EC-2500A

ELECTRICAL CONDUCTIVITY SENSOR

PRODUCT USER MANUAL

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1 Introduction

1.1 System Description

Thank you for purchasing the Greenspan Electrical Conductivity Sensor Model EC-2500A. This manual provides a guide to the configuration, operation and maintenance of these sensors to provide long term reliable and accurate monitoring.

The Greenspan EC-2500A Sensor combines robust, sealed construction with an electrode-less sensing system to offer unparalleled reliability and robustness.

The EC-2500A has a standard 4-20mA output with an option for 0-2.5Vdc.

1.2 Certification

The EC-2500A sensors are assembled and tested in accordance with ESS Earth Science's ISO 9001 Quality Certified System.

- ***The instrument is visually inspected, marked and labelled.***
- ***The complete sensor calibration record is archived for reference, and batch number information is kept on file for statistical analysis.***
- ***An individual Certificate of Conformance is issued to the customer.***

1.3 Unpacking and Inspection

Sensors are packed in new cartons for shipping. On receipt, the customer should inspect the packaging and contents for any signs of damage during transportation. The customer should also check that all items on the delivery note have been received.

A full set of documentation including Certificate of Conformance, Quick Start Guide, and User Manual will be provided with all equipment – either in hard copy format or in electronic format.

1.4 Serial Number

Checking the Model Number and Range

Before installing your Greenspan EC-2500A sensor check the information on the label is correct to confirm you have received the instrument you have ordered. The label will look similar to this.

MODEL EC250

RANGE 0 – xxxx µS NORM (S)

S/N 012345

The customer is advised to keep a record of the serial numbers in case the sensor is lost or the label damage. Greenspan keeps records of all sensors sold including a calibration history.

1.5 Warranty Policy

Greenspan warrants all new products against defects in materials and workmanship for **12 months** from the date of invoice.

Products that prove to be defective during the warranty period will be repaired or replaced at the discretion of Greenspan.

Under Greenspan warranty conditions; it is the responsibility of the customer to cover shipping charges back to the factory. Upon repair/replacement Greenspan will cover the return shipping charges to the customer.

This warranty does not apply to products or parts thereof which have been altered or repaired outside of the Greenspan factory or other authorised service centre; or products damaged by improper installation or application, or subjected to misuse, abuse neglect or accident. This warranty also excludes items such as reference electrodes and Dissolved Oxygen membranes that may degrade during normal use.

Greenspan will not be liable for any incidental or consequential damage or expense incurred by the user due to partial or incomplete inoperability of its products for any reason whatsoever or due to inaccurate information generated by its products.

Any sensor should not be dismantled unless under instruction from Greenspan Service staff. Incorrect handling will void the warranty.

1.6 Factory Service & Repair

If for some reason sensors are required to be returned to our factory or your sales representative, please note the model and serial number, describe the problem, including how and under what conditions the instrument was being used at the time of malfunction. Clean the product and cable. Decontaminate thoroughly if used in toxic or hazardous environment. Carefully pack product in original packaging if possible & include a statement certifying product and cable have been decontaminated with supporting information. Products returned for repair must be accompanied by a completed GRN (Goods Return Notification) form. All sensors returned for service and repair work must be properly decontaminated prior to return. A cleaning charge may be applied to sensors that require further decontamination. Service work will not commence until the quotation has been accepted by the customer. A purchase order for all repair and service work will be required before work is carried out.

2 Sensor Overview

2.1 Theory of Measurement

Conductivity is the measurement that indicates the ability of a solution to carry an electric current. It is defined as the inverse of resistance (Ohms) per unit square and is measured in units of Siemens/metre or micro-Siemens/centimetre.

The measurement of conductivity is necessary for the determination of a solutions salt content (the salinity). Salinity is proportional to conductivity and is expressed in terms of the concentration of salt per unit volume (mg/l, ppt, etc).

Electrical conductivity readings are a function of the number of ions present and their mobility. The electrical conductivity of a liquid changes at a rate of approximately 2% per degree Centigrade for neutral salt and is due to the ion mobility being temperature dependant. See Appendix A for further detail on this relationship. The temperature co-efficient of conductance (or the K factor) varies for salts and can be in the range 0.5 to 3.0.

As EC is a function of both salt concentration and temperature, it is preferable to normalise a conductivity measurement to a specific reference temperature (25°C) in order to separate EC changes due to salt concentration from those due to temperature changes.

2.2 Toroidal Sensing Head

The EC sensor uses an electromagnetic field for measuring conductivity. The black plastic head contains two ferrite cores configured as transformers within an encapsulated open ended tube. One ferrite core is excited with a 10KHz sinusoidal voltage and the corresponding secondary core senses an energised voltage when a conductive path couples the primary voltage. The degree of coupling is inversely proportional to the resistivity of the coupling medium. An increase in charged ion mobility or concentration causes a decrease in the resistivity and a corresponding increase in the output of the EC sensor. The advantage of toroidal sensing is the elimination of system errors caused by electrode degradation.

2.3 Temperature Sensor

A separate temperature sensor (PT100), independently monitors the temperature of the sample solution. The sensor provides both a temperature output and a signal to normalise the EC output.

2.4 Microprocessor Control Unit

The MCU and associated components provides an analogue output proportional to EC. The MCU manages an error correction system which ensures that non linearity and temperature drift errors are monitored and considerably reduced. A major feature of the MCU is the ability to provide a more accurate output. The MCU tracks the water temperature over a range of 0 to 30 degrees Celsius, with an accuracy of +/- 1% over the complete temperature range.

2.5 Supply Voltage

The EC sensor will operate with a supply voltage within the range 8 to 27 V DC. However, in order to ensure that the minimum required operating voltage is supplied to the EC sensor, it is necessary to consider both the length of the cable and the power requirements of the sensor circuitry.

2.5.1 Calculating the Minimum Supply Voltage

The minimum supply voltage (Vs) required to power the EC-2500A sensor can be determined from the formula:

Vs = 2 * (Sc * Cr * (Cl / 100)) + Vm

where:

Sc = Maximum sensor current drain (A)

Cr = Sensor cable resistance per 100 metres

Cl = Sensor cable length

Vm = Sensor minimum operating voltage

The maximum sensor current drain, Sc, is:

Sc = ECfs + PTfs + Sqc

where:

ECfs = EC sensor full scale current drain (A)

PTfs = Temperature sensor full scale current drain (A)

Sqc = Sensor quiescent current (A)

From the EC-2500A Specifications we find that, Cr = 9 ohms per 100 metres of cable, Sqc = 0.03A, Vm = 8.0. We know that for a 4-20 mA output sensor, full scale is 20 mA.

Therefore ECfs = 0.02 and PTfs = 0.02. Let us assume a cable length of 25 metres. We now can calculate Sc and hence Vs,

Sc = .02 +.02 + .03

= .07A

Vs = 2 x (.07 x 9 x 0.25) + 8.0

= 0.315 + 8.0

=8.315V

3 Applications

Applications in which the Greenspan EC-2500A can be used include:

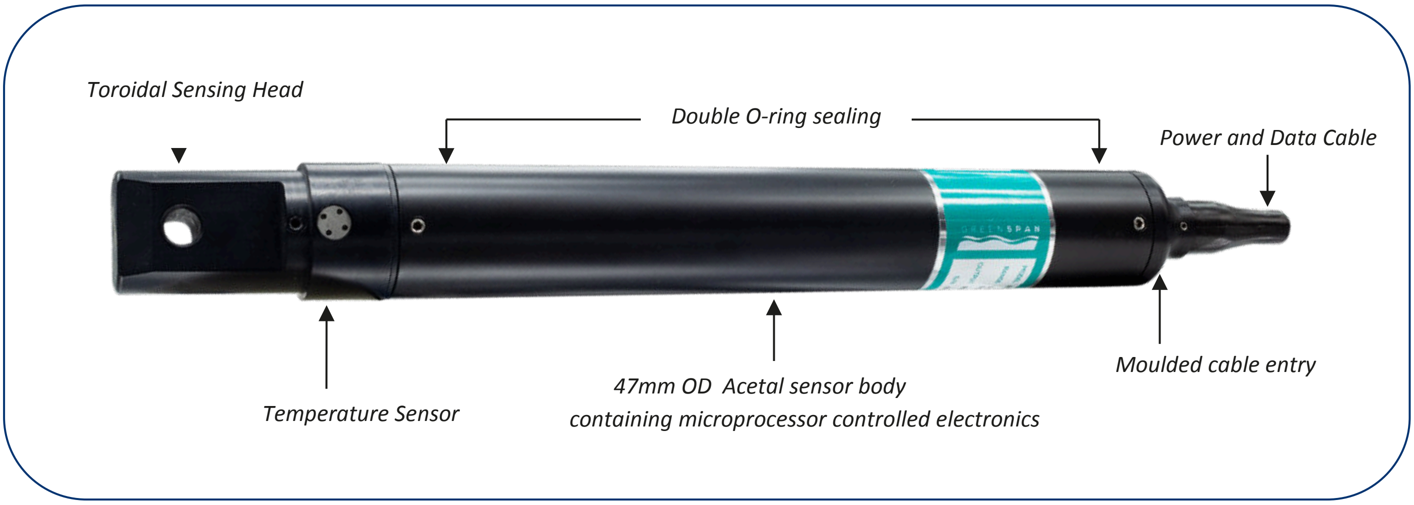
- Surface Water - Aquaculture, Rivers, Lakes, Ponds, Catchments.
- Ground Water - confined and unconfined aquifiers
- Ecological Sites, wetlands
- Mining Sites, Tailings Dams, Run off
- Industrial processing and Trade Waste

4 Instrument Details

4.1 Sensor Design

The Greenspan EC-2500A consists of the following primary elements:

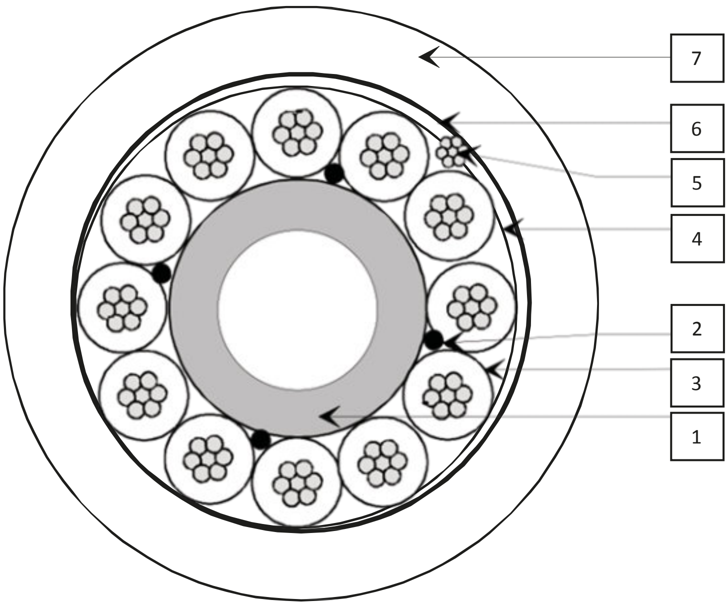
- Toroidal sensing head (conductivity sensor)
- Temperature sensor
- Microprocessor controlled signal conditioning and output device
- Data cable
- Acetal body
- Acetal packaging including protective shroud



4.1.1 Cable Details

All Greenspan sensors utilise a specially designed Polyurethane Cable. The cable is reinforced with Aramid fibres which provide superior tensile strength and low stretch properties. Changes in temperature have little effect on the overall length of the cable. This feature provides users with the benefit of self-suspending the sensor to depths of 300m without additional strain relief.

The cable contains 12 x conductors, 1 x drain wire, an internal vent tube and Aramid fibres. The outer jacket is made from UV stabilized Polyurethane and is suitable for all external, underwater or harsh environment applications. This common cable construction is utilized for vented and non-vented Greenspan sensors. Cables are generally factory fitted at time of manufacture in specified lengths.



Cable Construction

1 –*__Vent Tube:__ Polyamide*
(size ID x OD) 2.40 x 3.20 mm

2 – ***Aramid Fibre***

3 - ***12 x Conductors***
7 x 0.20 mm Tinned Copper
Section = 0.22mm2 AWG24
Insulation: Polypropylene
(size) = 1.10 mm ± 0.05 mm

4 - ***Tape:*** *Polyester*

5 – ***Drain Wire:*** *7x0.20 TinCu*

6- ***Tape:*** *Polyester Aluminium*

7 - ***Jacket:*** *Polyurethane black,*
(size OD) 8.05 mm ± 0.15

4.1.2 Mechanical Specifications

- Specially manufactured Greenspan cable with 12 cores and internal vent
- High chemical resilience and abrasive resistance
- Conductor cross section : AWG 24,
- Electrical Resistance 9 ohm per 100m (per conductor)
- Operating temperature: 85°C (max.),
- Bending radius (static) : 6 ,
- Bending radius (dynamic) 12.
- Max Operating voltage : 250V
- Jacket Printing (white colour each meter)
- Conductor colour codes : green, yellow, white, black, brown, turquoise, violet, pink, red, blue, grey

The moulded cable is fitted to the sensor using a double o ring seal and located using 2 x grub screws. The length of the cable is not critical to the long term calibration and operation of the sensor (provided the electrical requirements such as minimum supply voltage are maintained).

4.2 Sensor Factory Calibration

The sensor is assembled and calibrated to the required range in accordance with the Greenspan ISO9001:2008 Quality System

- The toroidal head is assembled and encapsulated with epoxy resin to completely seal against any water penetration and provide physical rigidity and protection.
- The complete unit is calibrated on the bench with resistors used to simulate EC readings and so correct the instrument for linearity errors.
- The EC probe is then placed in an environmental chamber and monitored over the temperature range of 0 to 30 °C. The chamber automatically steps through at 10 deg C intervals holding each level for 3 hours (ensuring complete temperature stabilisation at each stage).
- All system temperature errors are recorded and a fourth order polynomial is generated within the microprocessor to correct for any thermal drift.
- The sensor is then re-run through the environmental chamber to ensure that the temperature correction co-efficient curve is correct over the entire working range and the sensor meets specifications.
- The sensor is then linearised over the following fractions of full scale: FS, 3/4, 1/2, 1/4, 1/8,1/32, 1/64, 0 to generate a polynomial for the microprocessor to ensure that the linearity specification of ± 0.2% is met.
- A normalisation curve is downloaded to the microprocessor to standardise readings to 25 C (based on KCl standard curve of 2% per deg C @ 25C).
- The sensor is visually inspected and labelled ready for despatch.
- A Certificate of Conformance is generated as part of the production process and this is issued to the customer. The complete calibration records, sensor history and batch number are placed on file and archived.

5 Sensor Wiring & Connections

5.1 Standard Connections

EC-2500A provides two calibrated analogue outputs (4-20mA) for EC and temperature over the Sensor Full Scale Range. The sensor requires a nominal 12V DC power supply, but will operate from 8-27V DC.

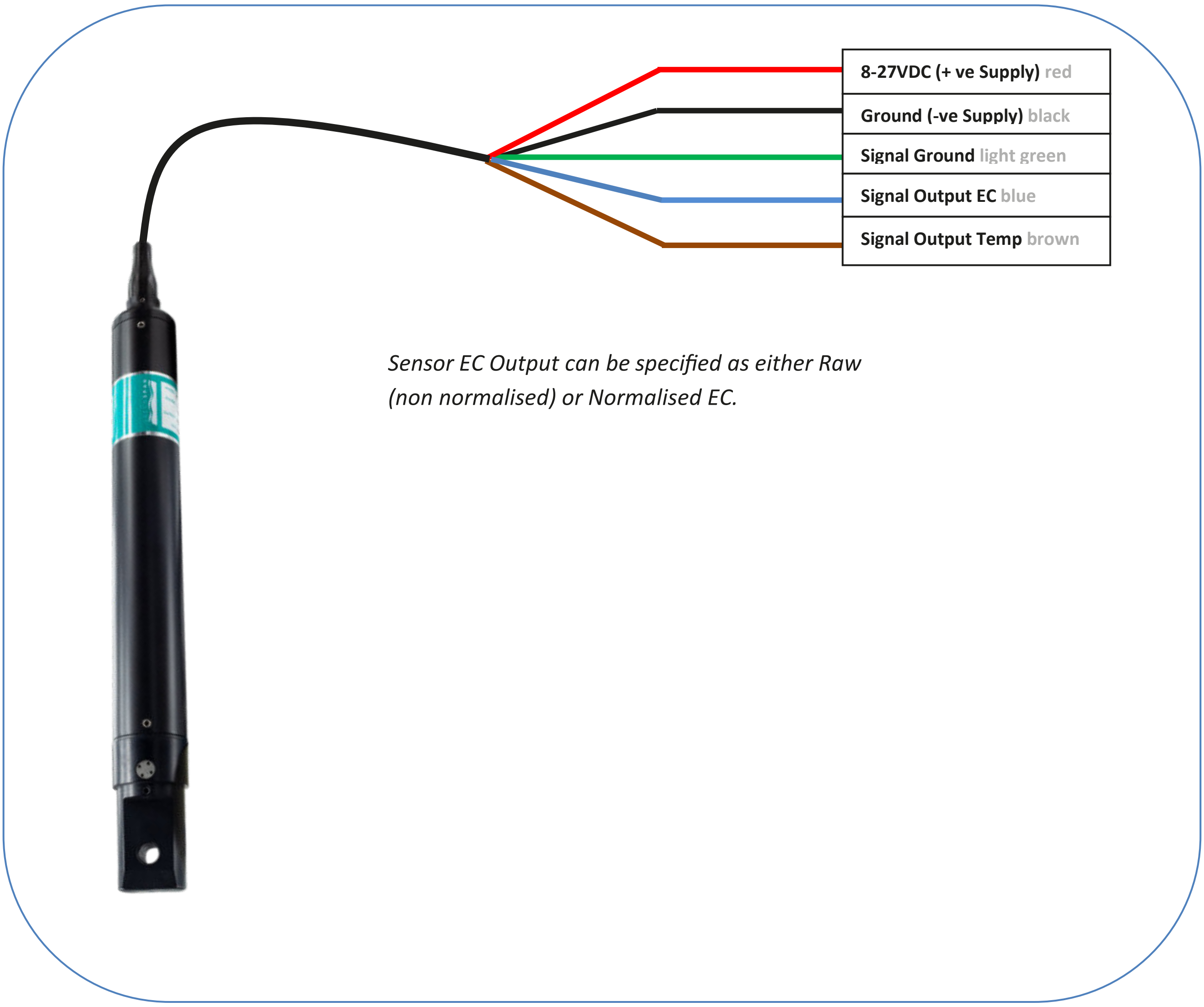


Figure 2: EC-2500A Sensor Connection

5.1.1 Voltage Output Sensors

As noted in the connection diagram (Figure 2) an additional Signal Ground wire is fitted to the sensor.

For sensors configured with the **Voltage Output** option it is essential to connect this wire to the input ground of the logging instrument or meter during installation in order to obtain the specific accuracy for this parameter.

If the Negative Battery wire is used for Signal Ground return, the voltage drop produced across it (as a consequence of the current consumption of the sensor itself) becomes a direct component included in the output signal.

As the outputs from the EC/Temp channels varies, the error component also changes. It must be realised that such changes are non-linear. Extended cable lengths increase the errors introduced.

Connection of the 'Signal Ground' wire must also be as close as possible to the Input Circuit of the Data Logger in order to maintain absolute accuracy for the parameter(s) measured.

For sensors configured with the Current Output option, use of the Signal Ground wire is recommended but not essential. No inaccuracy will be introduced by using the alternative Negative Battery wire as the signal return.

6 Installation and Deployment Considerations

6.1 Placement and Care of the Sensor

The main benefit derived from utilising toroidal sensing technology for the measurement of EC is the reduction in fouling resulting from complete isolation of the sensor cores from the liquid medium.

The toroidal sensors create an electric field around the sensing head and as such it is necessary to maintain a space of at least 100mm around the head to ensure complete accuracy.

The sensor should always be completely submerged and positioned such that the possibility of air bubbles becoming entrapped within the sensor hole is minimised. Large bubbles will cause errors if permanently trapped.

For applications in harsh environments it is recommended that the optional Acetal Body be specified.

The sensor head should be periodically inspected for fouling, the sensor can be cleaned with fresh water and damp cloth. . The protective shroud is easily unscrewed from the head for quick access. Bottle brushes are commonly used for cleansing the sensor hole.

Regular removal of encrustations may be necessary in marine/estuarine environments.

6.2 General Methods of Installation

There are a many ways of positioning sensors in the field in order to ensure the continuous gathering of data and the safety of the device.

Consideration needs to be given to the possibility of vandalism, animal damage, theft and extreme weather conditions.

Some methods commonly in use are:

- Installed in PVC conduit with sensor emerging from the immersed end.
- Strapped to pylon or post in areas that become submersed, cabled to bank.
- Hand operation for spot readings.
- Suspended sensor attached to a guide wire and winch board, which is useful for profiling applications.

6.3 Typical Locations

- Edge of river/stream/lake embankment.
- Mounted within a stilling well off stream from the main flow.
- Sensor anchored to bed of lake/stream
- Suspended from dam walls.
- Mounted within drainage channels/pipes

6.4 Field Installation Instructions

The Greenspan range of Water Quality Sensors can be installed into a variety of applications including:

- Rivers, Lakes and streams
- Bore Hole and groundwater wells
- Tanks and Reservoirs
- Wet Wells for Water and Sewer Systems

In all field applications, mechanical, electrical and physical protection of the Sensor, cabling and associated fittings must be provided.

Consideration needs to be given for the protection against vandalism, animal damage, theft and extreme weather conditions.

Field Installation must ensure:

- The sensor is anchored or held in position or located so it is not subject to any movement during normal operations.
- Sensor is protected from direct sunlight to avoid high temperature fluctuations
- Sensor is protected against high turbulence and possible debris loading during flow events

6.4.1 Option 1: Non Turbulent Conditions

Where there is no possibility of the sensor being affected by turbulence it can be suspended into the water body using a stainless steel hanger cable (e.g. where the sensor is installed into a large water storage tank). The sensor will hang vertically into the tank and not be subject to movement from water movements. The stainless steel wire prevents loading of the sensor cable.

In Sewer Wet Well and Water Tank applications where high turbulence and debris loading may affect the sensor, the following minimum installation standards must be followed:

6.4.2 Option 2: High Turbulent Conditions

Where turbulence and water movement will act on the sensor it is recommended to mount the sensor in a stilling well or mounting cradle attached to the side of the well. This could simply be a length of PVC pipe bolted to the well wall in which the sensor is located or could be an extension pole with a sensor cradle at the lower end. Potential ragging and debris build up on the sensor & cable should be overcome by extending the stilling well to above the high water level or by cable tying the sensor cable up the cradle mounting arm. The movement of the sensor must be eliminated such that the sensor is not subject to twisting motion from swirling water during pumping, or from sideways movement due to ragging of the sensor.

In all sewer wet well applications regardless of the mounting system used it is recommended to also utilise a stainless steel hanger cable* to prevent loading the sensor cable during installation, removal and maintenance. The stainless steel wire must be securely connected to the sensor using the hanger hook and the sensor cable should be cable tied at regular intervals up the stainless wire. An outer sheath of hose or tubing can be fitted over both cables to reduce ragging and debris build up on the cables. At the top of the well the stainless wire can be attached to a bolt or mounting point.

Under no circumstances must the sensor be installed such that it can collide with the sides of the well, or other solid objects within the well. Sensor installation under these circumstances will lead to sensor damage that will not be covered under our normal warranty conditions. In these cases the sensor must be mounted into a cradle or stilling well as per Option 2.

7 EC-2500A Specifications

Measurement technique	Toroidal measuring system
Standard EC ranges available	0-2,000µS, 0-5,000µS, 0-10,000µS, 0-20,000µS, 0-60,000µS, 0-70,000µS. Other ranges are available on request A calibration charge applies to non-standard ranges
Outputs	EC: 4-20mA Temperature: 4-20mA
Linearity	Temperature 0.2°C, EC 0.2% FS
Temperature accuracy	0.2°C
EC Accuracy, normalised to 25°C	2% FS @25°C
EC Accuracy, non-normalised	2% FS @ 25°C
Cable type	Polyurethane sheathed cable, OD 8mm, aramid reinforced moulded entry, bare wire connection
Cable Lengths	10, 20, 30, 50, 80, 100, 150, 200m
Non-standard cable lengths	Yes (Extra cable moulding time may be required)
Power Supply	8-27V
Reverse polarity protected	Yes
Surge protected	To 2kV
Warm-up/reading time	1 sec
Current Consumption	40-90mA (dependent on output)
Operating Temperature	0-50°C
Storage Temperature	-5°C to +60°C
Depth rating	100m
Weight	950g (Acetal)
Dimensions	Length 561.5mm (22.11” x 2.57”) OD 47mm
Wetted Materials	Acetal

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