the error detection
Temperature range:	0...70°C
Power supply:	10-30VDC direct current voltage (Version „D“) 12 VDC **or** 24 VDC direct current voltage (Version „A“)
Current:	approx. 100mA (Version „D“) , approx. 250 mA (Version „A“)
Housing:	BOPLA Aluboss
Material:	Al
Protection:	IP 54 bzw. IP 65 (Version „S“)
Dimension:	125 x 82 x 35 mm (L*W*H, only the housing without the connectors)
Weight:	approx. 200g

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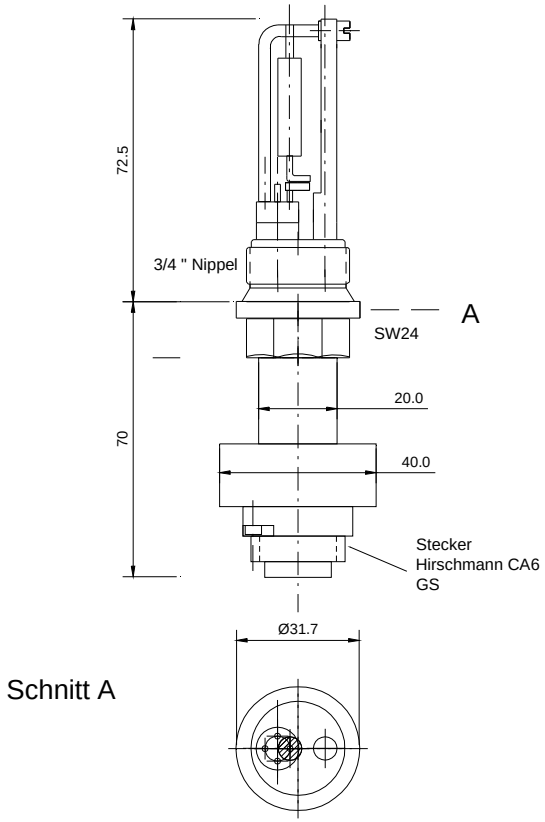
B. Sensor:



Sensor Module TQ78DP/VA (Oil Sensor)

Measuring range:	Viscosity (5 bis 1.500 mPas) Rel. Dielectric Constant (1 bis 10) Spez. electr. Conductivity (10 bis 1.000 nS/m) Temperature (0°C bis 130°C)
Fluid sensor:	Quartz torsional transducer (SiO_2), approx. 78kHz, shear rate appox. $4.9*10^5$ s^{-1}
Temperature sensor:	Silizium-Planar sensor KTY
Power supply:	max. 30V
Pressure range:	≤ 25 bar
Temperature:	-40°C bis 130°C (Fluid)
Temperature:	0...70°C (ambient)
Media:	Oil (electrical non-conductive liquids)
Calibration:	factory calibration in reference oil self-calibrating on users demand by use of fresh oil calibration knob
Sensor cable:	Special cable LIYY-LIYCY 6 x 0,5 with common shield , Quartz wires single shielded (max. length 20m / typ. 5m) with Hirschmann adapter CA6LD
Adapter:	Adapter RD24x1/8, 6-pole according to Hirschmann adapter CA6GS
Material:	stainless steel adapter (1.4571) & Ceramic Feedthrough
Protection:	IP 67
Size:	Total length 142.5mm, Sensor length 72.5mm, Adapater ¾“ (G3/4A)
Weight:	approx. 250g