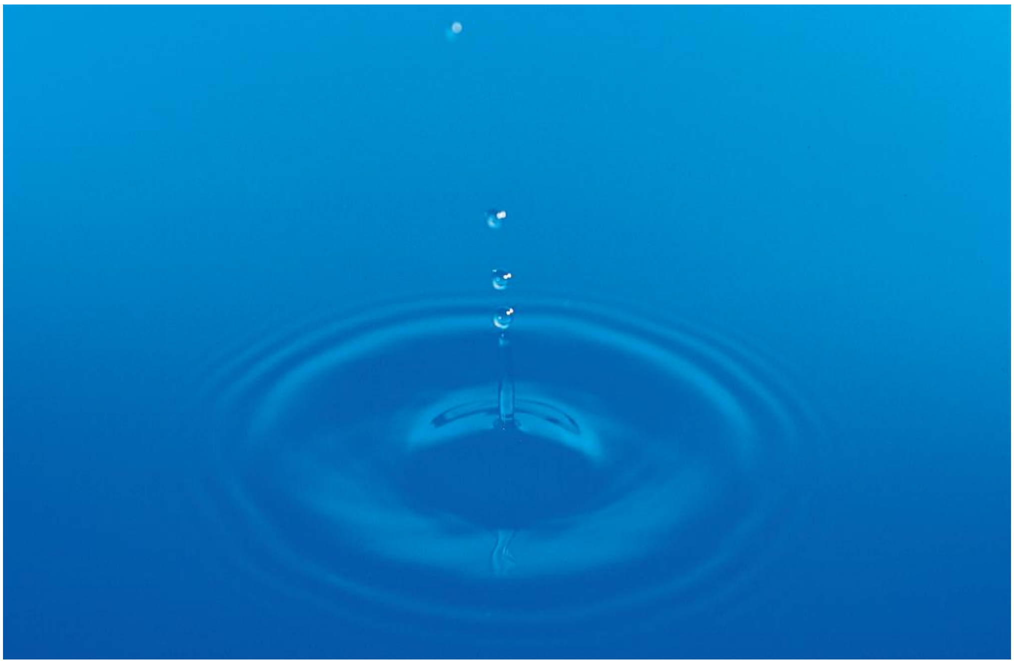

User Guide

QL40 OCEAN – Multi Parameter Water Quality Probe

MOUNT SOPRIS INSTRUMENTS

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v12.09.12

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1 General Information

The Idronaut Ocean Seven 303 probe combines the multi-parameter sensing unit manufactured by Idronaut and the ALT telemetry that enables the probe to be run on a standard logging wireline.
The Ocean Seven 303 multi-parameter probe sensor is manufactured by Idronaut srl, Via Monte Amiata, 10 20047 Brugherio, ITALY.

1.1 Overview

In the standard configuration the QL40 OCEAN probe is equipped with six sensors to measure: Pressure, Temperature, Conductivity, Dissolved Oxygen, pH and Oxidation-reduction (REDOX) potential. The probe can be equipped with others sensors. Please refer to the appendix to get the list of sensors currently supported by the acquisition software.

In order to run the Idronaut Ocean Seven on a standard wireline the sensor unit has been combined with the ALT telemetry and QL tool chassis. The probe is specially designed for borehole applications. It has a nominal maximum operating depth of 150 bars and temperature limit of 50°C.

This manual focuses on the ALT interface for the Idronaut Ocean Seven sensor unit. For more details about the sensor unit refer to the **Idronaut Ocean Seven Operator's Manual**.

1.2 Dimensions

Figure 1-1 *QL40 OCEAN probe overview*

1.3 Technical Specification

Tool

Diameter:	40mm
Length:	1.41m
Measurement point:	0.15m (from bottom)
Weight:	5.45 kgs
Max. Temp:	50°C
Max.Pressure:	150bar

Cable:

Cable type:	Mono, 4 or 7 conductor (for multi conductor only 1 line used)
Digital data transmission:	Up to 500 Kbits per second depending on wireline
Compatibility:	ALTLogger – ABOX – Matrix

Sensors:

The standard probe can be equipped with sensors to measure the following parameters:

Parameter	Range	Accuracy	Resolution	Time cst
Pressure	0.. 1000 dbar	0.05 %F.S.	0.0015% F.S.	50 ms
Temperature	-1.. +50°C	0.005 °C	0.001 °C	50 ms
Conductivity				
Salt water	0..70 mS/cm	0.007 mS/cm	0.01 mS/cm	50 ms
Fresh water	0.. 7000 µS/cm	5 µS/cm	0.1 µS/cm	50 ms
Oxygen	0.. 50 ppm	0.1 ppm	0.01 ppm	3s
	0..500 %sat.	0.2 1%sat.	0.02 0.1 %sat.	3s
pH	0.. 14 pH	0.01 pH	0.001 pH	3s
Redox	+/- 1000mV	1 mV	0.1 mV	3s

Table 1 *Parameters recorded with the standard configuration of the sensor unit*

Optional sensors are available:

Parameter	Range	Accuracy	Resolution	Time cst
Pressure	0.. 6000 dbar	0.01 %F.S.	0.002% F.S.	50 ms
Ammonia	0.. 100 mg/l-N		0.1 mV	
Nitrate	0.. 100 mg/l-N		0.1 mV	
Chloride	0.5.. 18000 mg/l-N		0.1 mV	

Table 2 *Parameters recorded with the extended configuration of the sensor unit*

2 Measurement Principle

The bottom section of the probe is 43mm in diameter and contains the Idronaut sensors and electronics.

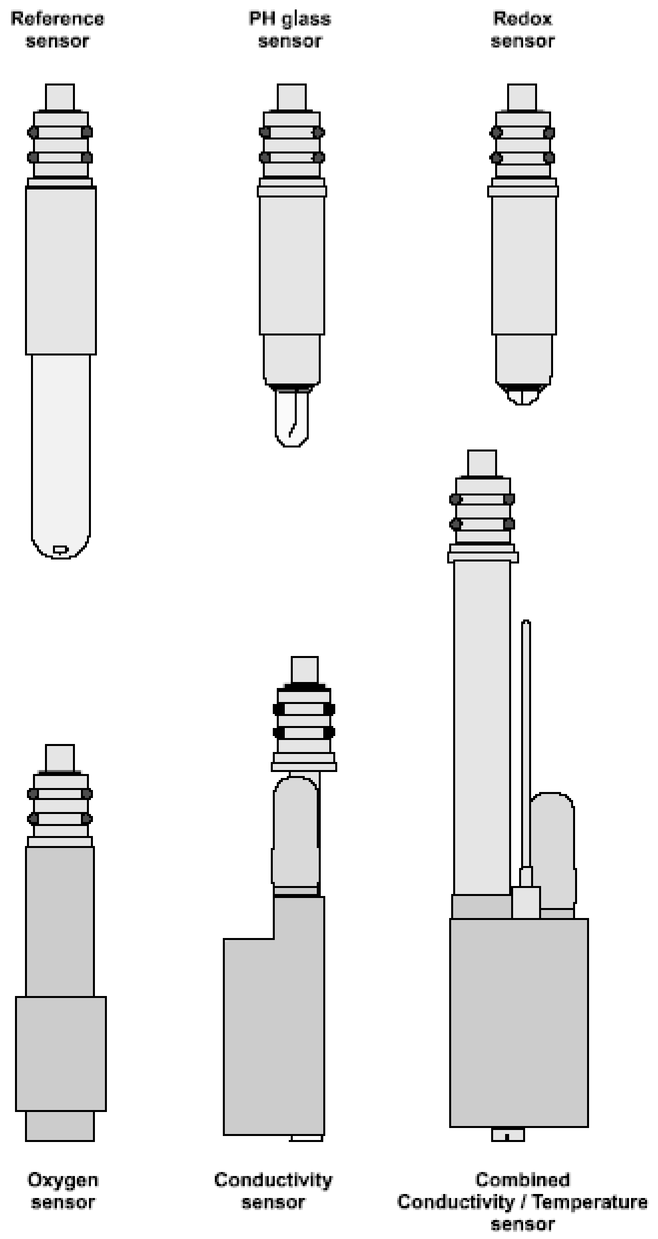


Figure 2-1 *Sensor view*

Pressure

A high quality pressure sensor is integrated. It is centrally mounted on the probe base and is capable of generating a linear signal output.

Temperature

The temperature sensor consists of a platinum resistance thermometer (Pt 100) fitted on a stainless steel housing. The sensor has a very low time response (50ms) and a high stability reading with ageing.

Conductivity

The conductivity sensor is a flow through cell with 7 platinum ring electrodes. The cell is mounted on a special cylindrical plastic body that guarantees thermic insulation and is filled with silicone oil. A rubber bellow is also integrated to achieve pressure compensation (for the 7000 dbar conductivity sensor version).

Oxygen sensor

The oxygen sensor is a polarographic type and consists of 2 half cells, the anode and the cathode. The anode is a silver tube that encircles a glass body where a platinum wire, the cathode, is sealed. The cathode ends at the tip of the sensor where the glass body is rounded. A special cap with a gas-permeable replaceable membrane screws onto the sensor. The inside of the cap is filled with an electrolyte which allows the measuring current to flow between the anode and the cathode. The anode acts as a reference cell, providing a constant potential with respect to the cathode.

The cathode, where oxygen is consumed or reduced, is separated from the sensor to be analysed by a thin layer of electrolyte and a special composite membrane.

Reference and pH sensors

The reference sensor is a Silver/Silver Chloride cell in a saturated potassium chloride solid gel. The contact with the solution to measure is made by means of a small hole drilled in the glass tip. The body of the reference sensor is made of stainless steel. The glass tip of the sensor is covered with a soft silicone rubber protective cap filled with a special solution. **This cap must be removed before using the probe.**

The pH sensor has a Titanium body and a pH sensitive glass tip. During storage, the glass tip is fitted with a plastic cap filled with a pH7 buffer solution to prevent any dehydration. **This cap must be removed before using the probe.**

Redox sensor

The redox sensor measures the oxydation reduction potential of the redox couples present in the medium. The sensor itself consists of a platinum wire that ends at the tip of the sensor where the glass body is rounded.

3 Notes on QL tool assembly

QL stands for **Q**uick **L**ink and describes an innovative connection between logging tools (subs) allowing to build custom tool stacks. QL40 describes a specific family of logging tools. Each sub is equipped with its own Telemetry board, Power supply element and A/D converter allowing an operation as stand-alone tool or as a stack in combination with other subs of the QL product family.
The QL40 probe line deals with two types of subs - Bottom Subs and Mid Subs.

Bottom Sub
A bottom sub is a tool that must have one or more sensors located at the bottom. It can be operated in combination with other QL subs connected to the top but it is not possible to connect another sub below. When used in stand-alone mode the bottom sub only needs a QL40 tool top adaptor, which fits the cable head.

Mid Sub
A mid sub is a tool that can be integrated anywhere within a stack of tools. When used at the bottom of a tool string a QL40 bottom plug must be used to terminate the string. If the mid sub is used as a stand-alone tool it needs a QL40 bottom plug at the lower end and a QL40 tool top adaptor at the top.

3.1 QL40 stack assembly

QL40 tool stacks are terminated by either a QL40 bottom sub or a QL40 bottom plug. At the top of the stack a QL40 tool top is required to connect the tool string to the cable head. Several tool tops are already available, special ones can be made on request.

To assemble and disassemble the subs the C-spanner delivered with the tool must be used (Figure 3-1). It is recommended that before each assembly the integrity of the O-rings (AS216 Viton shore 75) is verified. Prime the O-rings with the silicon grease that was supplied with the subs.

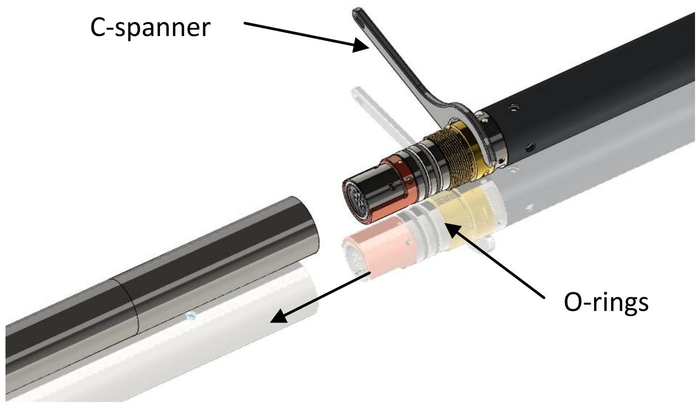


Figure 3-1 *C-spanner and O-rings of QL connection*

The following example of a QL40-ABI, QL40-GR and QL40-GO4 (Figure 3-2) describes how to replace the QL40-ABI with a QL40-Plug in order to run the QL40-GR sub stand-alone.

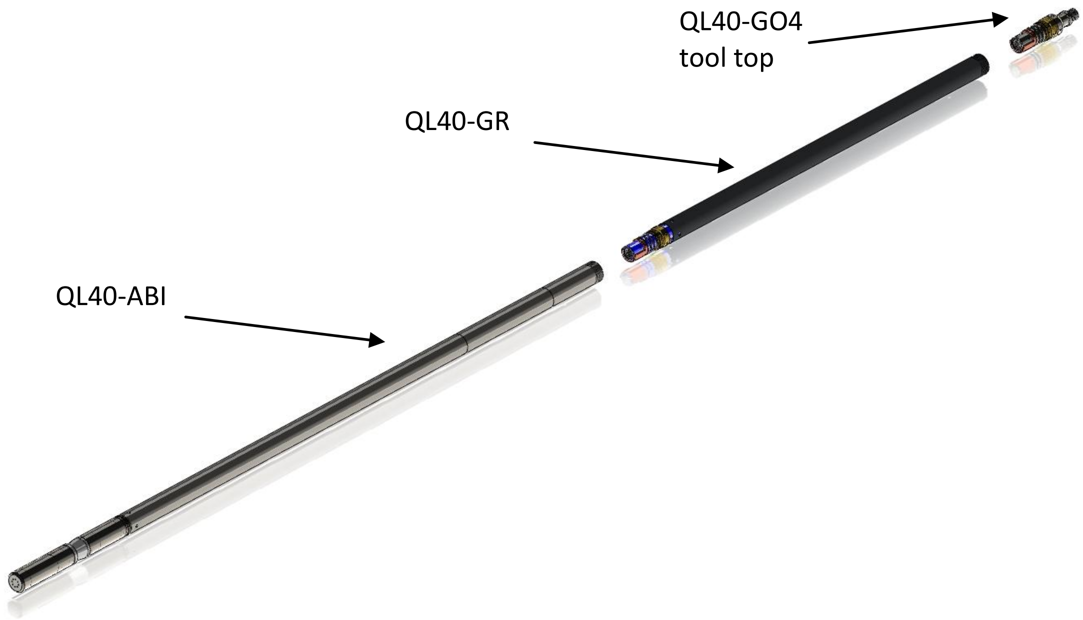


Figure 3-2 *Tool stack example*

To remove the QL40-ABI bottom sub attach the C-spanner to the thread ring as shown in Figure 3-3, unscrew the thread ring and remove the QL40-ABI bottom sub.

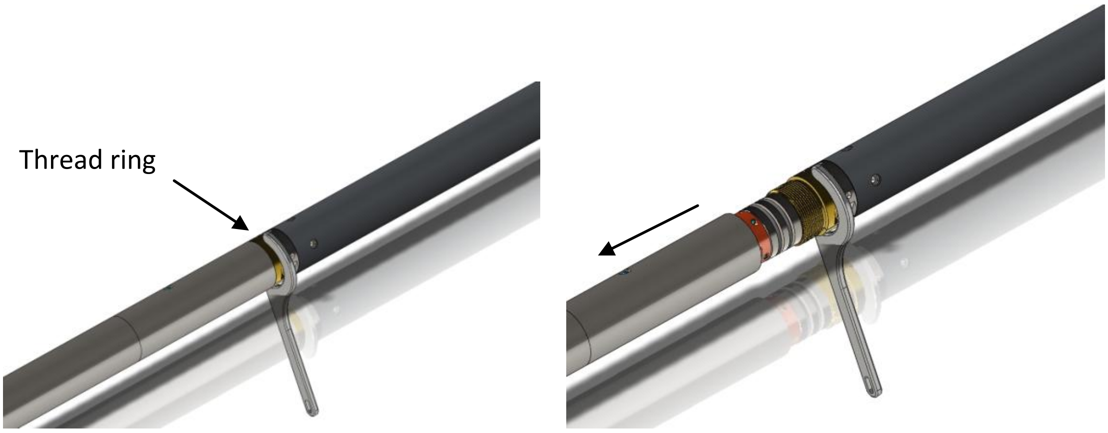


Figure 3-3 *Unscrewing the thread ring and removing the bottom sub*

After checking the O-ring integrity slip the QL40-Plug over the exposed QL connector (Figure 3-4) attach the C-spanner and screw the thread ring until the plug fits tight.

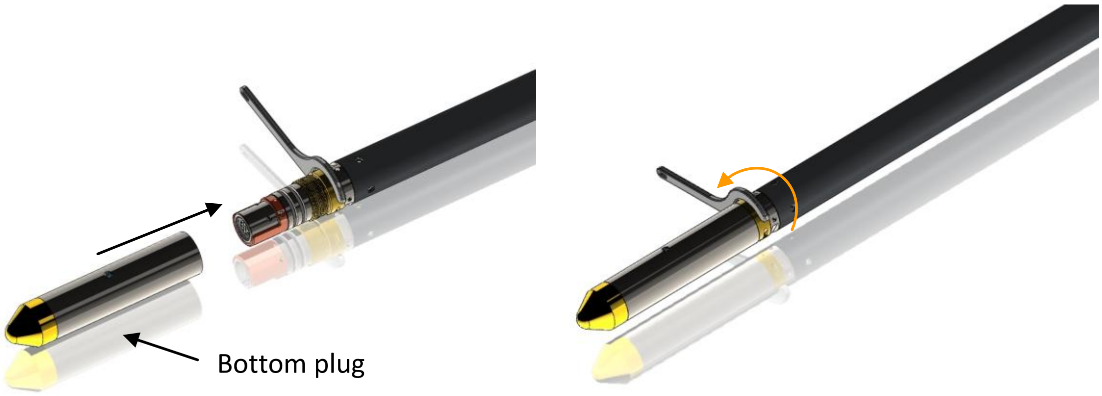


Figure 3-4 *Attaching the QL40-Plug*

The QL40-GR can now be run stand-alone (Figure 3-5).

Figure 3-5 *QL40-GR mid sub with tool top and bottom plug*

4 Operating Procedure

Note: Parts of the topics discussed in these sections below assume that the user is familiar with the ALTLog or MATRIX acquisition software. Refer to the corresponding operator manuals for more details. Information about assembly and configuration of tool stacks can be found in the same manuals.

4.1 Quick Start

1. Connect the QL40 OCEAN to your wireline and start the data acquisition software.

2. Select the relevant QL40 OCEAN tool from the drop down list (Figure 4-1) in the software's **Tool** panel (if your tool is not listed check that your tool configurations file is stored in the designated folder on your computer).

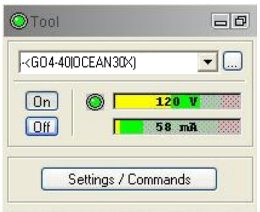


Figure 4-1 *Tool panel*

3. In the **Tool** panel switch on the tool (click **On** button) and verify that the power indicator shows a valid (green) level. The system goes through a short initialization sequence which sets the default parameters and communication settings held in the tool configuration file. The configuration returned by the tool is also checked during this procedure. (Setup the tool communication as explained in chapter 4.4 if an error message is displayed.)

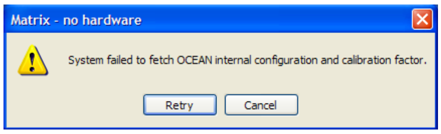


Figure 4-2 *Error message*

4. On the **Tool** panel (Figure 4-1) click the **Settings / Commands** button to configure your tool (see chapter 4.4 for details).

5. In the **Acquisition** panel (Figure 4-3) select the sampling mode (depth or time). Click on **Settings** and specify the corresponding sampling rate. Switch on the sampling (click the **ON** button).

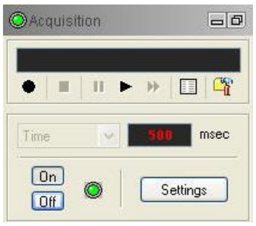


Figure 4-3 *Acquisition panel*

6. Press the **Record** button in the **Acquisition** panel (Figure 4-4), specify a file name and start the logging.

7. During logging observe the controls in the **Telemetry** panel:
   - Status must be valid (green light);
   - Bandwidth usage in green range;
   - Memory buffer should be 0%;
   - Number of **Data** increases and number of **Error**s negligible.

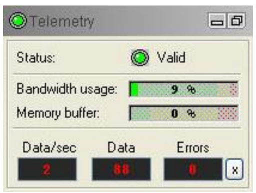


Figure 4-4 *Telemetry panel*

8. To end the logging procedure press the **Stop** button in the **Acquisition** panel and turn off the sampling (click **OFF** button).

9. In the **Tool** panel power off the tool.

Before starting any logging operation with the QL40 OCEAN probe, it is necessary to ***remove the pH and Reference sensor caps***. **Figure 4-5** illustrates how to get access to the sensor caps:

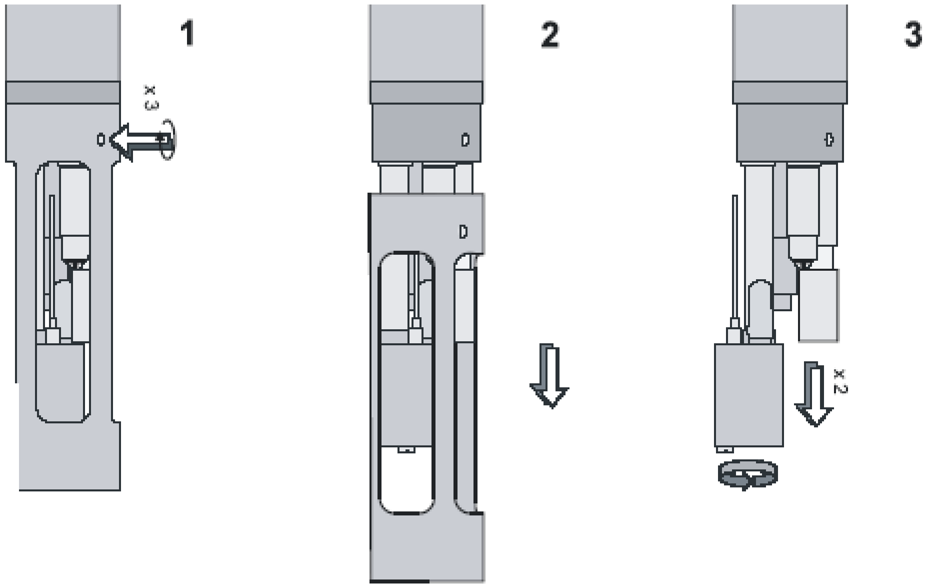


Figure 4-5 *Dismounting the sensor protection cage*

1. Screw **in** the three 4mm hexagonal head screws.
2. Pull and remove the protection sensor cage.
3. Rotate carefully the combined Conductivity/Temperature sensor to remove the pH and reference sensor caps.
4. Replace the protection cage before the logging operation.

After each logging job, sensors must be cleaned with demineralised water, protection caps must be fitted back on the sensors and filled with the appropriate storage solutions. Refer to chapter 6 – Probe maintenance for more details.

It is also recommended that **centralisers** be always used with the ALT-Idronaut sonde. Experience has shown that when not centralised the sonde has a tendency to lodge when running down a borehole and can catch on obstructions when running uphole.

4.2 Tool Communication with ALT Logger

The telemetry provided through the ALTLogger is self-tuning**.** In case communication status is not valid the user can manually adjust the settings. In the **Telemetry** panel of the dashboard click on **Settings** to display the **Configure Tool Telemetry** dialog box (Figure 4-4).
A procedure to achieve valid communication is given below:

- Change the **Baudrate** to 41666 kbps.
- Verify that the **Downhole Pulse width** knob is set on 20 (default value). This value is the preferred one and is suitable for a wide range of wirelines. For long wireline (over 2000m), increasing the pulse width could help to stabilize the communication. The reverse for short wireline (less than 500m).
- Set the **Uphole** discriminators in the middle of the range for which the communication status stays valid.
- Increase the **Baudrate**, check the communication status stays valid and the **Bandwidth usage** (in **Telemetry** panel of the dashboard) is below the critical level.
- When **Uphole** discriminators are properly set, store the new configuration as default. The tool should go through the initialisation sequence the next time it is turned on.

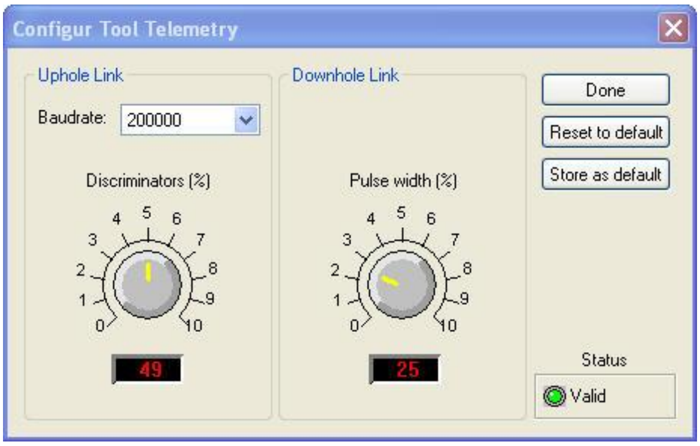


Figure 4-6 *Tool communication settings*

4.3 Tool Communication with MATRIX

The tool telemetry can be configured through the **Telemetry** panel of the Matrix dashboard. By clicking on **Settings**, the operator has access to the **Configure ALT Telemetry** dialog box (Figure 4-6) providing various controls to adjust the telemetry settings and monitor its current status.
The **Analysis View** displays the current discriminator levels (vertical yellow lines) and a histogram of the up-hole data signal. The scales of the **Analysis View** can be adjusted using the **Vertical Scale** and **Horizontal Scale** knobs and the **lin**ear / **log**arithmic scale buttons.
The status of the configuration should be flagged as Valid (indicated by the LED being green). In any other case (LED red) the telemetry should be adjusted (we assume a pulse signal is displayed in the analysis view). Click on the **Advanced** button to display additional controls to tune the telemetry.

The Automatic settings option is the preferred mode and should allow the telemetry to be configured for a wide range of wirelines without operator input. For wirelines with a more limited bandwidth, the operator might need to turn off the automatic mode and adjust the telemetry settings manually.
For each wireline configuration, the discriminators (vertical yellow lines) for the **positive** and **negative** pulses must be adjusted in order to obtain a valid communication status (see Figure 4-7) for an example of a suitable discriminator position). There is also the option to alter the **baudrate** in order to optimize the logging speed. The input **gain** can be increased (long wirelines) or decreased (short wirelines) in order to set up the discriminator levels correctly.

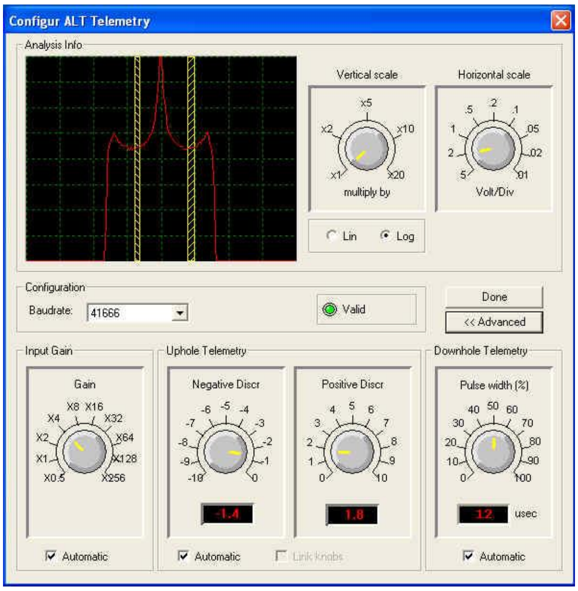


Figure 4-7 *Matrix telemetry settings*

Once the telemetry is correctly set, store the new settings as default. The tool should go through the initialization sequence in “Valid” status the next time the power is turned on.

4.4 Configuring Tool Parameters

The tool can be configured to operate on fresh or salty fluids. This allows the tool to select one scale or another for the conductivity measurement (see 5.1.3).

4.5 Recorded Parameters and Browsers

4.5.1 Recorded parameters

Raw sensors output data values are recorded by the acquisition software. These values are processed and calibrated by the OceanProc processor.

! Users should take care of running the OceanProc processor while logging.

4.5.2 OceanProc Processor

The OceanProc processor is activated once the tool is powered and communication established. It is imperative that the processor be started before powering ON the tool (as defined by default in the tool configuration file). During the tool power initialization, the system is fetching the tool internal configuration and is sending the necessary information to the OceanProc processor. The "Running" status means that the processor has received this information and is ready to work.

If the tool initialisation sequence failed at start up, the user will need to adjust the communication parameters, save them as default and power OFF /ON the tool again in order to obtain the "Running" status for the OceanProc processor.

OceanProc converts raw data sent by the sensors into calibrated data with their corresponding units using either the factory calibrations coefficients stored in the tool memory either the ones defined by the user. It computes also additional parameters as salinity, density and speed of sound.
New calibration factors can be applied and will be stored in the tool configuration file when the OceanProc calibration dialog box is used for the sensor calibration (refer to chapter 5 for more details).

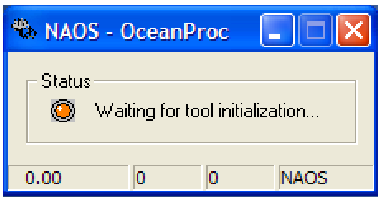


Figure 4-8 *OceanProc processor waiting for tool power/initialisation*

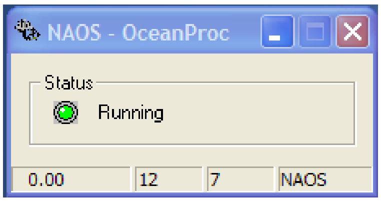


Figure 4-9 *OceanProc processor*

Below is a summary of the parameters handled by the OceanProc processor (also displayed in the About dialog box of OceanProc).

Parameter	Unit	Description
Pressure	dbar	
Temperature	'C	
Cond.(FW)	uS/cm	Fresh water conductivity
Cond.(SW)	uS/cm	Salt water conductivity
Redox	mV	
O2%	%	
O2ppm	ppm	
pH		
IOD	mV	
Cl	mV	
NO3	mV	
NH4	mV	
Cond20	uS/cm	Conductivity @20'C
Cond25	uS/cm	Conductivity @25'C
Salinity		
Density	kg/m3	
Sound Speed	m/s	

Table 3 *OceanProc computed parameters*

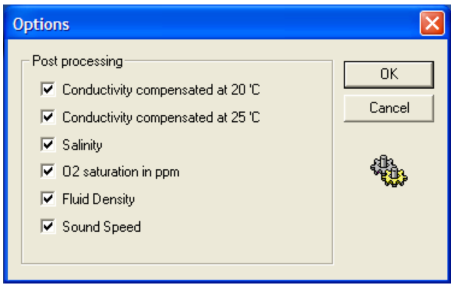


Figure 4-10 *Processing options*

4.5.3 MChCurve Browser

The MChCurve browser displays in real time the recorded parameters in the form of curves. The user is allowed to modify the curve presentation by double clicking on the log title (colours, column position, scale, filter,gridding,….)

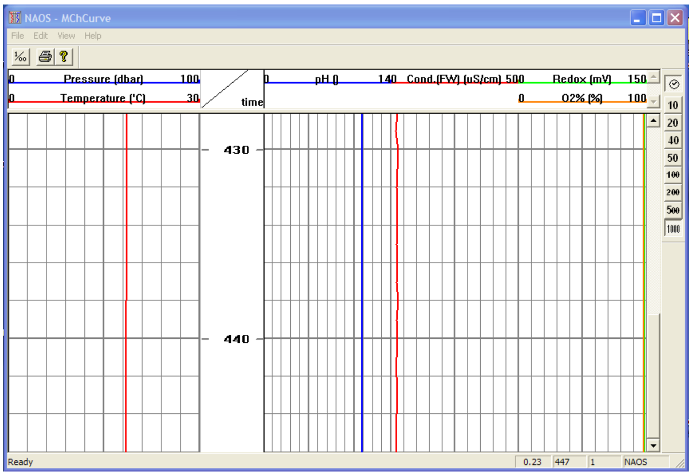


Figure 4-11 *Multi Channel Browser for curve display of data*

4.5.4 MChNum Browser

Figure 4-12 shows a typical example of the numerical values displayed in the MChNum browser window during logging.

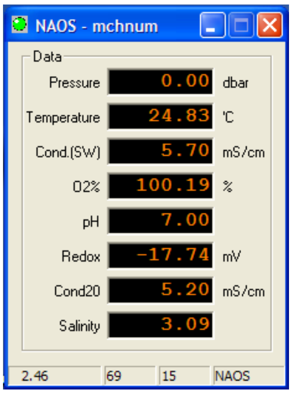


Figure 4-12 *Multi Channel Browser for Numerical Data (MChNum)*

5 Performance Check & Calibration

5.1 Calibration

As a general procedure each sensor is factory calibrated before delivery. Factory calibration coefficients are stored in the tool memory. Nevertheless, as a quality control on the data produced by the tool, it is recommended for the user to verify the calibration values regularly. The following table gives an idea of the calibration frequency for each sensor:

Sensor	Calibration Frequency
Pressure	monthly
Temperature	yearly
Conductivity	yearly
Oxygen	weekly
pH	monthly
Redox	Monthly

Table 4 *Overview of calibration frequency*

User has access to the sensor calibration pages by right clicking on the title of the OceanProc processor dialog box and by selecting the calibration option from the displayed menu.

5.1.1 Pressure sensor calibration

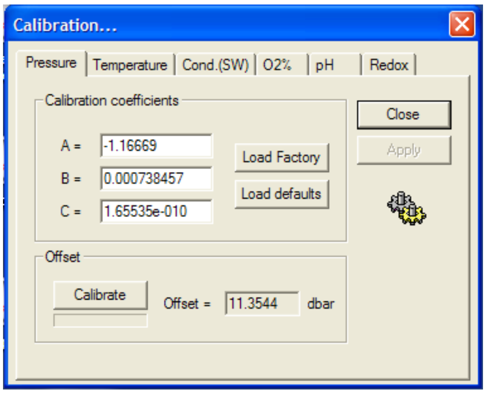


Figure 5-1 *Pressure sensor calibration*

To avoid a slight drift occurring in the pressure sensor, it is preferable to immerse the probe in water, roughly 10 cm from the probe housing, and wait a few seconds before starting the calibration. Pressure is calculated by means of a polynomial interpolation against a calibration curve.

```
Pressure (dbar) = A + Bx + Cx2 – Offset
```

where

x : Pressure sensor reading in ADC counts.

Offset : Automatically acquired at the end of calibration.

Once the three coefficients have been entered, press the button **Calibrate**. The probe will then perform the pressure sensor offset. Click on **Apply** to accept the new coefficients. They will be stored in the .tol file and will be used as default.

Pressing the **Load Factory** button will load the factory calibration coefficients. Pressing the **Load defaults** will load the calibration coefficients stored in the *.sub file. **When changing the calibration coefficients the user must force the probe to recalculate the pressure offset by pressing the button Calibrate.**

5.1.2 Temperature sensor calibration

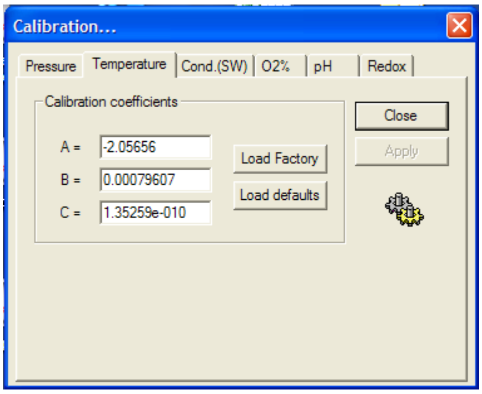


Figure 5-2 *Temperature calibration*

The temperature sensor calibration allows the user to enter either the factory calibration values or customized values. Temperature is calculated by means of a polynomial interpolation against a calibration curve.

```
Temp 'C = A + Bx + Cx2
```

where

x : temperature sensor reading in ADC counts.

The three coefficients **A**, **B** and **C** can be entered in this dialog box. Pressing on **Apply** will tell the processor to use the new coefficients and will store them in the *.sub file. Pressing the **Load Factory** button will load the factory calibration coefficients. Pressing the **Load defaults** will load the calibration coefficients stored in the *.sub file.

5.1.3 Conductivity sensor calibration

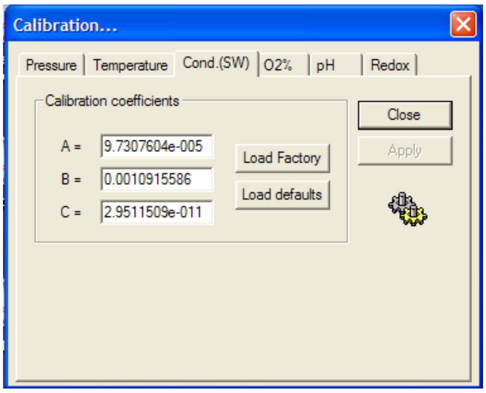


Figure 5-3 *Conductivity calibration*

The probe is able to work with two different conductivity scales. According to the parameter value ConductivityRange given in the .tol file, the software will display either the calibration page for the salt-water configuration, or that for the fresh water configuration.

Conductivity scale selection:
The conductivity range in use is stored in the **Default** section of the .sub file. Possible values are: **salt, fresh, none**.

Remark:
The change of the conductivity scale is set by editing the default section of the .sub file. See below

[Default]
ConductivityRange=salt

The conductivity is calculated by means of a polynomial interpolation against a calibration curve.

```
Cond (mScm-1) = a + bx + cx2
```

Where

x : Conductivity sensor reading in ADC counts.

The conductivity sensor is usually very stable and precise. A check against any drift over time or change in probe sensitivity can be performed using a Standard Solution. A worldwide used Standard Solution for conductivity is the so-called “Copenhagen Water” and is supplied by I.A.P.S.O. – Standard Seawater Service. The certified value of Chlorinity is 19.371 ppt, which corresponds to a Practical Salinity of 35.00 ppt. The temperature value is determined in the salinity calculation. Nevertheless, since the temperature sensor is much less prone to drift than the conductivity sensor, it is assumed that any variation, with respect to the certified value, is totally due to the conductivity sensor. The probe must be carefully rinsed with distilled water in order to remove any salt residue, and dried. These precautions are necessary to avoid diluting or contaminating the Reference Solution. Transfer some Copenhagen Water into a beaker and immerse the probe into it. The conductivity value is supposed to be coincident or very close to the theoretical one.

5.1.4 Oxygen sensor calibration

The oxygen sensor is the sensor that requires the most attention of all the QL40 OCEAN sensors. Maintenance (mostly membrane and electrolyte replacement) should be carried out at least every three months and assembling/disassembling requires great care.

Calibration of the sensor should be carried out:

- after a long period of disuse
- once a day during an extended field survey

It is preferable to calibrate the oxygen sensor in a liquid (ideally distilled water) saturated (i.e. in perfect equilibrium) with ambient air and well stirred for temperature homogeneity. If possible, check the oxygen saturation using the Winkler method. However, this procedure is rarely used because of the difficulties of obtaining a solution homogeneous in temperature and at saturation, particularly in the field. For this reason, the calibration is usually carried out in air.

Oxygen sensor calibration in air

Because of the differences in thermal mass and thermal transfer characteristics of the oxygen and temperature sensors when in air, it is important to ensure that they are both in thermal equilibrium with ambient air before proceeding with the calibration.
Where the probe has been used in water that is significantly different in temperature to the ambient air, then the time to reach thermal equilibrium may take up to 30 minutes.
When performing a calibration in the field, it is important to protect both the oxygen and temperature sensors from the effects of wind chill. In some instances, it may be beneficial to place the probe sensor head into a polythene bag or wrap the sensor head with cling-film.

Before calibration, it is important to be sure that both the oxygen and temperature sensors are perfectly dry. The oxygen sensor may be dried with a piece of clean cloth taking particular care not to damage the membrane. Dry the temperature sensor with clean cloth taking care not to touch the sensor or heat it in any other way above ambient temperature. After drying both sensors, leave them in a well-ventilated atmosphere, far from heat sources or direct sunrays, for at least one minute before proceeding with calibration.

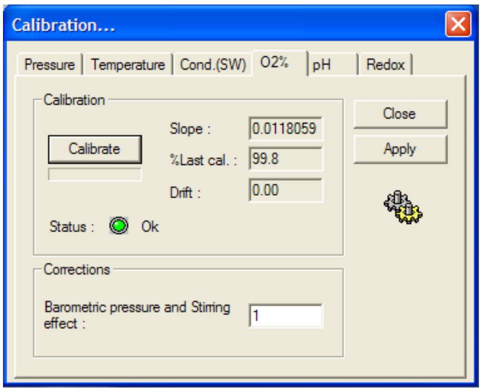


Figure 5-4 *Oxygen calibration*

%Last cal. is determined by `(new cal/old cal) x 100` and gives a measurement of ageing of the membrane and the electrode. If excessive drift is detected (> 2%), a status message will be displayed. If the message **Ok** appears it means that the calibration has been successful, and the calibration continues with the question concerning the atmospheric pressure/stirring effect compensation coefficient:

The operator must confirm the default coefficient 1.0 or enter a different value (see the note below).

Note regarding variations in barometric pressure (altitude) and the sensor membrane coefficient also called "Stirring Effect"

A correction coefficient different from the nominal 1.0 is needed for the following reasons:

1. To enter barometric pressure values differing from the 760 mmHg standard representing the normal B.P. at sea level. For example, if the measurements to be made are carried out in an area that is at 1340 meters above the sea level, then the nominal barometric pressure is only 655 mmHg. In this case the correction coefficient is given by the formula:

   ```
   Correction coefficient = (local nominal B.P./Standard
   nominal B.P.)
   ```

2. To correct (if considerable) the possible differences in readings from the gaseous phase (calibration) and the liquid measurements due to the oxygen consumption of the sensor during measurements.

3. If both of the above coefficients 1) and 2) are simultaneously requested, then the two relevant correction coefficients must be multiplied together to obtain the correction coefficient to be entered

4. To expand the scale of the oxygen sensor readings. For example, on entering a correction coefficient of 10, the read-out will be multiplied by a factor of 10.

5. For instance, to apply a double compensation due to the barometric effect and to the oxygen depletion, the following operation must be used:

   ```
   625/760 = Barometric coefficient = 0.822
   1.05 = stirring effect or oxygen depletion
   coefficient
   ```

   `1.05x0.822 = 0.863` total coefficient to be applied.

5.1.5 pH sensor calibration

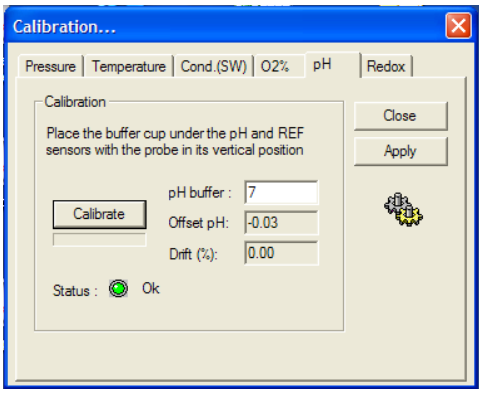


Figure 5-5 *pH calibration*

The pH sensor requires the use of a pH7 buffer. A Ph4 buffer can also be used in order to check the slope calibration and the good state of the sensor. The operator should enter the pH buffer value (in pH units) that he intends to use during the calibration. Pull out the calibration buffer cup from the accessory kit and fill it with the pH buffer solution. The buffer cup has been designed to simultaneously fit over the pH and reference sensors. It should be placed under these sensors with the probe in its vertical position. When complete, press the button **Calibrate**. The pH offset should be less than 0.7 pH units and the drift less than 0.3 %. Higher values indicate that the electrodes require some maintenance.

5.1.6 Redox sensor calibration

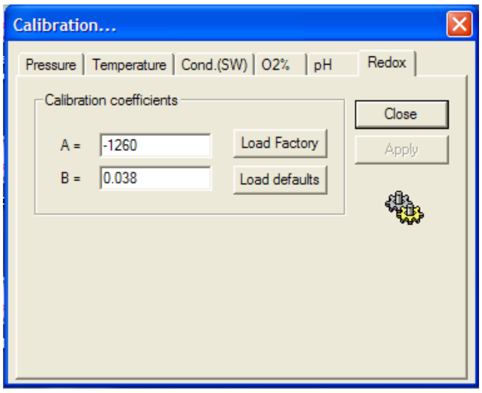


Figure 5-6 *Redox calibration*

Redox is calculated by means of a polynomial interpolation against a calibration curve.

$$\text{Redox (mV)} = A + Bx$$

where

x :Redox sensor reading in ADC counts

6 Maintenance

Warning: Removing the electronic chassis from pressure housing without prior consultation with ALT will void the tool warranty.

All the maintenance procedures necessary to keep the probe in prime operational condition are described in this section. The actions described mainly pertain to the sensors of the probe. In detail, Chapter 5 includes:

Oxygen sensor
Reference sensor
pH sensor
Conductivity sensor
Redox sensor
Temperature sensor
Pressure sensor
Routine maintenance schedule.

The following recommendations are to be followed when performing the sensor maintenance; suggestions on maintenance frequency are provided in a dedicated section.

6.1 Oxygen sensor

To ensure the best performance of the oxygen sensor, frequent full replacement of electrolyte (every month) and membrane (every 6 months) should be carried out.

Important remark on oxygen measurement:
Most polarographic oxygen sensors require a period of 5 to 10 minutes after they have been switched on to polarize and become stable. To overcome this inconvenience, Idronaut has added a nickel cadmium rechargeable battery inside the probe to maintain continuously the oxygen sensor in its correct polarized state. Please note that if the probe is not used for several months, the polarizing battery will become completely discharged and has to be replaced. It is therefore recommended that, during periods of inactivity, the probe is switched on for a few hours every 2 to 3 months to maintain the battery in a healthy condition.

6.1.1 Available membranes

The performance of the oxygen sensor depends on the type of membrane being used. Three membranes are available: “green” and “blue” as internal membranes, and “red” as an external membrane. The choice between “green” and “blue” membrane basically affects the time constant, the “blue” membrane being faster but more susceptible to stirring effects. **For normal uses (Single Point or Profiling acquisition) only the green membrane is to be used**.
The outer protective membrane “red” can be added in particular cases in order to:

- increase the life of the measuring membrane;
- limit the effect of fouling;
- avoid the need for sample stirring.

The use of the external membrane, however, considerably slows down the response of the sensor. For samples with very low oxygen content, or whenever fast reading is required, the use of the measuring membrane only is recommended.
To allow proper sample stirring, when using the internal membrane only, the probe must be lowered at a rate of at least 0.2 m/sec. The following table lists the configurations possible of membranes for the oxygen sensor to obtain the maximum performance for different types of applications.

Application	**Membrane colour Internal (measuring) External (protection)**	**Time[(a)]**	**Stirring effect[(b)]**	**Membrane material**
Single point	Green/Red	15 sec	3%	25µ,Teflon®/120£ silicone rubber
Profiling	Green/None	3 sec	25%	25 µTeflon®
Very fast profiling	Blue/None	0.9 sec	40%	18µ Teflon®

Table 5 *Membrane overview*

(a) Time constant: Nitrogen to air
(b) Stirring effect: difference between a sample well stirred and a completely stagnant one.

All values of the table are given for a temperature of 25 degrees Celsius. 1st and 2nd membrane configurations are the most commonly used. The probe is usually delivered with the green membrane installed.

6.1.2 Refilling oxygen sensor cap with electrolyte

1. Switch the probe ON and, if possible, achieve oxygen calibration.
2. Locate the oxygen sensor on the probe; then unscrew and remove the cap. Pay attention not to damage the glass tip of the sensor.
3. Wash the silver and glass assembly with distilled water and dry it with a lint-free paper towel. Do not touch the internal parts of the sensor with the fingers.
4. In this condition, with the sensor tip duly dried and cleaned, the sensor should read less than 0.2 ppm (if calibration has been previously achieved). The sensor should not be touched during this check. If the readout is higher, there is most probably a film of moisture still in contact with the sensor tip. Carefully dry the sensor tip.
5. Carefully fill the membrane cap with the O2 electrolyte; do this in such a way that drops are deposited directly into bottom of the membrane in order to prevent the formation of big air bubbles in the cap. To eliminate trapped air bubbles, gently tap the membrane cap.
6. Gently screw the membrane cap onto the sensor body, thus allowing the electrolyte in excess to be drained and then securely tighten the membrane cap.
7. Dry the sensor, and the membrane in particular, with a lint-free paper towel.

Note
After electrolyte refilling, recalibrate the oxygen channel.

IMPORTANT
Maximum stability of readout is achieved 30 minutes after the membrane cap and/or electrolyte replacement, thus enabling the sensor to reach a good polarization level. Oxygen analysis can, however, be carried out within a few minutes after the membrane cap replacement provided that a calibration is performed.
While the probe is not in use, the polarization of the oxygen sensor remains active with the necessary power being provided by a nickel cadmium battery placed inside the Probe. Battery recharge is performed when the probe is switched ON.
If necessary, the whole electrolyte must be replaced. Topping-up with fresh electrolyte must not be carried out since the solution would be contaminated by the old one thus resulting in a reduction of useful life.
It is recommended that only the IDRONAUT electrolyte be used, since its composition and pH guarantee the best performance and minimize the formation and growing of silver chloride on the anode.

6.1.3 Membrane(s) replacement (oxygen membrane cap)

Conditions which could require the membrane and electrolyte replacement are the following:

- Calibration is not systematically achieved (try at least three times).
- The oxygen sensor responds more slowly than usual or drifts.
- The membrane(s) of the cap is mechanically damaged and shows leakage, holes or scratches.
- Readout of over 0.2 ppm is displayed when carrying out the sensor check in the absence of oxygen.
- The oxygen sensor, filled with electrolyte, has been stored for a long time at temperatures outside those recommended (- 10 to 40o C).

6.1.4 Replacement of membrane(s) carried out using the OXYGEN SENSOR MAINTENANCE KIT

1. Locate and pull out the following parts from the maintenance kit:
    - One oxygen protective “red” membrane (external)(for Single point acquisition only).
    - One oxygen measuring (“green” or “blue”) membrane (internal).
    - One O-ring ring mounting tool.
2. Remove the protection ring from the membrane cap. Remove and discard the black o-ring and the membrane(s).
3. Fit the new o-ring over the mounting tool and roll it down to the widest part of the tool.
4. Place the cap on a tabletop with its narrow end facing up.
5. Position the measuring membrane (“green” or “blue”) on top of the cap. If the external “red” membrane is needed, carefully remove the protective square of white PVC from the back of it.

6. Place the widest part of the tool against the membrane(s). Slightly pressing the tool, slide the O-ring carefully into the slot of the cap thus holding the membrane(s) in position.
7. Cut away excessive membrane, with fine scissors, far from the O-ring to avoid damage to the membrane(s).
8. Finally, recap the protective plastic ring.

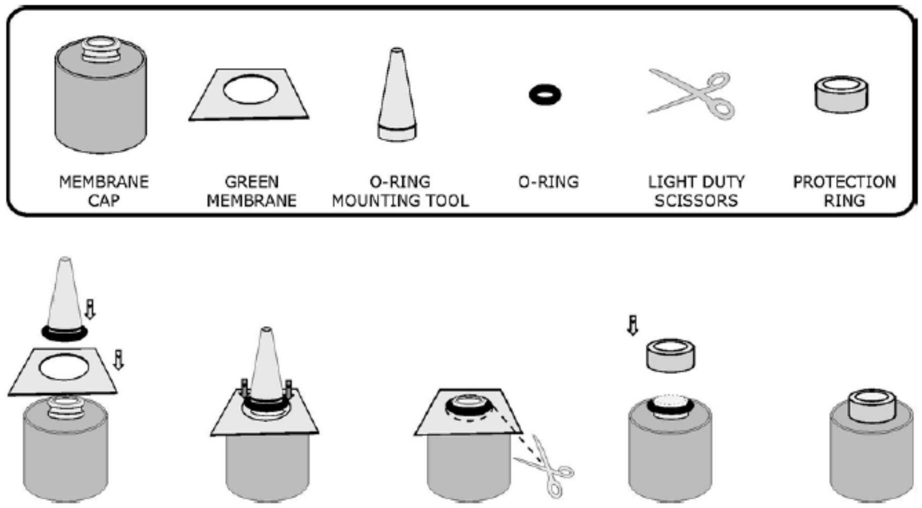


Figure 6-1 *Oxygen sensor maintenance kit*

6.1.5 Oxygen sensor cleaning

During the calibration procedure, the oxygen sensor current is shown: Checking oxygen sensor.

This current varies depending on the membranes; acceptable ranges are:

Membrane	Current nA
Green	50-100
Blue	100-200
Green/red	50-100
Blue/red	100-200

Table 6 *Oxygen sensor membranes*

If, after replacing the membrane cap and cleaning the sensor tip with filter paper, the oxygen sensor current is too low during calibration, it is necessary to polish the sensor tip with the abrasive paper included in the maintenance kit. It is sufficient to slightly rub the tip over the paper two or three times without applying an excessive pressure. Wash the sensor tip with distilled water, or with a few drops of electrolyte, to remove residues. If the silver anode appears completely black or covered with foreign materials, it is necessary to clean it with the abrasive paper. Wrap the paper around the silver body and rotate it to obtain original silver brightness. Wash the sensor under a tap or if possible use distilled water to remove residuals. The anode cleaning procedure is required every 2 or 3 years only. After these operations, the oxygen current, during calibration, will be higher than the normal one and will drop during the first few hours to reach the normal stability level of 0.1 to 0.3 ppm/week.

6.1.6 Oxygen check in the absence of oxygen

To guarantee maximum accuracy in results, it is a good practice to test the response of the sensor once a month in the absence of oxygen. Nitrogen is recommended for this check; should not Nitrogen be available, an aqueous solution, chemically reduced, can be used as an alternative. To carry out this test, it is important that the membrane cap should have been replaced for at least 15 minutes, thus allowing a complete sensor polarization.

Procedure

1. Connect a cuvette (body of a syringe) to a Nitrogen supply using a flexible tube.
2. Purge the line and adjust the gas flow rate at 200 ml/min. approx.
3. Calibrate the oxygen channel by exposing the sensor to room air.
4. Insert the sensor completely into the cuvette. The reading should rapidly decrease and within a few seconds to one minute, depending on the membrane(s) used, it should be less than 0.2 ppm. If the reading is more than 0.2 ppm, re-expose the sensor to room air and repeat the operation. Should the inconvenience persist, replace the membrane cap and/or the electrolyte.

Due to the high quality construction of this oxygen sensor, which reduces to insignificant the background current, no electronic zero calibration is necessary and possible.

6.2 Reference sensor

When not in use, the reference sensor must be always hydrated with the REFERENCE SENSOR STORAGE SOLUTION using the appropriate cap. Fill the cap to about one third with the solution. During insertion, the cap should be squeezed in order to limit the formation of air bubbles.

Before starting the measurements, carefully remove the protective cap from the sensor tip keeping the reference sensor hydrated during inactivity periods.

If the sensor has been exposed to air without its protective cap or if the solution in the cap has in the meantime evaporated, the solid electrolyte of the sensor may have contracted forming an internal air bubble in correspondence to the junction hole. If the air bubble has formed, it is necessary to fill the cavity with the REFERENCE SENSOR STORAGE SOLUTION. Please take a small syringe, i.e. 1.5 ml and aspirate a very small amount of REFERENCE SENSOR STORAGE SOLUTION that is supplied with the probe. Place the probe on a table in a horizontal position taking care that it does not rotate on the table. Carefully insert the needle of the syringe in the junction hole of the reference sensor without bending the needle to avoid breaking the glass sensor. Press the syringe plunger to inject some drops of solution inside to remove the air bubble. If the cavity is too big and the electrolyte added easily leaks, or should the cavity appear contaminated by foreign material, then the replacement of the reference sensor may become advisable.

If the sensor is left immersed in the measuring solution for an indefinite period, there will be a slow progressive loss of the KCl from the solid electrolyte. In such working conditions, the whole sensor should be replaced after 9-12 months.

6.3 pH sensor

The glass membrane of a pH sensor should always be hydrated prior to use. If the sensor is stored dry for an extended period (more than a couple of hours), the sensor's performance will deteriorate. The electrode sensitivity diminishes; the response times increase and signals tend to drift during measurements and calibrations. Before using the sensor after long storage periods, it is advisable to check the electrode performance using pH4 and pH7 buffers. Following calibration of the sensor with pH7 buffer (see the respective subsection), wash the sensor and calibration cup with distilled water. Then perform the following as described:

1. Dry the electrode with a soft tissue, making sure not to rub on the pH sensing region of the membrane (coloured part). The membrane may be partially dried by gently dabbing.
2. Fill the calibration cup with pH4 buffer and dip the pH and reference electrodes in this solution.
3. Gently swirl the buffer cup. At an ambient temperature of 20±2°C, the pH reading should be 4.00±0.10 pH. If the reading is outside this range, repeat the calibration at pH7 and then re-check at pH4. Both pH7 and pH4 buffers should be replaced after use as they can deteriorate with time. In case of doubt, use fresh solutions. If the electrodes are still not within tolerance, it is necessary to reactivate the pH sensor using the pH etching solution.

To etch the sensor, perform the following:

Note
Use gloves in order to avoid any direct skin contact with the pH sensor etching solution since the solution contains hydrofluoric acid and ammonium fluoride and is highly corrosive.

1. Half fill the transparent cap with the pH SENSOR ETCHING SOLUTION.

2. Place the cap on the pH sensor, gently squeezing the sides to limit the inclusion of air bubbles during insertion. Take care that the etching solution covers the full round end of the sensor. After no more than 1 minute, remove the cap and carefully rinse both the pH sensor and cap with plenty of water. The electrode should be left in distilled water overnight before use.

IMPORTANT

- The etching solution must not be used improperly, for instance to store the electrode as this will permanently damage its pH glass membrane. The electrodes should always be stored either in distilled water or a pH7 buffer solution.
- The treatment of the pH sensor with the etching solution cannot be performed indefinitely. After performing this step a few times, the treatment ceases to have any positive effect and the sensor should be replaced with a new one.
- Do not use the etching solution with the reference sensor. Permanent damage to the reference electrode will result.
- When not in use, the pH sensor must be fitted with the protective cap filled with either pH7 BUFFER or distilled water. (Alternatively, a salt solution - normally 3M KCl - can be used).

Important remark on the pH measurement
If the probe is not to be used for periods exceeding more than a few hours, always place the proper hydrating caps on the pH and reference electrodes. The caps must be filled with pH7 Buffer Solution and Reference Sensor Storage Solution respectively. Alternatively, immerse the whole probe in clean water to prevent the pH sensor dehydration.

6.4 Conductivity sensor

For accurate determinations of conductivity, it is important that the seven platinum electrodes of the sensor flow cell should not be contaminated with oils, biological growths or other foreign materials which can cause a reduction in the conductivity reading. During long terms monitoring, the growth of fouling within the cell can cause a decrease of performance.

Important remark on conductivity measurement in the field and in the laboratory
To obtain the best accuracy, the conductivity sensor and therefore the probe sensor head, must be immersed in clean sea water for at least 12 hours before readings are taken.
When the conductivity sensor is not in use, it is kept dry. Therefore, when the conductivity sensor is placed in water, very small bubbles may remain attached to the platinum ring electrodes (seven). If such a thing happens, the measured value of conductivity will be lower than the true one. To remove these air bubbles, clean the inside of the conductivity cell using cotton buds wetted with the Conductivity Sensor Cleaning Solution or with liquid soap. Gently rotate the cotton bud against the whole surface of the measuring cell. This will wet the platinum electrodes thus reducing the surface tension of the cell and considerably decreasing the risk of trapped micro air bubbles.

6.4.1 Conductivity sensor cleaning

To clean the conductivity cell use cotton buds and wet them with the CONDUCTIVITY SENSOR CLEANING SOLUTION gently rotating the cotton bud against the platinum ring surfaces. Replace the cotton bud after each ring cleaning. Repeat the above operation till the cotton buds used come out perfectly clean. If the above cleaning solution is not available, use common liquid soap (and cotton buds). If the above cleaning procedure is not enough to completely remove the contamination (for instance carbonate), rotate over the platinum ring surface a cotton bud wetted with 10% concentration of hydrochloric acid. Even a maximum 30 % concentration can be used, if necessary.

6.4.2 Wetting the Conductivity sensor before laboratory calibration tests

When the conductivity sensor is not in use, it is kept dry. Therefore, when the conductivity sensor is placed in water small bubbles may remain attached to the platinum ring electrodes (seven). If such a thing happens, the measured value of conductivity is lower than the true one. To remove these air bubbles, clean the inside of the conductivity cell using cotton buds wetted with the Conductivity Sensor Cleaning Solution.
Gently rotate the cotton bud against the whole surface of the measuring cell. This will wet the platinum electrodes thus reducing the surface tension of the cell and considerably decreasing the risk of trapped air bubbles.

6.5 Redox sensor

The redox sensor can be contaminated both by fouling or if some mud accidentally covers its sensitive tip. If redox potential measurement is of particular importance, it is wise to clean the sensor tip before each series of measurements. Use the abrasive paper provided in the OXYGEN SENSOR MAINTENANCE KIT. It is sufficient to slightly rub the tip on the abrasive surface of the paper two or three times. Wash the sensor tip with distilled water to remove residues.

6.6 Temperature sensor

The temperature sensor provides, via software, also the automatic temperature compensation for both pH and oxygen channels. The temperature sensor is almost maintenance free, however we suggest cleaning it once a year with sandpaper (the one included in the Oxygen Maintenance Kit) to remove carbonate which, if present, will greatly increase its time constant

6.7 Pressure sensor

The pressure sensor is almost a maintenance free device meeting the highest reliability standards and thus reducing the chance of possible failure. Replacement of the pressure transducer could however become necessary if an extension of the operating range (depth) is required.
In that case, the whole Probe must be returned to Idronaut to allow replacement, calibration and performance check of the sensor. The pressure transducer is located at the centre of the Probe bottom cover. Protection against fast thermal variation of water sample (thermocline) is obtained by means of a plastic black screwed cap. Lack of the protective cap may generate spikes of the signal generated by the transducer when severe thermoclines are encountered.

6.8 Oxygen sensor polarization battery

The internal (Oxygen sensor) NiCd battery is charged automatically during the probe ON periods. If the probe is not in use for a period longer than a week, the NiCd battery must be recharged, (minimum at least every two months), by keeping the probe ON for a night. The above procedure can be done by means of the IDRONAUT AC/DC laboratory power supply without discharging the probe main batteries.

RTC battery
The internal real-time clock is equipped with a lithium battery (3.7V, 0.9 A/h, ½ AA type cell) which allows 10 years of operation. In case of accident or malfunction of the RTC, please contact IDRONAUT to get the necessary assistance in order to replace the flat battery.

6.9 Routine maintenance schedule

The most important maintenance actions to be periodically carried out are listed below.

6.9.1 Monthly maintenance

1. Replace the electrolyte of the oxygen sensor
2. Check that pH and reference sensors be protected by proper caps and solutions if not in use.
3. Recharge the oxygen polarization Super Cap capacitor by keeping the probe ON for few hours.

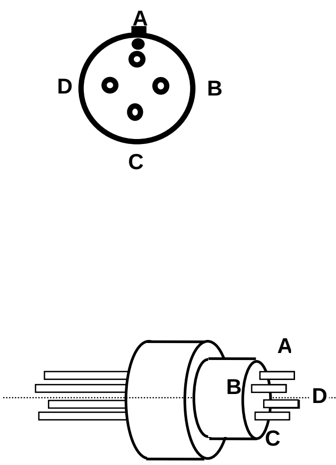
6.9.2 Quarterly maintenance

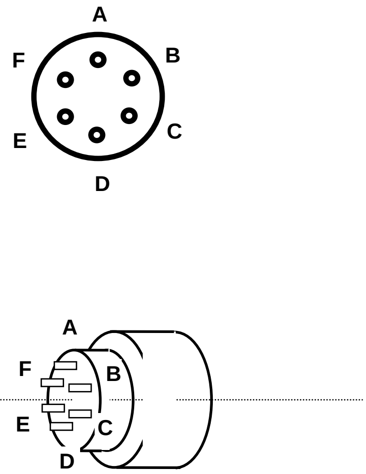
1. Replace the oxygen membrane.
2. Check the pH channel and renew the pH sensor, if necessary.
3. Clean the flow cell of the conductivity sensor.

6.10 Tool Head Wiring

The cable head socket and connector pins of the tool head should be checked for cleanliness before each use of the tool. The four pin insert has a locating mark that must line up with the slot mating with the wireline cable head.
The tool head is fixed to the steel pressure housing by four M4 hex screws and can be withdrawn from the pressure housing with a straight pull. The internal end of the tool head is fitted with a 6-way MIL socket. The internal electronic chassis is connected to this by a short spiral lead wired to a MIL plug that is disconnected to remove the head. When removing the tool head care must be taken not to overpull the head and damage this wire link.
Check seals and apply silicon grease before re-assembly. Silicon grease of a similar type to RS Components Ref 494-124 is suitable for this and other “O”ring seals.

Tool Head Wiring





4 Pin Insert
(viewed towards tool open end)

MIL-C-26482 Connector
(as marked)

Pin Insert	Function	Colour Code	Cannon Connector
A	Power/Data	Red	A
Armour-Gnd		Black	E
Armour-Gnd		Black	F

7 Troubleshooting

Observation	To Do
Tool not listed in Tool panel drop down list.	- Do you have a configuration file? - Has the configuration file been copied into the …/Tools folder (refer to MATRIX or ALTLog manual about details of the directory structure)?
Tool configuration error message when powering on the tool.	- Check all connections. - Adjust the telemetry settings for your wireline configuration (see chapter 4.2 or 4.3) and store the new settings as default. Apply the appropriate tool settings for your logging run (see chapter 4.4).
Tool panel - No current.	- Verify that the wireline armour is connected to the logging system. Test your interface cable between winch and data acquisition system. - Verify cable head integrity. - Verify voltage output at the cable head (it should be 120V).
Tool panel - Too much current (red area).	**! Immediately switch off the tool !** **-**Possible shortcut (voltage down, current up): Check for water ingress and cable head integrity - wireline continuity. - Verify the interface cable between winch slip ring and data acquisition system is not loose at the connectors. Check for possible source of a shortcut. - If the above shows no issues, use test cable to verify tool functionality. - If the problem still occurs, please contact service centre.
Telemetry panel - status shows red.	- Verify the telemetry settings for your wireline configuration (see chapter 4.2 or 4.3).
Telemetry panel - memory buffer shows 100%.	- Indicates that the systems internal memory buffer is full. PC can't receive incoming data streams fast enough. Ensure your PC has enough resources available.
Telemetry panel – bandwidth usage shows 100%. *(Overrun error message.)*	- Set the baudrate to highest value allowed by your wireline configuration. - Reduce logging speed or increase vertical sample step.
Telemetry panel - large number of errors.	- Verify the telemetry settings for your wireline configuration (see chapter 4.2 or 4.3). - Check bandwidth usage and telemetry error status.

8 Appendix

8.1 Parts list

8.1.1 Tool delivery kit QL40-xxx (ref. 209-016)

Item No.	Qty	Part No.	Description
1	1	xxx-xxx	Silicone grease Molykote111
2	2	xxx-xxx	C-spanner 40-42 (QL40-43)
3	6	xxx-xxx	Oring-V 26.57 x 3.53 75°
4	1	xxx-xxx	Grease Lubriplate L0034-086

8.1.2 QL40 OCEAN Consumables

Item No.	Qty	Part No.	Description
1	1	xxx-xxx	Membrane kit for Oxygen sensor, with tool, o-rings, membranes
2	1	xxx-xxx	Membrane cap for Oxygen sensor, pressure compensated
3	5	xxx-xxx	Membrane o-ring and Oxygen sensor cleaning paper
4	10	xxx-xxx	Oxygen green membrane
5	10	xxx-xxx	Oxygen red membrane
6	10	xxx-xxx	Oxygen blue membrane
7	1	xxx-xxx	Membrane cap for Nitrate sensor
8	1	xxx-xxx	Membrane cap for Ammonium sensor
9	1	xxx-xxx	pH Hydrating cap
10	1	xxx-xxx	Reference hydrating cap

8.1.3 QL40 OCEAN Solutions

Item No.	Qty	Part No.	Description
1	25 ml	xxx-xxx	Oxygen Electrolyte Solution
2	3 ml	xxx-xxx	pH sensor etching solution
3	25 ml	xxx-xxx	Reference sensor storage solution
4	25 ml	xxx-xxx	Conductivity sensor cleaning solution
5	100 ml	xxx-xxx	pH 4 buffer solution
6	100 ml	xxx-xxx	pH 7 buffer solution
7	5 ml	xxx-xxx	O-ring grease, syringe

8.1.4 Supported sensors

Some sensors are not supported by the acquisition software. Please refer to the table below.

Sensor description	Acronym	Measuring units	Measuring Range	Supported
Pressure transducer	Press	dbar	0..10000	yes
Temperature sensor	Temp	°C	-5..+50	yes
Conductivity sensor (Sea Water)	Cond	$mScm^{-1}$	0..90000	yes
Conductivity sensor (Fresh Water)	Cond	$uScm^{-1}$	0..9000	yes
Conductivity corrected to 20 °C	*Cond20*	*$uScm^{-1}$*	*0..9000*	*calculated*
Salinity	*Sal*	*ppt o PSU*	-	*calculated*
Dissolved oxygen in ppm	*O2ppm*	*ppm*	*0..50*	*calculated*
Dissolved oxygen sensor	O2%	sat %	0..500	yes
pH sensor	pH	pH	0..14	yes
Redox sensor	Eh	mV	+/-1250	yes
O2ppm (Unesco 1986)	*O2ppm*	*ppm*	*0..50*	*calculated*
CO_2 sensor	CO2	mV	0..5000	yes
Fluorometer	**CHL**	**ugl^{-1}**	**0..150**	**no**
Transmissometer	**Tr%**	**%**	**0..100**	**no**
Fluoride ION Selective sensor	Fluo	mV	0..5000	yes
PAR	**PAR**	**$umol\ s^{-1}\ m^{-2}$**	**0..360**	**no**
Sound Velocity	*SoundV*	*m^{s-1}*	-	*calculated*
Compensated Depth	**Depth**	**mt**	**0..10000**	**no**
Conductivity corrected to 25 °C	*Cond25*	*$uScm^{-1}$*	*0..9000*	*calculated*
Iodide ION Selective sensor	IOD	mV	0..5000	yes
Cloride ION Selective sensor	Cl	mV	0..5000	yes
Nitrate ION Selective sensor	NO3	mV	0..5000	yes
Sigma-Tau	*SigmaT*	*kg/dm^3*	-	*calculated*
Ammonia ION Selective sensor	NH4	mV	0..5000	yes
Turbidity sensor	Turb	FTU	-	yes
Sulphide ION Selective sensor	H2S	mV	0-5000	yes
Calcium sensor	Ca	mV	0..5000	yes
Copper sensor ION Selective sensor	Cu	mV	0.5000	yes
Bromide ION Selective sensor	Br	mV	0..5000	yes

Rem : A sensor not supported will be renamed as "Unknown" by the acquisition software and will have always a value of zero.

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