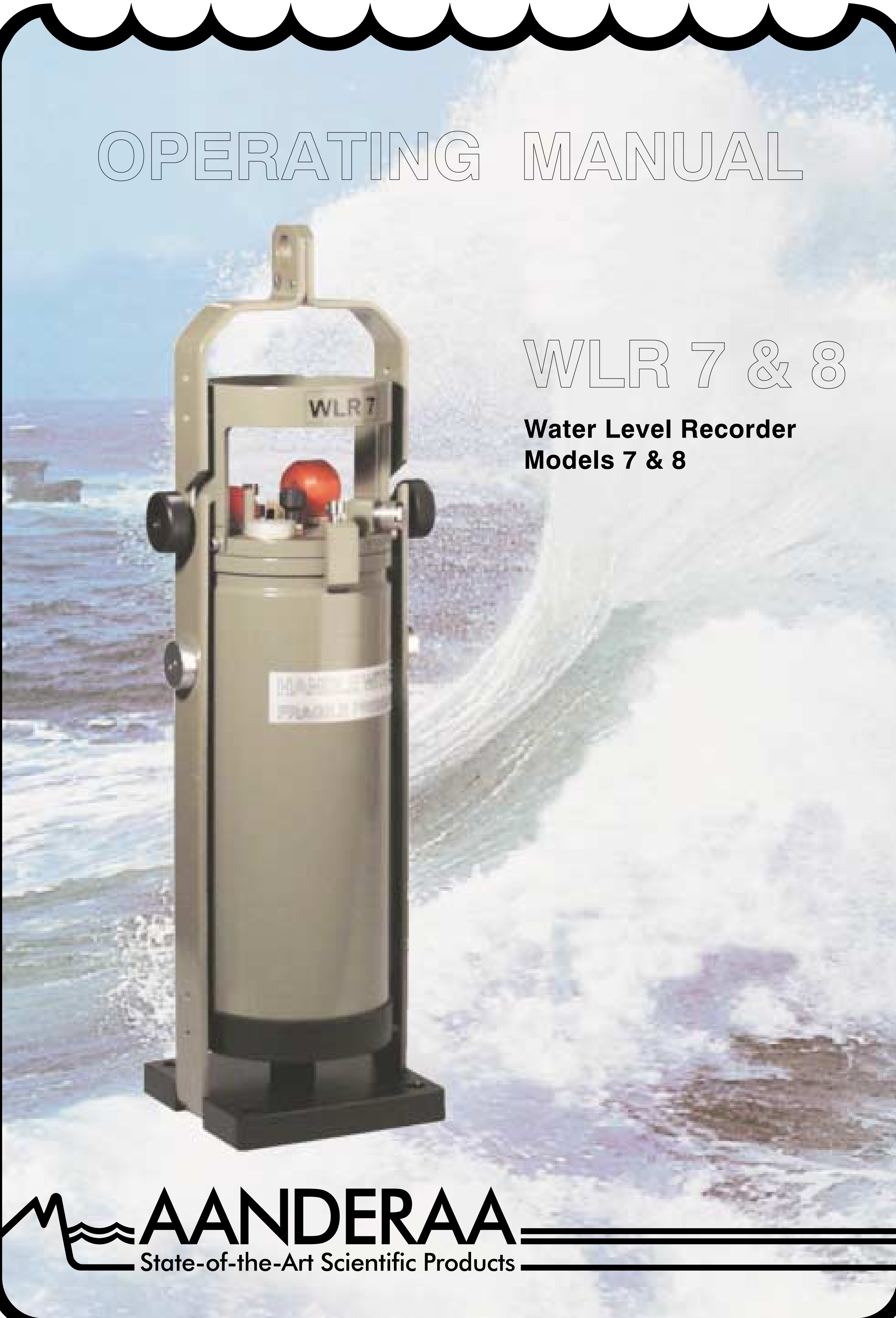
Technical Description No 175
February 2002

OPERATING MANUAL



WLR 7 & 8

Water Level Recorder
Models 7 & 8

AANDERAA
State-of-the-Art Scientific Products

CONTENTS: Page

CONTENTS: Page

PO BOX 160, NESTTUN
5852 BERGEN. NORWAY
FANAVEIEN 13B
5221 NESTTUN. NORWAY
TEL. +47 55 109900
FAX. +47 55 109910
E-MAIL: info@aanderaa.no
WEB: http://www.aanderaa.com

LIST OF FIGURES.

Figure No. Page No

INTRODUCTION

The Water Level Recorder WLR 7 and WLR 8, are high precision recording instruments for determining water level in the open sea. The water level is determined by measuring the hydrostatic pressure with an ultra precise quartz pressure sensor. Knowing the density of water and atmospheric pressure, the water level can then be found. The operation depth is limited by the range of the pressure transducer.

This manual describes the WLR`s as they are made at the time of writing, July 1997. The information given is valid for WLR, serial no. 1545, and subsequent units.

Chapter 7 describes the specification and parts specific to the WLR 8 model but chapters 1 through 6 are also valid for this version. The WLR 8 has the same features as the WLR 7 model, except for the physical dimensions of the top and bottom end plates, the pressure case and a special WLR 8 version of the electronic board. The mechanical parts are strengthened to withstand the pressure down to 6000m depth.

CHAPTER ONE

SHORT DESCRIPTION OF INSTRUMENT

The Water Level Recorder is specially designed to measure ocean water levels. Placed on seabeds, the instrument records pressure, temperature and conducti-vity at regular intervals. The data is stored in a removable and reusable solid-state Data Storage Unit (DSU) 2990. Five channels of 10 bits each are recorded in sequence. The channels are:

1. Reference
2. Temperature
3. Pressure, most significant part
4. Pressure, least significant part
5. Conductivity (optional)

The reference is a fixed reading that serves to indicate correct performance of the instrument and to identify data series from individual instruments.

The temperature is measured by a thermistor fitted into a stud extending into the water. The pressure sensor is based on a pressure controlled quartz crys-tal oscillator. The measurement is a 20-bit word, but is divided into two 10-bit words recorded in 2 successive channels. The real pressure value is easily reconstructed from the 2 words as described in chapter 5. Conductivity is measured by an electrodeless induction-type sensor. When the conductivity sensor is not installed the instrument will record a fixed value in channel 5.

Simultaneously with the recording of data, an acoustic transducer is keyed on and off according to the instrument´s PDC-4 output code. This feature permits monitoring of submerged instruments by use of a hydrophone receiver at the surface.

Figure 6.01 shows the WLR 7. The instrument is housed in a pressure case that is closed by two C-clamps. All external and internal parts are fastened to the top end plate so that the whole instrument can be removed from the pressure case as one unit. In addition to carrying the combined handle and protection ring, the acoustic transducer and the sensor inlet, the top end plate is furnished with a watertight receptacle. This terminal permits remote triggering and real-time reading of data by connecting cable. A digital display unit, e.g. Deck Unit 3127 will, when connected to this terminal, display raw data as they occur. This feature is useful for checking and calibrating the instrument as it permits triggering of the instrument and immediate display of the data. By use of the Deck Unit 3127, the output signals can be read by a PC via the same terminal and converted into engineering units.

Figure 6.02 shows the interior of the instrument seen from the Electronic Board side. The electronics are encapsulated in a board of low density polyurethane.

The switch for setting the triggering interval is built into this board. The quartz pressure sensor is also attached to the board by a shock absorbing bracket. The main switch is located near the battery. When the switch is turned on, the clock is reset. To start the instrument manually turn the interval selection to position 0 (MS) and then press the push-button located just above the main switch, see figure 6.04.

Figure 6.03 shows the instrument from the Data Storage Unit 2990 (DSU) side. The DSU is attached by means of its electrical connector at the top end and two snap-on locks at the lower.

To ease installation and mooring of the WLR 7, Mooring Frame 3130 is optionally available, see figure 6.04. The instrument is fastened to the frame by two locking bolts. This featuring allows for in-situ retrieval of the instrument by a diver.

When shipped, the instrument is packed in a durable plywood instrument case.
See overleaf for the instruments specifications.

The specifications of the Water Level Recorders, are as follows:

SPECIFICATIONS FOR WLR 7 and WLR 8

Measuring system:
A digital system based on counting pulses from a sensor with frequency output. Five channels are measured in sequence and a ten-bit binary word is produced for each channel.
The channels are:

Ch.1. Reference. A fixed reading obtained by hard wiring a shift register inside the electronic board to check the WLR's performance and to identify individual instruments

Ch.2. Temperature.

Sensor type:	The sensor is based on a thermistor controlled oscillator with frequency 2.048–4.096 kHz
Thermistor:	Fenwall GB32JM19
Range:	–3 to +35°C
Resolution:	0.04°C
Accuracy:	±0.1°C
Response time:	30 seconds

Ch.3. and 4. Pressure (10 + 10 bits)

Sensor type:	The sensor is based on a pressure controlled oscillator with frequency 36–40 kHz
Ranges WLR 7:	0 – 700 kPa (60 m) (standard) 0 – 3500 kPa (340 m) (standard)
Ranges WLR 8:	0 – 14MPa (1370 m) (standard) Other ranges on request
Resolution:	0.001% of range
Repeatability:	±0.01% of full scale
Calibration Accuracy:	0.02% of full scale
Integration Time:	40 seconds

The pressure inlet port is 341 mm above the bottom of the instrument for the WLR 7 and 360 mm for the WLR 8
The instrument is calibrated in upright position.

Ch.5. Conductivity (optional)

Sensor Type:	Conductivity Cell 3094 for WLR 7 Conductivity Cell 4094 for WLR 8
Ranges:	0 – 77 mmho/cm (standard) 0 – 42 mmho/cm (on request)
Resolution:	0.1% of range
Accuracy:	±0.25 mmho/cm

Sampling Intervals

Selectable:	MS(ManualStart),1, 2, 5, 10, 15,20, 30, 60 or 120 min.
Accuracy:	Better than ±2 s/day within 0 to 20°C
External Triggering:	A 6 volt pulse to the signal output terminal activates the instrument

Recording System Aanderaa standard type
Data Storage Unit 2990 or 2990E

Data Format:	PDC-4. (Pulse Duration Code 4 s.)
Storage Capacity:	
DSU 2990:	65500 10 bit words
DSU 2990E:	262000 10 bit words

Telemetry Acoustic Transducer

Acoustically:	Acoustic carrier keyed on and off
Frequency:	16.384 KHz ±5 Hz
Detection Range:	Up to 800 m with Hydrophone 3079

Note!
On the WLR 8 the Acoustic Transducer is optional.

Battery
High cap.Bat.3382: 7.2V, 14 Ah, sufficient for 343 days recording of all five channels at 10 minute intervals

Materials and Finish Nickel plated bronze and stainless acid proof steel. Durable epoxy coating

Weight (kg)

	WLR 7		WLR 8	
	Net	Gross	Net	Gross
in air:	13.7	19.1	15.2	20.5
in water:	9.2		10.9	

Dimensions (mm)

WLR 7:	432 x OD128
WLR 8:	450 x OD128

Accessories (included)

WLR 7:	Mooring Frame 3130
WLR 8:	Mooring Frame 3371 Weight: In air 3.2 kg, in water 2.7kg Pyramidical Mooring Frame 3438W for WRL 7 (optional)

Packing
Plywood case: 190 x 250 x 600 mm

Spares A set of recommended spares and accessories is included with the instrument

Warranty Two years against faulty materials and workmanship

CONVERSION FORMULA:

General formula for converting raw data into engineering units: $A+BN+CN^2+DN^3$. (A, B, C and D are the calibration coefficients).

Pressure: The depth of water may be calculated from: Depth (m) = $0.001 \cdot (P-AP) \cdot (1/d) \cdot (1/g)$ where P is the total pressure and AP is the atmospheric pressure both in Pascal. d is the density of water and g the earth's gravity in m/s^2 at the actual site of measurement. The N is derived from the readings in channels 3 and 4 (N_3 and N_4):
$N = N_3 \cdot 1024 + N_4$.

7971709	**Accessories and Recommende Spares for WLR 7/8**
1642100	Hex bolt M5 x 12, din 912 a4
1652007	Ø10,5mm washer, din 125a a4
1653002	10mm nippel nut brass 347 [2]
1861002	O-ring, sor 120 [7.1 x 1.6] [4]
1863001	O-ring, sor 9 [17.6 x 2.4mm] [2]
1865000	O-ring. sor 72 (I 14,5x3,0mm]
1913002	Allan key, nv 4mm l=71 mm
1913003	Wrench for c-clamp, dor 4/sd-5”
1963011	10mm sealing plug. WLR
1963026	Zinc anode Ø32mm
1963041	16mm sealing plug
1964064	Wrench for C-cell
7972577	Tectyl 506.
7972579	Repair lacquer, Jotun green.
1141021	Jiffy envelope, type D, self-sealing

0973814	**Maintenance Kit for WLR 7/8**
1642100	Hex bolt M5 x 12, din 912 a4 [3]
1963026	Zinc anode Ø32mm [3]
1642103	Hex bolt M5 x 16, din 912 a4 [2]
1963024	Zinc anode [half] for spindel [2]
1660003	Cotter pin Ø5 x 32mm, din 94 [4]
3963384	Pressure inlet
1863003	O-ring, sor 13 [26.5 x 3.0]
1865000	O-ring, sor 72 [114.5 x 3.0mm]
1865001	O-ring, sor 71 [109.5 x 3.0mm]
1260087	Kluber, syntheso gl ep 1. [0.04]
1988014	Plastic bag 80 x l20mm, minigrip

CHAPTER TWO

DESCRIPTION OF SYSTEM AND COMPONENTS

The recording unit is protected by a pressure case from which it can be removed as a whole. Both the recording unit and the combined handle and protection ring are fastened to the top end plate. The recording unit comprises sensor reading, storage of data in the Data Storage Unit, DSU 2990, and transmission of data via the acoustic transducer.

Electronics.

The Electronic Board 3047 generates the operating voltages for the sensors, reads and converts the sensor readings to Aanderaa 10-bit PDC-4 coded signals and directs the readings to the DSU, acoustic transducer and the Watertight Receptacle 2924G. Figure 2.01 shows a block diagram of the Electronic Board 3047. The corresponding circuit diagram is shown in figure 6.16.

Power is admitted to the sensors from the voltage regulators. The micro-processor controls the timing for powering the various sensors. The measuring cycle starts with the reference reading which is a fixed reading obtained from hard-wiring a shift register inside the electronic board. It checks the WLR’s performance and identifies individual instruments and the recorded data. (The reference reading is a digitally set 10-bit word). The next sensor to be activated is the temperature sensor, an RC controlled oscillator where the R-component is a thermistor. The temperature is measured in the same way as pressure, the measuring period being 0.5 seconds. The result of this measurement is a 10-bit word.

The hydrostatic pressure is measured by a quartz crystal that utilize a pressure-dependent frequency. It is powered and measures continuously for 40 seconds. This integration time is introduced to average out the effect of surface waves. While powered, the output pulses from the pressure sensor are counted. After 40 seconds, the resulting two 10-bit words are fed into a latch before being admitted to the microprocessor. The last sensor in the measuring cycle is the conductivity sensor. This sen-sor is analog and of the inductive type. The analog output is approximated in 10 steps to a digital reading, by the AD converter.

The quartz clock triggers the instrument at preset time intervals. Ten se-lectable intervals can be chosen from, and are set by a rotary switch embed-ded in the board.
The microprocessor controls the timing of activity in the various components. After one measuring cycle, it converts information to a serial output which has the timing of the common output code, PDC-4. This signal is then sent to the output electronics, essentially a buffered voltage level converter, where it is further directed to the PDC-4 output receptacle and to the acoustic transducer.

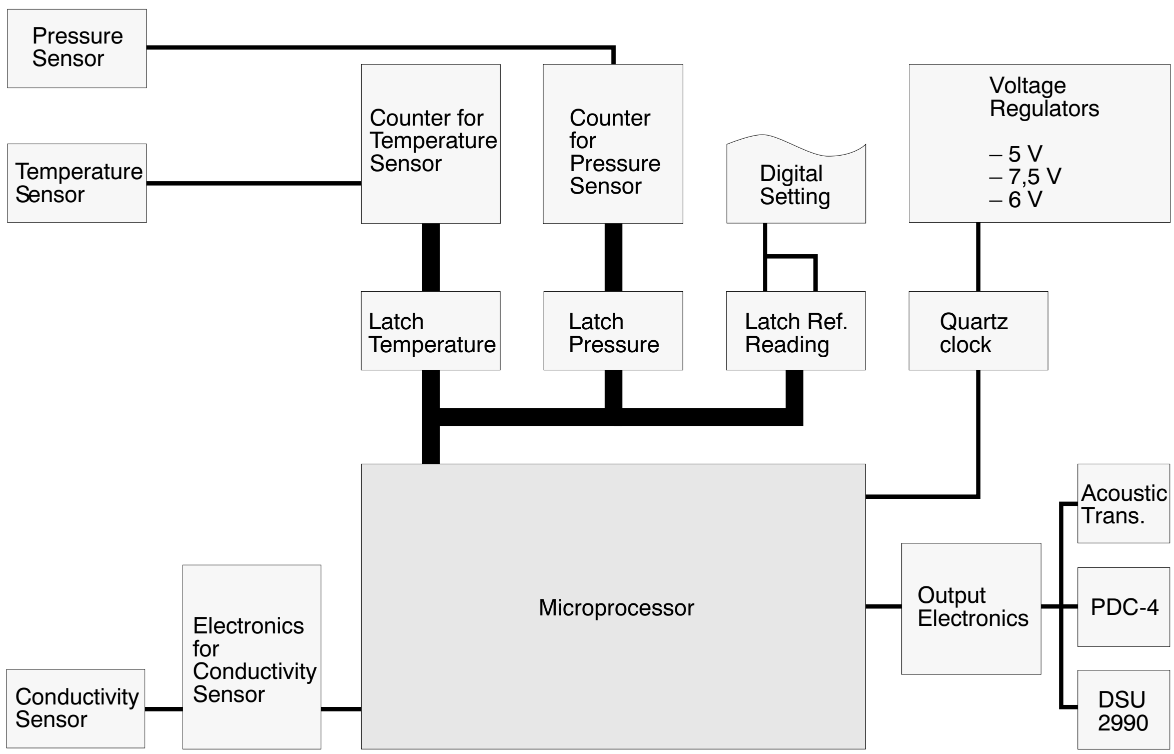


FIG. 2.01 Block Diagram for WLR 7.

Output signals.

The output signals are in the PDC-4 code, consisting of a 10-bit word for each reading. Binary 1 is a short pulse and binary 0 is a long pulse. A set of 5 words makes a record. "End of record" is indicated by a synch pulse. The timing of a record and the PDC-4 coded pulses are given overleaf.

The output pulses shown in the figures are fed simultaneously to the watertight output receptacle on the top end plate, to the acoustic transducer and to the DSU where all data is stored.

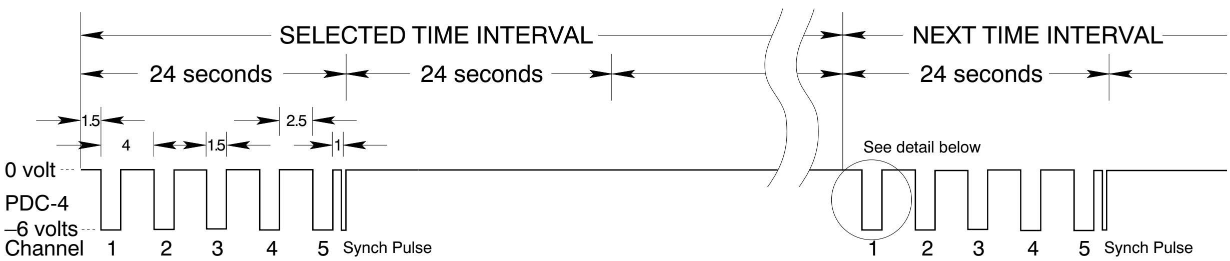


FIG. 2.02 Timing Diagram of one Record – Signal at Terminal 31.

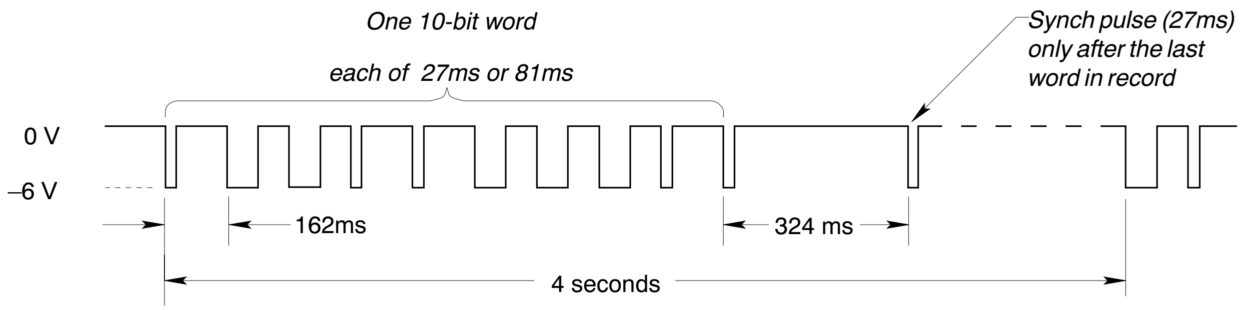


FIG. 2.03 One 10-bit word (Binary 1001100011 shown), PDC-4 Coded Output Pulses

Pressure case.

The pressure case consists of an OSNISIL copper alloy tube (95% Cu, 3.5% Ni, 0.9% Si) with end plate. The end plate, made of non-magnetic acid proof stainless steel (57% Fe, 17.5% Cr, 12.5% Ni, 2.7% Mo and max 0.06% C), is furnished with an O-ring and press fitted to the pressure tube. The lower outside end of the pressure case is equipped with a rubber base. The top end of the pressure case has a circular groove for the C-clamps.

All external metal parts of the instrument are coated with olive green epoxy coating applied by an electrostatic powder process. This coating stands up well to sea-water and protects the covered parts from corrosion. O-ring seatings are not coated but nickel-plated. The corrosion of these surfaces is inhibited by the sacrificial zinc anode fitted to the top end plate.

Top end plate.

The top end plate is made of the same acid proof steel alloy as the bottom end plate. All external and internal parts of the instrument are fastened to the top end plate so that the instrument can be removed from the pressure case as one unit. The seal between the top end plate and the pressure tube is maintained by an O-ring.

All top end plates are furnished with holes for the full set of sensors. If conductivity sensor is not fitted, its hole is sealed by Sealing Plug 2176. The Watertight Receptacle 2924G on the top end plate mates with plug 2828L.

Mooring frame.

A mooring frame, part no. 3130, is available to ease installation of the WLR on the seabed, see figure 6.04. The instrument is attached to the frame by two studs on the handle and a stand off that fits into a recess in the bottom of the instrument. The frame must be fastened to a disk shaped mooring weight of concrete by 4 stainless steel bolts (1/2").

Data Storage Unit.

The Data Storage Unit (DSU), figure 6.07 is a solid board molded in low den-sity polyurethane. It contains a set of EEPROMs for indefinite storage of data. On the top edge there is a 6-pin re-ceptacle for input/output of data. A 5-digit LCD on the front indicates the number of words stored. When reading the data, this number is counted down, and the display shows the remaining unread words.

The DSU is furnished with a built-in, presetable real-time clock to record time information. Wit-hin a temperature range of -10 to +45°C the accuracy of the clock is ±2 seconds a day. A time record consists of six 10-bit words. The first word, is the time and date, labelled binary 7, followed by 5 words indicating year, month, day, hour and minute. Time information is recorded for the first measurement after the main switch is turned on and subsequently for the first me-asurements after midnight. The clock features automatic leap year compensation.

Storage capacity is 65000 10-bit words. When the unit is full, the input port is blocked. A special version, 2990F will continue to receive new data after it is full thus deleting the oldest data. A version with an expanded capacity, 2990E, has a storage capacity of 262.000 10-bit words.

The DSU is normally powered by the instrument’s main battery. When the DSU is removed from the instrument a built-in lithium battery provides power for the display and the clock. The power consumption is very low which gives a shelf life for the battery in the DSU of at least 7 years. For reading of stored data, refer to chapter 3.

Temperature sensor.

The temperature sensor is shown in figure 6.08. The sensing element is a Fenwall GB32JM19 thermistor. The thermistor is the resistance in an RC oscillator that depends on the resistance value of the thermistor. It is molded into a stainless steel stud with polyurethane. The stud is fitted on the top end plate and extends into the water. The time constant for the sensor to reach 63% of a step change in temperature (response time) is about 12 seconds.

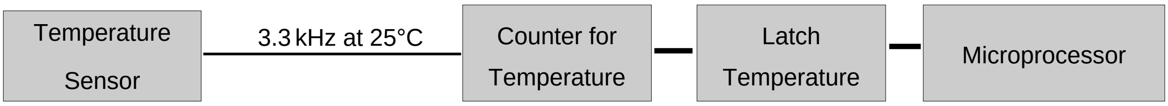


FIG. 2.04 Block Diagram for Temperature Sensor

Pressure Sensor.

The pressure sensor in the WLR is the Paroscientific Digiquartz Pressure Transducer. The pressure sensor's design is shown in figure 6.11. It is based on an oscillating quartz crystal that shifts frequency with the force applied to it. The frequency range is from 40 kHz at zero pressure to 36 kHz at full pressure. The sensor is built into a shock absorbing housing and attached to the Electronic Board as shown in figure 6.13. The pressure port and the connecting tube leading into the sensor are evacuated and filled with a dense silicone oil. The pressure inlet port is, for WLR7 341 mm and for WLR8 360mm above the bottom of the instrument. Several ranges are available. See page 1-03 for specifications. Care must be taken not to override the sensor's range, as this will permanently damaged it. A sensor calibrated at the factory can be fitted to any instrument. The sensor's calibration is not affected by the instrument it is placed in.

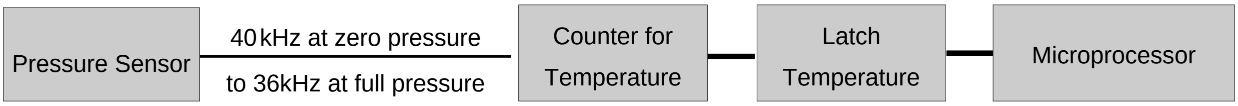


FIG. 2.05 Block Diagram for Pressure Sensor

Conductivity cell.

The conductivity cell, see figure 6.09, is an electrodeless induction type sensor made of 2 tape wound toroids encapsulated in polyurethane moulding.

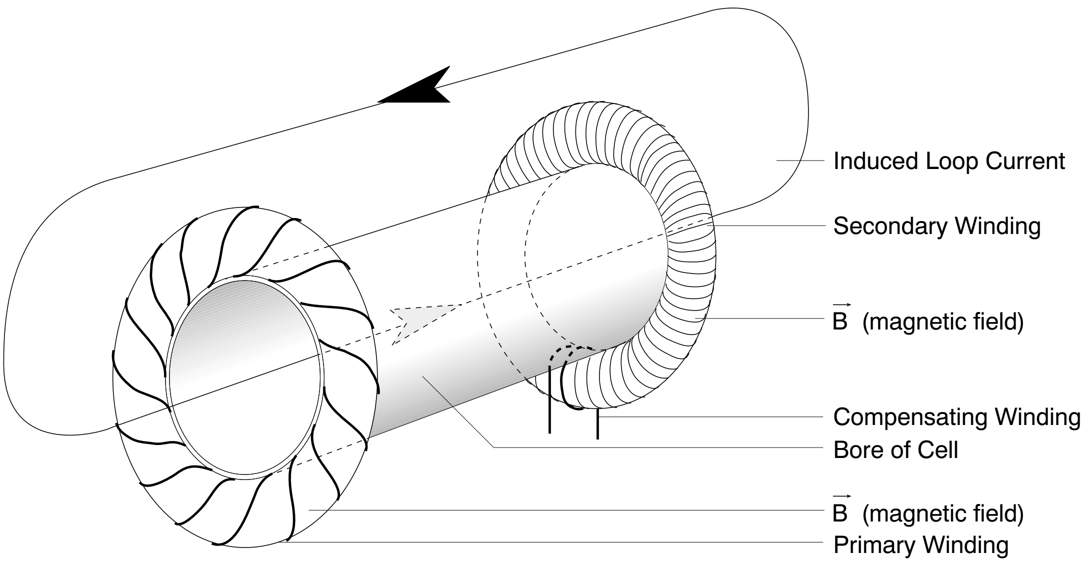


FIG. 2.06 Working Principle of Conductivity Cell

The toroids are made of Magnetic Metals, P/N 380u 9602, and equipped with copper windings. An amplifier is built into the stem of the sensor. In order to ob-tain a stable volume of the sea-water loop, a glass tube is installed in the bore of the cell.

When calibrating this sensor, be aware that small scars in the epoxy coating may influence the readings. A repair lacquer is available from the factory, part no. 2579. When the cell is not inserted, Sealing Plug 2176 is installed instead. Note that the cell should be installed with Type No./Serial No. facing outwards.

The working principle is outlined in figure 2.06. The current in the primary windings induces a conductivity dependent current loop in the water. The loop current passes through the bore of the cell where it induces a voltage in the secondary winding. The measuring system balances this current so that the voltage in the secondary equals zero. The current required in the compensating winding is a measure of the conductivity of the water. The measuring range of the cell is determined by the resistor WR5.
WR5 = 220 ohms gives the range 0 - 74 mmho/cm (standard). WR5 = 1200 ohms gives the range 0 - 41 mmho/cm (optional). See figure 2.07 and 6.14.

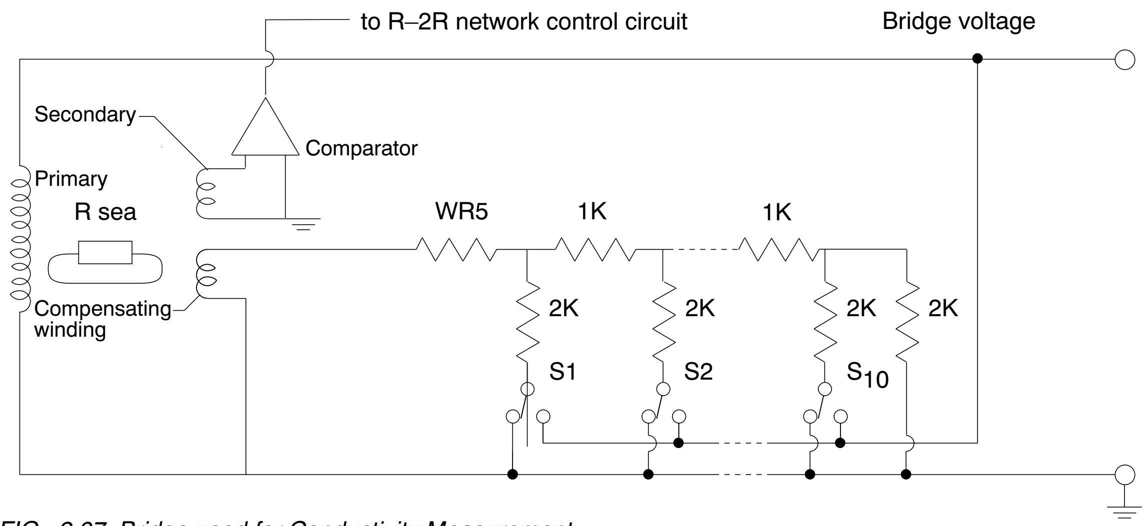


FIG. 2.07 Bridge used for Conductivity Measurement

Acoustic transducer (only for the WLR 7 model).

The design of the transducer is seen in figure 6.10. It is based upon a Channel Industries piezoelectric sphere ceramic part no. 390065, protected from the sea-water by a polyurethane molding.

A small tuneable transformer is placed in the base of the transducer. The inductance of the secondary coil of this transducer will, together with the capacitance of the ceramic, form a resonating circuit resonating at 16384 Hz. Small individual variations of the capacitance of the ceramic is compensated for by adjusting the trimmer of the transformer which is accessible through the stem of the transducer. The transducer is aged at the factory and retrimming is seldom necessary. The capacitance temperature coefficient of the ceramic is sufficiently low as to allow the transducer to operate efficiently within the temperature range of 0 - 30°C.

FIG. 2.08 Acoustic Transducer 3468

CHAPTER THREE

OPERATING INSTRUCTIONS

Receiving a new instrument and taking it into use.

The instrument is shipped in one case, see figure 6.06. It is fully assembled before shipment. The recording unit is equipped with batteries when shipped and the clock in the Data Storage Unit (DSU) 2990 is set to GMT. The only preparation needed is to check that the time interval is as desired and to switch on the main switch. Before doing this, it is recommended that the unit is checked for possible shipping damage. This check is best performed by following procedure given in the check-out list, Form No. 335.

When the check-out procedure is completed, the instrument is prepared for deployment as follows:

1) Remove the 2 C-clamps at the top end plate and lift the unit out of the pressure case.
2) Set the time interval switch to the desired interval.After the first records the LCD on the DSU will show 00011 (6 words for time information and 5 words for sensor channels). The clock on the DSU is set to GMT at the factory.
   Note!
   When the main switch is set to "ON" the pressure is integrated for 40 seconds to filter out waves before a measurement cycle is recorded. The DSU will first record time information and then the five channels.
3) Set the main Switch to "ON" and fill in the label on the DSU. Wait for one sampling interval and then control that the DSU display increases with 5 new words.
4) Put the instrument back into the pressure case and tighten the C-clamps until the top end plate rests against the edge of the pressure case. Note! Overtightening will cause damage to the C-clamps and O-ring.

Note! Ensure that a protective cap is fitted to the watertight receptacle.

The instrument is now ready for deployment.

Mooring and deployment.

The different uses of this instrument call for variety of mooring arrange-ments. Details of mooring will not be given here, three examples are shown below, see figure 3.01. Please be aware that the distance from the bottom of the instrument to the pressure inlet port is 355 mm. **Drawing A** shows deployment of the WLR mounted in Mooring Frame 3130 and an acoustic release device which makes instrument retrieval possible from all depths. The device will respond to an acoustic signal from the surface. The installation is lowered onto the seabed by means of a

winch with a self-releasing hook. This system is recommended for areas with heavy sea traffic.
Drawing B shows the WLR placed on the seabed. A diver can retrieve the WLR by loosening two fastening knobs on the mooring frame. This allows repeated measurements from the same location since the frame remains in place and only the WLR is brought to the surface for data retrieval.
Drawing C shows an arrangement used in shallow waters that permits real-time telemetry of data brought ashore by a cable. The same cable can also power the WLR from batteries or mains from land. Data can be transmitted further via VHF/UHF radio, satellite or telephone communication.

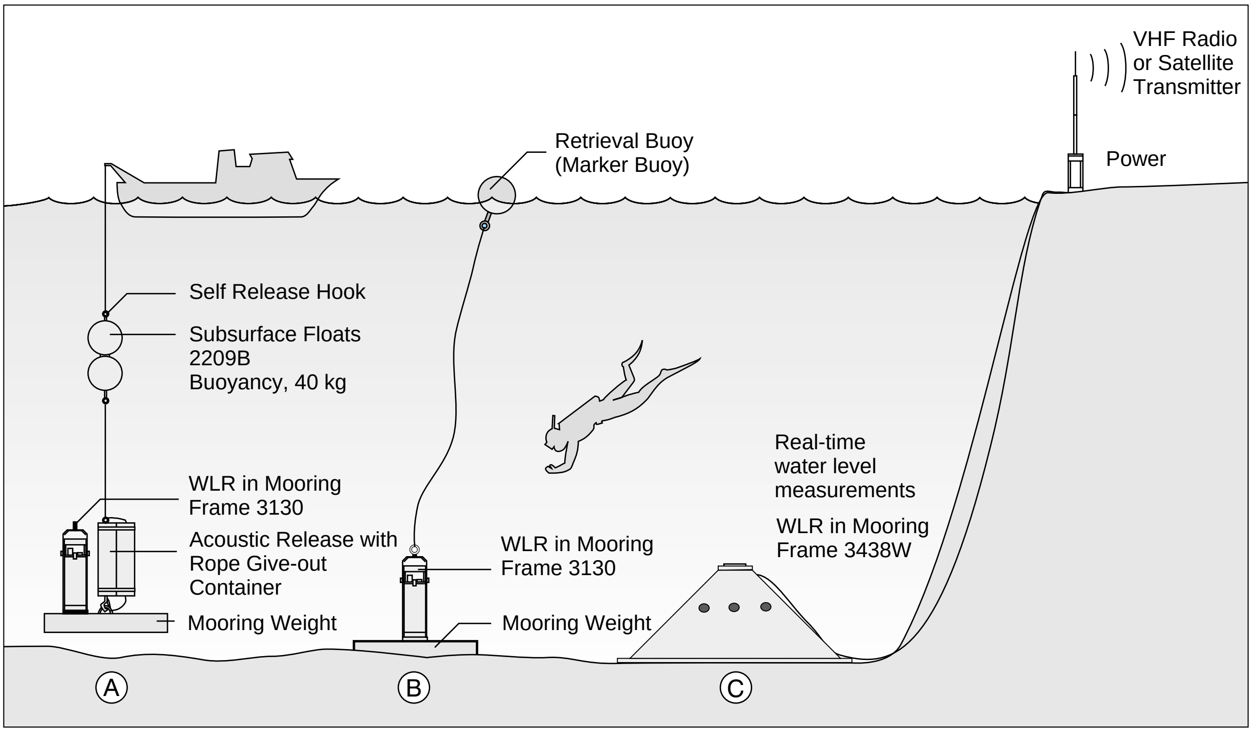


FIG.3.01 Typical moorings for WLR7.

Retrieval of instrument and removing DSU.

When an instrument is retrieved after a period of recording, it should first be rinsed in fresh water and dried. The unit should then be opened. If it appears to have functioned normally (amount of words stored in the DSU is as expected) follow this procedure (read the whole procedure before stopping the instrument):

1) Wait until the clock triggers the instrument,observe the DSU display and.write the time of the record on the lower DSU label.
2) When the instrument has finished the recording cycle turn the main switch off.
3) Remove the DSU from the recording unit by releasing the 2 snap-on locks at the lower end of the instrument. Pull out and then press the DSU down to release it from the connector.

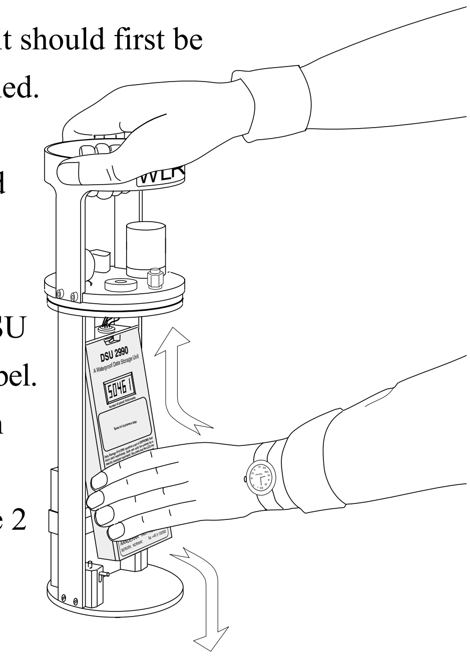


FIG. 3.02 Installation/removal of DSU 2990

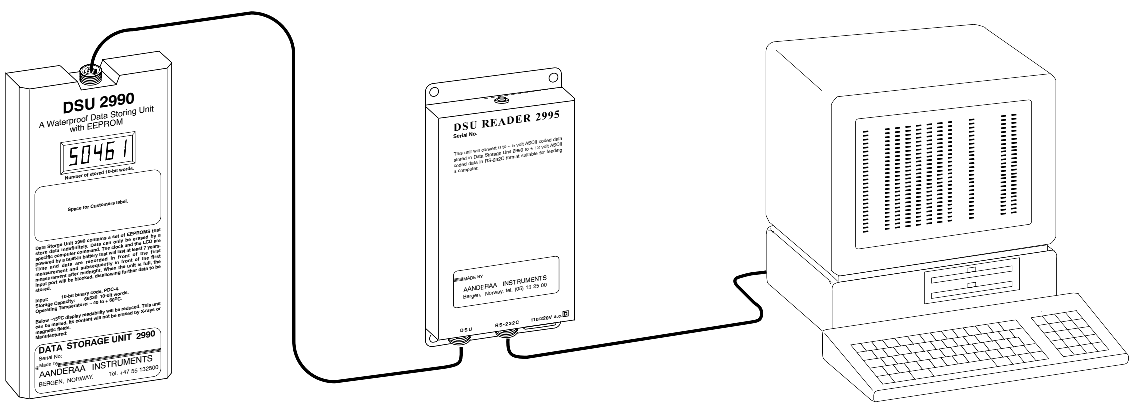
*Note! If the number in the display of the DSU is lower than expected do not erase the DSU because it can still hold a lot of data. Contact the factory for further information.

Reading of DSU and data processing.

Stored data is read by connecting the DSU, via a DSU Reader 2995, to the RS232C port of a computer, see figure 3.03. A suitable program must control the read-out process. The operating manual for the DSU Reader, Technical Description No. 145, provides the user with sufficient information to write his own read-out program.

The DSU Reader 2995 converts the 0 to -5V serial signals associated with the DSU to dual-polarity signals in accordance with the RS-232C standard. In addition it supplies the -6V control voltage for powering the DSU during the read-out process.
The DSU is connected to the DSU Reader 2995 by a standard Connecting Cable 2842C. A computer interfacing cable, 3016C, with a 6-pin 2828 Plug at one end and a 9 or 25-pin D-connector at the other, connects the DSU Reader to the PC's serial input port.

The DSU will examine bytes received from the computer and execute the command routines. In case of an invalid command, it will return to the stand-by mode. Altogether eleven command codes are valid for communication with the DSU. Beside the commands for controlling the data read-out, which will not erase the stored data, commands are also given for display and setting the real-time clock and for erasing the content of the DSU. With the exception of the 'ERASE' commands, all commands are single character.



Data Storage Unit 2990 DSU Reader 2995 Personal Computer with Program 5059

FIG. 3.03 Data Reading

Data Reading Program 5059
The Data Reading Program DRP 5059 is a totally new Win32 based program, designed using the most modern software technology presently available. Emphasized has been put on ease of use together with versatile, graphical user interface and system flexibility.

Minimum requirements are:
Pentium 166 Processor (recommended), 16MB RAM for Windows 95 and 98, 32MB RAM for Windows NT, 10MB Hard Disk. It can be used with Windows ©95, build 1111, Windows ©98 and Windows NT™ Sp3. The program replaces the Data Reading Program 4059. The program will not work with Windows 3.1 or 3.11, and customers working in these environments should still use the 4059 program.
It is a so-called component based program, built using a large set of independent binary components that become a part of your operating system instead of building the application into one huge executable file. As such, each component becomes available to any application that can make use of it.
The advantage of using this technique is that only one copy of the component resides on your disk although several applications may use it. This yields less chance for bugs or errors and it improves productivity through reuse of programming effort. An example of such a component is the AAICOMServer used to set up the serial (COM) ports and download the DSU. Used in the Display Program 3710, it has proven its reliability. Perhaps the most important feature is the possibility to design your own custom analysis tool components. The DRP 5059 incorporates a special hook-in mechanism for ActiveX components. The hook-in interface provides your ActiveX component with access to the database and to a window in which you can show the analysis result.
In most cases, you will probably be satisfied with the tools shipped with the program from the factory. These tools comprise graphing features, statistical analysis and signal analysis. Analyze the exported ASCII files from the database in other products such as Microsoft Excel.
The Data Reading Program 5059 is a so-called multi-document application. A document always links to a measurement session. A measurement session usually consists of the data that is stored in a single Data Storage Unit (DSU).
A DSU connects to a document via a COM port. Several documents can open at the same time. Each document uses a separate COM port, so to work with two DSUs at the same time, two COM ports must be available.
The COM port is, however only needed during the actual DSU download (reading) session and not while working with a previously downloaded DSU file or an imported ASCII file.
The Data Reading Program 5059 is a new, multifunction handling and data processing program. It contains:
A Template Library of standard instruments, stations and sensors from Aanderaa Instruments, a Custom Library to store customers' own product specifications and a Tooling section for different data handling functions as well as a faster data transfer mode. Two sample *.dsu files, located in the samples directory, allows for experimenting with the program without having to download a DSU item.
To download a complete version of the Data Reading Program 5059, see our web pages on the internet. The program grants a 30 day trial period during which time all functionality is available.
After the trial period the program reverts into a non- licensed, limited capability version. By

purchasing a license key from the manufacturer, or one of our representatives, the full functionality will be retained. The size of this file is 3253KB

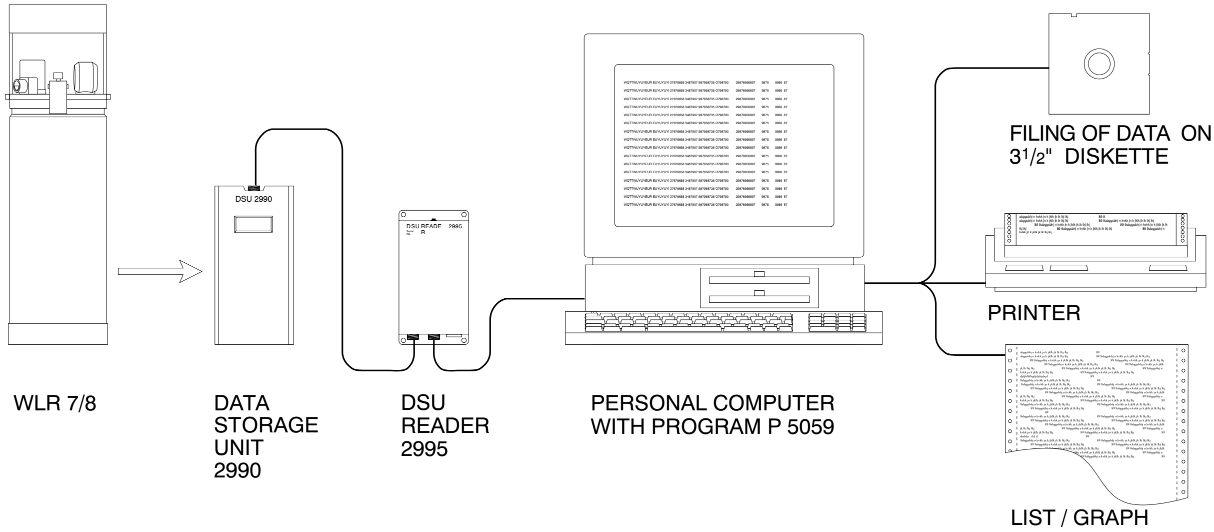


FIG. 3.04 Data Reading System

CHAPTER FOUR

MAINTENANCE

The WLR is designed to require a minimum of maintenance. Besides keeping the outside of the instrument clean, changing zinc anode and corroded parts, only the following yearly maintenance is required:

Yearly maintenance.

1) Check all screws and bolts for slack and retighten if necessary. Replace corroded parts. All crevices between metal surfaces and threaded screw holes must be filled with Tectyl 506 to avoid crevice corrosion.

2) Refill silicone oil in pressure sensor by use of a hypodermic syringe. Use silicone oil Dow Corning 1255, 1000 centistoke.

3) Check or recalibrate according to the recommendations given in chapter five.

4) Check the conductivity glass liner for cracks. If the glass liner is damaged a new calibrated glass liner can be delivered. Quote the sensor's serial number when ordering.

The manufacturer always keep a stock of spare parts, accessories and consumable parts for quick delivery. Orders may be placed by fax, telephone or mail.

Fresh battery.

Lithium Battery, 7.2 volt, 14 Ah, part number 3382 is recommended. Other types of batteries may be used. The table below will show how much data the battery is able to store in an WLR 7/8 at the different time intervals using DSU 2990 or the expanded DSU 2990E. The figures are calculated values and should be threated as such when deciding the operation time of the istrument.

When installing a battery always check that the battery terminals are well seated and give good contact.

Sampling Interval Minutes	Lithium Battery 3382, 14Ah			
	DSU 2990		DSU 2990E	
	Days	Words	Days	Words
1	9	65500	36	262100
2	18	65500	73	262100
5	45	65500	180	262100
10	90	65500	343	249024
20	178	65500	589	215580
30	267	65500	774	190410
60	520	65500	1128	142134
120	993	65500	1465	96696

Replacement of parts.

All parts of the instrument are uniformally made, a feature that allows changing of parts without influencing calibration or performance, e.g. the electronic board can be replaced without any adjustment or recalibration of the sensors. In the same way, calibration of a sensor is valid, regardless of the instrument that it is installed in.

Factory service.

Factory service is offered for maintenance, repair or calibration of instruments or parts. When returning instruments or parts for service, use “Instruments Service Order”, Form No. 135. General turn around time is four weeks, but on request the service department will make all possible efforts to meet customers` requirements.

Do nots!

Do not expose the instrument to higher pressure than the range of the pressure sensor, as this will damage the sensor.

Do not connect other metal parts to the exterior of the instrument as this may cause corrosion.

CHAPTER FIVE

CALIBRATION

General.

Each WLR is calibrated at the factory prior to shipment. Normally this cali-bration is valid for a year unless a change has been made to the instrument, i.e. change of defective sensors or change of sensor range. However, to en-sure maximum accuracy, the calibration should be checked once every 6 months.

The calibration procedures described in this chapter are those in use at the factory. During calibration the instrument is connected to a printer via the electrical terminal on the top end plate for direct read-out of the measured parameters.

The relationship between sensor readings (N) and the various quantities in physical units (y) is given in a three-term approximation. The expression:

$$y = A + B \times N + C \times N^2 + D \times N^3 \qquad (1)$$

represents the most accurate characteristic. The coefficients A, B, C and D are found by the method of the least squares. A minimum of 4 calibration points are used.

Pressure.

The WLR pressure measurement is recorded in two successive 10-bit words, in channel 3 and channel 4 in the formula:

$$N = N_3 \times 1024 + N_4 \qquad (2)$$

The N (pressure) is the reading in channel 3 x 1024 plus the reading in channel 4. Use Deck Unit 3127 to read channel 3 and 4.

Using a total of six calibration points, a formula in the form of equation (1) is constructed.

Pressure from a dead weight tester is applied to the instrument during calibration. This is done at 3 different water temperatures. A calibration sheet for the 3 operating temperatures is supplied with the instrument. When the pressure has been found using equation (1), the water depth is calculated from the following formula:

$$\text{Depth (m)} = 0.001\ (P - Pa) \times \frac{1}{d} \times \frac{1}{g} \qquad (3)$$

where P is total pressure (Pascal), Pa is atmospheric pressure (Pascal), d is density of water and g is the gravity (m/s^2) at actual site of measurement.
A curve of sea-water density versus temperature is given in Figure 6.20.
To take full advantage of the high-resolution pressure sensor, re-calibration every 6 months is recommended. Practical experience shows that most of the ageing effects are compensated for by correction of coefficient A from a single check of the WLR 7 reading against a precision barometer.

Temperature.
These measurements are performed with the instruments immersed in a tempera-ture stabilized bath which is stirred to avoid temperature gradients. The temperature is measured by a Platinum thermometer (Automatic Systems Laboratories LTD model F25). The instrument is frequently checked against the triple point of water (0.0098°C). Correct temperature stabilization is shown by a steady temperature reading of four to five samples. The instrument is calibrated at four different temperatures. Knowing the non-linearity of the sensor, the coefficients in equation (1) are calculated.

Conductivity.
The conductivity cell is best calibrated using a sea-water bath of known conductivity.
Calibration at the factory is performed by the use of a reference conductivity cell, which has a measuring range of 15 mS/cm. The reading of this cell is used to calculate the conductivity of the bath (the reference cell is checked once a year against water samples).
A quick check of the cell performance can be done by using a "sea-water loop" through the bore of the cell. "Sea-water loops" of 50 ohms, 70 ohms and 2000 ohms are supplied with the instrument and the readings with these loops in the bore of the cell are given in the calibration sheet accompanying the instrument.

CALCULATING OF SALINITY
The 4059/5059 DSU reader software will calculate the salinity in a seperate virtual channel. The salinity calculations will appear in the engineering units file as a seperate column. The formula used is presented below :

Input parameters
* CND : Conductivity : [mS/cm].
* T : Temperature : [°C]. (ref. IPTS-68).
* P : Presssure : [dbar].

Output parameters
* Sal : Salinity : [PPT] (ref PSS-78)

Functions

$R_{T35}(T)=$ $((((1.0031E\text{-}9)\cdot T-6.9698E\text{-}7)\cdot T+1.104259E\text{-}4)\cdot T+2.00564E\text{-}2)\cdot T+0.6766097$

$C(P) =$ $(((3.989E\text{-}15)\cdot P-6.370E\text{-}10)\cdot P+2.070E\text{-}5)\cdot P$

$B(T) =$ $((4.464E\text{-}4)\cdot T+3.426E\text{-}2)\cdot T+1$

$A(T) =$ $-(3.107E\text{-}3)\cdot T+0.4215$

Formulas

$D T = T - 15$

$$R = \frac{CND}{42.914mS/cm}$$

R=1 when T=15°C, P=0, Sal=35PPT

(Conversion from conductivity in mS/cm to relative conductivity R)

$$RT = \sqrt{\frac{R}{R_{T35}\cdot\left(1+\frac{C}{A\cdot R+B}\right)}}$$

$$Sal = ((((2.7081\cdot R_T - 7.0261)\cdot R_T+14.0941)\cdot R_T+25.3851)\cdot R_T-0.1692)\cdot R_T+0.0080+ \left(\frac{\Delta T}{1+0.0162\cdot\Delta T}\right)\cdot(((((0.0636-0.0144\cdot R_T)\cdot R_T - 0.0375)\cdot R_T - 0.0066)\cdot R_T-0.0056)\cdot(R_T+0.0005)$$

REFERENCES :

Also located in Unesco report No. 37 1981 practical salinity scale 1978 : E.L. Lewis IEEE Ocean eng. Jan 1980.

CHAPTER 6

ILLUSTRATIONS

FIG. 6.01 WLR 7 in Mooring Frame 3130.

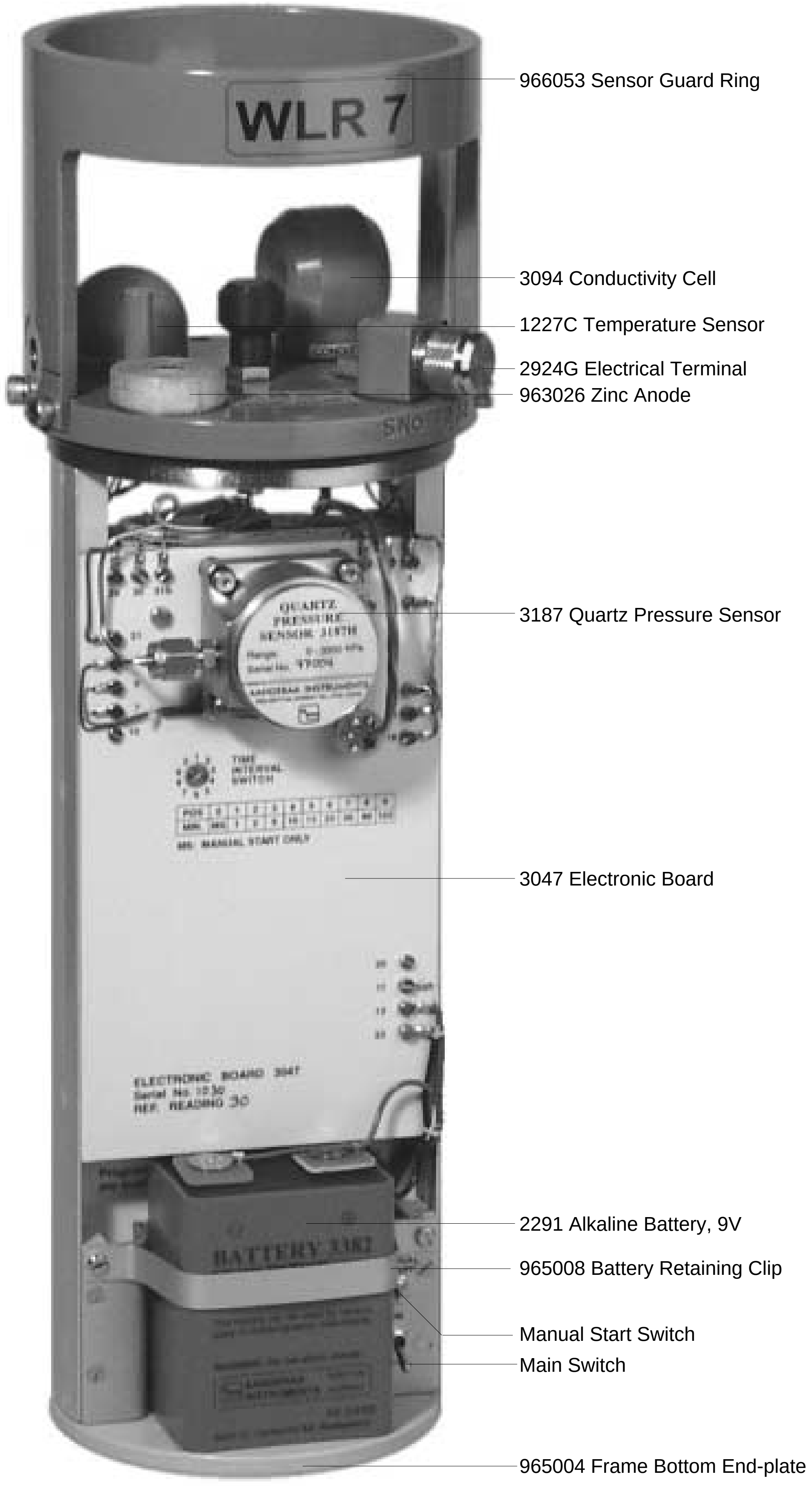


FIG. 6.02 Internal View of WLR7, Electronic Board side.

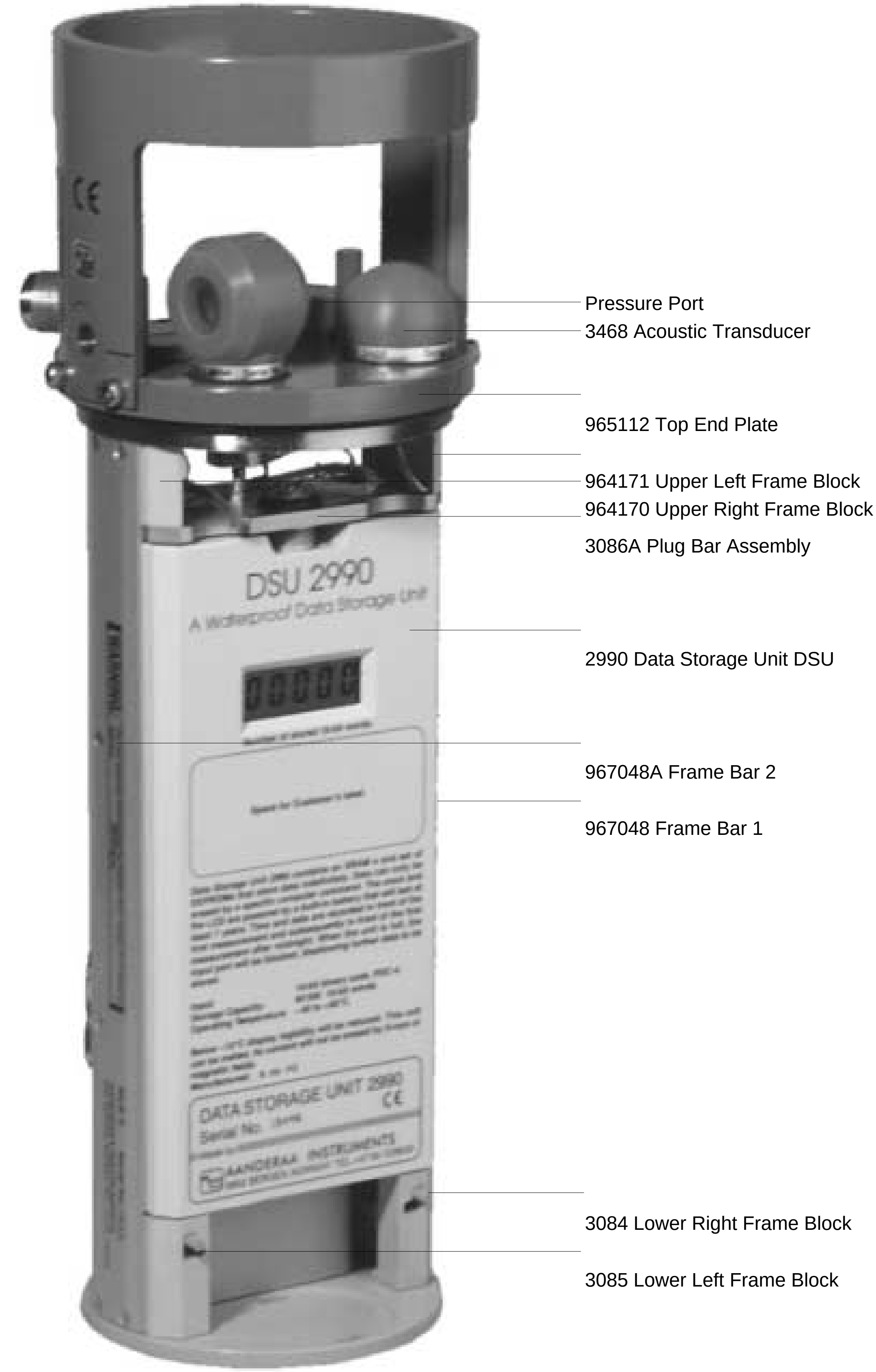


FIG. 6.03 Internal View, Data Storage Unit side.

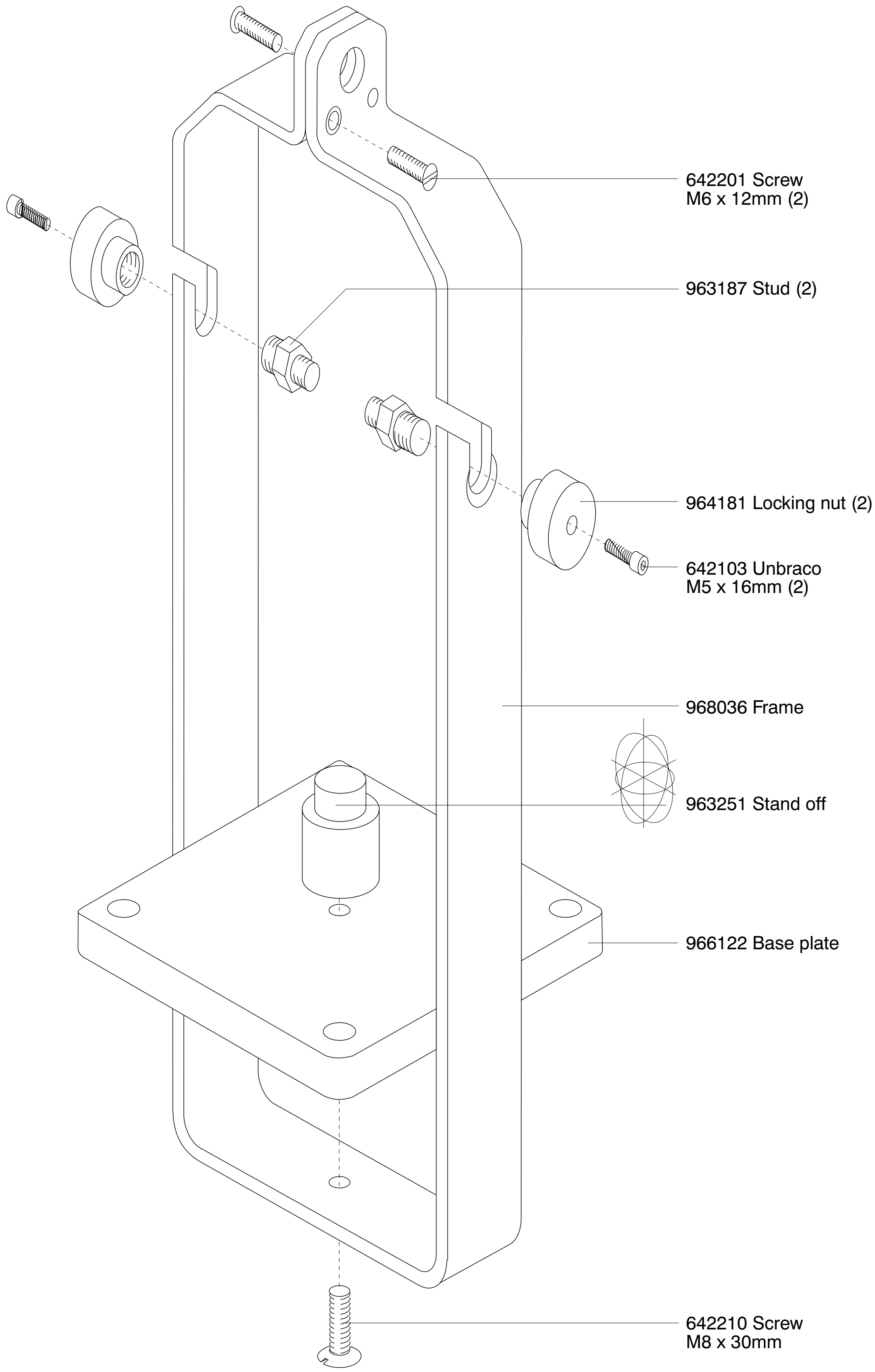


FIG. 6.04 Mooring Frame 3130.

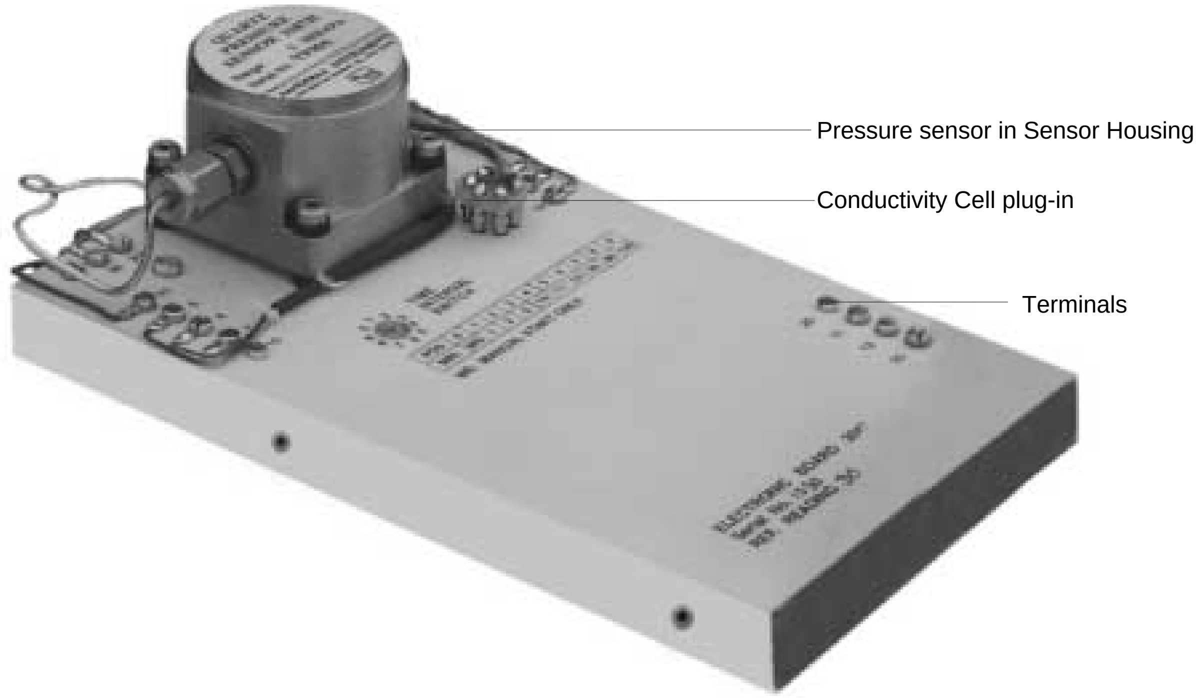


FIG. 6.05 Electronic Board 3047.

FIG. 6.06 WLR 7 packed.

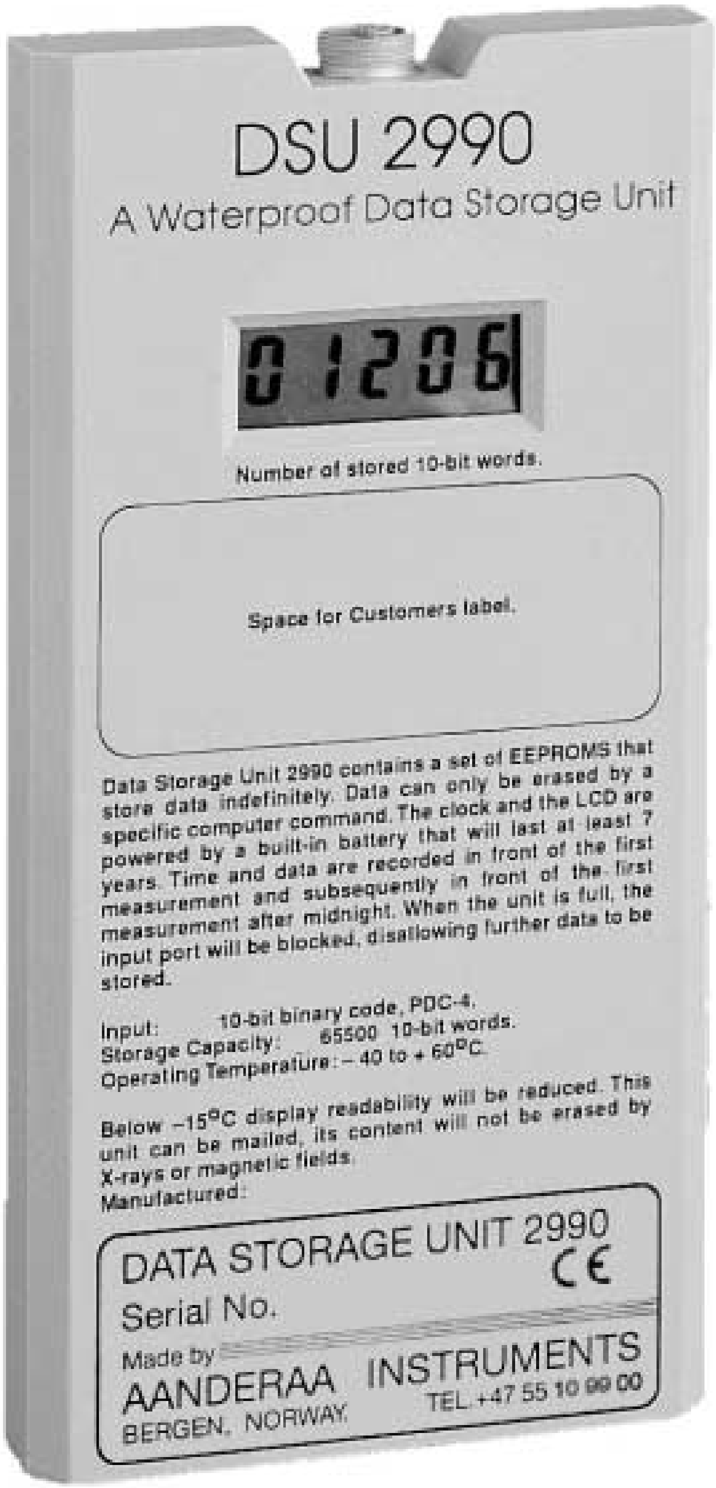


FIG. 6.07 Data Storage Unit 2990 (DSU).

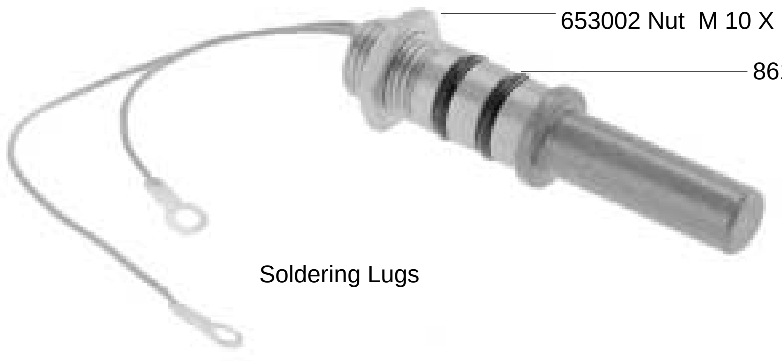


FIG. 6.08 Temperature Sensor 1227C.

FIG. 6.09 Conductivity Cell 3094.

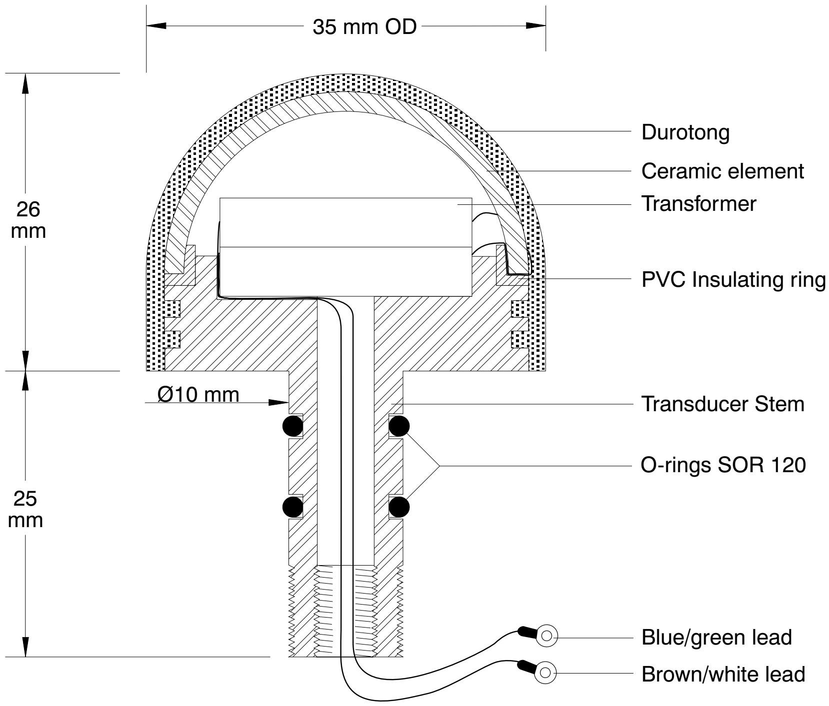


FIG. 6.10 Acoustic Transducer 3468.

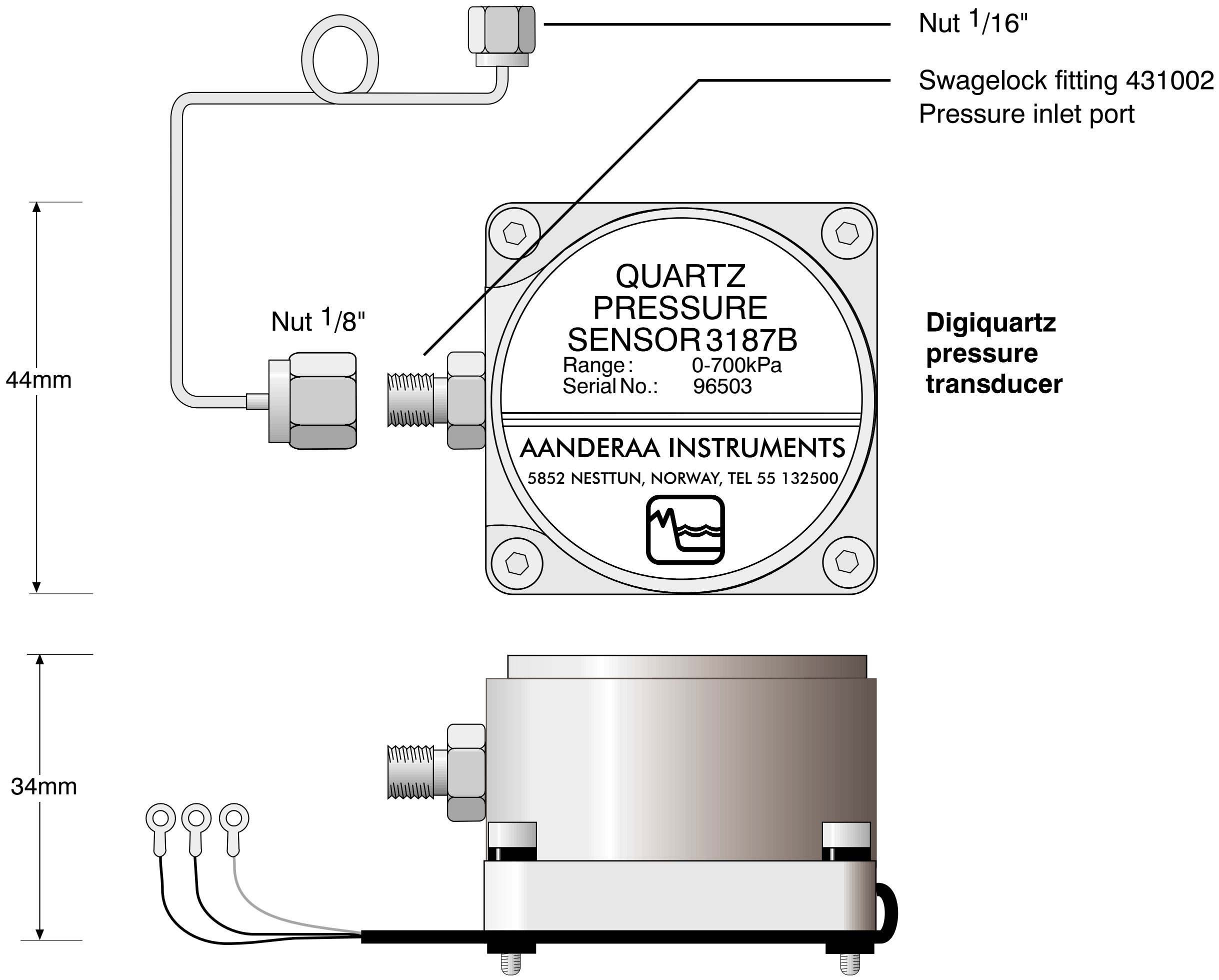


FIG. 6.11 Quartz Pressure Sensor 3187, WLR 7.

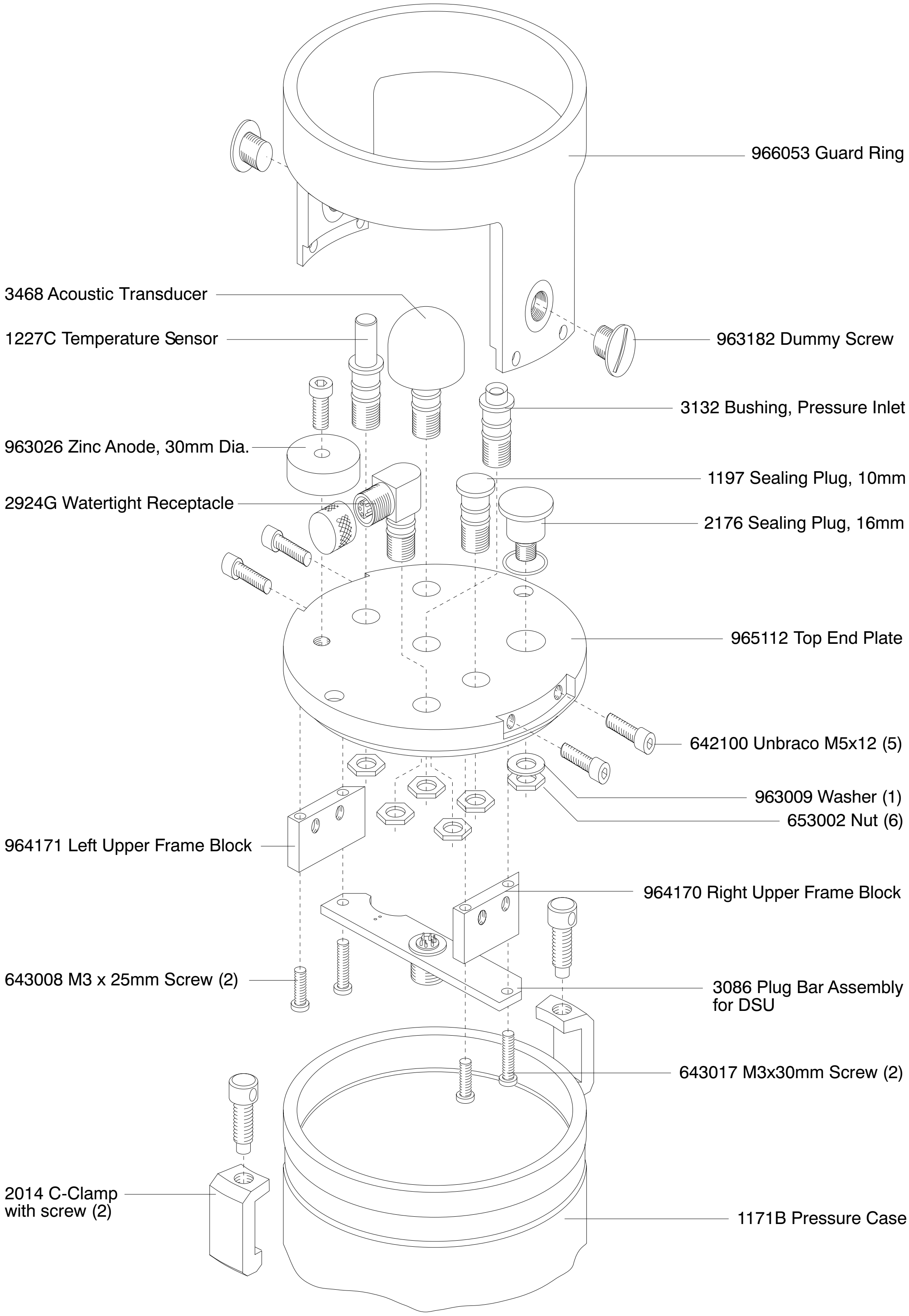


FIG. 6.12 Top Section, WLR 7.

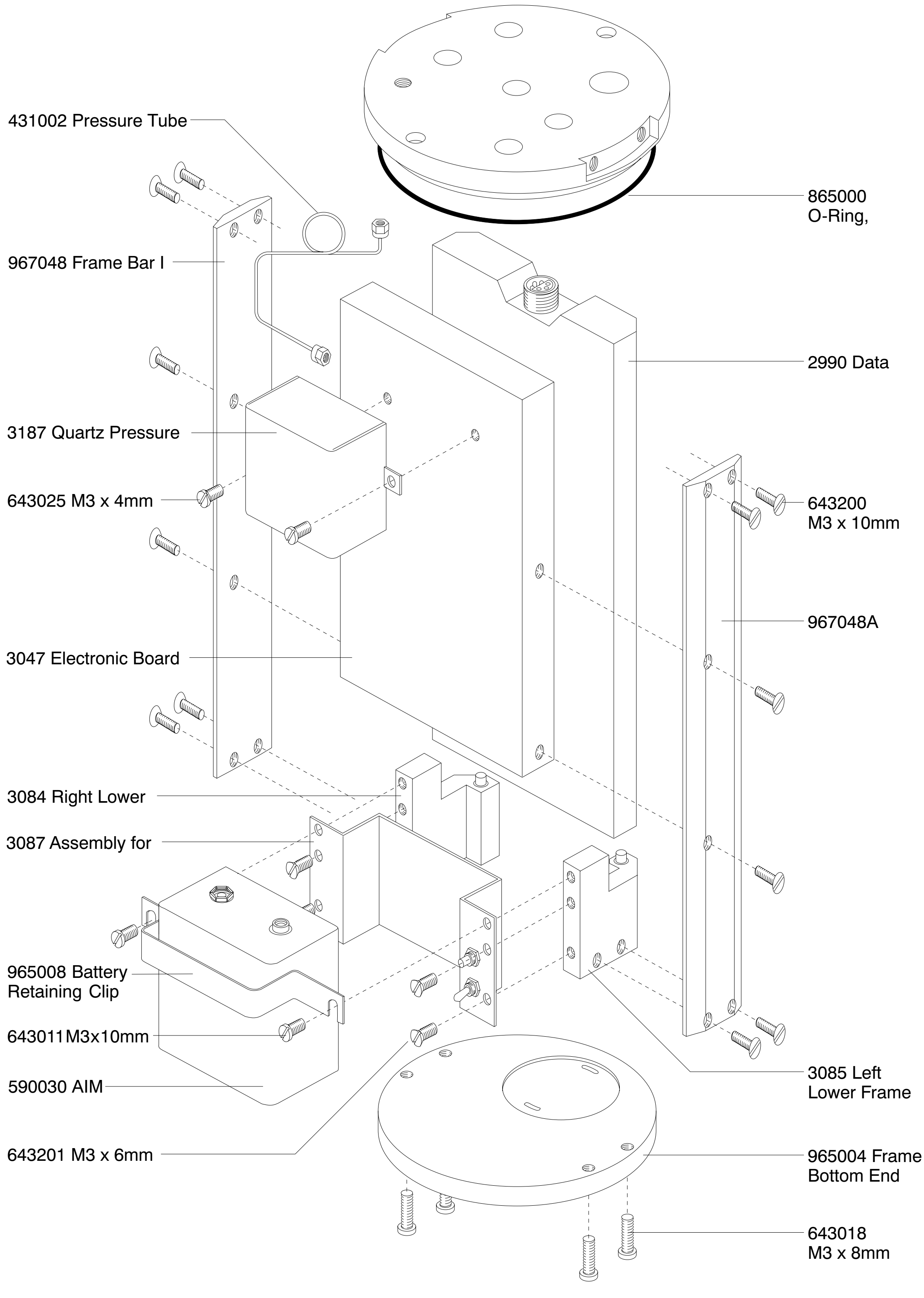


FIG. 6.13 Lower Section, WLR 7.

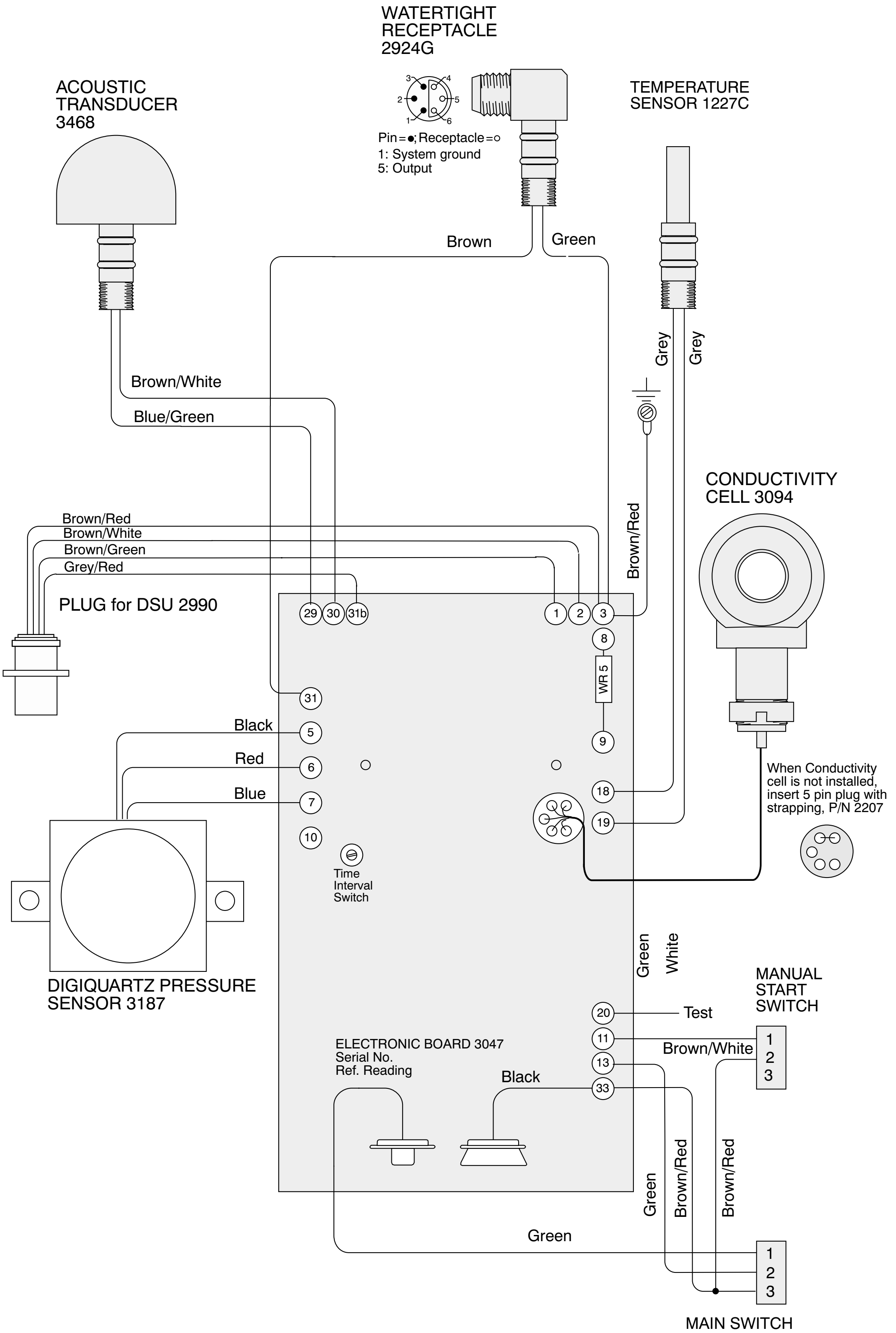


FIG. 6.14 Wiring Diagram, WLR 7.

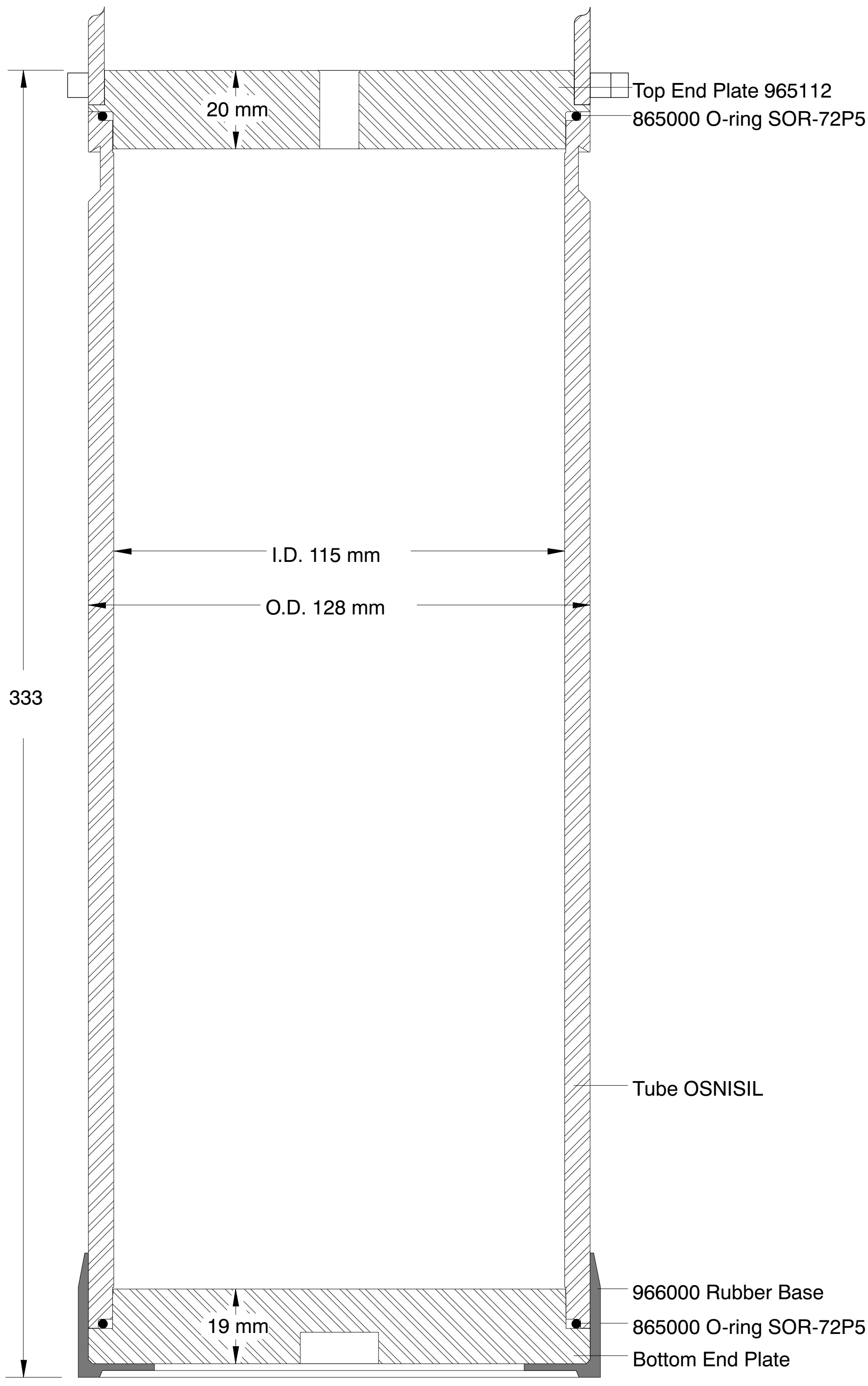


FIG. 6.15 Pressure Case 1171B.

AANDERAA
INSTRUMENTS
5852 Bergen, Norway.Tel. +47 55 10 99 00

Test and Specification Sheet

WLR ....

Serial No. ....

Component Specifications (for sensors and coefficients, see Calibration Sheet)

Component	Serial No.	Remarks
Electronic Board 3047 for WLR 7		Reference reading:
Electronic Board 3349 for WLR 8		Reference reading:
Data Storage Unit 2990		
Acoustic Transducer 3468		
Conducticity Cell 3094		
Quartz Pressure Sensor 3187		
Quartz Pressure Sensor 3188		

External Materials:

Pressure Case: OSNISIL Copper alloy (97.77% Cu, 1.73% Ni, 0.5% Si) and stainless acid proof steel (57.2% Fe, 17.5% Cr, 12.5% Ni, 2.7% Mo, maximum 0.06% C).

Other Metal Parts: Stainless acid proof steel or JNM 1 bronze (84% Cu, 6% Sn, 5% Pb, 5% Zn).

Surface Treatment, External Parts:

All Metal Parts: Olive green epoxy coated.

O-Ring Surfaces: Uncoated. If bronze, nickel plated.

Visual and Mechanical Checks:

Pressure sensor filled with oil .... ☐

Wire harness and screws .... ☐

Epoxy coating intact .... ☐

Zinc anode installed .... ☐

Performance Tests:

Current consumption when sensors are switched on ....mA

Check of operation at 0°C (all channels tested, data stored in DSU 2990. 16 hour run with 5 min. sampling interval) .... ☐

Clock function: Clock is reset when power is switched on. Check at .... minute intervals. .... ☐

Acoustic oscillator O.K .... ☐

Integration time ....

Date .... Sign ....

Performance Tests Prior to Shipment:

Maximum current consumption ....mA

Current consumption between measurements ....μA

Reading at 1 atmosphere, 20°C:

Channel No.	1	2	3	4	5
First Run					
Second Run					

Erased DSU 2990 installed .... ☐

Final assembling, inspection stamp .... ☐

O-Ring inspected, cleaned and greased .... ☐

Fresh battery installed, Type: .... Open loop voltage .... Voltage with 100Ω load .... ☐

Date .... Sign ....

FIG. 6.16 Test and Specification Sheet WLR 7 and WLR 8 (Form No. 294).

AANDERAA INSTRUMENTS
5852 Bergen, Norway. Tel. +47513 25 00

Calibration Sheet

WLR 7 and WLR 8

Serial No. ....

PRESSURE (Channels 3 and 4)
Calibration is performed by applying pressure from a dead-weight tester to the input port of the Quartz Pressure Sensor. Since the Quartz Pressure Sensor is slightly temperature dependant, the calibration is carried out at three different temperatures.

Pressure reference: Budenberg Dead-Weight Tester 280D, Serial No. 11570. Calibration Accuracy: <0.03% of actual pressure.

Quartz Pressure Sensor, Model: ....

Serial No: .... Range: .... PSIA.

Calibration Temperature °C

Pressure	Reading	
PSIA	N_3	N_4

Calibration Temperature °C

Pressure	Reading	
PSIA	N_3	N_4

Calibration Temperature °C

Pressure	Reading	
PSIA	N_3	N_4

These observations are used to calculate the coefficients in the following formula:
PRESSURE (PSIA) = $A + BN + CN^2 + DN^3$ where $N = N_3 \times 1024 + N_4$ (N_3 and N_4 are the readings in channels 3 and 4).

Coefficients valid for °C

A	
B	
C	
D	

Coefficients valid for °C

A	
B	
C	
D	

Coefficients valid for °C

A	
B	
C	
D	

TEMPERATURE (Channel 2)
When calibrating the temperature sensor, the instrument is submerged in a temperature regulated bath. The temperature is measured by a reference thermometer, type: ....
Temperature Sensor, Model 1227C, Range: –3 to +35°C.

Temp. °C	Reading

TEMPERATURE (°C) = $A + BN + CN^2 + DN^3$
(where N is the reading in channel 2).

Coefficients for the temperature formula:

A	B	C	D

CONDUCTIVITY (Channel 5)
When calibrating the conductivity cell, the instrument is submerged in a sea-water bath of known conductivity.
Sensor: .... Serial No: .... Range: .... mmho/cm.
Reading with sea-water loop: .... ohm, N = ... ohm, N = ...
The sensor has been calibrated at these conductivities:

mmho/cm	Reading, N

Cell form factor, K = ... cm^{-1}

The calibration points give the following coefficients:
Conductivity (mmho/cm) = A + BN (where N is the reading in channel 5).

A = ... B = ...

Date ....Sign. ....

FIG. 6.17 Calibration Sheet WLR 7 and WLR 8.

AANDERAA
INSTRUMENTS
5852 Bergen, Norway.Tel. + 47 55 13 25 00

Check-out List

WLR 7 and WLR 8

Serial No. ....

Visual and Mechanical Checks:

1. Epoxy coating intact (especially near Conductivity Cell) ☐
2. No corrosion, O-ring groove Pressure Case ☐
3. No corrosion, other parts ☐
4. No marine fouling ☐
5. Zinc anode installed ☐

Performance Test: (to be carried out with test battery and *Seico Printer or Deck Unit 3127* connected and with interval switch in “MANUAL START” (MS).

1st Test Run		
Ch. No.	Reading	Reading O.K.
1		
2		
3		
4		
5		

2nd Test Run		
Ch. No.	Reading	Reading O.K.
1		
2		
3		
4		
5		

Comments:
....
....
....
....
....

To decide whether a reading is O.K. compare with calibration sheet.

Clock function: Power switched on ....hour ....minutes   Acoustic Oscillator O.K. ☐
First triggering ....hour ....minutes
Second triggering ....hour ....minutes

Deployment Preparations:

Fresh main battery installed: ☐ Type: .... Open loop voltage: ....
Voltage with 100Ω load: .... DSU erased: ☐ DSU installed: ☐ DSU labelled ☐
Time of first measurement .... day:......... month:......... year:......... hour:......... minute:......... GMT ☐ LT ☐
Check that the pressure input port is clean and free of obstacles. Refill silicone oil Dowcoming 1255, 100 centilitres, in the pressure inlet port using a syringe: ☐
O-ring inspected, cleaned and greased: ☐
C-clamps tightened: ☐ Date ....Sign ....

Retrieval Phase:

Recording Unit cleaned and rinsed in fresh water : ☐
Time of last measurement:......... day:......... month:......... year:......... hour:......... minute:......... GMT: ☐ LT: ☐

State of Recording Unit:..
....
....

Form No. 335
August 1999

Date ....Sign ....

FIG. 6.18 Check-out List WLR 7 and WLR 8 (Form No. 335).

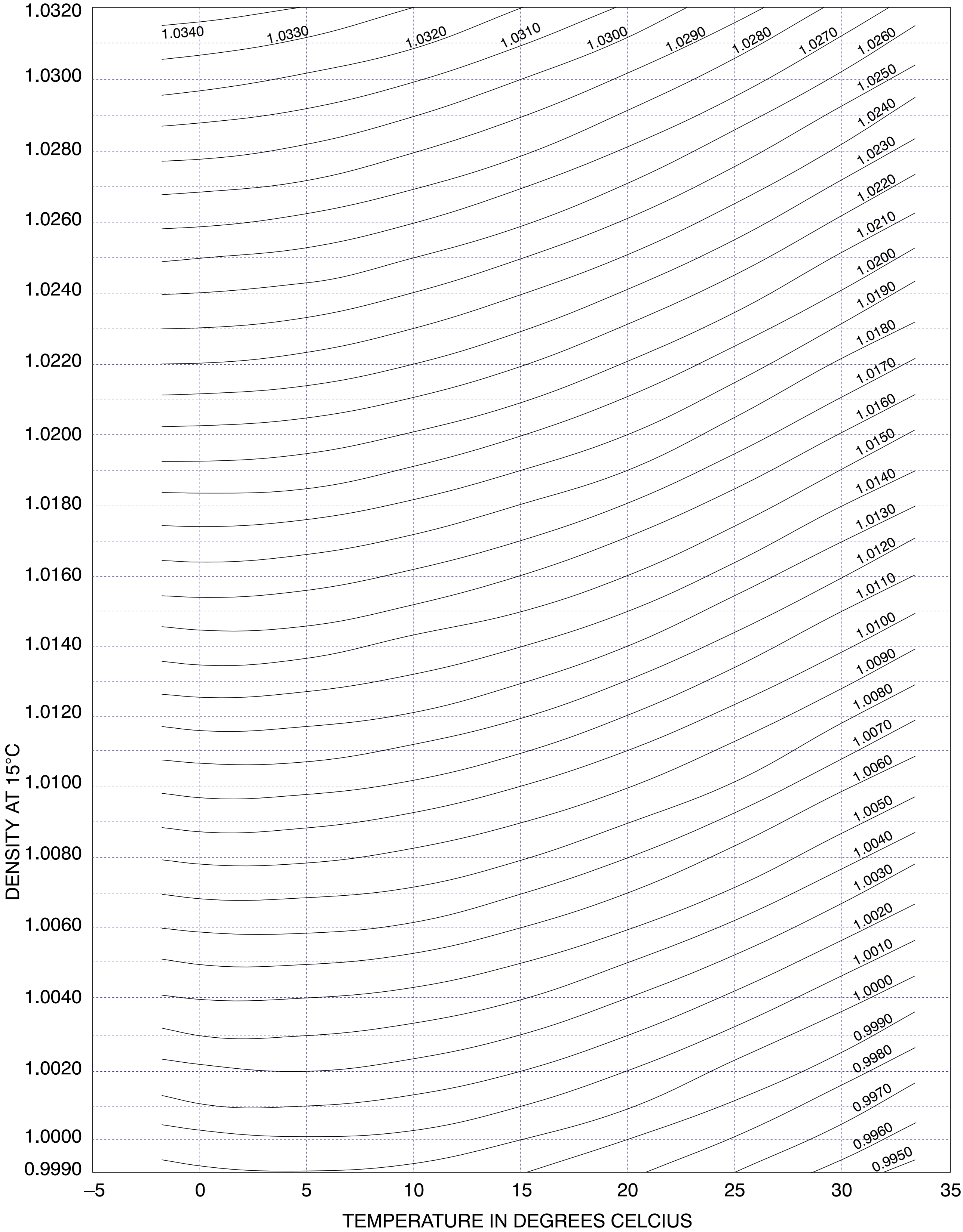


FIG. 6.19 Sea-water Density at Various Temperatures.

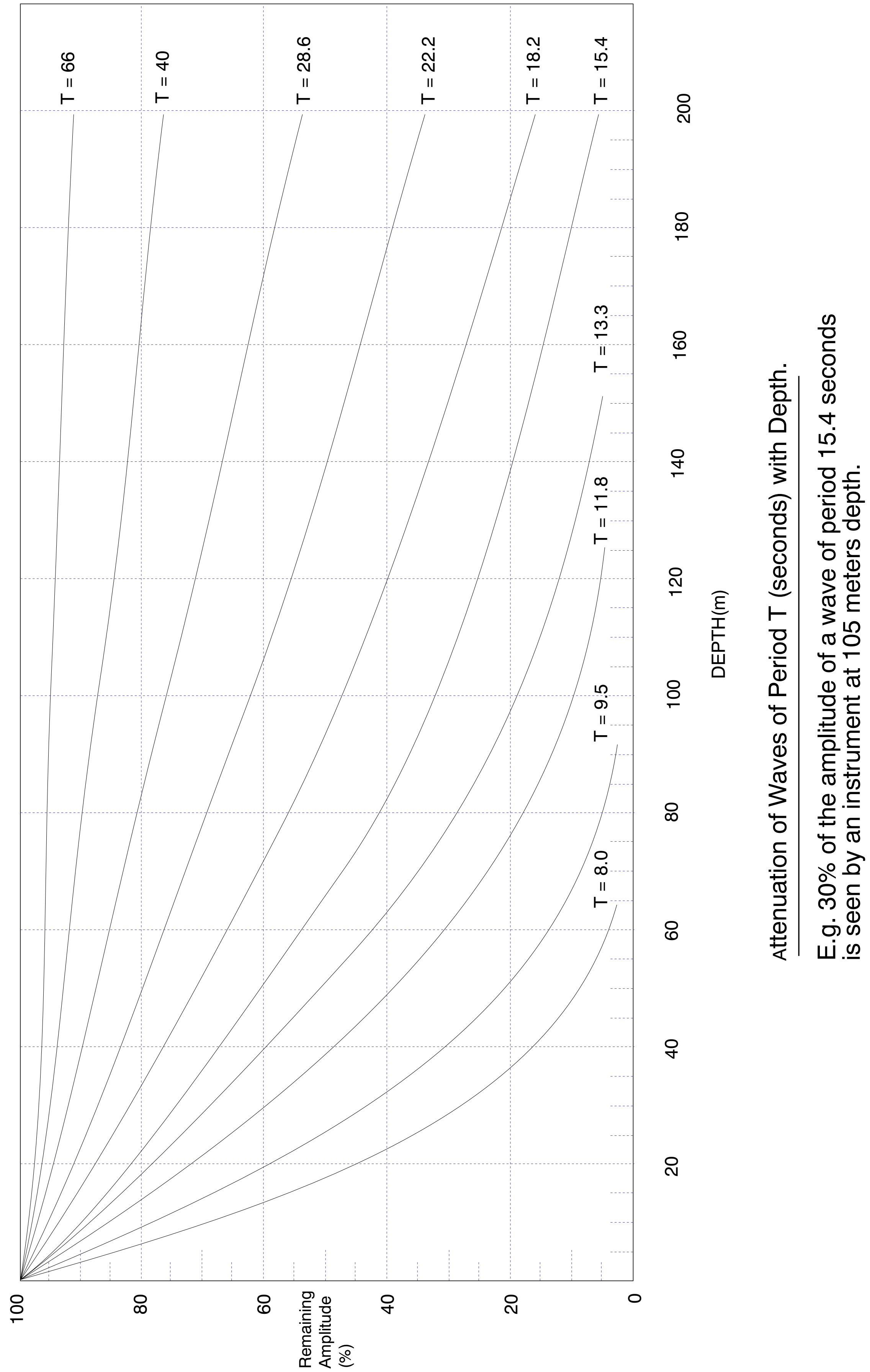


FIG. 6.20 Attenuation of Waves.

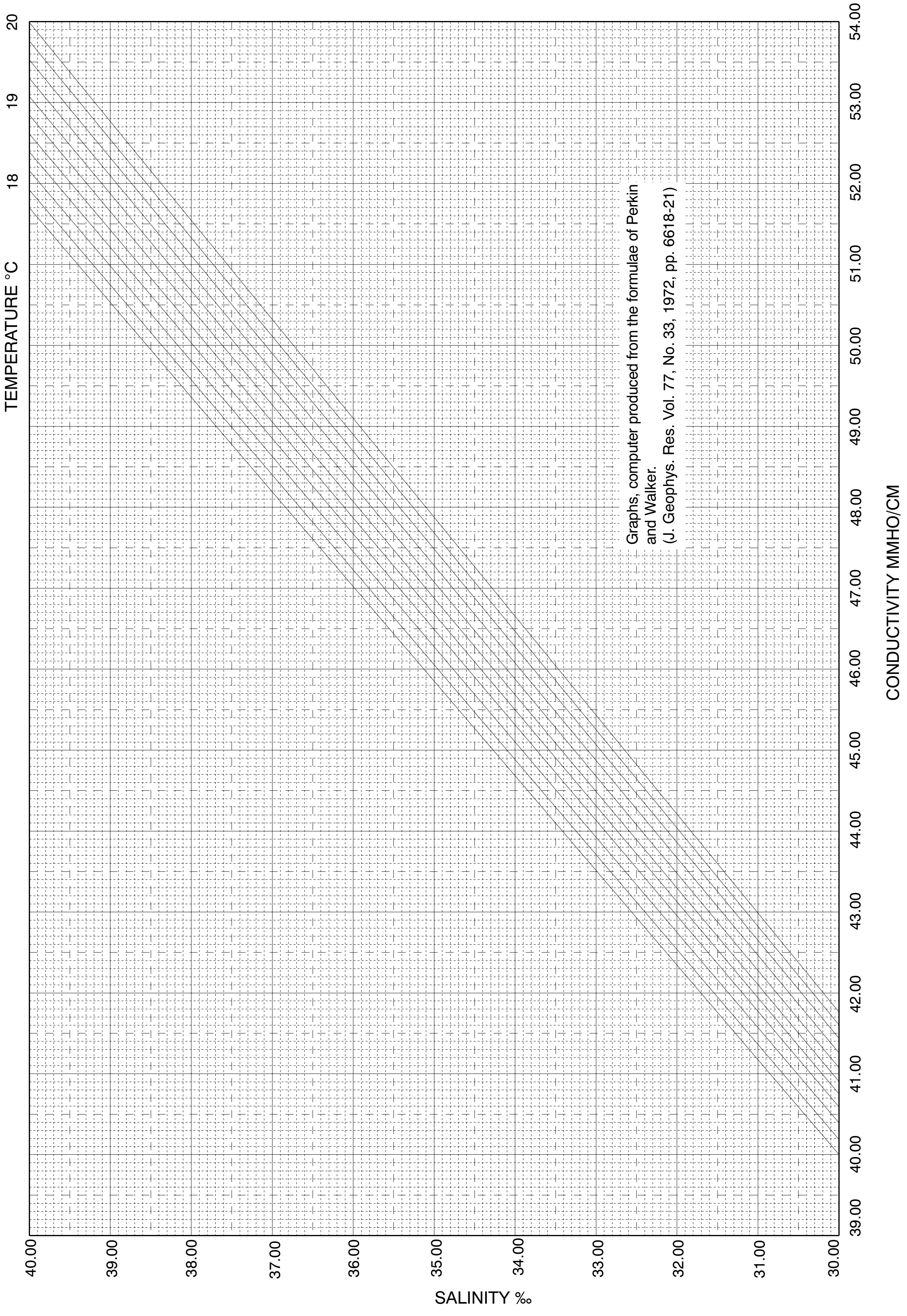


FIG. 6.21 Salinity Conversion Graph, 5 to 11°C.

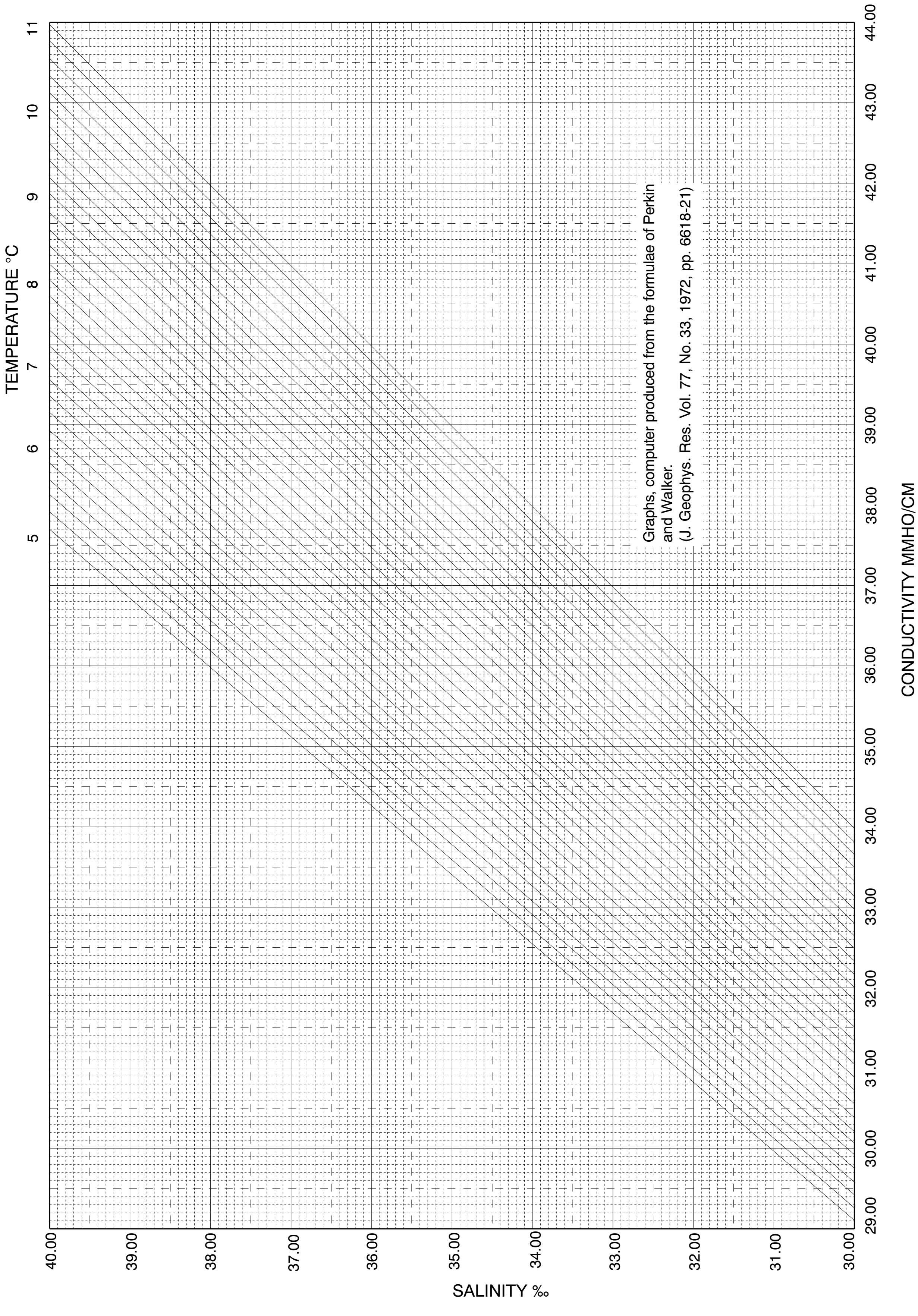


FIG. 6.22 Salinity Conversion Graph, 18 to 20°C.

AANDERAA INSTRUMENTS
5852 Bergen, Norway. Tel. +47 55 13 25 00

INSTRUMENT SERVICE ORDER

For Aanderaa Data Collecting Instruments

TO
AANDERAA INSTRUMENTS
PO BOX 160 NESTTUN
5852 BERGEN, NORWAY

ORIGINAL to be mailed to the manufacturer
BLUE COPY to be enclosed in instrument case
RED COPY to follow shipping documents
YELLOW COPY to be retained by sender

Service is requested for ....

Type of instrument Serial No.

and it will be shipped to the manufacturer by

' airfreight ' railway ' air/mail ' other means

Comments about shipment: ....

....

' General overhaul and inspection

' Repair (give a brief description)

....

....

....

....

....

....

Return address:

....

....

....

Invoicing address: Owner of instrument:

....

....

....

....

Damage or loss during shipment is at owner’s risk.

....

Place Date Signature

Please forward possible shipping documents directly to the manufacturer.

FIG. 6.23 Instrument Service Order, Form No. 135.

To:
AANDERAA INSTRUMENTS
P.O. Box 160 Nesttun
5852 Bergen, Norway
Tel.: + 47 55 10 99 00

DATA READING ORDER

From: --

Customers Order No. ------------------------------------

Original to accompany DSU/tape. Copy to be retained by sender.

NOTE: In customs forms, state that the DSU/tapes represent no commercial value. Loss or damage during shipment is at owner's risk.

SERVICE REQUIRED

- ☐ Printout Data in Engineering Units
- ☐ Plotting of Data as Graphs
- ☐ Statistical Report
- ☐ 3,5" diskette
- ☐ Filing in Raw data
- ☐ Filing in engineering units

Instrument type	Serial No.	DSU No.:

Sampling Interval in Minutes		Day/Month/Year
First measurement: Time:		
Last measurement: Time:		
Greenwich Mean Time		Local Time:

Fill in below if printout in engineering units or plots are requested.

CH. NO.	CHANNEL CONFIGURATION Sensor type	S.No	yes/no	PLOT SCALE lower limit [1]	upper limit [1]	STATISTIC SCALE lower limit	upper limit
1	REFERENCE	- - - - -	NO				
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

CALIBRATION COEFFICIENTS Fill in below if there are any changes in the coefficients after delivery.

CH. NO.	COEFFICIENTS IN FORMULA[2] $(A+a) + (b+b) \times N + C \times N^2 + d \times N^3$ A	a	B	b	C	d	Units
1	0	0	1	0	0	0	---------
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

1 and 2) See next page

Date --------------------------------- Sign ---

Form 167
August 1999

FIG. 6.24 Data Reading Order, Form No. 167.page 1 of 2

) Often the actual variation of a parameter will be less than the range of the sensor. In order to obtain the best resolution for the plot, the upper –and lower limit of actual variation may be used for the plot scale.

2) EXPLANATION OF DOUBLE COEFFICIENT FORMULA

The purpose of using double coefficient formulas is to simplify calibration of nonlinear sensors. When using double coefficient formulas, the curve characteristic of a nonlinear sensor is expressed as the sum of a linear part, being the least square line, and a nonlinear part. It is assumed that the nonlinear part is the same for individual sensors of the same type, i.e. that the variations among individual sensors are in the linear part only.

According to this, the behaviour of a nonlinear part can be expressed by the power series:

$$y = (A + a) + (B + b) \times N + c \times N^2 + d \times N^3$$

where coefficients a, b, c and d represent the nonlinear part, these coefficients are assumed, through knowledge of the physical nature of the sensor, or from several measuring points of the sensor. Coefficients A and B represent the linear part.

When a sensor is to be calibrated, the task is then reduced to determine coefficients A and B. To do this, it is necessary to select two calibration points, and then find the reading for these two ports.

Assume that we chose two calibration points y_1 and y_2, and that we find the corresponding readings N_1 and N_2. To find the numerical value of A and B, it is only necessary to solve the two equations:

$$y_1 = (A + a) + (B + b) \times N_1 + c \times N_1{}^2 + d\, N_1{}^3$$
$$y_2 = (A + a) + (B + b) \times N_2 + c \times N_2{}^2 + d\, N_2{}^3$$

From the two equations above we know the numerical values of a, b, c and d. The values of readings N_1 and N_2 and the values of parameter y_1 and y_2 and also known. The problem can then be reduced to two equations and two variables:

$$y_1 = A + B \times N_1 + C_1$$
$$y_2 = A + B \times N_2 + C_2$$

which easily gives us A and B.

Writing the formulas with double coefficients as shown here, has the advantage that the full formula for a sensor can be found easily from two sets of observations, and that the coefficients A and B, being coefficients for the best linear fit, can be used for quick calculation of the parameter value in cases where full accuracy is not required. For full accuracy the full formula should be used.

N = instrument reading in decimal code
For WLR $N = N_{ch3} \times 1024 + N_{ch4}$

FIG. 6.25 Data Reading Order, Form No. 167, page 2 of 2.

CHAPTER SEVEN

WATER LEVEL RECORDER, WLR8.

INTRODUCTION

Chapters 1 through 6 are also valid for the deep-sea version, the WLR 8. This version has the same features as the WLR 7 model, except for the physical dimensions of the top and bottom end plates, the pressure case and a special WLR 8 version of the electronic board. The mechanical parts are strengthened to withstand the pressure down to 6000m depths.

The WLR 8's electronic board 3349 is programmed for the high-pressure digiquartz transducer positive output as opposed to the low-pressure transducer negative output. The pressure transducer range available for this model is: 0-14MPa.
This chapter only describes the specifications and parts specific to the WLR 8.

Specifications.

Depth capability:		Limited by sensor range, maximum 6000 meters.
Net weight	in air:	15.2 kg.
	in water:	10.9 kg.
Gross weight:		20.5 kg
Dimensions:		450 x 128 mm.

3188 Quartz Pressure Sensor, 0-14MPa(1370meters).
Other ranges on request.

DESCRIPTION

Figure 7.01 shows the pressure case 2175B and the top-end plate 966173. In order to withstand the pressure at depths down to 6000m, the thickness of the top and bottom-end plates is increased to 30mm. To ensure a safe waterproof construction, piston seals between the tube and the end plates are employed. The bottom end plate is press fitted into the tube.
To strengthen the upper rim of the tube only two small grooves for the C-clamps are provided.
Due to the increased thickness of the top-end plate, special fastening nuts for components penetrating the plate are needed. See figure 7.02, upper section of the WLR 8.

Parts, specific for the WLR 8.

966173	Top End Plate, WLR 8.
2175B	Pressure Case, WLR 8/RCM 8.
962026	Nut for Sensor, WLR 8.
865001	O-ring for pressure case, SOR 71.
3349	Electronic Board, for WLR 8.
3371	Mooring Frame, for WLR 8.
3188	Quartz Pressure Sensor, for WLR 8.
4094	Conductivity Cell, for WLR 8

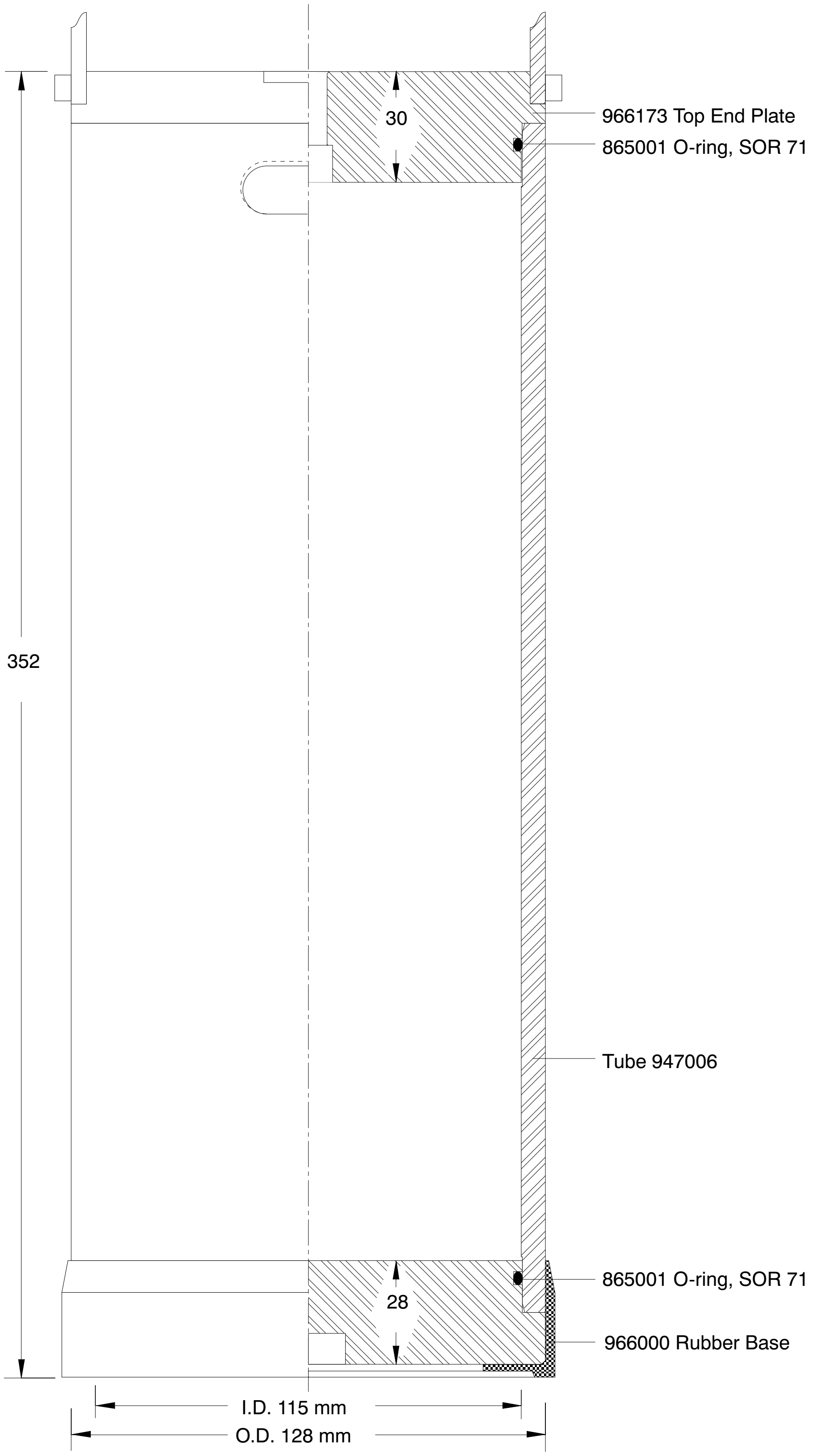


FIG. 7.01 Pressure Case 2175B with Top End Plate 966173 installed, WLR 8.

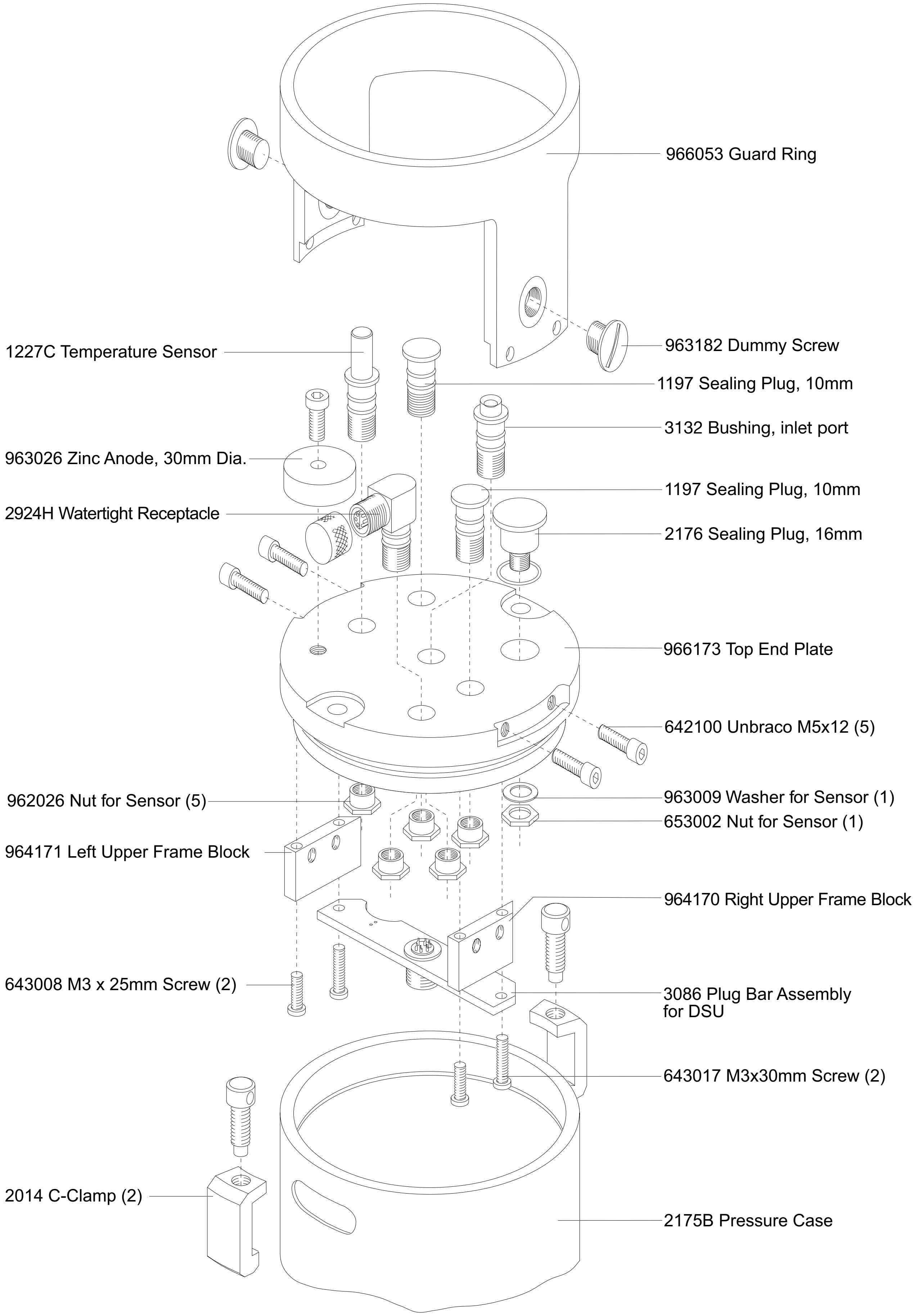


FIG. 7.02 Recording Unit, Top Section, WLR 8.

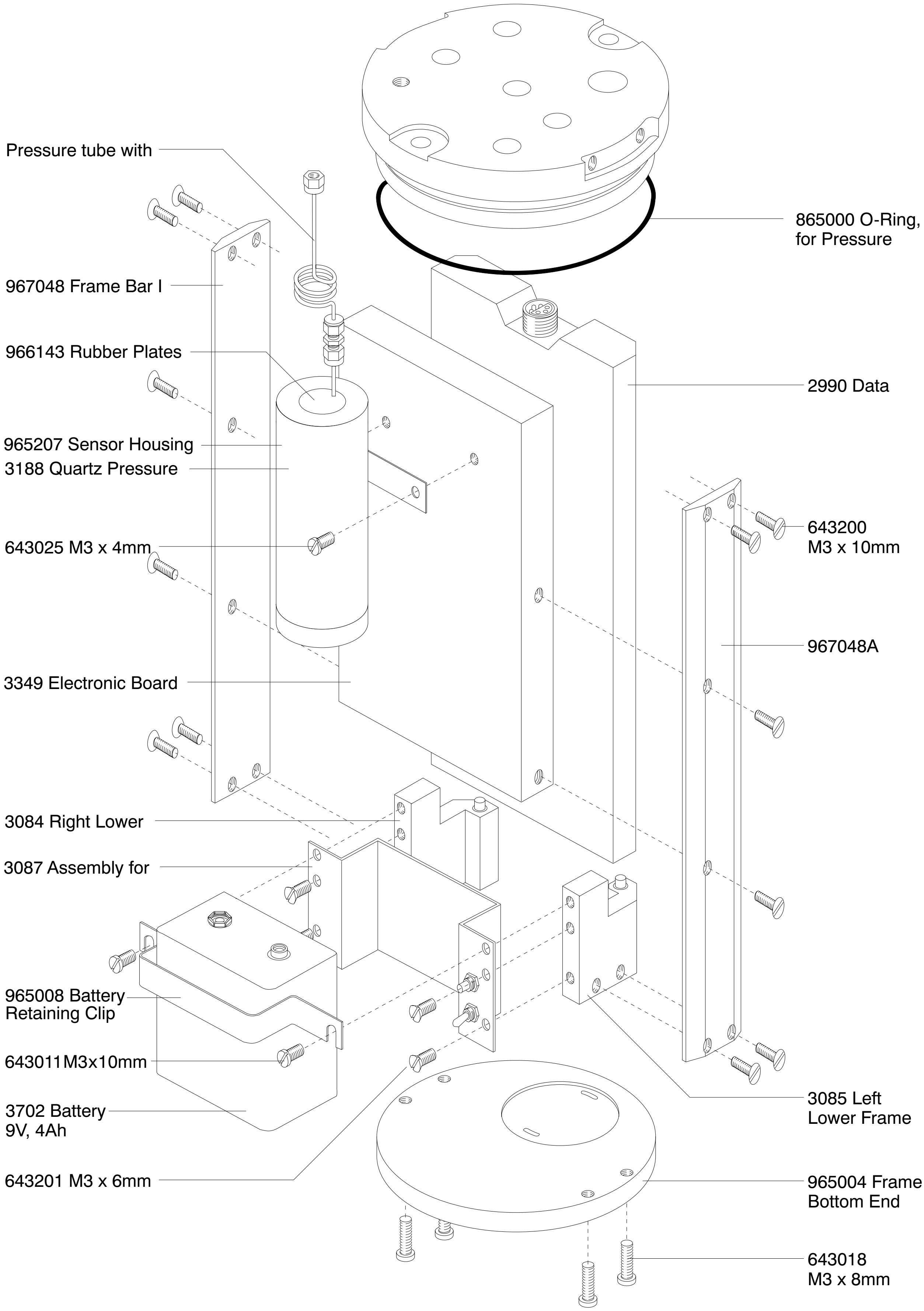


FIG. 7.03 Recording Unit, Lower Section, WLR 8.

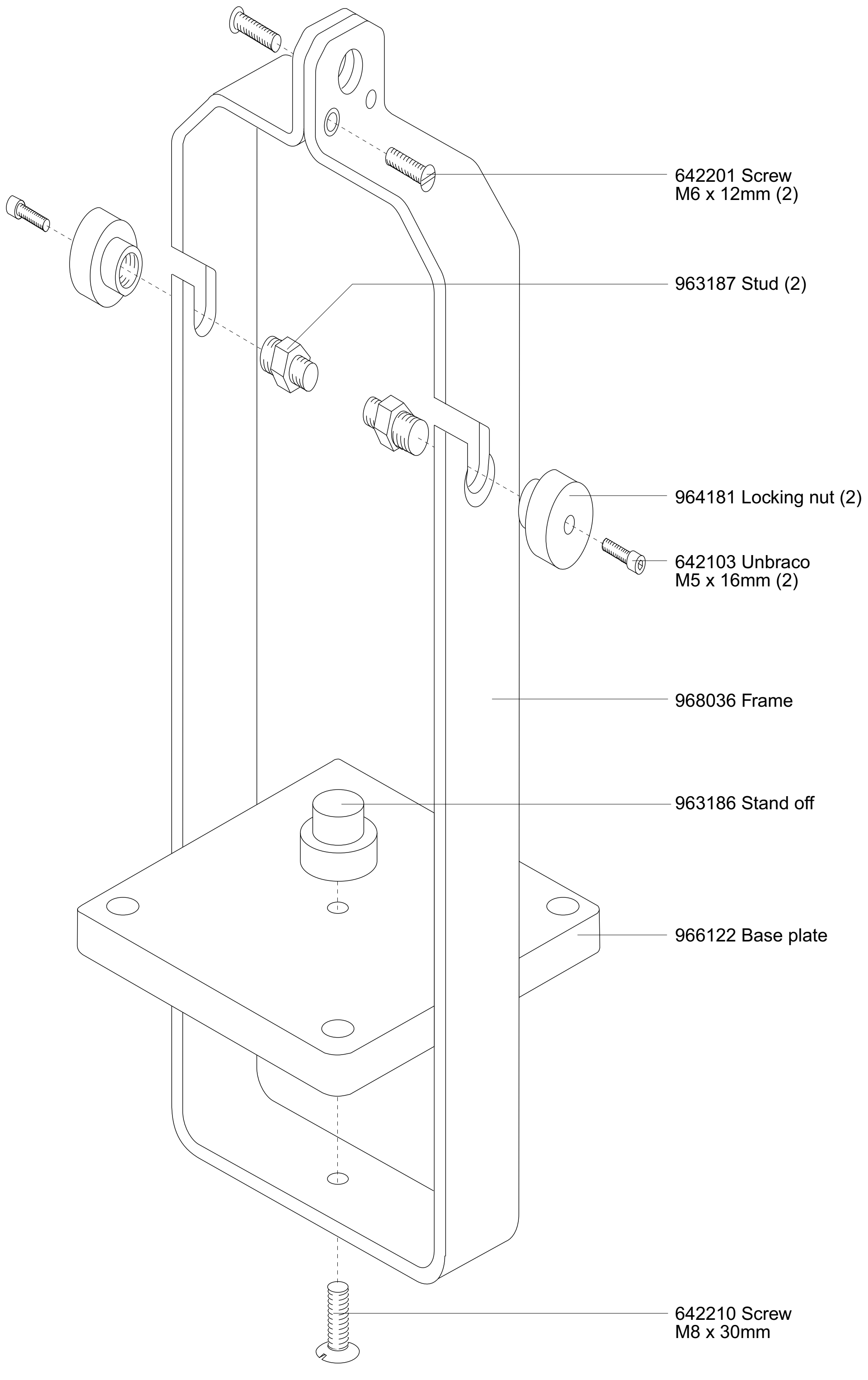


FIG. 7.04 Mooring Frame 3371, WLR 8.

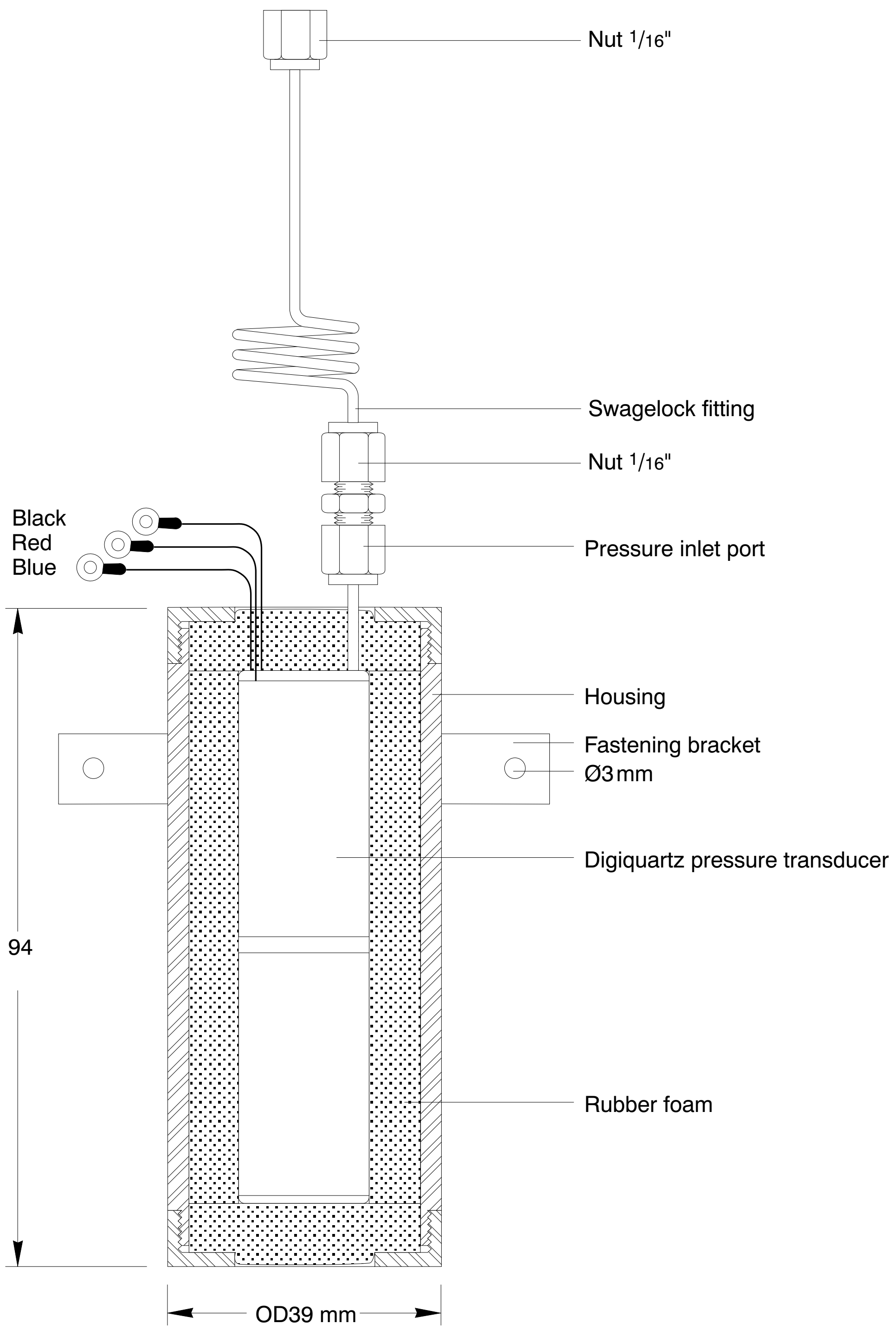


FIG. 7.05 Digiquartz Pressure Sensor 3188, WLR 8.

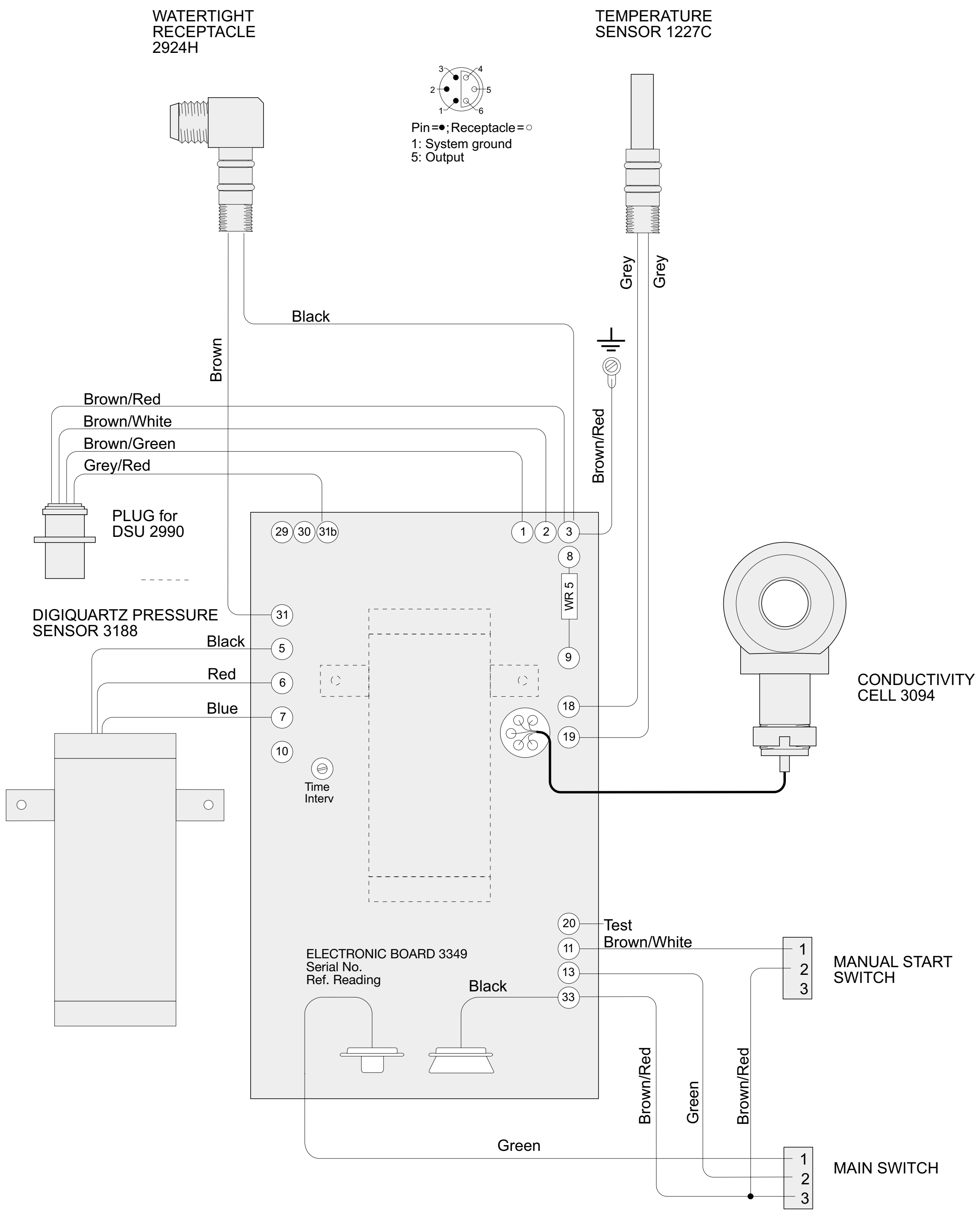


FIG. 7.06 Wiring Diagram, WLR 8.

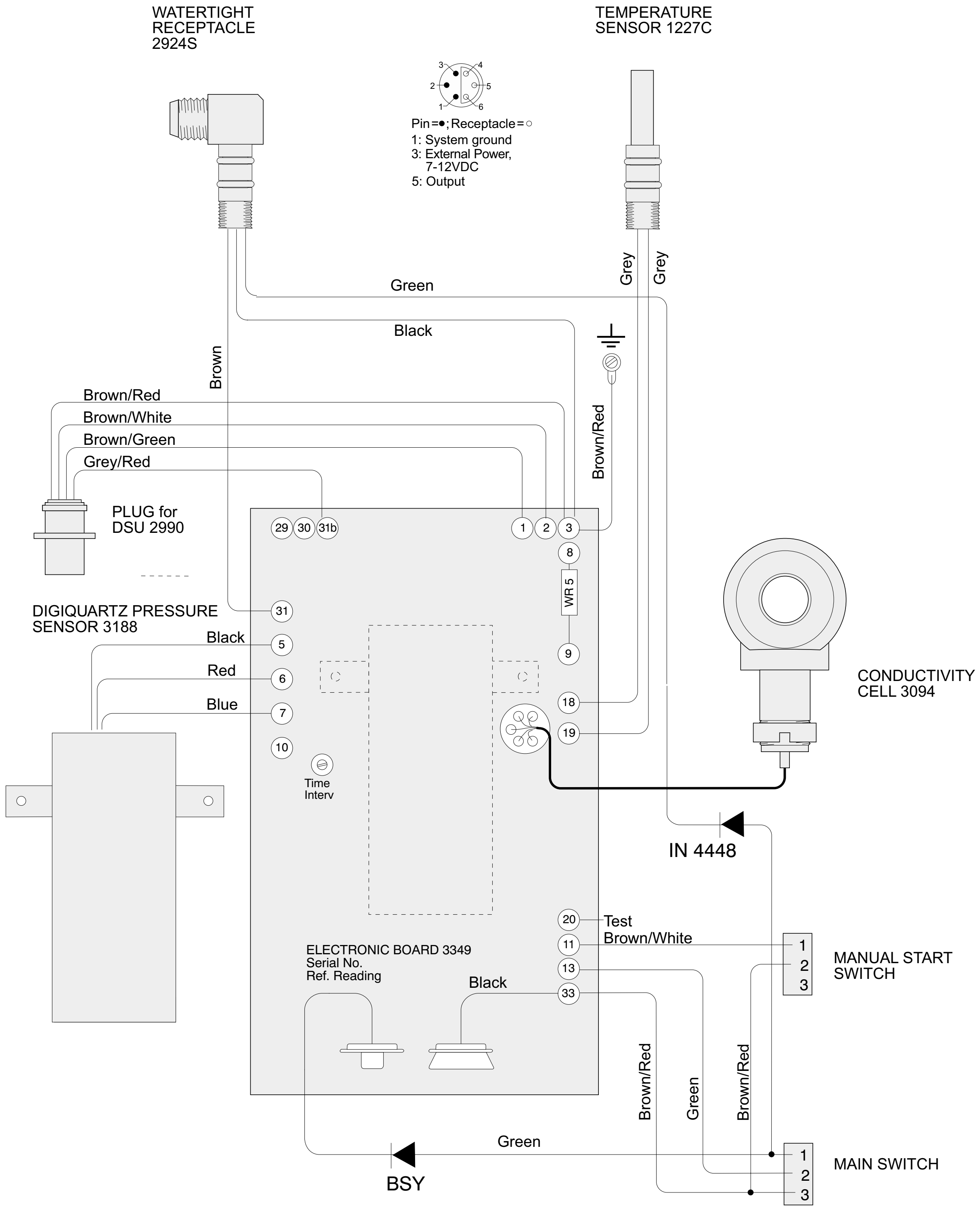


FIG. 7.07 Wiring Diagram, WLR, with external power.