Technical Manual

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Note: A detailed table of contents can be found at the beginning of each chapter.

SAFETY AND WARRANTY

This manual must be made available to the people in charge of installation, maintenance and to users of the Moisture in Oil Monitor (MO).

Carrying out installation, maintenance and operation of equipment in electric energy substations requires special care and, therefore, every recommendation made in this manual, applicable norms, safety procedures, safe work practices and sound judgment must be used in installing, operating and maintaining the Moisture in Oil Monitor (MO).

WARNING

With a view to ensuring user safety, protection and proper operation for the equipment, the following care must be taken during installation and in maintenance of the MO:

1. Read this Manual carefully before installing, operating or performing maintenance of MO. Errors in installing, maintaining or in the adjustments made to the MO may cause damage to the power equipment and/or to the equipment where they are used, undue alarm issues or even, problem situation indication alarms may remain unsounded.
2. Installation, adjustments and operation of the MO must be undertaken by trained personnel familiar with the use and operation of power transformers, high voltage apparatus, control devices and command circuits in substation equipment.
3. Special attention must be given to the installation procedures of the MO (see Chapters 5, 6 and sub-chapters), including type and gauge of the cables used, as well as the correct parameter programming (Chapter 7) and start up procedures (Chapter 8).
4. Disconnect the ground wire connected to terminal 17 of the Interface Module prior to performing industrial frequency dielectric tests in the wiring in order to avoid the destruction of overvoltage protections embedded in the device due to elevated voltages for long periods of time (for example, 2kV for 1 minute). These protections are internally connected between inputs/outputs and ground terminal to limit the voltage around 300V.

TERM OF WARRANTY

The Moisture in Oil Monitor MO is guaranteed by Treetech for the term of 2 (two) years, counted from the date of purchase, exclusively against eventual manufacture defects or quality vices that render the equipment unfit for use.

The warranty will not cover damages sustained by the product, as a consequence of accidents, improper handling, incorrect installation and use, inadequate tests or in case the warranty seal has been breached.

The eventual need for technical assistance must be informed to TREETECH, or to a technical assistance service appointed by the same, with the equipment being delivered together with the purchase invoice.

Treetech does not supply, nor is liable to, any other warranty, expressed or understood, in addition to the ones mentioned above. Treetech does not supply any guarantee of suitability of the MO to any specific application.

The dealer is not liable to any claims for damage to property, nor any other form of losses that might occur, in connection to or stemming from the acquisition of the equipment, of the performance of the equipment or of any other service possibly supplied together with the MO.

Under no circumstances will the dealer be made responsible for any losses incurred, included but not limited to: loss of profit or revenue, impossibility in using the MO or any other associated item of equipment, costs of capital, costs of energy acquired, costs of replacement equipment, facilities or services, costs of outages, complaints from clients or employees of the buyer, regardless of whether said damages, complaints or losses are based on contracts, warranties, negligence, felony or any other reason.

Under no circumstances can the dealer be made liable for any personal damage of any sort.

Revision History

Rev. No.	Date	By	Description
0	2006-09-25	Marcos	Original emission
1.01	2015-02-11	R.Gennari	Corrected range of parameter OFFS
1.02	2015-05-22	J. Victor Miranda	International Representatives updated

Part I – Operation Philosophy

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1. Introduction

Excess water in the insulating oil of high voltage equipment, such as transformers and reactors, causes well known adverse effects. High moisture content will cause reduction in dielectric strength and migration of water into the insulating paper, with the risk of formation of bubbles and accelerated aging in the presence of high temperatures, thus jeopardizing the equipment life cycle and integrity.

The Moisture in Oil Monitor MO is comprised of a Measurement Module, installed in contact with the oil, and an Interface Module that allow on line measuring and monitoring of the moisture present in the oil, generating important information in determining the equipment's current state:

- Water in oil relative saturation percentage (RS%) and oil temperature;
- Calculation of moisture saturation percentage converted to a reference temperature selected by the user (RS% @ TREF), allowing users to know, for instance, what would be the value for moisture saturation expected for the oil at a reference temperature or at the transformer's lowest operating temperature;
- Percentage of moisture saturation converted to a second value for temperature, measured by a Pt100Ω at 0ºC input sensor (RS% @ T2), allowing users to know, for instance, the level of moisture saturation if the transformer is de-energized and allowed to cool to ambient temperature (measured with a Pt100 RTD);
- Water content in oil in parts per million (ppm), calculated based on the readings for moisture saturation percentage and oil temperature with user programmable water solubility constants, allowing users to adjust the constants in accordance with the type and age of the oil;
- Evolution trend (rate of change) in the water content in the oil in ppm per day (ppm/24h).

Based on the above information, the MO's alarm activation limit values are programmed by the user for high or very high moisture saturation percentages (RS%, RS%@T_{REF} and RS%@T_2), high or very high water content (ppm) and high water content evolution trend.

(a) (b)

Illustration 1.1 – Moisture in Oil Monitor MO
(a) Interface Module - (b) Measurement Module

Main Features

- IED (Intelligent Electronic Device) designed specifically for substation yard conditions (interferences, extreme temperatures), suitable for integration into supervision or monitoring system through RS485 port (standard Modbus, DNP3.0 optional);
- Easy visualization LED display;
- Programmable analog output for remote reading of RS%, RS%@T_{REF}, RS%@T_2 or water content (ppm). User programmable output range: 0...1, 0...5, 0...10, 0...20 or 4...20mA;
- Six user programmable output relays for alarm indications;
- Self-diagnosis with 1 NC output relay for detection of any fault in sensors, connection wires, auxiliary power supply or internal fault.
- Total absence of mechanical parts in parameter definition and calibration.
- Internal clock with date and time;
- Optional mass memory for storing readings obtained for relative saturation, water content in oil, oil temperature, temperature of sensor 2 (when used), water content trend evolution and alarm events, based on internal clock with day, month, year, hour, minute and second. A memory record can be started by:
  - Time interval between recordings defined by users, or;
  - Occurrence of an alarm event.

2. Operating Philosophy

2.1. Relative saturation and Water Content

In order to obtain a reading of the moisture content in oil, the Sensor Module of the MO is installed in contact with the oil, usually through a valve sited where there is good circulation of oil, and containing a sensor that measures the relative saturation of water in oil, as a percentage (RS%).

Relative saturation is the ratio between the water content dissolved in oil (ppm) and the solubility of water in oil (ppm), with solubility being taken as the maximum values that water content dissolved in oil could reach. Therefore, water content in oil in ppm corresponds to the relative saturation multiplied by the water solubility rate.

The level of solubility of water in oil is dependent on the oil's own specific characteristics (make up, acidity, etc.), represented by their solubility constants A and B, and also varies as a function of the temperature. For this reason, the Sensor Module also measures the temperature of the oil, which together with the solubility constants A and B programmed by users allows MO to determine the solubility of water in oil.

Based on the solubility of water calculated and the reading for relative saturation, the MO is then able to calculate the content of water in oil, in ppm.

The water in oil solubility constants A are B programmed by users using typical values for the oil used or using assay-based values, as explained in Attachment A.

2.2. Conversions of Relative Saturation to different temperatures

Given that the solubility of water in oil varies as a function of temperature, it is natural that relative saturation should also do so, even if the water in oil content remains the constant in ppm. As the oil cools, water solubility drops, increasing relative saturation. If oil temperature reaches low enough levels, a point is reached where solubility borders on water content, with free water being formed in the oil and the consequent risk of equipment failure. In general, it is agreed that for relative saturation values of over 50% there already is the risk of free water forming in the oil.

From the above exposed, we can conclude that for equipment in operation at high temperatures there is no risk of free water being formed. However, when this equipment is powered down and cooled to ambient temperature, free water can appear in the oil and prevent the equipment from being re-energized.

For this reason, in addition to measuring water saturation at the equipment's operating temperature, MO also calculates conversion of water saturation for two other temperatures using the water in oil solubility constants A and B:

- A reference temperature, programmed by the user, which could be a standard value to allow comparison between equipments or also the lowest ambient temperature value expected for the year;
- Temperature read at the second Pt100 input point found in MO, used typically for measuring ambient temperature. In this way, the MO calculates on-line what the water in oil saturation value would be if the equipment were powered down. Using this second temperature reading input point is optional.

2.3. Alarms for excess water in oil

In order to signal conditions where excess water in oil might be hazardous for the equipment, alarm limits can be programmed in the MO based on different parameters measured and/or calculated:

- On-line High or Very High reading of water in oil saturation;
- High or Very High water in oil saturation converted to reference temperature;
- High or Very High water in oil saturation converted to ambient temperature;
- High or Very High water content in oil in ppm; and
- Evolution trend (variation rate, in ppm/day) for water content in oil.

3. Operation

All operations of the Moisture Monitor are performed using the display, LEDs and keys located on the front panel of the Interface Module, with the following functions:

Programming Key: On reading screens allows access to password to enter programming menu. In programming menus, quits current menu and returns to menu for the previous level. If pressed when changing a parameter, it returns system to the menu for the previous level without saving the alteration.

Up Key: navigation to menus and increments values programmed.

Down Key: navigation to menus and decrements values programmed.

Enter Key: Selects menus and parameters and saves values programmed.

3.1. Variable readings

In normal work mode, the Moisture Monitor MO displays the value of the variable indicated by the LED that is on to the left of the display, among the following options:

- RS% (Water in oil relative saturation, in %)
- RS% @ t_{ref} (Relative saturation converted to reference temperature t_{ref}, in %)
- RS% @ t_2 (Relative saturation converted to temperature t_2, in %)
- H_2O ppm (Water in oil content, in ppm)
- Temp. Oil (Oil Temperature at moisture sensor, in ºC)

Any of the above readings can be queried by pressing keys or . LEDs will indicate the reading being currently displayed by the MO.

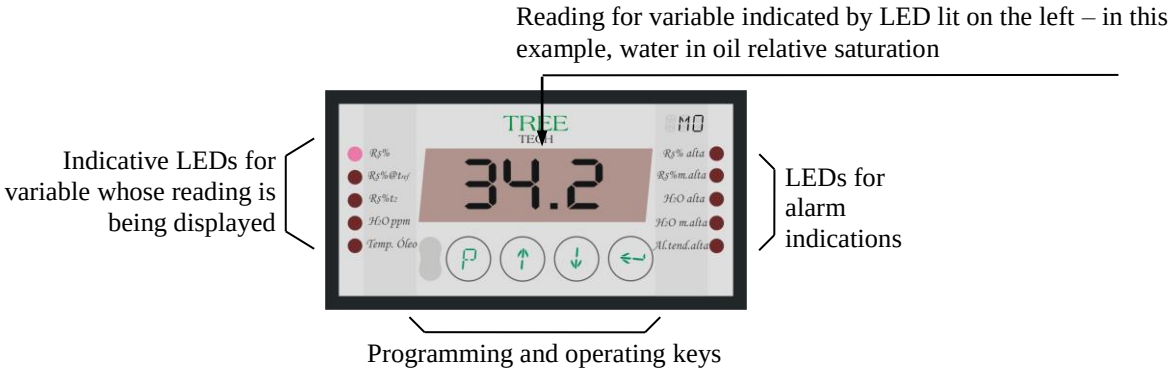

Figure 3.1 – Reading for variable on display

3.2. Alarm Indications

When the alarm value programmed for any of the variables is reached (% relative saturations, water content in ppm or evolution trend for water content), this condition is signaled by the corresponding LED at the right of the display, as shown in the example of figure 3.2. The output contact(s) programmed for this event are also activated.

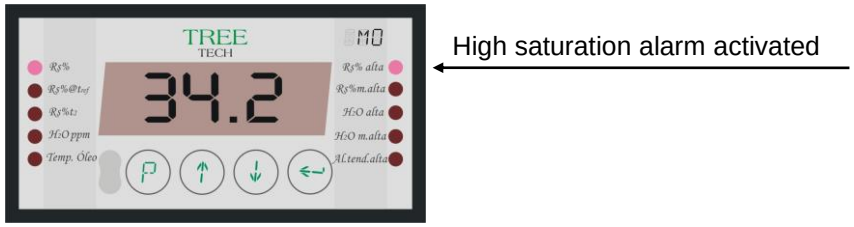

Figure 3.2 – Example of alarm indication

3.3. Query for additional variables

In addition to the variables discriminated by the LEDs on the left of the display, the MO also offers the following variables, which can be queried using the keys on the front keyboard:

- TRND – Evolution trend (rate of increase or decrease) for water in oil content in ppm per day (ppm/24h).
- T2 – Temperature read by temperature sensor 2 (if it is used), usually used in measuring ambient temperature.
- HOUR, MIN, SEC, DAY, MON, YEAR - Hour, minute, second, day, month and year of internal clock.

In order to query these variables, press key ↵, and the display will show acronym “TRND” alternating with the value recorded for the reading for evolution trend for water in oil content. By pressing consecutively the ↓ key, the query moves to the following variables: T2 (only available when temperature sensor 2 is being used), HOUR, MIN, SEC, DAY, MON and YEAR, and by pressing ↑, the query returns to the previous variables. At any moment, press P to return to the readings for the standard variables. If no user intervention occurs in a period of 20 seconds, the MO returns automatically to the readings for the standard variables.

3.4. Self-diagnostic readings

If the self-diagnostic system of the MO detects any problems through its reading sensors, connection cables or even due to internal failure, the corresponding error code will be displayed alternating with the acronym “ERR” (see error table, chapter IV).

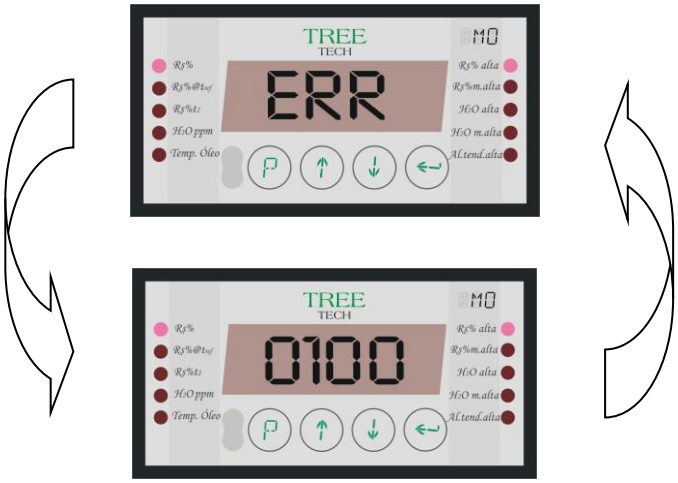

Figure 3.3 – Self-diagnostic indication

By pressing ↑ or ↓, the display returns to the indication of the variables, returning to displaying the error code indication if after some time no other key is pressed.

Part II – Project and Installation

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4. System Topology

A typical set up of the Moisture Monitor - MO uses the topology shown in figure 4.1.

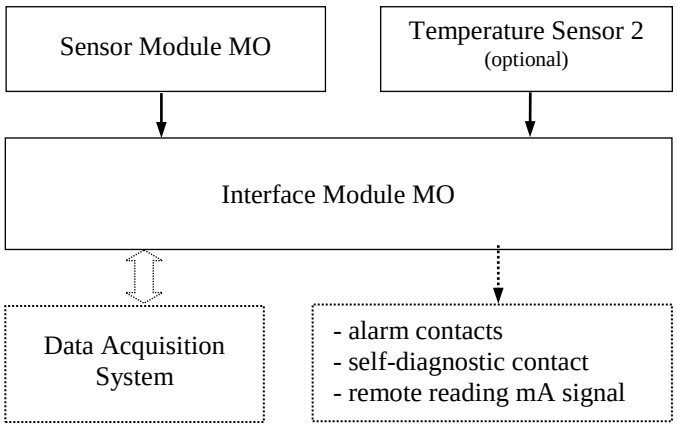


Figure 4.1 – Typical topology

The main items required for the set up are:

- MO Sensor Module
- MO Interface Module
- Temperature Sensor 2 (optional, for example, in measuring ambient temperature)
- 6-wire shielded cable for connecting Sensor Module to Interface Module
- 3-wire shielded cable for connecting Temperature Sensor 2 (when used) to Interface Module
- Shielded twisted pair cable for serial communication and/or remote reading via current loop (if used)
- Panel to install Interface Module outdoors (if applicable)
- Basic inputs: Teflon tape, cable ducts, etc.

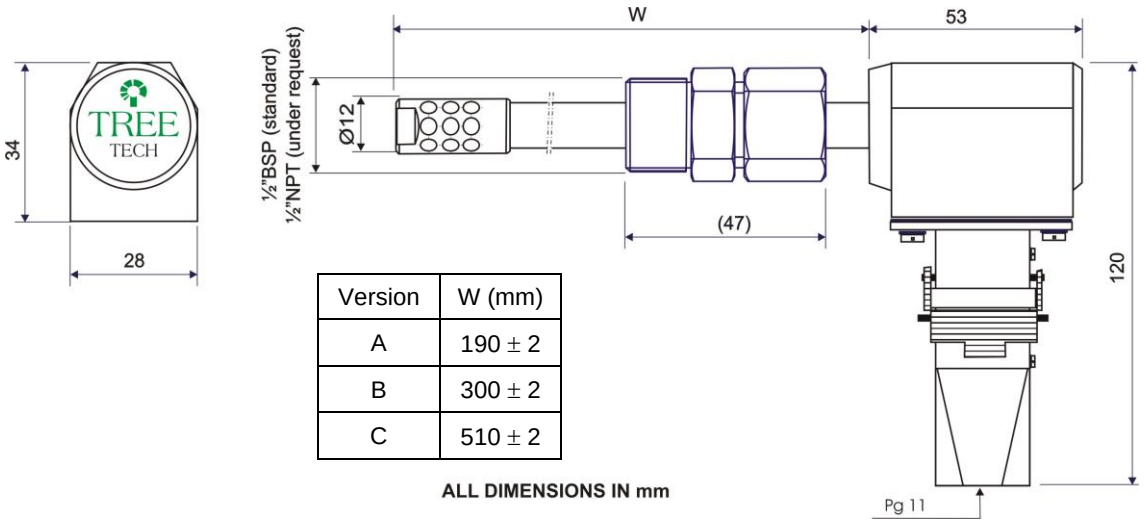
5. Mechanical Set Up

5.1. Sensor Module

The MO's Sensor Module must be installed in a valve with minimum ½" diameter that allows direct contact with the oil whose temperature is being measured. The valve used must be free passage, ball or drawer type. Valves that do not allow free passage, like the 'globe' type, should not be used.

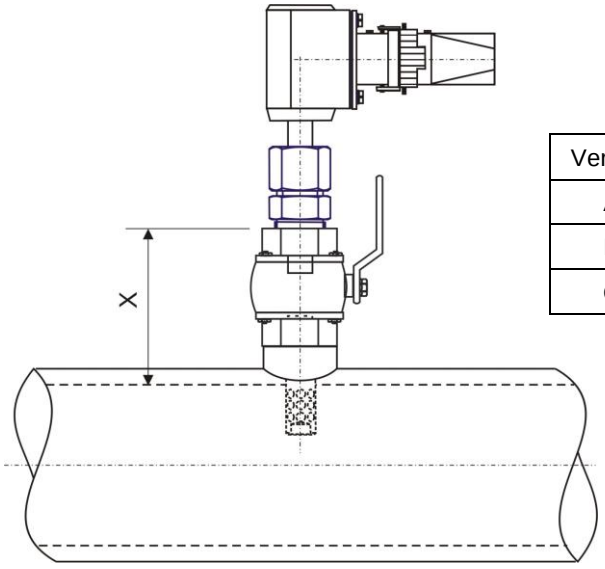
Sensor Module can be supplied with rods of two different lengths, as shown in figure 5.1. The length of rod chosen for use is a function of the distance of the end of the thread where the MO will be fixed to the flow of oil, which should preferably be under 115mm, for version A, or shorter than 225mm for version B, as shown in figure 5.2. This ensures that the sensor–bearing end is dipped into the flow of oil.

The Sensor Module external thread is ½" BSP or ½" NPT and can be used to fix the device directly on the valve, when the thread is compatible, or using a suitable adapter.



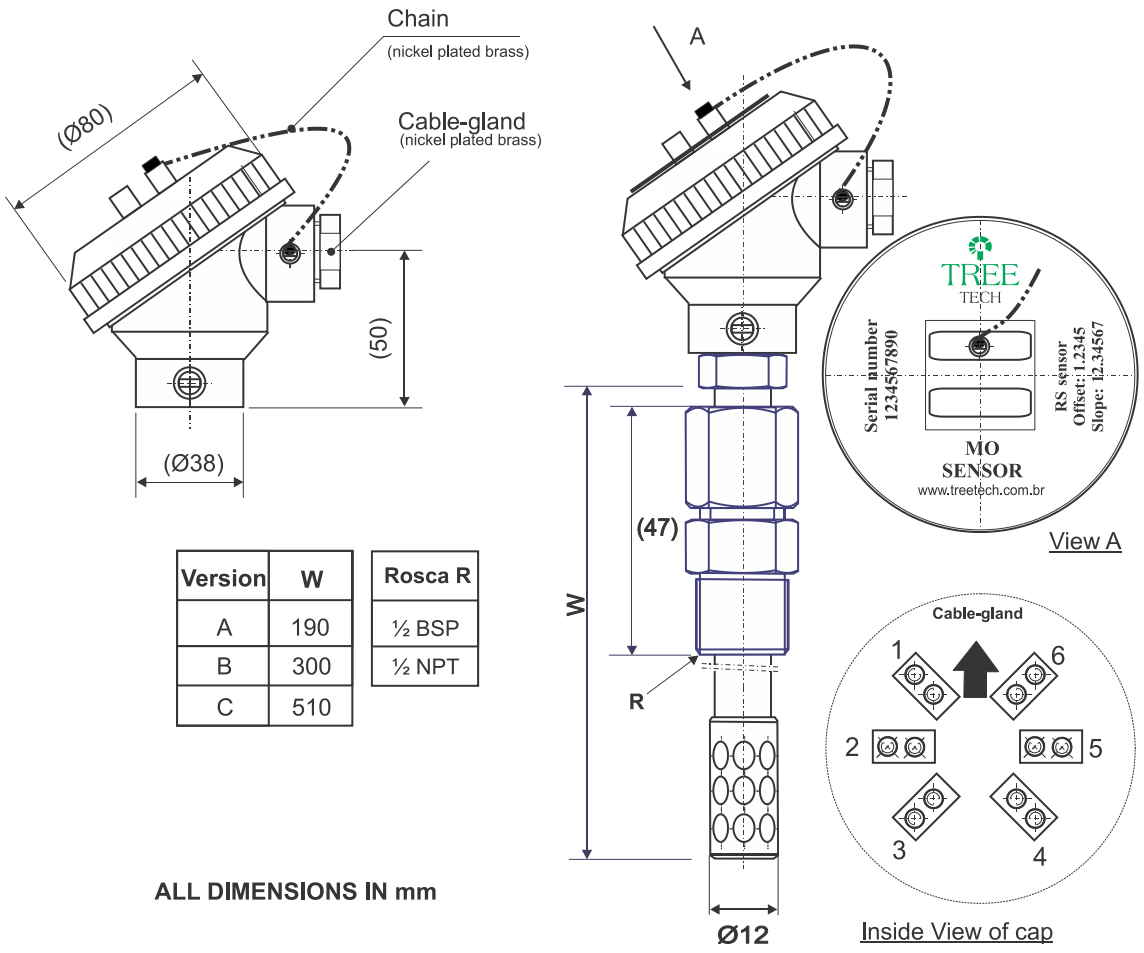
Version	W (mm)
A	190 ± 2
B	300 ± 2
C	510 ± 2

Figure 5.1 – Dimensions of Sensor Module



Version	X (mm)
A	< 115
B	< 225
C	< 435

Figure 5.2 – Maximum distance to install Sensor Module



Version	W
A	190
B	300
C	510

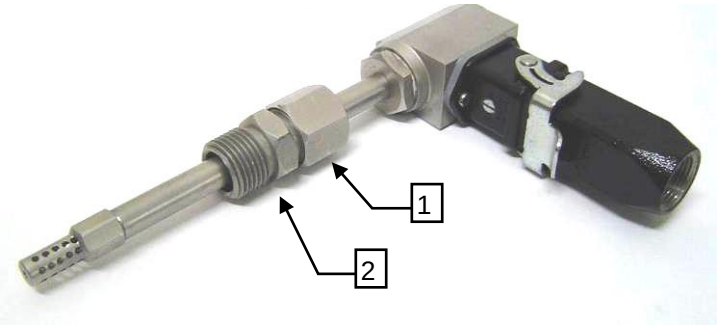
Rosca R
½ BSP
½ NPT

Figura 5.3 - Module with sensor head

The sensor should be set up in a place where there is good oil circulation, so that the moisture reading obtained is representative of the equipment's overall condition. At the same time, areas with lower temperatures are preferred, as a form of increasing accuracy of reading (for example, in a typical mineral oil, at every 1% variation in relative saturation there is a corresponding variation of a little over 1ppm in the water in oil content at 40ºC, while at 80ºC this same 1% variation corresponds to over 4ppm). The Sensor Module's operating temperature range should also be taken into account, from -40 to +85ºC.

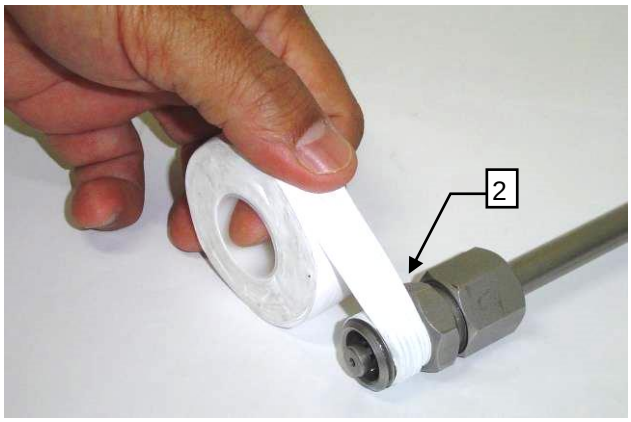
5.1.1. Set up procedure

a) Loosen nut (1) of the fixing element (2).



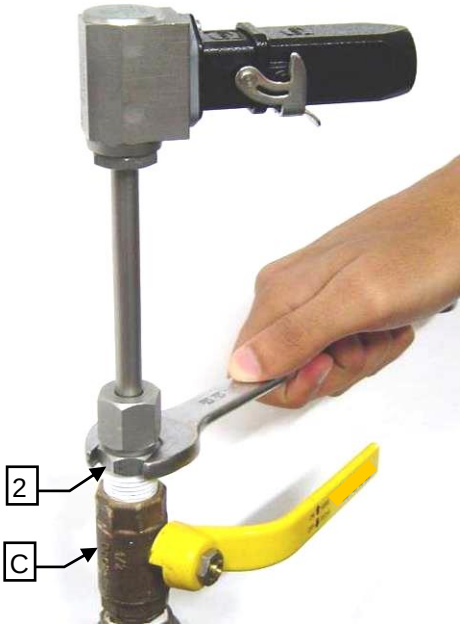
b) Push the fixing element (2) towards the end of the rod, so that the end of the rod slips up into the fixing element (2).

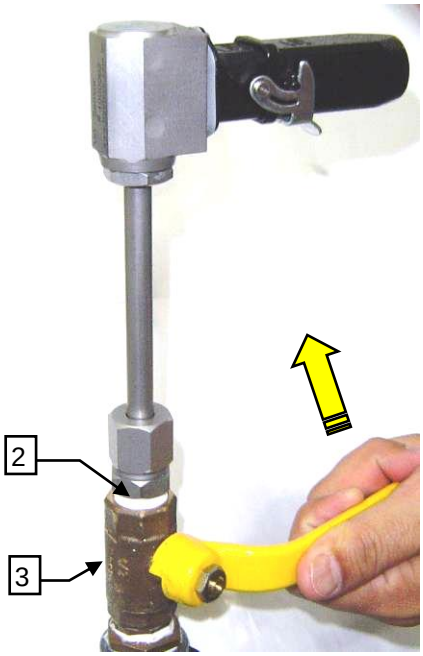
c) Apply enough Teflon tape on the thread of the fixing element (2).



d) Partially thread the fixing element (2) and the valve (3), leaving enough space for air to be expelled from inside the valve (3).

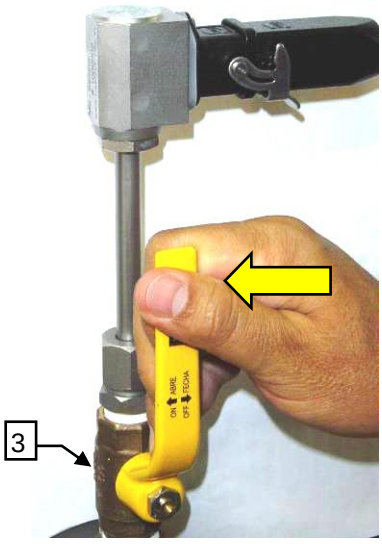
e) Open the valve slightly (3), allowing oil to seep in and expel the air through the space left on the thread of the fixing element (2). Catch any oil that comes out through the thread with cloth, keeping it from escaping into the environment.



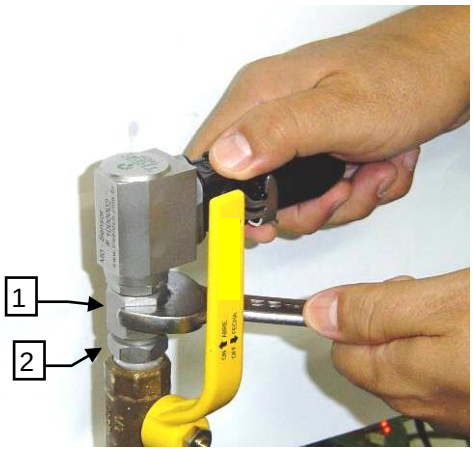


f) When all the air has been purged from the inside of the valve (3), finish threading in the fixing element (2) onto the valve (3) using a size 22 wrench (fixed size).

g) Open the valve totally (3) and insert the Sensor Module until the desired position is reached, preferably so that the rod's sensor-bearing end reaches the flow of oil. Special care must be taken for the rod of the Sensor Module not to come too close to areas subject to high electrical fields, in order not to compromise the insulation of the de transformer.



h) Tighten the nut (1) of the fixing element (2) using a size 22 (fixed size) wrench, in order to lock the Sensor Module in position.



5.2. Interface Module

The Interface Module of Moisture Monitor MO must be installed protected from the effects of weather, i.e. inside cabinets/panels or indoors. An anti-dew system is also advisable. The Interface Module is suitable for built-in set ups, and can be installed, for example, in doors or front panels using the clips supplied with the equipment. Figure 5.3 shows the main dimensions of the equipment, as well as dimensions for the cutout on the fixation sheet. Special attention must be given to the thickness of paint layers on the plate where the cut out is made, since in some cases, when thick paint coats are used, the ensuing reduction in the area of the cutout can impair insertion and/or removal of the device. Connection terminals are installed in the back part of the MO, in two removable connectors, in order to facilitate connections. Cables from 0.3 to 2,5mm2 can be used, bare or with “pin” type terminals (or “needle”).

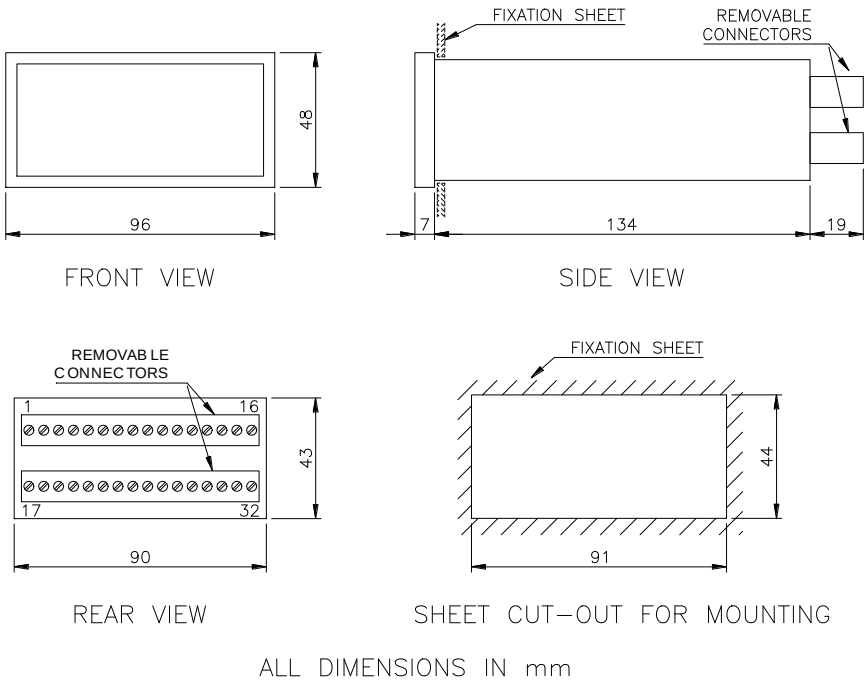
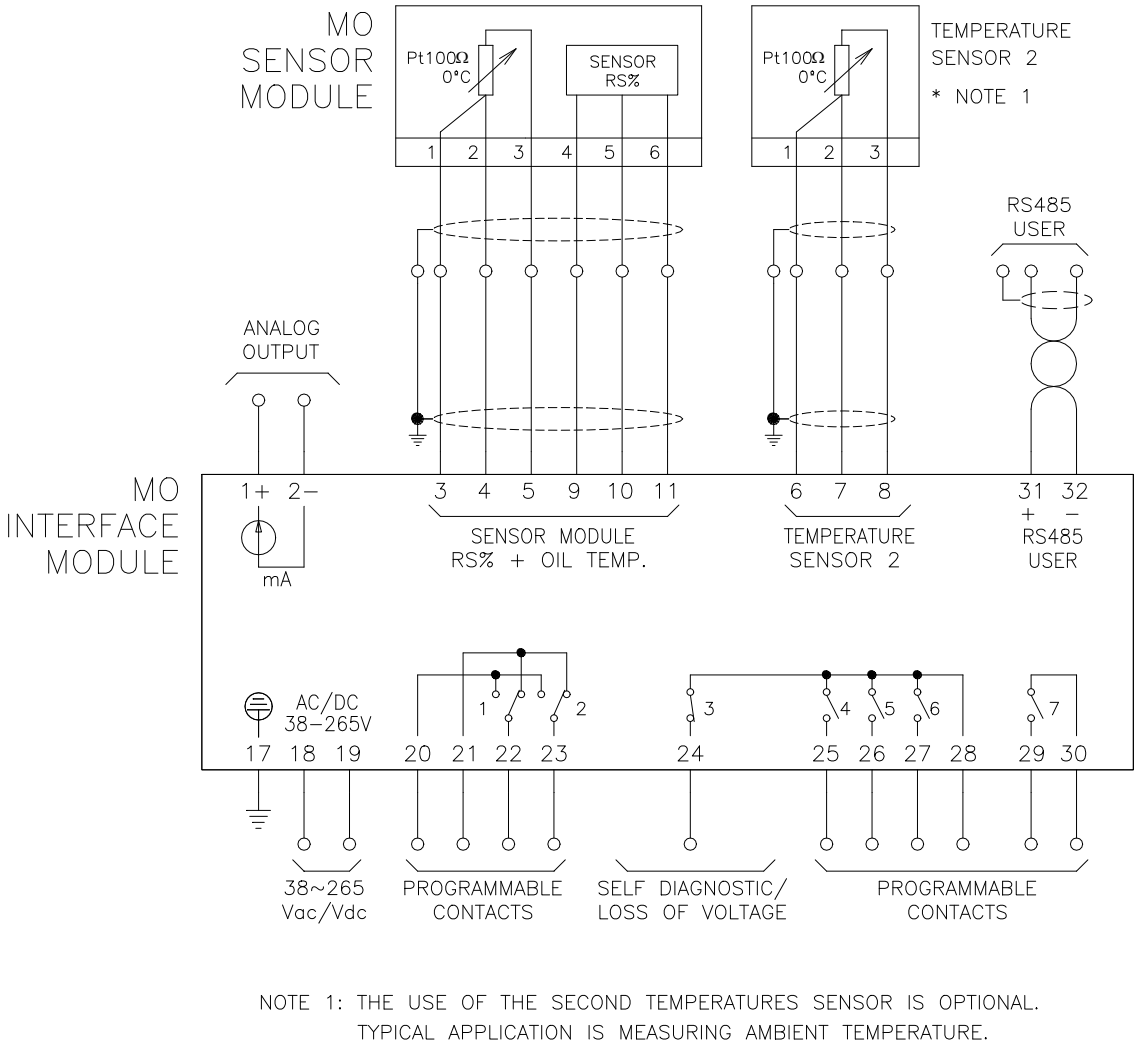


Figure 5.3 – Dimensions of Interface Module

6. Electrical Set Up

Figure 6.1 shows the general wiring scheme for installing the MO, including the link between the Measuring and Interface Modules and their inputs and outputs.



NOTE 1: THE USE OF THE SECOND TEMPERATURES SENSOR IS OPTIONAL.
TYPICAL APPLICATION IS MEASURING AMBIENT TEMPERATURE.

Figure 6.1 – Wiring diagram

6.1. Sensor Module and Temperature Sensor 2

The Sensor Module must be connected to the Interface Module using a shielded cable, with no interruption on the mesh, which must be grounded only close to the MO. If the connection requires intermediate terminals, the cable mesh must also go by the terminal, thus avoiding interruptions on the mesh, as shown in figure 6.2. The length of unshielded cable must be as short as possible.

The same is applicable in relation to Temperature Sensor 2, usually used in measuring ambient temperature: shielded cable must be used, grounded only at the end close to the MO and preserving the mesh uninterrupted, as shown in figure 6.2.

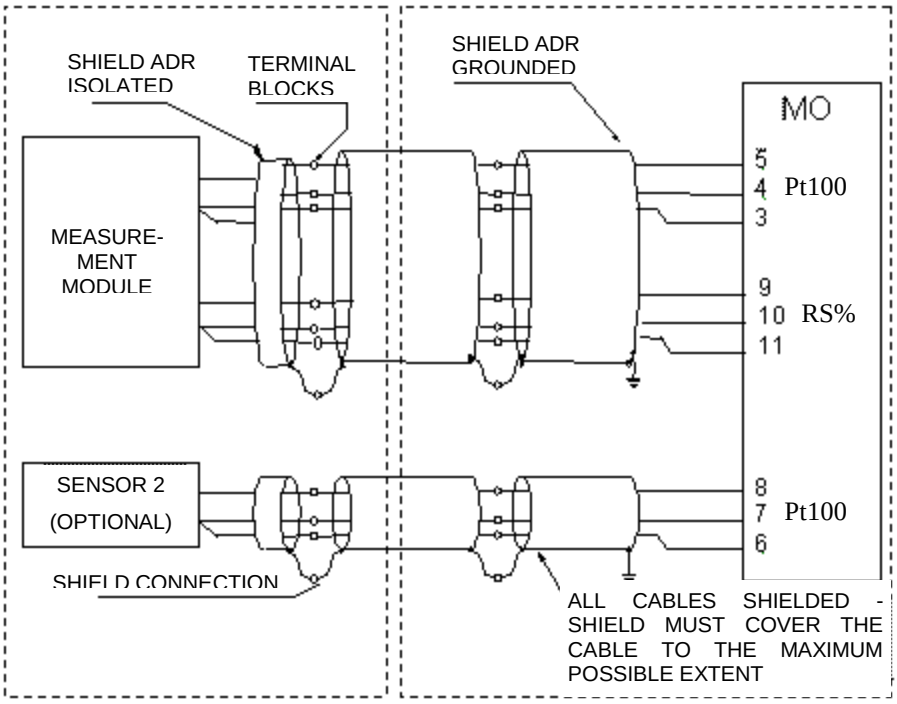


Figure 6.2 – Details of connection cable shielding for the Sensor Module

6.2. Interface Module

The Interface Module of the Moisture Monitor MO features the following inputs and outputs:

INPUTS	TERMINALS MO	
1) Ancillary power feed and ground: Universal power input (38 ~ 265 Vdc/Vac, <8W, 50/60Hz).	**17 – ground** **18 – dc/ac** **19 – dc/ac**	
2) Inputs for Sensor Module: Six inputs for direct connection of Sensor Module	**Sensor Pt100Ω□**	**3,4 e 5**
	Sensor RS%	**9,10 e 11**
3) Temperature Sensor 2 input: One optional input for direct connection to Pt100Ω□ at 0ºC sensor	**6, 7 e 8**	
4) Port RS485 – Scada (optional): Connection to data acquisition system, protocol MODBUS-RTU or DNP3.0, via shielded twisted pair cable.	**31 (+)** **32 (-)**	

OUTPUTS	TERMINALS MO
1) Current loop output: One output for remote reading with variable and output range (0...1, 0...5, 0...10, 0...20 or 4...20 mA) selected by user.	**1 (+)** **2 (-)**
2) Programmable relays: Two potential-free alarm contacts with user-programmable function and NO or NC operation mode.	**22 (relay 1)** **23 (relay 2)** **20/21 (common points for relays 1 and 2)**

3) Programmable Relays: Four potential free alarm contacts with user-programmable function and NO or NC operation mode.	**25 (relay 4)** **26 (relay 5)** **27 (relay 6)** **28 (common point to relays 4, 5, 6 and self-diagnostic)** **29 and 30 (relay 7)**
4) Self-Diagnostic Relay: NC Potential free contact to signal power failure, failure in connection cables, sensors or internal failure.	**24** **28 (common point to relays 4, 5 e 6)**

Serial communication RS485, when used, must be linked to the data acquisition system using a shielded twisted-pair cable, preserving the shield uninterrupted throughout the length of the path and grounding it at only one of the ends. If the connection requires intermediate terminals, the mesh must also cover the terminals, thus avoiding interrupting it, as shown in figure 6.3. The length of unshielded cable resulting from patching must be the shortest possible. Maximum distance admitted for this type of serial communication is 1300 meters. At each end of the communication cable a 120-ohm terminal resistor may need to be used.

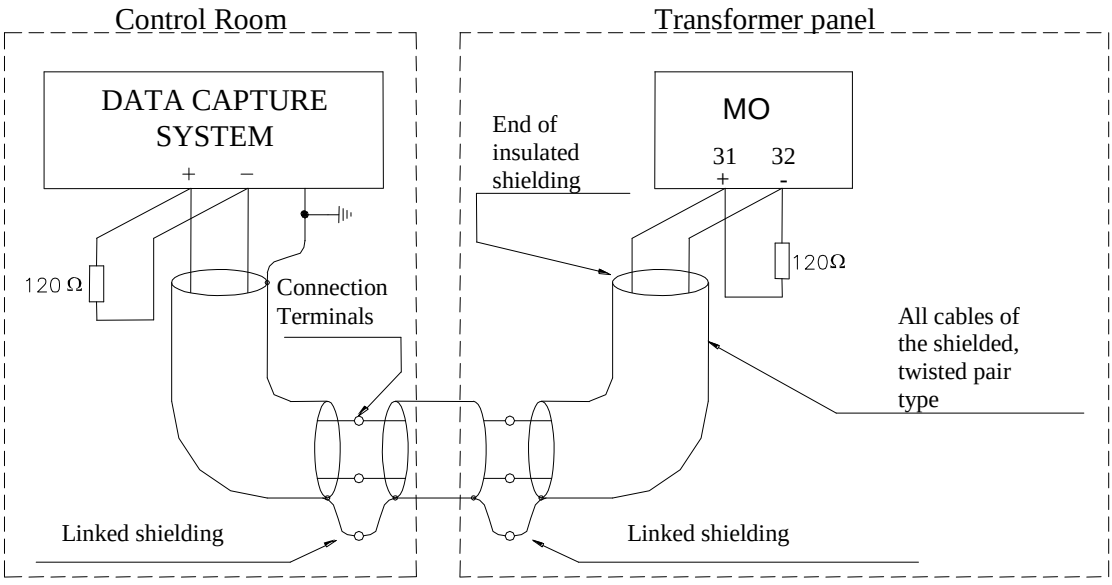


Figure 6.3 – Details of serial communication cable shielding

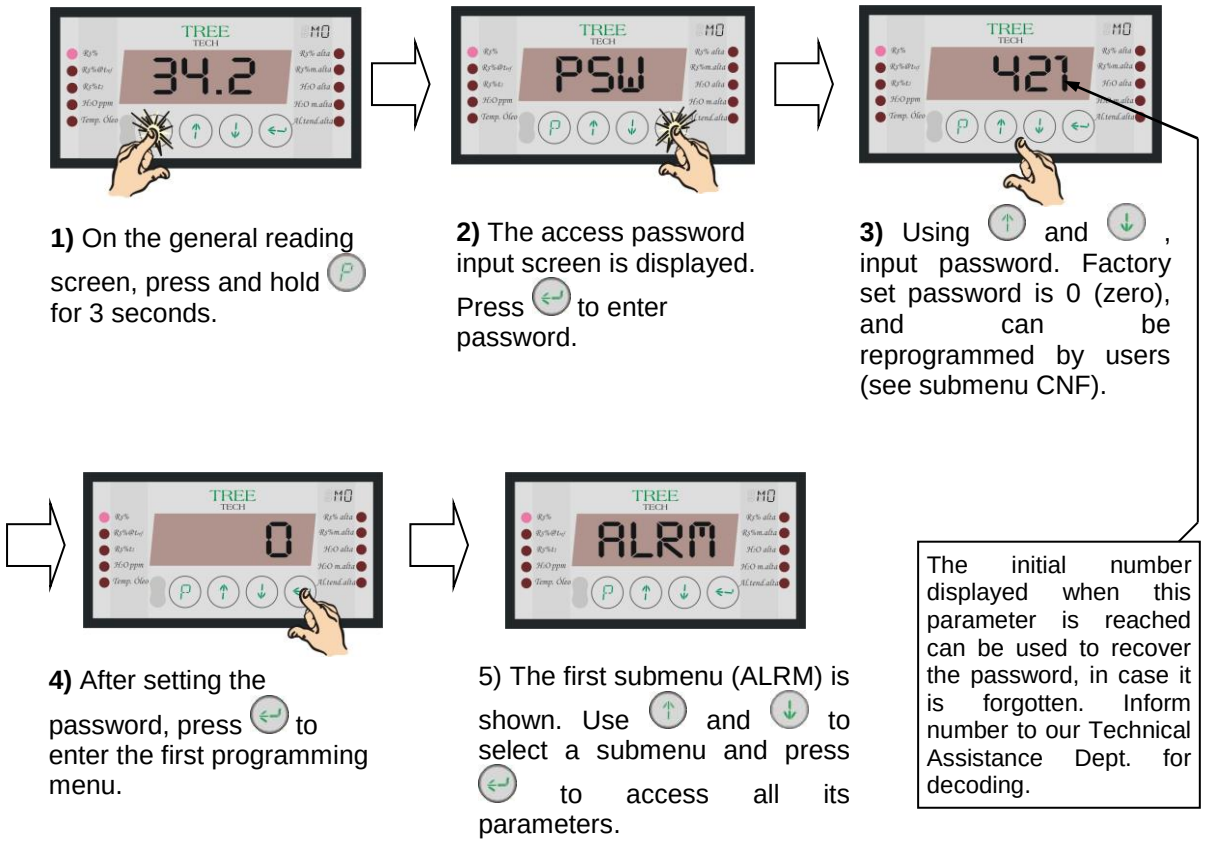
7. Parameter definition

In order to ensure proper operation of the system, several parameters must be adjusted and set on the Interface Module fro the MO to deliver to the equipment the necessary operating information. Adjustments can be made using the front panel keyboard, using the display, or else using the parameter definition software, by way of the RS485 serial communication port.

Programmable parameters are organized in menus with password protected access. From the main menu, users will be able to access programming submenus, where they can navigate and adjust values according to the features of the transformer and users' needs.

7.1. Access to programming menu

In order to access the programming menu of the Moisture Monitor MO, follow the procedure below:



1) On the general reading screen, press and hold P for 3 seconds.

2) The access password input screen is displayed. Press ↵ to enter password.

3) Using ↑ and ↓, input password. Factory set password is 0 (zero), and can be reprogrammed by users (see submenu CNF).

The initial number displayed when this parameter is reached can be used to recover the password, in case it is forgotten. Inform number to our Technical Assistance Dept. for decoding.

4) After setting the password, press ↵ to enter the first programming menu.

5) The first submenu (ALRM) is shown. Use ↑ and ↓ to select a submenu and press ↵ to access all its parameters.

Figure 7.1 – Access to programming menu

Programmable parameters are divided into the different submenus: ALRM (alarm set), CNF (device Configurations), SENS (features of the relative saturation sensor), MSRM (oil characteristics), LOG (mass memory Configurations, only when equipment is equipped with this optional function), CLK (clock set), FAC (password protected plant menu) and DWL (firmware update).

7.2. Submenu Access Structure:

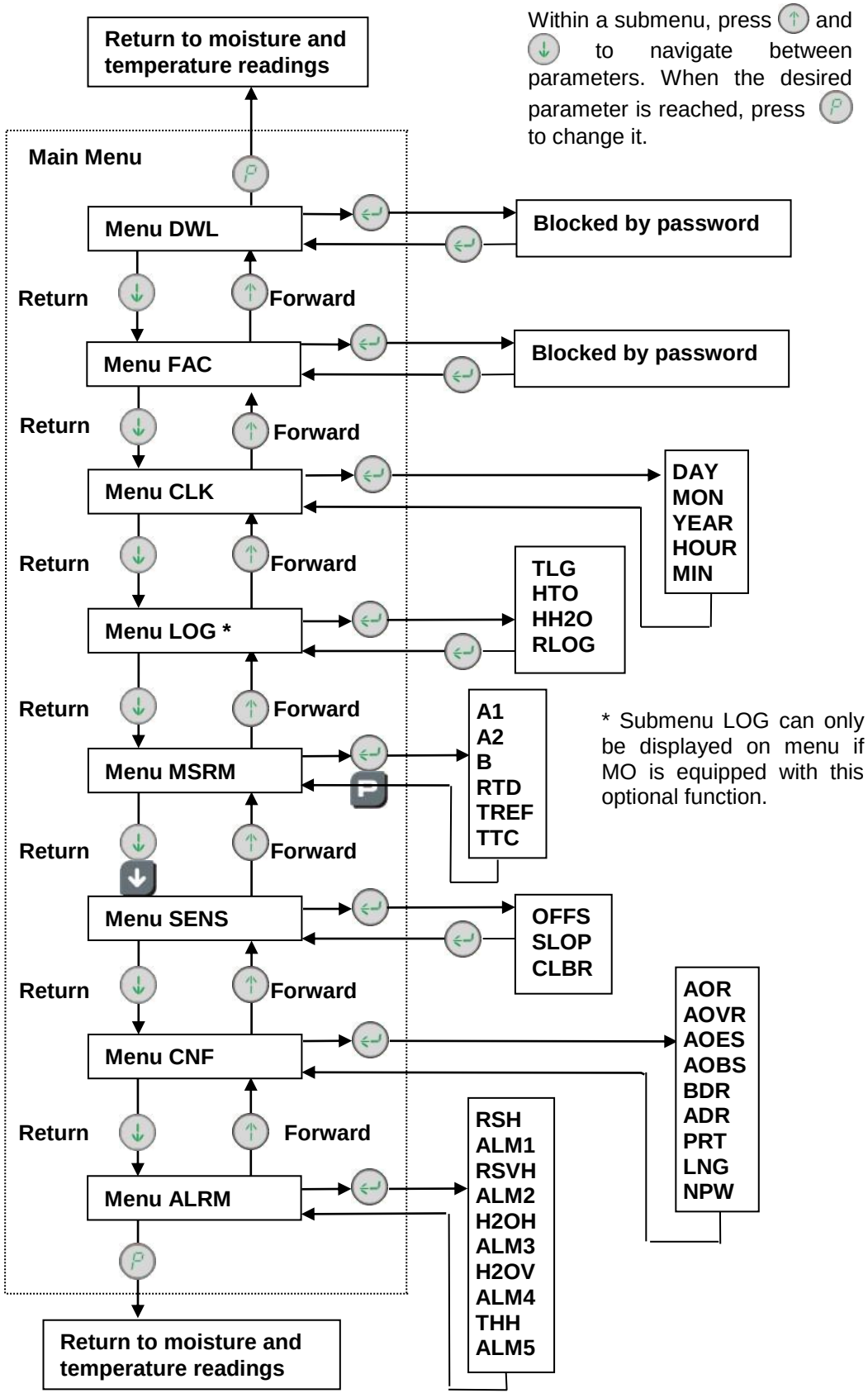


Figure 7.2 –Submenu access structure

7.2.1. Submenu ALRM (Alarms)

Allows access to all parameters related to the MO's alarms.

- With display showing ALRM, press ↵ to access alarm parameters, or - Press ↑ to go to the configuration menu CNF or P to return to moisture and Oil Temperature readings.	

- Use ↑ and ↓ to select parameter to change and press ↵ to confirm. Then, use ↑ and ↓ to set the desired value for the parameter. Press ↵ to save any changes made or P to abandon editing parameter without saving changes.
- The following parameters can be adjusted on submenu ALRM:

- **RSH – Alarm for High Water in Oil Saturation** Adjustment Range: 0 to 100%, in 1% increments Press ↑ to move to parameter ALM1	
- **ALM1 – RSH Alarm signal relay (High Water in Oil Saturation)** The high percentage of water in oil saturation can be signaled remotely using one of the MO's output contacts. This parameter selects the output relay for this function among relays RL1, RL2, RL4, RL5, RL6 and RL7. If there is no desire to use this alarm in an output relay, select option "NULL". The same relay can be used in signaling simultaneously other alarm conditions (see parameters ALM2, ALM3, ALM4 and ALM5). Press ↑ to move to parameter RSVH	
- **RSVH – Alarm for Very High Water in Oil Saturation** Adjustment Range: 0 to 100%, in 1% increments Press ↑ to move to parameter ALM2	

- **ALM2 –RSVH Alarm signal relay (Alarm for Very High Water in Oil Saturation)** The very high percentage of water in oil saturation can be signaled remotely using one of the MO's output contacts. This parameter selects the output relay for this function among relays RL1, RL2, RL4, RL5, RL6 and RL7. If there is no desire to use this alarm in an output relay, select option "NULL". The same relay can be used in signaling simultaneously other alarm conditions (see parameters ALM2, ALM3, ALM4 and ALM5). Press ↑ to move to parameter H2OH	
- **H2OH – High Water in oil content** Adjustment Range: 0 to 500ppm, in 1ppm increments Press ↑ to move to parameter ALM3	
- **ALM3 –H2OH Alarm signal relay (High Water in oil content)** The high water in oil content can be signaled remotely using one of the MO's output contacts. This parameter selects the output relay for this function among relays RL1, RL2, RL4, RL5, RL6 and RL7. If there is no desire to use this alarm in an output relay, select option "NULL". The same relay can be used in signaling simultaneously other alarm conditions (see parameters ALM2, ALM3, ALM4 and ALM5). Press ↑ to move to parameter H2OV	
- **H2OV – Very High Water in oil content** Adjustment Range: 0 to 1000ppm, in 1ppm increments Press ↑ to move to parameter ALM4	
- **ALM4 –H2OV Alarm signal relay (Very High Water in oil content)** The very high water in oil content can be signaled remotely using one of the MO's output contacts. This parameter selects the output relay for this function among relays RL1, RL2, RL4, RL5, RL6 and RL7. If there is no desire to use this alarm in an output relay, select option "NULL". The same relay can be used in signaling simultaneously other alarm conditions (see parameters ALM2, ALM3, ALM4 and ALM5). Press ↑ to move to parameter THH	

- **THH – alarm for evolution trend of water content high** Adjustment Range: 0 to 50,0 ppm/day, in 0.1 ppm/day increments Press ↑ to move to parameter ALM5	
- **ALM5 –THH alarm signal relay (Trend for evolution of water content high)** The high evolution trend of water content can be signaled remotely using one of the MO's output contacts. This parameter selects the output relay for this function among relays RL1, RL2, RL4, RL5, RL6 and RL7. If there is no desire to use this alarm in an output relay, select option "NULL". The same relay can be used in signaling simultaneously other alarm conditions (see parameters ALM2, ALM3, ALM4 and ALM5). Press P to return to Main Menu.	

7.2.2. Submenu CNF (Configurations)

Allows access to all the MO's general configuration parameters.

- With the display showing CNF, Press ↵ to access parameters of the MO or; - Press ↑ to go to SENS Configuration menu or ↓ to return to menu ALRM or P to return to moisture and Oil Temperature readings.	

- Use ↑ and ↓ to select parameter to change and press ↵ to confirm. Then, use ↑ and ↓ to set the desired value for the parameter. Press ↵ to save any changes made or P to abandon editing parameter without saving changes.
- The following parameters can be adjusted on submenu CONF:

- **AOR - select Analogical Output Range** Adjustment Range: **0- 1** 0- 1 mA; **0- 5** 0- 5 mA; **0-10** 0-10 mA; **0-20** 0-20 mA; **4-20** 4-20 mA Press ↑ to move to parameter AOVR	

- **AOVR – select Variable to be displayed on Analogical Output**

Adjustment Range:

RS	Water in oil saturation percentage
RSTR .	Water in oil saturation percentage, calculated based on reference temperature
RST2 .	Water in oil saturation percentage, calculated based on temperature 2
H2O	Water in oil content
TO	Oil Temperature
T2	Temperature measured by sensor 2
TRND	Evolution trend for water in oil content

Press ↑ to move to parameter AOES

- **AOES – adjusts value of variable for End of Scale of Analogical Output.**

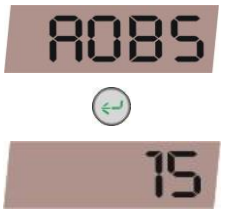
Adjustment Range: -55 to 500 in increments of 1

Press ↑ to move to parameter AOBS

- **AOBS – adjusts value of variable for Beginning of Scale of Analogical Output.**

Adjustment Range: -55 to 500 in increments of 1

Press ↑ to move to parameter BDR.



- **BDR – Selects serial communication baud rate (optional)**

Adjustment Range:

9.6 kbps
19.2 kbps
38.4 kbps

Press ↑ to move to parameter ADR

- **ADR – Address of MO in serial communication**

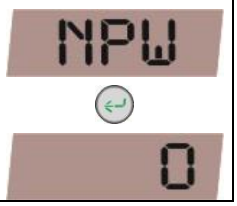
Adjustment Range: 1 to 31 in increments of 1

Press ↑ to move to parameter PRT

- **PRT – Communication Protocol of MO**

Adjustment Range: MDB (Modbus) or DNP (DNP3.0, only in version 1.03 and higher).

Press ↑ to move to parameter LNG

- **LNG – selection of language for Interface Module captions.** Adjustment Range: **POR =** Portuguese **ENG =** English **ESP =** Spanish Press ↑ again to move to parameter NPW	
- **NPW – sets new password for access to programming menus.** Adjustment Range: 0 to 999 in increments of 1. Plant set password is 0 (zero). Press P to return to main menu	

7.2.3. Submenu SENS (Sensor)

Allows user to inform Interface Module the features of the water saturation sensor. Values for these parameters can be obtained from the data sheet supplied with the Sensor Module or directly form the tag on it.

- With the display showing SENS, press ↵ for access to parameters of the water saturation sensor; - Press ↑ to go to the MSRM Configuration menu or ↓ to return to menu CNF or P to return to moisture and oil temperature readings.	

- Use ↑ and ↓ to select parameter to change and press ↵ to confirm. Then, use ↑ and ↓ to set the desired value for the parameter. Press ↵ to save any changes made or P to abandon editing parameter without saving changes.
- The following parameters can be adjusted on submenu SENS:

- **OFFS – features of the water saturation sensor** Program specific value for Sensor Module connected to Interface Module, obtained on tag fixed on the Sensor Module or informed in the device's data sheet. - Adjustment Range: 0.600 to 1.200, in 0.001 steps. Press ↑ to move to parameter SLOP	
- **SLOP – characteristic of water saturation sensor** Program specific value for Sensor Module connected to Interface Module, obtained on sticker tag fixed on the Sensor Module or informed in the device's data sheet. - Adjustment Range: 28.00 to 32.00, in 0.01 increments. Press P to return to Main Menu.	

- **CLBR – fine adjustment of relative saturation measurement (RS%)** Allows user to perform a fine calibration of measuring saturation relative (% RS) via a tuning offset. - - Setting range: -10.0 to +10.0 in 0.1 increments	

7.2.4. Submenu MSRM (Measurement)

Allows definition and setting of calculation parameters used by the MO, such as water in oil solubility characteristic and others.

- With display showing MSRM, Press ↵ for access to parameters; - Press ↑ to advance to optional submenu LOG, or press ↓ to return to menu SENS or P to return to moisture and Oil Temperature readings.	

- Use ↑ and ↓ to select parameter to change and press ↵ to confirm. Then, use ↑ and ↓ to set the desired value for the parameter. Press ↵ to save any changes made or P to abandon editing parameter without saving changes.
- The following parameters can be adjusted on submenu MSRM:

- **A1 – Water in oil solubility characteristic (unit and tenth)** Allows MO to determine the solubility of water in oil. These can be set to typical values, according to the type of oil (see table below), or values obtained in assays (see Appendix A). Remark: Concatenation of parameters A1 and A2 forms parameter A. Example: A1 = 7.0 and A2 = 895 ➔ Parameter A = 7.0895 **Oil Type** / **Typical value for A**: Mineral 7.0895; Silicone 6.2906; Envirotemp FR3 5.3318 Adjustment Range: 1.0 to 9.9, in 0.1 increments Press ↑ to move to parameter A2	
- **A2 – Water in oil solubility characteristic (hundredths)** Complement to parameter A1, to form parameter A. Adjustment Range: 0 to 999, in increments of 1 Press ↑ again to move to parameter B	

- **B – Water in oil solubility characteristic**

Allows MO to determine the solubility of water in oil. These can be set to typical values, according to the type of oil (see table below), or values obtained in tests (see Appendix A).

Oil Type	Typical value for B
Mineral	1567
Silicone	1187
Envirotemp FR3	687

Adjustment Range: 0 to 3000, in increments of 1

Press ↑ again to move to parameter RTD2

- **RTD2 – Temperature Sensor 2**

Allows enable or disable input to Temperature Sensor 2, usually used in reading ambient temperature. When this sensor is not used, the input must be disabled in order to avoid issuing a false self-diagnostic alarm.

- Adjustment Range: **ON =** Input to sensor 2 enabled
  OFF= Input to sensor 2 disabled

Press ↑ again to move to parameter TREF

- **TREF – reference temperature for calculation of RS%@t_{ref}**

Setting the reference temperature t_{ref}, used in calculating the relative saturation converted to the reference temperature (RS% @ t_{ref}).

Adjustment Range: -55 to 200ºC, In 1ºC increments

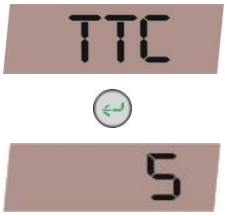
Press ↑ again to move to parameter TTC

- **TTC – Time Constant for Trend calculation**

Time Constant for the first order digital filter used in calculating the trend for evolution of water in oil content. This filter prevents temporary variations in water content from causing high trend calculation results, and thus triggering undue alarms.

Adjustment Range: 1 to 30 days, in 1 day increments.

Press P again to return to Main Menu.



7.2.5. Submenu LOG (Log for Readings and Events)

Allows setting storage Configurations for recording readings and events in the MO's mass memory. This submenu is only displayed if the MO is equipped with this optional function. The MO's mass memory is of the FIFO type (*First In First Out*), i.e., when the end of memory space is reached, the eldest data records are overwritten by the latest arrivals. A new memory recording can be started by time interval or by variation in readings for Oil Temperature and water in oil content superior to limits set. Memory capacity is for 1489 records, each Record with

readings for relative saturation, water in oil content, Oil Temperature, temperature of sensor 2 (when in use), water content evolution trend and alarm events.

- With display showing LOG, Press ↵ or access to parameters of the water saturation sensor; - Press ↑ to go to Configuration menu CLK or ↓ to return to menu MSRM or P to return to moisture and Oil Temperature readings.	

- Use ↑ and ↓ to select parameter to change and press ↵ to confirm. Then, use ↑ and ↓ to set the desired value for the parameter. Press ↵ to save any changes made or P to abandon editing parameter without saving changes.
- The following parameters can be adjusted on submenu LOG:

- **TLG – time interval between recordings in memory** Determines the time interval for MO to save a new record in mass memory, in minutes. - Adjustment Range: 1 to 1000 minutes, in increments of 1. Press ↑ to move to parameter HTO	
- **HTO – Variation of Oil Temperature required to trigger recording in MO's memory** Sets a value for variation of Oil Temperature, in ºC, which when exceeded causes MO to make new recording in mass memory. This resource allows extending time needed before new records begin overwriting the oldest ones, avoiding keeping records if readings do not vary significantly. - Adjustment Range: 0.1 to 10ºC, in 0.1 increments. Press ↑ to move to parameter HH2O	
- **HH2O – Variation of water in oil content required to trigger recording in MO's memory** Sets a value for variation of water content, in ppm, which when exceeded causes MO to make new recording in mass memory. This resource allows extending time needed before new records begin overwriting the oldest ones, avoiding keeping records if readings do not vary significantly. - Adjustment Range: 0,1 to 5ppm, in 0.1 increments. Press P to return to main menu	

- **RLOG - Reset of LOG** Performs the reset of the mass memory of MO. When you select "YES" and confirm all data from mass memory will be erased.	

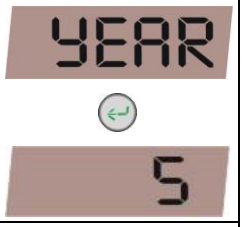
7.2.6. Submenu CLK (Clock)

Allows setting the clock and calendar of the device.

- With display showing CLK, Press ↵ to access clock set or; - Press ↑ to go to menu FAC or ↓ to return to menu LOG or P to return to moisture and Oil Temperature readings.	

- Use ↑ and ↓ to select parameter to change and press ↵ to confirm. Then, use ↑ and ↓ to set the desired value for the parameter. Press ↵ to save any changes made or P to abandon editing parameter without saving changes.

The following parameters can be adjusted on submenu CLK:

- **MON – setting calendar month** Adjustment Range: month 1 to 12, in 1-month increments. Press ↑ to move to parameter DAY	
- **DAY – setting calendar day** Adjustment Range: day 1 to 31, in 1-day increments. Press ↑ to move to parameter YEAR	
- **YEAR – set calendar year** Adjustment Range: year 05 (2005) to 99 (2099), in 1-year increments. Press ↑ to move to parameter HOUR	
- **HOUR – set clock time** Adjustment Range: 0 to 23 hours, in 1-hour increments. Press ↑ to move to parameter MIN	

- **MIN – set clock minutes** Adjustment Range: 0 to 59 minutes, in 1-minute increments. Press (P) to return to Main Menu	

7.2.7. Submenu FAC (Factory only)

Menu FAC is for exclusive use in the plant or by technical assistance department, being protected by a password that makes unavailable for access by users.

- With display showing FAC, Press (↵) for access to password screen or; - Press (↑) to go to menu DWL or (↓) to return to menu CLK or (P) to return to moisture and Oil Temperature readings.	

7.2.8. Submenu DWL (Download of firmware)

The DWL menu is used to update the firmware using serial communication access. This menu is password protected in order to prevent accidental access. Consult Treetech's Technical Assistance Department if you should need to use this function in order to update your MO's firmware.

- With display showing DWL, press (↵) for access to password screen; Adjustment Range: 0 to 999 in increments of 1. This password is the same used to access the main menu. Press (P) to return to moisture and Oil Temperature readings or press (↓) to return to menu FAC.	

Part III- Commissioning (Operation Start Up)

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8. Start up procedure

Once all the equipment has been installed according to the information found in Part II of this manual, start up and beginning to operate should follow the basics steps outlined below.

- Check mechanical installation of Sensor Module and the Interface Module according to the recommendations contained in chapter 5. Special care must be taken for the rod of the Sensor Module not to come too close to areas subject to high electrical fields, in order not to compromise the insulation of the transformer.
- Check electrical installation according to the recommendations of chapter 6. Check suitability of electrical wiring (for example, through continuity testing).
- If dielectric rigidity tests are carried out on the wiring (applied voltage), disconnect grounding cable connected to terminal 17 of Interface Module in order to prevent destruction of over-voltage protection equipment found in the device. These protections are connected internally between input/output terminals and ground, stapling voltage at about 300V. Application of high voltages for long periods of time (for example, 2kV for 1 minute) would destroy this protection.
- Reconnect ground cable to terminal 17 of Interface Module, if it was disconnected for the applied voltage test. Energize the MO's Interface Module with any voltage in the 38 to 265Vdc/Vac 50/60Hz range.
- Perform all the necessary parameter definitions for the MO, according to the instruction found in chapter 7. The parameter settings effected can be written down in the form of the next page, and must include:
  - The OFFS and SLOP parameters, corresponding to the Sensor Module deployed. Values for these parameters can be obtained from the data sheet supplied with the Sensor Module or directly from the tag placed on it. See sub-chapter 7.2.3.
  - The water in oil solubility constants A and B (see subchapter 7.2.4). Typical values for the oil type being used can be adopted or values can be calculated using the procedure described in Appendix A.
- Check if readings for relative saturation and water in oil content match values found in oil. If necessary, readjust water in oil solubility constants A and B according to procedure described in Appendix A.
- Check if oil temperature and ambient temperature (when used) readings on moisture sensor are correct.
- With a dc milli-amperemeter, check if current loop output displays value fitting with the magnitude and range of the variable attributed to it.
- With a continuity detection device, test action of alarm contacts. Contacts can be activated by reducing alarm set values to lower values than those for current readings.

Moisture in Oil Monitor MO – Parameter Settings			
Serial No. – Interface Module:		**Date:**	
Serial No. – Sensor Module:		**Responsible:**	

Submenu	Parameter	Description	Value Set
ALRM	RSH	Alarm by water in oil saturation high	%
	ALM1	Output relay for signaling of alarm RSH	
	RSVH	Alarm by water in oil saturation very high	%
	ALM2	Output relay for signaling of alarm RSVH	
	H2OH	Alarm by water in oil content high	ppm
	ALM3	Output relay for signaling of alarm H2OH	
	H2OV	Alarm by water in oil content very high	ppm
	ALM4	Output relay for signaling of alarm H2OV	
	THH	Alarm by evolution trend of H2O high	ppm/d
	ALM5	Output relay for signaling of alarm THH	
CNF	AOR	Analog output range	
	AOVR	Analog output variable	
	AOES	Analog output end-of-scale	
	AOBS	Analog output beginning-of-scale	
	BDR	Baud-rate of serial communication	bps
	ADR	Address in serial communication	
	PRT	Communication protocol	
	LNG	Language for interface	
	NPW	New password for menu access	
SENS	OFFS	Characteristic of water saturation sensor	
	SLOP	Characteristic of water saturation sensor	
	CLBR	Fine adjustment of RS measurement	%
MSRM	A1	Water solubility characteristic A (unit / tenth)	
	A2	Water solubility characteristic A (hundredths)	
	B	Water solubility characteristic B	
	RTD2	Temperature sensor 2	
	TREF	Reference temperature for RS%@t_{ref}	ºC
	TTC	Time-constant for evolution trend calculation	days
LOG (optional)	TLG	Time interval for log recording	min.
	HTO	Oil temperature variation for log recording	ºC
	HH2O	H2O variation for log recording	ppm
CLK	DAY	Day of calendar	
	MON	Month of calendar	
	YEAR	Year of calendar	
	HOUR	Hour of clock	
	MIN	Minute of clock	

Part IV – Troubleshooting

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List of Illustrations

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9. Problem solving:

If difficulties or problems are encountered in operating the system, we suggest consulting the simple possible causes and solutions list shown below. If this information is not enough to solve your difficulty, please contact Treetech's technical assistance or its authorized representative.

9.1. MO displays self-diagnostic messages on the display

The self-diagnostic function implemented in the MO allows detection and diagnosis of any eventual external defects or even internal failures of the equipment, in most cases allowing users to identify and correct problems quickly.

When a problem is detected, the MO will action the self-diagnostic contact and the display will display the abbreviation "ERR", alternating with the failure code for the failure that is occurring, as shown in figure 9.1. Failure code is indicated through the four digits of the display using hexadecimal format. The meaning for the different codes is shown in the tables below, respected the digit of the display in which the code appears. In case of simultaneous failures, the number indicated by a given figure will be the sum of individual errors.

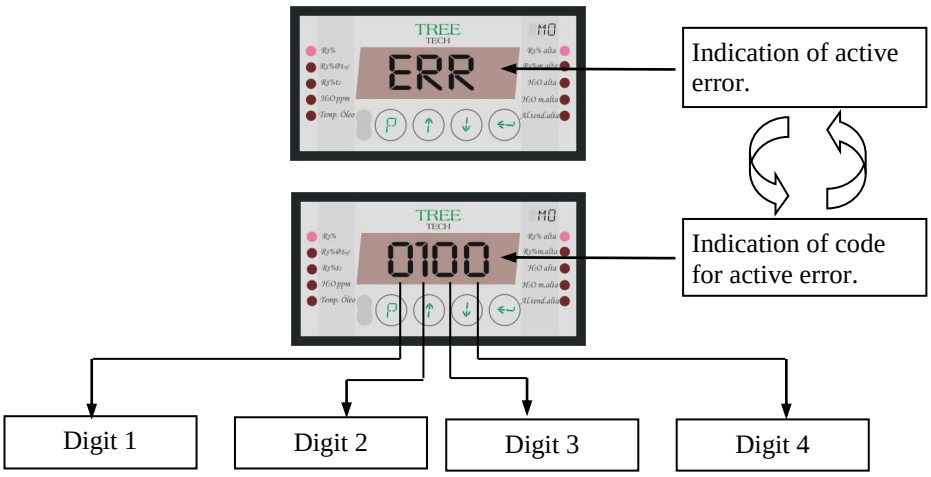

Figure 9.1 – Self-diagnostic indications

0000 Code displayed	Digit 1		
	Description	**Probable causes**	**Actions recommended**
0	No failure in this digit.	-	-
1	Failure in measuring Oil Temperature.	Bad contact on cable connected to terminal 3 of Sensor Module. See figure 6.1, page II-7.	Check for bad contact along the entire length of the cable connected to terminal 3 of the Sensor Module, including connection to Interface Module, passage terminals and to Sensor Module.
		Internal failure in Oil Temperature sensor.	Replace defective Sensor Module and contact Treetech Technical Assistance.
2	Failure in measuring temperature of sensor 2	Sensor 2 is not in use, but its reading is enabled in parameter RTD2.	Disable reading form this sensor on parameter RTD2, sub-chapter 7.2.4 page II-18.
		Bad contact on cable connected to terminal 3 of Pt100 sensor. see figure 6.1, page II-7.	Check for bad contact along the entire length of the cable connected to terminal 3 of Temperature Sensor 2, including connection to Interface Module , passage terminals and connection to Pt100 sensor.
3	Simultaneous occurrence of codes 1 and 2 above	see codes 1 and 2 above.	Proceed as indicated for codes 1 and 2 above

0000 Code displayed	Digit 2		
	Description	**Probable causes**	**Actions recommended**
0	No failure in this digit.	-	-
1	Failure in measuring Oil Temperature	Bad contact on cable connected to terminal 1 and/or terminal 2 of Sensor Module. See figure 6.1, page II-7.	Check for bad contact along the entire length of the cable connected to terminal 1 and/or terminal 2 of the Sensor Module, including connection to Interface Module, passage terminals and to Sensor Module.
2	Failure in measuring temperature of sensor 2	Sensor 2 is not in use, but its reading is enabled in parameter RTD2.	Disable reading form this sensor on parameter RTD2, sub-chapter 7.2.4 page II-18.
		Bad contact on cable connected to terminal 1 and/or terminal 2 of sensor Pt100. See figure 6.1, page II-7.	Check for bad contact along the entire length of the cable connected to terminal 1 and/or terminal 2 of Temperature Sensor 2, including connection to Interface Module, passage terminals and to Sensor Module.
3	Simultaneous occurrence of codes 1 and 2 above	see codes 1 and 2 above.	Proceed as indicated for codes 1 and 2 above

0000 Code displayed	Digit 3		
	Description	**Probable causes**	**Actions recommended**
0	No failure in this digit.	-	-
1	Failure in measuring relative saturation	Bad contact or disconnection in one of the cables connected to terminals 4, 5 and 6 of the Sensor Module. See figure 6.1, page II-7.	Check for bad contact or disconnections along the entire length of the cable connected to terminals 4, 5 and/or 6 of the Sensor Module, including connection to Interface Module, passage terminals and to Sensor Module.
		Short-circuit between cables connected to terminals 4, 5 and 6 of Sensor Module. See figure 6.1, page II-7.	Check for short-circuits along the entire length of the cable connected to terminals 4, 5 and/or 6 of the Sensor Module, including connection to Interface Module, passage terminals and to Sensor Module.
		Internal failure of relative saturation sensor.	Replace defective Sensor Module and contact Treetech Technical Assistance.
4	Internal Error – AD Converter	Internal failure of Interface Module .	Replace defective Interface Module and contact Treetech Technical Assistance.

0000 Code displayed	Digit 4		
	Description	**Probable causes**	**Actions recommended**
0	No failure in this digit.	-	-
1	Internal error – EEPROM Memory	Internal failure of Interface Module .	Replace defective Interface Module and contact Treetech Technical Assistance.

9.2. O MO does not read or reads incorrect value for water content and relative saturation

Probable causes	**Actions recommended**
Bad-contact, disconnection or inversion in one of the cables connected to terminals 4, 5 and 6 of Sensor Module.	Check for bad contact points, disconnections or inversions along the entire length of cables connected to terminals 4, 5 and/or 6 of Sensor Module, including connection to Interface Module, passage terminals and to Sensor Module. See figure 6.1, page II-7.
Unshielded cable, shielding without grounding or incorrectly grounded used in connection between Sensor Module and Interface Module .	Use shielded cable, connected in accordance with recommendations of subchapter 6.1, page II-7.
Failure of Sensor Module	Replace defective Sensor Module and contact Treetech Technical Assistance.

9.3. MO does not read or reads incorrect value for Oil Temperature

Probable causes	Actions recommended
Bad-contact in one of the cables connected to terminals 1, 2 or 3 of Sensor Module.	Check for bad contact points along the entire length of cables connected to terminals 1, 2 and/or 3 of Sensor Module, including connection to Interface Module, passage terminals and to Sensor Module. See figure 6.1, page II-7.
Unshielded cable, shielding without grounding or incorrectly grounded used in connection between Sensor Module and Interface Module .	Use shielded cable, connected in accordance with recommendations of subchapter 6.1, page II-7.
Failure of Sensor Module	Replace defective Sensor Module and contact Treetech Technical Assistance.

9.4. MO does not read or reads incorrect value for temperature of sensor RTD 2

Probable causes	Actions recommended
Sensor 2 reading is not enabled in parameter RTD2.	Enable reading from Temperature Sensor 2 in parameter RTD2, sub-chapter 7.2.4 page II-18.
Bad-contact in one of the cables connected to terminals 1, 2 or 3 of Temperature Sensor 2.	Check for bad contact points along the entire length of cables connected to terminals 1, 2 and/or 3 of Temperature Sensor 2, including connection to Interface Module, passage terminals and to Sensor Module. See figure 6.1, page II-7.
Unshielded cable, shielding without grounding or incorrectly grounded used in connection between Sensor Module and Interface Module .	Use shielded cable, connected in accordance with recommendations of subchapter 6.1, page II-7.
Failure of Temperature Sensor 2	Replace defective Temperature Sensor 2 and contact Treetech Technical Assistance.

9.5. MO does not communicate with data acquisition system

Probable causes	Actions recommended
Incorrect programming of serial communication parameters on Interface Module.	Check for correct programming of the following parameters on submenu CNF (sub-chapter 7.2.2): - Baud-rate – parameter BDR - Address – parameter ADR - Protocol – parameter PROT
Bad-contact, disconnection or inversion in one of the serial communication cables.	Check for bad contact points, disconnections or inversions along the entire length of communication cables, including connection to Interface Module, passage terminals and to Sensor Module. See figure 6.3, page II-9.
Unshielded cable, shielding without grounding or incorrectly grounded used in connection between data acquisition system and the Interface Module .	Use shielded cable, connected in accordance with recommendations of subchapter 6.2, page II-8, and figure 6.3, page II-9.
Incorrect type of cable used	Communication cable must be shielded twisted pair type. See sub-chapter 6.2, page II-8.
Distance between ends of communication network superior to 1300 meters	If total circuit length exceeds distance of 1300 meters, repeater modules or fiber optic cables must be used.

9.6. Remote reading through Analog Output incorrect

Probable causes	Actions recommended
Incorrect programming of current output parameters	Check programming of the following parameters on menu CNF (sub-chapter 7.2.2): - Output current range – AOR - Selection of variable for display – AOVR - End of scale value – AOES - Beginning of scale value – AOBS
Incorrect connection of connection cable	Check proper connection of cables (polarity, eventual short circuits, open links or grounding) between MO and measuring system. See figure 6,1, page II-7.
Maximum load excess	Check maximum load for each output standard selected. (See Technical data, Appendix B, page V-4).

Part V – Attachments

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Attachment A – Determination of Water in Oil Solubility

Water in oil solubility is the maximum water content (in ppm) that the oil is capable of dissolving at a given temperature. When water content reaches or exceeds the solubility value, the excess water separates out from the oil, forming free water.

The MO's Sensor Module measures the relative saturation (RS%) of water in oil, which is the ratio between the content of water dissolved in oil (ppm) and water in oil solubility (ppm). Relative saturation is an absolute measurement, and is not affected by the temperature or the type of oil. Based on this reading and also using the solubility for water, several indicators are calculated, such as water in oil content in ppm and conversions of relative saturation values to equivalents at the reference temperature and at ambient temperature. Hence the importance for the MO of determining water in oil solubility, in order to allow these calculations to be performed.

Water in oil solubility varies as a function of the oil's temperature, which is the reason for the Sensor Module to also carry out this reading, and is dependent also on the oil's own characteristics, represented by the oil's A and B solubility constants.

Water in oil solubility constants A and B vary in particular as a function of the type of oil, as shown by the typical values displayed in the table below.

Type of oil	Typical value for A	Typical value for B
Mineral	7.0895	1567
Silicone	6.2906	1187
Envirotemp FR3	5.3318	687

These typical values can be used by users in defining and setting parameters for the MO (see sub-chapter 7.2.4), with good results being obtained in most applications. However there may be situations where due to variations in other characteristics of the oil, such as very aged oil, acidity, or others, it becomes necessary to determine these constants specifically for the oil being worked, thus achieving higher accuracy. The procedure described below can be used to do this.

1. Install the MO in the oil whose solubility constants we wish to determine.
2. Vary oil temperature in order to obtain readings from the MO for at least two different temperatures, with three being desirable, with a minimum difference of 10ºC between them.
3. For each oil temperature, wait for about 20 minutes to ensure readings have stabilized and then take oil sample and note down values obtained for relative saturation (RS%) and Oil Temperature informed by the MO. For each temperature, a new oil sample must be taken, since there may be variations in water in oil content due to absorption or release of water by the insulation paper or yet due to the dissolution of the water that was free or vice-versa.
4. Analyze oil samples in laboratory in order to determine the water content levels. Fill in table below with results obtained. The data shown below is just an example of filling in:

Readings obtained from MO		*Ware content(ppm) obtained in laboratory*
Temperature ºC	***Relative saturation RS%***	
31.8	26.9	18.0
50.5	13.8	18.5
70.3	6.2	18.5

5. Based on the data above, fill in the table shown below:

Values for X	***Values for Y***
X = 1 / (273.1 + temperature ºC)	*Y = Log (100 x ppm / RS%)*
0.0032798	1.82552
0.0030902	2.12729
0.0029121	2.47478

6. The relationship between the values for X and Y on this table follow the equation for a straight line:

   Y = -B . X + A

   Where A and B are the water in oil solubility constants we are looking for.

   In order to obtain the values for these constants that best adapt to the data measured, the linear regression method can be applied. Linear regression can be easily done using software available on the market, such as for example, Microsoft® Excel®. If necessary, Treetech can supply an Excel spreadsheet to perform this calculation; contact us on e-mail: comercial@treetech.com.br.

   For the example above, linear regression of the data results in:

   Y = -1764 . X + 7.5999

   From which we get:

   A = 7.5999 and
   B = 1764

Attachment B – Technical Data

Interface Module

Input Voltage:	38 to 265 Vac/Vdc 50/60Hz
Maximum Consumption:	< 5 W
Operating Temperature:	-40 to +85 ºC
Degree of Protection:	IP 20
Wire size – removable connectors:	22 to 12 AWG, 0.3 to 2.5mm2
Fixation:	Built in panel
Direct temperature measurements: • Sensor: • Measuring range • Maximum error @ 20ºC: • Deviation by temperature variation: • Type of connection:	Two (oil + 2nd temperature selectable) Pt100Ω□@ 0ºC w/ continuous self-calibration -55...200ºC 0.5% of full scale 20ppm/ºC 3-wire sensor
Water saturation percentage measurement: • Type of Input: • Measuring range: • Maximum Error at 20ºC: • Connection:	 Treetech Moisture Sensor 0 to 100% of water saturation ±2% of water saturation Three wires
Analog output (optional): • Maximum error: • Options (selections) and maximum load:	One 0,5 % of full scale 0...1mA, 10kΩ 0...5mA, 2kΩ 0...10mA, 1kΩ 0...20mA, 500Ω 4...20 mA, 500Ω
Relay outputs: • Maximum switching power: • Maximum switching voltage: • Maximum conduction current:	Dry contacts 70 W (dc) / 220 VA (ac) 250 Vdc / 250 Vac 5 A
Serial Communication Ports (optional):	1 RS485 for supervision/monitoring systems
Communication protocols:	Modbus RTU or DNP3.0 level 1
Mass Memory (optional): • Recording interval: • Capacity:	Non-volatile type FIFO (First In First Out) 1 to 1000 minutes 1489 registers

Sensor Module

Operating Temperature – Ambient:	-40 to +85 ºC
Operating Temperature – Oil:	-40 to +85 ºC
Storage temperature:	-51 to +125 ºC
Typical response time:	10 minutes
Maximum pressure supported in the process:	0,1 MPa (1,0 bar) / full vacuum
Degree of Protection:	IP 66 (NEMA 4)

Wire size:	6 wires 0,3 to 1,5mm^2, 22 to 14 AWG
Installation:	Ball or Drawer valve 1/2” or larger
Connection to the valve:	Thread 1/2” BSP (standard) or 1/2" NPT (under request)

Appendix C – Product Order Specification

The Moisture Monitor MO is a universal equipment, with its characteristics being selected in its programming menus using the front panel keyboard or RS485 serial port. Power input is universal (38 to 265 Vdc/Vac 50/60Hz).

Therefore, in ordering your device, all that needs specifying is:

- Moisture Monitor MO – Sensor Module
  - Version of rod length desired: version A (190mm) or B (300mm)
  - Type of connection thread required: standard (1/2" BSP) or 1/2" NPT
  - Quantity.
- Moisture Monitor MO – Interface Module
  - Quantity (one Interface Module for each Sensor Module)
  - Optional functions desired (Optional 1 – Mass Memory)

BRAZIL
Treetech Sistemas Digitais Ltda
Praça Claudino Alves, 141, Centro
CEP 12.940-000 - Atibaia/SP
+ 55 11 2410-1190
comercial@treetech.com.br
www.treetechusa.com

INTERNATIONAL REPRESENTATIVES/DISTRIBUTORS

SOUTH AMERICA

CHILE - Santiago
INMOHA
+56 2531-7986
felix.morales.h@gmail.com

PARAGUAY - Asunción
Enertec
+595 21 214 814
paraguay@treetech.com.br

PERU - Lima
Logytec
+511 452 3111
ventas@logytec.com.pe

COLOMBIA - Medellín
Enersafe S.A
+57 4 604 32 72
daniel.restrepo@enersafe.com.co

NORTH AMERICA

The UNITED STATES of AMERICA - Portland
TechSales
+1 503 345 9710
terry@techsales-nw.com

MEXICO - Hidalgo
MCT
+52 779 796 4286
jgchirino@monitoreoycontrol.com

ASIA

INDIA - Raipur
Global Technology
+91 98261 22000
info@global-technology.in

OCEANIA

AUSTRALIA/NEW ZEALAND - Melbourne
Martec Asset Solutions
+61 (0)430 149 665
selwyn.braver@martecassetsolutions.com.au

EUROPE

PORTUGAL - Linda a Velha
Trafotech
+351 214 146 740
trafotech@trafotech.pt

NORWAY - Hokksund
EB Elektro
+47 31 01 37 00
simen.andreassen@eb-elektro.no