OPERATOR’S MANUAL

OCEAN SEVEN

316Plus CTD

Multiparameter Probe

IDRONAUT S.r.l.
Via Monte Amiata, 10 - 20861 BRUGHERIO (MB) - ITALY
Tel.  +39 039 879656 / 883832
Fax.  +39 039 883382
e-mail: idronaut@idronaut.it
Http://www.idronaut.it
OCEAN SEVEN 316Plus CTD
IMPORTANT REMARKS

ON/OFF SOUND ALERT
The Ocean Seven 316Plus CTD is equipped with a “buzzer” which, at the probe start-up, alerts/advises the operator on the undertaken operations.

The following codes are defined in the present software:
1 pulse : probe wakes up waiting for operator’s commands;
2 pulses : unattended linear profile in function of pressure increments starts;
3 pulses : unattended timed data acquisition operation starts.
4 pulses : unattended continuous data acquisition operation starts.
6 pulses : remote unattended monitoring operation starts.

INTERNAL BATTERY REPLACEMENT/RECHARGING
1) To gain access to the battery pack, remove the screws in the probe top cover. However, before doing this, please ensure to have removed any water droplets around the screw heads, to prevent them from running down inside the housing.
2) Rechargeable battery: disconnect the battery pack from the top cover and connect it to the external battery charger.
3) If the probe is not to be used for long periods (some months), remove the internal battery pack from the probe. This eliminates the possibility of damaging the electronic circuitry in case of battery leakage.
4) Do not leave the probe “magnetic rotary switch” in the ON position when the probe is not in use because a small amount of energy is drawn from the internal batteries by the probe electronic circuitry. This phenomenon causes batteries to run down and they may be damaged in a very long time. ALWAYS ROTATE THE SWITCH TO THE OFF POSITION WHEN THE CTD IS NOT IN USE.

SELF-RECORDING USE
The probe is equipped with a rotary magnetic power ON/OFF switch, present on the top cover. The probe is ON when the switching arm is over the dot marker to achieve self-recording data acquisitions, as described in the dedicated section of this manual. Once the self-recording configuration of the probe has been set, the probe can be switched OFF and then ON again at the sampling site, when it is ready for deployment.
VERY IMPORTANT: Allow a 30-second interval between each ON/OFF cycle.
CONDUCTIVITY MEASUREMENT
1) To obtain the best accuracy, the conductivity sensor and therefore the probe sensor head, must be immersed in clean seawater for at least 15 minutes before measurements. For fresh water application, the sensor does not require any hydration.
2) 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, degrease the inside of the conductivity cell using cotton buds wetted with liquid soap. Gently rotate the cotton bud against the whole internal surface of the quartz cell. This will wet the platinum electrodes, thus reducing the surface tension of the cell and considerably decreasing the risk of trapped air bubbles.

OXYGEN MEASUREMENT
Most polarographic oxygen sensors take 5 to 10 minutes after they have been switched on to polarize and become stable. To overcome this limitation, the IDRONAUT OS316Plus has been fitted with a small internal rechargeable battery, to maintain polarization of the oxygen sensor continuously. However, if the probe is not used for several months, the polarization battery may become completely discharged resulting in damage to the battery. It is recommended that the probe should be switched ON (and streaming real-time data) for at least a few hours every 2 to 3 months, to maintain this polarization battery in a healthy condition.

pH MEASUREMENT
The pH and reference sensors should never be allowed to completely dry out. For short-term storage of up to one day, the probe’s sensor head can simply be immersed in clean water. If the probe remains unused for periods longer than one day, always place the hydrating caps on both sensors. The pH sensor cap should be filled with the pH7 Buffer Solution (or simply with clean water). The reference sensor cap should be filled with the Idronaut Reference Sensor Storage Solution (or even with KCl saturated solution).

PROBE WASHING
After use, the probe must be always washed with fresh water in order to remove any salt water residual or dirtiness.

LIFETIME AND HOW TO REPLACE THE IDRONAUT SENSORS
The IDRONAUT sensors are all pressure compensated and, in particular, the physical sensors (pressure, temperature and conductivity) can last many years, if properly used. They are high-quality sensors, as they are well known by oceanographers to measure salinity with great accuracy.
If thoroughly maintained by their respective hydrating caps and solutions, the IDRONAUT pH and reference sensors can last several years. The sensor replacement requires that the closure screws on the top head of the probe be unscrewed with a common screwdriver and the cylindrical housing be removed (this takes very few minutes). The wire sensors are tin soldered on their respective connection points placed on the printed circuit board. All sensor heads have a standard 12 mm diameter and are provided with two o-rings (Parker 12-2) for sealing. This means that every sensor can be fitted in any of the five sensor head holes. The pressure sensor is a high-quality transducer, which lasts many years if properly used. Its replacement is not very easy and, moreover, it requires a Dead Weight Tester System to obtain the factory calibration accuracy of 0.05% full scale.

COPYRIGHT STATEMENT
ABOUT THIS MANUAL
This manual will serve as a guide to you when you use the OCEAN SEVEN 316Plus probes.
❖ Use it to understand the purpose of each of the probe components and functions.
❖ It will help you to understand the probe behaviour.
❖ It will guide you through the probe capabilities.
❖ It will serve you as a reference when some problems arise when using the probe.

HOW TO USE THIS MANUAL
The following topics are covered by this manual:

Section 1  A description of the OCEAN SEVEN 316Plus probe.
Section 2  Installation and start-up operations.
Section 3  Data acquisition functions and data processing capabilities.
Section 4  Data storage functions.
Section 5  Sensor calibration functions.
Section 6  Service functions (configuration, diagnostics).
Section 7  Probe maintenance.
Section 8  Troubleshooting
Appendix A  Internal and external battery pack description.
Appendix B  Data Processing Function Priming.
Appendix C  Highly precise pressure transducer
Appendix D  Advanced configuration and telemetry.
Appendix E  GENERAL OCEANICS Rosette interfacing.
Appendix F  IDRONAUT Windows Terminal Emulation Programme.
Appendix G  Antifouling device.
Appendix H  Conductivity with Integrated UV-LED Antifouling.
Appendix I  Wireless “Bluetooth™” Interface.
Appendix J  Submersible connectors and cable care.
Appendix K  Sensor cleaning and care.
Appendix L  String and weight bottom sensor.
Appendix M  CT sensor pair forced flow.
Appendix N  BLUE CAP optical dissolved oxygen sensor.

GETTING STARTED
To become familiar with the OCEAN SEVEN 316Plus probe capabilities and operation, we suggest reading through sections 1 and 2. It is necessary to also read sections 3 and 5 and section 7 before starting to deploy the probe. The remaining sections and appendices could be consulted only when needed. If the probe is supplied with external sensors, , deck unit or the Idronaut Portable Reader, useful information can be found in each dedicated Operator’s Manual.

Operator’s Manuals of all IDRONAUT products and software can be found on the CD-ROM included with this product in the “Literature & Manuals\Operator Manual” folder.

NOTATIONAL CONVENTIONS
Throughout this manual, the following conventions are used to distinguish the various elements of the text:

[PROBE COMMANDS]  They always appear in uppercase and between [ ] or <> brackets.

Probe messages, user inputs  They always appear in italics.
DEFINITION OF TERMS
Throughout this manual, the following terms are used:

Cast
As a whole of the data set collected in the same way in a determined sampling point.

Data set
As a whole of configured parameters expressed in physical or chemical units and acquisition date and time, collected at programmed sampling interval, (i.e. once per second, once per depth increment).

Raw data – ADC Counts
As a whole set of data acquired by means of the ADC and the conditioning circuits, from the configured sensors and are expressed in numeric decimal or hexadecimal format.

Non-verbose mode
This term refers to a probe that has been configured to use a communication protocol (computer oriented) to communicate with the operator.

Verbose mode
This term refers to a probe that has been configured to use the MMI functions to communicate with the operator.

ON condition
This term refers to a fully operative probe, waiting for commands from the operator or running the requested command.

OFF condition
This term refers to a probe electronically switched off. In this state, the probe draws negligible amount of current from the battery.

MMI
This term refers to the set of common rules, which the operator must follow during the operation of probe in verbose mode.

FSK
Frequency Shift Keying.

QAM
Quadrature Amplitude Modulation.

IDRONAUT DOCUMENTS PERTAINING TO THE OCEAN SEVEN 316Plus
The following documents are available in the “Literature & Manual” folder on the CD-ROM distributed with the OCEAN SEVEN 316Plus CTD.

❖ OCEAN SEVEN Probes Data Transmission Protocol Description.
❖ IDRONAUT Deck Unit Operator’s & Installation manual.
❖ REDAS-5 Condensed Manual.

SOFTWARE UPDATES AND TECHNICAL SUPPORT
Please visit our website download area for software updates and technical support: http://www.idronaut.it

WARRANTY
The OCEAN SEVEN 316Plus probe is covered by a one-year limited warranty that extends to all parts and labour and covers any malfunction that is due to poor workmanship or due to errors in the manufacturing process. The warranty does not cover shortcomings that are due to the design, nor does it cover any form of consequential damage because of errors in the measurements. If there is a problem with your OCEAN SEVEN 316Plus, first try to identify the problem by following the procedure outlined in the troubleshooting section of this manual. Please contact your representative or IDRONAUT Sr.I. if the problem is identified as a hardware problem or if you need additional help in identifying the problem. Please make sure to contact IDRONAUT S.r.l. to obtain the relevant instructions before the OCEAN SEVEN 316Plus or any module is returned to IDRONAUT (see cleaning instructions).

For systems under warranty, IDRONAUT S.r.l. will attempt to ship replacement parts before the malfunctioning part is returned. We encourage you to contact us immediately if a problem is detected and we will do our best to minimize the downtime. Every effort has been made to ensure the accuracy of this manual. However, IDRONAUT S.r.l. makes no warranties with respect to this documentation and disclaims any implied warranties of merchantability and fitness for a particular purpose. IDRONAUT S.r.l. shall not be liable for any errors or for incidental or consequential damages in connection with the furnishing, performance or use of this manual or the examples herein. The information in this document is subject to change without
CLEANING INSTRUCTIONS
Before the returned OCEAN SEVEN 316Plus can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source. If an OCEAN SEVEN 316Plus probe, or other part is returned for service without following the cleaning instructions, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination has been completed.

When service is required, either at the user’s facility or at IDRONAUT, the following steps must be taken to insure the safety of our service personnel.

➢ In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1-gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with 5% Lysol if this is more convenient to the user.

➢ The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur. If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.

➢ Any product being returned to the IDRONAUT S.r.l. laboratory for service or repair should be packed securely to prevent damage.

➢ Cleaning must be completed on any product before returning it to IDRONAUT S.r.l.

DISPOSAL OF WASTE EQUIPMENT BY USERS IN THE EUROPEAN UNION
The recycling bin symbol on the product or on its packaging indicates that this product must not be disposed of with your other waste. It is your responsibility to dispose of your waste equipment by handling it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling, please contact your local city office, your waste disposal service.
# TABLE OF CONTENTS

1 INTRODUCTION ............................................................................................................. 1
1.1 PROBE DESCRIPTION ................................................................................................. 1
1.2 SAMPLING MODES ................................................................................................... 2
1.3 REAL-TIME COMMUNICATIONS ............................................................................... 2
1.4 WIRELESS COMMUNICATION MODULE "BLUETOOTH®" ........................................... 2
1.5 PORTABLE READER .................................................................................................. 3
1.6 IDRONAUT TELEMETRY DECK UNIT ......................................................................... 3
1.7 INTERNAL BATTERIES ............................................................................................... 4
1.8 EXTERNAL SUBMERSIBLE RECHARGEABLE BATTERY PACKS .................................... 4
1.9 MAGNETIC POWER ON/OFF SWITCH ........................................................................ 4
1.10 MANAGEMENT PROGRAMMES .................................................................................. 4
1.11 STANDARD SENSOR SPECIFICATIONS ...................................................................... 5
1.12 OPTIONAL SENSOR SPECIFICATIONS ....................................................................... 5
1.13 ELECTRONIC SPECIFICATIONS ............................................................................... 6
1.14 PHYSICAL CHARACTERISTICS .................................................................................. 6
1.15 THE STANDARD SENSORS ....................................................................................... 6
1.15.1 The pressure sensor ............................................................................................. 6
1.15.2 The temperature sensor ....................................................................................... 7
1.15.3 The conductivity sensor equipped with the "IDRONAUT seven-ring cell" ............. 7
1.15.4 The oxygen sensor (standard 150bar and 700 bar versions) .............................. 8
1.15.5 The oxygen sensor maintenance-free version - 5 bar only ............................... 10
1.15.6 The Blue cap optical oxygen sensor ................................................................. 10
1.15.7 pH and reference sensors .................................................................................... 10
1.15.8 The redox sensor ................................................................................................ 12
1.16 CALCULATIONS ......................................................................................................... 13
1.16.1 Oxygen ................................................................................................................ 13
1.16.2 pH calculation and pH correction in relation to the sample temperature .......... 13
1.16.3 Conductivity compensated at 20 °C .................................................................. 14
1.17 PROBE FIRMWARE OVERVIEW .............................................................................. 15
1.17.1 User interface ...................................................................................................... 15
1.17.2 Menu & submenu structure ................................................................................ 16
1.17.3 Menu header structure ....................................................................................... 16
1.17.4 Probe Access Rights ........................................................................................... 17
1.17.5 Data transmission protocol ............................................................................... 17
1.17.6 Point-to-point protocol ...................................................................................... 17
1.17.7 Field upgradeable firmware ............................................................................. 18
1.17.8 Acquired data processing and post-processing .................................................. 18
1.17.9 Low power consumption .................................................................................. 18
1.17.10 Configuration .................................................................................................... 18
2 INSTALLATION AND START UP .................................................................................. 23
2.1 SHIPPING LIST ........................................................................................................ 23
2.1.1 Laboratory RS232C cable ................................................................................... 23
2.2 INSTALLATION ......................................................................................................... 23
2.2.1 Internal and external battery packs ..................................................................... 23
2.2.2 Telemetry Deck Unit installation .......................................................... 23
2.3 START-UP ............................................................................................... 24
2.3.1 RS232C/RS485 interface - Probe power ON ........................................ 24
2.3.2 Telemetry interface Probe power ON .................................................. 24
2.3.3 Standard start-up messages ............................................................... 24
2.4 THE MAIN MENU ................................................................................... 25
2.5 LOW POWER CONSUMPTION .............................................................. 25
3 DATA ACQUISITION .................................................................................. 27
3.1 THE DATA ACQUISITION MENU .......................................................... 27
3.2 ACQUIRED PARAMETERS ..................................................................... 27
3.3 COMMON RULES TO SET UP THE DATA ACQUISITION CYCLE ........... 27
3.4 COMMON RULES TO STORE ACQUIRED DATA .................................. 28
3.5 ON-LINE ACKNOWLEDGEMENT ............................................................ 28
3.6 UNATTENDED ACKNOWLEDGEMENT .................................................. 28
3.7 UPLOADING DATA STORED IN THE PROBE MEMORY ......................... 28
3.8 UNATTENDED ACQUISITIONS – IMPORTANT TIPS ................................. 29
3.8.1 Power consumption reduction ............................................................ 29
3.8.2 Warm-up ............................................................................................ 29
3.8.3 ON/OFF cycles ................................................................................ 29
3.9 SHIPPING CONDITIONS ...................................................................... 29
3.10 SENSORS .............................................................................................. 29
3.11 MANUAL DATA ACQUISITION .............................................................. 29
3.12 LINEAR DATA ACQUISITION .............................................................. 30
3.12.1 Routine operations to perform unattended linear profiles ..................... 31
3.12.2 Terminate the unattended linear profile ............................................. 31
3.12.3 Step-by-step Linear Profile procedure .............................................. 31
3.13 TIMED DATA ACQUISITION ............................................................... 32
3.13.1 Terminate a timed data acquisition ................................................... 34
3.13.2 Automatic power OFF procedure ..................................................... 34
3.13.3 Accidental power ON cycle ............................................................... 35
3.13.4 Magnetic power ON/OFF switch ...................................................... 35
3.13.5 Step-by-step procedure .................................................................. 35
3.14 PROGRAMMED DEPTH DATA ACQUISITION .................................... 36
3.14.1 Preset profiles .................................................................................. 36
3.15 CONDITIONAL DATA ACQUISITION ................................................ 37
3.15.1 Terminate the Conditional data acquisition ...................................... 38
3.16 CONTINUOUS DATA ACQUISITION .................................................. 39
3.16.1 Terminate the Continuous data acquisition ....................................... 40
4 DATA STORAGE ......................................................................................... 41
4.1 MEMORY ORGANIZATION .................................................................... 41
4.1.1 Cast area .......................................................................................... 41
4.1.2 Data records .................................................................................... 41
4.1.3 Data Sets .......................................................................................... 42
4.2 MEMORY MANAGEMENT ..................................................................... 42
4.3 SHOW MEMORY STATUS .................................................................... 42
4.4 SHOW STORED DATA ......................................................................... 43
4.5 SRAM MEMORY DELETE DATA ........................................................... 44
4.6 FLASH MEMORY DELETE DATA .......................................................... 44
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.7</td>
<td>INITIALIZE DATA MEMORY</td>
</tr>
<tr>
<td>5</td>
<td>SENSOR CALIBRATION</td>
</tr>
<tr>
<td>5.1</td>
<td>CALIBRATION STORING LAYOUT</td>
</tr>
<tr>
<td>5.1.1</td>
<td>Parameter/Sensor logical codes</td>
</tr>
<tr>
<td>5.2</td>
<td>CALIBRATION GLP (GOOD LABORATORY PRACTICE)</td>
</tr>
<tr>
<td>5.3</td>
<td>SENSOR CALIBRATION FUNCTIONS</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Updating the calibration information</td>
</tr>
<tr>
<td>5.4</td>
<td>CALIBRATE THE SENSORS</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Selecting a wrong sensor</td>
</tr>
<tr>
<td>5.5</td>
<td>CUSTOMIZED CALIBRATION PROCEDURE</td>
</tr>
<tr>
<td>5.5.1</td>
<td>Pressure sensor</td>
</tr>
<tr>
<td>5.5.2</td>
<td>Temperature &amp; Conductivity sensor calibration</td>
</tr>
<tr>
<td>5.5.3</td>
<td>Simple check of conductivity sensor calibration</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Oxygen sensor calibration</td>
</tr>
<tr>
<td>5.5.5</td>
<td>Blue cap optical dissolved oxygen sensor calibration</td>
</tr>
<tr>
<td>5.5.6</td>
<td>pH sensor calibration</td>
</tr>
<tr>
<td>5.5.7</td>
<td>Redox sensor calibration</td>
</tr>
<tr>
<td>5.6</td>
<td>OTHER CALIBRATION PROCEDURES</td>
</tr>
<tr>
<td>5.6.1</td>
<td>SEAPoint OEM Turbidity Meter</td>
</tr>
<tr>
<td>5.6.2</td>
<td>SEAPoint OEM Fluorometer</td>
</tr>
<tr>
<td>5.6.3</td>
<td>WETLabs - C-STAR Transmissometer</td>
</tr>
<tr>
<td>5.6.4</td>
<td>WETLabs - ECO Triplet Sensor</td>
</tr>
<tr>
<td>5.6.5</td>
<td>LICOR - PAR Sensor</td>
</tr>
<tr>
<td>5.6.6</td>
<td>Trilux/Unilux single/three-channel Fluorimeter</td>
</tr>
<tr>
<td>5.6.7</td>
<td>TURNER DESIGNS – CYCLOPS-7/CFLUOR calibration coefficients</td>
</tr>
<tr>
<td>5.7</td>
<td>CUSTOMIZE CALIBRATION DATA</td>
</tr>
<tr>
<td>5.8</td>
<td>CALIBRATING LOGGING</td>
</tr>
<tr>
<td>6</td>
<td>SERVICE, DIAGNOSTICS AND CONFIGURATION</td>
</tr>
<tr>
<td>6.1</td>
<td>THE SERVICE MENU</td>
</tr>
<tr>
<td>6.1.1</td>
<td>Raw data acquisition in ADC counts or mV</td>
</tr>
<tr>
<td>6.1.2</td>
<td>Firmware updating</td>
</tr>
<tr>
<td>6.1.3</td>
<td>Probe diagnostic functions</td>
</tr>
<tr>
<td>6.1.4</td>
<td>Probe configuration</td>
</tr>
<tr>
<td>7</td>
<td>PROBE MAINTENANCE</td>
</tr>
<tr>
<td>7.1</td>
<td>OXYGEN SENSOR</td>
</tr>
<tr>
<td>7.1.1</td>
<td>Important remark on oxygen measurement</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Green membrane</td>
</tr>
<tr>
<td>7.1.3</td>
<td>Refilling oxygen sensor cap with electrolyte</td>
</tr>
<tr>
<td>7.1.4</td>
<td>Membrane replacement (oxygen membrane cap)</td>
</tr>
<tr>
<td>7.1.5</td>
<td>Replacement of membrane(s) using the OXYGEN SENSOR MAINTENANCE KIT</td>
</tr>
<tr>
<td>7.1.6</td>
<td>Oxygen sensor cleaning</td>
</tr>
<tr>
<td>7.1.7</td>
<td>Oxygen sensor check in the absence of oxygen</td>
</tr>
<tr>
<td>7.2</td>
<td>REFERENCE SENSOR</td>
</tr>
<tr>
<td>7.3</td>
<td>pH SENSOR</td>
</tr>
<tr>
<td>7.3.1</td>
<td>Important remark on the pH measurement</td>
</tr>
<tr>
<td>7.4</td>
<td>CONDUCTIVITY SENSOR</td>
</tr>
<tr>
<td>7.4.1</td>
<td>Important remarks on conductivity measurement</td>
</tr>
<tr>
<td>7.4.2</td>
<td>Conductivity sensor cleaning</td>
</tr>
</tbody>
</table>
7.5 REDOX SENSOR .................................................................................................................. 80
7.6 TEMPERATURE SENSOR ...................................................................................................... 81
7.7 PRESSURE SENSOR .............................................................................................................. 81
7.8 BATTERY ENDURANCE AND RECHARGE ............................................................................ 81
7.8.1 Internal battery pack endurance ..................................................................................... 82
7.8.2 Oxygen sensor polarization battery ............................................................................... 82
7.8.3 Data Memory and RTC battery ....................................................................................... 82
7.9 ROUTINE MAINTENANCE SCHEDULE ............................................................................... 83
8 TROUBLESHOOTING .............................................................................................................. 84
D.2.1 Hardware set-up .............................................................................................................. 95
D.2.3 Software set-up – QAM Modem board Rev. 1 ................................................................. 100

APPENDIX

Appendix A Internal and external battery pack description .................................................. 85
Appendix B Data Processing Function Priming ....................................................................... 90
Appendix C Highly precise pressure transducer ..................................................................... 92
Appendix D Advanced configuration and telemetry ................................................................. 94
Appendix E Rosette interfacing .............................................................................................. 103
Appendix F IDRONAUT Windows Terminal Emulation Programme ........................................ 110
Appendix G Antifouling device ............................................................................................... 115
Appendix H Conductivity with Integrated UV-LED Antifouling ............................................ 117
Appendix I Wireless “Bluetooth™” Interface ........................................................................ 118
Appendix J Submersible connectors and cable care ............................................................... 119
Appendix K Sensor cleaning and care ..................................................................................... 122
Appendix L String and weight bottom sensor ......................................................................... 125
Appendix M CT sensor pair forced flow .................................................................................. 126
Appendix N BLUE CAP optical dissolved oxygen sensor ...................................................... 127
INTRODUCTION
This section describes the main components of the OCEAN SEVEN 316Plus CTD multiparameter probe.

1.1 PROBE DESCRIPTION
The OCEAN SEVEN 316Plus CTD multiparameter probe is the evolution of the well-known OCEAN SEVEN 316 probe (more than 1000 units sold all over the world). The complete restyling of the probe electronics and the built-in 18-bit digitizer give the OCEAN SEVEN 316Plus very advanced performance and better CTD sensor resolution and accuracy with respect to the original OCEAN SEVEN 316. The OCEAN SEVEN 316Plus is equipped with the well-known and proven IDRONAUT pressure balanced full ocean depth, pump free and long-term stability sensors. Central to which, is the high accuracy seven-platinum-ring conductivity sensor, which can be cleaned in the field without the need for re-calibration. For added flexibility, the OCEAN SEVEN 316Plus CTD multi parameter probe can be operated in either verbose or non-verbose modes, the latter being especially convenient for system integrations on buoys data loggers, ROVs and AUVs, making this CTD an ideal choice for both on-line profiling and self-recording moored applications.

Data is output using the standard RS232C interface or the telemetry option available for on-line full ocean depth real-time data transmission. Other interfaces like RS422 and Wireless Bluetooth can be optionally installed.

The OCEAN SEVEN 316Plus CTD multiparameter probe can also optionally accommodate up to a maximum of 16 sensor analogue inputs, including 2 digital inputs, which can be added later, if required. Two external connectors, located on the top cap, provide for optional external power supplies and data exchange with a suitable surface system. Also, on the top cap, a stainless-steel eyebolt is provided with which to attach the probe to a cable. On the opposite end, the sensor area is protected against accidental damage by a titanium cage. Optional copper screens can be fitted to the probe body to limit biofouling in situations where the probe will remain immersed for extended periods of time (see description in the dedicated appendix). The response time is 50ms for the CTD sensors and 3s for oxygen, pH and redox.

Software compensation is provided for changes in the internal temperature of the probe, in order to guarantee both high performance and long-term stability. The electronic boards are fitted in a sealed housing made of either PPS white plastic or AISI316 Stainless Steel or Titanium, depending on pressure and weight requirements.

The OCEAN SEVEN 316Plus CTD in its basic configuration is equipped with three sensors: pressure, temperature and conductivity. Other bulkhead sensors can be optionally added, like: highly precise pressure transducer (0.01%), dissolved oxygen, pH, redox, reference electrode and the OEM Seapoint Turbidity Meter. Oxygen concentration in ppm, salinity, density, sound velocity and other derived parameters are automatically calculated according to UNESCO recommendations and formulae.

It is possible to interface external sensors or equipment like: current meters, altimeters, fluorometers, transmissometers, PAR sensors, Rosette sampling systems, etc. The following equipment is currently interfaced:

- GENERAL OCEANICS - Rosettes mod. 1018 and 1015.
- SBE-32 CAROUSEL
- IDRONAUT – MISS Miniaturized Sampling System
- IDRONAUT – High precision 0.01% pressure transducer.
- IDRONAUT - String and Weight Bottom Sensor.
- WET Labs - C-Star Transmissometer and ECO single/three channel Fluorometer.
- CHELSEA - Unilux and Trilux Fluorometers.
- SEAPoint - Fluorometers and Turbidity Meter.
- TURNER DESIGNS – Cyclops-7 Fluorometers.
- D & A INSTRUMENT COMPANY - OBS-3 Sensor.
SECTION ONE – SYSTEM DESCRIPTION

- BIOSPHERICAL INSTRUMENTS - QSP-2200 – QSP-2300 Quantum Scalar PAR Sensor.
- VALEPORT - MiniSVS Sound Velocity Sensors.
- DATASONICS - PSA916D Sonar Altimeter, 6000 m.
- METS – Methane sensor
- SUNA - Nitrate sensor

*Other equipment, sensors or CTDs can be interfaced upon request.*

1.2 SAMPLING MODES

The probe is microprocessor-controlled and can be programmed to acquire and process data by various different methods. Processed or raw data can be either transmitted in real time or stored inside the instrument. Data acquisition methods includes:

- **Pressure**. Data is sampled at regular pressure intervals. Multiple profiles can be obtained by switching the probe ON and OFF.
- **Timed**. The probe collects a series of samples and then sleeps for the configured time interval before waking up again and repeating the acquisitions. Time interval can be configured from 0.1s up to 1 day. Battery power is conserved while the probe is in sleep mode.
- **Conditional**. Data is sampled at configurable sampling rates starting when the selected parameter overcomes the configured boundary. Sampling continues until the selected parameter falls below the configured boundary. Whenever the acquisition cycle starts, a configurable sampling rate 0.1..12 Hz is used. Monitoring of the selected parameter occurs at the configurable interval between 0.1s up to 1 day.
- **Continuous**. Data is sampled at configurable sampling rates starting when the operator switches on the probe. Sampling continues until the probe is switched off. Multiple cycles can be obtained by switching the CTD ON and OFF.
- **Real-time**. Data is sent to the control system at sampling rates of: **12 Hz and 20 Hz using REDAS5 software**.

The slender profile of the probe and the pressure-compensated sensor suite permit operation in either high speed profiling or in fixed depth monitoring applications to full ocean depths.

1.3 REAL-TIME COMMUNICATIONS

The OCEAN SEVEN 316 Plus CTD multiparameter probe communicates with a computer via a standard RS232C interface. Real-time data can be acquired by means of the REDAS-5 Windows software. An optional RS422/485 interface overcomes the limitation of the RS232C cable maximum length (200 m) and allows the probe to transmit data through distances up to 1000 m. The communication speed is user selectable among: 9600, 19200, and 38400. The probe can also be equipped with the IDRONAUT telemetry, which overcomes the cable limitations and allows the real-time communication with the probe through the standard oceanographic coaxial cables. It is important to mention that the OCEAN SEVEN 316 Plus CTD is insulated with respect to the communicating device, independently of the kind of interface that is used: RS232C, RS485, Telemetry. Insulation guarantees that the sensors are not affected or disturbed by ground loops or stray currents.

<table>
<thead>
<tr>
<th>Connection type</th>
<th>Max cable length</th>
<th>Max. transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS232C</td>
<td>200 m</td>
<td>38k4 bps</td>
</tr>
<tr>
<td>RS422/485</td>
<td>1000 m</td>
<td>38k4 bps</td>
</tr>
<tr>
<td>Telemetry</td>
<td>10000 m</td>
<td>14k4 bps</td>
</tr>
</tbody>
</table>

The above performance is obtained using the 6.4 mm diameter (1/4 inch) Rochester cable 1-H-255 which has an electrical resistance of 23 Ω/km and a capacity of 138 pF/m.

1.4 WIRELESS COMMUNICATION MODULE "BLUETOOTH®"

The OCEAN SEVEN 316 Plus probe can be optionally equipped with a Bluetooth® module which allows bidirectional full-duplex communications between the OCEAN SEVEN 316 Plus probe and a personal computer (Desktop, Laptop) or PDA devices equipped with a compatible Bluetooth® device. The wireless module is formed by a Bluetooth® OEM module mounted inside the OCEAN SEVEN 316 Plus probe housing and is designed to provide an interface conforming to the Bluetooth® v1.1 class 1. The
operating range of the adapter is specified in 100m although line-of-sight ranges of 300m can be achieved. However, if a class-2 Bluetooth® device is used to communicate with the OCEAN SEVEN 316Plus, then the range will be limited to 10-20m as foreseen by class-2 devices. The OCEAN SEVEN 316Plus Bluetooth Module allows instant wireless connectivity to any device supporting a compatible Bluetooth® SPP protocol. The connection with the OCEAN SEVEN 316Plus probe among the Bluetooth® devices registered on the network is guaranteed by means of the unique 8-digit PIN code, which identifies each OCEAN SEVEN 316Plus probe.

1.5 PORTABLE READER

The OCEAN SEVEN 316Plus probe can be interfaced with a portable lightweight and extremely rugged reader based on a high-performance Intel® XScale™ processor and on the Windows Mobile™ software for Pocket PC. Through this device, it is possible to perform the operations usually carried out by means of a portable personal computer, but without all limitations that the use of a portable computer in the field and in hostile environments normally implies, like: battery endurance, display reading under sunlight, water and dust tightness, weight, etc. The “Portable Reader” interfaces the OCEAN SEVEN 316Plus probe through a built-in RS232C interface and dedicated IDRONAUT programmes, specifically developed for the Windows Mobile PC operating system: ZTERM and µREDAS. These programmes interface the OCEAN SEVEN 316Plus probe and allow the operator to directly dialogue with the probes directly, thus performing: sensor calibration, real-time data acquisition, probe configuration, etc. All these operations are possible because of the OCEAN SEVEN 316Plus probe functions included in the management firmware. Furthermore, the “Portable Reader” not only shows real-time data sent by the OCEAN SEVEN 316Plus probe, but also stores it. Data is stored in binary files using the “Portable Reader” main or extension “Flash” memory, which can be later transferred to a desktop personal computer using the Microsoft ActiveSync programme. Data acquired by means of the “µREDAS” programme can be imported later on by the REDAS5 programme. Data storage capability of the “Portable Reader” is only limited by the size of the installed “Flash” compact memory card. The “Portable Reader” can operate for up to 15 hours continuously. Autonomy of operation of the interfaced OCEAN SEVEN 316Plus probe depends on the battery installed inside the probe and on the probe sensor suite.

1.6 IDRONAUT TELEMETRY DECK UNIT

The IDRONAUT Telemetry Deck Unit powers and interfaces, by coaxial oceanographic cables, the OCEAN SEVEN 316Plus probe with a personal computer RS232C interface. The Deck Unit is provided with a transceiver (modem) which allows half-duplex communication with the OCEAN SEVEN 316Plus probe. Two types of Deck Units are available: Portable and On-Board. The first one is provided with an internal mains rechargeable lead battery (12VDC, 7 A/h) which permits OCEAN SEVEN 316Plus probe operation even in the absence of the mains supply. The On-Board MKPlus Deck Unit is housed in a 19” rack-mountable unit and is designed for on-board operations. The On-Board MKPlus Deck Unit provides high voltage telemetry power supply: 220 VDC to allow the OCEAN SEVEN 316Plus probe to interface and power several additional power-hungry instruments like: GENERAL OCEANICS Rosette,
**SECTION ONE – SYSTEM DESCRIPTION**

Altimeter, Fluorometer, Transmissometer, etc.

1.7 **INTERNAL BATTERIES**

The OCEAN SEVEN 316Plus probe housing has in its upper part enough space to accommodate an internal battery pack (The battery pack cannot be installed if the optional data telemetry is installed). This is used whenever the probe performs unattended acquisition cycles without the connection in real time with a surface unit (PC). The internal rechargeable battery pack contains 12 (twelve) batteries: 1.2 V 2.85Ah, NiMH cells. The battery pack comes complete with an international battery charger.

When the probe is not used for long periods (e.g. 2 weeks or more), we suggest disconnecting the internal battery pack connector from the probe electronics or removing the internal battery pack from the probe to prevent the internal batteries from damaging the probe due to battery acid leakage. This is why the OCEAN SEVEN 316Plus is shipped without batteries installed. Please be aware that **it is not possible to recharge them when they are installed inside the probe**.

1.8 **EXTERNAL SUBMERSIBLE RECHARGEABLE BATTERY PACKS**

To overcome the limited autonomy of the internal battery pack, IDRONAUT developed two external submersible rechargeable battery packs that considerably increase the probe operating autonomy. Both battery packs accept no. 12 cells - 1.2VDC NiMH type HR-4/3FAU10 for a total of 14.4VDC and 4.5 Ah.

The following battery packs are available:

- External submersible rechargeable battery pack (Ø 75 x 315 mm), 1500 m max depth operation.
- External submersible rechargeable battery pack (Ø 66 x 315 mm), 7000 m max depth operation.

The external battery pack is held by the probe by means of POM flanges and connected to the RS232C input/output bulkhead connector by means of a submersible cable.

**Note**

The presence of the external battery pack does not interfere with the installation of the internal battery pack. The CTD drains energy from the higher voltage battery pack.

1.9 **MAGNETIC POWER ON/OFF SWITCH**

The OCEAN SEVEN 316Plus probe is equipped with a magnetic power ON/OFF switch, which allows the operator to effectively switch ON and OFF the probe. The probe is also able to switch on and off by itself whenever it performs self-recording acquisition cycles and uses the internal and/or external battery pack. The magnetic power ON/OFF switch is not used and is bypassed when the probe is used with data telemetry (please remove the internal batteries, if any, before operating the probe through the telemetry system). This switch also allows the operator to easily deploy a probe that is pre-configured to perform unattended data acquisition cycles and which will be switched ON by means of the power ON/OFF switch. When switching ON/OFF the probe by means of the magnetic switch, **please wait at least 60 seconds** between consecutive ON/OFF cycles.

1.10 **MANAGEMENT PROGRAMMES**

IDRONAUT programmes designed for the Windows 32/64bit operating systems allow the operator to communicate with the OCEAN SEVEN 316Plus probe to perform attended or unattended data acquisitions. Programmes include functions to upload data from the 512-MByte internal memory when the probe acts as a logger. The available programmes are:

**WTERM:**

**ITERM:**  IDRONAUT terminal emulation and probe management program to easily communicate with the OCEAN SEVEN 316Plus CTD multiparameter probe. Diagnostic and dedicated functions are included.

**ZTERM:**  Terminal emulation program for Windows Mobile Operating system. Terminal emulation program to easily communicate with the OS316Plus CTD multiparameter probe.
**uREDAS**  IDRonaUT real-time data acquisition software for Windows Mobile operating system. It allows acquiring and displaying data in real time storing it for later retrieval and processing using REDAS5 program. While acquiring, up to six different parameters are shown on screen.

**REDAS5**: Real-time data acquisition, processing and presentation programme, which allows the numerical display and plotting of the standard sensors and the derived variables such as salinity, sound speed, density, according to the UNESCO formulas and recommendations.

**MULTIPLEX**: Multiplex programme, which allows the acquisition from up to 16 OCEAN SEVEN 316Plus CTDs connected to a single personal computer. Data acquired in real time by means of the Multiplex programme can be later processed using the REDAS5 programme.

### 1.1 STANDARD SENSOR SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Initial Accuracy</th>
<th>Resolution</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>0.. 1000 dbar*</td>
<td>0.05% F.S.</td>
<td>0.002% F.S.</td>
<td>50 ms</td>
</tr>
<tr>
<td>Temperature</td>
<td>-3.. +50 °C</td>
<td>0.003 °C</td>
<td>0.0002 °C</td>
<td>50 ms</td>
</tr>
<tr>
<td>Conductivity</td>
<td>0.. 70 mS/cm</td>
<td>0.003 mS/cm</td>
<td>0.0003 mS/cm</td>
<td>50 ms*</td>
</tr>
<tr>
<td>Oxygen (polarographic)</td>
<td>0.. 50 ppm</td>
<td>0.1 ppm</td>
<td>0.01 ppm</td>
<td>3 s**</td>
</tr>
<tr>
<td>Oxygen (optical)</td>
<td>0.. 500 % sat.</td>
<td>1 % sat.</td>
<td>0.1 % sat.</td>
<td>3 s**</td>
</tr>
<tr>
<td>pH</td>
<td>0.. 14 pH</td>
<td>0.01 pH</td>
<td>0.001 pH</td>
<td>3 s</td>
</tr>
<tr>
<td>Redox</td>
<td>+/-1000 mV</td>
<td>1 mV</td>
<td>0.1 mV</td>
<td>3 s</td>
</tr>
<tr>
<td>Auxiliary inputs **</td>
<td>0..5000 mV</td>
<td>1 mV</td>
<td>0.1 mV</td>
<td>50 ms</td>
</tr>
</tbody>
</table>

* other standard pressure transducers, immediately available, have 10, 40, 100, 200, 500, 2000, 4000, 6000, 10000 dbar ranges.
+ at 1 m/second flow rate  ++ from nitrogen to air.
*6 auxiliary analogue inputs.

The fundamental properties of seawater, like:

**Salinity, Sound Speed, Water Density, Oxygen ppm** are automatically calculated using the algorithms described in the UNESCO technical papers in marine science no. 44 "Algorithms for computation of fundamental properties of seawater".

The freshwater properties, like:

**TDS (Total Dissolved Solids), Fresh Water Conductivity** corrected at 20°C and 25°C are automatically calculated.

### 1.12 OPTIONAL SENSOR SPECIFICATIONS

Among others, the OCEAN SEVEN 316Plus CTD can be optionally equipped with the Highly Accurate Precise (0.01%) Pressure Transducer, the optical IDRonaUT OEM SEAPoint Turbidity and Fluorometer sensors, the IDRonaUT OEM CHELSEA Single-Channel and Three-Channel Fluorimeters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Initial Accuracy</th>
<th>Resolution</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (1)</td>
<td>0..10000 dbar</td>
<td>0.01% F.S.</td>
<td>0.002% F.S.</td>
<td>50 ms</td>
</tr>
<tr>
<td>Turbidity Meter (2)</td>
<td>0.03.. 25 FTU/NTU</td>
<td>0.05 FTU/NTU</td>
<td>0.005 FTU/NTU</td>
<td>0.1 s</td>
</tr>
<tr>
<td>0.03.. 125 FTU/NTU</td>
<td>0.25 FTU/NTU</td>
<td>0.025 FTU/NTU</td>
<td>0.1 s</td>
<td></td>
</tr>
<tr>
<td>0.03.. 500 FTU/NTU</td>
<td>1 FTU/NTU</td>
<td>0.1 FTU/NTU</td>
<td>0.1 s</td>
<td></td>
</tr>
<tr>
<td>0.03.. 750 FTU/NTU</td>
<td>5 FTU/NTU</td>
<td>0.5 FTU/NTU</td>
<td>0.1 s</td>
<td></td>
</tr>
<tr>
<td>0.03..4000 FTU/NTU</td>
<td>5 FTU/NTU</td>
<td>0.5 FTU/NTU</td>
<td>0.1 s</td>
<td></td>
</tr>
</tbody>
</table>

(1) autre

(2) autres
SECTION ONE – SYSTEM DESCRIPTION

** output is non-linear above 750 FTU/NTU
*** output is non-linear above 1250 FTU/NTU
Please contact Idronaut to get the correct range.

<table>
<thead>
<tr>
<th>Fluorometer</th>
<th>0.02..5 µg/l</th>
<th>0.05 µg/l</th>
<th>0.002 µg/l</th>
<th>0.1 s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.02..15 µg/l</td>
<td>0.1 µg/l</td>
<td>0.006 µg/l</td>
<td>0.1 s</td>
</tr>
<tr>
<td></td>
<td>0.02..50 µg/l</td>
<td>0.5 µg/l</td>
<td>0.02 µg/l</td>
<td>0.1 s</td>
</tr>
<tr>
<td></td>
<td>0.02..150 µg/l</td>
<td>1 µg/l</td>
<td>0.06 µg/l</td>
<td>0.1 s</td>
</tr>
</tbody>
</table>

Chlorophyll-a (340) 0.100 µg/l < 0.01 µg/l
Fluorescein (340) 0.100 µg/l < 0.005 µg/l
Rhodamine WT (340) 0.100 µg/l < 0.02 µg/l
Phycoerythrin (340) 0.100 µg/l < 0.02 µg/l
Phycocyanin (340) 0.100 µg/l < 0.01 µg/l
Nephelometer/Turb. (340) 0..100 FTU < 0.02 FTU

Notes
1 - Available ranges are: 100, 1000, 3000, 4000, 7000 and 10000 dbar.
2 - Specifications refer to the IDRONAUT OEM SEAPOINT Turbidity meter and Fluorometer.
3 - Specifications refer to the IDRONAUT OEM Single-channel and Three-channel Chelsea Fluorimeters. The Three-channel fluorimeter can accommodate the following parameters: Chlorophyll a, Turbidity, Phycocyanin, Phycoerythrin, in a single sensor.
4 - User configurable up to 500 µg/L or 500 FTU.

1.13 ELECTRONIC SPECIFICATIONS
Sampling rate: user selectable: 12 and 20 Hz raw data CTD using REDAS5 software.
Communication protocol: proprietary binary and plain message protocol.
Operator interface: friendly menu-driven user interface.
Data memory: 2-Gbyte non-volatile memory.
Battery power supply: 9 .. 18 V, 150 mA @ 12 V.

1.14 PHYSICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Dimensions:</th>
<th>1500 dbar</th>
<th>1500 dbar</th>
<th>7000 dbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>housing diameter:</td>
<td>100 mm</td>
<td>75 mm</td>
<td>89 mm</td>
</tr>
<tr>
<td>total length:</td>
<td>710 mm</td>
<td>685 mm</td>
<td>760 mm</td>
</tr>
<tr>
<td>Weight:</td>
<td>4.2 kg</td>
<td>4.0 kg</td>
<td>8.0 kg</td>
</tr>
<tr>
<td>in air:</td>
<td>0.2 kg</td>
<td>1.7 kg</td>
<td>4.3 kg</td>
</tr>
<tr>
<td>in water:</td>
<td>white POM</td>
<td>black POM/ AISI316L</td>
<td>TITANIUM GR5</td>
</tr>
</tbody>
</table>

Diameter of protective cage/s: 260 mm, titanium.

1.15 THE STANDARD SENSORS
This section provides a detailed presentation of the OCEAN SEVEN sensors.

1.15.1 The pressure sensor
The pressure sensor is a high quality strain gauge, centrally mounted on the probe base, capable of generating a linear signal output, thus giving a resolution of 0.03% over the whole measuring range of 0 - 10000 dbar
SECTION ONE – SYSTEM DESCRIPTION

Type: strain gauge
Measurement range: 0..10000 dbar
Initial Accuracy: 0.05%FS
Resolution 0.002%FS
Response time: 50 ms
Measurement bridge resistance: @ 25°C Ω 3500 ± 20%
Excitation current: 0.6 mA
Insulation: @ 50 VCC MΩ 100
Operating temperature: °C -30…100
Sensor body: AISI 316L
Compensation: automatic compensation for temperature variations; not compensated for the barometric pressure variations.
Calibration frequency: yearly.
Maintenance: offset calibration in air.

1.15.2 The temperature sensor
The temperature sensor consists of a platinum resistance thermometer (type Pt 100 ohms at 0°C), fitted on a thin stainless steel housing, able to withstand up to 700 bar. The sensor has a very low response time (50 ms) and a high stability of reading with ageing. The drift of reading (sensor plus associated electronics) is less than 0.0003 °C per year.

Type: Pt100@0°C
Measurement range: -3..+50 °C
Initial Accuracy: 0.003 °C
Resolution: 0.0002 °C
Response time: 50 ms @1 m/s
Maximum pressure: 700 bar
Sensor body: AISI 316L
Calibration frequency: yearly
Compensation: none.
Maintenance: none.

1.15.3 The conductivity sensor equipped with the "IDRONAUT seven-ring cell"
The conductivity sensor is a unique flow-through self-flushed cell with seven platinum ring electrodes. The central ring is excited with alternate current flowing to both the outermost rings. The two adjacent pairs of rings sense the relative drop in voltage due to the electrical conductivity of the measured water. The outermost pair of rings is grounded to shield the measuring cell from any outside electrical interference. The cell is mounted in a special cylindrical plastic body, which guarantees thermic insulation and is filled with silicone oil and provided with a rubber bellow to achieve pressure compensation.
The IDRONAUT conductivity sensor and its associated electronics are designed to work both with plain and black platinised platinum electrodes. These electrodes have the advantage that, they can be used in both clean and dirty water without the fear of contamination. Should electrode contamination occur, they can be easily cleaned without affecting the CTD performance or requiring re-calibration. Because of its big internal diameter and short length, the cell does not need a pump, as it is easily flushed during profiles.
The other conductivity flow cell sensors available on the market do not have the technology of the “IDRONAUT seven-ring cell”.
The small, closely spaced temperature and conductivity free-flow sensors eliminate the need for adding pumping. Response time of the conductivity sensor is 50 ms, at 1 meter per second water flow.
Measurement cell: 7 platinum rings deposited inside a quartz tube. Internal diameter 8mm, length 45mm.

Measurement range: 0.70 mS/cm
Initial Accuracy: 0.003 mS/cm
Resolution: 0.0003 mS/cm
Response time: 50 ms @1 m/s
Max pressure: 700 bar
Sensor body: black plastic and titanium
Compensation: automatic compensation of the pressure and thermal effect on the cell geometry are performed by the acquisition software.

Calibration frequency: yearly.
Maintenance: cleaning using the liquid soap

1.15.4 The oxygen sensor (standard 150 bar and 700 bar versions)

The oxygen sensor is of the polarographic type and consists of two half-cells, the anode and the cathode. The anode is a silver tube inside the sensor, which encircles a glass body where a platinum wire, forming the cathode, is sealed. The platinum wire (cathode) ends at the tip of the sensor where the glass body is rounded. A special membrane cap with a gas-permeable replaceable membrane screws onto the sensor. The inside of the cap is filled with a special electrolyte which allows the current (measuring) to flow between the anode and the cathode. The membrane is shielded from accidental bumps by a protective ring. 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 sample to be analyzed by a thin layer of electrolyte and a special composite membrane. The electrolyte permits the chemical reaction to occur whereas the membrane constitutes a barrier against ions and other substances. By applying a polarizing voltage to the half-cells, the sensor develops a current proportional to the concentration of oxygen in the sample in front of the cathode. Oxygen from the sample is drawn across the membrane, at the sensor tip, in the area of the cathode. The applied polarization voltage is such that the sensor only responds to oxygen. The sensor is insensitive to nitrogen, nitrous oxide, carbon dioxide and other gases. In order to avoid stray ground current leaks, in case of membrane leaks, the anode is kept at ground potential while the cathode is polarized at a fixed negative voltage. The oxygen sensor limits stirring effects on the measurement and reads at least 97% of the true value, even with a stagnant aqueous sample. This is because the very small cathode area and special cathode geometry, associated with a unique composite membrane, minimize the consumption of the oxygen contained in the sample in contact with the membrane. The function of this sensor depends on the reduction of oxygen at the cathode, as expressed by the formula:

\[ \text{O}_2 + 2 \text{H}_2\text{O} + 4e^- \rightarrow 4 \text{OH}^- \]

The developed electrons represent the measuring current and are supplied by the silver/silver chloride anode.
**Standard version, 150 bar**

*Type:* polarographic with Pt/Ir cathode and Ag(99.99%) anode.

*Measurement range:* 0... 50 ppm 0... 500% sat.

*Initial Accuracy:* 0.1 ppm 1 % sat.

*Resolution:* 0.01 ppm 0.1% sat.

*Polarization voltage:* 650 mV DC.

*Response time:* 3s

*Max Pressure:* 150 bar.

*Sensor body:* plastic and titanium.

*Compensation:* automatic compensation of pressure and thermal variations.

*Life:* 2 years if intensively used to perform continuous monitoring, up to 4 years if used weekly to perform daily profiling or monitoring.

*Calibration frequency:* weekly.

*Maintenance:* measuring membrane replacement, electrolyte replacement.

---

**Standard version 700 bar**

*Type:* polarographic with Pt/Ir cathode and Ag(99.99%) anode.

*Measurement range:* 0... 50 ppm 0... 500% sat.

*Initial Accuracy:* 0.1 ppm 1 % sat.

*Resolution:* 0.01 ppm 0.1% sat.

*Polarization voltage:* 650 mV DC.

*Response time:* 3s

*Max Pressure:* 700 bar.

*Sensor body:* titanium.

*Compensation:* automatic compensation of pressure and thermal variations.

*Life:* 2 years if intensively used to perform continuous monitoring, up to 4 years if used weekly to perform daily profiling or monitoring.

*Calibration frequency:* weekly.

*Maintenance:* measuring membrane replacement, electrolyte replacement.
1.15.5 The oxygen sensor maintenance-free version - 5 bar only

Type: polarographic with Pt/Ir cathode and Ag(99.99%) anode

Measurement range: 0... 50 ppm 0... 500% sat.

Initial Accuracy: 0.1 ppm 1 % sat.

Resolution: 0.01 ppm 0.1% sat.

Polarization voltage: 650 mV DC

Response time: 30 s

Max Pressure: 5 bar

Sensor body: black plastic (PPS)

Compensation: automatic compensation of pressure and thermal variations.

Life: 2 years if intensively used to perform continuous monitoring, up to 4 years if used weekly to perform daily profiling or monitoring.

Calibration frequency: weekly.

Maintenance: maintenance free.

1.15.6 The Blue cap optical oxygen sensor

A detailed description of the IDRONAUT optical dissolved oxygen sensor can be found in appendix N.

1.15.6.1 Oxygen measurement priming

The OCEAN SEVEN 316Plus CTD allows the operator to obtain the oxygen data either expressed in ppm or % Saturation. The formula which connects these two functions is given as by:

$$
\text{ppm} = \text{Saturation} \times \text{Solubility} / 100
$$

The relevant formulae for the computation of saturation and solubility can be found in the below “Calculation” section. The oxygen sensor for practical purposes is normally calibrated in air. The reading obtained during the calibration is defined as the 100% saturation value for that particular air temperature. This reading will vary with both temperature (3% per °C) and to a lesser extent with barometric pressure (about 1% every 10 mBar or 7.6 mmHg). For the above reason during calibration, the temperature is also automatically recorded and used by the OCEAN SEVEN 316Plus CTD to immediately compensate the calibration sensor slope for the temperature effect. This operation is performed during real-time acquisition as well. Although the effect of barometric change is much smaller, the OCEAN SEVEN 316Plus CTD allows the operator to manually enter a correction coefficient during the calibration procedure.

1.15.6.2 Oxygen depletion / Stirring effect and/or Barometric pressure correction coefficients

The oxygen sensor, like all the oxygen polarographic Clark sensors, sometimes needs that one or more correction coefficients be applied to the final readings in order to account for extraneous factors. The OCEAN SEVEN 316Plus CTD has been designed such that, the application of such correction factors by the operator is a relatively straightforward procedure. The oxygen sensor calibration and the correction coefficient calculation are both described in the “Sensors Calibration” section of this manual.

1.15.7 pH and reference sensors

The measurement of pH in seawater demands high accuracy since seawater has a high ionic strength and is weakly buffered. The pH range in the oceans is particularly restricted and, only in very special cases, the observed values are outside the range of 7.8 and 8.4 pH and, in some seas, the range extends...
from 6.5 to 9.0 pH. Some problems have always arisen from the use of traditional reference sensors with porous diaphragms, when measuring the pH in seawater, in particular at pressures in excess of a few bars, due to the high and variable junction potentials that are generated. The IDRONAUT reference sensor is in contact with the unknown solution by means of a small hole in the glass tip. This minimizes and stabilizes the junction potential between the inner gel electrolyte and the liquid to be measured. The reference sensor is a Silver/Silver Chloride cell in a saturated potassium chloride solid gel and the sensor head is made of titanium. It is also available a reference sensor specifically developed for long-term monitoring of seawater where the internal cell is 0.7 mol NaCl. The glass body of the sensor is fitted with a plastic hydrating cap filled with the IDRONAUT REFERENCE SENSOR STORAGE SOLUTION based on 3-mol KCl (or NaCl) or, if not available, even with KCl saturated solution to avoid drying of the gel when not in use. This cap must be removed before measurements. The pH sensor has a titanium head, a glass body and a pH sensitive glass tip, which can withstand pressures up to 150 bar or even 700 bar (special version). During all periods of inactivity, the glass tip must be fitted with a white plastic hydrating cap filled with the pH 7 Buffer Solution, or simply with clean water. This is to prevent the pH-sensitive glass from dehydration, which slows down the sensor response. This cap must be removed before measurements.

**pH sensor**

- Type: blue glass membrane (100 Mohm @ 20°C).
- Measurement range: 0..14 pH
- Initial Accuracy: 0.01 pH
- Resolution: 0.001 pH
- Drift: 0.05 pH/month
- Response time: 3 s
- Max pressure: 700 bar
- Sensor body: titanium
- Compensation: automatic thermal compensation.
- Life: 2 years if intensively used for monitoring, up to 4 years if used weekly for daily profiling or monitoring
- Calibration frequency: monthly.

**Reference sensor**

- Internal cell: Ag/AgCl – using solid gel
- Max pressure: 700 bar
- Sensor body: titanium
- Life: 1 year if intensively used for monitoring, up to 2 years if used weekly for daily profiling or monitoring.
- Maintenance: stored with the Reference Sensor Storage Solution.

**WARNING**

The above stated life performance implies that the pH and reference sensors are properly hydrated by means of the hydrating plastic cap filled with distilled water for the pH sensor and with the Reference Sensor Storage solution for the reference sensor.
STANDARD POTENTIALS OF THE SILVER/SILVER CHLORIDE REFERENCE ELECTRODE FILLED WITH SATURATED KCl WITH RESPECT TO THE HYDROGEN ELECTRODE

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Uo (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>220,5</td>
</tr>
<tr>
<td>5</td>
<td>216,1</td>
</tr>
<tr>
<td>10</td>
<td>211,5</td>
</tr>
<tr>
<td>15</td>
<td>206,8</td>
</tr>
<tr>
<td>20</td>
<td>201,9</td>
</tr>
<tr>
<td>25</td>
<td>197</td>
</tr>
<tr>
<td>30</td>
<td>191,9</td>
</tr>
<tr>
<td>35</td>
<td>186,7</td>
</tr>
<tr>
<td>40</td>
<td>181,4</td>
</tr>
<tr>
<td>45</td>
<td>176,1</td>
</tr>
<tr>
<td>50</td>
<td>170,7</td>
</tr>
<tr>
<td>55</td>
<td>165,3</td>
</tr>
<tr>
<td>60</td>
<td>159,8</td>
</tr>
<tr>
<td>65</td>
<td>154,3</td>
</tr>
</tbody>
</table>

1.15.8 The redox sensor

The REDOX sensor measures the oxidation-reduction potential of the REDOX couples present in the medium; it makes use of the same reference sensor of pH as a reference. The sensor itself consists of a platinum wire, which ends at the tip of the glass body (in which it is embedded), where the glass body is rounded. The REDOX state of any natural environment is the result of a combined effect of chemical and biological processes of reversible and/or irreversible nature and, therefore, difficult to define. Because of the number of unknown reactions and lack of reversibility, the measured potential is not representative of a true Eh value but is only the e.m.f. of an electrochemical cell (e.g. Pt + reference electrode). Such cell difference potentials measured in natural environments are still very often referred to the hydrogen scale and expressed as REDOX potentials or Eh. The potential of our reference electrode (Ag/AgCl;KCl sat.) is +202 mV at 20°C which is to be added to the measured value. Therefore, if for example we measure a value of 100 mV, the true Eh value is +302 mV, whereas, if we measure a value of -100 mV, the true Eh value is +102 mV, and so on. In other words, the positive potential of the reference electrode with respect to hydrogen must be always added to the value measured by our CTD. When using reference electrodes different from the hydrogen ones, it is usual practice to present data as Eh by obviously taking into account the potential of the reference electrode with respect to the hydrogen electrode. For this reason, we present REDOX data as Eh.

Type: platinum electrode.
Measurement range: -1000 to +1000 mV.
Initial Accuracy: 1 mV.
Resolution: 0.1 mV.
Max Pressure: 700 bar.
Response time: 3s.
Sensor Body: titanium.
Compensation: none.
Calibration frequency: not available.
Maintenance: cleaning of the glass/Pt surface with special sandpaper.
1.16 **CALCULATIONS**

Unless otherwise specified, the computation of algorithms is taken from UNESCO technical papers in the marine science document no. 44 "Algorithms for computations of fundamental properties of seawater" 1983.

1.16.1 **Oxygen**

Calculation of the oxygen content in parts per million (ppm) is carried out in three steps.

1.16.1.1 **Calculation of solubility**

The following constants are required for calculation of solubility:

\[
\begin{align*}
\text{a1} &= -173.4292 \\
\text{a3} &= 143.3483 \\
\text{b1} &= -0.033096 \\
\text{b3} &= -0.001700 \\
\text{a2} &= 249.6339 \\
\text{a4} &= -21.8492 \\
\text{b2} &= 0.014259 \\
\text{cnv} &= 1.428
\end{align*}
\]

The following variable is required for the calculation of solubility:

\[
\text{tempK} = \text{tempC} + 273.15
\]

the formula is:

\[
\begin{align*}
\text{r1} &= \text{a1} + (\text{a2} \times (100/\text{temp})) + (\text{a3} \times \ln(\text{temp}/100)) + (\text{a4} \times \text{temp}/100) \\
\text{r2} &= \text{salinity} \times (\text{b1} + (\text{b2} \times (\text{temp}/100)) + (\text{b3} \times (\text{temp}/100 \times \text{temp}/100))) \\
\text{Solubility (mg/l)} &= \text{cnv} \times \exp(\text{r1} + \text{r2})
\end{align*}
\]

1.16.1.2 **Calculation of % saturation**

The following proprietary coefficients are required for the calculation of % saturation to compensate the IDRONAUT membrane permeability to oxygen due to the temperature and pressure variation respectively.

\[
\text{Saturation %} = \text{Coeff. x O}_2(1) \times \text{SlopeO}_2 \times \exp(T_1 \times \text{C}_1 + \text{Pressure} \times \text{C}_2)
\]

Where:

\[
\begin{align*}
\text{C}_1 &= -0.029 \\
\text{C}_2 &= 0.000115 \\
\text{Coeff.} &= \text{Stirring effect and barometric pressure compensation (*)} \\
\text{SlopeO}_2 &= 1/\exp(T_2 \times \text{C}_2) \times \text{O}_2(2) / 100 \\
\text{O}_2(1) &= \text{Oxygen sensor reading in counts} \\
\text{T}_1 &= \text{Temperature sensor reading in °C} \\
\text{T}_2 &= \text{Temperature sensor reading in °C during calibration} \\
\text{Pressure} &= \text{Pressure reading in dbar}
\end{align*}
\]

(*) Description of the stirring effect and barometric pressure compensation coefficient can be found in the section describing the oxygen sensor.

1.16.1.3 **Calculation of ppm**

The formula is:

\[
\text{ppm (mg/l)} = \text{Saturation x Solubility} / 100
\]

1.16.2 **pH calculation and pH correction in relation to the sample temperature**

This calculation corrects the pH value as read by the sensor considering the temperature at the moment of acquisition.

\[
\text{pH} = (((\text{sensor reading} + \text{sensor offset}) \times \text{pH transfer coefficient}) / \text{pH temperature compensation}) + 7.0
\]

where:

\[
\begin{align*}
\text{sensor reading} &= \text{sample value in counts (ADC output)} \\
\text{sensor offset} &= 7.0 \text{ buffer value in counts (ADC output) read during the calibration procedure} \\
\text{pH transfer coefficient} &= 58.168 / \text{counts per pH unit} \\
58.168 &= \text{Nerst constant at 20° C}
\end{align*}
\]
counts per pH unit = Delta counts per pH unit (value factory set)
P pH temperature compensation = 54.2 + (Temperature \times 0.1984)
Temperature = sample temperature
54.2 = Nerst constant at 0° C
0.1984 = mV per pH unit per Centigrade degree

The above calculation is based on the following assumption:
The NERST equation, \( E = E_0 + 2.303 \frac{RT}{nF} \log a \), predicts the theoretical output of any electrochemical cell.
Applying this equation to the glass electrode system, it can be shown that the mV response per pH unit varies with centigrade temperature in the following way:

- \( 0°C \): 54.20 mV/pH
- \( 25°C \): 61.53 mV/pH
- \( 30°C \): 64.04 mV/pH
- \( 100°C \): 74.04 mV/pH

The potential response of the electrode system changes 0.1984 mV per pH unit per Centigrade degree.

### 1.16.3 Conductivity compensated at 20°C

As reported in the Ambühl formula, the conductivity is compensated with the following calculation:

\[
K_{20°C} = \frac{a - b \times temp + c \times temp^2 - d \times temp^3}{cond \times K}
\]

Where:

- \( cond \) = conductivity sensor output
- \( a = 1.721183 \)
- \( c = 0.0011484224 \)
- \( b = 0.05413696 \)
- \( d = 0.00001226563 \)

### STANDARD SEA WATER K15 0.99999 - VERSUS TEMPERATURE TABLE

<table>
<thead>
<tr>
<th>TEMP (°C)</th>
<th>COND (mS/cm)</th>
<th>TEMP (°C)</th>
<th>COND (mS/cm)</th>
<th>TEMP (°C)</th>
<th>COND (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00</td>
<td>38.08</td>
<td>16.75</td>
<td>44.64</td>
<td>23.50</td>
<td>51.49</td>
</tr>
<tr>
<td>10.25</td>
<td>38.32</td>
<td>17.00</td>
<td>44.89</td>
<td>23.75</td>
<td>51.75</td>
</tr>
<tr>
<td>10.50</td>
<td>38.56</td>
<td>17.25</td>
<td>45.14</td>
<td>24.00</td>
<td>52.01</td>
</tr>
<tr>
<td>10.75</td>
<td>38.79</td>
<td>17.50</td>
<td>45.39</td>
<td>24.25</td>
<td>52.27</td>
</tr>
<tr>
<td>11.00</td>
<td>39.03</td>
<td>17.75</td>
<td>45.64</td>
<td>24.50</td>
<td>52.53</td>
</tr>
<tr>
<td>11.25</td>
<td>39.27</td>
<td>18.00</td>
<td>45.89</td>
<td>24.75</td>
<td>52.79</td>
</tr>
<tr>
<td>11.50</td>
<td>39.51</td>
<td>18.25</td>
<td>46.14</td>
<td>25.00</td>
<td>53.05</td>
</tr>
<tr>
<td>11.75</td>
<td>39.75</td>
<td>18.50</td>
<td>46.39</td>
<td>25.25</td>
<td>53.32</td>
</tr>
<tr>
<td>12.00</td>
<td>39.99</td>
<td>18.75</td>
<td>46.64</td>
<td>25.50</td>
<td>53.58</td>
</tr>
<tr>
<td>12.25</td>
<td>40.23</td>
<td>19.00</td>
<td>46.89</td>
<td>25.75</td>
<td>53.84</td>
</tr>
<tr>
<td>12.50</td>
<td>40.47</td>
<td>19.25</td>
<td>47.14</td>
<td>26.00</td>
<td>54.10</td>
</tr>
<tr>
<td>12.75</td>
<td>40.71</td>
<td>19.50</td>
<td>47.40</td>
<td>26.25</td>
<td>54.36</td>
</tr>
<tr>
<td>13.00</td>
<td>40.95</td>
<td>19.75</td>
<td>47.65</td>
<td>26.50</td>
<td>54.63</td>
</tr>
<tr>
<td>13.25</td>
<td>41.20</td>
<td>20.00</td>
<td>47.90</td>
<td>26.75</td>
<td>54.89</td>
</tr>
<tr>
<td>13.50</td>
<td>41.44</td>
<td>20.25</td>
<td>48.16</td>
<td>27.00</td>
<td>55.15</td>
</tr>
<tr>
<td>13.75</td>
<td>41.68</td>
<td>20.50</td>
<td>48.41</td>
<td>27.25</td>
<td>55.42</td>
</tr>
<tr>
<td>14.00</td>
<td>41.93</td>
<td>20.75</td>
<td>48.67</td>
<td>27.50</td>
<td>55.68</td>
</tr>
<tr>
<td>14.25</td>
<td>42.17</td>
<td>21.00</td>
<td>48.92</td>
<td>27.75</td>
<td>55.94</td>
</tr>
<tr>
<td>14.50</td>
<td>42.42</td>
<td>21.25</td>
<td>49.18</td>
<td>28.00</td>
<td>56.21</td>
</tr>
<tr>
<td>14.75</td>
<td>42.66</td>
<td>21.50</td>
<td>49.43</td>
<td>28.25</td>
<td>56.47</td>
</tr>
<tr>
<td>15.00</td>
<td>42.91</td>
<td>21.75</td>
<td>49.69</td>
<td>28.50</td>
<td>56.74</td>
</tr>
<tr>
<td>15.25</td>
<td>43.15</td>
<td>22.00</td>
<td>49.95</td>
<td>28.75</td>
<td>57.01</td>
</tr>
<tr>
<td>15.50</td>
<td>43.40</td>
<td>22.25</td>
<td>50.20</td>
<td>29.00</td>
<td>57.27</td>
</tr>
<tr>
<td>15.75</td>
<td>43.65</td>
<td>22.50</td>
<td>50.46</td>
<td>29.25</td>
<td>57.54</td>
</tr>
<tr>
<td>16.00</td>
<td>43.89</td>
<td>22.75</td>
<td>50.72</td>
<td>29.50</td>
<td>57.80</td>
</tr>
<tr>
<td>16.25</td>
<td>44.14</td>
<td>23.00</td>
<td>50.98</td>
<td>29.75</td>
<td>58.07</td>
</tr>
<tr>
<td>16.50</td>
<td>44.39</td>
<td>23.25</td>
<td>51.24</td>
<td>30.00</td>
<td>58.34</td>
</tr>
</tbody>
</table>
1.17 PROBE FIRMWARE OVERVIEW

The probe is equipped with a firmware that manages all the probe operations. The most important management functions are described in the following subsection.

1.17.1 User interface

Whenever the CTD runs in “VERBOSE MODE”, interaction with the user is carried out by means of the "USER INTERFACE". With the term “USER INTERFACE” or "MMI" (Man Machine Interface), we mean the firmware layers that react to the user input and instruct the lower layers of the firmware to perform the desired action. The "USER INTERFACE" is a so-called menu driven interface, that is, at any time it is possible to select just one option among various possible choices. Each option will in turn perform the desired action or invoke a sub-menu containing further topics. The "USER INTERFACE" makes extensive use of different kinds of menus, among which we have: menu, sub-menus and data entry menus. A brief and exhaustive description of these menus will follow in the next subsection.

1.17.1.1 Menu & Submenus

A menu is shown mentioning first the menu title, firmware release and current date & time and then a list of the available items, one for each line. Each item is shown with four capital letters contained in two square brackets followed by an explanatory message. A number contained in the "<>" brackets allows fast selection of items. The programme has one main menu and four submenus. The "MAIN MENU", which is shown at the end of the "START-UP PROCEDURE", allows the selection of the underlying menus. To select an item (and invoke the related submenu), the user must enter the four capital letters contained in the square brackets or the number contained in the "<>" brackets. Once one of the submenus is shown, it is possible to return to the upper layer by means of the <ESC> key. Typing the <ESC> key from the "MAIN MENU" makes the CTD operate in the “LOW POWER MODE” (see the related subsection). The <ENTER> key re-displays the shown menu. Although the selectable items are shown in capital letters, the command can also be invoked with lower-case letters or numbers indicated inside the <> bracket.

1.17.1.2 Data entry functions

These kinds of functions allow the user to modify the shown items. The way the items are modified depends on the type of data itself. A set of rules guides the user during the item modification:

❖ The <ENTER> key, whenever the item is shown, skips the data entry to the next available item, without changing the item itself.
❖ The <ESC> key always aborts data item modification; the value reverts to its initial values.
❖ Any key different from <ESC> and <ENTER> starts data entry for the shown item.
❖ Whenever the modification of the item starts, the <ENTER> key confirms the new item.
❖ The numerical entry is automatically range checked. If the modified value is outside the range, this is shown and the user is requested to re-enter the data.
❖ Numerical data input is performed following the English rules such as "." for the decimal point. The introduction of coefficients can be accomplished by means of the exponent notation (i.e. 10e-37).

Data entry functions automatically end after a pre-defined time-out (30 s). This prevents the probe from halting during a data entry function inadvertently not completed by the operator. Whenever the data entry function terminates due to the time-out, the item under modification remains unchanged.
1.17.2 Menu & submenu structure

Top-down diagram of the OCEAN SEVEN 316Plus menu structure.

1.17.3 Menu header structure

The menu and submenus show a list of commands preceded by two header lines, which identify the menu or submenu and show the relevant information about the probe in square, round and glyph brackets.

OCEAN SEVEN 316Plus - ID:[430][USR](7.5_10-12/2006) Tue Jan 02 12:48:32.64 2007

They are:

**OCEAN SEVEN 316Plus**

Type of probe and name.

**ID:[430]**

Identification Code. This code corresponds to the last three digits of the serial number too.

**[USR]**

Indicates the access rights to the probe functions and configuration. It dynamically changes whenever the access rights command is carried out and according to the entered password. The access rights acronyms are: USR, SRV, ADM (see the dedicated description).

**(7.5_10 12/2006)**

Probe firmware release number and firmware release date.
1.17.4 **Probe Access Rights**

Some OCEAN SEVEN 316Plus configurations and functions are password protected to avoid unwanted modifications or running of functions that can lead to probe unpredictable behaviours. In each probe menu and sub-menu, it is present a hidden command `<CNHI>`, which allows the operator to modify the probe access rights. Three different access rights are foreseen by the OCEAN SEVEN 316Plus management firmware:

- **USR** User access to perform daily operations and standard probe configuration and management. At this level, it is not possible to modify certain sensors configuration or probe operating parameters. Moreover, some probe commands are hidden.
- **SRV** Service access to allow the operator to carry out advanced set-up and advanced diagnostic functions.
- **ADM** Administrative access to allow full control of the OCEAN SEVEN 316Plus. This access is reserved to IDRONAUT technicians or to trained operators. Upon request and under IDRONAUT control, administrative access can be granted to the operator to carry out dedicated functions or configurations.

The probe access right is indicated on the menu headers with an acronym shown inside {} brackets:

```
OCEAN SEVEN 316Plus - ID:[0430][USR](7.5_10-12/2006) Tue Jan 02 12:48:32.64 2007
```

At the start up, the probe operates in user “USR” mode. Service or Administrator access must be configured using the access rights configuration command. Once the `<CNHI>` command is invoked, the following message appears on screen:

```
Set the PROBE Access rights<<
```

The customer must reply to the password request with a 10-character message. The possible answers are

- “SERVICE316” or
- “SERVICE3XX”
- “***************”

It is worthwhile mentioning that the probe always wakes up with “USR” access right. The modification of the access right remains valid until the probe is switched off or the access right is modified. Typing an arbitrary password causes the probe access right to return to the USR level.

1.17.5 **Data transmission protocol**

Whenever the probe runs in “NON-VERBOSE MODE”, interaction with the user is performed by means of the “DATA TRANSMISSION PROTOCOL”. Selection among the data transmission protocols can be done by means of the configuration parameters.

1.17.6 **Point-to-point protocol**

The ASCII based protocol is easy to use and allows data transmissions point by point. The protocol implies bidirectional half-duplex data transmission between the probe and a PC. The probe, which is always the slave device, does not send any message unless requested by the master PC. Special characters used by the PTP protocol are:

- `<CTRL-T>` switches the probe immediately from verbose to non-verbose operating mode.
- `<CTRL-J>` special character used to terminate the PTP protocol messages.
- `<DEL>` special character used to clean the probe PTP protocol message input buffer.
1.17.7 **Field upgradeable firmware**
Like most up-to-date high technology products, the OS316Plus is equipped with "FLASH" memories. This kind of memory allows storing the probe configuration, sensor calibrations and management firmware. A special function of the management firmware allows the user to upgrade the firmware to the last release flawlessly and without opening the probe. Extensive description of the firmware upgrading procedure can be found in the dedicated section.

1.17.8 **Acquired data processing and post-processing**
Conversion of the raw data measurements (ADC Counts) into engineering units is configurable by the user; please see the description in the dedicated appendix and in the section “Calculations”.

1.17.9 **Low power consumption**
Probe electronics is accomplished using high integration CMOS devices, low power consumption integrated circuits, and discrete components. The power consumption of the OCEAN SEVEN 316Plus probe is very low if compared to its high performance. The low power consumption is further reduced whenever the probe is not used for more than 1 minute. In fact, the management firmware powers OFF all unused resources while waiting for a command from the operator. Furthermore, whenever the probe remains in this low power condition for more than five minutes, it automatically shuts down by itself.

1.17.10 **Configuration**
The OCEAN SEVEN 316Plus probe configuration parameters are stored in the non-volatile "FLASH" memories. The configuration parameters are checked at the probe start-up using a CRC 32-bit wide algorithm. By means of the CRC 32-bit code, corruption of probe configuration is promptly detected and restoration of the “factory” default configuration is automatically carried out by the probe.
SENSOR BODIES ARE MADE OF TITANIUM (TO PREVENT CORROSION) APART FROM THE TEMPERATURE SENSOR, WHICH IS MADE OF AISI 316L TO ACHIEVE THE BEST RESPONSE TIME.
**SECTION ONE – SYSTEM DESCRIPTION**

**OCEAN SEVEN 316Plus – 75 mm diameter – AISI 316 L**

*maximum pressure 150 bar*

---

**TOP VIEW**

**CONNECTORS TABLE (most used configurations)**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TELEMETRY</strong></td>
<td><strong>none</strong></td>
</tr>
<tr>
<td><strong>RS232C interface</strong></td>
<td><strong>none</strong></td>
</tr>
<tr>
<td><strong>RS232C interface</strong></td>
<td><strong>TELEMETRY</strong></td>
</tr>
<tr>
<td><strong>RS232C interface</strong></td>
<td><strong>Auxiliary sensors input</strong></td>
</tr>
</tbody>
</table>

---

**BOTTOM VIEW**

*Note: lubricate the rubber molded connectors and seals with Parker-O-lube grease*
SECTION ONE – SYSTEM DESCRIPTION

OCEAN SEVEN 316Plus – 100 mm diameter – PLASTIC WHITE POM

*maximum pressure 150 bar*

CONNECTORS TABLE

1 = TELEMETRY
2 = none
1 = RS232C interface
2 = TELEMETRY
1 = RS232C interface
2 = Auxiliary sensors input
1 = TELEMETRY
2 = RS232C interface
3 = Auxiliary sensors input

Note: lubricate the rubber molded connectors and seals with Parker-O-lube grease
OCEAN SEVEN 316Plus – 89 mm diameter – TITANIUM GR5

maximum pressure 700 bar

Note: lubricate the rubber molded connectors and seals with Parker-O-lube grease
SECTION TWO- INSTALLATION AND START-UP

2 INSTALLATION AND START UP

Unpacking, installation and start-up procedures concerning the OCEAN SEVEN 316Plus are described in this section.

2.1 SHIPPING LIST

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. OCEAN SEVEN 316Plus probe</td>
<td>1</td>
</tr>
<tr>
<td>B. Telemetry Deck Unit</td>
<td>1</td>
</tr>
<tr>
<td>C. Cable for probe connection to a PC via RS232C</td>
<td>1 x 3 m</td>
</tr>
<tr>
<td>D. Cable simulator to connect the probe to the Telemetry Deck Unit</td>
<td>1 x 3 m</td>
</tr>
<tr>
<td>E. Cable to connect the Telemetry Deck Unit to a PC</td>
<td>1 x 3 m</td>
</tr>
<tr>
<td>F. Cable to power the Telemetry Deck Unit</td>
<td>1</td>
</tr>
<tr>
<td>G. Dummy cap for probe connector/s</td>
<td>1 x connector</td>
</tr>
<tr>
<td>H. Sensor maintenance kit, including:</td>
<td></td>
</tr>
<tr>
<td>❖ Conductivity sensor cleaning solution</td>
<td>1x 25 ml</td>
</tr>
<tr>
<td>❖ Spare membrane cap for oxygen sensor</td>
<td>1</td>
</tr>
<tr>
<td>❖ Oxygen maintenance kit</td>
<td>1</td>
</tr>
<tr>
<td>❖ Oxygen electrolyte</td>
<td>2 x 25 ml</td>
</tr>
<tr>
<td>❖ pH calibration cup</td>
<td>1</td>
</tr>
<tr>
<td>❖ Spare pH sensor hydrating cap</td>
<td>1</td>
</tr>
<tr>
<td>❖ Spare reference sensor hydrating cap</td>
<td>1</td>
</tr>
<tr>
<td>❖ pH buffer solution - pH 7</td>
<td>1x100 ml</td>
</tr>
<tr>
<td>❖ pH buffer solution - pH 4</td>
<td>1x100 ml</td>
</tr>
<tr>
<td>❖ pH reference sensor storage solution</td>
<td>2 x 25 ml</td>
</tr>
<tr>
<td>I. Media with software and documentation</td>
<td>1</td>
</tr>
</tbody>
</table>

Note
➢ Items B,D,E,F are present only when the purchase order includes the telemetry optional interfaces.
➢ Item B includes the battery charger, if it is a Telemetry Portable Deck Unit.
➢ Sensor maintenance kit contents (item H) depends on the probe sensor suite.
➢ Customized submersible cables can be included in the shipping list if external sensors are interfaced with the OCEAN SEVEN 316Plus probe.

2.1.1 Laboratory RS232C cable
A laboratory RS232C cable is provided to interface the probe to a personal computer: its 6-pin female underwater connector fits the 6-pin male connector of the probe; its 9-pin female connector (Cannon DB9) fits a standard AT type RS232C serial interface. Wiring of the cable can be found in the documents enclosed to the Operator’s Manual and describing the bulkhead connectors and cables completing the probe package. The laboratory RS232C cable comes complete with a probe international power supply AC/DC converter.

2.2 INSTALLATION
Unpack and inspect the shipped parts; check the materials of the above shipping list and be sure that no damage has occurred during transport.

2.2.1 Internal and external battery packs
The probe is shipped without batteries installed. Therefore, if needed, install the battery. A detailed description can be found in Appendix “A”. In case the high-voltage telemetry is installed, the internal battery must not be present or installable. In this case it is mandatory to use external submersible battery pack. When the RS232 submersible cable is present, the battery pack is not installed in the probe because it is powered through the RS232 cable from the surface.

2.2.2 Telemetry Deck Unit installation
To install the Telemetry Deck Unit, please refer to the IDRONAUT Telemetry Deck Unit Operator’s and Installation Manual.
2.3 **START-UP**

The OCEAN SEVEN 316Plus probe is able to communicate through two interfaces: the RS232C/RS485 and the telemetry interface. Furthermore, the probe can be equipped with an internal and/or external battery pack. In the following paragraph, you can find the description to start up the OCEAN SEVEN 316Plus probe using the telemetry or the RS232C/RS485 interface and in each of the two operating modes: “verbose” and “non-verbose”. In addition to the probe and cable, even a personal computer is needed to interface the OCEAN SEVEN 316Plus probe. Therefore, before proceeding with the probe start-up operations, please turn the personal computer ON, install and run the ITERM IDRONAUT terminal emulation programme.

Please be aware that, after its installation, the ITERM automatically selects the PC communication port #1 and the proper communication port parameters. In case the communication port #1 does not exist, it is assigned to another device or it is not installed in the PC. Please proceed to properly select the communication port to be used during the communication with the OCEAN SEVEN 316Plus probe. Details about the ITERM programme set-up can be found in a dedicated appendix.

### 2.3.1 RS232C/RS485 interface - Probe power ON

Remove the underwater cap from the OCEAN SEVEN 316Plus 6-pin male bulkhead connector marked as “RS232C & Battery input”. Connect the 6-pin female connector of the 3-m laboratory serial cable to the 6-pin male connector on the probe top cover. Connect the other end of the cable to the serial port of the PC. Insert the AC/DC converter in a mains supply socket. Afterwards, rotating the arm of the magnetic switch on the probe top cover to the red dot switches the probe ON. When ON, the probe immediately sends the start-up messages to the PC and they immediately appear on PC screen.

### 2.3.2 Telemetry interface - Probe power ON

Before proceeding, install the telemetry deck unit as explained in the Telemetry Deck Unit Operator’s & Installation manual. Then, remove the underwater cap from the OCEAN SEVEN 316Plus 2-pin male bulkhead connector, marked as “Telemetry”. Connect the 2-pin female connector of telemetry simulator cable to the 2-pin male connector on the probe top cover. Connect the other telemetry end connector to the IDRONAUT telemetry deck unit probe input. Turn ON the probe by acting on the Telemetry Deck Unit power switch. The probe immediately turns on and the standard start-up messages will appear on PC screen.

**Note**

When the OCEAN SEVEN 316Plus is interfaced through the telemetry interface, it is necessary to modify the FLOW CONTROL of the PC programme configuring it to CTS/RTS. Related information can be found in the appendix describing the PC programme. Position the top cover magnetic switch to the OFF position before turning on the telemetry. We strongly suggest removing the internal battery or the external submersible battery, if any, when the CTD is interfaced through the telemetry.

### 2.3.3 Standard start-up messages

Independently of the hardware interface and operating mode, the following messages will appear once the probe is turned ON.

```
Reset:Extern
OCEAN SEVEN 316Plus - Id:0430(7.5_10-12/2006) -Power ON- Tue Jan 02 12:25:06.26 2007
HwSetup.rs
DATA memory EXT>>[000000 Size: 512 MByte]...oK Used[000%% 000%%]
Start-Up (OPERATOR) Op.mode Verbose
Aux Devices oK
Analogue Battery( 12.50 VDC)VAC( 4714.5 mV)iT(16.9 C) oK!
Awaiting the warm-up delay time (5 seconds) -----
```

If one (or more) of the start up procedures is unsuccessful, an explanatory error message will be shown. In this case, the probe will automatically accomplish the restoring procedure by itself. The probe operating modes can be:
Start-Up (OPERATOR) Op.mode Verbose

or

Start-Up (OPERATOR) Op.mode Non-Verbose protocol [PTP]

If the probe is operating in “Verbose” mode, at the end of the above message, the probe “Main Menu” appears; otherwise, if the probe is operating in “Non Verbose” mode, at the end of the above messages, it will show the following message, waiting for instructions.

Start of Non-Verbose Point To Point protocol--
--return to the verbose mode by means of--
--<VT^J> command where: ^= CONTROL KEY PRESSED--
ER 000

Details about the PTP protocol and the relevant command and communication protocol rules can be found in the “OCEAN SEVEN 3xx probes Data Transmission Protocol” manual. The manual can be freely downloaded from the IDRONAUT web site “http://www.idronaut.it”. To switch the probe to verbose mode, type the VT characters followed by the CTRL-J sequence (keep pressed the CTRL key while typing the J character). Alternatively, use the “Identify” function available under the “CTD” menu of the ITERM programme.

2.4 THE MAIN MENU

At the end of start-up, when the probe initialization process is completed, the probe main menu appears:

```
OCEAN SEVEN 316Plus - ID:[0430][USR](7.5_10-12/2006) Tue Jan 02 12:25:06.26 2007
Main menu
<0>[SHUT]-Shutdown
<1>[DATA]-Data acquisition
<2>[MEMO]-Memory
<3>[CALB]-Calibration
<4>[SERV]-Service
<5>[OPMD]-Non-Verbose mode
```

**<0>[SHUT]** This command starts the “SHUTDOWN PROCEDURE” which saves the probe status and powers OFF the probe. To complete the shutdown software procedure, please rotate the probe magnetic switch and the deck unit power on switch to OFF position.

**<1> [DATA]** This command gives access to the data acquisition menu.

**<2> [MEMO]** This command gives access to the memory management menu.

**<3> [CALB]** This command gives access to the calibration menu.

**<4> [SERV]** This command gives access to the service menu.

**<5> [OPMD]** This command allows the operator to immediately switch the probe from “VERBOSE MODE” to “NON-VERBOSE MODE”. The probe automatically wakes up and starts up with the last operating selected mode.

**[ESC]** Enter the probe in “LOW POWER CONSUMPTION MODE”. Whenever the probe is in “LOW POWER CONSUMPTION MODE”, the prompt command switches from “cmd>” to “$$”.

2.5 LOW POWER CONSUMPTION

If the probe is not used for more than one minute, it goes into the low power consumption mode automatically. This condition is identified by the presence of $$ prompt on PC screen. In this condition, the OCEAN SEVEN 316Plus probe power consumption is reduced by about 40%. If the probe is
interfaced through the RS232C interface, it remains in this condition for 1 minute, waiting for the operator’s instructions. Afterwards, to enhance the life of the internal batteries further, the probe automatically shuts down by itself. The probe can be re-started after one minute by typing a character on the PC keyboard which executes a new "START-UP PROCEDURE". Alternatively, switch off the probe by rotating the magnetic switch to OFF position and, after one minute, rotate back the switch to ON position to wake up the probe.

Note
When the probe is operated by means of the telemetry interface, the “low power consumption” is activated but the probe does not automatically shut down even if it is not used for a long time.
3 DATA ACQUISITION

Data acquisition functions are the core of the probe management firmware. The aim of data acquisition functions is to collect, convert, show and store in memory (if needed) data acquired from all the installed sensors. Acquired data is stored in ADC counts (probe digitizer output), but is shown in engineering format to simplify the comprehension of the acquired values by human operators.

Conversion from ADC counts to engineering units takes place using the algorithm described in the calculation section and by means of the calibration values. Invalid engineering data is obtained if the sensors have not been calibrated at least once. In this situation, acquired data is represented by the -9999.9 value.

The operations performed by the probe for each data acquisition function are described below. Data acquisition can be run with the probe operating in "Verbose" and/or “Non-verbose” mode. In the latter case, procedures on how to start and stop data acquisition are described in the “Ocean Seven 3xx PTP Data Transmission protocol” manual. The below paragraphs describe data acquisition functions once the probe operates in “Verbose” mode.

3.1 THE DATA ACQUISITION MENU

Whenever data acquisition is selected from the probe Main Menu, the following message appears:

```
OCEAN SEVEN 316Plus - ID:(0430)[USR](7.5_10-12/2006) Tue Jan 02 12:48:32.64 2007
Data acquisition menu
<0>[DAUP] -Leave data acquisition menu
<1>[DAMD] -Manual data acquisition
<2>[DALD] -Linear data acquisition
<3>[DATD] -Timed data acquisition
<4>[DAPR] -Programmed depth data acquisition
<5>[DACN] -Conditional data acquisition
<6>[DACO] -Continuous data acquisition
>cmd:
```

Selection of the desired function is performed by typing one of the acronyms contained in the square brackets or pressing the corresponding digit contained in the <> bracket. Pressing <ESC> key or [DAUP] command forces the programme to go back to the "Main Menu"; pressing <ENTER> key re-displays the "Data Acquisition Menu".

3.2 ACQUIRED PARAMETERS

Acquired and shown parameters are those that have been configured using the probe commands available under the “Configuration” menu. All data acquisition functions use the configuration information to acquire, show and store data in memory. Details about data storing method and processing can be found in the dedicated section of this manual. While data acquisition cycles are running, two different methods can be used to show acquired data in real time. The first method shows data in scrolling up rows, with a column assigned to each parameter; the second method shows data on a screen basis, one parameter per row with two columns only. Selection between these two display methods is done by means of a configuration parameter.

3.3 COMMON RULES TO SET UP THE DATA ACQUISITION CYCLE

Configuration of wrong parameters during the set-up of a measurement cycle can cause the malfunction of the probe and, in some cases, the probe cannot respond to the operator’s request to perform or interrupt the configured data acquisition cycle. Should this accident happen, please contact IDRONAUT to obtain the relevant instructions on how to revive the probe operation. As a general rule, never configure a value to 0 unless explicitly foreseen or requested by the configuration procedure and well described in the manual.
SECTION THREE - DATA ACQUISITION

3.4 COMMON RULES TO STORE ACQUIRED DATA
At the end of an acquisition cycle, data “temporarily” stored in memory must be confirmed and afterward uploaded. The data acknowledgement procedure for all the data acquisition methods is different if the probe is working on line or if it is performing unattended acquisitions.

3.5 ON-LINE ACKNOWLEDGEMENT
Operator can freely decide to confirm the stored data or upload it by opportunistly answering the following question:

`Cast|5| Dataset|300|
Confirm data stored?: Yes`

The operator confirms the acquired and stored data by answering `<YES>` or upload it by answering `<NO>`. If the operator answers `Yes`, the data acknowledgement procedure goes on as follows:

`CAST...`
`Enter area identification code: new string [max length 7]< sample`

Now, the operator must enter a sampling area identification code. The maximum length is 7 characters. When the sampling area code is entered, the probe automatically updates data in memory and returns to the data acquisition menu.

`Updating Flush_EXT Memory...Ok`
`Done`

3.6 UNATTENDED ACKNOWLEDGEMENT
When the probe operates in unattended mode, the operator is not present when the probe terminates a data acquisition cycle. Therefore, the probe automatically confirms the stored data and carries out an automatic acknowledgement procedure. This procedure identifies the acquired data by assigning to the sampling area identification code a message that later allows the operator to distinguish between the causes of termination. The first three characters of the sampling area identification code are configured as “ER-”, while, the remaining four characters are used to represent a numerical code, which uniquely identifies the causes of data acquisition cycle termination, like:

0102 - Memory full
0105 - All data has been acquired
0111 - Data acquisition error
0112 - Operator ends timed data acquisition
0113 - Probe internal batteries flat
0115 - Date&Time calculation error

Thus: ER-0102

3.7 UPLOADING DATA STORED IN THE PROBE MEMORY
At the end of the unattended acquisition, data stored in the probe memory can be retrieved. The following instructions explain how to do that with the IDRONAUT programs: ITERM/WTERM and REDAS5.

“ITERM / WTERM”
1. Run programme.
2. Switch the probe ON by means of the magnetic switch.
3. Wait until the probe Main Menu appears.
4. From the probe menu, select the identify command. Wait until the program identifies the connected probe and the probe main menu appears again.
5. From the probe menu, select upload stored data.
6. Wait until shows the probe memory cast area contents in the pop-up upload window.
SECTION THREE - DATA ACQUISITION

7. Select the folder where data will be saved.
8. Select the cast to be uploaded. CTRL and SHIFT can help to select more than one cast at a time.
9. Start the uploading of the selected cast.

**REDAS5**
1. Run REDAS5 programme.
2. Switch the probe ON by means of the magnetic switch.
3. Run the upload cast function from the remote menu.
4. Wait until the list showing the casts stored in the probe memory appears in the pop-up window.
5. Using the mouse, select the cast to upload. CTRL and SHIFT can help to select more than one cast at a time.
6. Press the OK key and wait until REDAS5 retrieves the selected cast from the probe memory.

### 3.8 UNATTENDED ACQUISITIONS – IMPORTANT TIPS
The following points are important when an unattended cycle is performed using the OCEAN SEVEN 316Plus probe.

#### 3.8.1 Power consumption reduction
The probe is equipped with a firmware protection to prevent the battery pack from running down. At the beginning of the unattended acquisition cycles and each minute during the unattended acquisitions, the battery energy is monitored and compared to a configurable limit. If the battery voltage falls below the configured limit, the unattended acquisition is immediately terminated.

#### 3.8.2 Warm-up
A warm-up time-out to stabilize the sensor reading is mandatory. In case of physical sensors, a 3-second time-out is sufficient, while, a 5-second time-out is needed if the probe is equipped with chemical sensors like oxygen and pH.

#### 3.8.3 ON/OFF cycles
Whenever you switch OFF the probe, please wait 30 seconds before switching it ON again. This waiting time allows the probe to perform a correct start-up procedure.

### 3.9 SHIPPING CONDITIONS
The probe is shipped without batteries and with the pH and reference sensor hydrating caps installed. The latter must be routinely refilled with the proper solutions to guarantee the pH and reference sensor hydration.

### 3.10 SENSORS

**Pressure sensor**
Before executing a data acquisition in relation to pressure, calibrate (null) the pressure sensor offset.

**Conductivity sensor**
After using the probe in seawater, wash the conductivity sensor with fresh water (preferably distilled water). Wet it before starting a long-term deployment. Do not leave the probe exposed to direct sunlight. Wet the conductivity sensor for one night before starting the measurement campaign.

**Oxygen sensor**
Calibrate the sensor before starting the acquisition cycles. Do not perform any calibration on the deck where air concentrated of water and/or oil aerosol can disturb the calibration.

### 3.11 MANUAL DATA ACQUISITION
Real-time data is immediately shown on PC screen. This method allows the shown data sets to be collected in the probe data memory upon operator’s request. Data collection is achieved by pressing <S> key. Once pressed at the end of data, an “M+” appears indicating that the shown data has been stored in the probe memory. The <ESC> key terminates the manual data acquisition. At the end of data acquisition, in case some data has been collected, the data acknowledgement procedure is performed (see the descriptive paragraph at the beginning of this section).

**Place the CTD on the sampling point** - type<br><ESC> to start, <ESC> to abandon<br>**Manual data acquisition** - type <S> to toggle data storage, <ESC> to leave<br>**Press** Temp Cond Sal Dens O2 ppm O2 sat% pH Eh Time & Memory<br>0.12 17.05545.35335.3521.02582.35 30.1 7.895 214.8 11:14:26.8 M+
### 3.12 **LINEAR DATA ACQUISITION**

This data acquisition method allows the data sets to be collected at preset pressure intervals, during the probe immersion. This procedure is commonly used whenever the probe must be used without a real-time connection with a surface PC; in this case, the probe is preset before deployment. Afterwards, the probe can be deployed for profiling at different sampling sites. Acquisition is performed acting on the magnetic switch. Once invoked, the following message appears on PC screen.

**LINEAR PROFILE DATA ACQUISITION**

Execute unattended linear profiles?: No type [Y]es or [N]o < y

Answer **NO** if an active connection (probe connected through telemetry or RS232 cable) will be used to acquire and collect data in function of pressure increments. Answer **YES** if the probe will be used without a connection with a surface PC during the probe deployment.

**Linear profile acquisition step:** 0.5

Data collection step expressed in dbar. Please be aware that data will be collected only during downward profile, or better, only if the pressure increases.

**Number of data sets to acquire per each sampling point:** 2

For each pressure step, it is possible to collect in memory more than one data set contemporaneously.

*Profile ending condition:* (0) Pressure, (1) Conductivity, (2) Both

*Condition:* 2

*Pressure upper limit [dbar]:* 0

*Conductivity limit [mS/cm]:* 0.1

Once the probe is operated in unattended mode, the operator is unaware of the probe operations. The “Profile end condition” helps the operator to define a secure method to interrupt the running profile and to prepare the probe to perform the next profile. Apart from the predefined end conditions, which are:

- the probe is switched off by means of the magnetic switch;
- the probe internal battery is below the minimum operating limit;
- the probe data memory is full;

Three end conditions can be configured by operator:

1. When the real-time acquisition of the pressure sensor is lower than the configured pressure limit.
2. When the real-time acquisition of the conductivity sensor is lower than the configured conductivity limit.
3. When one or both real-time acquisitions from pressure and conductivity sensors are lower than the configured limits.

**Note**

The end conditions configured by the probe are valid only if the probe collects data at least at three different sampling depths. (i.e. configuring 0.5 dbar means that the end conditions are checked only after the probe overpasses the 1.5 dbar). This filtering method is mandatory to avoid the probe detecting false profiles once it is on the surface and the operator is waiting for the stabilization time before deploying. In fact, without this filtering
method, the boat pitching and rolling or the sea waves could create false profiles. The only drawback of this filtering method is that a minimum of three sampling points must be acquired each time.

When the end condition is confirmed, the probe is ready to perform the first profile and sends the following message before automatically switching off by itself.

```
----- UNATTENDED Linear Profiles ------
To start switch-ON the CTD
To stop while switched-ON type <ESC> until confirmation message appears
```

Now, the operator must switch off the probe by rotating the magnetic switch to OFF position.

**Note**

If the probe interfaces a “Rosette” water sampling device, some questions about the water sampling method and steps are presented to the operator. Details about the water sampling set-up can be found in the dedicated appendix.

3.12.1 **Routine operations to perform unattended linear profiles**

Once the probe is switched ON by means of the magnetic switch, it watches the pressure sensor waiting for pressure increments (probe lowering in water). Ending of data acquisition is achieved once the probe returns to the surface and one of the end conditions is met. Afterwards, the probe can be switched OFF or lowered again to perform a new unattended linear profile.

**Note**

- The magnetic power ON/OFF switch or the Deck Unit ON/OFF switch can start and/or stop an unattended measuring cycle.
- Please be aware that, during the unattended linear profiles, the probe does not reduce its power consumption nor does it switch OFF by itself when back from a profile. To reduce the power consumption, it must be turned OFF once on the surface.
- Please protect the not-in-use bulkhead connectors with the proper caps.
- When carrying out the unattended linear profiles, the probe monitors the battery voltage. In case it reaches the lower operating limits, the unattended profile immediately ends and the probe switches OFF by itself. No other profiles will be accomplished. It is therefore important to verify the battery conditions before starting a series of profiles.
- Each unattended linear profile is stored in a different cast.

3.12.2 **Terminate the unattended linear profile**

To terminate the unattended linear profile, connect the probe to a PC and then switch the probe ON. It will try to start an unattended linear profile again. When the probe shows the acquired data waiting for pressure increment, type the <ESC> key and answer <YES> to the following answer:

```
Do you want to terminate the unattended linear profile Yes, No
```

The probe will terminate the current acquisition and returns to the Data Acquisition Menu.

3.12.3 **Step-by-step Linear Profile procedure**

This paragraph describes a step-by-step procedure to perform an unattended linear profile. After establishing a valid connection with the probe using the "Verbose operating mode", proceed as follows:

**A) Preliminary configuration**

1. Run the “ITERM” programme.
2. Switch ON the probe.
3. If the Main Menu does not appear, type <VT> followed by a <CTRL-J>. The Main Menu must appear.
4. From the Main Menu, select the “Calibration sub-menu” by means of the CALB command.
5. From the Calibration Sub-menu, select the sensor calibration by means of the CASE command.
6. From the list of sensors, select the Pressure transducer and then follow the on-screen instructions.
7. At the end of the pressure sensor calibration, type the <ESC> key twice and you will return to the Main Menu.
8. From the Main Menu, select the "Data Acquisition sub-menu" through the DATA command.
9. From the "Data sub-menu", select the "Linear profile" by means of the DALD command.
10. The first question concerns the intention of performing unattended profiles. Answer YES.
11. The second question concerns the pressure step in dbar to use during the data acquisition.
12. The third question concerns the number of data sets to acquire for each sampling point. You can decide to acquire more than one data set for each sampling depth.
13. The last question concerns the end condition to meet before starting a new profile (see above).
14. Now, the probe switches OFF by itself and is ready to perform the data acquisition.
15. Switch the probe OFF by means of the magnetic switch.

B) Field operations
1. Once you have reached the sampling site, switch ON the probe by means of the magnetic switch; the probe watches the pressure sensor value to start the acquisition. Lowering the probe in water starts the data acquisition and data storing. Before lowering the probe in water, wait at least 30s to stabilize the sensors readings.
2. When the probe returns to the surface, switch it OFF by means of the magnetic switch; data acquisition ends immediately. Alternatively, lowering again the probe in water starts a new data acquisition cycle immediately.

The above operations can be executed repeatedly until the probe batteries have run down or until the probe memory is full of data. Each time a data acquisition is performed, a new data header is automatically generated.

C) Ending the unattended data acquisitions
1. Run the “ITERM” programme.
2. Switch the probe ON by means of the magnetic switch.
3. After the start-up messages, the probe starts to acquire data watching for depth increments.
4. Type the <ESC> key until a message appears.
5. Answer YES to the given question.
6. The unattended profile is ended and the probe is working in the standard VERBOSE mode.

The acquired data is stored in memory and you can have a quick look at it by means of the functions available in the "DATA STORAGE” menu.

3.13 Timed data acquisition
Timed data acquisition method allows the acquisition of data sets in relation of predefined time intervals. This method allows the probe to perform acquisitions in function of time intervals for short or very long periods by means of the probe integrated data logger capabilities. These capabilities mainly consist in the fact that the probe is able to carry out the power OFF and ON cycles at pre-set time intervals and can operate in an unattended mode.
This capability prolongs the battery life because, once the probe waits for the data acquisition interval time, it does not consume power as it is in OFF condition. The built-in real-time clock calendar is used to automatically and precisely set up the time intervals and wake up the probe at the right time.

When selected from the main menu, the following message appears on the PC screen:

OCEAN SEVEN 316Plus - Tue Jan 02 14:43:04.97 2007
Timed data acquisition configuration
Data acquisition step: 00:00:00.00
This time, entered in the format [hh:mm:ss.hh] (from 00:00:00.01 to 23:59:59.99), represents the time interval between two consecutive data measurements. The operator is requested to enter the time in the format: hours, minutes, seconds, hundredths of second. When the built-in OFF/ON power capabilities of the probe are used to perform unattended time measurements, the step cannot be shorter than 30 seconds. Vice versa, if the entered time interval is less than one second, the hundredth-second data acquisition is used.

**Note**

In case one hundredth second is configured and the probe sampling rate is higher than the configured interval, the configured data acquisition interval could not be guaranteed. In that case, the longer time-out will become the effective time between measurements. We suggest carrying out some experiments in the laboratory trying different configurations before setting up the probe for the sampling site deployment.

After the data acquisition interval is configured, the following message appears:

*Number of acquisitions:0 enter new value< 100*

The operator must enter the number of timed acquisition cycles he intends to perform.

*Data set to be stored per each acquisition:2 enter new value< 2*

For each timed acquisition cycle, it is possible to acquire more than one data set. The number of data sets and the number of timed acquisition cycles are controlled to guarantee that there is enough space in memory to store the data that will be acquired. If the request overpasses the memory capability, a message informs the operator that the configuration cannot be accepted. In case the time step used is hundredths of seconds, the number of data set must be configured as 1.

*Do you want to switch OFF the probe between measurements ?:No*

This parameter allows the operator to switch off the probe between two consecutive measurements. Switching off the probe between consecutive acquisitions has the advantage to greatly increase the probe battery endurance. Furthermore, in case a hundredth-second step has been chosen, answering <YES> will allow the probe to carry out many unattended cycles by just switching the probe ON and OFF by means of the probe bulkhead magnetic switch.

*Enter the starting acquisition time [HH:MM:SS]*

Starting time: 00:00:00

The operator can decide the time when the first measurement cycle will be carried out. In case the entered time is higher than the present time by more than 30 seconds, the interval time will be automatically spent with the probe in an OFF condition. Confirming the default value of 0 tells the probe to perform the first measurement immediately. This parameter completes the Timed data acquisition cycle configuration. Afterwards, the probe automatically executes a “Shut-Down procedure” and switches off by itself if the time interval to wait is greater than 30s:

*Shut-down procedure successfully completed...*

or it shows the following message:

*Waiting time before starting the data acquisition type <ESC> to immediately start*

Cur time Fri January 31 15:49:45.6 2007 left to start [30].sec.
SECTION THREE - DATA ACQUISITION

Typing `<ESC>` forces the probe to start immediately. Once started, the following message appears:

```
Timed data acquisition - type <ESC> to leave
Press Temp Cond Sal Dens O2ppm O2sat% pH eH Time & Memory
```

Afterwards, the probe waits in OFF or in ON condition that the next data acquisition time is met.

**Note**

If the probe interfaces a “Rosette” water sampling device, some questions about the water sampling method and steps are presented to the operator. Details about the water sampling set-up can be found in the dedicated appendix.

3.13.1 **Terminate a timed data acquisition**

The timed data acquisition ends whenever one of the following events occurs:

- **Battery has run down**
  
  The probe automatically checks the battery voltage against the preset boundary each time it wakes up or at regular intervals when it is always ON. In case the battery has run down, the following message appears:

  ```
  No more power supply to continue the timed data acquisition
  ```

- **Operator stops the acquisition**
  
  The operator can terminate the timed data acquisition by pressing the `<ESC>` key while the probe is ON or by pressing `<ESC>` once the probe is OFF and by answering `<YES>` to the question about the intention to conclude the timed acquisition cycle. In this case, the following message appears on the PC screen at the end of the probe start-up.

  ```
  Timed data acquisition illegal acquisition time
  Do you want to terminate the timed data acquisition ? (Y)es (N)o
  ```

  Pressing `<Y>` for Yes immediately terminates the timed data acquisition. Pressing `<N>` for No, the probe immediately starts an automatic power OFF procedure calculating the next data acquisition time. The operator has 30s to answer the question. If no answer is received from the probe, it shuts down by itself configuring the next acquisition time.

- **Data acquisition error**
  
  In case the probe does not complete a data acquisition procedure due to hardware or sensor problems, the following message appears:

  ```
  Error during the timed data acquisition
  ```

  After this message is shown, the timed data acquisition is automatically concluded as this error is unrecoverable. Data acquired since the accident is automatically confirmed in memory.

- **Acquisition completed**
  
  The timed data acquisition automatically ends whenever the total number of data sets to acquire has been stored. Data acquired and stored is automatically confirmed in memory.

3.13.2 **Automatic power OFF procedure**

During the timed data acquisition, once the configured data set has been acquired and stored, the power
OFF procedure is carried out by the probe to save battery energy. When this happens, the following message appears:

Number of acquisitions left: 100
Next data acquisition on Fri March 31 15:49:45.6 2007
Shut-down procedure successfully completed.

3.13.3 Accidental power ON cycle
In case of accidental power ON cycle, while the probe is OFF waiting for the next acquisition time, the probe wakes up and allows the operator to interrupt the timed acquisition cycle.

Timed data acquisition illegal acquisition time
Do you want to terminate the timed data acquisition? (Y)es (N)o

In case no answer to the above probe request is received in 30s, the probe shuts down by itself and configures the next timed acquisition time.

3.13.4 Magnetic power ON/OFF switch
The magnetic power ON/OFF switch can be used to temporarily interrupt the time sequence of the timed data acquisition cycle. When the probe is switched ON again, it immediately starts a data acquisition cycle and then continues with the measurement cycles as configured. The successive acquisition time is calculated by adding the configured interval to the probe wake-up time.

3.13.5 Step-by-step procedure
After establishing a valid connection with the probe using the "Verbose operating mode", proceed as follows:

A) Preliminary configuration
1. Run the "ITERM" programme.
2. Switch ON the probe.
3. If the Main Menu does not appear, type <VT> followed by a <CTRL-J>. The Main Menu appears.
4. From the Main Menu, select the "Data Acquisition sub-menu" through the DATA command.
5. From the "Data sub-menu", select the "Timed Data acquisitions" by means of the DATD command.
6. The first question concerns the data acquisition interval or step. An interval from 1 tenth up to 23h59m59s can be configured.
7. The second question concerns the number of acquisition cycles to perform.
8. The third question concerns the number of data sets that must be acquired during each acquisition cycle.
9. The fourth question, which only appears whether the data acquisition interval is greater than 30s or when a hundredth-second interval is configured, allows the operator to enable the automatic switching OFF and ON of the probe.
10. The fifth question concerns the data acquisition starting time.
11. Now the probe, depending on the previous configuration, acts according to one of the following possibilities: i) it executes a data acquisition cycle, then switches OFF by itself and waits for the next acquisition time. ii) it waits for the data acquisition starting time. iii) it starts to acquire and store data as configured without switching OFF.
12. Switch OFF the probe.

B) Field operations
1. Once you have reached the sampling site, switch ON the probe by means of the magnetic switch; the probe performs the first acquisition cycle and then configures the successive acquisition time by itself.
2. When the probe is recovered and returns to the surface, you can switch it OFF by means of the magnetic switch and the data acquisition is temporarily interrupted.

C) Ending the unattended data acquisitions
1. Run the "ITERM" programme.
2. Switch the probe ON.
3. After the start-up messages, the probe starts by showing a warning question about the intention to stop the measurement cycle.
4. Answer YES to the given question.
5. The unattended timed acquisition is ended.

The acquired data is stored in memory and you can have a quick look at it by means of the functions available in the "DATA STORAGE" menu.

3.14 PROGRAMMED DEPTH DATA ACQUISITION

This data acquisition method allows the user to select any of the five pre-configured pressure profiles. Each profile can include up to 50 depth acquisition points. The five profiles can be modified by means of a dedicated command available under the “Configuration” menu.

3.14.1 Preset Profiles

The below table shows the 5 preset pressure profiles. Tabled data is expressed in dbar.

<table>
<thead>
<tr>
<th>Index</th>
<th>Prof #1</th>
<th>Prof #2</th>
<th>Prof #3</th>
<th>Prof #4</th>
<th>Prof #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>10</td>
<td>3</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>15</td>
<td>5</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>20</td>
<td>7.5</td>
<td>16</td>
<td>75</td>
</tr>
<tr>
<td>7</td>
<td>35</td>
<td>25</td>
<td>10</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>30</td>
<td>15</td>
<td>64</td>
<td>150</td>
</tr>
<tr>
<td>9</td>
<td>45</td>
<td>40</td>
<td>20</td>
<td>128</td>
<td>200</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>256</td>
<td>250</td>
</tr>
<tr>
<td>11</td>
<td>55</td>
<td>60</td>
<td>30</td>
<td>512</td>
<td>300</td>
</tr>
<tr>
<td>12</td>
<td>60</td>
<td>70</td>
<td>40</td>
<td>1024</td>
<td>400</td>
</tr>
<tr>
<td>13</td>
<td>65</td>
<td>80</td>
<td>50</td>
<td>2048</td>
<td>500</td>
</tr>
<tr>
<td>14</td>
<td>70</td>
<td>90</td>
<td>60</td>
<td>4096</td>
<td>600</td>
</tr>
<tr>
<td>15</td>
<td>75</td>
<td>100</td>
<td>70</td>
<td>8192</td>
<td>700</td>
</tr>
<tr>
<td>16</td>
<td>80</td>
<td>120</td>
<td>80</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>85</td>
<td>140</td>
<td>100</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>90</td>
<td>160</td>
<td>120</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>95</td>
<td>180</td>
<td>150</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>110</td>
<td>240</td>
<td>250</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>120</td>
<td>280</td>
<td>300</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>130</td>
<td>320</td>
<td>400</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>140</td>
<td>360</td>
<td>500</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>150</td>
<td>400</td>
<td>600</td>
<td>6000</td>
<td></td>
</tr>
</tbody>
</table>

Once the programmed depth acquisition function is selected, the following message appears:

*Place the probe on the sampling point - type any key to start, <ESC> to abandon*

Pressing <ESC> immediately terminates the data acquisition cycle, whereas, typing a character will start the measurement cycle. Now, the operator must select among the available programmed profiles:

*Programmed profile: 0*

In case the chosen profile is not correctly configured, the following message appears on the PC screen:

*The chosen programmed profile has not been configured*
If the chosen profile is correctly configured, the data acquisition procedure starts as follows:

- **Programmed profile**: PRG#2
- **Programmed depth point**: 25
- **Pressure (Press)**: 0.12
  - Temperature (Temp): 17.055
  - Conductivity (Cond): 45.353
  - Salinity (Sal): 35.21
  - Density (Dens): 1.0258
  - Dissolved Oxygen (O2ppm): 7.895
  - Saturation of Oxygen (O2sat%): 214.8
  - pH: 2.35
  - Redox Potential (Eh): 30.1
  - Time & Memory: 11:14:26.8 M+

- **Programmed depth point**: 0.19
  - Temperature (Temp): 17.010
  - Conductivity (Cond): 45.304
  - Salinity (Sal): 35.350
  - Density (Dens): 1.0258
  - Dissolved Oxygen (O2ppm): 7.902
  - Saturation of Oxygen (O2sat%): 208.7
  - pH: 2.17
  - Redox Potential (Eh): 27.8
  - Time & Memory: 11:14:27.0 M+

While running, the probe checks:

- **The probe battery**: In case the battery runs down, the data acquisition cycle ends immediately and the automatic acknowledgement of the acquired data is carried out.
- **The probe memory**: In case the memory is full, the data acquisition cycle continues but acquired data is not stored in memory.
- **The operator input**: If the operator types the <ESC> key, the data acquisition cycle ends immediately.

At the end of the data acquisition, if some data has been acquired, the data acknowledgement procedure is performed, and the "Data Acquisition menu" is re-displayed.

### 3.15 CONDITIONAL DATA ACQUISITION

Conditional data acquisition is used to perform burst measurements whenever a sensor reading is greater than a configured trigger limit. The sensor can be selected among those installed in the probe and the trigger limit can be freely configured by operator. In order to perform the monitoring of the sensor reading, the probe asks the operator for the configuration of a monitoring interval (from 60s to 1day). During the measurement cycles, the probe wakes up at the configured interval to monitor the sensor reading and to compare the sensor reading against the configured trigger limit. To save the battery energy, the probe waits in OFF condition for the time between two consecutive sensor measurements. Whenever the sensor reading is greater than the configured trigger limit, the probe starts to acquire a burst of data. Data acquired from sensors is shown and stored in the probe data memory.

The data acquisition (burst measurements) takes place at the configured sampling rate and continues until the selected sensor reading does not fall again under the configured trigger limit. There is no limit to the amount of data acquired during a burst measurement. The cycle continues indefinitely until it is interrupted by operator. Acting on the magnetic switch, it is possible to temporarily interrupt and restart the measurement cycle. Each time the burst measurement cycle starts, a new cast is automatically generated to separate the acquired data from the one stored before.

Whenever this command is selected from the data acquisition menu, the following message appears on the PC screen:

```
Conditional Sampling setup
Monitoring time-out: 00:00:00 enter time [hh:mm:ss] < 00:01:00
```

The operator must enter the time-out used by the probe to monitor the sensor reading. The time-out can be configured from 60s to 1day. Afterwards, the sensor to be used to condition the measurements can be selected:

- **Parameter**
  - Press: 000
  - Temp: 001
  - Cond: 002
  - O2Sat%: 006
  - O2ppm: 005
  - pH: 007
  - Eh: 008

**Sensor logical code: 0 enter new value < 2**

The probe shows on the PC screen a list representing all the sensors installed in the probe. The operator can select one of the shown sensors to be used as an acquisition condition by entering the numerical value indicated under the logical code column. Once selected, the operator can enter the trigger value.
used to start and/or stop the data acquisition cycle.

Sensor trigger value: 0 enter new value < 30.0

The value must be entered in engineering values (ppm, dbar, °C, mS/cm, etc.) taking into consideration the selected sensor and its measuring unit. Therefore, a value of 100 is fine if the selected parameter is the oxygen saturation, but it is completely wrong if the selected parameter is the temperature sensor, as 100°C cannot be measured by the OCEAN SEVEN 316Plus probe. Therefore, this condition, even if accepted, will be never met by the temperature sensor reading.

The last parameter to enter is the sampling rate that will be used by the probe whenever the burst data acquisition cycle starts.

Data acquisition sampling rate [50ms]: 50 enter new value < 250

The operator can select a sampling rate between 0.1 and 20 Hz by configuring the associated time between measurements expressed in ms, the most common are:

<table>
<thead>
<tr>
<th>Sampling rate</th>
<th>Interval to configure</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Hz</td>
<td>50 ms</td>
</tr>
<tr>
<td>10 Hz</td>
<td>100 ms</td>
</tr>
<tr>
<td>5 Hz</td>
<td>200 ms</td>
</tr>
<tr>
<td>1 Hz</td>
<td>1000 ms</td>
</tr>
<tr>
<td>0.1 Hz</td>
<td>10000 ms</td>
</tr>
</tbody>
</table>

After the sampling rate has been entered, the probe is ready to start the conditional data acquisition cycle. The following message appears on the PC screen:

Configuration updating. Done
----- UNATTENDED Conditional Acquisitions -------
To start the measuring cycle Switch OFF now the probe and then Switch it ON when ready
To stop while the probe is ON, type <ESC> until a message appears
Between acquisition cycles, while the probe is on surface, wait 1 minute before switching OFF the probe
Wait at least 30 seconds before executing a new Start-Up

Now, the operator must switch OFF the probe using the magnetic switch on the probe top cover. Afterwards, the probe will be switched ON to start the conditional data acquisition cycle when the operator is ready to deploy the probe in the field. Once switched ON, the probe starts to monitor the trigger condition according to the configured interval.

Note
If the probe interfaces a “Rosette” water sampling device, some questions about the water sampling method and steps are presented to the operator. Details about the water sampling set-up can be found in the dedicated appendix.

3.15.1 Terminate the Conditional data acquisition
The conditional data acquisition ends whenever one of the following events occurs:

Memory is full
Whenever the data memory is full, the probe stops to acquire data and automatically concludes the conditional data acquisition cycle. Acquired data is automatically confirmed in the probe memory.

Battery has run down
The probe automatically checks the battery voltage against the preset boundary each time it wakes up or at regular intervals when it is always in ON condition (burst measurements). In case the battery has run down, the following message appears:
No more power supply to continue the conditional data acquisition

After this message is shown, the conditional data acquisition procedure is automatically concluded and the probe shows the “Data acquisition menu” again. Acquired data is automatically confirmed in the probe memory.

**Operator stops acquisition**

The operator can terminate the conditional data acquisition by pressing the <ESC> key, while the probe is ON, or by pressing the <ESC> key once the probe is OFF and answering positively to the question about the intention to conclude the conditional acquisition cycle. In this case, the following message appears on the PC screen after the start-up procedure is concluded:

*Do you want to terminate the Conditional data acquisition? (Y)es (N)o*

Pressing <Y> for Yes immediately terminates the conditional data acquisition cycle. By pressing <N> for No, the probe immediately starts an automatic power OFF procedure calculating the next sensor monitoring time. The operator has 30s to answer the question. If no answer is received, the probe shuts down by itself going on with the conditional cycle.

**Data acquisition error**

In case the probe does not complete a data acquisition procedure due to hardware or sensor problems, the following message appears:

*Error during data acquisition*

After this message is displayed, the conditional data acquisition is automatically concluded. Acquired data is automatically confirmed in the probe memory.

### 3.16 CONTINUOUS DATA ACQUISITION

The continuous data acquisition is a very simple and straightforward acquisition method. After the cycle configuration, all the times the probe is switched on, it starts to acquire, show and store in memory the acquired data according to the configured sampling rate (0.1 Hz to 20 Hz). An indefinite number of measurements can be performed for each cycle. An indefinite number of cycles can be performed by switching ON and OFF the probe.

**Continuous data acquisition setup**

*Data acquisition scan rate [50ms]: 50 enter new value< 250*

The operator can select a sampling rate between 0.1 and 20 Hz by configuring the associated time among the samplings expressed in ms, the most common are:

<table>
<thead>
<tr>
<th>Sampling rate</th>
<th>Interval to configure</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Hz</td>
<td>50 ms</td>
</tr>
<tr>
<td>10 Hz</td>
<td>100 ms</td>
</tr>
<tr>
<td>5 Hz</td>
<td>200 ms</td>
</tr>
<tr>
<td>1 Hz</td>
<td>1000 ms</td>
</tr>
<tr>
<td>0.1 Hz</td>
<td>10000 ms</td>
</tr>
</tbody>
</table>

After the data acquisition rate has been entered, the probe is ready to start the continuous data acquisition cycle, and the following message appears on the PC screen:

*Configuration updating. Done*

*------ UNATTENDED Continuous Acquisitions ------*

IDRONAUT – Brugherio (MB)  OCEAN SEVEN 316Plus PROBE  11-2019
SECTION THREE- DATA ACQUISITION

To start the measuring cycle, switch OFF the probe now and then switch it ON when ready
To stop while the probe is ON, type <ESC> until a message appears
Between acquisition cycles, while the probe is on surface, wait 1 minute before switching OFF the probe
Wait at least 30 seconds before executing a new start-up

Now, the operator must switch off the probe using the magnetic switch on the probe top cover. The probe will be switched on again to start the first continuous data acquisition cycle when the operator is ready to deploy the probe in the field.
Once switched on, the probe starts to acquire, show and store data in memory until one of the terminate conditions is met.

3.16.1 Terminate the Continuous data acquisition
The continuous data acquisition ends whenever one of the following events occurs:

Memory is full
Whenever the data memory is full, the probe stops to acquire data and automatically concludes the continuous data acquisition cycle. Acquired data is automatically confirmed in the probe memory.

Battery has run down
The probe automatically checks the battery voltage against the preset boundary each time it wakes up or at regular intervals when it is always ON. In case the battery has run down, the following message appears:

No more power supply to continue the continuous data acquisition

After this message is shown, the continuous data acquisition procedure is automatically concluded and the probe shows the "Data acquisition" menu again. Acquired data is automatically confirmed in the probe memory.

Operator stops acquisition
The operator can terminate the continuous data acquisition by pressing the <ESC> key while the probe is ON or by pressing the <ESC> key once the probe is OFF and answering positively to the question about the intention of concluding the continuous acquisition cycle. In this case, the following message appears on the PC screen at the end of the probe start-up.

Do you want to terminate the Continuous data acquisition ? (Y)es (N)o

Pressing <Y> for Yes immediately terminates the continuous data acquisition cycle. By pressing <N> for No, the probe continues the data acquisition. The operator has 30s to answer the question. If no answer is received, the probe shuts down by itself going on with the continuous cycle.

Data acquisition error
In case the probe does not complete a data acquisition procedure due to hardware or sensor problems, the following message appears:

Error during data acquisition

After this message is shown, the continuous data acquisition is automatically concluded. Acquired data is automatically confirmed in the probe memory.
DATA STORAGE

During the data acquisition cycle, the probe not only shows acquired data in real time but also acts as a data logger, storing the acquired data in its internal non-volatile memory. Depending on the probe configuration and options, the probe can be equipped with 1-MByte SRAM or with 4GByte FLASH memory.

4.1 MEMORY ORGANIZATION

Apart from the type of memory (SRAM, FLASH) present in the probe, data memory is organized in two main areas. The first area is called “CAST”; it stores the information about “when” and “how” data has been acquired by the probe. The second area is called “DATA”; it stores acquired data subdivided into data records, 4 bytes long. A data record is associated to each true sensor when data is being stored in memory. The probe acquires and stores data relative to all the installed sensors. A group of data records about all the installed sensors becomes a single “data set”. The probe stores and retrieves single or groups of “data sets”.

Acquired data is stored in memory in ADC counts. Only data belonging to true installed sensors are stored in memory. Parameters relative to derived units, like salinity, are not stored in memory. They are immediately calculated once the operator asks to show stored data or to transfer stored data to a PC. In fact, stored data is converted from ADC counts into “engineering units” once the probe shows a stored cast or when it transfers a stored cast to a PC.

The conversion from ADC count into engineering units is done by means of the algorithms described in the introduction section and by means of the sensors calibration values.

As a common-sense rule, it is important that the probe internal memory is not used as an archival memory to keep data for very long time. It is important that stored data is transferred to a PC and then archived there, immediately after the field campaign is concluded. Increase of the probe performance can be obtained if, before starting a new measurement campaign, the probe memory is initialized.

Therefore, we strongly suggest that you upload data immediately after the field campaign and initialize the probe memory immediately before starting the next field campaign.

4.1.1 Cast area

Allocated space of the “CAST” area is for 2000 casts. The number of data records, associated with a certain number of casts, is only limited by the number of free data records. This means that a single cast can head a set of data, which uses all the data area, or that the data stored for 2000 casts does not use all the data area. The number of storable casts does not depend on the memory size. It is fixed at 2000.

The header information stored for each cast is:

❖ data acquisition starting time;
❖ sampling area identification code;
❖ type of data acquisition;
❖ time intervals or depth steps used to acquire and store data;
❖ number of parameters stored for each acquisition;
❖ number of data records stored for this cast;
❖ first data record stored for this cast.

The above information is presented to operator when the [Show Memory Status] command is used (see below).

4.1.2 Data records

Each data record is 4 bytes long. Either data record can contain a parameter value in raw format (ADC counts) or the acquisition time expressed in hundredths of second. The number of data records that can be stored in the probe internal memory depends on the size of the probe memory. A bigger memory allows storing more data records.
4.1.3 **Data Sets**

Data records are grouped in sets to form single “Data Sets”. Each data set is composed of the recorded data for each installed sensor plus one dedicated to store the date & time of acquisition. Memory capacity of the OCEAN SEVEN 316Plus is judged in terms of available “CASTs” and available “Data Sets”. Some examples follow:

**SRAM Memory**

Considering a probe with the following sensors installed: pressure, temperature, conductivity, oxygen sat.%, pH, redox,

Storable data sets = $\frac{205.500}{\text{(no. of installed sensor +1 date & time)}} = \frac{29.357}{7} = 4.193$

**FLASH Memory**

Considering a probe with the following sensors installed: pressure, temperature, conductivity, oxygen sat.%, pH, redox,

Storable data sets = $\frac{4,294,967,296}{4/\text{(no. of installed Sensor +1 date & time(7))}} = 153,391,689$

**Note**

The IDRONAUT “OS3xx PROBE Autonomy” is distributed together with the probe documentation. This tool allows calculating the probe autonomy by means of a simplified user interface. More details can be found in the probe maintenance section.

4.2 **MEMORY MANAGEMENT**

The “Memory menu” is presented on the computer screen by selecting: `<MEMO>` from the probe “Main menu”. Once selected, the following message is displayed:

```
OCEAN SEVEN 316Plus - ID:[0430][USR](7.5_10-12/2006) Tue Jan 02 12:48:32.64 2007
Data acquisition menu
<0> [MEUP] - Leave memory menu
<1> [MESM] - Show memory status
<2> [MESD] - Show stored data
<3> [MEDM] - Delete data
<4> [MEIN] - Initialize data memory
```

cmd>

Selection of the desired function is performed by typing one of the acronyms contained in the [] square brackets or the number in the <> brackets. By pressing the <ESC> key or <0>[MEUP] command, the programme returns to the “Main menu”, while pressing the <ENTER> key re-displays the “Memory menu”.

4.3 **SHOW MEMORY STATUS**

This function shows the information about the probe memory status. Once invoked, the following message appears:

```
Data memory statistics
Type                       Maximum  Used  Free
Cast area                  2000    3     1997
Data area (Dataset)        4014080  25   4014055
Data area (Data byte)      128450560 800 1284509760
------------------------------- Data area usage -------------------------------
000000 KByte:XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
008192KByte:XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```
### 4.4 SHOW STORED DATA

This function allows the operator to inspect stored data. The operator must choose the cast to inspect before stored data is shown on the PC screen. Once invoked, this function shows the following messages containing the list of stored casts:

<table>
<thead>
<tr>
<th>Cast</th>
<th>Bytes</th>
<th>Acq. Stored</th>
<th>Dataset</th>
<th>First - Last</th>
<th>Stat Type</th>
<th>Area code</th>
<th>Date&amp;Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64</td>
<td>9 8 2 202</td>
<td>OK LINEAR</td>
<td>ER-0112</td>
<td>Tue Jan 02 14:06:35.62 2007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>640</td>
<td>9 8 20 203</td>
<td>OK TIMED</td>
<td>ER-0112</td>
<td>Tue Jan 02 14:48:40.62 2007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>9 8 3 205</td>
<td>OK MANUAL</td>
<td>sample</td>
<td>Wed Jan 03 12:04:38.62 2007</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The operator must select the cast to be shown from the stored ones. After choosing the cast, the following message appears:

*Show stored data in counts ?* No
The operator must choose whether to show the data in ADC counts or engineering units. The first method can be useful to carry out calibration or sensor verification.

**Show stored data records in engineering units**

<table>
<thead>
<tr>
<th>Press</th>
<th>Temp</th>
<th>Cond</th>
<th>Sal</th>
<th>Dens</th>
<th>O2ppm</th>
<th>O2sat%</th>
<th>pH</th>
<th>eH</th>
<th>Time&amp;Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12</td>
<td>17.055</td>
<td>45.353</td>
<td>35.352</td>
<td>1.0258</td>
<td>2.35</td>
<td>30.1</td>
<td>7.895</td>
<td>214.8</td>
<td>11:14:26.8</td>
</tr>
<tr>
<td>0.19</td>
<td>17.010</td>
<td>45.304</td>
<td>35.350</td>
<td>1.0258</td>
<td>2.17</td>
<td>27.8</td>
<td>7.902</td>
<td>208.7</td>
<td>11:14:27.0</td>
</tr>
</tbody>
</table>

Type <any key> To continue

**Show stored data records in ADC counts**

<table>
<thead>
<tr>
<th>Press</th>
<th>Temp</th>
<th>Cond</th>
<th>Sal</th>
<th>Dens</th>
<th>O2ppm</th>
<th>O2sat%</th>
<th>pH</th>
<th>eH</th>
<th>Time &amp; Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>194.1</td>
<td>22000.9</td>
<td>41393.6</td>
<td>-9999.0</td>
<td>-9999.0</td>
<td>11963.4</td>
<td>1689.4</td>
<td>6108.9</td>
<td>11:14:26.8</td>
<td></td>
</tr>
<tr>
<td>195.3</td>
<td>22003.7</td>
<td>41391.3</td>
<td>-9999.0</td>
<td>-9999.0</td>
<td>11955.8</td>
<td>1689.5</td>
<td>6108.7</td>
<td>11:14:27.0</td>
<td></td>
</tr>
</tbody>
</table>

Type <any key> to continue

Typing a character on the PC keyboard terminates the show data function and the probe “Memory Menu” appears again.

**Note**

Whenever the “Show stored data records in ADC counts” is selected, the derived parameters (like salinity) not belonging to a sensor are shown with the value -9999.0.

### 4.5 SRAM MEMORY DELETE DATA

This function allows stored cast data to be deleted. Deleted cast can be retrieved if it is stored in the Flash memory. Deleted cast cannot be restored if it is stored in the internal 1Mbyte memory.

After invoked, this function shows the following message:

**Stored casts**

<table>
<thead>
<tr>
<th>Data</th>
<th>Sensors</th>
<th>EXT Mem Sector</th>
<th>Acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast</td>
<td>Bytes</td>
<td>Acq. Stored</td>
<td>Dataset</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td>1</td>
<td>64</td>
<td>9 8 2 202</td>
<td>202</td>
</tr>
<tr>
<td>2</td>
<td>640</td>
<td>9 8 20 203</td>
<td>204</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>9 8 3 205</td>
<td>206</td>
</tr>
</tbody>
</table>

Select the cast to delete: 0 enter new value = 3

From the stored casts, the operator must select the one that will be deleted. After choosing the cast, it is deleted from memory. The following message confirms the memory deletion in case of 1-Mbyte memory:

Data memory reorganization ...
Data area compaction ...
Cast memory compaction ...

At the end of the deletion process, the “Memory Menu” appears again.

### 4.6 FLASH MEMORY DELETE DATA

This function allows stored cast data to be marked as deleted. Casts marked as deleted cannot be further retrieved. After invoked, this function shows the following message:

**Stored casts**

<table>
<thead>
<tr>
<th>Data</th>
<th>Sensors</th>
<th>EXT Mem Sector</th>
<th>Acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast</td>
<td>Bytes</td>
<td>Acq. Stored</td>
<td>Dataset</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td>1</td>
<td>64</td>
<td>9 8 2 202</td>
<td>202</td>
</tr>
<tr>
<td>2</td>
<td>640</td>
<td>9 8 20 203</td>
<td>204</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>9 8 3 205</td>
<td>206</td>
</tr>
</tbody>
</table>

Select the cast to delete: 0 enter new value = 3

From the stored casts, the operator must select the one that will be deleted. After choosing the cast, it is marked as deleted. At the end of the deletion process, the “Memory Menu” appears again.
4.7 **INITIALIZE DATA MEMORY**

By means of this function, it is possible to initialise the probe memory. Obviously, after the initialization, all stored data will be lost. However, the operator must answer two questions before the initialization starts. Once invoked, the following message appears:

*Initialize data storage area*

*Warning, the initialize procedure deletes all data records and casts stored permanently*

*Are you sure?* No type [Y]es or [N]o < y

The operator must confirm his intention to perform a data memory initialization.

*Confirm again your intention!* No type [Y]es or [N]o < y

The operator must confirm again his intention to perform a data memory initialization

*Data storage area has been initialized.*

After this message appears, the programme returns to the “Memory menu”.
5 SENSOR CALIBRATION
This section provides general information about how the probe manages and keeps the sensor calibration coefficients stored, and describes the functions available in the “Calibration Menu”. The aim of the “Calibration Menu” is to allow the operator to carry out the calibration procedures needed by any sensor installed. The aim of the calibration information is to define the coefficients and the mathematical procedure needed by the probe to convert the ADC counts acquired from a particular sensor into engineering units like: ppm, mS/cm, °C, dbar, etc..

5.1 CALIBRATION STORING LAYOUT
Information on calibration is stored in a non-volatile memory, which can keep up to 128 different calibration records. Each record is associated to a sensor calibration. However, depending on the probe operations, a sensor can be associated with more than one calibration record. In fact, a sensor calibration record is associated with a configured sensor or/to a cast stored in memory. This means that two stored casts can have different calibration records associated with the same sensor. The probe management programme automatically indexes and uses the proper calibration records during the conversion of stored or real-time data from ADC counts into engineering units.

The items stored for each calibrated sensor are:
❖ Calibration date & time.
❖ Calibration status.
❖ Index of the stored cast, if any.
❖ Index of the sensor configuration.
❖ Sensor logical code.
❖ Number of coefficients or/and degree of polynomial.
❖ Polynomial coefficients or calibration values.

5.1.1 Parameter/Sensor logical codes
The management firmware uniquely identifies a derived parameter or sensor among the others by means of a predefined logical numerical code. The most common logical codes can be found in Appendix “B” of this manual, while, the complete list of logical codes can be found in the “Ocean Seven 3xx Data Transmission protocol” document.

5.2 CALIBRATION GLP (GOOD LABORATORY PRACTICE)
The Ocean Seven 316Plus, according to the GLP European directive: “Good Laboratory Practice (GLP) embodies a set of principles that provides a framework within which laboratory studies are planned, performed, monitored, recorded, reported and archived. These studies are undertaken to generate data by which the hazards and risks to users, consumers and third parties, including the environment, can be assessed for pharmaceuticals (only preclinical studies), agrochemicals, cosmetics, food additives, feed additives and contaminants, novel foods, biocides, detergents etc.... GLP helps assure regulatory authorities that the data submitted are a true reflection of the results obtained during the study and can therefore be relied upon when making risk/safety assessments” keeps trace of the calibrations carried out on the sensors. The stored calibration information can be then used by the operator to further analyze the sensors behaviour with the passing of time. The OCEAN SEVEN 316Plus keeps up to 1024 calibration log records. Each calibration log record registers, apart from the date and time of calibration, the most important information about the status of each type of sensors.

5.3 SENSOR CALIBRATION FUNCTIONS
The ”Calibration Menu” is displayed on the user’s terminal by selecting: <CALB> from the ”Main Menu”. The following menu is displayed:

```
OCEAN SEVEN 316Plus - ID:[0430][USR](7.5_10-12/2006) Tue Jan 02 12:48:32.64 2007
Calibration menu
<0>{CAUP} - Leave calibration menu
<1>{CASE} - Calibrate sensors
<2>{CACU} - Customize calibration data
<3>{CALO} - Calibration log
```
SECTION FIVE - SENSOR CALIBRATION

Selection of the desired function is performed by typing one of the acronyms contained in the square brackets, or by typing the number between the <> brackets. By pressing the <ESC> key or [CAUP] command, the programme returns to the "Main Menu", while, pressing the <ENTER> key re-displays the "Calibration Menu".

5.3.1 **Updating the calibration information**
At the end of the sensor calibration procedure, the probe automatically updates the calibration record storage area in the dedicated non-volatile memory.

```
Update calibration parameters  
Configuration updating, Ok  
[xxx][xxx] calibration values updated..
```

This message notifies the operator that the calibration record storage area has been updated. The “xxx” fields depend on the type of calibrated sensor and on the calibration record associated to the sensor.

5.4 **CALIBRATE THE SENSORS**
This function allows the operator to perform the sensor calibration. Once invoked, the following message appears:

```
Sensors Calibration  
Index   Sensor   Data&Time  
00 - Leave sensor calibration  
01 [ 0]000   Pres   Thu Jan 04 11:33:04.81 2007  
02 [ 1]001   Temp   Thu Jan 04 11:33:04.81 2007  
Select the sensor: 0
```

The operator must select the sensor to be calibrated from the shown sensor list. After choosing the sensor by means of the **index** (the number indicated in the first column of the above list), the programme goes on depending on the chosen parameter, as described in the paragraphs below. Selecting 0 causes the immediate exit from the “calibrate sensor” function and the “Calibration Menu” will be shown.

5.4.1 **Selecting a wrong sensor**
If the operator selects a sensor that cannot be calibrated or a sensor not well configured, the following message appears:

```
The selected parameter is not correctly configured; before going on with calibration, you must properly configure it
```

This message also terminates the calibrate sensor function. The program returns to the "Calibration Menu".

5.5 **CUSTOMIZED CALIBRATION PROCEDURE**
Some sensors have specialized data processing and calibration methods, which mainly depend on the kind of answer to physical or chemical variations in the measured samples and on the conditioning circuits. They are:

❖ Pressure
5.5.1 Pressure sensor
The aim of the pressure sensor calibration is the offset zeroing. It is preferable to immerse the probe in water, up to about 10 cm from the probe housing, and wait for few seconds before starting the calibration. Once the pressure sensor calibration is chosen, the following message appears:

Do you intend to review the calibration coefficients?

By answering <NO> (the default choice), the operator will continue with the sensor calibration sensor, whereas, answering <YES> will allow the operator to see and modify the calibration coefficients.

Pressure = a + bx + cx2

The calibration coefficients: a, b, and c are indicated on the probe “Calibration Certificate”.

Pressure sensor calibration
Zeroing pressure offset - Immerse the probe and wait few seconds to stabilize the sensors temperature
Type <any key> To continue, <ESC> To leave

The operator must type any key to continue with the pressure calibration, whereas, if the <ESC> key is typed, the calibration procedure immediately terminates. The pressure calibration procedure goes on with the following message:

Pressure calibration in progress
Calibration statistics
Sensor Offset - ADC counts dbar
111.0 0.8

At the end of this procedure, the programme updates the calibration values and shows the “Calibration menu”.

5.5.2 Temperature & Conductivity sensor calibration
Once selected the sensor to be calibrated, the following message appears:

Current calibration values
Polynomial coefficients a + bx + cx2 + dx3
a = x.xxx
bx = x.xxx
cx2 = x.xxx

cx3 = x.xxx

At the end of the current calibration value, the following message appears:
Enter the polynomial degree and number of coefficients

Polynomial degree:

The operator is requested to enter the degree of polynomial (1..3), and then to enter the coefficient values for each degree:

Coefficients:

The above request is repeated for the degree of polynomial. At the end of the coefficients data entry, the sensor selection list appears again.

5.5.3 Simple check of conductivity sensor calibration

The conductivity sensor is usually very accurate. A check of any drift with time or calibration can be performed by using a Standard Seawater. A worldwide used Standard Seawater for conductivity is the so-called “Copenhagen Water” which is supplied by I.A.P.S.O. - Standard Seawater Service. The certified value of Chlorinity is 19.371 ppt, that corresponds to a Practical Salinity of 35.00 ppt. The temperature value is used in the salinity calculation, as explained in the sensor description paragraph; 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 then dried. These precautions are necessary for not diluting or contaminating the Standard Seawater. Transfer some Standard Seawater into a beaker provided with a magnetic stirrer and immerse the probe into it. From the data acquisition functions, check that the value for conductivity and temperature can be read. The conductivity value is supposed to be coincident or very close to the theoretical one which can be found in the "STANDARD SEA WATER K15 0,99999 - CONDUCTIVITY VERSUS TEMPERATURE TABLE". If a considerable difference is present, a calibration procedure must be performed.

5.5.4 Oxygen sensor calibration

The dissolved oxygen sensor requires most attention of all the OCEAN SEVEN 316Plus 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;
❖ once a month if the probe is installed on a Buoy Profiler or is used in a continuous monitoring.

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 to have homogeneous temperature. 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 on the field. **For this reason, the calibration is usually carried out in air.** Once selected the sensor to be calibrated, the following message appears:

O2sat% sensor calibration
Gently wipe O2 membrane and Temperature sensor
Type <any key> To continue, <ESC> To leave

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 towelling taking particular care not to damage the membrane. Dry the temperature sensor with clean towelling 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 and direct sun rays, for at least one minute before proceeding with calibration. When ready, press any key to continue; the following message appears:

**Oxygen calibration in progress**

**Calibration statistics**

<table>
<thead>
<tr>
<th>Sensor Current</th>
<th>% Last cal.</th>
<th>Drift</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>64.80 nA</td>
<td>118.8 %</td>
<td>19.6 Count</td>
<td>18.013 C</td>
</tr>
</tbody>
</table>

“% of last calibration” is given by (new cal/old cal) x100 and gives a measure of ageing of the membrane and the electrode. Sensor drift is automatically checked by the probe and is compared against predefined limits. If excessive drift is detected, this message appears:

**Oxygen sensor error, see Operator’s Manual**

Please proceed with the maintenance procedures, as illustrated in the probe maintenance section. If the last message does not appear, it means that the calibration procedure can continue, and the atmospheric pressure coefficient should be entered:

**Oxygen correction coefficient for**

1) **Barometric pressure deviation from the 760 mmHg**
2) **Stirring effect on the sensor**

Enter Altitude above sea level [m]: 0

If the atmospheric pressure is 760 mmHg (sea level) and no correction is required, leave the shown coefficient (0); the probe will propose a correction coefficient of 1.0. If a value different from 0 is entered, the probe calculates the correction coefficient by itself and then propose it to the operator for approval.

\[
\text{coefficient} = 1.0
\]

At the end of this procedure, the programme shows the "Calibration menu".

**NOTE REGARDING VARIATIONS IN BAROMETRIC PRESSURE (ALTITUDE) AND THE SENSOR MEMBRANE COEFFICIENT ALSO CALLED “STIRRING EFFECT”**
The correction coefficient different from the nominal one 1.0 is needed for the following reasons:

1) To enter barometric pressure values differing from the 760 mmHg standard which represents the nominal B.P. at sea level. For example, if the measurements to be made are carried out in an area which is at 1.340 metres above sea level, then the nominal local barometric pressure is only 655 mmHg. In this case, the correction coefficient is given by the formula:

\[
\frac{\text{Local nominal B.P.}}{\text{Standard nominal B.P.}}
\]

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 readout will be multiplied by a factor of 10.

5) In case of moored applications, where the probe remains steady measuring for long periods, the
coefficient 1.05 should be entered to compensate for the stirring effect on the surface membrane. For instance, to apply a double compensation due to the barometric effect and to the oxygen depletion, the following operation must be used:

\[
\begin{align*}
760 \\
\text{i.e.} \quad - \quad \quad &= \quad \text{Barometric correction coefficient} = 1.216 \\
625 \\
1.05 &= \quad \text{Stirring effect or oxygen depletion coefficient standard value (5%)} \\
1.05 \times 1.216 &= \quad 1.2768 \quad \text{Total coefficient to be applied.}
\end{align*}
\]

Note
The latest probe firmware release takes one further step forward in the simplification of the dissolved oxygen sensor calibration by introducing the automatic calculation of the barometric pressure compensation using an algorithm which calculates the coefficients depending on the altitude. The above procedure is therefore replaced by:

\[
\begin{align*}
\text{Oxygen correction coefficient for} \\
1 \quad &\text{- Barometric pressure deviation from the 760 mmHg} \\
2 \quad &\text{- Stirring effect on the sensor} \\
\text{Enter Altitude above sea level [m]}:0
\end{align*}
\]

The operator must enter the elevation above sea-level in meters. Afterwards, the probe calculates by itself the new correction coefficient. The new coefficient is then shown for the operator’s approval.

\[
\begin{align*}
\text{New correction coefficient}:1
\end{align*}
\]

The new coefficient can be approved or modified. In the latter case, the rules explained above are still valid.

5.5.5 Blue cap optical dissolved oxygen sensor calibration
A detailed description of the sensor and of the associated calibration procedure can be found in the appendix N.

5.5.6 pH sensor calibration
The pH sensor calibration is carried out using a single buffer solution: pH7. A second buffer pH4 can be used, to verify the calibration and the good state of the sensor. After the “pH sensor” has been selected from the list of sensors to be calibrated, the operator must enter the pH buffer value (in pH units) which he intends to use during the pH calibration.

\[
\begin{align*}
\text{pH Sensor calibration} \\
pH \text{ buffer value : 7.0}
\end{align*}
\]

Afterwards, the following message appears:

\[
\begin{align*}
pH \text{ Sensor calibration} \\
\text{Place the buffer cup} \\
\text{Type any key to continue, <ESC> to abort}
\end{align*}
\]

Pull out the calibration buffer cup from the accessory kit and fill it with the pH7 buffer solution. The buffer cup has been designed to simultaneously fit over the pH and reference sensors and should be
placed under these sensors with the probe in its vertical position (sensor looking at the floor). When the preparation is complete, press any key to continue. In case of trouble, type <ESC> to abandon the pH sensor calibration.

The following message appears:

```plaintext
pH calibration in progress
Calibration statistics
Sensor offset — Drift Temperature
0.09 pH 0.09 pH 0.76 mV 19.679
```

The sensor offset is intended as the offset from 7.0; values <= +/- 0.6 can be considered reasonable, whereas, higher values indicate that the sensors (pH and/or reference) require some maintenance. The drift is automatically controlled by the probe during the calibration. If the drift is lower than the preset limit during the following 20 seconds, the calibration is achieved; otherwise, the message:

```plaintext
pH sensor error, see Operator’s Manual
```

will appear after which the system returns to the “Calibration Menu”. If no error is detected, the probe asks the operator to select the pH temperature compensation mode.

```plaintext
Automatic temperature compensation ?
```

Should a special and fixed temperature compensation be requested, the reference temperature value must be entered:

```plaintext
pH reference temperature:
```

At the end of this procedure, the programme shows the sensor list.

**Note**

*pH variations in function of temperature of the pH7 (Phosphate) and pH4 (Phthalate) buffer solutions:*

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>pH4</th>
<th>pH7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.00</td>
<td>7.12</td>
</tr>
<tr>
<td>10</td>
<td>4.00</td>
<td>7.06</td>
</tr>
<tr>
<td>20</td>
<td>4.00</td>
<td>7.02</td>
</tr>
<tr>
<td>25</td>
<td>4.00</td>
<td>7.00</td>
</tr>
<tr>
<td>30</td>
<td>4.01</td>
<td>6.99</td>
</tr>
<tr>
<td>40</td>
<td>4.03</td>
<td>6.97</td>
</tr>
<tr>
<td>50</td>
<td>4.05</td>
<td>6.96</td>
</tr>
<tr>
<td>60</td>
<td>4.08</td>
<td>6.97</td>
</tr>
<tr>
<td>70</td>
<td>4.12</td>
<td>6.98</td>
</tr>
<tr>
<td>80</td>
<td>4.16</td>
<td>7.00</td>
</tr>
<tr>
<td>90</td>
<td>4.21</td>
<td>7.03</td>
</tr>
</tbody>
</table>

### 5.5.7 Redox sensor calibration

Once selected the sensor to be calibrated, the following message appears:

```plaintext
eH sensor calibration
Select the available number of Redox Buffers
Buffer solutions:
```

This message allows the operator to enter the number of “REDOX buffer” solutions from a minimum of 2 to a maximum of 10. Selecting 0 enables a special calibration function, which imposes a factory default
calibration value and immediately terminates the calibration procedure (the default coefficients are used to convert the sensor readings in mV).

Selecting a value of buffer solution greater than 1 starts the REDOX sensor calibration sequence.

Immediately Redox and Reference sensors into
the calibration cup filled with the 1st REDOX BUFFER
Type <any key> To continue, <ESC> To leave

Pull out the calibration buffer cup from the accessory kit and fill it with the redox LOW concentration buffer solution. The buffer cup has been designed to simultaneously fit over the eH and the reference sensors and should be placed under these sensors with the probe in its vertical position. When the preparation is complete, press any key to continue. The following message appears:

<table>
<thead>
<tr>
<th>Reading [1st] BUFFER</th>
<th>Redox</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>-18336.3 Count</td>
<td>19.894 C</td>
<td></td>
</tr>
</tbody>
</table>

After few seconds during which the probe acquires and shows the redox sensor reading, the following message appears:

Enter the BUFFER concentration value corrected for temperature
Concentration [units] -700

The operator is requested to enter the calibration value (units) of the "REDOX Buffer" solution corrected for the shown temperature. Calibration goes on with the next "BUFFER" until all the selected standard solutions have been acquired.

At the end of the acquisition process, the programme automatically calculates the coefficients of the straight line that interpolates all the acquired REDOX Buffers and shows the following message:

\[
\text{REDOX} = a + bx \\
a = 0.412418 \\
b = 0.0381531 \\
r \text{correlation coefficient} = 1 \\
c \% \text{ of variability} = 100
\]

At the end of this procedure, the REDOX calibration values are updated and the programme shows the list of sensors.

5.6 OTHER CALIBRATION PROCEDURES

Apart from the standard IDRONAUT sensors, the OCEAN SEVEN 316Plus probe can interface additional probes, like:

- IDRONAUT - String and Weight Bottom Sensor.
- IDRONAUT - High Precision 0.01%FS Pressure Transducer.
- IDRONAUT - Blue cap optical dissolved oxygen
- SEAPoint - Fluorometers and Turbidity Meter.
- WET Labs – C-Star Transmissometer and ECO Triplet Fluorometer.
- Trilux/Unilux SINGLE/THREE-CHANNEL FLUORIMETERS.
- TURNER DESIGNS – Cyclops-7 Fluorometers
- DATASONICS - PSA916D Sonar Altimeter, 6000 m
- D & A INSTRUMENT COMPANY - OBS-3 Sensor.
- BIOSPHERICAL INSTRUMENTS - QSP-2200 – QSP-2300 PAR Sensors...
- VALEPORT - MiniSVS Sound Velocity Sensors.
Below are described the calibration procedures of the most common sensors. New sensors (not included in the above list) or dedicated procedures, not covered in this Operator’s Manual, are described in a dedicated addendum manual enclosed to this manual.

5.6.1 **SEAPoint OEM Turbidity Meter**

The SEAPoint OEM Turbidity Meter is a sensor that measures turbidity by detecting scattered light from suspended particles in water. Its small size, very low power consumption, high sensitivity, wide dynamic range and 6000-m depth capability allow this sensor to be used in most applications where turbidity or suspended particle concentrations are to be measured. The sensor is also insensitive to ambient light when underwater and has a very low temperature coefficient. The SEAPoint Turbidity Meter senses scattered light from a small volume within 5 centimetres of the sensor windows. Confining the sensing volume allows the sensor to be calibrated in relatively small water containers without errors from surface and wall reflections. It also allows the sensor to be used in tight spaces such as crowded instrumentation packages, pipes and shallow streams.

Each sensor is factory calibrated using formazine Turbidity Standard. The user may also calibrate the sensor with particles of interest to measure their suspended concentrations. The SEAPoint Turbidity Meter is constructed from rugged, corrosion-free materials and quality surface mount electronic components for durability and high reliability. Some more information can be found in an application note distributed with the Operator’s Manual.

Once the Turbidity Meter is selected from the list of sensors to be calibrated, the following message and questions appear:

```
Turb. sensor calibration
Measuring scale 1, Full scale [>750 FTU]
Current Calibration values
Offset = 0.0
Slope = 1.0
r correlation coefficient = 1
c % of variability = 100
Do you already know ‘SLOPE & OFFSET’ coefficients ?: No
```

The operator can decide to enter the calibration coefficients received with the probe or to let the probe calculate new coefficients using experimental data obtained from the turbidity sensor in the laboratory (please refer to the dedicated application note).

Answering <YES>, the following messages appear in sequence:

```
Offset = 0.0  Slope = 1.0
```

The operator must enter the offset and slope coefficients indicated in the calibration certificate.

By answering <NO>, the following message appears:

```
Number of calibration points:0 enter new value< 2
```

Answer with the number of solutions used to calibrate the 750 FTU measuring scale. Now, starting from the lowest solution and going towards the most concentrated solution, the operator must enter the value acquired during the laboratory calibration procedure

```
Sample value (units)  Answer with the concentration value of the solution.
Sample reading (bit)   Answer with the probe reading.
```
The above questions about the units and bit (ADC Counts) are repeated for the number of “Calibration points” entered. Afterwards, the probe shows the result of the linear interpolation:

\[
\begin{align*}
\text{Turbidity} &= a + bx \\
\text{offset} &= 0.0 \\
\text{slope} &= 1.0 \\
\text{r correlation coefficient} &= 1.0 \\
\text{c % of variability} &= 100%
\end{align*}
\]

The operator can now confirm or modify the offset and slope coefficients.

\[
\text{Offset} = 0.0 \quad \text{Slope} = 1.0
\]

The Turbidity meter sensor calibration proceeds as above with the calibration of the remaining measuring scales:

- Measuring scale 2, Full scale [500 FTU]
- Measuring scale 3, Full scale [125FTU]
- Measuring scale 4, Full scale [25 FTU]

After the last coefficients have been confirmed, the operator must choose the measuring scale that the probe sets up after the wake-up. During data acquisition, the turbidity meter measuring scale is automatically selected by the probe management firmware to be the most sensitive one.

**Turbidity meter scale:** (1)>750 FTU, (2)500 FTU, (3)125 FTU, (4)25 FTU

### 5.6.2 SEAPOINT OEM Fluorometer

The SEAPOINT Fluorometer allows the user to monitor chlorophyll concentration by directly measuring the amount of fluorescence emission from a given sample of water. The sample media is pumped through a quartz tube mounted through the long axis of the instrument. Chlorophyll, when excited by the presence of an external light source, absorbs light in certain regions of the visible spectrum and re-emits a small portion of this light as fluorescence at longer wavelengths. SEAPOINT uses two bright blue LEDs (centred at 455 nm and modulated at 1 kHz) to provide the excitation. Blue interference filters are used to reject the small amount of red light emitted by the LEDs. A detector, positioned at 90° to the axis of the LED mounts, measures the emitted light from the sample volume. The approximately 0.25 cm³ sample volume is defined by the intersection of the excitation light with the field of view of the detector, within the quartz flow tube. A red interference filter is used to discriminate against the scattered blue excitation light. The red fluorescence emitted at 90° is synchronously detected at 1 kHz by a silicon photodiode. The amplified and demodulated voltage output of the photodiode is provided to the user for connection to a digital voltmeter or an a-d converter. The calibration procedure is the same described for the turbidity meter. The only differences are the measuring scales, which in the case of the fluorometer are: 5, 15, 50 and 160 µg/l.

### 5.6.3 WETLabs - C-STAR Transmissometer

The C-Star Transmissometer measures light transmittance at a single wavelength over a known path. The instrument is configured at the time of purchase to have a path length of 25 or 10 cm and wavelengths of either 370, 470, 530, or 660 nm. In general, losses of light propagating through water can be attributed to two primary causes: scattering and absorption. By projecting a collimated beam of light through the water and placing a focused receiver at a known distance away, one can quantify these losses. The ratio of light gathered by the receiver to the amount originating at the source is known as the beam transmittance (Tr). This is the fundamental measurement performed by the C-Star. Suspended particles, phytoplankton, bacteria and dissolved organic matter all contribute to the losses sensed by the instrument. They, combined with the intrinsic optical properties of the water itself, govern the radiative transfer properties within the earth's natural waters. Thus, the information provided by the C-Star provides both an indication of the total concentrations of matter in the water as well as a value of the water clarity. The beam attenuation coefficient is an absolute term to represent these losses. For
a given wavelength, transmittance is related to the beam attenuation coefficient by the following transfer equation. In the expression
\[ T = e^{-\alpha x} \]

where \( x \) is the path length (10 or 25 cm) of the water volume being measured. The below figure is a simple description of the C-Star configuration. The appropriate LED light source (depending on the wavelength) provides light that is focused and collimated by an aperture and lens that transmit the light within a given narrow bandwidth. The light passes through a beam splitter so that a portion of the transmitted light can be monitored by the reference detector and used in a feedback circuit to account for variations in the LED source over time as well as changes in the instrument’s internal temperature. The light enters the sample volume after passing through the first pressure window, transmits the sample volume and enters the receiver optics after passing through the other pressure window. The light passes through additional focusing optics and finally strikes a silicon photodiode detector which converts the amount of received light to a corresponding 0–5 V analogue output signal which represents the amount of light received.

Calibration procedure of the C-Star implies the following preliminary calculation that must be done using the probe and the C-Star calibration certificate:

\[
\begin{align*}
V_{\text{dark (wetlabs)}} & = 60 \text{ mV} \\
V_{\text{ref Water (wetlabs)}} & = 4786 \text{ mV} \\
\text{OS316Plus Hw scale} & = 2.00032688
\end{align*}
\]

from which the following parameters must be calculated:

\[
\begin{align*}
V_{\text{dark (bit)}} & = \left( \frac{V_{\text{dark (wetlabs)}}}{\text{HwScale (Idronaut)}} \right) \times 52.4288 \\
V_{\text{ref Water (bit)}} & = \left( \frac{V_{\text{ref Water (wetlabs)}}}{\text{HwScale (Idronaut)}} \right) \times 54.4288
\end{align*}
\]

Example:

\[
\begin{align*}
1570.29750 & = \left( \frac{60 \text{ mV}}{2.0032688} \right) \times 52.4288 \\
125257.3977 & = \left( \frac{4786 \text{ mV}}{2.0032688} \right) \times 54.4288
\end{align*}
\]

The \( V_{\text{dark (bit)}} \) and \( V_{\text{ref Water (bit)}} \) are therefore associated to the 0 and to the C-STAR full scale transmittance or 100 %. Thus, a table of experimental data can be generated as follows:

<table>
<thead>
<tr>
<th>Units (Tr %)</th>
<th>OS316Plus ADC Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1570.29750</td>
</tr>
<tr>
<td>100</td>
<td>125257.3977</td>
</tr>
</tbody>
</table>
From the above table of data, the offset and slope coefficients to be entered during the C-STAR calibration procedure must be calculated by the operator. This can be done using the “Interpolate” tool distributed with the IDRONAUT ITERM program or by using the probe calibration procedure. Selecting the C-STAR sensor from the list of sensors, the following calibration procedure arises:

Do you already know ‘SLOPE & OFFSET’ coefficients?: No

The operator can decide to enter the calibration coefficients received with the probe or to let the probe calculate new coefficients using the table calculated as above described.

Answering <YES>, the following messages appear in sequence:

Offset = 0.0  Slope = 1.0

The operator must enter the offset and slope coefficients, while answering <NO> the following message appears:

Number of calibration points: 0 enter new value < 2

The operator must answer using the tabled data:

Sample value (units)
Sample reading (bit)

The above questions about the units and bit (ADC Counts) are repeated for the number of “Calibration points” entered. Afterwards, the probe shows the result of the linear interpolation:

\[ Ty\% = a + bx \]

\[ \text{offset} = 0.0 \]

\[ \text{slope} = 1.0 \]

\[ r \text{ correlation coefficient} = 1.0 \]

\[ c \% \text{ of variability} = 100\% \]

The operator can now confirm or modify the offset and slope coefficients.

Offset = 0.0  Slope = 1.0

In the end, the list of sensors appears again.

5.6.4 WETLabs - ECO Triplet Sensor

WETLabs offers the custom ECO Triplet as a three-sensor instrument that can be configured for a variety of measurements:

- Three scattering measurements.
- Two scattering and one fluorescence measurements.
- Three fluorescence measurements.
- Two fluorescence and one scattering measurements.

Available measurement options:

<table>
<thead>
<tr>
<th>Scattering</th>
<th>Fluorescence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>Chlorophyll</td>
</tr>
<tr>
<td>Green</td>
<td>CDOM (limited to one CDOM channel)</td>
</tr>
<tr>
<td>Red</td>
<td>Uranine (fluorescein)</td>
</tr>
<tr>
<td></td>
<td>Phycoerythrin, phycocyanin</td>
</tr>
<tr>
<td></td>
<td>Rhodamine</td>
</tr>
<tr>
<td></td>
<td>Phycoerythrin, phycocyanin</td>
</tr>
<tr>
<td></td>
<td>Rhodamine</td>
</tr>
</tbody>
</table>
The logical codes associated to each parameter are:

<table>
<thead>
<tr>
<th>Logical code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>114</td>
<td>Fluorometer Chl-(a)</td>
</tr>
<tr>
<td>115</td>
<td>CDOM</td>
</tr>
<tr>
<td>116</td>
<td>Scattering</td>
</tr>
<tr>
<td>117</td>
<td>Phycocyanin</td>
</tr>
<tr>
<td>118</td>
<td>Phycoerithrin</td>
</tr>
<tr>
<td>119</td>
<td>Rhodamine</td>
</tr>
<tr>
<td>120</td>
<td>Uranine</td>
</tr>
</tbody>
</table>

No. of digits to show: 6
No. of digits after the dot: 2
Do you want to store it? Yes
Do you want to show data? Yes
Data processing method: 2 = Proprietary&UNESCO
Mux. Channel: 246
Mux. Delay: 0

Note
The parameter configuration must be repeated for each ECO sensor.

The calibration procedure of the ECO sensors implies the introduction of the WETLAB original coefficients found in the “characterization sheet” accompanying the instrument. After selecting the ECO sensor from the list of sensors, then the operator must enter in sequence:

ECO Sensor dark counts
ECO Sensor scale factor

5.6.5 **LICOR - PAR Sensor**

The LICOR LI-193SA Underwater Spherical Quantum Sensor gives an added dimension to underwater PAR measurements as it measures photon flux from all directions. This measurement is referred to as Photosynthetic Photon Flux Fluence Rate (PPFFR) or Quantum Scalar Irradiance. This is important, for example, when studying phytoplankton, which utilizes radiation from all directions for photosynthesis. The LI-193SA features a high sensitivity optical design and compact, rugged construction (3400 kPa, 350 meters depth). The LI-193SA analogue interface of the OCEAN SEVEN 316Plus probe transforms, by means of a linear current to voltage pre-amplifier, the LI-193SA sensor output (current in µA) into ADC counts. Calculation of the calibration coefficients implies a preliminary calculation that is carried out by using the LICOR calibration certificate and the probe calibration certificate. By applying the below calculation, the OCEAN SEVEN 316Plus transforms the sensor readings into µmol s^{-1} m^{-2}.

**Calibration constants**

*LI-193SA calibration constant in water* = 4.71 µA per 1000 µmol s^{-1} m^{-2}

*OCEAN SEVEN 316Plus Full Scale current* = 9.83 µA equivalent to = 131072 ADC counts

**Calculation of the full scale PAR sensor**

F.S. (9.83 µA / 4.71) * 1000 = 2087.048832 µmol s^{-1} m^{-2}
Afterwards, the calibration coefficients \((a+bx)\) can be calculated using the value tabled below:

<table>
<thead>
<tr>
<th>μmol (s^{-1} m^{-2})</th>
<th>ADC counts (bit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2087.048832</td>
<td>131072</td>
</tr>
</tbody>
</table>

From the above table of data, the offset and slope coefficients to be entered during the PAR calibration procedure must be calculated by the operator. This can be done using the “Interpolate” tool distributed with the IDRONAUT ITERM program or by using the probe calibration procedure. Selecting the PAR sensor from the list of sensors, the following calibration procedure arises:

*Do you already know ‘SLOPE & OFFSET’ coefficients?: No*

The operator can decide to enter the calibration coefficients received with the probe or to let the probe calculate new coefficients using the table calculated as above described.

By answering <YES>, the following messages appear in sequence:

*Offset = 0.0  Slope = 1.0*

The operator must enter the offset and slope coefficients, while by answering <NO> the following message appears:

*Number of calibration points:0 enter new value< 2*

The operator must answer using the tabled data:

<table>
<thead>
<tr>
<th>Sample value (units)</th>
<th>Sample reading (bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(PAR) = (a+bx)</td>
<td>(offset = 0.0)</td>
</tr>
<tr>
<td>(slope = 1.0)</td>
<td>(r \text{ correlation coefficient} = 1.0)</td>
</tr>
<tr>
<td>(c % \text{ of variability} = 100%)</td>
<td></td>
</tr>
</tbody>
</table>

The operator can now confirm or modify the offset and slope coefficients.

*Offset = 0.0  Slope = 1.0*

In the end, the list of sensors appears again.
5.6.6 **Trilux/Unilux single/three-channel Fluorimeter**

The innovative Single/Three-Channel Fluorimeter makes available to the marine, freshwater, surveying markets a high performance sensor providing the user with increased functionality when compared to other standard fluorimeters. The Single/Three-Channel Fluorimeter can be tailored to measure a wide range of fluorescent parameters (see the below table). Moreover, it is possible to extend the measurement range through the use of dynamic range function. Dynamic range can be adjusted simply by varying the LED intensity, while still maintaining the factory set calibration via the internal referencing of LED output.

All versions of the Three-Channel Fluorimeter come with a Chlorophyll *a* channel as standard; two other channels can then be selected from phycoerythrin, phycocyanin or nephelometer (turbidity) options.

The Three-Channel Fluorimeter allows the user to assess the relative contribution to Chlorophyll *a* fluorescence emission from the different light harvesting pigments absorbing light at each of the chosen excitation wavelengths. This information can then be used to make an assessment of the different classes of phytoplankton present in the sample under analysis.

**Features**
- Range of wavelengths available.
- High rejection of ambient daylight.
- Low noise high sensitivity.
- Low turbidity breakthrough.
- Low power consumption.
- Rugged corrosion free “Acetal C” housing.
- Internal referencing of excitation intensity.

**Applications**
- In Situ Chlorophyll & Algal class study.
- Environmental monitoring.
- Particulate studies.
- River and Stream monitoring.
- Pollution monitoring.
- Water and Wastewater quality

<table>
<thead>
<tr>
<th>Fluorescent Parameter</th>
<th>Dynamic Range (*)</th>
<th>Limit of detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll <em>a</em></td>
<td>0..100 µg/l</td>
<td>&lt; 0.01 µg/l</td>
</tr>
<tr>
<td>Fluorescein</td>
<td>0..100 µg/l</td>
<td>&lt; 0.005 µg/l</td>
</tr>
<tr>
<td>Rhodamine WT</td>
<td>0..100 µg/l</td>
<td>&lt; 0.02 µg/l</td>
</tr>
<tr>
<td>Phycoerythrin</td>
<td>0..100 µg/l</td>
<td>&lt; 0.02 µg/l</td>
</tr>
<tr>
<td>Phycocyanin</td>
<td>0..100 µg/l</td>
<td>&lt; 0.01 µg/l</td>
</tr>
<tr>
<td>Nephelometer (Turbidity)</td>
<td>0..100 FTU</td>
<td>&lt; 0.02 FTU</td>
</tr>
</tbody>
</table>

(*) User configurable up to 500 µg/L or 500 FTU

**Note**

In case the Single/Three-Channel Fluorimeter is installed in an OCEAN SEVEN 316Plus CTD which carries out monitoring by means of the “TIMED DATA ACQUISITION” cycle, it is mandatory to set up the “Number of data sets per acquisition” up to 10.

5.6.6.1 **Fluorimeter special calibration procedure**

The Single/Three-Channel Fluorimeter can be re-calibrated by the user using the procedure described in the dedicated Fluorimeter Operator’s Manual. The calibration is done by using the dedicated interface software. Therefore, before starting the calibration operations, it is mandatory to install the software in a personal computer.
This section describes the step-by-step procedure to run the software on the PC to communicate with the Single/Three-Channel Fluorimeter installed in the OCEAN SEVEN 316Plus CTD.

1) Connect the OS316Plus to a personal computer with the RS232 laboratory cable.
2) Run the ITERM program.
3) Switch on the OS316Plus.
4) At the end of the start-up messages from the Main Menu, select the “SERVICE Menu”.
5) From the “Service Menu”, select the “DIAGNOSTIC menu”.
6) From the “Diagnostic Menu”, select the “DISI”, diagnostic serial interface. The following message appears:

   Test communication port associated to auxiliary devices
   Coms:(0)Quit,(1)Aux1,(2)Aux2,(3)Aux3,(4)Aux4
   Aux:0

7) From the shown list of auxiliary systems to test, select 2 for the auxiliary #2. Once selected, the following message appears on the ITERM screen.

   COM-Test:<^X>Quit,<^Z>Show CTRL chars,<^Y>Break

   Afterwards, any typed character transmitted by the PC is sent to the interfaced Single/Three-Channel Fluorimeter through the selected serial communication port.

8) Wait few seconds after the selection; in the meantime, you should see that the real-time measurements from the fluorimeter appears on the ITERM.

9) Close the ITERM communication port using the “Port->Close” command.

10) Leave the ITERM program running and start the interface software.

11) The communication with the fluorimeter may last 1 hour; after that period, the OCEAN SEVEN 316Plus interrupts the communication and the procedure must be repeated starting from point 4. However, to communicate with the OCEAN SEVEN 316Plus, it is mandatory to close the software and enable the communication port of the ITERM. This last operation can be done by means of the “Port->Open” command.

   **Note**
   To interrupt the diagnostic communication with the Single/Three-Channel Fluorimeter before the automatic time-out, after the ITERM communication port is re-opened, type CTRL-X on the keyboard. The OCEAN SEVEN 316Plus immediately terminates the diagnostic test function showing the diagnostic menu.

5.6.6.2 OCEAN SEVEN 316Plus - Single/Three-Channel predefined calibration coefficients
After selecting each parameter associated with the Single/Three-Channel Fluorimeter from the calibration list, the following calibration procedure arises:

   Do you already know ‘SLOPE & OFFSET’ coefficients?: No

The operator must answer “YES” and then answer as follows to the coefficients request.
By answering <YES>, the following messages appears in sequence:

   Offset = 0.0   Slope = 1.0
5.6.7 **TURNER DESIGNS – CYCLOPS-7/CFLUOR calibration coefficients**

The CYCLOPS-7®/CFLUOR line of submersible sensors is designed for integration into multiparameter platforms requiring high performance and compact sensors at a significantly lower price than traditional submersible sensors. After selecting the CYCLOPS/CFLUOR fluorimeter from the calibration list, the following calibration procedure arises:

*Do you already know ‘SLOPE & OFFSET’ coefficients?: No*

The operator must answer “YES” and then answer as follows to the coefficients request.

By answering <YES>, the following messages appears in sequence:

```
Offset = 0.0
Slope = 1.0
```

The offset and slope are indicated on a dedicated calibration sheet which accompanies the CYCLOPS/CFLUOR sensors and that are prepared by Idronaut.

The CYCLOPS-7 fluorometers has an advanced interface which allows the operator to set the CYCLOPS working gain between: x1, x10 and x100. If available, the following message appears at the end of the calibration procedure:

```
Analog interface #1: Optical hw scale (1)x1, (2)x10, (3)x100
Hw Scale[1..3] = 1
```

The operator can select the most appropriate scale. Please set the coefficients for the selected measuring scale.

5.7 **CUSTOMIZE CALIBRATION DATA**

Customization of calibration allows the operator to modify the calibration coefficients. Therefore, rather than applying a detailed procedure, the operator can simply enter a coefficient. Other than the calibration coefficients, through this command, it is possible to modify the algorithm used to convert ADC counts into engineering values. Once invoked, the following message appears:

```
Sensors Calibration
Index Sensor Data&Time
00 - Leave sensor calibration
01 [ ] 000 Pres Thu Jan 04 11:33:04.81 2007
02 [ 1] 001 Temp Thu Jan 04 11:33:04.81 2007
Select the sensor: 0
```

The operator must select the sensor from the shown list and then, following the message which appears on screen, customize the calibration. The detailed description of the “Calibration Customization” is out of the scope of this manual. The operator can experience by himself, by getting into touch with the sensor calibration customization procedures. However, as a general rule, the “calibration customization” allows the operator to modify the calibration coefficients and data processing methods associated to the selected sensor, by requesting the numerical values instead of following a customized, dedicated step-by-step procedure.
5.8 **CALIBRATING LOGGING**

The OS316Plus probe implements the GLP (Good Laboratory Practice) protocol, which allows the operator to keep trace of up to 1000 calibrations. Once invoked, the following menu appears on screen:

*Cal Log cmd>> Q)uit,L)ist,S)howOne,sH)owAll,sH)owSensor,C)lear*

The commands are:

- **Quit**: returns to the calibration menu.
- **ShowOne**: shows one of the 1000 calibration logs.
- **ShowAll**: shows, in sequence, all the stored calibration logs.
- **ShowSensor**: allows showing the calibration log of the selected sensor.
- **List**: shows the calibration log list.
- **Clear**: initializes the calibration log.

The logged information about sensor calibration depends on the type of sensor.
6  SERVICE, DIAGNOSTICS AND CONFIGURATION
This section describes the probe service functions available under the service menu. Among other commands from the service menu, it is possible to access the probe diagnostics and configuration menus. Most service, diagnostics and configuration functions are available only under “Administrative or Service” probe access rights and are described in a dedicated appendix. Service, diagnostics and configuration available under “user” access rights are here described.

6.1  THE SERVICE MENU
The Service menu is selected from the Main Menu.

```
OCEAN SEVEN 316Plus - ID:[0430][USR](7.5_10-12/2006) Fri Jan 05 10:45:47.48 2007
Service menu
<0>[SVUP]   -Leave the service menu
<1>[CONF]   -Configuration
<2>[DIAG]   -Diagnostics
<3>[RAWC]   -Raw data acquisition in counts (bit)
<4>[RAWM]   -Raw data acquisition in mV
<5>[FWUP]   -Firmware updating
```

6.1.1  Raw data acquisition in ADC counts or mV
The RAWC and RAWM commands respectively allow the operator to acquire real-time data from all the installed sensors and represent it in ADC counts or mV. These two representations are very useful to detect problems with the sensor or to collect data that will be then used to carry out the calibration procedure. Both commands allow the operator to store acquired data by typing <S> key. Typing <ESC> key immediately ends the data acquisition and the "Service Menu" is re-displayed. At the end of the data acquisition, if data has been acquired, the data acknowledgement procedure is performed (see the data acquisition section). In case the SEAPOINT Fluorometer and/or Turbidity meter are interfaced by the probe, two more commands allow the operator to cycle through these sensors measuring scales: <T> for the Turbidity meter and <F> for the Fluorometer. While running, the following message appears:

```
Place the probe on the sampling point - type<any key>to start,<ESC>to leave
```

The operator must type any character to start or <ESC> to exit.

```
ADC Counts
Raw data acquisition {counts}
Keyb.Cmd:<S>Store,<ESC>Quit,<F>Flurometer-Scales,<T>Turbidity-Scales
Fluorometer:<0>[150 ug/l]-Turbidity:<0>[750 FTU]
Press Temp Cond O2Sat% O2ppm pH Chl(a) Turb. PAR Time&Memory
476.3 107784.1 9.4 30689.1 0.0 -38322.4 7.8 12.3 62.4 10:55:12.77
```

```
mV
Raw data acquisition {mV}
Keyb.Cmd:<S>Store,<ESC>Quit,<F>Flurometer-Scales,<T>Turbidity-Scales
Fluorometer:<0>[150 ug/l]-Turbidity:<0>[750 FTU]
Press Temp Cond O2Sat% O2ppm pH Chl(a) Turb. PAR Time&Memory
8.57 1945.06 0.15 553.70 0.0 -679.10 0.13 0.23 1.12 10:56:05.01
```
6.1.2 Firmware updating

The firmware updating function allows the operator to upgrade the probe management program (firmware) to a new version. To simplify the firmware upgrading procedure, a dedicated function of the ITERM program has been specifically developed. The below section describes how to perform the firmware upgrading using the FWUP command and the ITERM firmware upgrading function.

6.1.2.1 Foreword

Like most of up-to-date high technology products, the OCEAN SEVEN 316Plus probe is equipped with FLASH memories. This kind of memory allows the probe management firmware to store configuration, calibrations and the probe firmware. A special function of the management firmware allows the operator to upgrade the firmware to the last release flawlessly and without opening the probe or accessing the internal circuitry. Before starting to upgrade the probe firmware, it is important to remember that all data stored in the probe memory will be lost and that, for some firmware releases, a “Set Default” procedure is automatically performed by the probe at the start-up succeeding the firmware upgrading. The “Set Default” procedure destroys the information concerning configuration and calibration. Therefore, before starting the firmware upgrading, upload all stored data from the probe memory and take note of the modifications done on the configuration and calibrations. Details about the new firmware are distributed with firmware in a text file called “Read me”.

6.1.2.2 Firmware distribution package

Any new firmware release can be freely uploaded from the IDRONAUT web site http://www.idronaut.it, download area, in the “Software/Firmware” section. The firmware is distributed together with the IDRONAUT ITERM terminal emulation and firmware upgrading utility. This program guides the operator during the firmware upgrading. “ITERM” is described in an appendix of this Operator’s Manual. The firmware and “ITERM” programme are packaged in a self-extracting file called “OSEVEN.EXE”. After uploading the file, run it and select a folder where the upgrading files and the “ITERM” programme will be extracted. At the end of the operation, the following files will be present in the folder:

- **ITERM.EXE**: Terminal emulation and firmware upgrading programme.
- **ITERM.RTF**: Help file
- **Codereference.txt**: Firmware reference file
- **OS316_xxxx_readme.txt**: OCEAN SEVEN 316 Rev. 5.0 README file; it contains the information about the new firmware. READ IT before upgrading the probe.
- **OS316_xxxx.txt**: OCEAN SEVEN 316 Rev. 5.0 latest firmware.
- **OS316y2k_xxxx_readme.txt**: OCEAN SEVEN 316 Rev. 6.0 README file; it contains the information about the new firmware. READ IT before proceeding to upgrade upgrading the probe.
- **OS316y2k_xxxx.txt**: OCEAN SEVEN 316 Rev. 6.0 latest firmware.
- **OS316Plus_xxxx_readme.txt**: OCEAN SEVEN 316 Rev. 7.0 README file; it contains the information about the new firmware. READ IT before proceeding to upgrade the probe.
- **OS316Plus_xxxx.txt**: OCEAN SEVEN 316 Rev. 7.0 latest firmware.
- **OS316Plus_Rev8_xxxx.txt**: OCEAN SEVEN 316 Rev. 8.0 latest firmware.

The firmware is distributed by means of ASCII files containing the operating instructions in “MOTOROLA Exormax” format. “xxxx” numerical value is used to address the new firmware release (i.e. 7510)
6.1.2.3 How to carry out the firmware upgrading procedure

The following parts are needed to carry out the firmware upgrading procedure:

❖ The IDRONAUT TERMINAL Emulation “ITERM” program installed and running.
❖ The 3m long, laboratory cable that will be used to connect the probe RS232C interface to the PC serial interface.

Note
✓ Never try to upgrade the probe firmware through the telemetry!
✓ Upgrade the firmware by using a controlled power supply and a reliable PC!

6.1.2.4 The upgrading procedure

Step-by-step upgrading procedure:

1) Identify the connected probe and start the upgrading function.
2) Download the new firmware to the probe temporary memory.
3) Update the new firmware from the temporary memory to the FLASH definitive memory.
4) Restart the probe.

Before proceeding, we strongly suggest that you should carefully read the README file that accompanies the firmware for your probe.

6.1.2.5 Probe identification

The “ITERM” software identifies the interfaced probe by means of the “Identify” function available under the ITERM probe menu. First of all, run this function and wait for the program operations. At the end of the probe identification process, the probe characteristics are shown in the ITERM windows title and status bar. When the probe has been identified, it is possible to proceed with the second step.

If the probe identification process fails, please contact IDRONAUT and send them the “Detect.log” file, which is automatically created by the programme during the identification process. This file, together with the information about your probe, will help IDRONAUT to understand your problem.

6.1.2.6 Download firmware

After the probe has been identified, run the “Upgrade” available under the ITERM program probe menu. ITERM will communicate with the probe and, if needed, it will propose a pop-up window to guide the operator during the remaining steps of the firmware upgrading procedure. In case the probe firmware is already up to date, a pop-up window informs the operator and the firmware upgrading procedure is automatically concluded. If the probe firmware can be upgraded, a pop-up box guides the operator with the relevant operations to be done to accomplish the firmware downloading, which are:

1) Enter the firmware upgrading command <FWUP> at the probe prompt.
2) Enter the password to access this function “SERVICE316”.
3) Select the firmware file to upload by pressing the dedicated button with the mouse.

During the firmware downloading procedure, a dialogue window shows in real time the undertaken data transfer process. The firmware transfer can last up to 30m. At the end of the downloading procedure, the dialogue window disappears and three diagnostic messages appear on the PC screen:

Number of Exormax Srecords :1230
Total Xor of the Exormax Srecords :F8
Number of uploaded bytes :145600

The shown values must correspond to those indicated in the pop-up box shown on the PC screen; otherwise, the downloading firmware procedure must be repeated; alternatively, contact IDRONAUT to find out the trouble.

Note
Never download the firmware using the telemetry interface!
6.1.2.7 **Updating the new firmware in the definitive FLASH memory**

The final step to upgrade the probe to the new firmware consists in the procedure which copies the new firmware just downloaded into the probe definitive FLASH memory. At that moment and before going on with the below procedure, you have the possibility to abort the probe firmware upgrading procedure by simply switching OFF the probe. It will wake up again using the old firmware. To copy/update the definitive FLASH memory with the new firmware contained in the temporary memory, type the command suggested by the “ITERM” pop-up window.

*Note*
Depending on the probe hardware version (5.0, 6.0, 1.0, 7.0, etc.), there are different commands and options. Please strictly use the commands suggested by the “ITERM” programme, otherwise permanent damage of the probe FLASH memory could arise. If you have any doubts or the procedure is not clear enough, stop here and call IDRONAUT to have support and clarifications. Indication on the correct command is also reported in the “Read me” file, which accompanies the firmware.

Copy of the firmware from the temporary to the definitive memory takes few seconds. The copy is automatically performed by the probe after the correct command is carried out. After the new firmware has been copied to the definitive FLASH memory, it is possible that the probe restarts by itself or that the probe command prompt appears again.

If the probe command prompt appears again, please use the “BT”<ENTER> command to restart the probe.

6.1.2.8 **Firmware upgrading procedure failure**

If the probe does not answer with the start-up procedure after the firmware upgrading procedure, it is possible that the malfunctioning be due to a failure during the firmware upgrading procedure. In this case, immediately contact the local sales representative office or IDRONAUT directly.

6.1.3 **Probe diagnostic functions**

The OCEAN SEVEN 316Plus management firmware allows the operator to perform some simple diagnostic function to verify probe internal devices and/or functions. More powerful and potentially dangerous diagnostic functions are available under the “ADMINISTRATOR” and “SERVICE” access rights. They are described in a dedicated appendix.

6.1.3.1 **The Diagnostics Menu**

The Diagnostics Menu is presented by selecting: `<2>` [DIAG] from the “Service menu”.

```
Diagnostics menu
<0>[DIUP]-Leave Diagnostics menu
<1>[DITT]-Test A/D Converter and multiplexer
<2>[DISR]-Service reading
<3>[DISI]-Serial interface
<4>[DIRT]-Real time clock/calendar

Selection of the desired function is performed by typing one of the acronyms in square brackets or the numeric key between the <> brackets. By pressing the <ESC> key or <DIUP> command, the programme returns to the “Service Menu”, while pressing the <ENTER> key re-displays the “Diagnostics menu”.

6.1.3.2 **Test A/D Converter & mux**

This command allows the operator to watch the probe analogue inputs. Once invoked, this command shows the following acquisitions in real time on the PC screen until a character is typed on the PC keyboard. Acquired data is shown in ADC Counts, decimal and hexadecimal notations and in mV
Read from the 16-bit ADConverter

Max  [Scaled value Dec|Hex] [Voltage]
00-[  29284| 7264] [2234.2]mV
01-[  211| 15] [1.6]mV
02-[  141| e] [1.1]mV
03-[  171| 11] [1.3]mV
04-[  301| e] [2.3]mV
05-[  201| 14] [1.5]mV
06-[ -6401| ffff6ff] [-488.4]mV
07-[ 23213| 5aad] [1771.0]mV
08-[ -3839| ffffff01] [-292.9]mV
09-[  1791| b3] [13.7]mV
10-[  1831| b7] [14.0]mV
11-[  317| 13d] [24.2]mV
12-[  196| c4] [15.0]mV
13-[  2351| eb] [17.9]mV
14- [  229| e5] [17.5]mV
15- [  491| 31] [3.7]mV

6.1.3.3 Service reading

This command shows in real time the acquisition concerning the probe internal temperature, and analogue reference voltage. The following message appears on the PC screen:

Service reading
Ref. VAC     I.Temp.     Battery
4714.55 mV   20.21 C    12.367 V
Type <any key> To continue

To terminate the service reading and return to the diagnostics menu, type a character on the PC keyboard.

6.1.3.4 Serial interface

In case some external equipment (probe, sensor, etc.) is interfaced with the OCEAN SEVEN 316Plus through the two digital interfaces (serial interfaces) present in the probe, this function allows the operator to directly communicate with the interfaced equipment bypassing the OCEAN SEVEN 316Plus probe firmware. The following message allows the selection of the probe communication input/output port to be used during the serial interface test.

Coms:(0)Quit,(2)Com2,(3)Com3,(4)Com4,(5)Com5,(6)USB
Coms:0

If the operator selects a not configured interface, the function is automatically concluded and the diagnostics menu is shown. Otherwise, the following message appears:

COM-Test:<^X>Quit,<^Z>Show CTRL chars,<^Y>Break"

Any character typed on the PC keyboard is sent to the interfaced instrument through the selected serial communication port; each character received from the interfaced instrument is echoed on the PC screen. The following special characters have dedicated functions:

<CTRL-X> Terminates the serial interface test.
<CTRL-Z> Shows the ASCII representation of the typed/received character.
69

SECTION SIX- SERVICE, DIAGNOSTICS AND CONFIGURATION

<CTRL-Y> Sends a break signal to the interfaced instrument.

If not concluded before by means of the <CTRL-X>, the test is automatically concluded after 10’. At the end of the test, the diagnostics menu is shown again.

6.1.3.5 Real-time clock

This function shows the probe date & time in real time as follows.

Test Real Time Clock device, type <any key> to leave
Cur time Fri Jan 05 12:08:02.22 2007

Typing a character on the PC keyboard causes the probe to conclude the RTC test and show the diagnostics menu.

6.1.4 Probe configuration

This section provides general information about the probe configuration and configuration functions available under the “Configuration Menu”. The below configuration is valid once the probe is running under the USER access rights. More configuration commands and configuration parameters are available once the probe is running under the SERVICE or ADMINISTRATOR rights. The latter are described in a dedicated appendix.

6.1.4.1 Configuration memory layout

The configuration information is stored in a section of the non-volatile FLASH memory, which also stores the probe management firmware. The probe, when necessary, automatically updates the section containing the configuration. The configuration integrity is guaranteed by a CRC code 32bit long. In case the configuration integrity is compromised, the “default factory” configuration is restored and used. The configuration contains information pertaining to the probe:

❖ Operations.
❖ Data acquisition.
❖ Serial interfaces.
❖ Interfaced sensors.
❖ Programmed depth acquisition profiles.
❖ Interfaced external equipment: sensor, probes, Rosette, etc...

For each of the above listed information, a dedicated configuration function is provided.

6.1.4.2 Default configuration

The factory preset configuration reported on the “Probe configuration sheet” is stored in a dedicated and protected section of the FLASH memory. If needed, it can be resumed under the operator’s control. In case the current configuration is corrupted, the probe automatically resumes by itself the factory configuration at the start-up.

6.1.4.3 Updating the configuration

Before the program shows back the “Service Menu” and in case the probe configuration information has been modified, the following message appears:

Do you want to update the configuration ? Yes/No

If the operator confirms the modified information typing <YES>, the following message appears:

Updating of the configuration in progress...
New configuration has been successfully updated
This message notifies the operator that the configuration area has been updated and the new configuration values have been stored in the FLASH memory. If the operator answers <NO> to the above question, all the modifications done to the configuration will be lost and the previous configuration will be automatically restored by the probe itself.

### 6.1.4.4 Configuration Menu

Once the Configuration Menu is requested from the Service Menu, the following message appears on the PC screen:

```
Configuration menu
<0>[CNUP]-Leave configuration menu
<1>[CNDA]-Data acquisition parameter
<2>[CNOP]-Operating parameter
<3>[CNAP]-Acquired sensor parameters
<4>[CNNR]-Programmed depth acquisitions
<5>[CNQT]-Change current Date&Time
<7>[CNES]-External system
```

Selection of the desired function is performed by typing one of the acronyms in square brackets or the number in <> brackets. Pressing the <ESC> key or <CNUP> command returns the probe control back to the Main Menu, while pressing the <ENTER> key re-displays the Configuration Menu.

### 6.1.4.5 Data acquisition

Through this command, it is possible to customize some aspects of the probe data acquisition functions. The customizable parameters are in sequence:

```
----------- Configure the data acquisition parameters -----------
Unattended profile
Default ending conditions:(0)Pressure,(1)Conductivity,(2)Both
Default condition:2
```

The operator can customize the type of condition that, by default, will be used by the probe to conclude an unattended data acquisition cycle (see data acquisition).

```
Pressure upper limit [dbar]:0
```

Pressure limit configuration.

```
Conductivity limit [mS/cm]:0.1
```

Conductivity limit configuration.

### 6.1.4.6 Operating parameters

Through this command, it is possible to customize some aspects of the probe operation. The customizable parameters are:

```
--- Configure the Operating parameters ---
```
**CTD warm up timeout [s]: 5**

The operator can customize the time-out used by the probe at the wake-up to wait for the sensor stabilization. The default value is 5. In case unattended profiles or monitoring must be performed and the probe is equipped with chemical sensors, we suggest a warm-up of 30s.

**Transmission delay/Telemetry mute [ms]: 10**

This delay is used between consecutive transmissions once the probe operates through the telemetry system.

**Number of lines between header : 22**

This parameter allows the operator to configure the number of data lines that will be shown between two consecutive data header lines.

**Max. number of char. per line : 160**

This parameter allows the operator to configure the number of characters per line. The data acquisition functions use this parameter to break data message below this limit.

**Emulate the Digital VT100 VTU ? : Yes**

Once the operating mode is configured as “VERBOSE MODE”, this parameter allows the management firmware to use the control codes, which permit the management of a DIGITAL VT100. This results in a better look and feel of the user interface.

**Show acquired data in rows ? : No**

This parameter allows the operator to define whether to have the acquired data on a row basis (many parameters in a single row) or on a screen basis (one parameter in a single row).

**Test battery voltage ?: Yes**

This parameter enables the automatic function, which tests the battery voltage.

**Battery reference voltage [mV]: 1.0e+04**

This parameter allows the operator to configure the lowest power supply voltage boundary. By default, this value refers to the internal batteries and it is 10.000 mV. At the end of this command, the “Configuration Menu” is shown.

### 6.1.4.7 Acquired sensors

Through this command, it is possible to customize the type and number of the interfaced sensors. Once invoked, the list of the acquired sensors appear on the PC screen as follows:

```plaintext
CTD parameter list
Index Parameter Mux.Input Type Logical Code Cal.Rec
```
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Code</th>
<th>Length</th>
<th>Mode</th>
<th>Code</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pres</td>
<td>008</td>
<td>18bit-AC</td>
<td>000</td>
<td>000</td>
<td></td>
</tr>
<tr>
<td>Temp</td>
<td>009</td>
<td>18bit-AC</td>
<td>001</td>
<td>002</td>
<td></td>
</tr>
<tr>
<td>Cond</td>
<td>010</td>
<td>18bit-AC</td>
<td>002</td>
<td>004</td>
<td></td>
</tr>
<tr>
<td>O2Sat%</td>
<td>001</td>
<td>18bit-DC</td>
<td>006</td>
<td>001</td>
<td></td>
</tr>
<tr>
<td>O2ppm</td>
<td>255</td>
<td>--------</td>
<td>009</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>002</td>
<td>18bit-DC</td>
<td>007</td>
<td>007</td>
<td></td>
</tr>
<tr>
<td>Chl(a)</td>
<td>004</td>
<td>18bit-DC</td>
<td>011</td>
<td>005</td>
<td></td>
</tr>
<tr>
<td>Turb.</td>
<td>005</td>
<td>18bit-DC</td>
<td>024</td>
<td>003</td>
<td></td>
</tr>
<tr>
<td>PAR</td>
<td>006</td>
<td>18bit-DC</td>
<td>025</td>
<td>009</td>
<td></td>
</tr>
<tr>
<td>Tr%</td>
<td>000</td>
<td>18bit-DC</td>
<td>012</td>
<td>008</td>
<td></td>
</tr>
</tbody>
</table>

CMD:(A)dd,(D)elete,(M)odify,(Q)uit

The list of the acquired sensors ends with the commands available for the customization list.

### 6.1.4.8 Available commands

**Add/ Modify**

The add/modify command allows the operator to add a new sensor or to modify one sensor already configured. When you select the modify function, the following message appears:

**Modify the parameter: 0**

The parameter/sensor to be modified or added must be selected by means of the index indicated in the first column of the above list. The add function will insert a new parameter at the selected position moving the remaining parameters in the list, one position below the insertion point. In both cases, the following answers appear on the PC screen:

- **Logical code**: 12
- **Description**: Tr%
- **N. of digits to show**: 0
- **N. of digits after the dot**: 0
- **Do you want to store it?**: No
- **Do you want to show data?**: No
- **Data processing method**
  - **Method**: (0)Counts, (1)mV, (2)Proprietary&UNESCO, (4,6)Reserved
  - **Method**: (3)Polynomial coefficients, (5)Polynomial interpolation
  - **Method**: (7)Linear, (8)Exponential, (9)Logarithmic - interpolations

Data processing method: 7
- **Mux. channel** [255=none]: 0
- **Mux. delay** [0..255ms]: 0

See below for a complete description of the above parameters.

**Initialize**

Choosing the “Initialize” command will cause the acquired parameter to be preset to a default condition. Anyhow, please be aware that calibrations are lost if this command is invoked.

**Delete**

Choosing the “Delete” command will cause the following message to appear:

**Delete the parameter: 0**

By means of the index, the operator must select the parameter to delete.
Typical parameters that can be configured for each sensor in the above list are:

**Logical code**
Assigns a logical code to the sensor, from the list of pre-defined sensors/parameters (see below).

**Description**
A seven-character acronym that is used by the probe to identify data acquired from this sensor.

**No. of digits to show**
Number of digits used by the probe to numerically show the acquired data for this sensor.

**No. of digits after the dot**
Number of digits used to show the fractional part of the acquired data for this sensor.

**Do you want to store it?**
It is possible to acquire and not show the value or to acquire and show it.

**Do you want to show data?**
It is possible to acquire and not store in memory acquired data.

**Data processing method:**
Kind of algorithm used to convert ADC counts reading from a sensor into engineering values. Predefined values are: (0)Counts, (1)mV, (2)Proprietary&UNESCO, (4,6)Reserved, (3)Polynomial coefficients, (5)Polynomial interpolation, (7)Linear, (8)Exponential, (9)Logarithmic.

**Mux. Channel**
Analogue input can be 0..16. The 255 value is used to identify a derived parameter like salinity, which does not belong to a single sensor.

**Mux. Delay**
Delay in ms to be spent during acquisition to wait for the stabilization of the sensor pre-amplifier before acquiring.

### List of the common sensor logical codes

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Logical code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>0</td>
</tr>
<tr>
<td>Temperature</td>
<td>1</td>
</tr>
<tr>
<td>Conductivity</td>
<td>2</td>
</tr>
<tr>
<td>Salinity</td>
<td>4</td>
</tr>
<tr>
<td>Oxygen ppm</td>
<td>5</td>
</tr>
<tr>
<td>Oxygen %</td>
<td>6</td>
</tr>
<tr>
<td>pH</td>
<td>7</td>
</tr>
<tr>
<td>Fluorometer</td>
<td>11</td>
</tr>
<tr>
<td>Transmissometer</td>
<td>12</td>
</tr>
<tr>
<td>Sound Velocity</td>
<td>16</td>
</tr>
<tr>
<td>Density (SigmaT)</td>
<td>22</td>
</tr>
<tr>
<td>Turbidity meter</td>
<td>24</td>
</tr>
<tr>
<td>PAR</td>
<td>25</td>
</tr>
</tbody>
</table>

**Note**
The complete list of the sensor logical codes can be found in the document describing the probe communication protocol and in Appendix “B”.

### Programmed depth

Through this command, it is possible to modify the preset programmed depth acquisition profiles (see data acquisition).
programmed depth profile customization.

Modify the [01] profile

Profile Id: new string [max length 7]< Test
Number of depth point: 0 enter new value< 3

The operator must enter the number of depth points for the profile being customized (1..50). Typing 0 ends the programmed depth profile customization.

Configure the [01] depth data acquisition/Bottle firing point

Depth [dbar]: 0 enter new value< 10

The operator must enter the pressure value for each depth point. They must be configured increasing from the previous depth. At the end of this command, the “Configuration Menu” is shown.

6.1.4.11 Change date & time

Probe RTC date and time can be configured.

Enter Date & Time: 05/01/2007 13:47:26 06

The probe date and time can be modified. At the end of this command, the “Configuration Menu” is shown.

Note
The day of the week is numbered starting from Sunday (1).

6.1.4.12 External systems

The external equipment interfaced by the probe through digital, analogue or serial interface I/O can be configured.

After selecting the Rosette type, the following question must be answered depending on the chosen Rosette type:

Rosette bottles position [1..36]
GO-1016/1014 waiting for Rosette answer timeout [10..240]
GO-1015 firing cap, charge timeout [3..20]

Further details are shown in the Rosette appendix.

Aux CTDs: (0) None, (1..3) Reserved, (4) Nortek Acquadopp
Aux. system: 0

Auxiliary system 1 can be configured as: Current Meters.

Aux sensor: (0) None, (1) VALEPORT miniSVS, (2) Ander AA 3975 Optode, (3) Trilux-Unilux
Aux. sensors:0

Auxiliary system 2 can be configured as: MiniSVS, Single/Three-Channel Fluorimeter or OPTODE. See the dedicated appendix to this Operator’s Manual.

Special sensors:(0)None,(1)Hull Temperature,(2)Pressure Transmitter
Special sensors:0

Auxiliary system 3 can be configured as: Hull temperature or Highly Precise Pressure Transmitter. See the dedicated annexe to this Operator’s Manual.

AUX analog:(0)None,(1)OCI200,(2)OCR200,(3)OCI/OCR200,(4)24-Redox,(5)Extension
Analog system:0

The above question allows the operator to select among the possible analogue measurement systems that have been currently interfaced with the Ocean Seven probe through an optional analogue daughter board. At the end of this command, the “Configuration menu” is shown.
7 PROBE MAINTENANCE
All the maintenance procedures necessary to keep the probe in its best operating conditions are described in this section. The actions described mainly pertain to the sensors of the probe. In detail, this section includes:

➢ Oxygen sensor.
➢ Reference sensor.
➢ pH sensor.
➢ Conductivity sensor.
➢ Redox sensor.
➢ Temperature sensor.
➢ Pressure sensor.
➢ Battery endurance and recharge.
➢ 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.

IMPORTANT NOTE
The following section 7.1 refers to the oxygen sensor – standard versions (150 and 700 bar) only. It is not applicable when the probe is equipped with the MAINTENANCE-FREE DISSOLVED OXYGEN SENSOR (5 bar) or to the IDRONAUT OPTICAL DISSOLVED OXYGEN sensor (see dedicated appendix).

7.1 OXYGEN SENSOR
To ensure the best performance of the oxygen sensor, frequent full replacement of electrolyte (every month) and membrane (every 6 months) is to be performed.

7.1.1 Important remark on oxygen measurement
Most polarographic oxygen sensors take 5 to 10 minutes after they have been switched on to polarize and become stable. To overcome this limitation, the Idronaut OS316Plus has been fitted with a small internal rechargeable battery, to maintain polarization of the oxygen sensor continuously. However, if the probe is not used for several months, the polarizing battery may become completely discharged resulting in damage to the battery. It is recommended that the probe should be switched ON (and streaming real-time data) for at least a few hours every 2 to 3 months, to maintain this polarization battery in a healthy condition.

7.1.2 Green membrane
IDRONAUT green membrane is ideal for profiling acquisitions. To allow proper sample stirring, the probe must be lowered at a rate of at least 0.2 m/sec. The following table shows the characteristics of the green membrane:

<table>
<thead>
<tr>
<th>Application</th>
<th>Membrane colour</th>
<th>Time const. (a)</th>
<th>Stirring effect (b)</th>
<th>Membrane material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profiling</td>
<td>Green</td>
<td>3 sec.</td>
<td>5% (c)</td>
<td>25µ, Teflon®</td>
</tr>
</tbody>
</table>

Note
(a) Response Time = nitrogen to air.
(b) Stirring effect = measuring difference between a sample well stirred and a completely stagnant one.
(c) Algorithm compensates for this 5% reading decreasing.
All values of the table are given for a temperature of 25°C.
The probe is delivered with the green membrane installed.

7.1.3 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
A. 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.
B. While the probe is not used, oxygen sensor polarization remains active since the necessary power is provided by a rechargeable battery placed inside the probe. Battery back-up is performed when the probe is switched ON.
C. 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 life.
D. 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.

7.1.4 Membrane replacement (oxygen membrane cap)
Conditions which could require the membrane and electrolyte replacement are the following:
1) Calibration is not systematically achieved (try at least three times) and “OXYGEN SENSOR CALIBRATION ERROR” appears on screen.
2) The oxygen sensor responds more slowly than usual or drifts.
3) The membrane of the cap is mechanically damaged and shows leakage, holes or scratches.
4) Readout of over 0.2 ppm is displayed when carrying out the sensor check in the absence of oxygen.
5) The oxygen sensor, filled with electrolyte, has been stored for a long time at temperatures outside those recommended (−10 to 40°C).

7.1.5 Replacement of membrane(s) using the OXYGEN SENSOR MAINTENANCE KIT:
1) Locate and pull out the following parts from the maintenance kit:
   ❖ One oxygen measuring “green” membrane (internal).
   ❖ One O-ring.
   ❖ O-ring mounting tool.
2) Remove the protection ring from the membrane cap. Remove and discard the black o-ring and the membrane.
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 desktop with its narrow end facing up.
5) Position the measuring membrane “green” on top of the cap.
6) Place the widest part of the tool against the membrane. Slightly pressing the tool, slide the o-ring carefully into the slot of the cap thus holding the membrane in position.
7) Cut away the excessive membrane, with fine scissors, far from the o-ring to avoid damaging the membrane.
8) Finally, recap the protective plastic ring.

7.1.6 Oxygen sensor cleaning
During the calibration procedure, the oxygen sensor current is shown:

Checking oxygen sensor:
Current: XXX nA. % of last calibration. XXX.X%

This acceptable range is:

<table>
<thead>
<tr>
<th>Membrane</th>
<th>Current (nA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>50-100</td>
</tr>
</tbody>
</table>

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 (which must be wet) 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
7.1.7 **Oxygen sensor 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 alternatively used. 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, 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.**

7.2 **REFERENCE SENSOR**

- During all periods of inactivity, the reference sensor must be always hydrated with the IDRONAUT REFERENCE SENSOR STORAGE SOLUTION or, if not available, even with KCl saturated solution, using the plastic hydrating cap. Fill the cap to about one third with the solution. The cap should be squeezed in order to allow an easy insertion.
- Before starting the measurements, the plastic hydrating cap must be removed.
- If the sensor has been exposed to air without its protective cap or if the solution in the cap is not present, the solid electrolyte of the sensor may have contracted forming internal air bubbles, in particular by the junction hole. In this case, it is necessary to fill the cavity with the IDRONAUT REFERENCE SENSOR STORAGE SOLUTION. Take a small syringe, i.e. 1.5 ml and aspirate a small amount of the IDRONAUT REFERENCE SENSOR STORAGE SOLUTION (supplied with the probe). Place the probe on a table in a horizontal position taking care that it does not rotate. 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. Gently press the syringe plunger to inject some drops of solution inside to eliminate the air bubbles. 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 necessary.
- If the sensor is left immersed in the measuring environment for an indefinite period, there will be a slow progressive loss of the KCl from the solid electrolyte. In such working conditions, the reference sensor needs to be replaced within 6 months ÷ 1 year.

7.3 **pH SENSOR**

The glass membrane of the pH sensor must be always kept hydrated. If the sensor is stored dry for an extended period (more than half a day), the sensor’s performance may 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 pH7 and pH4 buffers. Following calibration of the sensor with pH7 buffer (see the relevant section), 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 sensor tip.
2) Fill the calibration cup with pH4 buffer and dip the pH and reference electrodes in the cup.

3) Gently stir the buffer cup vertically. 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 reading at pH4. If pH4 reading is still not within tolerance contact IDRONAUT to obtain the relevant instructions.

Both pH7 and pH4 buffer solutions used in the cup must be thrown away and not placed in the pH7 and pH4 bottles again. The pH7 and pH4 buffer solutions will generally last no longer than one year after opening the bottles, as the ambient CO₂ and pollutants can deteriorate with them. In case of doubt or of bad results, use fresh pH7 and pH4 buffer solutions as, in many cases, the pH problems are simply due to bad pH solutions.

7.3.1 Important remark on the pH measurement

The pH and reference sensors should never be allowed to completely dry out. For short-term storage of up to one day, the probe’s sensor head can simply be immersed in clean water. If the probe remains unused for periods longer than one day, always place the hydrating caps on both sensors. The pH sensor cap should be filled with the pH7 Buffer Solution (or simply with clean water). The reference sensor cap should be filled with the Idronaut Reference Sensor Storage Solution (or even with KCl saturated solution).

7.4 Conductivity Sensor

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

7.4.1 Important remarks on conductivity measurement

1) To obtain the best accuracy, the conductivity sensor and therefore the probe sensor head, must be immersed in clean seawater for at least 15 minutes before measurements. For fresh water application, the sensor does not require any hydration.

2) 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, degrease the inside of the conductivity cell using cotton buds wetted with liquid soap. Gently rotate the cotton bud against the whole internal surface of the quartz cell. This will wet the platinum electrodes thus reducing the surface tension of the cell and considerably decreasing the risk of trapped air bubbles.

This wetting operation must be always carried out before laboratory calibration tests.

7.4.2 Conductivity sensor cleaning

To clean the conductivity cell, use cotton buds and wet them with liquid soap gently rotating the cotton bud against the platinum ring surfaces. Replace the cotton bud after each ring cleaning. Repeat the above operation until the cotton buds used come out perfectly cleaned.

7.5 Redox Sensor

The redox sensor can be contaminated by fouling or if some mud accidentally covers its sensitive tip. In this case, it is wise to clean the sensor tip before each series of measurements. Use the abrasive paper (which must be wet) provided in the OXYGEN SENSOR MAINTENANCE KIT. It is sufficient to slightly rub the glass tip (where, at its centre, the platinum wire is placed) on the abrasive surface of the paper two or three times. Wash the sensor tip with distilled water to remove residues.
7.6 **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 (3M, 400 grid), included in the Oxygen Maintenance Kit, to remove carbonate which, if present, will greatly increase its response time.

7.7 **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 flange. Protection against fast thermal variation of water sample (thermocline) is obtained by means of a plastic o-ring cap provided with a small hole in the centre. Lack of the protective cap may generate spikes of the signal generated by the transducer when severe thermoclines are encountered.

7.8 **BATTERY ENDURANCE AND RECHARGE**
Three different batteries are used to operate the probe:
- internal battery pack (typically no. 12 batteries, 1.2V, 2.85 Ah, NiMH cells);
- battery for permanent oxygen electrode polarization;
- battery for the built-in real-time clock and data memory backup.
7.8.1 **Internal battery pack endurance**

The internal probe battery endurance can be easily calculated using the “Os3xxCTDAutonomy” tool, which is distributed with the ITERM program and the REDAS-5 program. This tool, through a simplified user interface (see below), allows the operator to select the probe type, select the sensors interfaced by the probe and then calculate the probe battery autonomy.

![Image of the “Os3xxCTDAutonomy” tool](image.png)

7.8.2 **Oxygen sensor polarization battery**

The internal (oxygen sensor) battery is automatically charged during the probe ON periods. If the probe is not in use for more than two months, the battery must be recharged (at least every two months) by keeping the probe ON for at least 8 hours. The above procedure can be done by means of the TELEMETRY DECK UNIT, if available, or by means of a DC power supply (12 V, 200 mA).

The state of the internal battery can be verified by opening the probe and inserting the jumper as shown in the picture. If the green LED lights on, the battery is OK. If the yellow LED lights on, the battery should be recharged; if the red LED lights on, the battery should be replaced because it is dead.

7.8.3 **Data Memory and RTC battery**

The internal real-time clock and data memory contents are kept using a lithium battery (3.0V, 1.9 A/h, AA type cell) which should allow 10 years of operation. In case of accident or malfunction of the RTC or continuous loss of stored data, please contact IDRONAUT to get the necessary assistance in order to replace the dead battery.
7.9 **ROUTINE MAINTENANCE SCHEDULE**

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

**Monthly maintenance**
- Replace electrolyte of the oxygen sensor.
- Check that pH and reference sensors be protected by proper caps and solutions, if not in use.
- Recharge the oxygen polarization battery by keeping the probe ON for few hours.

**Quarterly maintenance**
- Replace the oxygen membrane.
- Check the pH channel and renew the pH sensor, if necessary.
- Clean the flow cell of the conductivity sensor.
TROUBLESHOOTING

Most common errors and the suggested solutions are listed below. In case of trouble, contact IDRONAUT at idronaut@idronaut.it.

Please always mention the probe serial number in your request for support.

<table>
<thead>
<tr>
<th>DEFECT</th>
<th>SOLUTION</th>
</tr>
</thead>
</table>
| No communication with the probe using ITERM or/and REDAS-5            | ❖ If working with telemetry, try to communicate using the RS232C laboratory cable.  
                        |   ❖ Verify that the battery and/or the power supply are correct.          |
|                                                                      |   ❖ Verify that the communication port used by the program corresponds to the hardware interface where the cable is connected. |
|                                                                      |   ❖ If working with battery or external power supply, switch the probe on by means of the magnetic switch.   |
|                                                                      |   ❖ Close and restart the ITERM program.                                  |
|                                                                      |   ❖ If working with REDAS, try to communicate using the ITERM program    |
| The measurement cycle cannot be stopped.                              | ❖ In case the measurement cycle was started in non-verbose mode, use the ITERM program “Stop Cast” function to stop the measurement cycle. |
|                                                                      |   ❖ Run ITERM, switch on the probe and, when acquired data starts to appear on the PC screen, type the <ESC> key. Answer <YES> to the given question to stop the measurement cycle. |
| Partial data stored in memory                                         | ❖ In case the probe is performing unattended acquisition, verify the code indicated in the area code of the stored cast. Most of the times, the reason for the partial data can be understood by analyzing the area code of the stored cast. |
|                                                                      |   ❖ Verify the battery status.                                           |
|                                                                      |   ❖ Verify the memory status.                                            |
| Data cannot be stored in memory                                       | ❖ Most of the times, initializing the memory solves the problem.          |
| REDAS-5 does not detect or initialize the probe                      | ❖ The REDAS-5 condensed manual describes a step-by-step configuration which should allow to complete the probe initialization and detect it without problem. |
|                                                                      |   ❖ If the probe is interfaced through the telemetry, check the suggestions on the deck unit installation and operator’s manual. |
| Oxygen sensor calibration error                                       | ❖ Perform the oxygen sensor maintenance procedure described in the maintenance section. |
| pH sensor calibration error                                           | ❖ Perform the pH sensor maintenance procedure described in the maintenance section. |
INSTRUCTIONS TO RECHARGE THE INTERNAL BATTERIES of the 100 mm - 1500 dbar HOUSING

The rechargeable battery pack is composed of 12 x NiMH 1.2VDC AA cells, assembled in series, to create a unique 14.4VDC, 2.85Ah battery pack. The battery pack comes complete with an international battery charger.

1) Dry the probe and lay it down on a table.

2) Remove the six screws on the probe cover with the hexagonal wrench included in the CTD accessories.

3) When extracting the cover, dry the fissure between the cover and the body of probe with a strip of paper inserted edgewise and dry any trace of water in the proximity of the external side of the o-ring.

4) Pull the battery pack off and remove the cable connector.

5) After connecting the battery pack, the charger immediately checks the nominal voltage, thus automatically selecting the most appropriate action to carry out.

**LED indicators**
- Yellow ON: battery not connected or starting battery analysis.
- Orange ON: quick charging started.
- Green flushing: top of charge.
- Green ON: tricky charging.
- Alternate Orange/Green: battery problems.

**Note**
*At the end of the quick-charging procedure, the charger undertakes a low-current equilibration charging procedure which lasts 30 m. This procedure is also called tricky-charging procedure. The aim of this procedure is to keep the battery cells in good condition, thus compensating for the auto-discharge.*

6) Replace the cover on the probe and lift the probe itself vertically.

7) Check the correct position of the o-ring and close again the probe with the six screws. Gradually tighten the six screws in sequence such as to close the cover uniformly.
INSTRUCTIONS TO RECHARGE THE INTERNAL BATTERIES of the 75 mm - 1500 dbar HOUSING

The rechargeable battery pack is composed of 12 NiMH 1.2VDC AA cells, assembled in series, to create a unique 14.4VDC, 2.85Ah battery pack. The battery pack comes complete with an international battery charger.

1) Dry the probe and lay it down on a table.

2) Loosen the two closing screws on the probe cover with a proper screwdriver and pull them completely.

3) When extracting the cover, dry the fissure between the cover and the body of probe with a strip of paper inserted edgewise and dry any trace of water in the proximity of the external side of the o-ring.

4) Pull the battery pack off and remove the cable connector.

5) After connecting the battery pack, the charger immediately checks the nominal voltage, thus automatically selecting the most appropriate action to carry out

LED indicators
Yellow ON: battery not connected or starting battery analysis.
Orange ON: quick charging started.
Green flushing: top of charge.
Green ON: tricky charging.
Alternate Orange/Green: battery problems.

Note
At the end of the quick-charging procedure, the charger undertakes a low-current equilibration charging procedure which lasts 30 m. This procedure is also called tricky-charging procedure. The aim of this procedure is to keep the battery cells in good condition, thus compensating for the auto-discharge.

6) Replace the cover on the probe and lift the probe itself vertically.

7) Close again the probe with the two closing screws. Gradually tighten the screws in sequence such as to close the cover uniformly.
INSTRUCTIONS TO RECHARGE THE INTERNAL BATTERIES of the 89 mm 7000 dbar TITANIUM HOUSING

The rechargeable battery pack is composed of 12 NiMH 1.2VDC AA cells, assembled in series, to create a unique 14.4VDC 2.8Ah battery pack. The battery pack comes complete with an international battery charger.

1) Dry the probe and lay it down on a table.

2) Remove the four titanium fixing bolts on the probe cover with the hexagonal wrench included in the probe accessories.

3) In case the cover does not come out easily, screw the four bolts (previously removed) into the blind holes in order to extract the probe cover. Gradually screw the bolts alternating between them such as to raise the cover evenly.

4) When extracting the cover, dry the fissure between the cover and the body of probe with a strip of paper inserted edgewise and dry any trace of water in the proximity of the external side of the o-ring.

5) Pull the battery pack off and remove the cable connector.

6) Connecting the battery pack, the charger immediately checks the nominal voltage, thus automatically selecting the most appropriate action to carry out.

**LED indicators**
- Yellow ON: battery not connected or starting battery analysis.
- Orange ON: quick charging started.
- Green flushing: top of charge.
- Green ON: tricky charging.
- Alternate Orange/Green: battery problems.

**Note**
At the end of the quick-charging procedure, the charger undertakes a low-current equilibration charging procedure which lasts 30 m. This procedure is also called tricky-charging procedure. The aim of this procedure is to keep the battery cells in good condition, thus compensating for the auto-discharge.

7) Replace the cover on the probe and lift the probe itself vertically.

8) Close again the probe with the four bolts. Gradually tighten the bolts in sequence such as to close the cover uniformly.

**SUBMERSIBLE 150-bar/700-bar RECHARGEABLE (4.5 Ah) BATTERY PACKS**
DESCRIPTION
The OCEAN SEVEN submersible 150-bar and 700-bar rechargeable battery packs are housed in a plastic and a titanium grade 5 container respectively and are composed of 12 NiMH 1.2VDC cells, assembled in series, to create a unique 14.4VDC 4.5Ah battery pack. The battery pack comes complete with a plastic flange (to join the battery pack to the OCEAN SEVEN 3xx probes), with an international battery charger and with the submersible cable needed to connect the battery pack to the Ocean Seven 3xx probes.

Electrical:
- **Voltage**: 14.4 VDC (nominal voltage).
- **Capacity**: 4.5 Ah.
- **Cells**: 12 cells – 1.2VDC NiMH type HR-4/3FAU
- **Charger**: international battery charger.

Housing
- **Material**: White plastic POM / Titanium GR2.
- **Diameter**: 75 mm / 66 mm
- **Length**: 315 mm without top connector.
- **Weight**: 2.5 kg (including batteries) / 4 kg (including batteries)
- **Max pressure**: 150 bar – 700 bar
- **Connector**: 2-pole SEA CON® connector.

INSTRUCTIONS ON HOW TO RECHARGE THE BATTERY PACK

➢ Dry the battery pack and lay it down on a table.

➢ Loosen the four closing screws on the cover with the hexagonal wrench included in the probe accessories.

➢ Pull the screws completely out and gently move the cover to one side of the battery pack.

➢ Dry any trace of water in the proximity of the external side of the o-ring.

➢ Connect the battery charger to the top head connector.

➢ Read the below “Battery Charger” instructions.

➢ Put the cover on the battery pack.

➢ Check the correct position of the o-ring and close the battery pack again with the four screws.

➢ Gradually tighten the screws alternating one screw with another. DO NOT TIGHTEN EXCESSIVELY – PLASTIC POM HOUSING.

➢ It is enough that you tighten a quarter of a turn of the screw at the end of stroke of the screw thread (plastic POM housing).

BATTERY CHARGER
After connecting the battery pack, the charger immediately checks the nominal voltage thus automatically selecting the most appropriate action to carry out as:
1. If the battery voltage is lower than 1.2 V x cell, the charger carries out the standard charging procedure which implies the recharging at a moderate current for 30m. Whenever the battery reaches the nominal voltage, the charger automatically starts the quick-charging procedure.

2. If the battery voltage is higher than 1.2 V x cell, the charger carries out the quick-charging procedure.

3. If the battery voltage is lower than 0.2 V x cell, the charger carries out the standard charging procedure thus inhibiting the quick-charging procedure.

**Note**

At the end of the quick-charging procedure, the charger undertakes a low-current equilibration charging procedure which lasts 30 m. This procedure is also called tricky-charging procedure. The aim of this procedure is to keep the battery cells in good condition, thus compensating for the auto-discharge.

**LED INDICATORS**

Green ON: charger powered.

Yellow BLINKS: standard charging procedure/equilibration procedure.

Yellow ON: quick charging procedure.

Yellow OFF: batteries are fully charged.

Red ON: bad battery; immediately stop the charging procedure and disconnect the battery.

**SPECIFICATIONS**

**Power:** 100 – 250 VAC 50/60Hz, 25 W.

**Protection:** 2 A fuse, transient voltage suppressor.

Reverse battery polarity.

Reverse current.

**Charge current:**

1.1 A quick charge, maximum time 6 hours.

120 mA standard charging procedure, maximum time 30m.

120 mA equilibration charging procedure, maximum time 15m.

40 mA tricky-charging procedure

**Time-out:**

8 hours.

**Hold-off:**

15 m.

**Cells:**

this charger has been configured for 12 1.2V cells.

**PRECAUTIONS**

✓ Do not charge warm/hot batteries.

✓ Do not charge batteries if the air temperature is higher than +35°C.

✓ Do not charge lead batteries.

✓ Do not charge in the field.

✓ Do not try to recharge a closed battery pack.
B.0 FOREWORD
The OCEAN SEVEN 316Plus CTD multiparameter probe automatically performs sensor data processing functions needed to guarantee the probe measurement accuracy and precision. This section briefly explains the data processing procedures.

B.1 RAW DATA PROCESSING
The aim of the “raw data processing functions” is to attenuate the noise in the acquired data without affecting the signal content. In the following subsection, the available raw data processing functions are described, while how to configure the related parameters is explained in the “Advanced Configuration” appendix. It should be noted that modifying the raw data processing method and parameter can lead to malfunction of the probe and can cause the probe to deviate from the stated measurement accuracy and/or precision.

B.1.1 Average
This form of processing allows the acquisition of a configurable number of raw data. At the end of the data acquisition, the averaged value of each acquired parameter is obtained and, afterwards, it is automatically stored in memory and converted into engineering units before showing it to the operator. Depending on the kind of sensor, it is possible to define two different numbers of samples to be averaged. The first value is associated with the averaging of the CTD sensors, while, the second value is associated with the averaging of all the other sensors. By using the default averaging method, the probe acquires and averages data from the standard 6 sensors (CTD + O2 + pH + Redox) at the rate of 50ms (20 Hz) which corresponds, considering an average profiling speed of 1 m/s, to a spatial resolution of 50 mm.

B.1.2 Time average
This raw data processing method allows the data averaging for a configurable interval. Acquired data is accumulated for the configured interval. At the end of the averaging interval, the averaged data for each sensor is obtained, stored in memory and converted into engineering units before showing it to the operator. Time average implies the configuration of one averaging interval. It will be used to average data acquired from all the sensors installed on the probe. Spatial resolution of this averaging method depends on the configured averaging interval.

B.1.3 Thermal compensation
The thermal compensation procedure is applied to the CTD (Conductivity, Temperature and Pressure) sensors only. The thermal compensation algorithm compensates deviation of the electronic preamplifier of the CTD sensors due to the variation of the ambient temperature inside the probe housing. The thermal compensation is performed by acquiring, at preset intervals, the probe internal temperature and by applying a thermal compensation algorithm based on a table of compensations collected in the laboratory by means of repeated thermal characterization cycles. Each OCEAN SEVEN 316Plus CTD and each CTD sensor have different compensation coefficients.

B.1.4 Temperature sensor self-heating minimizing
To eliminate the self-heating effect of the temperature sensor, the OCEAN SEVEN 316Plus probe powers off the temperature sensor excitation when not needed. Without this precaution, the temperature sensor itself is capable of changing the temperature of the small volume of water immediately around it by a fraction of milli-degrees °C in the presence of a modest water flow.

B.2 CONVERSION INTO ENGINEERING UNITS
Raw data consists of digitised voltages or ADC counts acquired from the sensors through the electronic sensor conditioning circuits (sensor preamplifiers). Raw data values are converted into physical and chemical units by means of calibration data and data conversion algorithms.
B.2.1 Dedicated conversion procedure

Conversion of signals coming from a sensor into engineering units is the result of a processing algorithm, which for some sensors cannot be directly correlated with a standard mathematical method. For such parameters, a dedicated data conversion function is provided. The OCEAN SEVEN 316Plus has dedicated processing algorithms for the following sensors:

- Dissolved oxygen sensor saturation.
- Dissolved oxygen sensor expressed in ppm.
- pH expressed in mpH.
- REDOX.

An overview of the processing algorithms and parameters is described in the introduction section.

B.2.2 Common conversion procedure

Sensors which do not require dedicated conversion procedure use polynomial (up to the 2nd order) or first order interpolation algorithms to convert the ADC counts into engineering values.

- Polynomial interpolation: \( y = a + bx + cx^2 + dx^3 \)
- 1st order interpolation:
  - linear: \( y = a + bx \)
  - logarithmic: \( y = a + \log(bx) \)
  - exponential: \( y = a + \exp(bx) \)

B.3 Derived parameters

Derived parameters like: Salinity, Sound Speed, Pressure to Depth Conversion, Theta, Sigma T, etc. are obtained using the algorithms described in the UNESCO technical papers in marine science no. 44 "Algorithms for computation of fundamental properties of sea water".

B.4 Sensor logical code table

The following logical code table shows the most common sensors and derived parameters. A complete list of the sensor logical codes can be found in the “Ocean Seven 3xx Data Transmission Protocol” document.

<table>
<thead>
<tr>
<th>Description</th>
<th>Logical code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>0</td>
</tr>
<tr>
<td>Temperature</td>
<td>1</td>
</tr>
<tr>
<td>Conductivity salt waters</td>
<td>2</td>
</tr>
<tr>
<td>Conductivity fresh waters @20°C</td>
<td>3</td>
</tr>
<tr>
<td>Salinity (UNESCO FORMULA)</td>
<td>4</td>
</tr>
<tr>
<td>Dissolved Oxygen ppm</td>
<td>5</td>
</tr>
<tr>
<td>Dissolved Oxygen %</td>
<td>6</td>
</tr>
<tr>
<td>pH</td>
<td>7</td>
</tr>
<tr>
<td>Redox</td>
<td>8</td>
</tr>
<tr>
<td>Dissolved Oxygen ppm (UNESCO FORMULA)</td>
<td>9</td>
</tr>
<tr>
<td>Fluorometer</td>
<td>11</td>
</tr>
<tr>
<td>Transmissometer</td>
<td>12</td>
</tr>
<tr>
<td>Sound Velocity (UNESCO FORMULA)</td>
<td>16</td>
</tr>
<tr>
<td>Depth (UNESCO FORMULA)</td>
<td>20</td>
</tr>
<tr>
<td>Sigma T (Density UNESCO FORMULA)</td>
<td>22</td>
</tr>
<tr>
<td>Turbidity Meter</td>
<td>24</td>
</tr>
<tr>
<td>PAR – generic</td>
<td>25</td>
</tr>
<tr>
<td>Potential Temperature (THETA)</td>
<td>44</td>
</tr>
<tr>
<td>Conductivity fresh water @25°C</td>
<td>80</td>
</tr>
<tr>
<td>Conductivity fresh water</td>
<td>89</td>
</tr>
<tr>
<td>PAR – QSP200L</td>
<td>99</td>
</tr>
<tr>
<td>Rhodamine</td>
<td>112</td>
</tr>
</tbody>
</table>
APPENDIX “C” – HIGHLY PRECISE PRESSURE TRANSDUCER

C.0 INTRODUCTION

The OCEAN SEVEN 316Plus probe can interface the Highly Precise Pressure Sensor through a dedicated hardware and software interface.

C.1 FOREWORD

The pressure transducers cover all pressure ranges from 100 mbar to 1000 bar. They are all delivered with engraved serial number and electrical lead outs. Several millions of these pressure transducers are in use worldwide in a variety of different applications. The main fields of application are level technology, pneumatics, hydraulics, and avionics. A high-sensitivity piezo-resistive silicon chip is used for pressure sensing. The chip is protected against ambient influences by a stainless steel housing sealed with a concentrically corrugated diaphragm. The housing is filled with silicone oil so as to ensure the transfer of the pressure from the diaphragm to the sensing component. All metallic parts in contact with the pressure media are made of stainless steel AISI316L. The fully welded housing is vacuum-tight. Each pressure transducer is subject to comprehensive tests as to its pressure response and temperature characteristic, and is delivered with an individual calibration certificate stating the characteristics as well as the results of all tests that were performed.

C.2 TECHNICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Available ranges:</th>
<th>08…12 3 10 30 100 300 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpressure:</td>
<td>2 5 20 60 200 400 1000</td>
</tr>
<tr>
<td>Output:</td>
<td>RS 485</td>
</tr>
<tr>
<td>Supply (V):</td>
<td>8…28 Vcc</td>
</tr>
<tr>
<td>Precision:</td>
<td>0,01 %FS</td>
</tr>
<tr>
<td>Output Rate:</td>
<td>400 Hz</td>
</tr>
<tr>
<td>Resolution:</td>
<td>0,002 %FS</td>
</tr>
<tr>
<td>Insulation:</td>
<td>100 Mohm / 50 V</td>
</tr>
<tr>
<td>Pressure Endurance:</td>
<td>10 Million Pressure Cycles 0…100 %FS at 25 °C</td>
</tr>
<tr>
<td>Material in Contact with Media:</td>
<td>HASTELLOY</td>
</tr>
</tbody>
</table>

C.3 ACCURACY AND PRECISION

“Accuracy” is an absolute term, “Precision” a relative term. Deadweight testers are primary standards for pressure, where the pressure is defined by the primary values of mass, length and time. Higher-class primary standards in national laboratories indicate the uncertainty of their pressure references with 70 to 90 ppm or close to 0.01%. Commercial deadweight testers used to calibrate the transmitters indicate an uncertainty or accuracy of 0.025 %. Below these levels, expression “Precision” is the ability of a pressure transmitter to be at each pressure point within 0.01 %FS relative to these commercial standards.

C.4 POLYNOMIAL COMPENSATION

This uses a mathematical model to derive the precise pressure value (P) from the signals measured by the pressure sensor (S) and the temperature sensor (T). The microprocessor in the transmitter calculates P using the following polynomial:

\[ P(S,T) = A(T).S0 + B(T).S1 + C(T).S2 + D(T).S3 \]

With the following coefficients A(T)…D(T) depending on the temperature:
A(T) = A0 \cdot T0 + A1 \cdot T1 + A2 \cdot T2 + A3 \cdot T3
B(T) = B0 \cdot T0 + B1 \cdot T1 + B2 \cdot T2 + B3 \cdot T3
C(T) = C0 \cdot T0 + C1 \cdot T1 + C2 \cdot T2 + C3 \cdot T3
D(T) = D0 \cdot T0 + D1 \cdot T1 + D2 \cdot T2 + D3 \cdot T3

The transmitter is factory-tested at various levels of pressure and temperature. The corresponding measured values of S, together with the exact pressure and temperature values, allow the coefficients A0...D3 to be calculated. These are written into the EEPROM of the microprocessor. When the pressure transmitter is in service, the microprocessor measures the signals (S) and (T), calculates the coefficients according to the temperature and produces the exact pressure value by solving the P(S,T) equation. Calculations and conversions are performed at least 400 times per second.

C.5 CONFIGURATION

Through the probe set-up, it is possible to configure the Highly Precise Sensor by adding or modifying an existing sensor and associating the logical code 0 to this sensor and associating the multiplexer input 252 special code. Afterwards, the external system must be configured as follows:

Special sensors: (0) None, (1) Hull Temperature, (2) Pressure Transmitter
Special sensors: 2
Coms: (1) Main Port, (2) COM2 OPTODE Acoustic, (3) COM3 Go1018 Sos Htr, (4) COM4 N.u., (5) COM5 Press
Coms: 5
BD: (0) 110, (1) 150, (2) 300, (3) 600, (4) 1k2, (5) 2k4, (6) 4k8, (7) 9k6, (8) 19k2, (9) 38k4
Baud Rate = 9
Data Bit: (0) 7 bit, (1) 8
Data bit = 1
Parity: (0) None, (1) Even, (2) Odd
Parity type = 0
Stop Bit: (0) 1 bit, (1) 2 bit
Stop bit = 0

At the end of the configuration of external systems, the configuration procedure is completed. To make the entered configuration effective, it is mandatory to switch off and then on the OCEAN SEVEN 316Plus.

C.6 SENSOR CALIBRATION

Calibration is carried out as described in the Operator’s Manual for the standard pressure sensor. However, the following calibration coefficients must be configured:

Coefficient (a) = 0.0
Coefficient (b) = 10.0
Coefficient (c) = 0.0
This section describes the configuration parameters which can be configured when the probe access rights are configured as SERVICE or ADMINISTRATOR.

By means of the `<CNOP>` configuration command, available under the Configuration Menu, it is possible to modify the below listed parameters:

<table>
<thead>
<tr>
<th>Cmd. Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand-by between commands?</td>
<td>Yes</td>
<td>Allows the probe to enter in stand-by and consumes less power</td>
</tr>
<tr>
<td>Watching time for valid command [s]</td>
<td>30</td>
<td>Interval used to wait during command selection.</td>
</tr>
<tr>
<td>Watching time for valid parameter[s]</td>
<td>30</td>
<td>Interval used to wait during parameter entry.</td>
</tr>
<tr>
<td>Data show at the end of start-up ?</td>
<td>No</td>
<td>Starts to acquire data immediately after the start-up.</td>
</tr>
<tr>
<td>Min. depth step during unattended</td>
<td>0.01</td>
<td>Minimum step for pressure data acquisition set-up.</td>
</tr>
<tr>
<td>Store data into a unique CAST during the unattended profiles?</td>
<td>No</td>
<td>It is possible to store all acquired data in a single cast overriding the standard procedure that implies the storage of multiple casts.</td>
</tr>
<tr>
<td>Log data into memory during REDAS-5 real-time profile?</td>
<td>No</td>
<td>Data sent to the PC when communicating by means of the REDAS-5 program can be stored in memory for safety purposes.</td>
</tr>
<tr>
<td>QAM Telemetry speed (BPS): 0)4K8, 1)7K2, 2)9K6, 3)14K4 ?</td>
<td>0..3</td>
<td>If the OCEAN SEVEN 316Plus is equipped with an IDRONAUT QAM telemetry system, through this parameter, it is possible to configure the communication speed to be used. The Deck Unit QAM telemetry must be configured accordingly! The below section describes in detail the telemetry set-up.</td>
</tr>
<tr>
<td>Send the ER xxx time-out messages:</td>
<td>Yes</td>
<td>Disables the communication protocol error messages.</td>
</tr>
<tr>
<td>Cons:(1)MainPort,(2-COM2)OPTODE-Acoustic,(3-COM3) Go1018-Svs-Htr,(4-COM4)N.u.,(5-COM5-Press</td>
<td>1</td>
<td>MAIN Communication port. Do not change it!</td>
</tr>
<tr>
<td>BD:(0)110,(1)150,(2)300,(3)600,(4)1k2,(5)2k4,(6)4k8,(7)9k6,(8)19k2,(9)38k4 Baud Rate</td>
<td>7</td>
<td>Communication speed. In case telemetry is installed, see the below text.</td>
</tr>
<tr>
<td>Data Bit:(0)7 bit, (1)8 bit</td>
<td>1</td>
<td>Length of data sent to PC. Do not change it!</td>
</tr>
<tr>
<td>Parity:(0)None,(1)Even,(2)Odd</td>
<td>0</td>
<td>Parity type. Do not change it!</td>
</tr>
</tbody>
</table>
APPENDIX “D” – ADVANCED CONFIGURATION AND TELEMETRY

Stop Bit:(0)1 bit, (1)2 bit 0 Stop bit. Do not change it!

Flow Control:(0)None,(1)XON/XOFF, (2)CTS/RTS,(3)DelayTx 0 Flow control. See the below text.

D.2 QAM TELEMETRY SET-UP

This section describes how to set up the internal telemetry modem of the probe for the: 4k8, 7k2, 9k6 and 14k4 data transmission rates. Three different methods are available to set up the internal modem:

1. Hardware set-up of QAM modem board revision 0 – OCEAN SEVEN 316Plus manufactured after July 2011.
2. Software set-up of QAM modem board revision 0 – OCEAN SEVEN 316Plus manufactured after July 2011.

Starting from June 2011, the OCEAN SEVEN 316Plus probes allow adopting the “software set-up” solution. When possible, we strongly suggest adopting the software set-up.

D.2.1 Hardware set-up

To set up the probe internal modem, it is needed to completely open the probe, thus exposing the internal electronic boards. Afterwards, the “modem” daughter boards (see below pictures) must be identified. They are located in the upper part of the probe electronic boards. When the modem boards are identified, it is necessary to find the V32/V32bis jumpers (see below pictures). The jumpers must be installed according to the chosen rate. Afterwards, the probe communication speed must be modified according to the jumpers (see above configuration). Please do not forget to set up the MKPlus Deck Unit telemetry according to the rate selected on the probe modem, otherwise the communication session cannot be successfully established.

Note

- After the set-up is completed, we suggest trying a connection before closing the probe to verify the working conditions.
- Unless specifically declared, the “Rate 3” is the default shipping condition of the OCEAN SEVEN 316Plus probe telemetry modem and the MKPlus Deck Unit.

<table>
<thead>
<tr>
<th>QAM TELEMETRY SPEED/RATE</th>
<th>PROBE COMMUNICATION SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>4K8</td>
<td>4K8</td>
</tr>
<tr>
<td>7K2</td>
<td>4K8</td>
</tr>
<tr>
<td>9K6</td>
<td>9K6</td>
</tr>
<tr>
<td>14K4</td>
<td>9K6</td>
</tr>
</tbody>
</table>
Lowest rate 0 – 4k8V32
To configure the probe modem for the 4k8 bps V32 rate, it is necessary to install both rate selection jumpers (the two aligned on a single row) as shown in the picture.
The probe communication speed must be configured to: 4k8 bps. Please be aware that, after setting up the communication speed to 4k8bps, the ITERM communication program set-up must be configured accordingly, otherwise communications with the probe will be impossible. Afterwards and before starting the test of the new rate, please change the QAM modem rate of the MKPlus Deck Unit accordingly.

Medium rate 1 – 7k2V32
To configure the probe modem for the 7k2 bps V32 rate, it is necessary to install one of the two rate selection jumpers (the two aligned on a single row) as shown in the picture. The probe communication speed must be configured to: 4k8 bps. Please be aware that, after setting up the communication speed to 4k8bps, the ITERM communication program set-up must be configured accordingly, otherwise communications with the probe will be impossible. Afterwards and before starting the test of the new rate, please change the QAM modem rate of the MKPlus Deck Unit accordingly.

High rate 2 – 9k6V32
To configure the probe modem for the 9k6 bps V32 rate, it is necessary to install one of the two rate selection jumpers (the two aligned on a single row) as shown in the picture. The probe communication speed must be configured to: 9k6 bps. Afterwards and before starting the test of the new rate, please change the QAM modem rate of the MKPlus Deck unit accordingly.

Highest Rate 3 – 14k4V32bis
To configure the probe modem for the 14k4 bps V32bis rate, it is necessary to remove both rate selection jumpers (the two aligned on a single row) as shown in the picture. The probe communication speed must be configured to: 9k6 bps. Afterwards and before starting the test of the new rate, please change the QAM modem rate of the MKPlus Deck unit accordingly.
D.2.2 **Software set-up – QAM Modem board Rev. 0**

Starting from June 2011, the OCEAN SEVEN 316Plus probes allow the tuning of the QAM telemetry modem revision 0 through a software set-up procedure instead of a hardware set-up. Therefore, to modify the communication rate, it is not needed to open the probe to access the internal modem. The below sequence of commands allows the tuning of the QAM telemetry modem.

1. Connect the probe to a personal computer using the **RS232C laboratory cable**.
2. Run the ITERM program on the PC.
3. Switch the probe on and wait until the Main Menu appears. In case the probe is configured to use the PTP protocol, switch it to the menu mode using the VT^J command.
4. From the Main Menu, select the Service Menu.
5. From the Service Menu, select the Configuration Menu.
6. From the Configuration Menu, run the CNHI command and answer with the SERVICE3XX password.
7. From the Configuration Menu, select the CNOP command.
8. Go through the shown parameters until the following request appears.

```
QAM Telemetry speed (BPS): 0)4K8, 1)7K2, 2)9K6, 3)14K4
Speed:
```

Enter the speed according to the negotiation rate configured on the MKPlus Deck Unit.

9. Afterwards, go through the parameters and change the probe communication speed according to the below table:

<table>
<thead>
<tr>
<th>QAM TELEMETRY SPEED/RATE</th>
<th>PROBE COMMUNICATION SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>4K8</td>
<td>4K8</td>
</tr>
<tr>
<td>7K2</td>
<td>4K8</td>
</tr>
<tr>
<td>9K6</td>
<td>9K6</td>
</tr>
<tr>
<td>14K4</td>
<td>9K6</td>
</tr>
</tbody>
</table>

10. Complete the probe configuration commands until the Configuration Menu appears again.
11. From the Configuration Menu, select the CNUP command.
12. Reply YES to the question about the confirmation of the new probe set-up.
13. In case the probe communication speed has been modified, the ITERM program communication speed must be changed too, otherwise the communication with the probe is impossible.
14. Modify the ITERM communication speed, if needed !!!
15. Return to the probe Main Menu.
16. Remove the RS232C laboratory cable and connect the probe to the MKPlus Deck Unit through the sea cable.
17. Connect the MKPlus Deck Unit to the ITERM, configuring the default speed: 9600bps and the CTS/RTS handshaking.
The below pictures graphically show the telemetry working conditions at the end of the set-up for each of the four standard QAM rates: 14k4, 9k6, 7k2, 4k8.

Telemetry rate: 14k4

Telemetry rate: 9k6
Telemetry rate: 7k2

Telemetry rate: 4k8
D.2.3 Software set-up – QAM Modem board Rev. 1

Starting from May 2013, the OCEAN SEVEN 316Plus probes allow the tuning of the QAM telemetry modem revision 1, through a simplified software set-up procedure. Therefore, to modify the communication rate, it is not needed to open the probe to access the internal modem. The below sequence of commands allows the tuning of the QAM telemetry modem revision 1.

1. Connect the probe to a personal computer using the RS232C laboratory cable.
2. Run the ITERM program on the PC.
3. Switch the probe on and wait until the Main Menu appears. In case the probe is configured to use the PTP protocol, switch it to the menu mode using the VT^J command.
4. From the Main Menu, select the Service Menu.
5. From the Service Menu, select the Configuration Menu.
6. From the Configuration Menu, run the CNHI command and answer with the SERVICE3XX password.
7. From the Configuration Menu, select the CNOP command.
8. Go through the shown parameters until the following request appears.

   **QAM Telemetry speed (BPS):** 0)4K8, 1)7K2, 2)9K6, 3)14K4
   **Speed:**

   Enter the speed according to the negotiation rate previously configured on the MKPlus Deck Unit.

9. Afterwards, go through the parameters and confirm the remaining parameters.
10. Although the QAM Telelemetry speed is modified, please check that the probe communication speed is configured according to the below table:

<table>
<thead>
<tr>
<th>QAM TELEMETRY SPEED/RATE</th>
<th>PROBE COMMUNICATION SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>4K8</td>
<td>9K6</td>
</tr>
<tr>
<td>7K2</td>
<td>9K6</td>
</tr>
<tr>
<td>9K6</td>
<td>9K6</td>
</tr>
<tr>
<td>14K4</td>
<td>9K6</td>
</tr>
</tbody>
</table>

11. Change or verify that the probe main port flow control is configured for the CTS/RTS protocol (OPTION 2).

   **Flow Control:** (0)None, (1)XON/XOFF, (2)CTS/RTS, (3)DelayTx

   Therefore, type 2 to the above question!

12. Complete the probe configuration commands until the Configuration Menu appears again.
13. From the Configuration Menu, select the CNUP command.
14. Reply YES to the question about the confirmation of the new probe set-up.
15. Return to the probe Main Menu.
16. Remove the RS232C laboratory cable and connect the probe to the MKPlus Deck Unit through the sea cable.
17. Connect the MKPlus Deck Unit to the ITERM and proceed with the connection.
The below pictures graphically show the telemetry working conditions at the end of the set-up for each of the four standard QAM rates: 14k4, 9k6, 7k2, 4k8.

**Telemetry rate: 14k4**

**Telemetry rate: 9k6**
Telemetry rate: 7k2

Telemetry rate: 4k8
E.0 FOREWORD
The aim of this section is the description of operations needed by OCEAN SEVEN probe customers to perform unattended sampling of bottles using an intelligent GENERAL OCEANICS Rosette joined to an OCEAN SEVEN 316Plus probe. Bottles can be sampled in function of pressure or time step. Please find below a step-by-step procedure to be followed during the set-up of the unattended cycles and the suggestions on how to successfully accomplish the bottle sampling. Obviously, the OCEAN SEVEN 316Plus probe must be equipped with the software and hardware interface for the 1018 General Oceans Rosette. Unattended bottle sampling method cannot be used with the 1015 rosette type. From the hardware point of view and due to the energy needed by the rosette to perform its operations (bottle closing), it is mandatory that the OCEAN SEVEN 316Plus probe is equipped with an external submersible battery pack. This is to guarantee that there is enough energy to power the most demanding OCEAN SEVEN 316Plus probe and the interfaced General Oceans Rosette.

E.1 BOTTLE SAMPLING IN FUNCTION OF TIME
Bottles can be sampled in function of time only when the probe is configured to perform a timed data acquisition cycle. The interval used to take bottle sampling must be a multiple of the configured data acquisition interval. A bottle is closed when the data acquisition interval coincides with the bottle-sampling interval. Bottles are closed starting from the first configured bottle to the last configured one. During the time between acquisitions, the Rosette and the OCEAN SEVEN 316Plus probe are in OFF condition and do not consume battery energy. The following message is shown by the probe once the timed data acquisition function is invoked and a Rosette is connected to the probe.

GENERAL OCEANICS (1014-1015-1016-1018) ROSETTE
Number of bottle positions: 12
Number of bottles to fire: 12
Bottle step: 1
First bottle to fire: 1
Reverse depth value: 1500.00
Bottle firing depth step: 100.00
Bottle firing time step: 00:00:00
Bottle firing depth profile: 1
Bottle firing method: TIME STEP
Do you want to fire bottles? Yes, No

If the operator answers <NO>, the bottle will not be sampled. If the operator answers <YES>, the set-up continues as follows:

Bottles position [1..36]

The operator must enter the maximum number of positions available on the interfaced Rosette.

Bottles to fire [1..96]

The operator must enter the number of bottles. The bottles are sampled consecutively starting from the first bottle and ending with the last bottle, increasing the bottle number after each bottle sampling.

First bottle to fire [1..36]

The operator must enter the first bottle to fire. It must be any value between 1 and the number of Rosette positions.

Step between bottle [1..36]

This allows the operator to define the number of bottles position between two installed bottles. The step
value is used to advance the number of bottle in preparation of the next bottle to fire. The default value is 1.

**Firing bottle time step [hh:mm:ss]**

The operator must enter the bottle time step taking into account that it must be a multiple of the interval used to acquire data. The probe automatically checks that the operator’s set-up meets these criteria and, in case it doesn’t, the following message appears:

*Warning: the Firing step must be a multiple of the acquisition step*

And the operator must enter again the time interval. This procedure ends only whenever a valid bottle time step is entered. After the bottle time step is correctly entered, the probe automatically shuts down by itself and configures the first data acquisition cycle time. Bottle sampling interval evaluation starts once the first acquisition in function of time is performed by the probe.

**Note**
The probe warm-up time-out must be increased from the standard 5 seconds to the more appropriate 30 seconds. This quite long time-out is needed to cover the home positioning procedure taken by the Rosette once it awakes. In fact, during the home positioning procedure, the Rosette does not answer the probe bottle firing request.

### E.2 BOTTLE SAMPLING IN FUNCTION OF PRESSURE

Two different methods can be selected by the operator to close the bottles once the probe is performing an unattended acquisition cycle in function of pressure step. Bottle can be closed down or up cast.

#### E.2.1 Downcast bottle firing

When an unattended data acquisition cycle in function of pressure is configured it is possible to choose between the downcast or upcast bottle firing method. The special downcast firing setup follows.

**Bottles to fire [1..96]**

The operator must enter the number of bottles. The bottles are sampled consecutively starting from the first bottle and ending with the last bottle, increasing the bottle number after each bottle sampling.

**First bottle to fire [1..36]**

The operator must enter the first bottle to fire. It must be any value between 1 and the number of Rosette positions.

**Step between bottle [1..36]**

This allows the operator to define the number of bottles position between two installed bottles. The step value is used to advance the number of bottle in preparation of the next bottle to fire. The default value is 1.

The operator select now the look-up table that will be used during the downcast to fire the bottles.

**Firing Look-Up depth table [1..5]**

**Bottle pressure look-up table preparation**

The look-up table containing the pressure when the bottle should be closed can be prepared by using the “programmed” profile set-up command. Up to five different look-up tables can be configured. The look-up table pressure values must be configured starting from the shallow pressure values going towards deeper pressure values.
The function to set up the look-up table is available under the Configuration Menu of the Ocean Seven 316Plus probe. The look-up table is kept in the non-volatile memory used to keep the probe configuration. Therefore, it can be set up once and used many times.

It is possible to force the automatic closure (firing) of all the remaining bottles installed on the rosette when the CTD & Rosette reach the bottom depth.

**Bottom bottle closure enabled?**

In case the bottom bottle closure is enabled the following parameters must set:

- **Pressure to enable bottom bottle [dbar]**
- **Speed limit to enable bottom bottle [m/s]**
- **Stationary time on bottom [1..720 s]**

Once the bottom closure procedure starts the inserted timeout is waited to allow the water stabilization before starting the sequence of bottles closure.

### E.2.2 UpCast bottle firing

Bottles can be closed using a predefined pressure “table look-up” or by using a pressure step. In both cases, bottles are closed when the probe rises to the surface coming from deep waters. Decision to start the bottle closing procedure is taken using different possibilities depending on the bottle sampling method selected:

- **Pressure step:** During the downcast, the probe overpasses the configured maximum reverse depth. The difference between the maximum downcast pressure and the pressure during the upcast is greater than the configured bottle sampling step.

- **Look-up pressure table:** During the downcast, the probe overpasses the pressure associated to the first bottle to fire. The probe detects that it is starting to rise toward shallow water by an amount greater than the configured step.

**Bottle pressure look-up table preparation**

The look-up table containing the pressure when the bottle should be closed can be prepared by using the “programmed” profile set-up command. Up to five different look-up tables can be configured. The look-up table pressure values must be configured starting from the deeper pressure values going towards shallow pressure values. The function to set up the look-up table is available under the Configuration Menu of the Ocean Seven 316Plus probe. The look-up table is kept in the non-volatile memory used to keep the probe configuration. Therefore, it can be set up once and used many times.

When a bottle is closed, a complete data set is acquired and stored in a dedicated cast. Stored data also reports the number of the bottle closed. Therefore, at the end of the data acquisition and bottle sampling, two different casts are stored in memory: the first one describing the profile data and the second one
describing the acquisition done during the bottle sampling. The following Rosette set-up message is shown by the probe once the unattended acquisition in function of the pressure interval is invoked.

**GENERAL OCEANICS (1014-1015-1016-1018) ROSETTE**

- Number of bottle positions: 12
- Number of bottles to fire: 12
- Bottle step: 1
- First bottle to fire: 1
- Reverse depth value: 1500.00
- Bottle firing depth step: 100.01
- Bottle firing time step: 01:00:00
- Bottle firing depth profile: 1
- Bottle firing method: DEPTH STEP
- Do you want to fire bottles? Yes, No

If the operator answers <NO>, the bottle will not be sampled. If the operator answers <YES>, the set-up continues as follows:

- **Bottle firing method:** (1) Depth step, (2) Depth profile

The operator must select the type of bottle sampling method he wants to use selecting between the depth/pressure step and the look-up table. After the selection of the bottle firing method, two different set-ups arise depending on the selected method.

### E.2.2.1 Depth/Pressure step set-up

- **Bottles position** [1..36]

The operator must enter the maximum number of positions available on the interfaced Rosette.

- **Bottles to fire** [1..96]

The operator must enter the number of bottles installed on the Rosette. The bottles are sampled consecutively starting from the first bottle and ending with the last bottle, increasing the bottle number after each bottle sampling.

- **First bottle to fire** [1..36]

The operator must enter the first bottle to fire. It must be any value between 1 and the number of Rosette positions.

- **Step between bottles** [1..36]

This allows the operator to define the number of bottles position between two installed bottles. The step value is used to advance the number of bottle in preparation of the next bottle to fire. The default value is 1.

- **Reverse depth value** [dbar]

The operator must enter the pressure value used to judge the starting of the bottle closing procedure. When this pressure value is exceeded, the bottle sampling procedure starts.
**Bottle firing depth step**  [d-bar]

The operator must enter the pressure or depth step used to close consecutive bottles.

### E.2.2.2  Look-up table set-up

**Bottle position**  [1..36]

The operator must enter the maximum number of positions available on the interfaced Rosette.

**Bottles to fire**  [1..36]

The operator must enter the number of bottles installed on the Rosette. It must be any value between 1 and the number of Rosette positions. The bottles are sampled consecutively starting from the first bottle and ending with the last bottle, increasing the bottle number after each bottle sampling.

**First bottle to fire**  [1..36]

The operator must enter the first bottle to fire. It must be any value between 1 and the number of Rosette positions.

**Step between bottle**  [1..36]

This allows the operator to define the number of bottles position between two installed bottles. The step value is used to advance the number of bottle in preparation of the next bottle to fire. The default value is 1.

**Firing Look-Up depth table**  [1..5]

The operator must enter the number of the look-up table to be used to close the bottles. At the end of the set-up, the probe shuts down by itself waiting to start the pressure profile.

**Step to judge up-cast**  [d-bar]

This parameter allows the operator to define a pressure step that will be used by the OCEAN SEVEN 316Plus to judge if the up-cast (return of the probe and rosette to surface) has been started. If this condition is met, the bottle firing procedure is immediately undertaken. In that case, all the bottles which have a deep pressure associated in the look-up table will be immediately and consecutively closed.

**Note**

The probe warm-up time-out must be increased from the standard 5 seconds to the more appropriate 30 seconds. This quite long time-out is needed to cover the home positioning procedure taken by the Rosette once it awakes. In fact, during the home positioning procedure, the Rosette does not answer the probe bottle firing request.

### E.3  BOTTLE SAMPLING IN FUNCTION OF THE SENSOR CONDITION

Bottles can be sampled in function of the sensor condition, when the probe is carrying out unattended “Conditional” cycles. When the foreseen condition is met, the bottles are fired according to a configurable time delay. Bottles are closed starting from the first configured bottle to the last configured one. The following message is shown by the probe once the conditional data acquisition function is invoked and a Rosette is connected to the probe.

**GENERAL OCEANICS (1014-1015-1016-1018) ROSETTE**

- Number of bottle positions: 12
- Number of bottles to fire: 12
- Bottle step: 1
- First bottle to fire: 1
- Reverse depth value: 1500.00
- Bottle firing depth step: 100.00
APPENDIX “E” – GENERAL OCEANICS ROSETTE INTERFACE

<table>
<thead>
<tr>
<th>Bottle firing time step:</th>
<th>00:00:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottle firing depth profile:</td>
<td>1</td>
</tr>
<tr>
<td>Bottle firing method:</td>
<td>CONDITIONAL TIME STEP</td>
</tr>
<tr>
<td>Do you want to fire bottles?</td>
<td>Y(es, N(o)</td>
</tr>
</tbody>
</table>

If the operator answers <NO>, the bottle will not be sampled. If the operator answers <YES>, the set-up continues as follows:

**Bottles position [1..36]**

The operator must enter the maximum number of positions available on the interfaced Rosette.

**Bottles to fire [1..36]**

The operator must enter the number of bottles installed in the Rosette. It must be any value between 1 and the number of Rosette positions. The bottles are sampled consecutively starting from the first bottle and ending with the last bottle, increasing the bottle number after each bottle sampling.

**First bottle to fire [1..36]**

The operator must enter the first bottle to fire. It must be any value between 1 and the number of Rosette positions.

**Step between bottle [1..36]**

This allows the operator to define the number of bottle positions between two installed bottles. The step value is used to advance the number of bottles in preparation of the next bottle to fire. The default value is 1.

**Bottle Trigger SENSOR logical code**

A list of parameters that can be used to start the bottle firing is shown and the operator must select the most appropriate one.

**SENSOR trigger value**

The trigger value which will be then used by the probe to start the firing bottle must be configured. The value will be compared with the real-time reading taken by the probe. If the real-time reading is less than the configured trigger value, the bottle firing process is activated. This will go on until the trigger condition is met. Please be aware that the condition is evaluated only if the probe is acquiring data in real time according to the “Unattended Conditional” measurement cycle set-up.

**Firing bottle time step (MAX 600s)**

The operator can select the time step between the firing of two consecutive bottles.

**Note**

The probe warm-up time-out must be increased from the standard 5 seconds to the more appropriate 30 seconds. This quite long time-out is needed to cover the home positioning procedure taken by the Rosette once it awakes. In fact, during the home positioning procedure, the Rosette does not answer the probe bottle firing request.

E.4 **CONFIGURING THE ROSETTE**

External equipment interfaced by the probe through digital, analogue or serial interface I/O can be configured by means of the CNES command available under the Configuration Menu.
E.5  **TEST ROSETTE INTERFACING**

Once configured, it is possible to test the Rosette interfacing and Rosette operations by means of two functions which are automatically added to the Service Menu. Therefore, after the Rosette configuration, the service menu appears as:

---

**APPENDIX “E” – GENERAL OCEANICS ROSETTE INTERFACE**

---

**OCEAN SEVEN 316Plus - ID:[0430][USR]/(7.5_10-12/2006) Fri Jan 05 13:47:03.15 2007**

-- Configure the external system --

G.O.Rosettes:(0)None,(1)1014/1016/1018,(2)Voltage-1015,(3)Tone-1015

**Rosette:0**

After selecting the Rosette type, the following question must be answered depending on the chosen Rosette type:

**Rosette bottles position [1..36]**

Enter the number of positions of your Rosette:

**GO-1016/1014 waiting for Rosette answer time-out [10..240]**

Enter the time-out that the probe should wait when a bottle firing is running. Default value is 120s:

**GO-1015 firing cap, charge time-out [3..20]**

Enter the time-out used by the OCEAN SEVEN 316Plus to charge the internal Rosette circuitry used to fire a bottle. This question is valid only for the 1015 Rosette voltage type. The default value is 10. In case the selected Rosette is of type 1018 or 1016 or 1014, the following additional parameter must be configured:

**Coms: (1)MainPort, (2-COM2)OPTODE-Acoustic, (3-COM3)Go1018-Ses-Htr, (4-COM4)N.u., (5-COM5-Press**

The Rosette communication port is the number 3. **Do not change it!**

**BD:(0)110,(1)150,(2)300,(3)600,(4)1k2,(5)2k4,(6)4k8,(7)9k6,(8)19k2,(9)38k4 Baud Rate**

The Rosette communication speed is 2. **Do not change it!**

**Data Bit:(0)7 bit, (1)8 bit**

The Rosette communication number of bits is 7. **Do not change it!**

**Parity:(0)None,(1)Even,(2)Odd**

The Rosette communication parity setting is even. **Do not change it!**

**Stop Bit:(0)1 bit, (1)2 bit**

The Rosette number of stop bit is 1. **Do not change it!**

**Flow Control:(0)None,(1)XON/XOFF,(2)CTS/RTS,(3)DelayTx**

The Rosette flow control is none. **Do not change it!**
The two new commands: FIRE and HOME allow the operator to respectively fire a bottle (close a bottle) and return the bottle closing arm to the resting position.

E.6 1015 ROSETTE VOLTAGE
In case the chosen Rosette is a 1015 voltage type and before connecting the Rosette to the OCEAN SEVEN 316Plus CTD, please verify that the voltage selector inside the 1015 Rosette pylon is configured to the “NORMAL” position, otherwise damage of the Rosette electronic circuitry and of the OCEAN SEVEN 316Plus Rosette interface circuitry can arise. Please be aware that the 1015 ROSETTE is a sequential only rosette type.

E.7 SBE32 CAROUSEL
The OCEAN SEVEN 316Plus CTD, can interface the SBE (SEABIRD) 32 CAROUSEL. The performances are the same described in the above sections.

E.6 MISS 6 BOTTLE MINI-ROSETTE
The OCEAN SEVEN 316Plus CTD, can interface the IDRONAUT MISS sampling system. The MISS sampling system is equipped with maximum 6 bottle and can close the bottle only sequentially.
**F.1 INTRODUCTION**
The aim of the ITERM and/or WTERM programmes is to provide a simple and reliable tool that IDRONAUT customers can freely use to communicate with their products, like the OCEAN SEVEN probes. ITERM does not need any special Windows installation procedure, while WTERM has a dedicated windows installation procedure. WTERM is provided with multilanguage support: Italian, English, Spanish, Russian, Cinese and Korean.

**F.8 PROGRAMMES DISTRIBUTED WITH THE ITERM/WTERM SOFTWARE**
The following programmes are distributed FOC:
- Interpolate.
- OS3xx Probe Memory & Battery Autonomy.
- Water Properties calculator.

*Note*
The Ocean Seven Probe Memory & Battery Autonomy calculator is described in the maintenance section.

**F.8.1 Interpolate**
This program allows calculating the “a” and “b” coefficients (slope and offset) to interpolate a set of 10 tabbed data (see picture) using: linear, logarithmic or exponential interpolation technique.

**F.8.2 Sea Water Fundamental property calculation**
This tool allows the probe to calculate the most important fundamental properties of seawater. Through a very simple interface, the operator can enter the Temperature, Conductivity and Pressure sensor values and calculate the derived parameters instantaneously. Calculation is performed using the UNESCO formulae and recommendations.
G.0 **FOREWORD**
The aim of this section is the description of operations needed to operate the OCEAN SEVEN 316Plus probes equipped with the IDRONAUT innovative not harmful antifouling device (patent pending).

G.1 **THE ANTIFOULING DEVICE**
The antifouling kit, installed by the measuring sensors of the Ocean Seven 3xx probes, is composed of a central titanium electrode which supplies an electrical current towards six external titanium electrodes on which a copper foil (replaceable) surrounding the sensors, can be wrapped. In addition to chloride formation, there is copper dissolution in an ionic form by the sensors. The copper foil has a typical endurance of more than one year. The sensors are washed when the probe starts profiling.

G.2 **HOW IT WORKS**
The fouling probably represents the major difficulty during continuous monitoring of waters and, although many efforts in research at worldwide level have been dedicated to this problem during the past decades, a definitive solution is not yet available. Therefore, a compromise must be found each time according to the specific difficulty met with.

Since our monitoring equipment (Buoy Profiler, OCEAN SEVEN 316Plus probes) operates to study the environmental conditions where fishes grow, we have not taken into consideration the antifouling system based on the slow release of Tributyltin (TBT) oxide or other heavily poisoning chemical substances. We have then decided to simply use metallic copper to act as an antifouling protection by the measuring sensors. The picture shows an OCEAN SEVEN 316Plus probe during the antifouling device development test with the antifouling device not active after a monitoring of two months.

A foil of copper (1 mm thickness) has been placed around the sensor cage in such a way that it can be easily replaced with a new one without damaging the measuring sensors and to also avoid reducing the flow of water to be measured. The presence of this simple device has, on average, increased the time between each cleaning from 1 to 2 weeks only.

This is because the metallic surface of the copper easily becomes oxidised in a few days and, after that, it loses most of its activity. In fact, copper is not able any more to dissolve in an ionic form in the water surrounding the sensors and the inside of the copper protection.

Therefore, to avoid the copper passivation, we have installed in the centre of the probe, where the measuring sensors are placed, a titanium electrode, which “impresses” an electrical current versus the copper foil. In this way the copper foil, which acts as a flow-measuring chamber, is always clean and so this allows the copper dissolution in an ionic form. This effect has drastically decreased the formation of fouling by the measuring sensors.

The current between the titanium and the copper electrodes is applied when the probe is not carrying out measurements. Vice versa, when the probe starts descending, the current is not applied any more and the water to be measured flows between the sensors and washes them of the ionic copper previously dissolved. This improvement considerably increases the “time between cleanings” up to three/four weeks, depending on the water quality.

To the best of our knowledge, this kind of antifouling system does not appear in the scientific literature and not even an industrial company has ever used it until now. Therefore, we are applying for a patent on it.
G.3 OCEAN SEVEN 316Plus POWER SUPPLY AND POWER CONSUMPTION
The OCEAN SEVEN 316Plus probe equipped with the antifouling device requires that a continuous power supply 9...18 VDC be present for the whole monitoring period. The power supply shall be present during the measurements and during the periods between consecutive measurements. The electronics driving circuit of the OCEAN SEVEN 316Plus probe antifouling device uses the power supply to generate the low AC voltage which is imposed to the antifouling electrodes. During the measuring periods, the OCEAN SEVEN 316Plus probe power consumption depends on the sensors equipping the probe.
Vice versa, during the periods between the measurements, the probe power consumption is 30mA@12V. The antifouling driving circuit to generate the low AC voltage, which is continuously applied to the antifouling device electrodes, uses this energy.

G.4 OCEAN SEVEN 316Plus PROBE OPERATIONS IN THE FIELD
Whenever the probe is performing unattended acquisitions in function of time (monitoring), the probe itself automatically manages the antifouling device. The operator must provide the energy to power the probe through the internal or external battery pack or through an external power source: 9...18 VDC.

G.5 OCEAN SEVEN 316Plus INTERFACING FROM NON IDRONAUT MONITORING EQUIPMENT
When the probe is interfaced from some monitoring equipment, in order to correctly use the antifouling device, it is necessary to:

➢ power the probe continuously;
➢ switch the probe on/off by means of the PTP communication protocol commands (see below).

G.6 PROBE SWITCHING ON
Sending a character through the probe serial interface causes the probe to wake up immediately. At the conclusion of the warm-up period (usually 30s), the probe is ready to accept commands from the monitoring equipment. In case the probe is not interrogated for more than 5 minutes, it shuts down by itself.

G.7 PROBE SWITCHING OFF
The PTP protocol “KP” command allows the monitoring equipment to switch off the probe. Alternatively, if the probe is not interrogated for more than 5 minutes, it switches off by itself.

G.8 PTP PROTOCOL
A detailed description of the OCEAN SEVEN PTP communication protocol can be freely obtained from the download area on the Idronaut web site “http://www.idronaut.it”.
H.1 INTRODUCTION
A UV-LED (Ultraviolet 250 – 300 nm @ 500 µW, Light-Emitting Diode) is integrated into the conductivity sensor quartz cell (patent pending). The UV-LED sterilizes the early growth of biofouling, thus eliminating environmental drift in the conductivity sensor.

This innovative solution does not break the European rules, which do not permit the use of Tributyltin (TBT), a very toxic and poisoning (carcinogenic) substance which has been banned by the international government agencies, mandatory to protect any recessed conductivity cell, which present a very small diameter and may get contaminated or even clogged.

The UV-LED is excited, for a configurable amount of seconds, when the CTD wakes up and during the time spent during the measurements, according to the following rules.

The UV-LED sterilization is automatically switched off at the end of the sterilization time-out if:

- the CTD is interrogated through the operating menus or the communication protocol functions;
- the CTD enters stand-by mode;
- the CTD carries out a measurement cycle in function of pressure interval, real-time acquisitions or continuous acquisitions;
- the CTD carries out an autonomous cycle: LINEAR, CONTINUOUS, CONDITIONAL.

H.2 SET-UP OF THE UV-LED ANTIFOULING STERILIZATION TIME
Through the CTD set-up, it is possible to configure the UV-LED antifouling sterilization time in seconds. This time is spent by the probe during the wake-up to sterile the conductivity sensor. The sterilization continues (as it does not affect the conductivity measurements) until the CTD switches off by itself and configures the next data acquisition time according to the above rules.

Configuration of the UV-LED sterilization time-out in seconds is done by modifying the conductivity sensor configuration:

```
OCEAN SEVEN 316Plus
Id  Name  Code  Mux  Digits
01  Press  0000  253  0002
02  Temp  0001  253  0003
03  Cond  0002  254  0003
04  Sal  0004  255  0003
CMD: Initialize, Modify, Delete, Quit
```

At the end of the list, commands available to perform the configuration are shown below:

- **Initialize:** completely deletes the list.
- **Modify:** allows the operator to enter a new sensor/parameter in the list or modify an existing one. See below for the details about configuration.
- **Delete:** allows the operator to delete a configured sensor/parameter from the list.
- **Quit:** terminates the parameter editing and ends the configuration command too. The new configuration is stored in a non-volatile memory.

The following parameters can be configured by means of the “Modify” command by selecting the CONDUCTIVITY sensor from the above list:

```
Sensor code [0..24,255=NUI]< 2
Sensor mux [0..3,255=NUI]< 1
Sensor precision [0..6]< 3
UV disinfection time [0.255]<
```
APPENDIX “I” – WIRELESS “BLUETOOTH®” MODULE

1.1 BLUETOOTH® MODULE
The IDRONAUT Wireless Module allows bidirectional full duplex communications between the OCEAN SEVEN 316Plus probes and a personal computer (Desktop, Laptop) or PDA devices equipped with a Bluetooth® device. The IDRONAUT Wireless Module is formed by a Bluetooth® OEM module mounted inside the OCEAN SEVEN 316Plus probe housing and is designed to provide an interface conforming to the Bluetooth® v1.1 class 1.

The operating range of the adapter is specified in 100m although line of sight ranges of 300m can be achieved. However, if a class-2 Bluetooth® device is used to communicate with the IDRONAUT Wireless Module, then the range will be limited to 10-20m as foreseen by class-2 devices.

The IDRONAUT Wireless Module allows instant wireless connectivity to any device supporting a compatible Bluetooth® SPP protocol. The connection with the OCEAN SEVEN 316Plus probe among the Bluetooth® devices registered on the network is guaranteed by means of the unique 8-digit PIN code which identifies each IDRONAUT OCEAN SEVEN 316Plus probe.

Features:
❖ Fully Bluetooth® Class 1 v1.1, SPP compliant.
❖ Wireless range of over 100m (330ft).
❖ Platform independent.
❖ Access security guaranteed by means of a unique 8-digit PIN code.
❖ Low power sleep mode when not in use.
❖ Integrated antenna.
❖ Power supply: powered by the probe.

IDRONAUT Windows programs like REDAS-5 and ITERM flawlessly operate the OCEAN SEVEN 316Plus through the Wireless Module as if it were connected through an RS232 cable.

1.2 HOW IT WORKS
The OCEAN SEVEN 316Plus Wireless Module is always powered (low power stand-by) and is ready to accept wireless connections once the probe is in ON condition. Communications through the OCEAN SEVEN 316Plus Bluetooth® Wireless Module can be only achieved after a valid Bluetooth session is established.

Whenever the communication session is established, the probe automatically and autonomously switches the communications from the wired interface: RS232C/RS422 or Telemetry to the Wireless Module. Afterwards, communication continues using the wireless module until the communication session drops or the OCEAN SEVEN 316Plus probe is switched off.

The only limitation is that the probe cannot be used with both interfaces (wire and wireless) at the same time.
Appendix ‘J’ – Submersible Connectors and Cable Care

J.0 Foreword
This appendix describes the proper care of submersible connectors and cables installed in the IDRONAUT OCEAN SEVEN 3xx series probes. The text refers to the XSG/RMG connector and to the standard MCBH/MCIL one (detailed characteristics of these connectors can be found on www.impulse-ent.com).

J.1 Bulkhead Connectors
Bulkhead connectors must be carefully inspected and cleaned: i) before every cruise, ii) during the cruise; iii) as part of the yearly probe maintenance procedure.
Inspect connector pins for any possible sign of corrosion. The pins must be shiny and bright. In case of any sign of corrosion on the pins, immediately check the associated dummy plug or the submersible cable end. It may be possible that the corrosion is present in the cable end too.
Check the integrity of the connector plastic body for cracks or other flaws that may compromise the seal.
Clean the bulkhead connectors by removing all grease, dirtiness and any other contamination. It is possible to use a soft tool or soft brush and alcohol.
In case of corrosion or damages to the pins or to the connector plastic body (see pictures) that may affect the connector integrity, contact IDRONAUT to get assistance.

J.2 Submersible Cables
Cable end connectors must be inspected and cleaned: i) before every cruise, ii) during the cruise; iii) as part of the yearly probe maintenance procedure. Check that the cable end does not have any problems that may compromise the seal when plugged on the bulkhead connector.
Clean cable end connectors by removing all grease, dirtiness, and any other contamination. It is possible to use a soft tool or soft brush and alcohol. Cable end connectors may be greased before installing them in the bulkhead connector (please see the dedicated section).
A slack, not well inserted or damaged cable end connector may cause the damaging of the bulkhead connector and malfunctioning of the OCEAN SEVEN 3xx probe.

J.3 Dummy Plugs
The purpose of the dummy plug is to protect the connector contacts from being in contact with water during the probe immersion. The dummy plug connector integrity is as important as the submersible cable end connector. Always clean and inspect the dummy plug integrity: i) before every cruise, ii) during the cruise; iii) as part of the yearly probe maintenance procedure.
Check that the dummy plug does not have any problems that may compromise the seal when plugged on the bulkhead connector.
Clean dummy plug by removing all grease, dirtiness, and any other contamination. It is possible to use a soft tool or soft brush and alcohol. Dummy plugs like connectors may be greased before installing them in the bulkhead connector (please see the dedicated section).
A slack, not well inserted or damaged dummy plug may cause the damaging of the bulkhead connector and malfunctioning of the OCEAN SEVEN 3xx probe. Always use the locking sleeve with dummy plug.

J.4 Locking Sleeve
The purpose of the locking sleeve is to secure the cable end or dummy plug to the bulkhead connector, thus preventing it from being accidentally disconnected. Locking sleeve does not help in any way to improve the water tightness of connection.
When installing the locking sleeve, it is important to tighten it by hand (do not use a wrench tool). Over-tightening the locking sleeve may break the threads. Furthermore, removing an over-tightened locking sleeve may results in the unthread of the bulkhead connector from the probe top cover. A slack connector will lead to a flooded probe. After immersing in seawater, always rinse the mated connection with fresh water.
J.5.1 **XSG/RMG connector type only**

**Guidelines**
- Female can trap water (suggest flush with alcohol and blow dry).
- Lubricate male mating side with 3M Silicon Spray or DOW Corning #111 valve lubricant or equivalent.
- Avoid contact with noxious solvent.
- Connector must be lubricated on a regular basis.
- Elastomers can be seriously degraded if exposed to direct sunlight or high ozone levels for extended periods of time.

**Bulkhead connector greasing**
Squeeze the silicone grease onto the end of your finger and apply a light film, even coating of grease, to the plastic body of the connector.

**Dummy plug/cable end greasing**
Squeeze the silicone grease onto the end of your finger. Apply a light film, even coating of grease, to the inside of the cable end or dummy plug.

After cleaning and inspecting and before inserting the dummy plug or the cable end onto a bulkhead connector, proceed to properly grease using 100% silicone grease (Dow DC-4 or equivalent). Do **not** use petroleum-based lubricants, as they will damage the connectors.

In alternative to grease, we suggest using a 100% silicon spray.

J.5.2 **Connector insertion**

Always align the bump on the cable end or dummy plug with the big pin on the bulkhead connector. Push the cable end or the dummy plug straight onto the bulkhead connector; do not twist the cable end or dummy plug during the insertion. Twisting can cause bent pins on the bulkhead connector.

**Air trapped**
It may be possible that some air remains trapped between the bulkhead connector plastic body and the plug-in connector. It happens more often with newer cables or dummy plugs or in cold waters (see the below dedicated session).

Therefore, after the cable or dummy plug is mated, pass your fingers along the cable end or dummy plug toward the bulkhead connector, thus making any trapped air leak out. Please be aware that failure to eject the trapped air will result in the connector leakage, with some consequent problems during deployment like OCEAN SEVEN 3xx probe malfunctions and bulkhead connector pin and cable end corosions.

**Cold Environments**
In cold environments or when retrieving the probe from cold water, the cable or dummy plug may be hard to install and remove. In such cases, wrap some cloth round the dummy plug or connector end and pour hot water on the cloth. Let it for some minutes and then try again. The warmed plastic should become flexible enough to facilitate the removing.

Whenever possible, always install the dummy plug and cable end in warm environments.

J.5.3 **MCBH/MCIL connector type only**

OCEAN SEVEN 3xx with titanium housing may use wet-pluggable MCBH/MCIL connectors instead of the standard XSG/RMG ones. These kinds of connector are easy to mate and require less force to be
removed or installed even in cold environments. Wet-pluggable connectors may be installed in wet conditions as their pins do not need to be dried before. Anyhow, they must not be mated while submerged. Like the XSG/RMG connectors, the MCBH/MCIL ones may be lubricated and require care and cleanliness as above described. Installation of cable end or dummy plug is simpler. Proceed to align the female and male connectors looking at the connector’s shape and insert them in a straight way.

Guidelines
- Lubricate mating surface with 3M Silicon Spray or equivalent, DO NOT grease!
- Connector must be lubricated on a regular basis.
- Elastomers can be seriously degraded if exposed to direct sunlight or high ozone levels for extended periods of time.
- Grip main body of connector during mating and un-mating. Do not pull on cable to disconnect.
- Avoid sharp bends at cable entry to connector.
FOREWORD

The IDRONAUT sensors are all pressure compensated and, in particular, the physical sensors (conductivity, temperature and pressure) can last several years, if properly used. They are high-quality sensors and are well known by oceanographers to measure salinity with great accuracy. Even the chemical sensors: pH, dissolved oxygen and redox, if thoroughly maintained with their respective hydrating caps and solutions, can last some years.

The aim of this application note is to make recommendations, based on our experience, on cleaning, care and storage of the IDRONAUT chemical and physical sensors installed in the OCEAN SEVEN 3xx probes. Most of the recommendations below reported are taken from the OCEAN SEVEN 3xx Operator’s Manuals.

This application note is divided into three sections:

➢ OCEAN SEVEN 3xx probes general cleaning.
➢ Sensor dedicated care and cleaning.
➢ Special cleaning for the OCEAN SEVEN 3xx probes used to carry out long-term monitoring in salt and fresh water

GENERAL CLEANING

After use, the OCEAN SEVEN 3xx probe must be always washed to remove any salt water residual or dirtiness. Deionized water, distilled water or fresh, tap water can be used. Verify that fresh water used to clean the probe is not contaminated even by any small quantity of oil. In this case, do not use this water.

In case the probe body or the sensors have any visible deposits of marine growths, we recommend cleaning the probe body with some liquid soap and a small “soft” brush to clean the sensor bulkheads between the sensors. In case the OCEAN SEVEN 3xx sensors had been exposed to oil, we suggest using the Triton X-100 (solution at 1-2 %) in place of the liquid soap.

Alternatively to the “Liquid soap” or the Triton X-100, it is possible to use a solution of 70% isopropyl alcohol or a solution of 1/4 cup of bleach in 4 litres of tap water.

In case the OCEAN SEVEN 3xx probe is used in wastewater, it may be disinfected with 5% Lysol if this is more convenient to the user.

SENSOR DEDICATED CLEANING AND CARE

Pressure sensor

The pressure sensor is an almost maintenance-free device, which meets the highest reliability standards thus reducing the chance of possible failures. The pressure transducer is located in the middle of the probe bottom flange, protected by a plastic black cap. Every five years, ask IDRONAUT to remove the pressure sensor plastic o-ring cap and brush any sediment using a soft-haired brush. Remove excess grease using a tissue or cotton bud. Take care not to damage the very thin pressure sensor diaphragm. Gently apply a thin layer of grease on the sensor surface to minimize any device corrosion. Ensure that the holes in the pressure sensor cover are not blocked with sediment.
K.2.2 Temperature Sensor
The temperature sensor is almost maintenance free; however, we suggest cleaning it once a year with sandpaper (3M, 400 grid) - which is included in the Oxygen Maintenance Kit - to remove carbonate which, if present, will greatly increase its response time.

K.2.3 Conductivity Cell.
The IDRONAUT conductivity cell has the advantage that it can be used both in clean and unclean water without fear of contamination. When the conductivity cell is not in use, it is kept dry. Should cell contamination occur, it can be easily cleaned without affecting the conductivity cell performance or requiring re-calibration. To clean the conductivity cell, use common cotton buds. The cleaning can be done using the liquid soap. At the end of cleaning, rinse very well the conductivity cell with tap, deionized or distilled water.

K.2.4 Oxygen Sensor
At the end of the OCEAN SEVEN 3xx general cleaning, remove the oxygen sensor cap, clean and wash it again if needed, then refill the cap with oxygen electrolyte. If mechanically damaged or stressed, replace the measuring membrane too, usually the green one.

K.2.5 Reference Sensor
At the end of the OCEAN SEVEN 3xx general cleaning, install the hydration cap to keep the reference sensor hydrated. Fill the hydration cap by about 1/3 with the Idronaut “Reference Sensor Storage Solution”. During insertion, the cap should be squeezed in order to limit the formation of air bubbles.

⚠️ If the sensor has been exposed to air for a long time (days) 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 thus forming an internal air bubble by the junction hole. In that case, the sensor must be replaced if pH calibration is not achievable any more (open circuit).

K.2.6 pH sensor
At the end of the OCEAN SEVEN 3xx general cleaning, install the hydration cap to keep the pH sensor hydrated. Fill the hydration cap by about 1/3 with the pH7 Buffer Solution or distilled water. During insertion, the cap should be squeezed in order to limit the formation of air bubbles.

⚠️ The glass membrane of the pH sensor should be always hydrated prior to use. If the sensor is stored dry for an extended period (more than a couple of days), the sensor performance may deteriorate.
K.3 SPECIAL CLEANING FOR OCEAN SEVEN 3xx PROBES USED TO CARRY OUT LONG-TERM MONITORING IN SALT WATER

OCEAN SEVEN 3xx probes used to carry out long-term monitoring are equipped with the IDRONAUT antifouling device (patent pending). The IDRONAUT antifouling device helps to keep the confined area surrounding the measuring sensors (see the picture) clean.

When the probe is left for long periods to carry out monitoring in warm, polluted and highly productive waters, the marine organisms may attack the probe body and sensors even if protected by the antifouling device.

Under these circumstances, we suggest a strong and special cleaning procedure to revert the OCEAN SEVEN 3xx and sensors to their original state.

Prepare a solution with 10% hydrochloric acid diluted in clean fresh water. Leave the probe immersed in the solution for 1 hour. This procedure should dissolve carbonate that may be deposited and should remove any marine growths from the probe body and sensors. Afterwards, carry out the cleaning procedure described in the above paragraph “Generic Cleaning”.

---

10% hydrochloric acid diluted in clean fresh water.
L.0 DESCRIPTION

The aim of the bottom switch is to give the alarm when the probe is approaching the ocean floor. The bottom switch is an alternative to the acoustic altimeters.

The bottom switch is activated when it is released because the weight attached with a string (rope) to the switch hits the ocean floor. The rope length sustaining the weight should not exceed 10m and the weight should not be more than 3 kg.

Through the REDAS-5 software, it is possible to associate an audible alarm to the bottom switch thus providing an early warning that the probe is approaching the ocean floor.

1) Plastic string which holds the bottom switch body to the probe body.

2) Bottom switch body.

3) Spring which keeps the bottom switch closed when the weight is released.

4) Plastic holder which keeps the bottom contact switch body in position.

5) Bottom contact switch piston. It attaches the weight using a robust rope. **The weight must not exceed 3 kg**
M.1 DESCRIPTION
The OCEAN SEVEN 316Plus Conductivity and Temperature sensor pair can be optionally pumped to guarantee a constant sample flow through the CT sensors. The pump rotation speed is factory adjusted to 1000 RPM which allows 10 ml/s flow ratio. This setting guarantees that the sample is renewed every 200ms independently of the OS316Plus probe deployment speed (profiling speed). If required, the pump rotation speed can be factory adjusted up to 2000 RPM.

M.2 MAINTENANCE
At the end of each profile, carefully wash with fresh or possibly distilled water the CT sensor pair and the pump by flushing from the pump output port through the pipe until the water leaks out of the CT sensor pair upper hole. In case the OCEAN SEVEN 316Plus is not used for long periods of time, the water remaining inside the CT sensor pair can be removed by simply reverting the probe up and down. In order to clean the conductivity quartz cell, dismount the sensor protection ring and remove the black pipe adapter (see below instructions).

M.3 INSTRUCTIONS ON HOW TO REMOVE THE CT SENSOR PUMP PIPE ADAPTER
To dismount the CT sensor pump pipe adapter, remove the four titanium nuts and washers and the plastic screw which keeps the black pipe adapter in position.

Remove the lower protection ring.

Remove the Tygon tubing from the pump side.

Remove the CT sensor pump pipe adapter.

To reassemble the CT sensor pump pipe adapter, simply reverse the above described dismounting procedure.
N.1 INTRODUCTION

Oxygen optical sensors work according to the principle of dynamic fluorescence quenching. The sensor contains fluorescent dye that is excited by light of a certain wavelength. Depending on the amount of oxygen molecules present, the luminescence response of the optical sensor varies. A polymer fiber transmits the excitation light of the sensor and at the same time also transmits the fluorescence response of the sensor to the measurement device. The oxygen sensitive dye is immobilized in a polymer matrix. This polymer can be applied to carrier material and used as sensor spots or sensor foil. It can also be coated directly onto the optical fiber. Oxygen quenching luminophores have been studied from at least 1939 when Kautsky described quenching of luminescence by oxygen. More recently, as optical sources, detectors, and data processing have become more advanced, the application of luminophores to the measurement of oxygen concentrations in liquids has resulted in bench-top instruments and optodes, with significant advances since 1990.

Recent advances in blue light-emitting diodes and low-power high-speed electronics have enabled the miniaturization of oxygen sensitive optodes to the point of field-deployable units. The sensors do not consume oxygen and are stable over long deployment periods.

The new REDFLASH technology is based on the unique oxygen-sensitive REDFLASH dyes. In contrast to common techniques using blue-light excitation, the REDFLASH dyes are excitable with orange-red light and show oxygen-dependent luminescence in the near infrared (NIR). The REDFLASH technology impresses by its high precision, high reliability, low power consumption, low cross-sensitivity, and fast response time. The orange-red light excitation significantly reduces interferences caused by autofluorescence samples. Further, the NIR detection technology significantly reduces interference with ambient light, known from the old-blue-light techniques. The new REDFLASH technology is based on the unique oxygen-sensitive REDFLASH indicator showing excellent brightness. The measuring principle is based on the quenching of the REDFLASH indicator luminescence caused by collision between oxygen molecules and the REDFLASH indicator immobilized on the sensor tip or surface. The REDFLASH indicators are excitable with the red light (More precisely orange-red at a wavelength of 610-630nm) and show an oxygen-dependent luminescence in the near infrared (NIR 760-790 nm).

Principle: Red light exited the REDFLASH indicators show luminescence in the near infrared, which decreases with the increasing of oxygen (quenching effect). A) High NIR emission at low oxygen and B) low NIR at high oxygen. The measuring principle is based on a sinusoidally modulated red excitation light. This results in a phase-shifted sinusoidally modulated emission in the NIR. The measurement device measures this phase shift (termed dphi in the software) The phase shift is then converted into oxygen units based on the Stem-Vollmer-Theory. The red light excitation significantly reduces interferences caused by auto-fluorescence and reduces stress in the biological systems. The REDFLASH indicators show much higher luminescence brightness than other optical sensor working with blue light excitation. Further due to the excellent luminescence brightness of the REDFLASH indicator, the actual sensor matrix can be now prepared much thinner, leading to fast response times of the oxygen sensors.

N.2 BLUE CAP DESCRIPTION

The external part of the Blue Cap Oxygen Optical Sensor is a titanium support with a 11,7mm diameter, where at its centre is placed a 3mm fiber optics well sealed to guarantee 700 bar operation. The length of the support is about 44mm (without the Blue replaceable membrane cap installed); two 2-12 Parker O-rings seal the support onto the probe housing. The measuring membrane cap is simply fitted inside the titanium support till it stops and is provided with a friction system (groovers) to prevent unwanted removal or accidental loss. The membrane cap is made of blue plastic to better shield the external light and is very similar to the Idronaut pH watering cap. The only
APPENDIX “N” – BLUE CAP DISSOLVED OXYGEN SENSOR

difference is that a hole at its bottom allows the factory installation of the glass window on its inside. The black sensor spot which allows the oxygen measurement is centrally placed on the outside of the glass window. He other side of the optical fiber remains inside the CTD housing and is fitted in a unique miniaturized transducer whose optics and electronics transform the optical signal into RS485 output.

N.3 SPECIFICATIONS

Measuring range: 0-250% O₂ (0-45 mg/l)
Detection limit: 0.02% O₂ (0.01 mg/l)
Resolution: 0.01% O₂ (0.005 mg/l) at 1% O₂
Initial Accuracy: +0.02% O₂ (0.01 mg/l) at 1% O₂
+0.2% O₂ (0.1 mg/l) at 100% O₂
Temperature range: 0 to 50°C
Response time (t90) gas/water: sensor spot down to 5 s
No cross-sensitivity: pH 1-14, CH4, CO2, H2S, any ionic species
Cleaning procedures: 3 % H2O2, ethanol, soap solution
Storage time: >3 years in darkness at room temperature. A black cap is provided to dark the blue cap membrane installed on the CTD. Please remove it before deploying the CTD in water and before carrying out the calibration.

Calibration: single point
Optical Isolation: the sensor spots are covered with a final black layer in order to minimize influence of strong external illumination

N.4 CONFIGURATION

Through the CTD configuration menu and the external sensor setup (CNES, command from the CONFIGURATION MENU) it is possible to configure the optical dissolved oxygen sensor as below described. The CTD propose by itself the correct parameters, they must be only confirmed using the enter key.

Auxiliary #3 Select:(0)None, (1)miniSVS, (2)AA-Optode, (3)NK-Aquadopp, (4)Rsv, (5)IDRO-DO2
Aux.#3 System:5
CTD Com:(2)COM2, (3)COM3, (4)COM4, (5)COM5
Com:4
CTD Speed (BPS):(0)300, (1)2k4, (2)4k8, (3)7k2(4)9k6, (5)19k2, (6)38k4, (7)57k6, (8)115k2
Baud Rate:5
Data Bit:(0)7 bit, (1)8 bit
Data bit:1
Parity:(0)None, (1)Even, (2)Odd
Parity type:0
Stop Bit:(0)1 bit, (1)2 bit
Stop bit:0
Flow Control:(0)None, (1)XON/XOFF, (2)CTS/RTS, (3)DelayTx
Flow cnt:0
Wait communication timeout (ms):1000

At the end of the configuration of external sensors the configuration procedure is completed. To make the new configuration effective, it is mandatory to exit from configuration confirming it and afterward switching off and then on the OCEAN SEVEN 316Plus.

N.5 SENSOR CALIBRATION

Calibration is carried out by using the CNES command available under the CALIBRATION MENU. Two calibration must be carried out: Saturation and ppm.

When the list of sensors appear on the ITERM window select in sequence first the Saturation Optical dissolved oxygen sensor OPT_O2% and then the PPM optical dissolved oxygen sensor OPT_O2.
N.6 O2% SATURATION CALIBRATION

Once selected the OPT_O2% sensor from the list the below message appear on the ITERM window:

OPT_O2% sensor calibration
Gently wipe O2 membrane and Temperature sensor
Type <any key> To continue, <ESC> To leave

Using a soft paper gently wipe and well dry the O2 membrane and the temperature sensor as suggested.

Enter Altitude above sea level [m]: 0

If the altitude is 0 (sea level) no correction is required, leave the shown value (0); Otherwise enter the altitude. The CTD calculates by themselves the relative atmospheric pressure. Afterward the calibration procedure is carried out automatically. The below message appear:

Optical oxygen calibration in progress

At the end of the calibration procedure the below diagnostic messages appear.

Calibration completed:
Phase shift 0%=53000, 100%=20550
Signal Intensity : 358.162000
Ambient light intensity : 49.550000

Signal intensity should be, for optimal sensor operation between 300 and 500. Anyhow the sensor operates even if the value is outside the indicated range. The ambient light intensity is indicated for diagnostic purposes only. Afterward the correction coefficient can be introduced

Oxygen correction coefficient
Correction coefficient: 1

NOTE REGARDING THE CORRECTION COEFFICIENT

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

• To expand the scale of the oxygen sensor readings. For example, on entering a correction coefficient of 10, the readout will be multiplied by a factor of 10.
• In case of moored applications, where the CTD remains steady measuring for long periods, a coefficient different from 1 can be entered to compensate for the stirring effect on the surface membrane.

At the end of the calibration procedure the below message appear and the calibration is concluded.

Update calibration parameters Logged[5-2-0]
Configuration updating Ok
[001][OPT_O2%] calibration values updated.

N.7 O2 PPM CALIBRATION
Once selected the OPT_O2 sensor from the list the below message appear on the ITERM window:

```
OPT_O2 sensor calibration
OPTICAL OXYGEN - Calibration
Scale factor from uMol/l to ppm:0.032
```

The optical dissolved oxygen sensor measuring unit calculates the dissolved oxygen concentration in µmol/L and in % of saturation. The concentration value can be shown using different scale. Thus the scale factor can be customized to show concentration value in mg/L or mL/L by enter the coefficient:

- **Dissolved O2 concentration mg/L = ppm** Scale factor: $[\text{mg/L}] = [\mu\text{mol/L}] \times 0.032$
- **Dissolved O2 concentration mL/L = ppm** Scale factor: $[\text{mL/L}] = [\mu\text{mol/L}] \times 0.02241$

At the end of the calibration procedure the below message appear and the calibration is concluded.

```
Update calibration parameters
[002][OPT_O2] calibration values updated
Configuration updating.Done
```