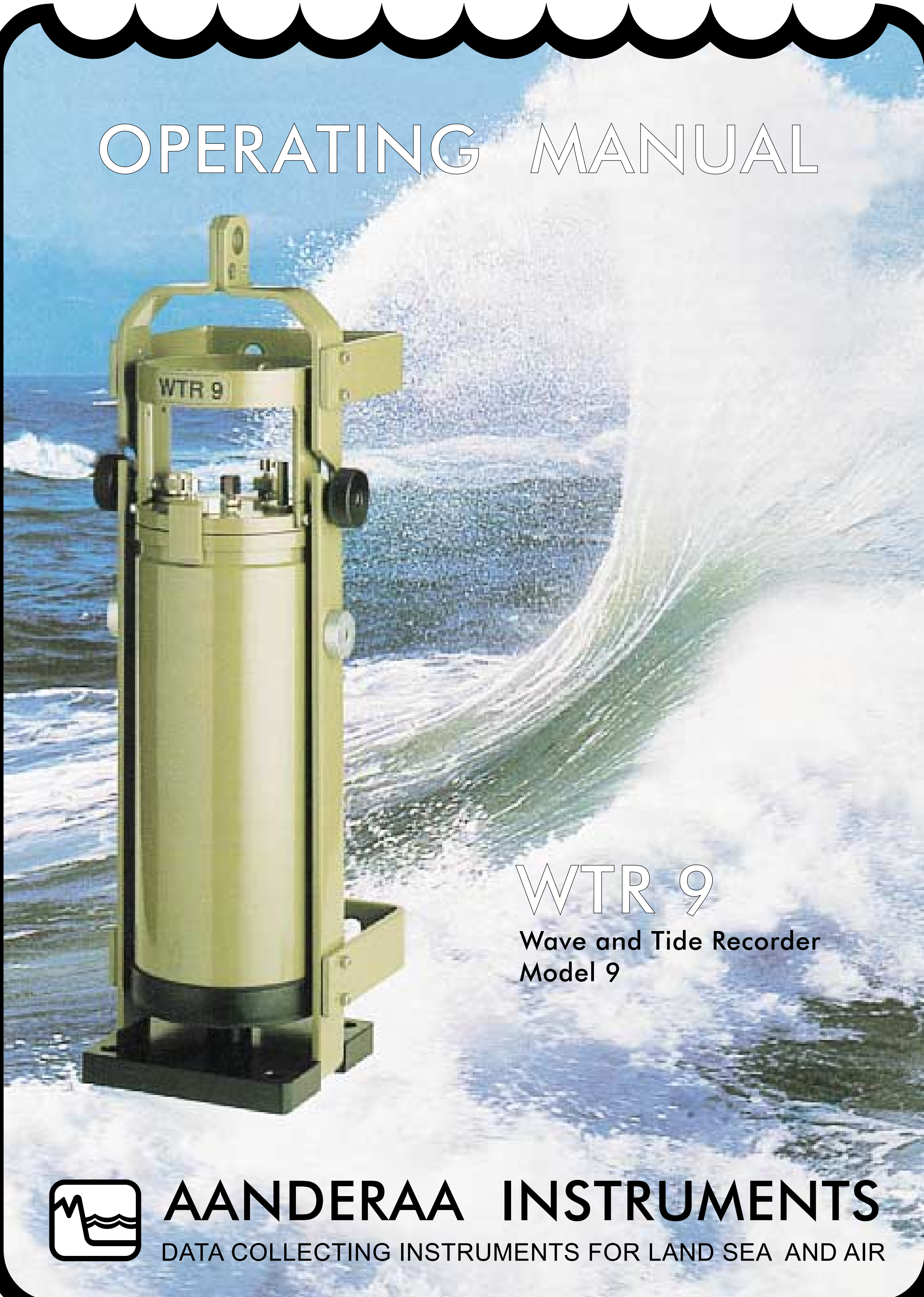
Technical Description No. 194
September 2001

# OPERATING MANUAL




# WTR 9

## Wave and Tide Recorder
## Model 9

AANDERAA INSTRUMENTS
DATA COLLECTING INSTRUMENTS FOR LAND SEA AND AIR

CONTENTS:


| | | Page |
|---|---|---|
| | INTRODUCTION | 0-04 |
| CHAPTER 1. | SHORT DESCRIPTION OF INSTRUMENT | 1-01 |
| | Specifications | 1-03 |
| CHAPTER 2. | THEORY OF OPERATION | 2-01 |
| | Electronic Board | 2-01 |
| | Pressure Measurements | 2-02 |
| | Wave Analysis Program | 3-03 |
| | Depth Setting | 3-04 |
| | Serial Communication | 3-05 |
| | Flow Chart for Wave Analysis Program | 3-06 |
| | Reference and Temperature | 3-07 |
| | Temperature Sensor | 3-08 |
| | Output Signals | 2-09 |
| | Data Storage Unit | 2-10 |
| | Pressure Case | 2-11 |
| | Top End Plate | 2-11 |
| | Mooring Frame | 2-12 |
| | Interconnecting WTR 9 and Signal/Power Cable 3669 | 2-12 |
| CHAPTER 3. | OPERATING INSTRUCTIONS | 3-01 |
| | Receiving a new instrument and taking it into use | 3-01 |
| | Mooring and Deployment | 3-02 |
| | Retrieval of Instrument and Removing DSU | 3-03 |
| | Reading of DSU and Data Processing | 3-04 |
| | PC-compatible Program | 3-05 |
| CHAPTER 4. | MAINTENANCE | 4-01 |
| | Yearly Maintenance | 4-01 |
| | Replacement of parts | 4-01 |
| | Recommended Spares,Consumables and Accessories | 4-01 |
| | Factory Service | 4-02 |
| | Do nots! | 4-02 |
| | Fresh Battery | 4-02 |
| | Check-out List, WTR 9 | 4-03 |
| | Instrument Service Order, Form 135 | 4-04 |

CHAPTER 5. CALIBRATION ....5-01
General ....5-01
Tide and Wave Parameters ....5-01
Temperature ....5-02
Calibration Sheet, WTR 9, sample ....5-03
Calibration Sheet, Temperature sensor 3621 ....5-04

CHAPTER 6. ILLUSTRATIONS ....6-01
Fig. 6.01 WTR 9 in Mooring Frame 3110. ....6.01
Fig. 6.02 WTR 9 Internal View, Electronic Board side. ....6.02
Fig. 6.03 WTR 9 Internal View, Data Storage Unit side ....6.03
Fig. 6.04 Electronic Board 3525 ....6.04
Fig. 6.05 WTR 9 as shipped ....6.04
Fig. 6.06 Mooring Frame 3130 with Wall Bracket ....6.05
Fig. 6.07 WTR 9 Assembly drawing ....6.06
Fig. 6.09 WTR 9 Wiring Diagram V–7270 ....6.07
Fig.6.10 Circuit Diagram, Electronic Board 3525 ....6.08
Fig. 6.11 Test and Specification Sheet, WTR 9 ....6.09
Fig.6.12 Test & Spec. sheet, El. board 3625 ....6.10
Fig. 6.13 Graph 1, Wave Length. WTR 9 ....6.11
Fig. 6.14 Graph 2, Wave Length. WTR 9 ....6.12
Fig. 6.15 Graph 3, Wave Length. WTR 9 ....6-13

# INTRODUCTION

This manual describes the Wave and Tide Recorder WTR9.
This is a high precision instrument measuring wave parameters, water level and temperature. The wave and tide parameters is based on pressure measurements using a high precision quartz pressure sensor.

The use of this instrument requires practical insight in several fields such as mooring, deployment and recovery of instrument, operation and maintenance, sensor calibration, data processing and interpretation. It is our intention to give sufficient background information and documentation for the user to ensure successful operation of the instrument.

# CHAPTER ONE

## SHORT DESCRIPTION OF INSTRUMENT

The wave and tide recorder is designed to measure the significant wave height, the mean zero crossing period, the maximum wave height and the water level.
The instrument measures pressure and temperature and calculates wave parameters at regular intervals.

The data is stored in a removable and reusable solid-state Data Storage Unit (DSU) 2990.

The output parameters/ channels are as follows:

1. Reference.
2. Temperature.
3. Hydrostatic Pressure , most significant part.
4. Hydrostatic Pressure , least significant part.
5. Significant wave height, $H_{m0}$.
6. Mean zero crossing period, $T_{m02}$.
7. Maximum wave height, E[Hmax].

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 water.

The pressure sensor is based on a high precision quartz crystal oscillator. The pressure is measured every 0.5 seconds and 1024 samples are taken (512 seconds) and stored in internal RAM for further wave analysis.
The 80 last measurements are averaged to give the hydrostatic pressure measurement. The hydrostatic pressure measurement is a 20 bit word divided into two channels (each channel is 10 bits).

Based on the time series a spectrum analysis is carried out starting immediately after the recording of the time series. From the wave spectrum the wave parameters described above are calculated.

The parameters/channels are transmitted as Aanderaa standard PDC-4 from the electronic control board to the removable Data Storage Unit. This  PDC-4 signal can also be transmitted by cable to an onshore receiving station.

Figure 6.01 shows the WTR 9. 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 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. A Mode switch with a test and serial communication setting, a depth setting switch and a recording interval switch is built into this board. The quartz pressure sensor is also attached to the board by a shock absorbing bracket.

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 WTR 9,the instrument is delivered with Mooring Frame 3130, see figure 6.01. This frame is used when installing the instrument on the seabed, to a wall, pole, jetty or to an offshore vertical installation. An optional self leveling Mooring Frame, part no.3438 for installation on the sea-bed is also available, see fig.2-12.

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

The specifications of the wave and tide recorders, are as follows:

**Maximum deployment depth:** 60 m
**Recommended deployment depths:** Down to 15 m
**Depth setting:** (selectable)
- Deep water (Pos.1)
- Seabed (Pos.2)
- Set distance from top plate to sea-bed in range 6 - 36.5m (Pos. 3 - 11) User specified position 12

**Operating temperature:** -2.5 to 35°C
**Storage temperature:** -30 to 40°C
**Wave sampling frequency:** 1 Hz/2 Hz (default 2 Hz)
**Number of samplings:** 256, 512 or default 1024

**Output parameters:**

**Ch.1 Reference:** A fixed reading to check performance and to identify individual instruments

**Ch.2 Temperature:**
**Sensor Type:** Thermistor Fenwall GB32JM19
**Accuracy:** ±0.1°C
**Resolution:** 0.04°C
**Range:** -2.5 to +35°C
**Response time:** 30 s

**Ch.3 & 4 Hydrostatic pressure:**
Defined as: Average of 80 last pressure registrations in 512s time series sampled at 2 Hz
**Sensor Type:** Quartz pressure sensor based on a pressure controlled oscillator; frequency 30 - 45kHz
**Inlet port (Reference level ):** 8 mm above top plate
**Range:** 0-690kPa[1)] (aprox. 0 - 60m depth)
**Accuracy:** ± 210Pa
**Resolution:** 7Pa (aprox. 0.07 cm)

**Ch.5 Significant wave height, $H_{m0}$:**
Based on: 512s pressure time series sampled at 2Hz
**Resolution:** 2.0 cm
**Range:** 0-20 m

**Ch.6 Mean zero crossing period, $T_{m02}$:**
Based on 512s pressure time series sampled at 2Hz
**Resolution:** 0.02s
**Range:** 0 - 20s

**Ch.7 Maximum wave height, E [Hmax]:**
Based on: 512s pressure time series sampled at 2Hz
**Resolution:** 2.5cm
**Range:** 0 - 25m

**Output signal:** PDC-4 to DSU 2990 and external unit
**Recording intervals:** Selectable, 0.5,1,2,3,6,12 or 24 hours or remote start.[2)] Stability: ± 2s/day within 0 to 20°C
**External triggering:** A 5 volt positive pulse to the signal output terminal on the top end plate activates the instrument
**Recording System** Aanderaa standard type Data Storage Unit 2990 or 2990E
Data Format: PDC-4. (Pulse Duration Code 4s.)
Storage Capacity:
DSU 2990: 65500 10 bit words
DSU 2990E: 262000 10 bit words

**Power:**
Supply: -7 to -14 volt DC
Battery: 3614 Alkaline Battery, 9V, 15Ah
Average quiescent current consumption: 100µA
Average active current consumption: 10mA

**Materials and finish:**
Pressure case: Epoxy coated Osnisil (95% Cu,3.5% Ni, 0.9% Si)
Top & bottom plate: Epoxy coated acid proof steel
Mooring frame : Acid proof steel SIS 2343
Printed Circuit Board: Cast in polyurethane

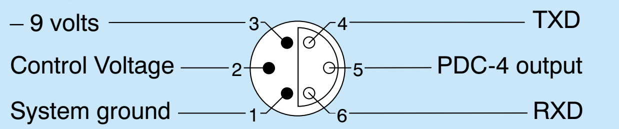
**Dimensions and Weight:**
Height, incl. guard ring: 432 mm
Outer diameter: 128mm
Weight: 13.7kg (in air), 9.2kg (in water)
Height & width, frame: 576 x 141 x169mm
Weight, frame: ~ 3.7kg (in air) ~ 3.2kg (in water)

**Accessories**
Included: Mooring frame 3130
Programming Cable 3709
Optional: Underwater Signal/Power cable 3669 (Max length of cable is 1km)
Deck Unit 3127/Computing Unit 3015
Brackets (2ea.) 3685 for Mooring frame 3130
Self-leveling Mooring frame 3438 for seabed deployment

**Electrical Terminal:**

**PIN CONFIGURATION**

Receptacle, exterior view; pin=●, bushing=○




**Packing:**
Plywood case: 240 x 250 x 600mm

**Warranty:**
Two years against faulty materials and workmanship. Our standard warranty (2 years) is not applicable in cases where breakage or malfunction occur to the cable during installation or when caused by excessive wear or other external forces.

1) Overpressure is 1.5 x range
2) In remote start, the instrument measures continuously and when the remote start trigger pulse is received, the last calculated data is transmitted.

# CHAPTER TWO

## THEORY OF OPERATION

### Electronic Board:

The Electronic Board 3525 shown in figure 6.04 contains the main electronic circuitry of the instrument. It comprises a printed circuit board with screw terminals for sensor connections, supply connection etc. and three control switches all embedded in a polyurethane casting. This design makes the component a solid board which will not be affected by a harsh environment. The electrical functions can be divided into 8 main functions or circuits:

1. Voltage regulator and power on/off circuit.
2. Quartz clock.
3. Control switches.
4. Pressure measurement circuit.
5. RAM.
6. EEPROM
7. ADC and multiplexer.
8. Output signal circuit.

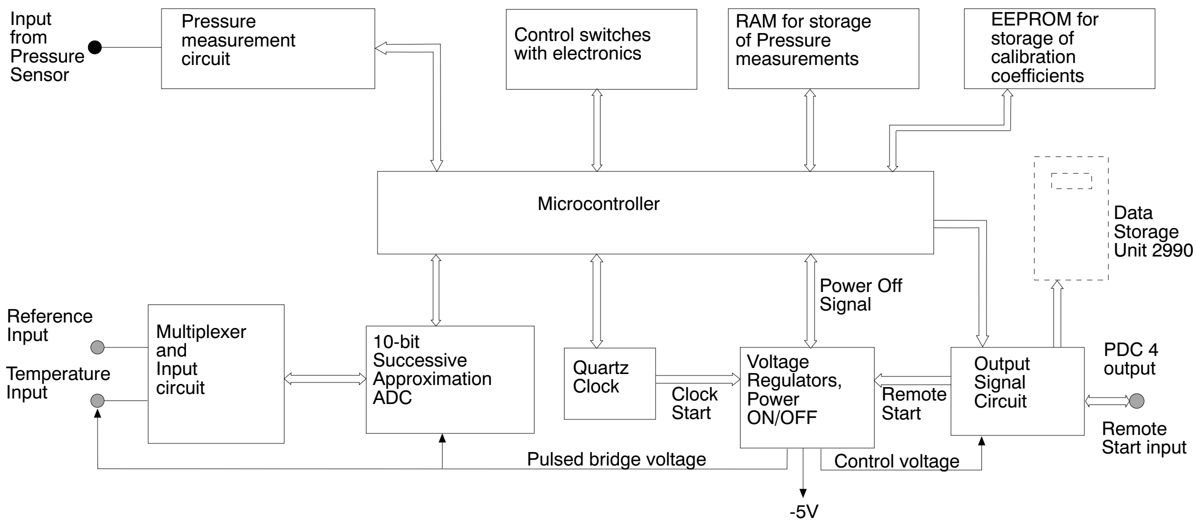



*Fig. 2.01 Block Diagram, El.Board*

The voltage regulator supplies the components on the electronic board and the sensors connected to the board. A pulsed bridge voltage is supplied to the AD-converter circuit, the reference and the temperature sensor.

After power on the internal real-time clock is set to start the instrument 10 to 25 minutes before the selected recording interval. This time is dependent on the selected sampling frequency and number of measurements (for details on settings see page 2-05) as shown in the following table:

| Number of Samples | Sampling Frequency (Hz) | Time Interval (minutes) |
|---|---|---|
| 256 | 2 | 10 |
| 256 | 1 | 15 |
| 512 | 2 | 15 |
| 512 | 1 | 15 |
| 1024 | 2 | 15 |
| 1024 | 1 | 25 |

The electronics are in a quiescent state until they are woken by the clock. Then 1024 pressure samples are taken at a 2 Hz sampling speed (default setting). This takes 512 seconds (8.5 minutes). If lower power consumption is required, the number of samples can be changed to shorten the measuring period. The highest accuracy is acheived with the default setting.

After the measurements are taken, the instrument calculates the wave parameters. When the calculations are completed the electronics fall into a quiescent state until the real-time clock wakes them again to output the data after the first recording interval.

Available recording intervals are $^1/_2$, 1, 2, 3, 6, 12 and 24 hour. The recording interval switch has also got a remote start position. In the remote start mode the instrument measures continuously. On reception of a 5V remote trigger pulse on the PDC-4 output the last calculated data is transmitted.

If the remote triggering interval is too short (time between two pulses), the data is not updated on each triggering. The remote triggering interval has to be long enough to enable at least 256 samples to be taken.

## Pressure measurement

The WTR9 uses a high precision quarts pressure sensor from Pressure systems. This sensor has a frequency output inverse proportional to the pressure applied, where the nominal zero frequency is 40kHz and the span is approximately 4kHz.

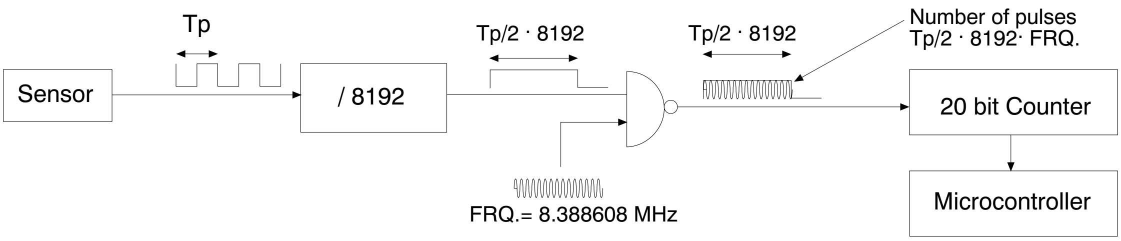
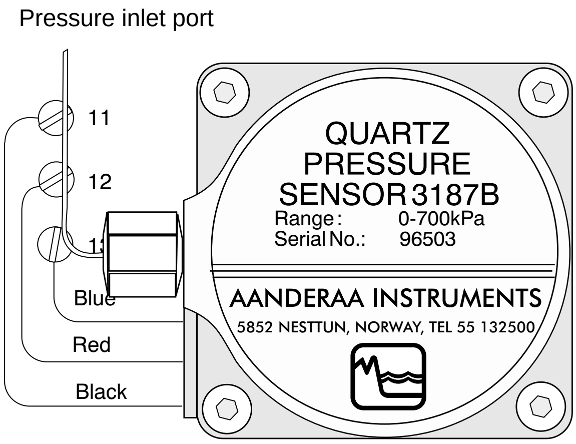



*Fig. 2-02 Pressure Block diagram*

The frequency output from the sensor is first divided by 8192. This gives a time window/period that gates a high frequency further to a 20-bit counter. The high frequency count is a direct measure of the signals period, and the period of the sensor signal can be calculated as $Tp = C/(4096 \cdot FRQ)$, where C is the value from the 20-bit counter, FRQ is the high frequency value and Tp is the time period of the signal from the sensor.

The counter is read by a microcontroller and the time period Tp is calculated using the formula described above. Thereafter the calibration coefficients from Pressure systems, which is stored in an internal EEPROM circuit is used to convert the time period to pressure in psia. The temperature has to be measured prior to this to give a temperature compensation.




The calibration formulas from Pressure Systems scientific are as follows:

$$P = C\cdot(1-T_0^2/T^2)\cdot(1-D\cdot(1-T_0^2/T^2))$$

where P is the pressure in psia, T is the time period and

$$C = C_1+C_2\cdot U+C_3\cdot U^2;\ D = D_1+D_2\cdot U \text{ and } T_0 = T_1+T_2\cdot U+T_3\cdot U^2+T_4\cdot U^3+T_5\cdot U^4$$

where U is the temperature in centigrade; $C_1, C_2, C_3$, $D_1, D_2, D_3$, and $T_1, T_2, T_3, T_4, T_5$ are the coefficients provided by Pressure Systems.

Each pressure measurement takes approximately 100ms (102.4-114ms if sensor frequency is 40-36 kHz). The pressure is measured every 0.5 seconds (2Hz sampling frequency ) and 1024 measurements are taken. The measurements are stored in internal RAM for further analysis.

Wave analysis program

Based on the 512s pressure time series, a pressure spectrum is computed using a Discrete Fourier Transform (DFT). The pressure spectrum is converted to a wave spectrum by multiplying each spectral component by a pressure to surface elevation-transfer function.

The wave induced pressure in the ocean decreases exponentially with depth. This implies that at a given depth and for wave frequencies > $f_{cutoff}$, the wave induced pressure is below the detection limit of the WTR 9. Accordingly, the wave spectrum is only calculated for the frequency range [$f_{min}$, $f_{cutoff}$] where $f_{min}$ is 1/T, where T equals the duration of the time series (512 s).

| Deployment depth[m] | $f_{cutoff}$ [Hz] |
|---|---|
| > 5 | 0.5 |
| 5-10 | 0.33 |
| 10-15 | 0.31 |
| 15-20 | 0.27 |
| 20-30 | 0.23 |
| 30-40 | 0.19 |
| 40-50 | 0.17 |
| 50-60 | 0.16 |

Based on the wave spectrum S(f) the moments $m_k$ are defined as $\int f^k\, S(f)df$.

The significant wave height, Hm0 is defined as $4(m_0)^{1/2}$, the mean zero crossing period, $Tm_{02}$ is defined as $(m_0/m_2)^{1/2}$ and the maximum wave height, $H_{max}$ is defined as

$$0.25\ Hm0(\ ßln\ (K)^{1/\alpha}[1+0.5772/(\alpha ln(K))]$$

where K is the number of waves occurring, i.e T/Tm02, and α and ß are constants. The expression for $H_{max}$ is the expected value of the maximum wave height for the observed Hm0.

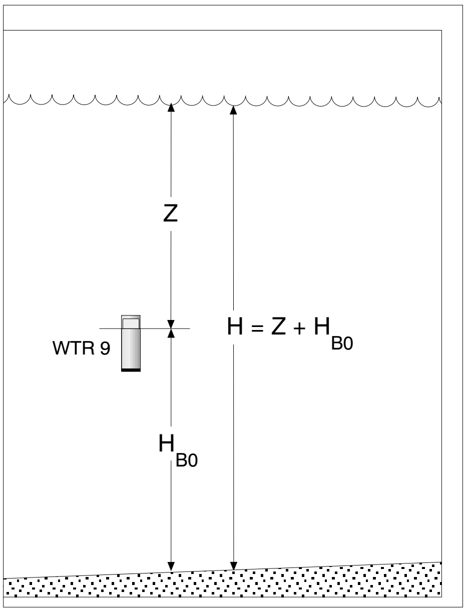
Depth Setting

In each case the user must determine the deployment depth in view of the tidal variations, the expected wave heights and the requirements on the wave measurement. It is recommended to deploy the WTR 9 in the range 5 to 15m below the undisturbed sea surface.

In order to calculate the “pressure to surface elevation transfer function”, the distance from the top plate to the sea bed must be approximately known.

A total of 12 depth ranges can be selected using the depth setting switch. Pos. 1 corresponds to deep water and Pos. 2 corresponds to deploying the instrument on the bottom in a dedicated bottom frame. Pos. 3 to 11 represent distances from the top plate to the sea bed in the range 6 m to 36.5 m. The user can also set the distance from PC, and set the depth setting switch to position 12 (see page 2-05 and 2-06 for details). The deep water setting should be used for water depths exceeding 50 m. Z is the distance from the pressure inlet port to the sea surface. $H_{B0}$ is the distance from the top end plate to the sea bed. H is the water depth. $H = Z + H_{B0}$

Z is measured by the WTR 9 and $H_{B0}$ is selected using the depth setting switch positions 2-12. The settings are:




| Position | Water Depth |
|---|---|
| 1 | Deep water (H ≥ 50m) |
| 2 | 0,45-0,55m ($H_{B0}$ ≈ 0,5m) |
| 3 | 6-7,5m ($H_{B0}$ ≈ 6,7m) |
| 4 | 7,5-9m ($H_{B0}$ ≈ 8,3m) |
| 5 | 9-11m ($H_{B0}$ ≈ 10m) |
| 6 | 11-13,5m ($H_{B0}$ ≈ 12,2m) |
| 7 | 13,5+16,5m ($H_{B0}$ ≈ 15m) |
| 8 | 16,5-20m ($H_{B0}$ ≈ 18,3m) |
| 9 | 20-24,5m ($H_{B0}$ ≈ 22,2m) |
| 10 | 24,5-30m ($H_{B0}$ ≈ 27,2m) |
| 11 | 30-36,5m ($H_{B0}$ ≈ 33,3m) |
| 12 | User Specified |

This depth setting information is printed on the reverse side of the electronic board. Remove the DSU 2990 to get access to this information.

Position 1 should be selected if the water depth H ≥ 50m. If position 1 is selected or the selected distance $H_{B0}$ plus the measured instrument depth Z is ≥ 50m then the wave analysis program uses a deep water transfer function. Otherwise it uses a finite depth transfer function.

Serial Communication

Connect the PC to the WTR 9 with the Programming Cable 3709. Use a serial communication program, 9600 baud, no parity, 8 data bit, 1 stop bit. Set the Mode Switch to the ‘MENU’ position. This menu is displayed on the PC´s screen.

SETTINGS

1. Depth setting (distance from Top Plate to seabed).
2. Number of samples (256/512/1024).
3. Sampling frequency (1Hz/2Hz).
4. Display settings.

?. Show this menu.

This enables the user to set the accurate distance from the top endplate to the seabed. The depth setting entered by the user is only used when the depth setting switch is in position 12. It is also possible to select the numbers of samples and the sampling frequency. The default settings are 0.5m, 1024 samples and 2 Hz.

## Flow Chart for Wave Analyzis Program

1)
Pressure Raw Time Series

Pressure measured every 0,5s.
The 1024 samples are stored in RAM.
This is period measurements of the Quarztronix frequency output.

2)
Pressure time series with "DC offset", converted to [Pa]

The absolute pressure measured consists of hydrostatic pressure and wave induced pressure

3)
Calculation of average pressure $\bar{P}$

All the samples are added and divided by the number of samples to get the hydrostatic pressure.

4)
Pressure time series only "AC-component" in [Pa]

Wave induced pressure=
Absolute pressure - hydrostatic pressure

5)
Fourier Transformed pressure time series and squared out to get the pressure spectrum.

$fj = j \frac{1}{T}$, T = 512s

$f_0$ = 2Hz, sampling frequency

The pressure spectrum is multiplied with a pressure to surface elevation transfer function to get the correct spectrum.
Two transfer functions are used, one for deep water(depth>50m) and one for finte depth.

6)
Wave Spectrum

7)
Calculation of Significant Wave Height, mean zero crossing period and maximum wave height.

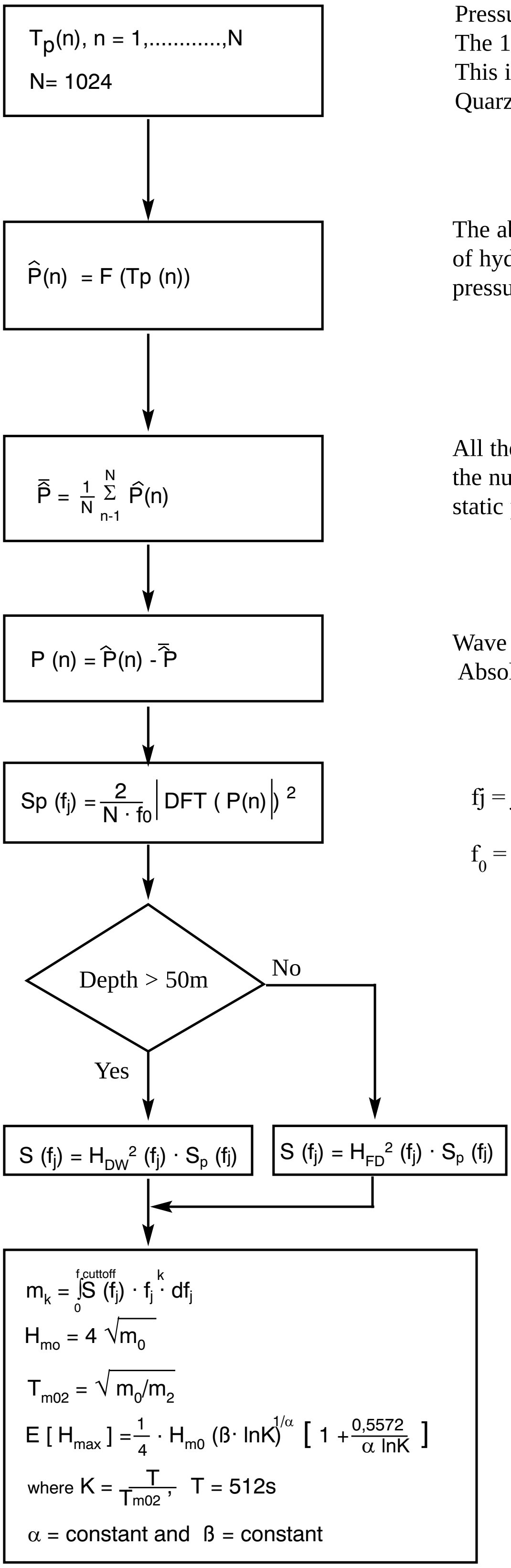



*Fig. 2.03 Flow Chart for Wave Analysis Program*

Reference and Temperature

The WTR9 uses a 10-bit successive approximation AD-converter to measure the reference setting and the temperature sensor. This ADC converts analog VR22 signals (Voltage range 1/22). When reading an analog VR22 signal, the sensor acts as the left half of a Wheatstone measuring bridge, and an R-2R network inside the electronic board as the other half of the bridge (see figure 2.01). The bridge is balanced successively in 10 binary steps by setting the switches $S_1$,$S_2$...$S_{10}$.

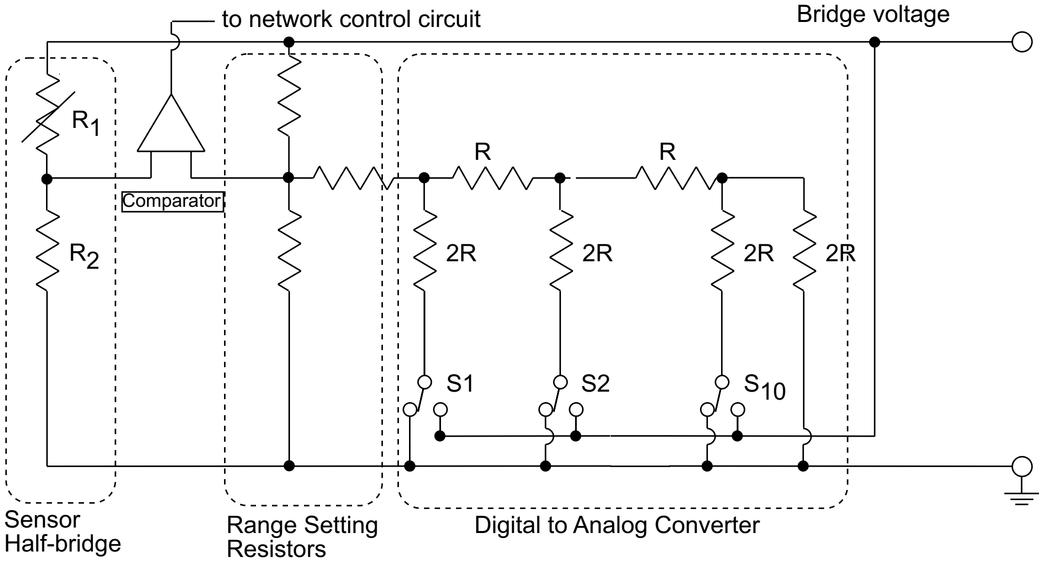



*Fig. 2.04 VR22 Measuring Circuit*

This cycle forms a 10 bit binary word that represents the ratio between the resistors in the half bridge of the sensor.

By equipping the sensor bridge with one resistor that varies with the parameter that needs to be measured i.e temperature, a simple sensor is made. Since such sensing resistors usually has a relatively small change of resistance in the measuring range, the output range of VR22 sensors are set to be 1/22'nd. of the applied Bridge Voltage varying ±1/44'th around the middle.

A multiplexer makes it possible to read both the reference voltage and the temperature sensor voltage with the same AD-converter input.

The reference consists of to resistors in a half bridge configuration. By choosing appropriate resistor values, it is possible to get a reading between 0 and 1023. The reference reading acts as a performance check and is also used to identify individual instruments.

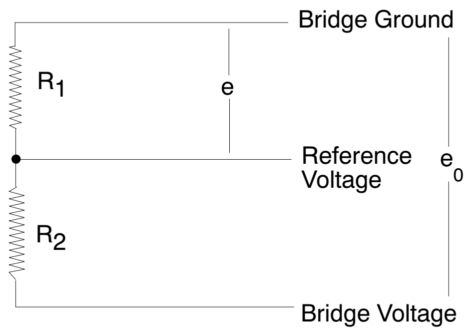



*Fig. 2-05 Reference circuit*

The output signal from the reference resistors:

$$e = \frac{R_1}{R_1 + R_2} \quad e_0$$

where $e_0$ is the applied bridge voltage. When connecting the the sensor to a data logging system with scanning range $^1/22$ of the bridge voltage, the reading N will be:

$$N = \left( \frac{R_1}{R_1 + R_2} - \frac{21}{44} \right) 22 \cdot 1023$$

Temperature sensor 3621.

The temperature sensing thermistor is housed in a stainless steel stud, fitted to the top end plate by a 16mm stem and extends into the water. The thermistor, Fenwall GB 32JM19, is molded into the stud with polyurethane. The time constant for the temperature to reach 63% of a step change in temperature is about 12 seconds. Together with a set of resistors the thermistor forms a half-bridge.

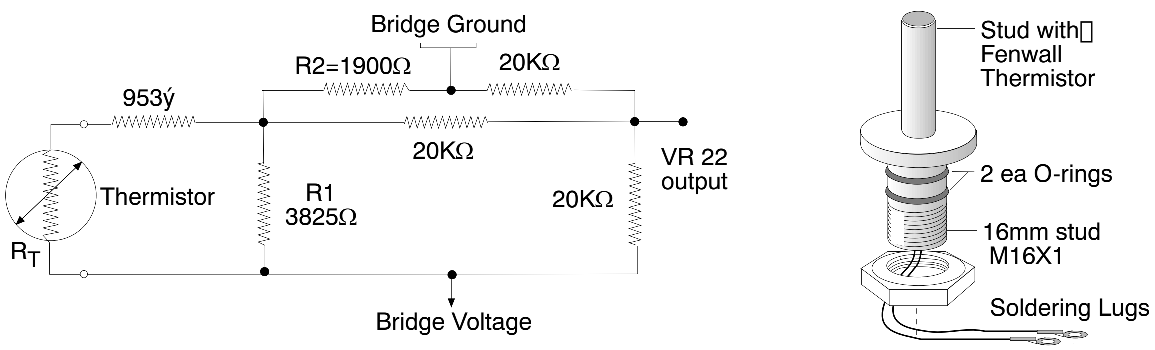



*Fig.2.06 Temperature sensor and measurement circuit*

The temperature raw data reading N is a function of the thermistor resistance $R_T$ as well as the range reducing resistors $R_1$ and $R_2$. The following formula gives the raw data:

$$\text{Raw Data }(R_T) = \left[ \frac{R_1\,R_2\,(R_T + 953 + 40K) + 20K\,(R_T + 953)\,(R_1 + 2R_2)}{2R_1\,R_2\,(R_T + 953 + 30K) + 60K\,(R_T + 953)\,(R_1 + R_2)} - \frac{1}{2} \right] \cdot 22 \cdot 1024 + 512$$

When Fenwal's data over nominal thermistor resistance versus temperature is inserted in the above formula, the following table can be calculated:

| Temperature,°C | $R_T$ ohm | Raw Data N |
|---|---|---|
| -2.5 | 6386.2 | 8 |
| 0 | 5700.0 | 69 |
| 5 | 4564.7 | 199 |
| 10 | 3680.1 | 334 |
| 15 | 2985.8 | 474 |
| 20 | 2437.2 | 613 |
| 25 | 2001.0 | 751 |
| 30 | 1652.1 | 883 |
| 35 | 1371.5 | 1008 |

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 7 words (channels) 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 below.

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

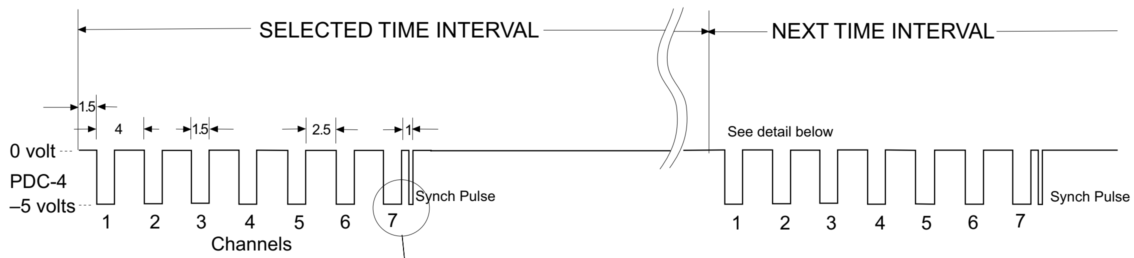



*Fig. 2.07 Timing Diagram of one Record*

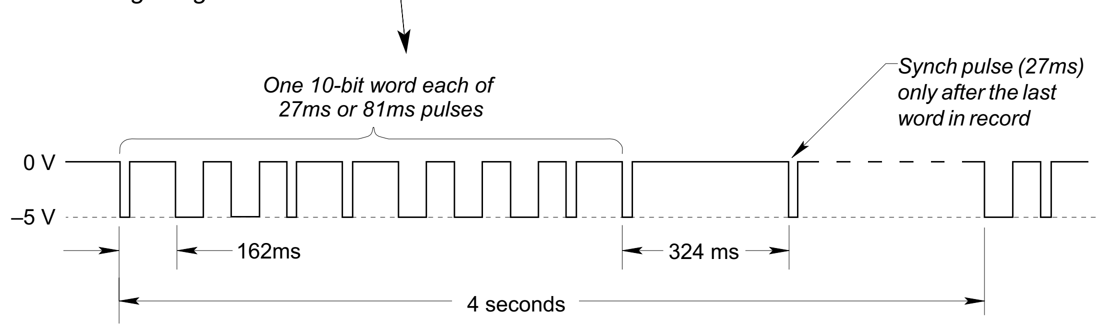



*Fig. 2.08 One 10-bit word (Binary 1001100011 shown) PDC-4 code output pulses.*

## Main Components

Data Storage Unit.

The Data Storage Unit (DSU) fig 2-09, is a solid board molded in low density polyurethane. It contains a set of EEPROMs for indefinite storage of data. On the top edge there is a 6-pin receptacle 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. Within 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, labeled 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 measurements after midnight. The clock features automatic leap year compensation.

Storage capacity is 65500 10-bit words. When the unit is full, the input port is blocked. A special version, 2990X will continue to receive new data after it is full thus deleting the oldest data.

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.

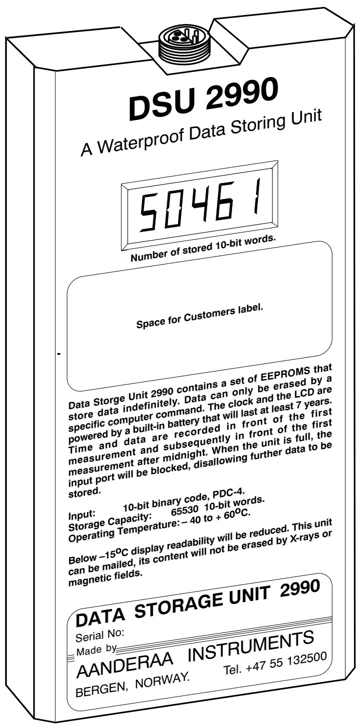



*Fig. 2-09 Data Storage Unit 2990*

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.

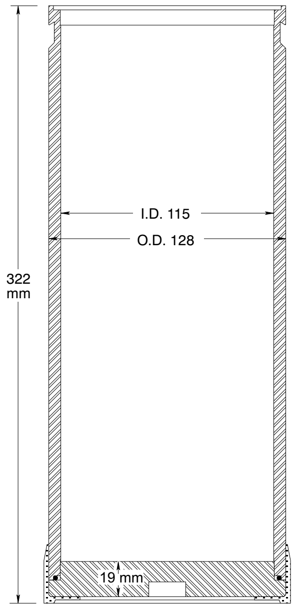



*Fig. 2-10 Pressure case 1171B*

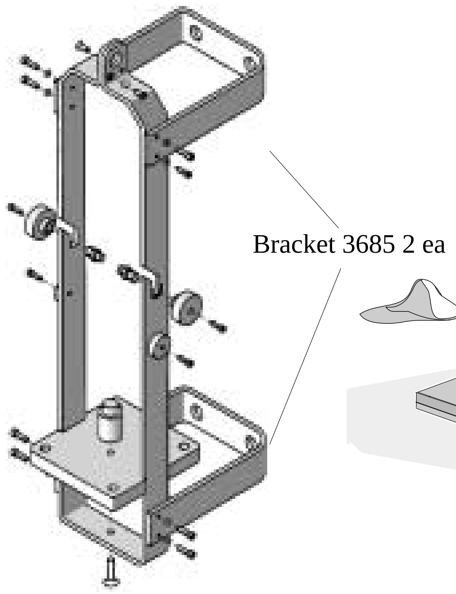
Top end plate.

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. The Watertight Receptacle 3622 on the topend plate mates with plug 2828L.

## Mooring Frame

Two mooring frames are available to ease the installation of the WTR 9.

Mooring frame, part no. 3130, with Brackets 3685 is used when installing the WTR to a pole or a jetty, see below. However, it can also be used for installation on the seabed but then the brackets are not needed. 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 can be fastened to a mooring weight of concrete by 4 stainless steel bolts (1/2"). Mooring frame, part no. 3438 is self-leveling and can also be used when placing the WTR on the seabed. The frame can also be equipped with an underwater signal/power cable that brought ashore will provide real time data as well as power to the instrument from shore.



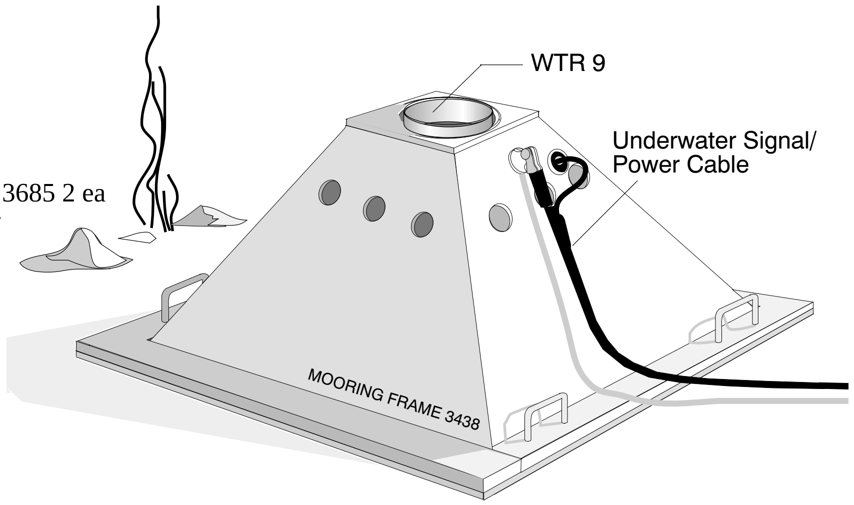
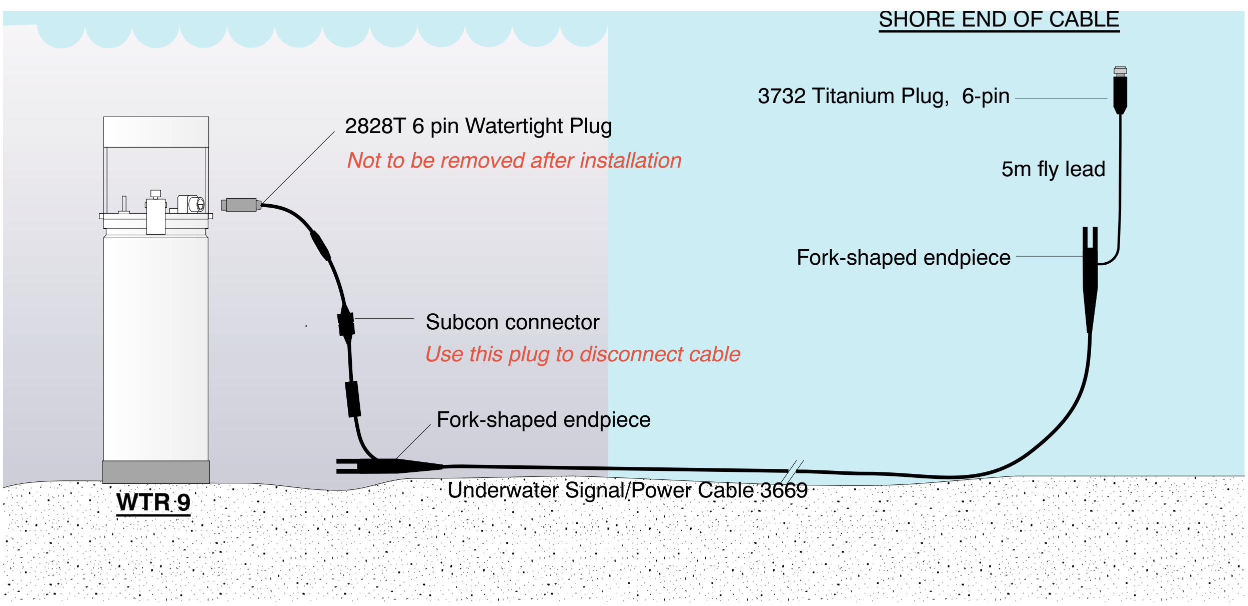




*Fig. 2-11 Mooring frame 3130* *Fig. 2-12 Mooring Frame 3438*

*Fig. 2-13 Interconnecting WTR9 and Underwater Signal/Power Cable 3669*



# CHAPTER THREE

## OPERATING INSTRUCTIONS

### Receiving a new instrument and taking it into use.

The instrument with mooring frame is shipped in one plywood case, see figure 6.05. When shipped, the unit is furnished with battery and the clock in the Data Storage Unit (DSU) 2990E is set to GMT. The only preparation needed is to check that the recording interval switch and the depth setting switch are set as desired. Before doing so, it is recommended that the unit is checked for possible shipping damage.

If everything looks OK, prepare the instrument 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 Recording Interval Switch as desired.

3) Set the Depth Setting Switch. See chapter 2, page 2-04 for details.

4) Place the ON/OFF Switch to the test mode position. Now the measuring cycle starts and the instrument does a 40 second pressure measurement and the DSU records time information and one measuring cycle of the 7 channels. At the end of the cycle, aprox. 68 seconds, the DSU display will show 00013.( 6 words for time information and 7 words for the sensor channels.
5) Set the switch to ON position and 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-clamp.

Note!
The Cover Cap 3007 must be fitted to the watertight receptacle and tightened up to avoid leakage.

The instrument can now be fastened to the Mooring Frame and deployed.

Mooring and deployment.

The different uses of this instrument call for variety of mooring arrange-ments. Details of mooring will not be given here, but examples are shown in the illustration below, see figure 3.01. Please be aware that the distance from the bottom of the instrument to the pressure inlet port(reference level) is 355 mm.

A. A recording only WTR 9 is installed in Mooring Frame 3130 and placed on the sea-bed. The location is marked with a retrieval buoy.

B. The second example shows two ways of installing the WTR 9 for real-time transfer of data from the WTR 9. The same mooring fixture can be used for sea-bed installation as well as fastening the instrument to a pier or a jetty. The real-time data is brought ashore by use of the underwater signal/power cable whish is connected to Relay Station 2960. Data is sent further, via VHF radio or satellite transmitter.

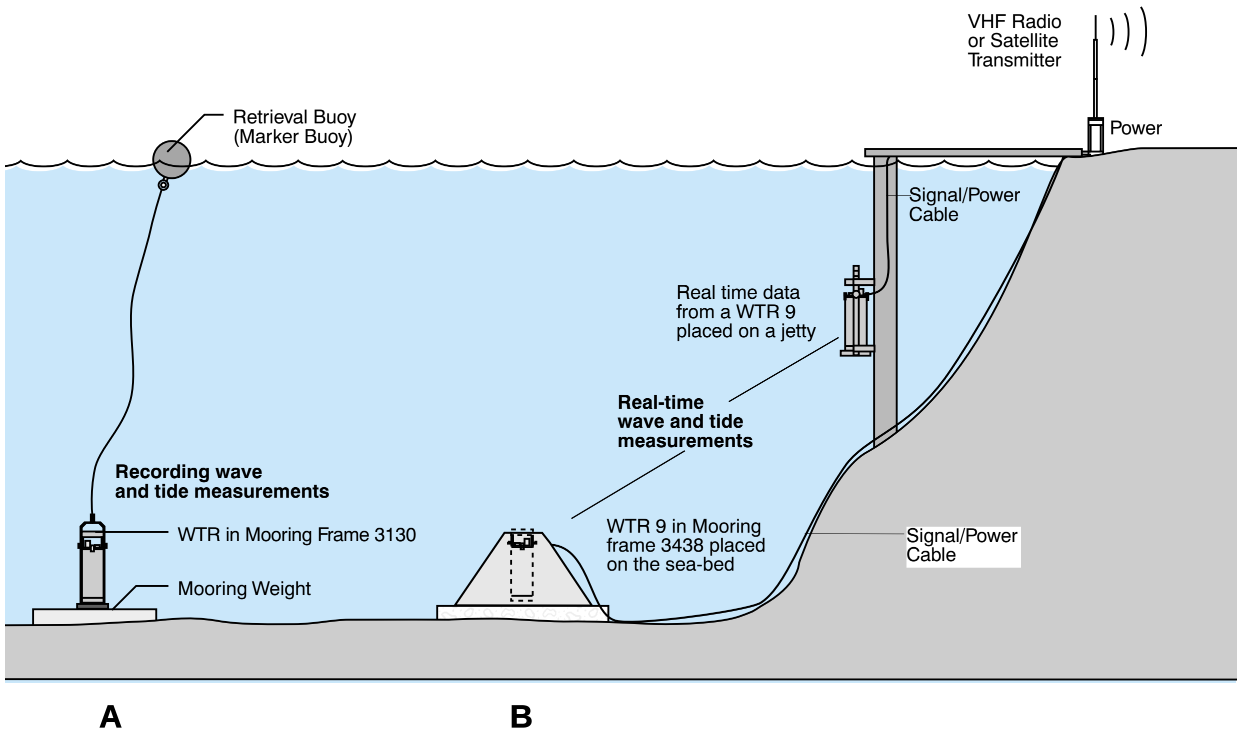



*Fig. 3.01 Typical moorings for WTR 9.*

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.

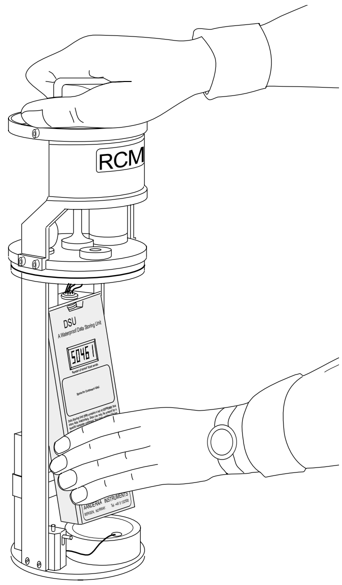



*Fig. 3.02 Installation of DSU 2990*

*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. Send the DSU back to the factory for servicing.

READING OF DSU AND DATA PROCESSING

Stored data is read by connecting the Data Storage Unit (DSU) 2990 via a DSU Reader 2995, to the RS-232C port of a computer, see figure 5.01. 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-pin D-connector at the other, connects the DSU Reader to the PC's serial input port.

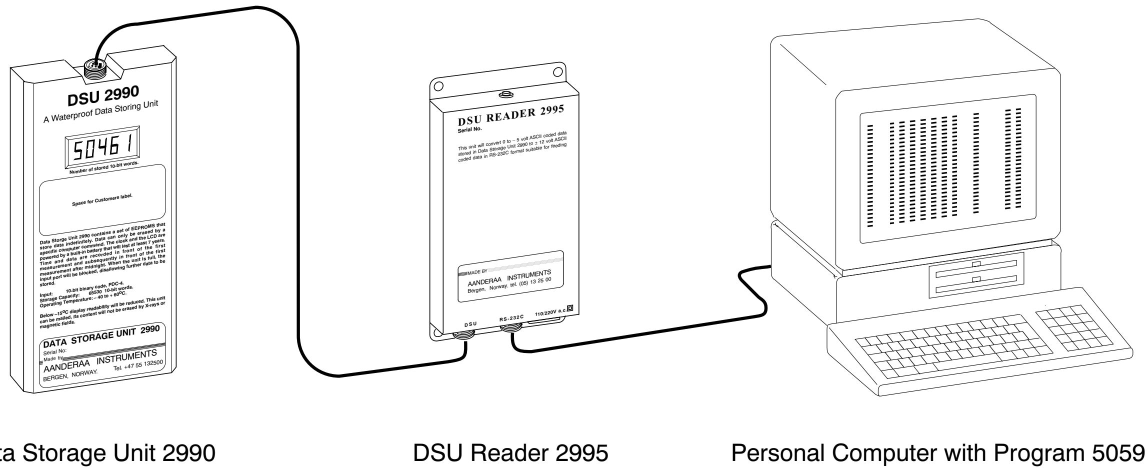



FIG. 3.03 Data Reading

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 characters.

**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 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.

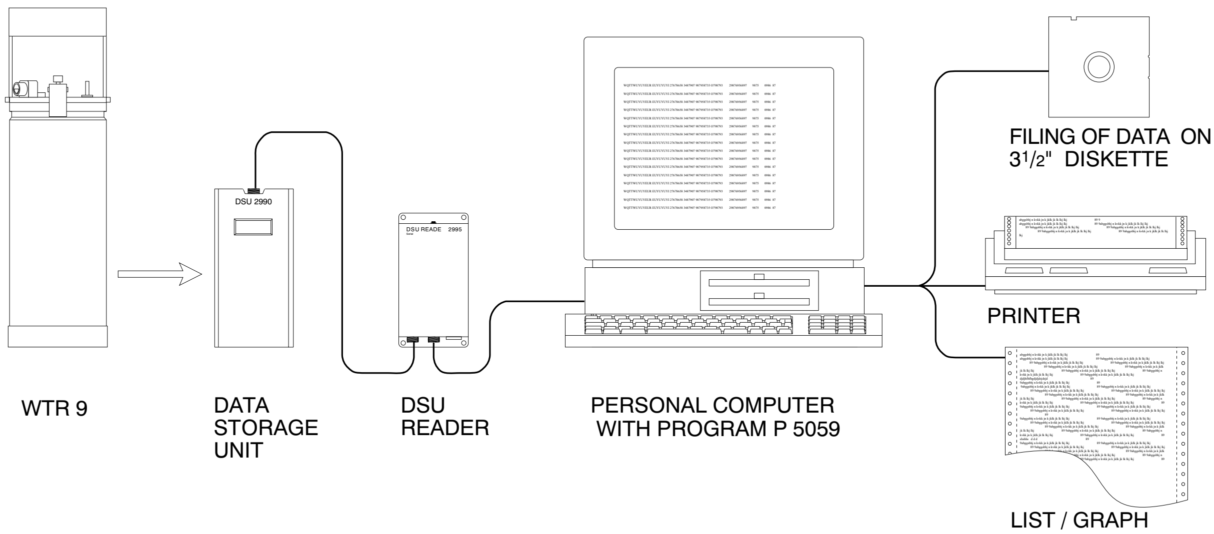



*FIG. 3.04 Data Reading System*

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 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

# CHAPTER FOUR

## MAINTENANCE

The WTR 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.

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.

### Replacement of parts.

Spare parts are available from the factory or from appointed resellers. All spares comes with necessary fastening screws.

Each WTR 9 is delivered with a set of recommended spares, consumable parts and accessories.

**Recommended Spares, Consumables and Accessories 3683**

| Qty | Part No. | Description | Qty | Part No. | Description |
|---|---|---|---|---|---|
| 1 | 2577 | Tectyl 205, 5 cl. | 1 | 963026 | Zinc Anode |
| 1 | 2579 | Repair Lacquer, 5 cl. | 1 | 963346 | Sealing Plug, for 16mm stud |
| 1 | 865000 | O-ring, SOR 72 | 1 | 642100 | Umbraco Screw, M 15X12 |
| 4 | 862006 | O-ring, for 16mm stud. | 1 | 913002 | Allen Key, for 4mm Screw. |
| 1 | 913003 | Wrench for C-clamp. | 1 | 750015 | Glass spheres, 3.369mm |
| 1 | 913018 | Wrench, 19mm for 16mm nut. | 1 | 963360 | Nut, stainless steel |

**Maintenance Kit 3814**

| Qty | Part No. | Description | Qty | Part No. | Description |
|---|---|---|---|---|---|
| 2 | 642100 | Umbraco Screw, M 15X12 | 1 | 920104 | Customer Label, DSU 2990 |
| 2 | 865000 | O-ring, SOR 72 | 1 | 963384 | Pressure Inlet |
| 1 | 963026 | Zinc Anode | 1 | 3738 | Grease for O-rings, 50ml |
| 1 | 2577 | Tectyl 205, 5 cl. | 1 | 3739 | Un-lock, 50ml |
| 1 | 2579 | Repair Lacquer, 5 cl. | | | |

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. See page 4-04. 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.

Fresh battery.

When using **Alkaline Battery 3614** 9 volt, 15 Ah. and Data Storage Unit DSU 2990, the deployment time is given in the table below.

| Recording intervals | Deployment time |
|---|---|
| 0.5 hour | 3.9 months |
| 1 hour | 7.7 months |
| 2 hours | 14.5 months |
| 3 hours | 20.7 months |
| 6 hours | 35.5 months |

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

SAMPLE

**Serial No.:** ......................

**Visual and Mechanical Checks:**

1. Epoxy coating intact: ............ ☐
2. No corrosion, O-ring groove Pressure Case: ............ ☐
3. No corrosion, other parts: ............ ☐
4. No marine fouling: ............ ☐
5. Zinc anode installed: ............ ☐

**Performance Test:**

Use a Deck Unit 3127 to read the data from the instrument, or read the contents of the DSU2990

First Test Run:

| Channel No. | Parameter | Reading | Reading O.K |
|---|---|---|---|
| 1 | Reference | | |
| 2 | Temperature | | |
| 3 | Hydrostatic pressure, MSW | | |
| 4 | Hydrostatic pressure, LSW | | |
| 5. | Significant wave height | | |
| 6 | Mean zero crossing periode | | |
| 7 | Maximum wave height | | |

**Second Test Run:**

| Channel No. | Parameter | Reading | Reading O.K |
|---|---|---|---|
| 1 | Reference | | |
| 2 | Temperature | | |
| 3 | Hydrostatic pressure, MSW | | |
| 4 | Hydrostatic pressure, LSW | | |
| 5 | Significant wave height | | |
| 6 | Mean zero crossing periode | | |
| 7 | Maximum wave height | | |

To decide whether a reading is O.K. or not compare it with the calibration sheet and use the coefficients given there. The significant wave height and the maximum wave height gives a low reading in atmospheric pressure (normally 1) and the mean zero crossing period gives a high reading.

**Deployment Preparation:**

Fresh main battery installed: ☐ Type:............ Open loop voltage ............
Voltage with 100ohm load:............ DSU erased: ☐ DSU installed: ☐ DSU labeled :☐
Time of first measurement: ............day:............month: ............year:............hour: ............minute: ............GMT:☐ LT:☐
Check that the pressure input port is clean and free of obstacles. Using a syringe, refill the pressure inlet port with 100 centiliters of Dowcorning 1255 silicon oil: ☐
O-ring inspected, cleaned and greased: ☐
C-clamps tightened: ☐

**Retrieval Phase:**

Recording Unit cleaned and rinsed in fresh water:

Time of first measurement: ............day:............month: ............year:............hour: ............minute: ............GMT: ☐ LT:☐

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

............

............

*Fig. 4. 01 Check-out list, WTR 9*

Date ............Sign ............

AANDERAA
INSTRUMENTS
5852 Bergen, Norway.Tel. + 47 55 10 99 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. 4. 02 Instrument Service Order ( Form 135 )*

# CHAPTER FIVE

## CALIBRATION

### General

Each WTR9 is calibrated at the factory prior to delivery. Normally this calibration is valid for several years, unless a change has been made to the instrument, i.e. change of temperature sensor or pressure sensor.

The relation between the sensor readings (N) and the various quantities in physical units (y) is given as a power series of third degree:

$$y= A+B\cdot N+C\cdot N^2+D\cdot N^3$$

The coefficients A,B,C and D are found using the method of least squares.

The calculated calibration coefficients are written to the EEPROM circuit on the electronic board , and these coefficients are used by the microcontroller to convert from raw data to engineering units. Since the output from this instrument is integer values, the output parameters are scaled prior to output to maintain the resolution. Thus the calibration coefficients provided by us in the calibration sheet are fixed coefficients for inverse scaling of the output parameters.

### Tide and Wave parameters

These parameters are calculated based on precise measurements of hydrostatic pressure.This instrument uses a high precision pressure sensor from Pressure Systems, range: 0-690 kPa.

The calibration coefficients provided by Pressure Systems are written to the EEPROM circuit on the electronic board. The microcontroller uses these coefficients to convert the raw data to pressure. The sensor is checked against a dead weight tester prior to installation.

The hydrostatic pressure given in channel 3 and 4 is the average of the last 80 pressure samplings taken in the pressure time series (80·0.5s = 40s). Channel 3($N_3$) is the most significant part and channel 4($N_4$) the least significant part, and the hydrostatic pressure reading N is calculated as follows:

$$N= N_3\cdot 1024+ N_4 \qquad \text{(Pascal)}$$

This value can be used to calculate the water depth using the formula:

Depth(N) = (N-atm)/(d·g)    (meter)

where atm is the atmospheric pressure (Pascal), d is the water density ($kg/m^3$) and g is the gravitational acceleration ($m/s^2$).

## Temperature

The ISO-curve type thermistor used in this sensor has well defined characteristics where the coefficients C and D in the formula on page 5-01 make no significant difference to the individual sensor. Thus factory calibration of individual sensors is restricted to measurements at two different temperatures from which the values of A and B are calculated and stored in the EEPROM. The calculation is performed with fixed C and D coefficients.

These measurements are performed with the instruments immersed in a temperature stabilized bath which is stirred to avoid temperature gradients. The temperature is measured by a platina thermometer (Automatic Systems Laboratories, model F25) which is frequently checked against an Equiphase Cell *(Trademark of Trans-sonic, Inc., Burlington, Massachusetts.)* establishing the triple point of water (0.01 °C).

During calibration, the instrument must be allowed sufficient time for proper temperature stabilization. This takes normally 1,5 to 2 hours.

AANDERAA INSTRUMENTS
5050 Nesttun, Norway.Tel. + 47 55 13 25 00

**Calibration Sheet**

**Wave and Tide Recorder, WTR 9**

Serial No.......................................

Reference (Channel 1):..................



| **Components included** | **Model No.** | **Serial No.** |
|---|---|---|
| Electronic Board | 3525 | |
| Temperature sensor | 3621 | |
| Pressure Sensor | 3187B | |

**Temperature**
The instrument is submerged in a temperature regulated bath during calibration. The calibration coefficients are used by the instrument to convert the raw data to degrees Centigrade. Accuracy = ±0.1°C
Temperature reference: Automatic Systems Laboratories model F25

Calibration control:

| | | |
|---|---|---|
| Temperature in water,°C | | |
| Temperature Reading WTR 9, °C | | |

**Pressure**
The coefficients provided by the manufacturer, Pressure Systems, are used by the instrument to convert raw data to pressure in Pascal.
The hydrostatic pressure reading is checked against a dead weight tester. Because this reading is devided between two channels, channel 3 (N3) and channel 4 (N4), the hydrostatic reading is calculated as N = N3   1024 + N4 and used in the formula described below. Accuracy = ± 210 Pa

Pressure reference: Budenberg, Model 280D
Calibration control:

| | | | |
|---|---|---|---|
| Pressure (Pa) | | | |
| Pressure reading, WTR 9 (Pa) | | | |

**Calibration coefficients (scaling coefficients):**
The calibration coefficients obtained during calibration are stored in an EEPROM on the electronic board. The microcontroller uses these coefficients to convert raw data to engineering units.
The output parameters are presented as integer values. To maintain the resolution the output parameters are scaled prior to output. An inverse scaling is necessary to get the correct values. The formula $A + BN + CN^2 + DN^3$ is used to convert the instruments output to correct engineering units.

| Channel | Parameter | A | B | C | D | Unit |
|---|---|---|---|---|---|---|
| 1. | Reference | 0.000E+00 | 1.000E+00 | 0.000E+00 | 0.000E+00 | - |
| 2. | Temperature | -5.404E-00 | 4.040E-02 | 0.000E+00 | 0.000E+00 | C |
| 3 and 4. | Hydrostatic pressure | 0.000E+00 | 1.000E+00 | 0.000E+00 | 0.000E+00 | Pa |
| 5. | Significant wave height | 0.000E+00 | 2.000E-02 | 0.000E+00 | 0.000E+00 | m |
| 6. | Mean zero crossing point | 0.000E+00 | 2.000E-02 | 0.000E+00 | 0.000E+00 | s |
| 7. | Maximum wave height | 0.000E+00 | 2.500E-02 | 0.000E+00 | 0.000E+00 | m |

Form 458
September1997

Date:................................................ Sign.:..........................................................................................................

AANDERAA INSTRUMENTS
5050 Nesttun, Norway.Tel. + 47 55 13 25 00

SAMPLE

**Calibration Sheet**

**Temperature Sensor 3621**

Serial No. ..............................

Installed on WTR 9

Serial No. ..............................

The calibration is performed in a temperature stabilized water bath. The temperature is determined by a reference thermometer *Automatic Systems Laboratories*, model F 25.
To get the raw data readings N from the instrument, the WTR 9 is set to.Temperature Calibration Mode.

The ISO - curve type thermistor used in this sensor has well defined characteristics where coefficients S and T in the formula make no significant difference between the individual sensors. Thus factory calibration is restricted to measurement at two different temperatures from which the values of Q and R are calculated.

The instrument is checked at two temperatures with the following raw data readings:

**Calibration points used:**

| | | |
|---|---|---|
| Temperature,°C | | |
| Readings, N | | |

**Calibration coefficients:**

Q =

R =

S =

T =

Temperature (°C) = $Q + RN + SN^2 + TN^3$

The calibration coefficients obtained during calibration are used by the instrument internally to convert from raw data to temperature in degrees Centigrade.

To convert the instrument’s output to correct engineering units, see Calibration Sheet for WTR 9, Form No. 458K.

Date .............................. Sign ..............................................................................

Form No. 521
October 1997

# CHAPTER 6

## ILLUSTRATIONS

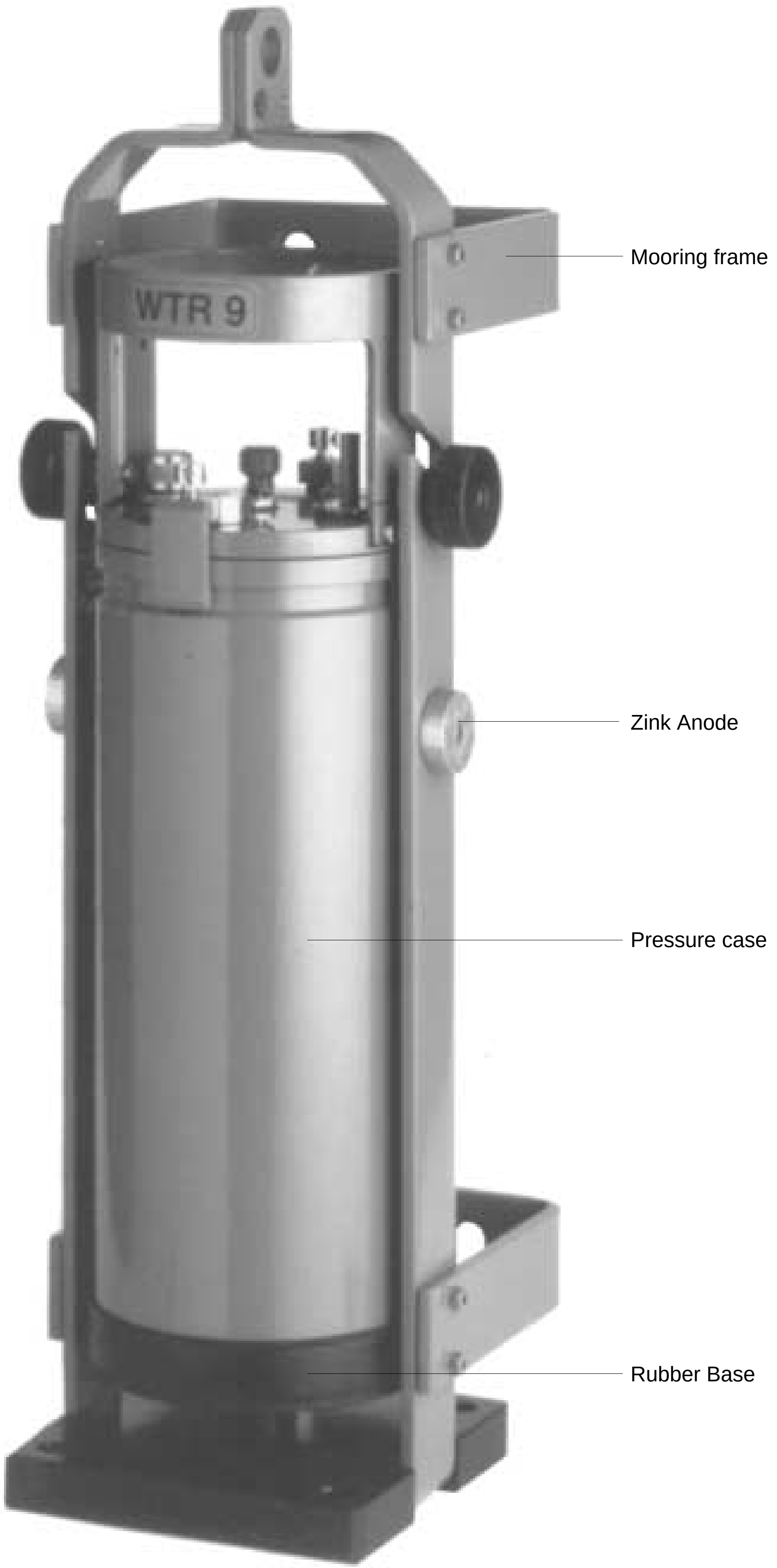



*Fig. 6.01 WTR 9 in Mooring Frame 3110.*

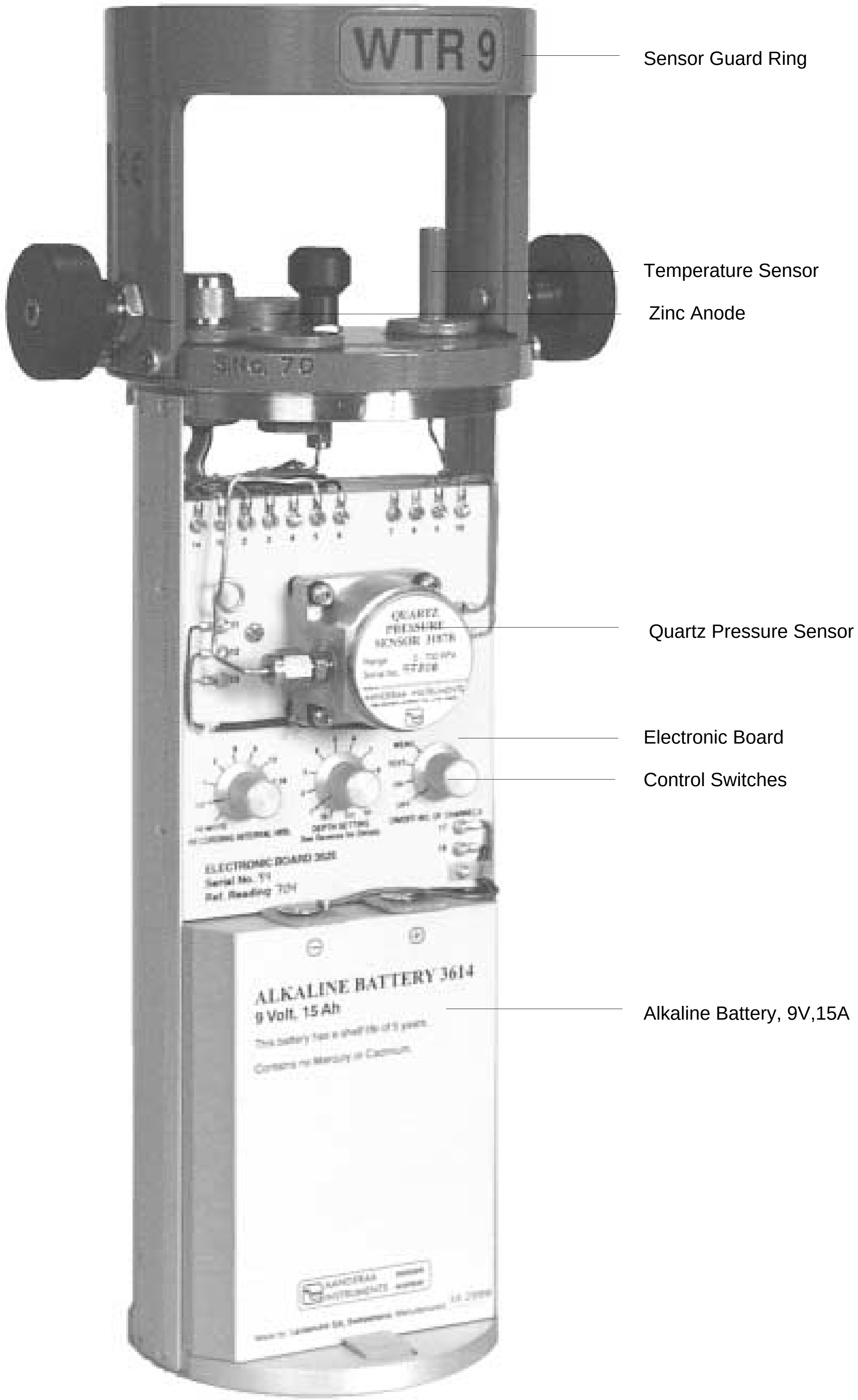



*Fig. 6.02 WTR 9 Internal View, Electronic Board side.*


*Fig. 6.03 WTR 9 Internal View, Data Storage Unit side.*

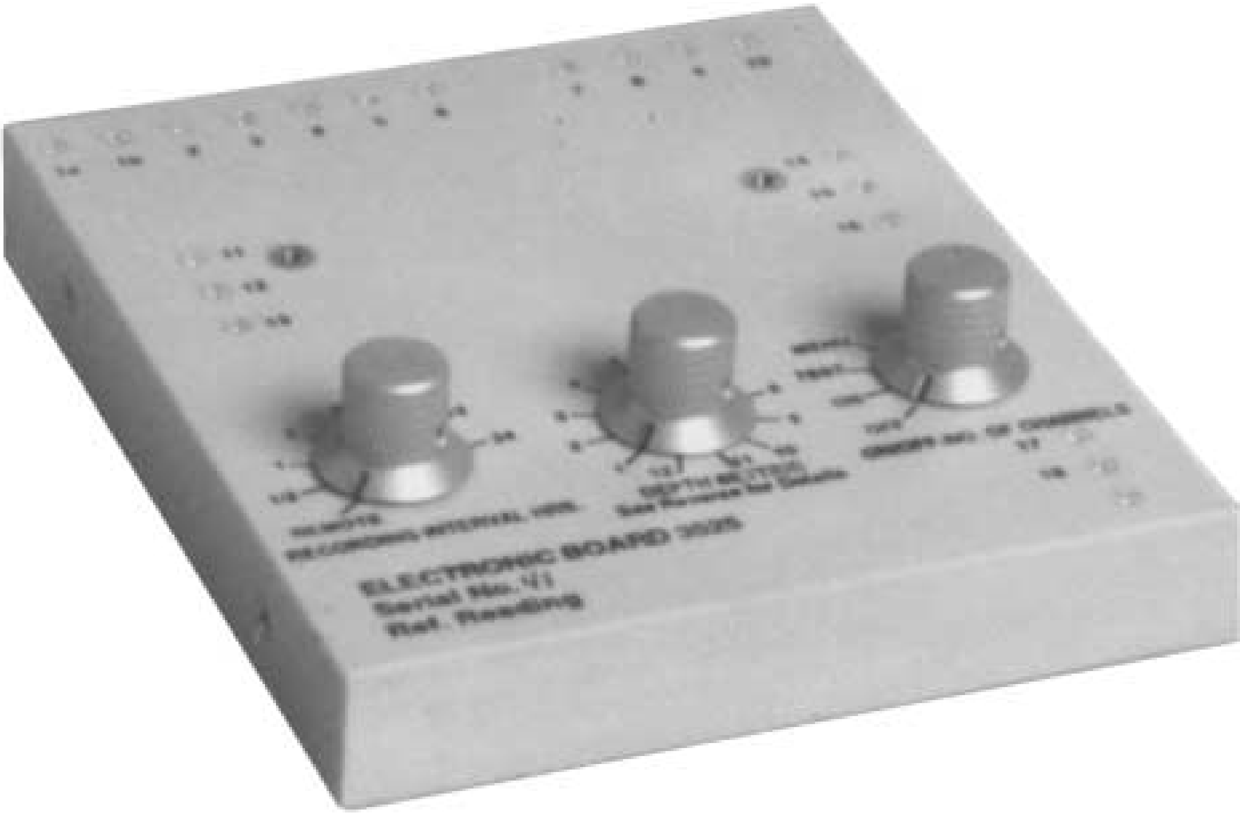



*Fig. 6.04  Electronic Board 3525*

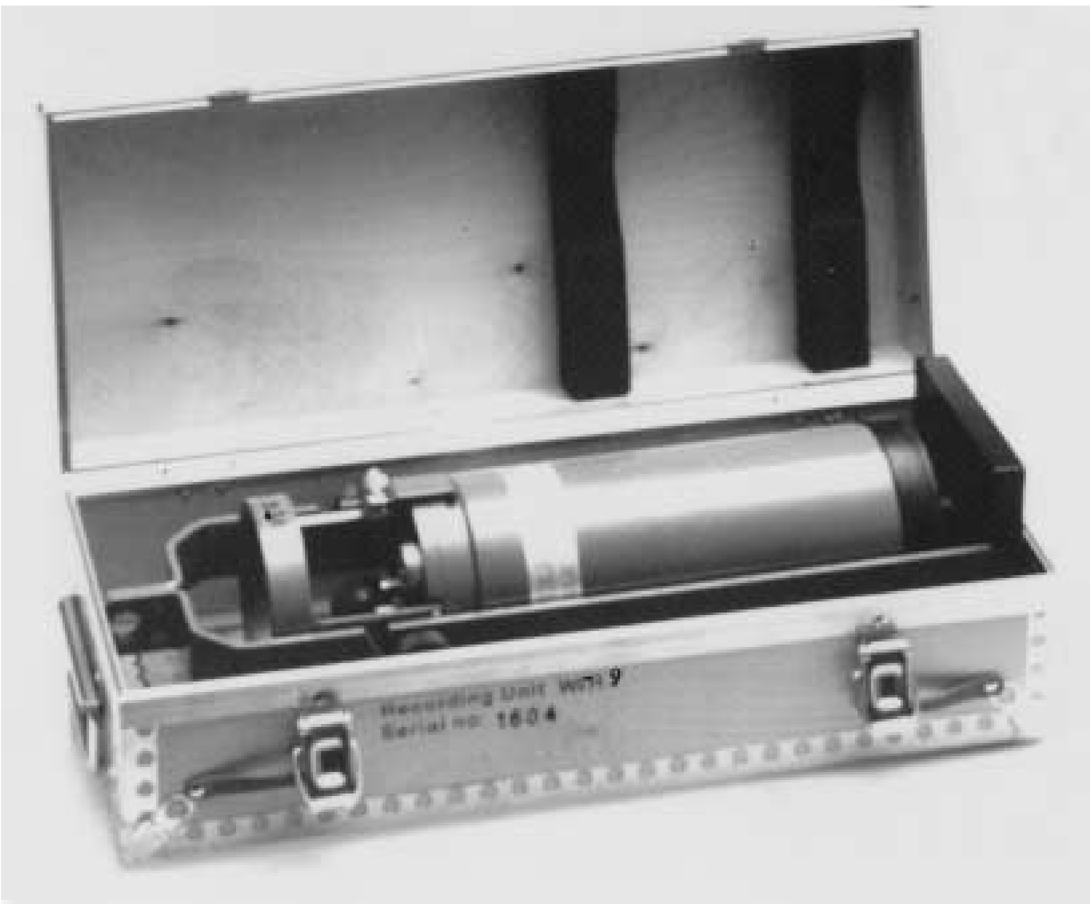
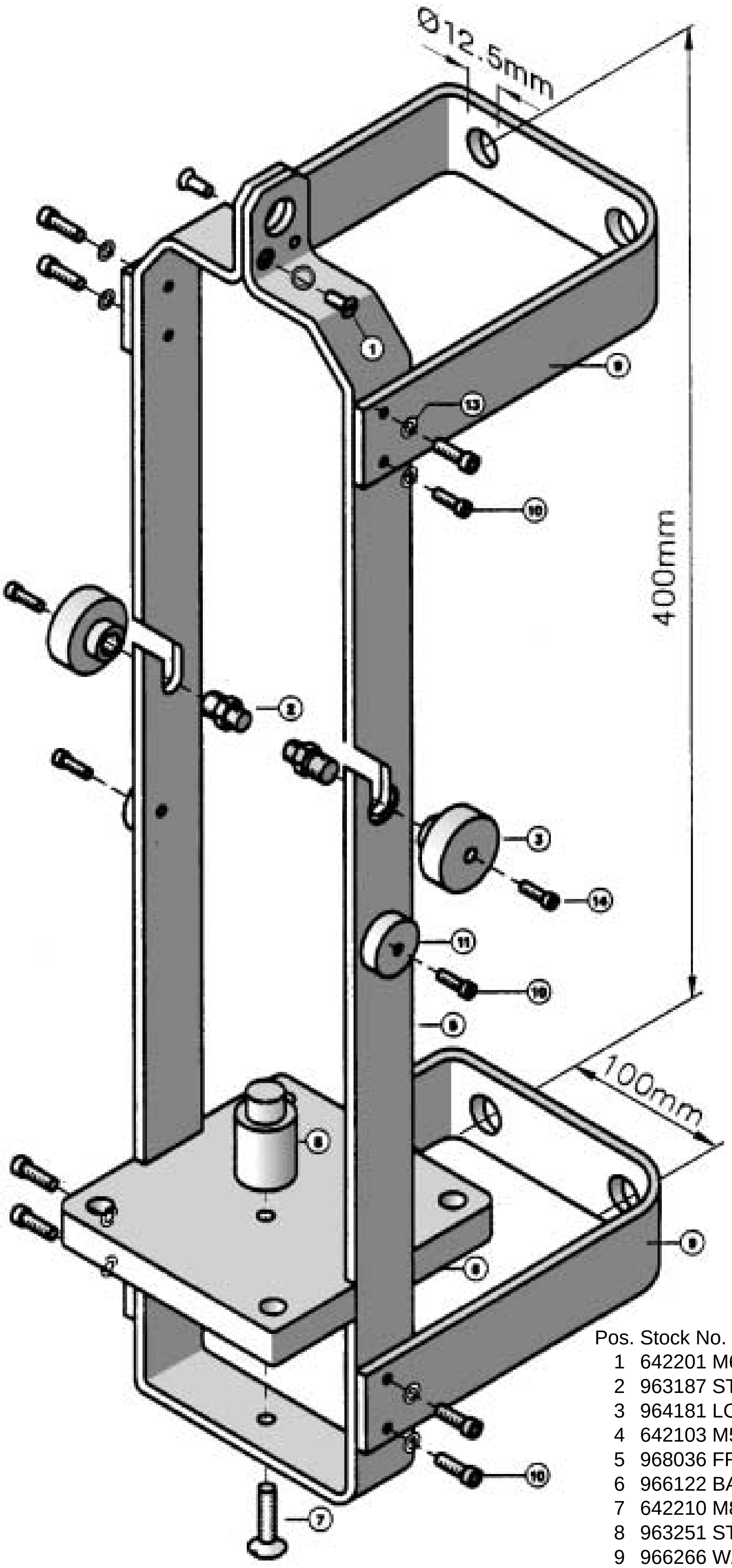


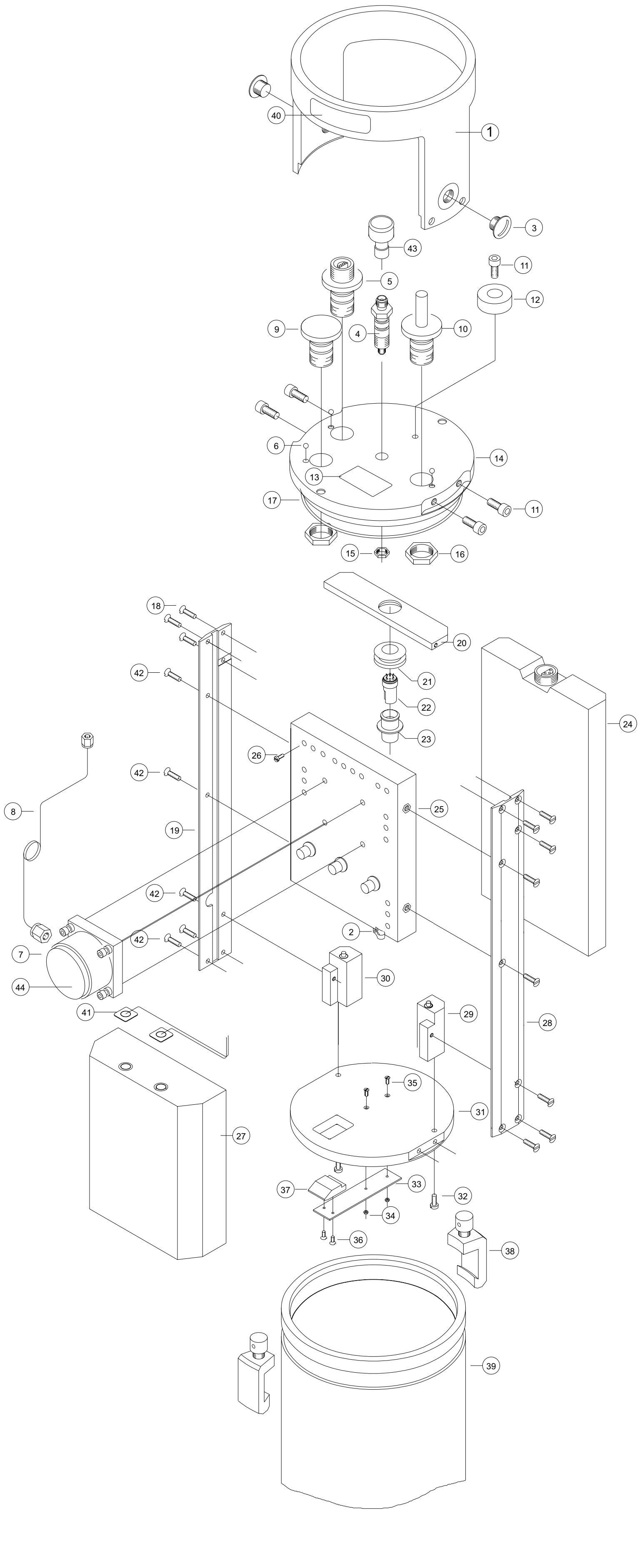

*Fig. 6.05  WTR 9 as shipped*




PART LIST

| Pos. | Stock No. / Description | Dwg. No. | Qty. |
|---|---|---|---|
| 1 | 642201 M6 x 12mm DIN 963 A4 | | 2 |
| 2 | 963187 STUD | V-5717 | 2 |
| 3 | 964181 LOCKING NUT | V-5718 | |
| 4 | 642103 M5x16 UNBRACO A 4 | | 2 |
| 5 | 968036 FRAME | V-3523 | 2 |
| 6 | 966122 BASE PLATE | V-3522 | 2 |
| 7 | 642210 M8 x 30mm DIN 963 A 4 | | 1 |
| 8 | 963251 STAND OFF, MODEL 7 | V-6516 | 1 |
| 9 | 966266 WALL BRACKET | V-7763 | 2 |
| 10 | 642108 M6 x l6m UNBRACO | | 8 |
| 11 | 933026 ZINC ANODE Ø30mm | V-4898 | 2 |
| 12 | 966266 WALL BRACKET | V-7763 | 2 |
| 13 | 652010 Ø6.4mm WASHER | | 8 |
| 14 | 642100 M5 x 12mm UNBRACO | | 2 |

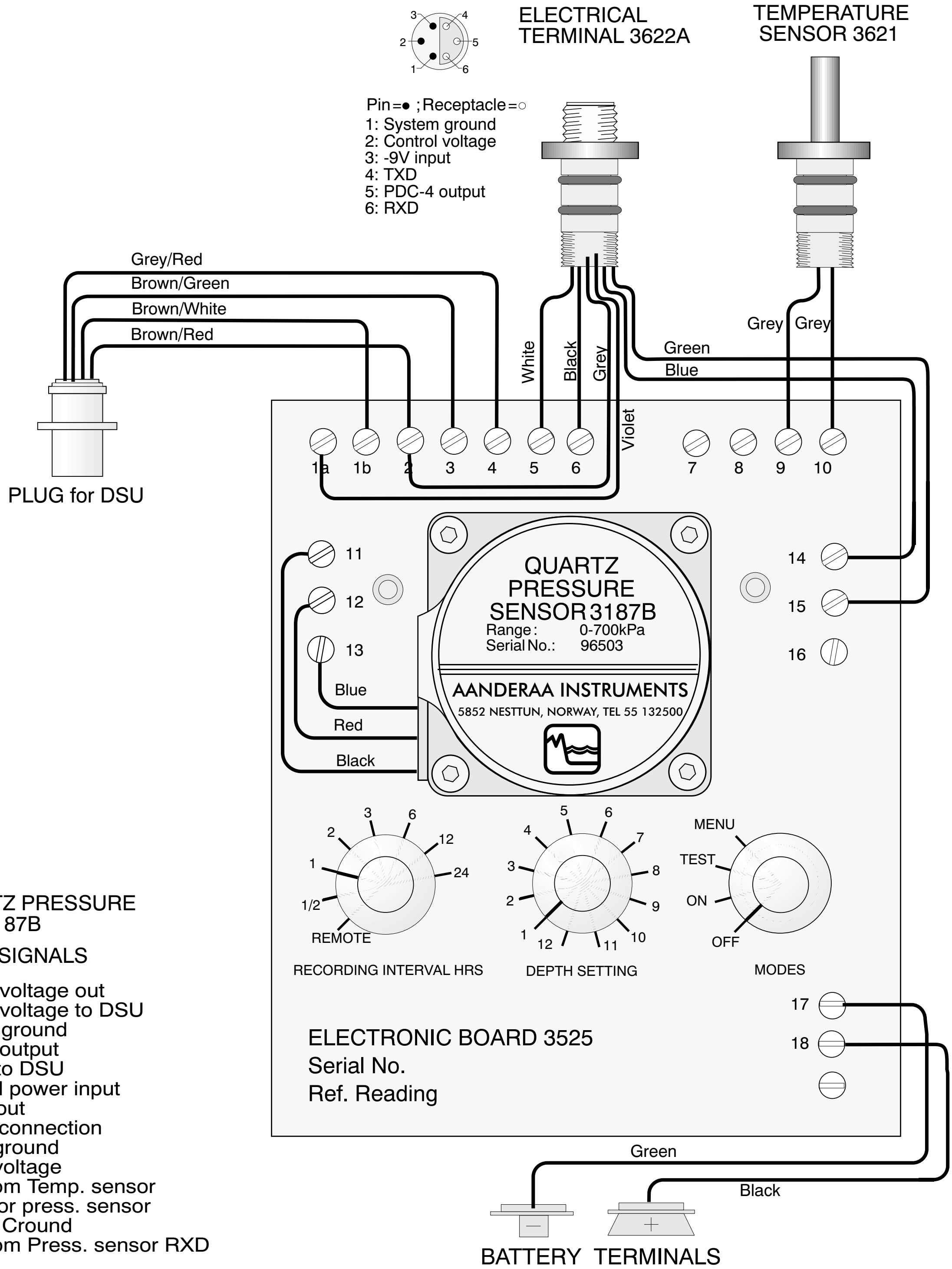
*Fig. 6.06  Mooring Frame 3130 with Wall Bracket*




| Pos. | Part-List<br>Stock No. / Description | Dwg. No. | Qty. |
|---|---|---|---|
| 1 | 96 6053 GUARD RING | V-3222 | 1 |
| 2 | 96 3361 STRAIN RELIEVER | V-7602 | 1 |
| 3 | 96 3182 DUMMY SCREW | V-5684 | 2 |
| 4 | 3132 BUSHING, PR. INLET | V-5696 | 1 |
| 5 | 3622A WATERTIGHT RECEPT. | V-5591 | 1 |
| 6 | 75 0015 ORIENTATION BALL | | 3 |
| 7 | 43 1002C QUARTZ PR. SENSOR | | 1 |
| 8 | 43 1003D TUBE FOR PR. SENS. | V-8219 | 1 |
| 9 | 3625 SEALING PLUG | V-7572 | 1 |
| 10 | 3621 TEMP. SENSOR | V-7571 | 1 |
| 11 | 64 2100 M5x12mm UNBRACO | | 5 |
| 12 | 96 3026 ZINC ANODE | V-4898 | 1 |
| 13 | 92 0248 LABEL | V-7767 | 1 |
| 14 | 96 6235 TOP END PLATE | V-3883 | 1 |
| 15 | 65 3002 M10mm NUT | | - |
| 16 | 96 3360 M16x1mm NUT | V-7668 | - |
| 17 | 86 5000 O-RING SOR72 | | 1 |
| 18 | 64 2211 M3x6mm SCREW | | 4 |
| 19 | 96 7117 FRAME BAR I | V-7829 | 1 |
| 20 | 96 5334 PLUG BAR | V-7828 | 1 |
| 21 | 68 0039 RING GASKET | | 1 |
| 22 | 56 0034 LEMO INSERT | | 1 |
| 23 | 96 3173 PLUG HOUSING | V-5594 | 1 |
| 24 | 2990E DATA STORAGE UNIT | V-5701 | - |
| 25 | 92 1235 ELECTRONIC BOARD | V-3854 | 1 |
| 26 | 64 3006 M2.3x6mm SCREW | | 18 |
| 27 | 3614 BATTERY 9V, 15Ah | V-7660 | - |
| 28 | 96 7118 FRAME BAR II | V-7830 | 1 |
| 29 | 3637 LEFT LOWER FR.BLOCK | V-7658 | 1 |
| 30 | 3636 RIGHT LOW. FR. BLOCK | V-7659 | 1 |
| 31 | 96 5316 FR. BOTT. END PLATE | V-7583 | 1 |
| 32 | 64 3011 M3x10mm SCREW | | 2 |
| 33 | 96 5315 SPRING FOR BATTERY | V-7596 | 1 |
| 34 | 65 3005 M2.5mm NUT | | 2 |
| 35 | 64 3205 M2.5x6mm SCREW | | 2 |
| 36 | 64 3203 M2.3x4mm SCREW | | 2 |
| 37 | 96 3355 BUTTON FOR SPRING | V-7597 | 1 |
| 38 | 2014 C-CLAMP | V-5296 | 2 |
| 39 | 1171B PRESSURE CASE | V-5302 | 1 |
| 40 | 92 0249 LABEL | V-7768 | 1 |
| 41 | 3639 BATTERY WIRES | V-7656 | 1 |
| 42 | 64 3200 M3x10mm SCREW DIN963 | | 12 |
| 43 | 96 3384 PRESSURE INLET | V-7756 | 1 |
| 44 | 92 0113H LABEL | V-5933 | 1 |

| | | |
|---|---|---|
| Last correction: B 15.05.01 I.H. | Date 28.03.96 | Constr. by |
| WAVE AND TIDE RECORDER 3659, WTR 9 ASSEMBLY DRAWING | Scale | Drawn by E.R-M |
| | Refer to: | Contr. by |
| AANDERAA INSTRUMENTS<br>5050 NESTTUN, NORWAY, Tel.+47 55 10 99 00 | Drawing no. V-3929C | |

*Fig. 6.07 WTR 9 Assembly drawing*



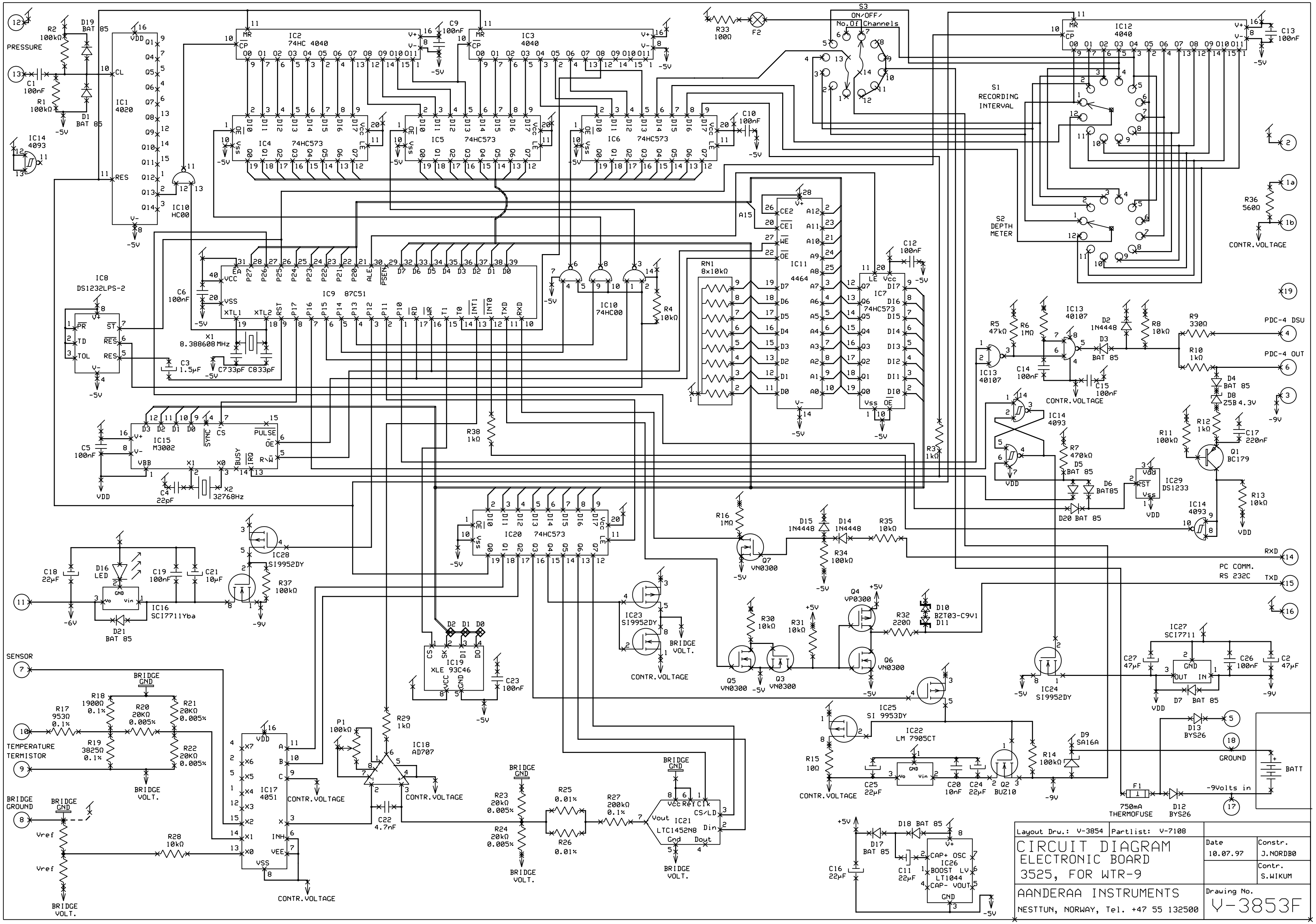

DIGIQUARTZ PRESSURE SENSOR 3187B

TERMINAL SIGNALS

1a Control voltage out
1b Control voltage to DSU
2 System ground
3 – 9 volt output
4 PDC-4 to DSU
5 External power input
6 PDC-4 out
7 Sensor connection
8 Bridge ground
9 Bridge voltage
10 Input from Temp. sensor
11 Power for press. sensor
12 System Cround
13 Input from Press. sensor RXD
14 RXD
15 TXD
16 System ground
17 -9V power input(Battery)
18 System ground

Fig. 6.09 WTR 9 Wiring Diagram V–7270

Fig.6.10 Circuit Diagram, Electronic Board 3525



AANDERAA
INSTRUMENTS
5050 Nesttun, Norway.Tel. + 47 5513 25 00

**Test and Specification Sheet**
**WTR 9**
Serial No.........................

**Component Specification:**

| Component | Serial No. | Remarks |
|---|---|---|
| Electronic Board 3525 | | Reference Reading: |
| DSU 2990 | | |
| Temperature Sensor 3621 | | |
| Pressure Sensor 3187B | | Range: 0 - 700kPa |

**Visual and Mechanical Check:**

Pressure sensor oil-filled: ☐
Wire harness and screws: ☐
Epoxy coating intact on metal parts: ☐
Zinc Anode Installed: ☐
O-ring groove inspected, cleaned and greased: ☐

**Performance Test:**

Set ON/OFF switch to TEST mode.
Current consumption and voltages with pressure sensor connected: ☐
- During measurements , maximun 7mA (First 40s): ☐
- During calculations, maximum 16mA (After measurements): ☐
- \- 5 V Control voltage: ☐
- Supply voltage to pressure sensor (-6.6 V ±0.2V) ☐

Set ON/OFF switch to ON.
- Quiescent current, maximum 100µA: ☐

Set recording interval to REMOTE and trigger after 12 minutes.
- Remote Control: ☐
- Electrical isolation between system ground and top endplate: ☐

Enter pressure coefficients and set recording interval switch to half hour and depth setting 2.
- Temperature cycling test, -5 to + 40°C : ☐
  (Data stored in DSU 2990 during a 16 hr test)

Date:..................................Sign.:...........................................................................

**Performance Test prior to Shipment:**

Reading at 1 atmosphere and room temperature.

Set ON/OFF switch to TEST position

| Channel Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| First run | | | | | | | |
| Second run | | | | | | | |

Erased DSU installed: ☐
Final assembling , inspection tag: ☐
O-ring inspected, cleaned and greased: ☐
Fresh battery installed, type3614. Open loop voltage..........Voltage with 100 load........... ☐

*Fig. 6.11 Test and Specification Sheet, WTR 9*

AANDERAA INSTRUMENTS
5050 Nesttun, Norway.Tel. + 47 55 13 25 00

**Test and Specification Sheet**
**Electronic Board 3525**
Serial No.................................

Lay-out No. 1235...............
Circuit Diagram No. V-3853..........

| | | Before casting | After casting |
|---|---|---|---|
| **1. Visual and Mechanical Check:** | | | |
| 1.1 | Components correctly inserted | ☐ | |
| 1.2 | Soldering quality | ☐ | |
| 1.3 | Switch stoppers correctly inserted | ☐ | |
| 1.4 | Surface quality | ☐ | |
| **2. Electrical Check:** | | | |
| 2.1 | Reference reading | .................... | |
| 2.2 | 5V supply voltage ( -5V± 0.2V ) | ☐ | |
| 2.3 | -6V supply voltage to pressure sensor ( -6.4V ± 0.2 ) | ☐ | ☐ |
| 2.4 | Quiescent current consumption ( max. 100µA ) | .................... µA | .................... µA |
| 2.5 | Operating current during measurements, first 8.5 min ( max. 5mA) | ....................mA | ....................mA |
| 2.6 | Operating current during calculations, after 8.5 min ( max. 16mA ) | ....................mA | ....................mA |
| 2.7 | Switch test | ☐ | ☐ |
| 2.8 | C.V and PDC-4 test | | |
| | Control Voltage, fall and rise time max. 3ms, voltage -5± 0.2V | ☐ | ☐ |
| | Bridge Voltage, fall and rise time max. 100µs, voltage -5± 0.2V | ☐ | ☐ |
| | PDC-4 Pulses, fall and rise time max. 100µs, voltage -5± 0.2V | ☐ | ☐ |
| 2.9 | RAM, EEPROM and Real time clock test | ☐ | ☐ |
| 2.10 | Second pulse from real-time clock ( 999.992 - 1000,000ms ) | ☐ | |
| 2.11 | AD-converter adjusted (± 1bit) | ☐ | ☐ |
| 2.12 | Crystal frequency measured, 30kHz and 3,8Vp-p on pressure sensor input (8.388608MHz ± 2000Hz) | ☐ | ☐ |
| **3. Performance Test:** | | | |
| 3.1 | Connect a decade resistance box to the temperature sensor input | | |
| | Raw data reading with 6386.2 ohm (8±2) | ☐ | ☐ |
| | Raw data reading with 1371.5 ohm (1008 ±2) | ☐ | ☐ |
| 3.2 | Remote start test (5V positive pulse to PDC-4 output) | ☐ | ☐ |

Date:.................................................Sign:..................................................................................

*Fig.6.12 Test & Spec. sheet, El. board 3625*

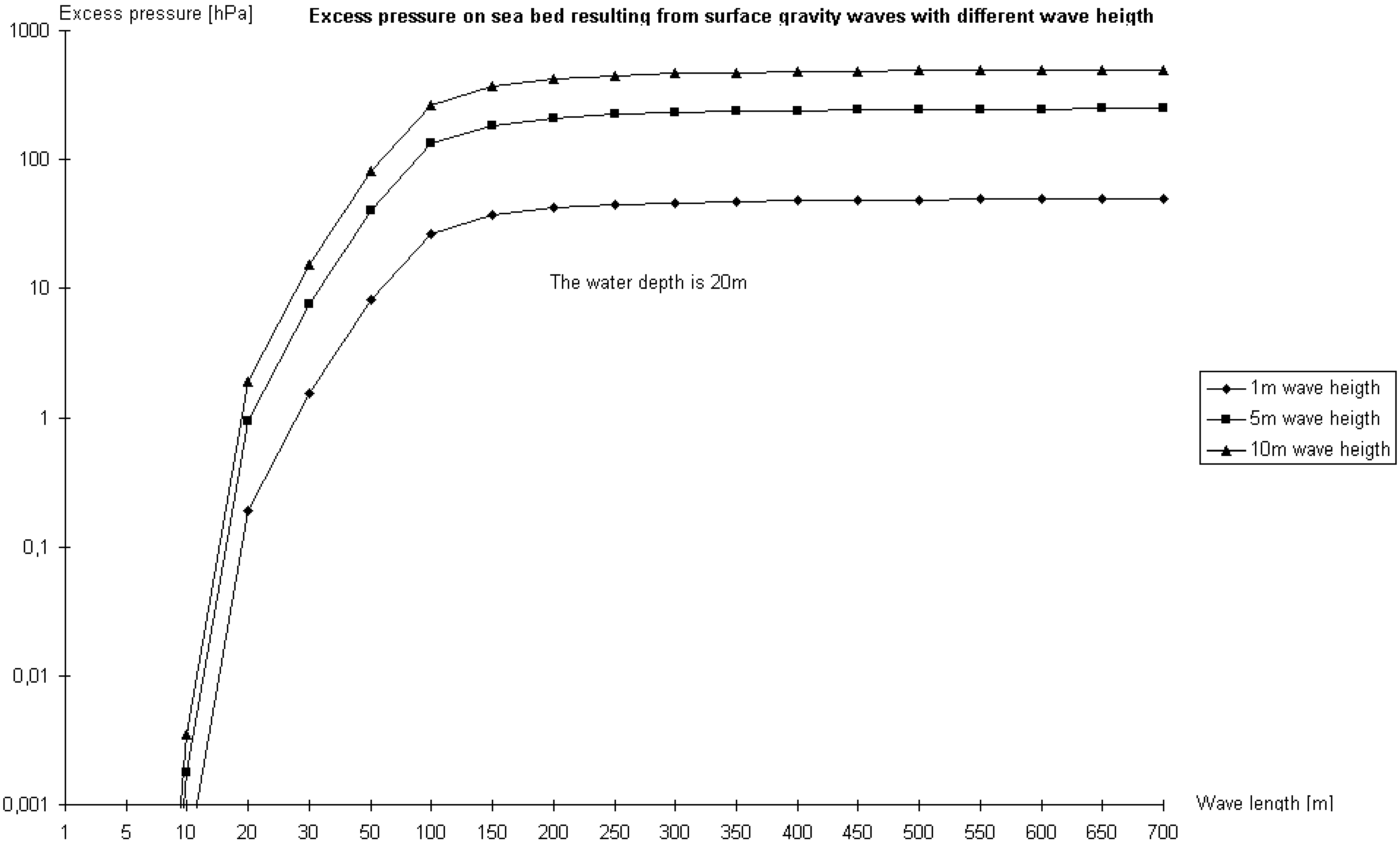



*Fig. 6.13 Graph 1, Wave Length. WTR 9*

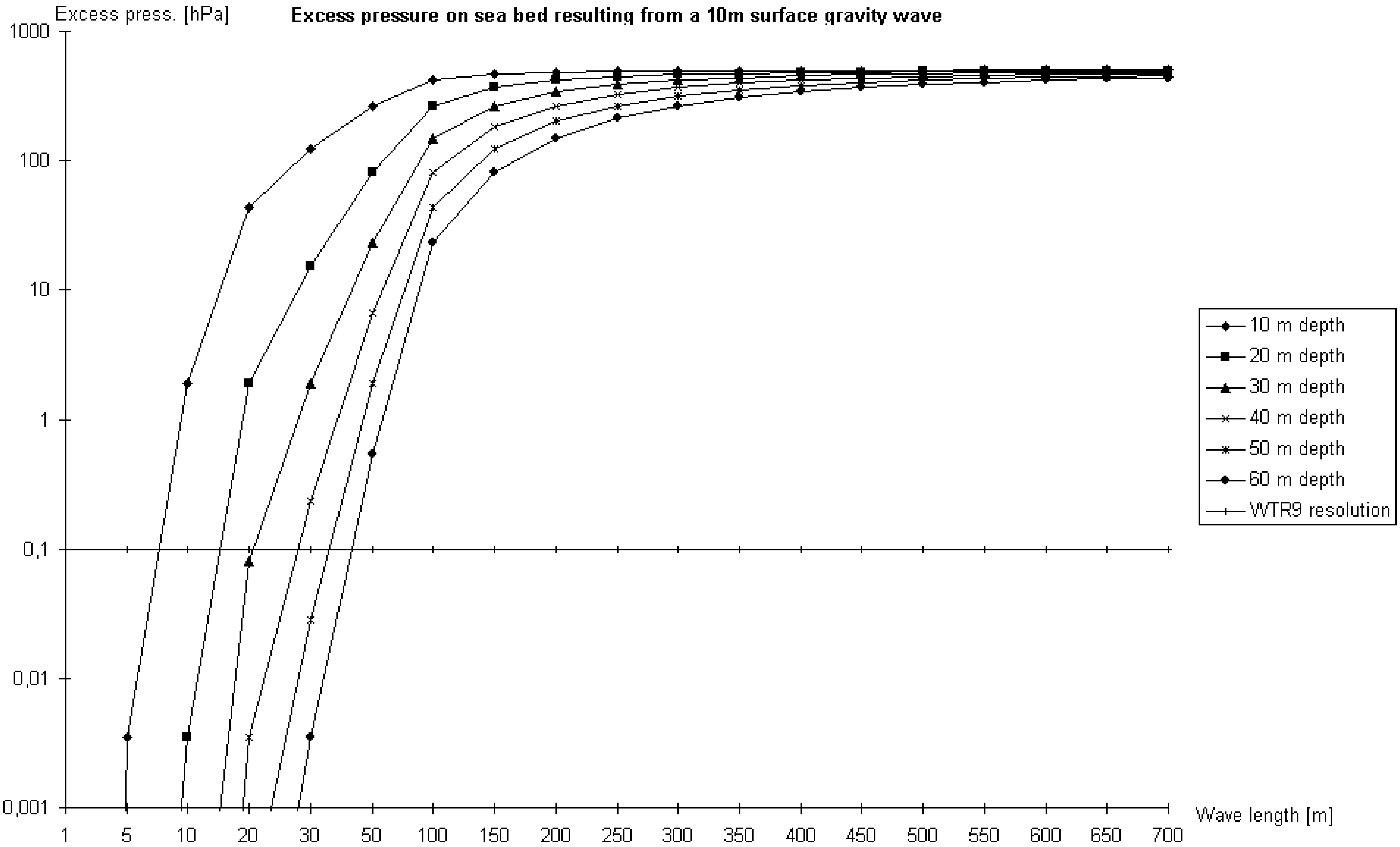



*Fig. 6.14 Graph 2, Wave Length. WTR 9*

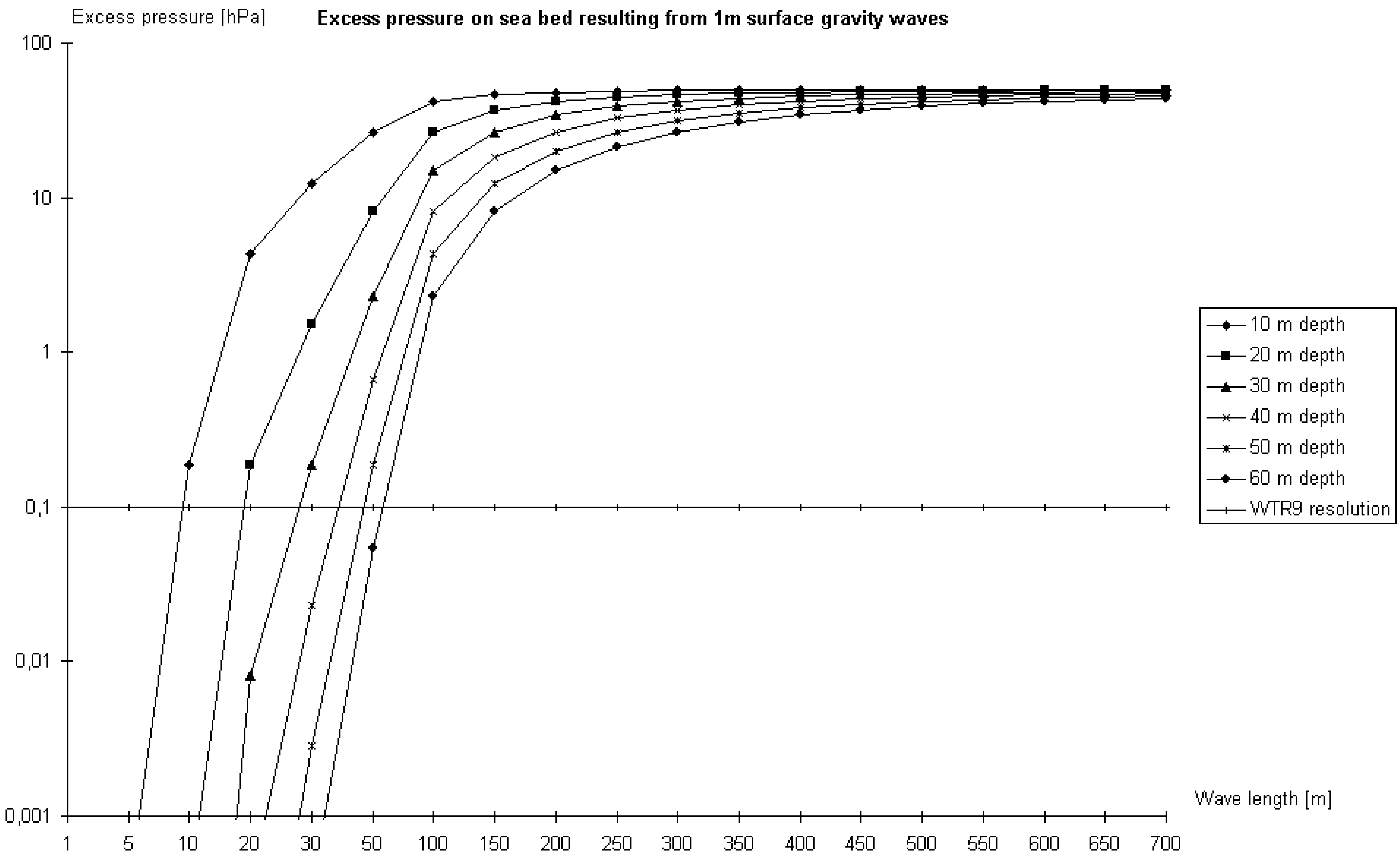



*Fig. 6.15 Graph 3, Wave Length. WTR 9*