TD Diver
CTD Diver
OTD Diver

Product manual

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Contents

Introduction

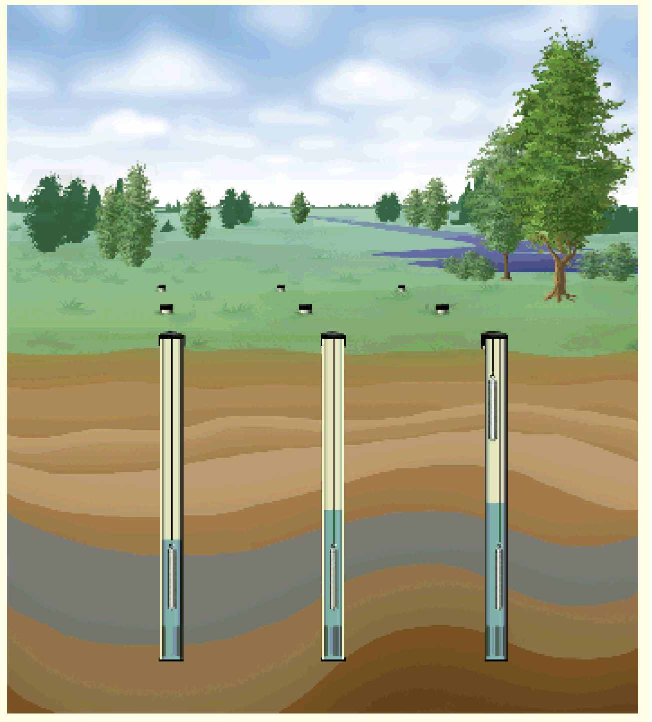
The manual

This manual contains information on the Divers manufactured by Van Essen Instruments.

In the following chapters, we will explain how to install and maintain each type of Diver. Every chapter comprises a section with technical information describing how the instruments are made and how they work.

The Divers

The Diver is designed to perform measurements and register the results in a monitoring well.

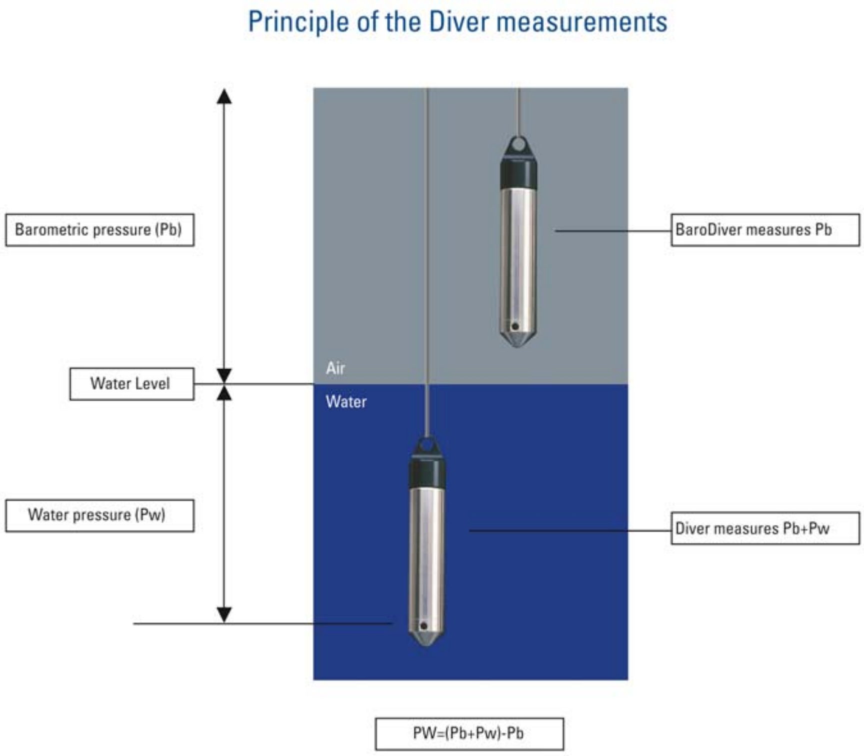


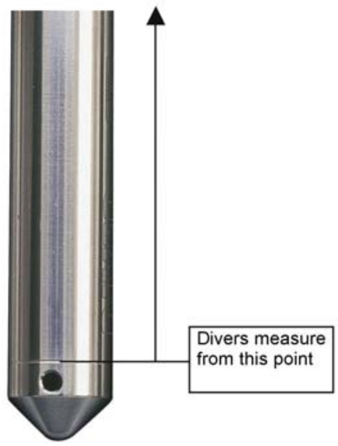
There are various types of Diver available for measuring water levels and quality: the TD Diver, the CTD Diver and the OTD Diver. A BaroDiver is used to measure air pressure variations.

All Divers measure the level and temperature of the groundwater. The CTD Diver also measures the electrical conductivity. In addition to water level and temperature, the OTD Diver also measures the content of dissolved oxygen.

Level

All Divers determine the height of a water column by measuring the water pressure with a built-in pressure sensor. As long as the Diver is above water, it measures the atmospheric pressure, like a barometer. Once under water, the water pressure is an added factor: the higher the water column, the higher the pressure. Since the specific gravity of water is known, the measured pressure can be used to establish the height of the water column above the pressure sensor in the Diver.





Variations in ambient air pressure influence measurements. A BaroDiver is used in each measuring area to measure these air pressure variations. Compensating for these air pressure variations takes place simply and quickly with the aid of the software package LoggerDataManager (LDM) or its predecessor EnviroMon.

The compensated values can be related to a point of reference, such as the top edge of the monitoring well or Amsterdam Ordnance Datum (NAP). To do so, you have to measure the groundwater level by hand in relation to the required point of reference. This could be done when the Diver starts measuring, for example. Once the Diver is started up and installed, it is important for the manual measurement to be taken at more or less the same time as a Diver measurement. If the times vary too much, there is a risk that the differences between the Diver measurement and the manual measurement reflect groundwater fluctuations. If you install the Diver, the groundwater level may rise briefly! You can then relate the collected level measurements to the reference point using LDM. You will find more information about air pressure compensation and how to relate it to the point of reference in the LDM manual.

Temperature

All Divers measure the temperature of the groundwater. This can provide information on groundwater flows, for example, enabling determination of the spread of (polluted) water.

Temperature is measured using a semiconductor sensor. The temperature is not only registered, it is also used to compensate the pressure sensor measurements for temperature influences.

Conductivity

The CTD Diver measures the level, the temperature and the electrical conductivity of water in milliSiemens per centimetre (mS/cm). A change in conductivity may be an indication of flow alterations or of increasing or decreasing contamination or salinity, for example.

The CTD Diver measures the conductivity of the liquid. The CTD Diver can calculate the *specific* conductance at 25°C on the basis of the established conductivity and temperature. You can opt for registration of the conductivity or the specific conductance.

Conductivity is measured using a four-electrode measuring cell. This kind of measuring cell is relatively insensitive to dirty sensors, so maintenance can be kept to a minimum. The cell is ideal for measuring high or low conductivity values.

Content of dissolved oxygen

The OTD Diver measures the level, the temperature and the content of dissolved oxygen in the water, so it can be used in all kinds of applications for monitoring the water quality in situations where biological processes play a role, such as:

- soil cleaning projects
- monitoring the quality of swimming water
- monitoring ground and surface water near dumpsites and landfills
- monitoring the amount of air in the soil during an active soil remediation operation

The content of dissolved oxygen is measured using an optical sensor. The measuring principle is based on the extinction time of fluorescence, which depends on the concentration of dissolved oxygen in the water.

To measure the oxygen, the oxygen-sensitive coating, a metal complex in a polymer matrix is exposed to a pulse of blue light, causing the electrons to rise to a higher energy level.

Because electrons always prefer to be in the most favourable (i.e. lowest) energy condition, they will then return to their original state. In the process, they transmit red light (fluorescence). When oxygen is present, the electrons will return to this state faster and the extinction time of the fluorescent light is shorter.

The advantages of this measuring principle in comparison to traditional methods include a rapid response time, accurate measurement of low oxygen concentrations and less sensitivity to contamination in the water.

The software: LoggerDataManager

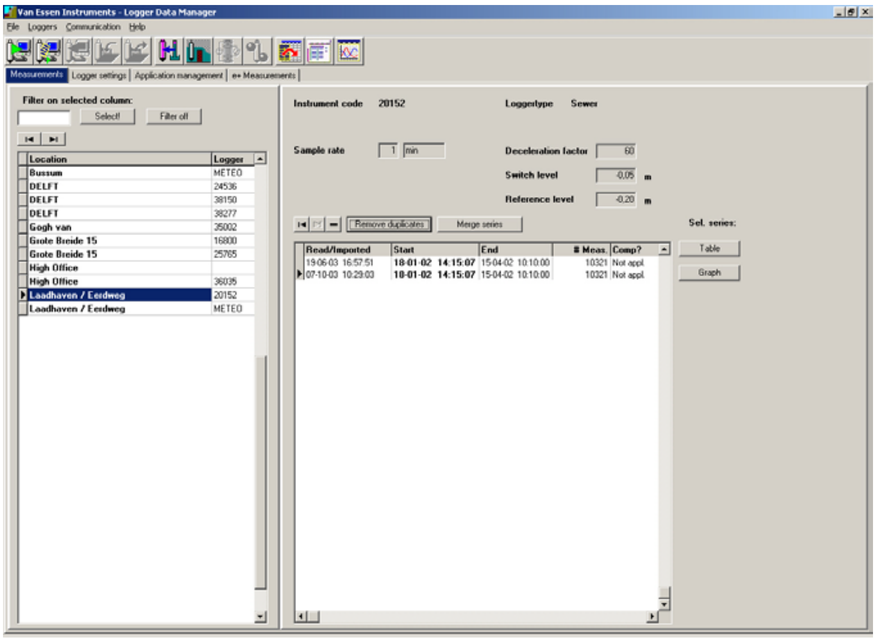
This software package can be used with all types of Divers and replaces the EnviroMon program.

You can read out the measurement values registered by the Divers at any given time using LDM. You can use it to consult measurement data, compensate for air pressure variations and print/export data to a variety of file formats for further processing with other software.

If you used a DiverMate (see FAQ) to read out data from the Divers, you can import the files you saved with it into the LDM database.

You can also adjust the logger settings, start up and shut down Divers and (in the case of CTD and OTD Divers) perform a field calibration.

You will find more information on how to use LDM in the program manual.



Technical information on Divers

General

The Diver is a datalogger in a cylindrical housing with a suspension eye at the top. The eye can be screwed off and serves to install the Diver in the monitoring well and protect the optical connector. The maintenance-free electronics, sensors and battery are inside the housing. Do not open the Diver yourself. If you have a problem, please contact your supplier.

The name of the datalogger, the model number, measuring range and serial number (SN) are clearly marked on the side of the Diver. This information is laser-etched, chemically neutral and non-erasable.

Incidental communication problem

At a sampling speed of less than 1x10 seconds, an incidental communication problem may occur when reading data from a Diver. This is due to the way in which your computer communicates with the Diver.

Using Divers at height

You can use Divers at any elevation, from 300 metres below sea level to 3,000 metres above. It is advisable, however, to use all Divers and

BaroDivers in a single network at the same elevation. You will find more information on the use of Divers at height in Appendix III.

TD Diver

Calibration procedure

Before shipping, the Divers are tuned and tested according to a specific procedure. The most important test is the calibration procedure.

The Diver measures pressure and is calibrated in centimetres water column (cm wc) conventional. The pressure in cm wc relates to the pressure in bars as follows:

1 mbar = 1.01972 cm or 1 cm = 0.980665 mbar

During the calibration process, the Diver is fully immersed in a bath. The temperature of the water is stabilised at 15°C and 35°C. The Diver is calibrated at both temperatures. Pressure variation is applied at both temperatures. This pressure variation consists of a rising and falling series of pressures at 10%, 30%, 50%, 70% and 90% of the total range. The Diver is approved if all specifications are met. A factory certificate is available upon request.

Specifications

As well as the BaroDiver (DI250) for air pressure measurements, there are five TD Diver models for measuring water levels:

- to 5 metres (DI240)
- to 10 metres (DI241)
- to 20 metres (DI242)
- to 30 metres (DI243)

- to 100 metres (DI245)

All models meet the following specifications:

Outside diameter	Ø22 mm
Length	125 mm including suspension eye
Weight	approx. 160 grams
Protection class	IP68
Storage/transport temperature	-20°C to 80°C (affects the life of the battery)
Material	
– *housing*	316L stainless steel (material no. 1.4404)
– *pressure sensor*	aluminium oxide (Al_2O_3)
– *suspension eye*	Akulon (fibreglass-reinforced)
Communication	RS232 (optically separated)
Memory	24,000 measurements (non-volatile memory), each measurement consists of date, time, level and temperature
Sample rate	0.5 sec. to 99 hrs
Sample method	fixed sample rate, three pump tests or variation-dependent
*Battery life**	average of 8 years, depending on use
– *theoretical capacity*	2,000,000 measurements 2,000 read-outs 2,000 times programmable
*Clock accuracy***	better than 2 sec. per day at 25°C
CE mark	according to directive 89/336/EEC
- *Impermeability (ESD)*	to electrostatic discharge according to EN 61000-6-2 (1999)
- *Impermeability (EMC)*	to electromagnetic fields according to EN 50081-1 (1992) and EN 50082-1 (1997)
- *Test report number*	01C00089CRT01

The following applies to the temperature measurement of the TD Divers:

Measuring range	-20°C to 80°C 0°C to 40°C (Operating Temperature (OT))
Accuracy	±0.1°C (OT)
Resolution	0.01°C

*The TD Diver is always active. The leakage current of the internal battery depends on the temperature. If you keep the Diver at a high temperature or transport it for long periods of time, this may shorten the life of the battery.

**The accuracy of the clock depends on a variety of factors. When used at a different temperature, the clock accuracy is increased by a factor of -0.04 ppm times the difference between that temperature and 25°C squared.

The specifications for air and water pressure measurements differ from Diver to Diver:

	DI240	**DI241**
Range	950-1,450 cm wc	950-1,950 cm wc
Calibrated range	500 cm wc	1,000 cm wc
Usable range	400 cm wc	900 cm wc
Accuracy	±0.1% typ.@ OT	
	±0.2% max.@ OT	
Long-term stability	±1 cm	±2 cm
Resolution	0.1 cm	0.2 cm
Maximum pressure	1,000 cm wc	2,000 cm wc

	DI242	**DI243**
Range	950-2,950 cm wc	950-3,950 cm wc
Calibrated range	2,000 cm wc	3,000 cm wc
Usable range	1,900 cm wc	2,900 cm wc

	DI242	**DI243**
Accuracy	±0.1% typ.@ OT	
	±0.2% max.@ OT	
Long-term stability	±3 cm	±3 cm
Resolution	0.4 cm	0.6 cm
Maximum pressure	4,000 cm wc	6,000 cm wc

	DI245	**DI250 (Baro)**
Range	950-10,950 cm wc	950-1,100 cm wc
Calibrated range	10,000 cm wc	150 cm wc
Usable range	9,900 cm wc	150 cm wc
Accuracy	±0.1% typ.@ OT	
	±0.2% max.@ OT	
Long-term stability	±10 cm	±1 cm
Resolution	2 cm	0.1 cm
Maximum pressure	15,000 cm wc	1,000 cm wc

N.B.! Because the Diver also measures air pressure variations, which can vary between 950-1,050 mbar, there is a difference between the calibrated range and the usable range. The usable range is the calibrated range minus the total possible air pressure variations (i.e. ±100 cm wc).

CTD Diver

Calibration procedure

Before shipping, the CTD Diver is tuned and tested according to a specific procedure. The pressure sensor and conductivity measuring cell are calibrated at the same time.

You can also calibrate the conductivity measuring cell yourself (field calibration). You will find more information on this subject on page 11 in the section '*Calibrating the conductivity cell*'.

Calibrating the pressure sensor

The Diver measures pressure and is calibrated in centimetres water column (cm wc) conventional. The pressure in cm wc relates to the pressure in bars as follows:

1 mbar = 1.01972 cm or 1 cm = 0.980665 mbar

During the calibration process, the Diver is fully immersed in a bath. The temperature of the water is stabilised at 15°C and 35°C. The Diver is calibrated at both temperatures. Pressure variation is applied at both temperatures. This pressure variation consists of a rising and falling series of pressures at 10%, 30%, 50%, 70% and 90% of the total range. The Diver is approved if all specifications are met. A factory certificate is available upon request.

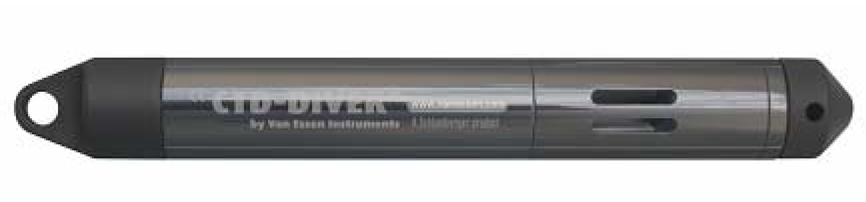
Calibrating the conductivity cell

Each CTD Diver is subjected to an automatic calibration procedure during production. Van Essen Instruments stores the calibration data of each individual instrument. The calibration table is also used in the CTD Diver in question as a reference during field calibration. Field calibrations can be carried out using the LoggerDataManager (LDM) software program, an exact description of which can be found in the LDM manual.

Specifications

Different models of CTD Diver are available.

- to 10 metres (DI261)
- to 30 metres (DI263)
- to 100 metres (DI265)



The elongated apertures at the nose of the CTD Diver ensure that the liquid flows through smoothly.

All models meet the following specifications:

Outside diameter	Ø22 mm
Length	183 mm including suspension eye
Weight	approx. 150 grams
Protection class	IP68
Storage/transport temperature	-20°C to 80°C (affects the life of the battery)
Material	
– *housing*	zirconia (ZrO_2)
– *pressure sensor*	aluminium oxide (Al_2O_3)
– *suspension eye*	Akulon (fibreglass-reinforced)
– *nose cone*	Akulon (fibreglass-reinforced)
Communication	RS232 (optically separated)
Memory	16,000 measurements (non-volatile memory), each measurement consists of date, time, level, temperature and conductivity
Sample rate	1.0 sec. to 99 hrs
Sample method	fixed sample rate or variation-dependent (conductivity channel)
*Battery life**	average of 8-10 years, depending on use
– *theoretical capacity*	2,000,000 measurements 500 full memory read-outs
Clock accuracy[**]	better than 2 sec. per day at 25°C

CE mark	according to directive 89/336/EEC
- *Impermeability (ESD)*	to electrostatic discharge according to EN 61000-4-2 (1995)+A1 (1998)+A2 (2001)
- *Impermeability (EMC)*	to electromagnetic fields according to EN 61000-4-3 (2001)+A1 (2002)
- *Test report number*	04C00491RPT01

The following applies to the temperature measurements of the CTD Divers:

Measuring range	-20°C to 80°C 0°C to 40°C (Operating Temperature (OT))
Accuracy	±0.1°C (OT)
Resolution	0.01°C

The specifications for the water pressure measurements differ from CTD Diver to CTD Driver:

	DI261	**DI263**	**DI265**
Pressure range			
Range	950-1,950 cm wc	950-3,950 cm wc	950-10,950 cm wc
Usable range (full scale (FS))	900 cm wc	2,900 cm wc	9,900 cm wc
Zero pressure range	650 cm wc		
Accuracy	±0.1% FS typ.@ OT		
Resolution	0.2 cm wc	0.6 cm wc	2 cm wc
Maximum pressure (MP)	2,000 cm wc	3,500 cm wc	15,000 cm wc
Long-term stability	±2 cm wc	±3 cm wc	±10 cm wc

Conductivity

Measuring cell housing	aluminium oxide (Al_2O_3)
Range (full scale (FS))	20 μS/cm tot 80 mS/cm (auto ranging)

*Accuracy****	typ. ±1% measurement value or 10 μS/cm, whichever is higher
Resolution	0.1% measurement value or 0.1 μS/cm, whichever is higher
User calibration	at 1.413 mS/cm, 5.00 mS/cm, 12.88 mS/cm and 80.0 mS/cm

General

Transport	suitable for transport by road, water and air; supplied in case
Vibration resistance	according to MIL-810
Mechanical shock test	according to MIL-810, lightweight equipment

Chemical resistance

Dirt	Insensitive to hydrogen sulphide (H_2S), Na, Cl and Fe ions. Stable in ethanol and BTEX components and chlorinated hydrocarbons. This applies to concentrations that are normally found in groundwater.
Corrosion resistance	Within the specified temperature ranges, the materials used for the housing, the suspension eye and the nose cone are suitable for continuous use in fresh, brackish or saltwater.

* The CTD Diver is always active. The leakage current of the internal battery depends on the temperature. If you keep the Diver at a high temperature or transport it for long periods of time, this may shorten the life of the battery.

**The accuracy of the clock depends on a variety of factors. When used at a different temperature, the clock accuracy is increased by a factor of -0.04 ppm times the difference between that temperature and 25°C squared.

***The accuracy of the conductivity measurement depends on the field calibration. The specified accuracy figures across the entire measurement range only apply if you calibrate all four features of the CTD Diver. You will find more information on this subject on page 11 in the section ‘*Calibrating the conductivity cell*’.

OTD Diver

Calibration procedure

Before shipping, the OTD Diver is tuned and tested according to a specific procedure. The pressure sensor, the temperature sensor and the oxygen sensor are set at the same time. You can also calibrate the oxygen sensor yourself (field calibration). You will find more information on this subject on page 21 in the section '*Maintaining a Diver'*.

Calibrating the pressure sensor

The Diver measures pressure and is calibrated in centimetres water column (cm wc) conventional. The pressure in cm wc relates to the pressure in bars as follows:

1 mbar = 1.01972 cm or 1 cm = 0.980665 mbar

During the calibration process, the Diver is fully immersed in a bath. The temperature of the water is stabilised at 15°C and 35°C. The Diver is calibrated at both temperatures. Pressure variation is applied at both temperatures. This pressure variation consists of a rising and falling series of pressures at 10%, 30%, 50%, 70% and 90% of the total range. The Diver is approved if all specifications are met. A factory certificate is available upon request.

Specifications

There are three types of OTD Diver:

- to 5 metres (DI302)
- to 30 metres (DI303)
- to 100 metres (DI304)

All models meet the following specifications:

Outside diameter	Ø22 mm
Length	320 mm including suspension eye
Weight	approx. 300 grams
Protection class	IP68
Storage/transport temperature	-20°C to 80°C (affects the life of the battery)

Material	
– *housing*	316L stainless steel (material no. 1.4404)
– *pressure sensor*	aluminium oxide (Al_2O_3)
Communication	RS232 (optically separated)
Memory	16,000 measurements, each measurement consists of date, time, level, temperature and dissolved oxygen
Sample rate	10 sec. to 99 hrs.
Sample method	fixed sample rate or variation-dependent (oxygen channel)
*Battery life**	average of 6 years
– *theoretical capacity*	600,000 measurements 1,000 read-outs 1,000 times programmable
*Clock accuracy***	better than 2 sec. per day at 25°C
CE mark	according to directive 89/336/EEC
- *Impermeability (ESD)*	to electrostatic discharge according to EN 61000-6-2 (1999)
- *Impermeability (EMC)*	to electromagnetic fields according to EN 50081-1 (1992) and EN 50082-1 (1997)
- *Test report number*	01C00505CRT02

The following applies to the temperature measurements of the OTD Divers:

Measuring range	-20°C to 80°C 0°C to 40°C (Operating Temperature (OT))
Accuracy	±0.1°C (OT)
Resolution	0.01°C

The specifications for the water pressure measurements differ from OTD Diver to OTD Driver

Pressure	**DI302**	**DI303**	**DI304**
Range	950-1,450 cm wc	950-3,950 cm wc	950-10,950 cm wc
Calibrated range	500 cm wc	3,000 cm wc	10,000 cm wc
Usable range	400 cm wc	2,900 cm wc	9,900 cm wc
Accuracy	±0.1% typ.@ OT ±0.2% max.@ OT		
Resolution	0.1 cm	0.6 cm	2 cm
Maximum pressure	1,000 cm wc	5,000 cm wc	15,000 cm wc
Long-term stability	±1 cm	±3 cm	±10 cm

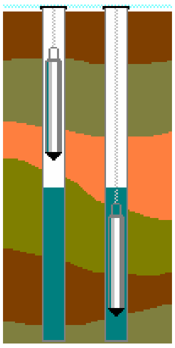
Dissolved oxygen

Measuring range	0-20 mg/l
Accuracy	±0.1 mg/l typ.@ OT
	±0.2 mg/l max.@ OT
Resolution	0.01 mg/l

Installing a Diver

General

In practice, the Diver is usually suspended in a monitoring well, as illustrated below.



The illustration shows an ordinary Diver and a BaroDiver for barometric compensation.

In addition to the ordinary Divers, a BaroDiver is also installed in each measuring area to register atmospheric pressure. Air pressure data can be used to compensate the level measurements for air pressure variations. We recommend the use of a BaroDiver (DI250), which is ideal for measuring air pressure. Generally speaking, one BaroDiver is enough for an area of fifteen square kilometres. Terrain conditions also play a role, however. See the section '*Using Divers at height'* in Appendix III.

The following section describes how to install the Divers and the BaroDiver.

Diver

Most Divers are suspended underwater in a monitoring well. The depth at which you can hang a Diver depends on the measuring range of the instrument.

You will find more information about the range of a Diver in the section '*Technical information on Divers'* on page 6.

Start by ascertaining the required length of the stretch-proof suspension wire on the basis of the lowest groundwater level and cut the cord at least to that length. Remember that you will need some slack to attach the steel wire to the wire clamps. Now attach the wire with wire clamps to the well cover and the suspension eye on the Diver.

You can also install the Diver using a Direct Read Cable (DRC), to enable you to read out the Diver at the top of the monitoring well.

Diver on steel wire

Diver on a DRC

N.B.! If you use a DRC, screw the connector onto the Diver hand-tight. Excessive pressure may damage the Diver internally.

BaroDiver

You can install the BaroDiver in a monitoring well, but it must be suspended above the waterline. To make sure that a BaroDiver is not immersed in water, it should always be hung above the highest groundwater level. You suspend the BaroDiver in a monitoring well in the same way as the TD, CTD or OTD Divers.

Do not use a Diver in seawater

The TD Diver and the OTD Diver are made of 316L stainless steel, which is unsuitable for use in seawater because it may corrode! It is difficult to indicate whether water is brackish or salt. Corrosion is not only caused by the salt content, but also by the temperature and composition of the water. If you have any doubts, we advise you to contact Van Essen Instruments or your distributor.

The new CTD Diver is made of a ceramic material called zirconia, which is resistant to seawater.

Maintaining a Diver

General

Maintenance of a Diver consists of cleaning the outside and the circulation holes. The need for maintenance largely depends on how the Diver is used. In clean freshwater, there is virtually no contamination, but corrosion and algae growth may occur in polluted water and groundwater.

When you take the Diver out of the monitoring well, make sure it is completely clean. If necessary, use a soft cloth to remove any scale. Limescale and other deposits can be removed with a highly diluted solution of acetic or phosphoric acid.

N.B.! Only use acid solutions if the Diver is very dirty and other cleaning methods do not help. Never use hard brushes, abrasives or sharp objects to clean the Diver and always rinse it thoroughly after cleaning with clean water, particularly around the circulation holes.

CTD Diver

A reliable measurement of conductivity requires precise calibration of the measuring cell. We recommend calibrating the CTD Diver at the beginning of each new measuring session. If you calibrate the CTD Diver after a measuring session as well, you will have a better understanding of any irregularities during the measuring session. If necessary, you can adjust the measured values once they have been exported to a spreadsheet program.

The specification referred to above concerning the accuracy of the conductivity cell across the entire measuring range of 0-80 mS/cm can only be achieved if the CTD Diver is calibrated at all four points (1.413, 5, 12.88 and 80 mS/cm) during the field calibration.

If you opt to use the CTD Diver in a specific measuring area, you may decide to conduct the calibration at a minimum of one or a maximum of two points. This means that in that particular measuring range, the CTD Diver meets the specifications. Outside the calibrated measuring range, the CTD Diver may deviate slightly.

Example: if you use the CTD Diver in a measuring range of 2-3 mS/cm, perform the field calibration at 1.413 and/or 5 mS/cm. This will put the CTD Diver within the specifications in the measuring range in question of 1.413 tot 5 mS/cm.

If you carry out the calibration later at the four calibration points, the CTD Diver will meet its specifications across the entire measuring range.

The procedure for calibrating a CTD Diver can be found in the manual supplied with the LDM program.

We also advise you to allow the CTD Diver to become acclimatised if it has not been used for a long period. Immerse it in ordinary tap water for a day at a fixed sample rate of one minute.

OTD Diver

The oxygen sensor in the OTD Diver is easily accessible and therefore susceptible to damage, so it should be subjected to extra inspections for scratches or scale. If in any doubt, calibrate it.

For reliable measurements, the oxygen sensor in the OTD Diver should be calibrated at least once a year. For the best possible measuring results, you may decide to do so prior to a long-term measuring session, for example. If you calibrate the OTD Diver after a measuring session as well, you will have a better understanding of any irregularities during the measuring session. You will find more information on calibrating an OTD Diver in the manual supplied with the LDM program.

FAQs

This section contains an overview of questions we receive from many of our customers and the answers to them. If you do not find the answer you are looking for, please contact Van Essen Instruments.

Q: *How do I install my Diver?*
A: Most Divers are installed underwater in a monitoring well. The depth at which you can suspend a Diver depends on the measuring range of the instrument. For installation, determine the lowest possible water level measured from the top of the well (or another reference point). If you then hang the Diver at at least this depth, you will be certain that the Diver can always measure the water level. The Diver can be suspended from a Direct Read Cable (DRC) or from a stretch-proof steel wire by means of a suspension eye. Attach the Diver to the well cover and the suspension eye with two wire clamps.

Q: *How do I connect a Diver to my computer?*
A: This depends on how the Diver is installed in the monitoring well:

- A Diver that is hanging in the well on a steel cable has to be removed from the well before it can be read out with a DiverMate or by your computer using a readout unit:

    1. Connect the readout unit to your computer via the COM or USB port. If you are using a DiverMate, you can only use a readout unit with a RS232 port.
    2. Unscrew the suspension eye from the Diver.
    3. Insert the Diver upside down into the readout unit.

- A Diver suspended from a DRC can be left in the well. Read the Diver out with a DiverMate or on your computer with a DRC interface cable:

    1. Connect the DRC interface cable to your computer. If you are using a DiverMate, connect the DRC interface cable to the DiverMate.
    2. Unscrew the protective cap from the end of the DRC.
    3. Connect the connector on the interface cable to the end of the DRC.

4. Read the Diver measurements out on your computer or DiverMate.
5. Place the protective cap back on the DRC.

Q; *What is a DiverMate?*
A: A DiverMate is an instrument that enables easy readout of the measurements taken by a series of Divers in the field. While reading the results, the DiverMate stores the data and the Diver settings in its memory.

Q: *Is it only possible to use the Divers at sea level?*
A: No, you can use the Divers at any elevation from 300 m below sea level to 3,000 m above. You can pre-program the elevation at which you intend to use the TD, OTD or CTD Diver by means of the LDM software.

Q: *Do you always need two Divers for a single measurement in a monitoring well?*
A: No, but you must include at least one BaroDiver for each network to monitor barometric pressure. In a network of 20 monitoring wells, for example, you would have to install 20 Divers and one BaroDiver. For larger networks, we recommend installing one extra BaroDiver as a reserve.

Q: *Within what radius of the Divers should I hang a BaroDiver to obtain good air pressure compensation?*
A: Within a radius of 15 km from the Divers.

Q: *How can the results of the (Baro)Diver measurements be converted from cm water column (e.g. 70.74 cm wc) into atmospheric pressure (mbar)?*
A: The (Baro)Diver measures in cm water column (cm wc) from 950 cm wc. To convert the measured value from cm wc into mbar, you divide the sum of the measured value plus 950 cm wc by 1.01972. An example: 70.74 + 950 / 1.01972 = 1,001 mbar.

Q: *How long does a Diver battery last?*
A: The life of a battery depends on the measuring frequencies, readout and programming cycles and the type of Diver.

- The battery in the TD Diver has the capacity to perform:
  - 2,000,000 measurements
  - 2,000 readout cycles
  - 2,000 programming cycles
- The battery in the CTD Diver has the capacity to perform:
  - 2,000,000 measurements
  - 500 full memory readouts
- The battery in the Diver has the capacity to perform:
  - 600,000 measurements
  - 1,000 readout cycles
  - 1,000 programming cycles

Q: *Can the Divers be used in seawater?*
A: The TD and OTD Divers are made of 316L stainless steel, which is not suitable for use in seawater. The new CTD Diver is made of a ceramic material called zirconia. This material does not corrode, so the new CTD Diver can be used in seawater, unlike previous models of the CTD Diver, which are made of 316L stainless steel and are not suitable for use in seawater.

Q: *How do I clean my Diver if it is very dirty?*
A: If your Diver is very dirty, use a highly diluted solution of acetic or phosphoric acid. Immerse the deactivated Diver in the solution for some time. After cleaning, always rinse the Diver with clean water, particularly around the circulation holes. If necessary, use a soft cloth to remove any scale. Never use hard brushes, abrasives or sharp objects to clean your Diver.

Q: *How do I clean the sensor in the OTD Diver?*
A: Clean it carefully with a very soft brush. The hairs should only touch the sensor, do not use force. The oxygen sensor is easily accessible and therefore susceptible to damage.

Q: *Does the Diver have to be calibrated?*
A: Van Essen Instruments calibrates its Divers before they are sold. A factory calibration certificate is available upon request.

- After the factory calibration, the TD Divers do not have to be calibrated.
- The conductivity measuring cell of the CTD Diver has to be calibrated regularly to ensure that measurement results remain reliable.
- The oxygen sensor of the OTD Diver has to be calibrated regularly to ensure that measurement results remain reliable.

Q: *When does the CTD Diver have to be calibrated?*
A: We recommend calibrating the CTD Diver at the beginning of a new measuring session. If you calibrate the CTD Diver after the measuring session as well, you will have a better understanding of any irregularities during the measuring session.

Q: *How do I calibrate my CTD Diver?*
A: A CTD Diver is easy to calibrate using either the LDM or the EnviroMon software programs, both have a calibration wizard that calibrate the Diver automatically. You only have to make sure that the CTD Diver is immersed in a calibrant with standard conductivity. The CTD Diver’s range determines what calibrant you should use. The following applies to the old model CTD Diver:

- For a CTD Diver with a range of 5 mS/cm, use a calibrant of 5,000 mS/cm.
- For a CTD Diver with a range of 50 mS/cm, use a calibrant of 12,880 mS/cm.

The new CTD Diver can be calibrated at four points. To get the Diver within the specifications across the entire measuring range, it should be calibrated at these points, i.e. 1.413, 5, 12.88 and 80 mS/cm. If you opt for a two-point calibration, the conductivity measurement between these two points meets the specifications. A deviation may occur outside them. You will find more details in the manual supplied with the LDM software.

Q: *When should the OTD Diver be calibrated?*
A: For reliable measurements, the oxygen sensor in the OTD Diver should be calibrated at least once a year. For the best possible results, you would be advised to calibrate it before starting a long-term measuring session. If you calibrate the CTD Diver after a measuring session as well,

you will have a better understanding of any irregularities during the measuring session. We recommend calibrating OTD Divers after cleaning. The oxygen sensor is readily accessible, making it susceptible to damage. You can check for any damage by calibrating it.

Q: *How do I calibrate my OTD Diver?*
A: An OTD Diver is easy to calibrate using either the LDM or the EnviroMon software programs, both have a calibration wizard that calibrate the Diver automatically. You have to make sure that the OTD is immersed in water that is saturated with oxygen at a temperature of between 1°C and 30°C. You will find more details in the manual supplied with the LDM software.

Q: *How do I make a saturated oxygen solution?*
A: You make a saturated oxygen solution by half filling a bottle with clean water. Now shake the bottle vigorously for 30 seconds to saturate the water with air. Open the bottle to allow air into the water. Repeat this procedure three times.

Q: *When should a CTD Diver be used?*
A: A CTD Diver measures the level, temperature and electrical conductivity of groundwater, so a CTD Diver can be used in situations of increasing or decreasing contamination or salinisation of the groundwater.

Q: *When should an OTD Diver be used?*
A: An OTD Diver measures the level, temperature and content of dissolved oxygen of the groundwater, so an OTD Diver can be used in a variety of conditions to monitor the water quality in situations where biological processes play a role, such as:

- soil remediation projects
- swimming water
- groundwater and surface water in the vicinity of dumpsites and landfills

Appendix I - Using Divers in surface water

Installing a Diver

If you intend to use a Diver in surface water, it is important to ensure an adequate flow of water around the Diver's sensors. This prevents the well blocking up and you can be sure that the Diver is actually measuring the ambient water and not the stagnant water in the monitoring well itself. We recommend using a monitoring well measuring at least 2" and keep the opening as free as possible of algae or plant growth, for example.

If you are using a steel pipe (see photos) with a 1" monitoring well in it, you can allow the nose of the Diver to protrude from the end of the well, so the sensors are in contact with the water.

Install the attachment pole with the monitoring well in such a way that the Diver can benefit from the maximum depth and current of the water, in the middle of an irrigation ditch, for example. To avoid the risk of vandalism, you can use a steel pipe with a steel cap that can be locked.

The photo shows an OTD Diver with the sensor protruding from the bottom of the monitoring well. A thinner monitoring well has been placed in the steel pipe to install the Diver in.

Appendix II - Installing a BaroDiver

A BaroDiver is usually installed in a monitoring well above the waterline. It is logical then that a BaroDiver will be exposed to greater temperature variations than a TD, CTD or OTD Diver that measures the groundwater. It is, however, important that the temperature variations the BaroDiver is subjected to closely match those confronting the Diver placed in the groundwater.

If you place the BaroDiver at the top of the monitoring well, the temperature may be affected by sunlight on a steel well or by frost, for example. Major temperature variations between the BaroDiver and the ordinary Diver may result in a deviation in the compensated water level.

Divers have a pressure sensor in the nose and a temperature sensor elsewhere in the housing. The response time of the temperature sensor is longer than that of the pressure sensor, and this difference may impact measurement accuracy. Gradual or minor temperature changes will have little effect. Major, rapid temperature changes on the BaroDiver may have an effect, however, if these changes deviate from the temperature regimen on the ordinary Diver. If the values of the latter Diver are compensated for with values from the BaroDiver, a deviation in the compensated values may occur.

Solutions:

It is important that the temperature changes the BaroDiver is subjected to closely match those confronting the (groundwater) Diver, for which it collects compensation value information. The BaroDiver can consequently best be positioned as follows:

- For groundwater measurements: As deep as possible in the monitoring well, but above the maximum groundwater level.
- In an office or pumping station for smaller or more gradual temperature effects.

- For surface water measurements: Use a ‘floating’ BaroDiver. The BaroDiver is connected to a float and placed in a pipe sleeve. The BaroDiver is now free to move up and down with the water level but maintains a constant distance from the water level. This exposes the BaroDiver to the same temperature effects as the Diver in the surface water.

Appendix III - Using Divers at height

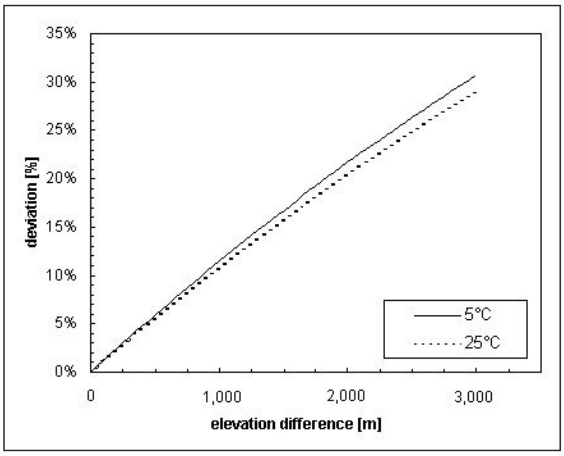
You can use Divers at any elevation, from 300 metres below sea level to 3,000 metres above. It is, however, advisable to use all Diver and BaroDivers in a single network at the same elevation.

The relationship between air pressure (variations) and elevation is not linear but exponential:

$P_h = P_0 \cdot e^{-(M.g.H)/(R.T)}$

P_h) = air pressure at elevation H
P_0 = air pressure at 0
M = 28.8x10^{-3} kg/mol (molecular mass of air)
g = 9.81 m per s^2
H = elevation
R = 8.314 Joule/mol/Kelvin(gas constant)
T = temperature in Kelvin

If you place the BaroDiver at a different elevation in relation to the other Divers in a measuring network, the relationship above may cause deviations in the barometrically compensated data. At a temperature of 273 Kelvin, the following graph applies:



The table relating to the graph shows that at an elevation difference of H = 100 m, the deviation P/P0 = 1 – 0.987641 = 0.0124 m = 1.24%.

At an elevation difference of H = 1,000 m, the deviation is P/P0 = 1 - 0.883064 = 0.1169 m = 11.7%. This is why we recommend placing all Divers and BaroDivers in a measuring network in such a way as to keep the elevation differences to a minimum.

Index