Geovista Sonde Operations Manual

TCME
Temperature Conductivity Multiple Electrode Sonde

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Temperature / Conductivity
Multiple Electrode Sonde

Measurements

This sonde measures simultaneously borehole fluid conductivity and temperature.

The temperature measurement is useful both to normalise conductivity readings and to locate temperature anomalies caused by such events as fluid flow into the borehole. The conductivity measurement is a useful water quality parameter.

Recommended mnemonic TCME

Sonde measurement parameters

Parameter	Range	Resolution	Accuracy
Temperature	0°C To 80°C	0.001°C	+/- 0.3°C
Conductivity	50 to 50,000 µSiemens /cm	0.05 µSiemens/cm	+/- 2%
VMON	0 – 100 mV	0.5 mV	NA

Sonde Dimensions

Sonde length 0.71 metres
Sonde diameter 38 millimetres
Sonde weight 3.2 Kgs

Conductivity Measurement Principle

The conductivity of the borehole fluid is measured as it flows through the bore of the bottom part of the sonde. Inside this bore in the sonde, there are a series of electrodes, a total of seven electrodes. The arrangement of these electrodes is shown schematically in Fig 1 below.

The principle applied is that known as the “4 wire measurement”, with a mirror image set of electrodes to suit the practicalities of a borehole sonde. The outer electrodes, labelled B, are at ground potential. An AC voltage is applied to the A electrode from the voltage source as shown, causing a current to flow through the fluid between the A and B electrodes. This current is sampled by the measuring the voltage across the resistor RSample

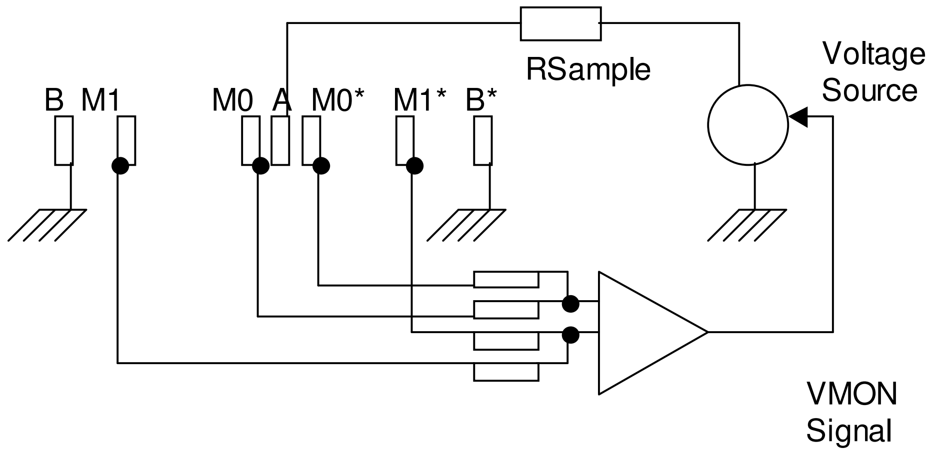

Fig 1. 7 Electrode Array Schematic

The voltage difference caused by the current flowing through the fluid is measured by the monitor electrodes, M0, M1, M0* & M1*. The potential measured is developed at the output of the amplifier and is then used to maintain this potential at a constant level by means of controlling the output level of the controllable voltage source.

Thus, the electrode array and the associated electronics ensures that there is a constant potential across a constant volume of fluid. Consequently, the magnitude of the current passing through the A electrode is a measure of the conductivity of the fluid.

The current is measured by measuring the voltage across the resistor R Sample. It is this signal that is sent to surface and calibrated as the conductivity channel.

The use of 7 electrodes may seem elaborate, but there is a very good reason for this. If the A and B electrodes become fouled because of debris in the borehole, then the feed back system employed will ensure that the correct potential is maintained across the measure electrodes.

Due to the very high impedance of the amplifier, fouling on the monitor electrodes has no significant effect. Uncorrected fouling of the A and B electrodes can have a large effect on the measurement system if not corrected.

To ensure that the feedback system is operating correctly, the output of the amplifier is measured downhole and sent to surface, where correct operation can be verified. The nominal voltage measured at the output of the amplifier is 20 mV. If this voltage is within range, then the system is known to be operating correctly.

In extreme circumstances, the circuit will be unable to maintain the correct potential, and will be observed as a drop in the value seen in the VMON channel. If this occurs then the user should take measures to clean the electrode array.

Conductivity Measurement Calibration

When delivered, the sonde is calibrated and ready for use. The stability of the electronic circuits coupled with the use of the 7 electrode array ensures stable readings for a long period of time.

However, good practice requires that frequent checks of the measurement are made, and this is most easily achieved using solutions that are purchased ready mixed and with conductivities of known values.

The procedure applied can be modified locally, but following these steps will give good results;

1. Firstly, make sure that the sonde and test solutions have been stored in the same location for several hours. This is to ensure that all parts and solutions are at the same temperature. A quantity of fresh water should also be stored at the same time for washing of parts.
2. Wash the sonde electrode array thoroughly with the fresh water and dry with a clean paper towel or similar.
3. Tape up the three fluid exit holes of the sonde (amalgamating tape is best for this), and mount in a vertical position with the open end of the sonde upwards.
4. Start the system logging on the computer screen and pour in sufficient of the solution with the lowest conductivity to be used so that all the electrodes are covered. Pour the solution so as to minimize the introduction of air bubbles, and remove any trapped air by tapping the outside of the sonde. Note that there will be a period of time where the temperature and conductivity drift as thermal gradients settle out.
5. After stabilisation, take a note of the values from the diagnostic screen using the averaging function. Also make a note of the conductivity of the test solution at the temperature recorded on the sonde temperature probe.
6. Repeat steps 2 to 5 for as many solutions are to be used.

At the end of the process you should have a set of results similar to these, depending on the solutions used

Temperature °C	Solution Conductivity At temperature	Bit Value Recorded In Sonde
18.5	470	10,450
18.4	5,200	110,350
18.3	15,000	335,750

Table 1 Conductivity Calibration Results

Temperature

The temperature measurement uses a Platinum resistance type of probe. The electrical resistance of this device varies with temperature in a well characterised manner.

Due to the repeatability of the temperature sensor response, it is quite acceptable to replace the sensor without recalibrating the electronics, should the sensor become damaged in use.

Calibration Of The temperature Sensor.

In the GeoVista system, calibration of the temperature measurement circuit is a two stage process. Before these processes are explained, a brief discussion on the methodology of Platinum Resistance Thermometry (PRT) is required.

A PRT sensor consists of a length of high purity platinum wire, terminated as a 4 wire measurement device and encapsulated in a stainless steel housing.

Suppliers of PRT sensors supply sensors that conform to a particular standard. Those used by GeoVista conform to IEC 751:1983, equivalent to BS EN 60751:1996. Part of this specification relates the resistance of the sensor against temperature. This relationship is;

$R_t = R_0(1 + At + Bt^2)$ …………………… (1)

R_t is the resistance, in Ohms, at temperature t °C
R_0 is the resistance, in Ohms, at 0°C.
A and B are given constants

For those sensors used in GeoVista sondes, R_0 is 100 Ohms.

Within the standard is provision for different qualities of sensor with different accuracies. GeoVista uses the Class A sensor, which has a maximum error, over the range 0°C to 80°C of +/-0.3°C.

So, what is required of the GeoVista sonde is a measurement circuit that measures resistance to a very high accuracy. The measurement circuit operates by comparing the resistance of the PRT sensor to the resistance of a precision resistor, so any electronic drift is removed due to the ratiometric mode of operation.

The temperature section of the sonde is calibrated against high quality precision resistors, achieved in the usual manner of sonde calibration. Thus the sonde is initially calibrated into Ohms. The software then has the second stage of calibration where equation (1) is applied to generate a value in °C, as required.

It is unlikely that any problems will occur with the calibration of the temperature measurement. Experience has shown that no significant drift occurs. If the user is convinced that a problem exists, then the recommendation would be to return the sonde or replace the circuit board, which ever is most convenient.

Operation

Prior to running the sonde in the hole, it is advisable to clean the electrodes. Usually the use of clean water will be sufficient if the post-operation procedures have been observed. In the event that the electrodes have become heavily fouled, sonde disassembly is advised.

This sonde is usually run while logging down. Refer to the “GeoVista Platform Logger” software manual for points to observe while logging down.

After logging, the cleaning of the electrodes should be performed as soon as practical.

Quality Control

There is a quality control channel on the TCME sonde, named VMON.
VMON is a measure of the potential across the moniter electrodes and should remain constant throughout the logged interval, at a value of approximately 20 millivolts.

If electrode fouling occurs to the extent that the feed back system cannot maintain the required potential across the moniter electrodes, then this voltage will start to reduce. If this occurs, then the fouling is extreme and the only solution is to remove the sonde from the borehole and clean the electrodes.
The availability of this VMON channel gives a high degree of confidence in the measured conductivity.

Normalisation

As mentioned before, it is useful to normalise the conductivity readings to a standard temperature, so as to allow comparison between different boreholes. There are several equations used for this normalisation, depending on the type of fluid in the borehole. A standard conversion is shown here which is suitable for NaCl solutions. The user should verify the value of this conversion in the locale before application.

$$COND_{corr} = 46.5/(t + 21.5) * COND_{log\ value} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$COND_{log\ value}$ is the conductivity measurement from the sonde at temperature t
$COND_{corr}$ is the equivalent conductivity at temperature 25°C
t is the temperature recorded in °C

A user function is attached which performs this function.

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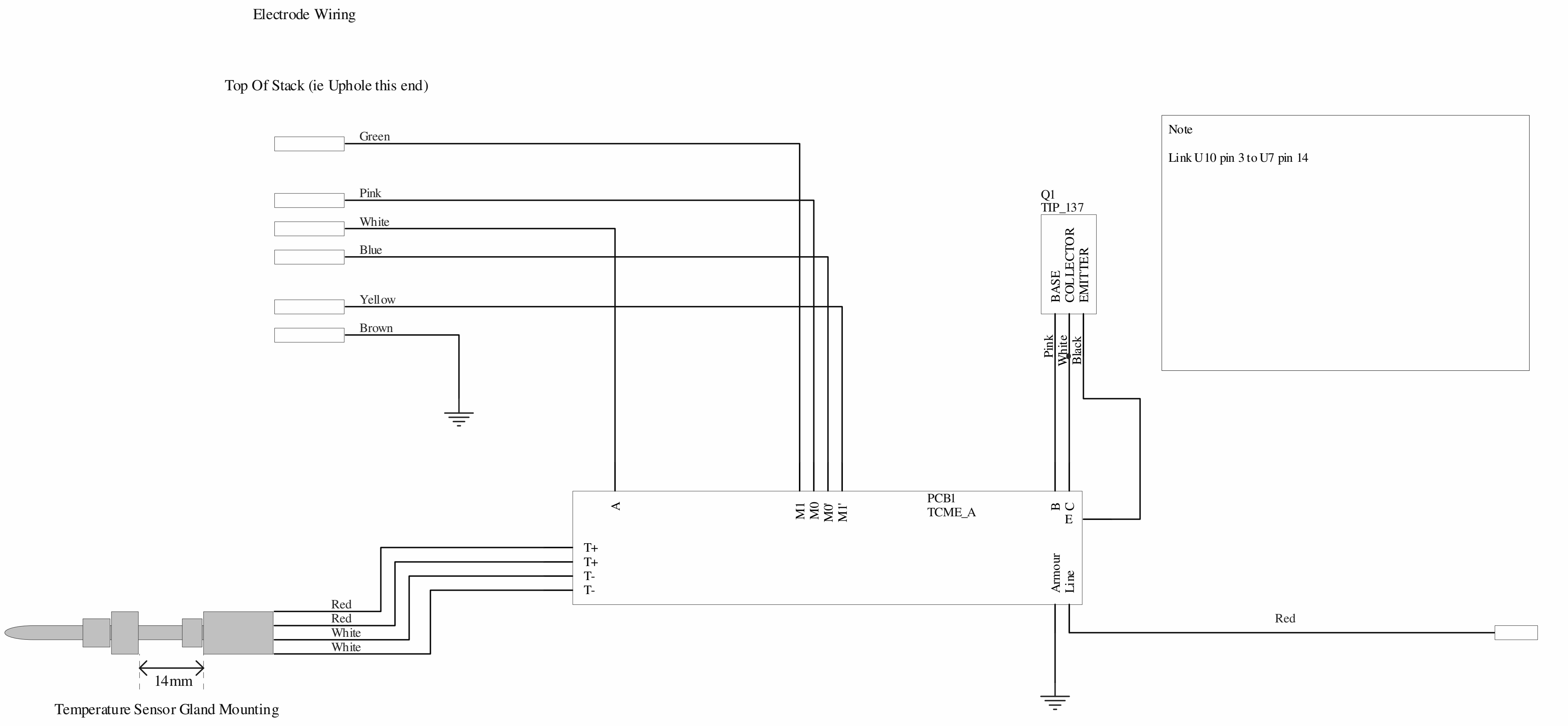
Manual Revision Record

Version 1.0	April 2002	Author Martin Payne
Version 2	April 2003	M Payne Added calibration descriptions
Version 3	Dec 2004	S Messamah – removed section on isolator sub.



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Drawn	Issue	Circuit Description	Checked	Date	Issue	Parts List	Checked	Date
Date								

Title: TCME Wiring

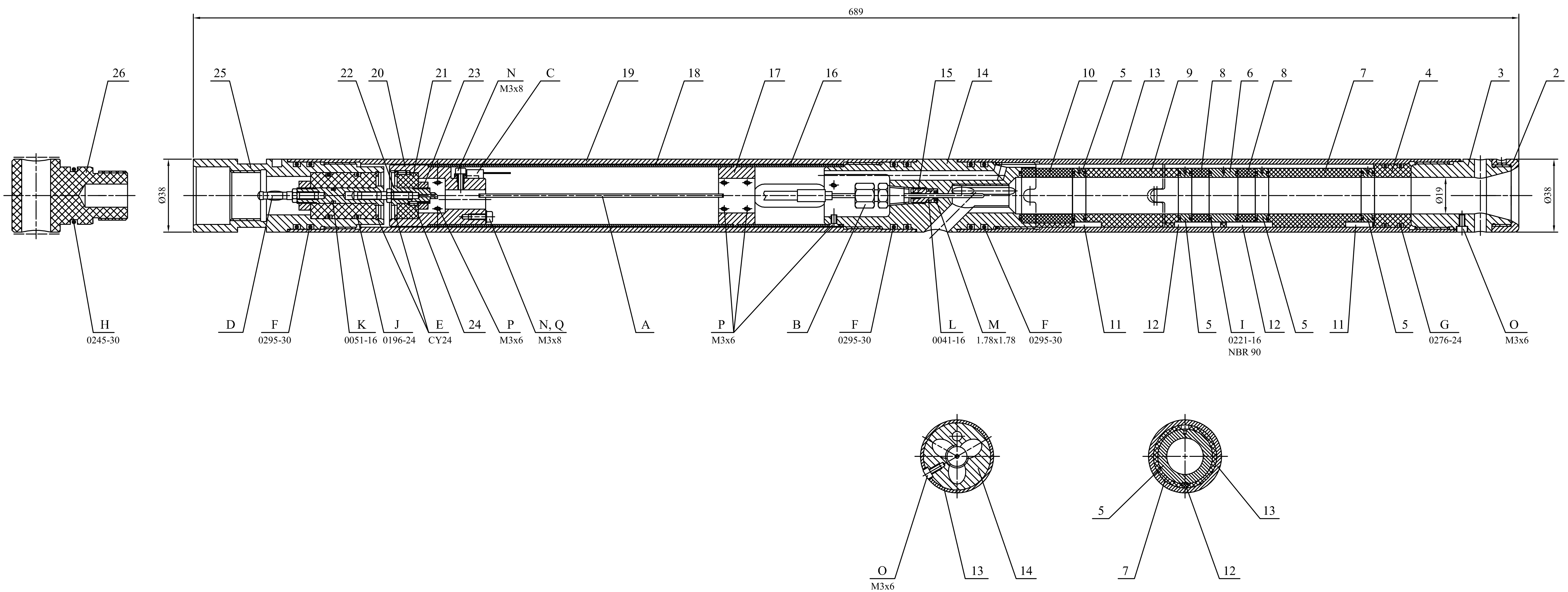
PCB Ident:

Filename TCON_D_3.SCH

Issue

Sheet Of

Project TCON Sonde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Inline Temperature /Conductivity Adapter Assembly

To fit the Temperature / Conductivity (TCON) sonde adapter for in-line operation, follow this procedure;

1. Remove the 3 screws holding the bottom section

Fig 1.0

2. Gently pull bottom section and disengage the feed-through boot by pull it off.

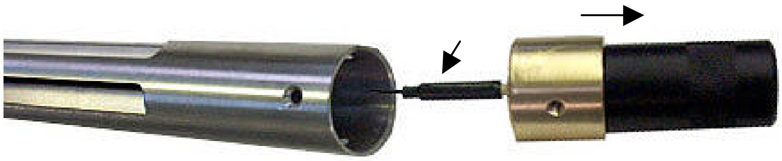


Fig 2.0

3. Release the feed-through wire from the clamp and from any securing tape, then carefully unscrew the sleeve body from the top section.

Fig 3.0

4 Remove the black cap and connect the TCON sonde.

Fig 4.0

5 Pull the wire out of the feed-through wire from body and tape it along the TCON sonde body

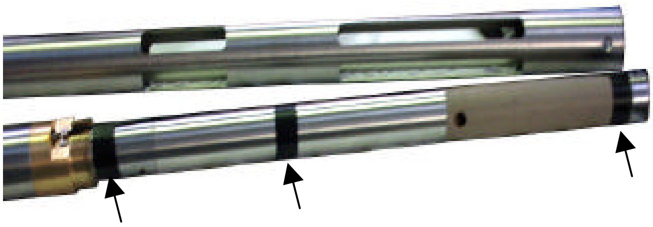


Fig.5.0

6 Carefully insert the sleeve body over the TCON sonde, making sure that the feed-through wire is not trapped or cut.

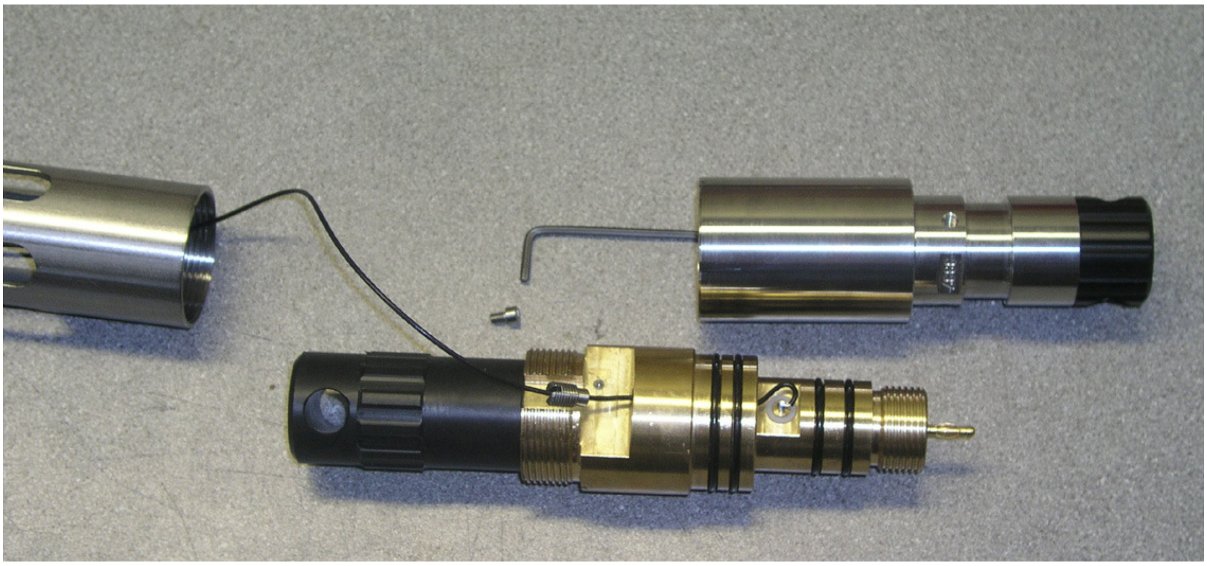
7 Apply a thin layer of silicone grease to the feed-through on the bottom section and slide the boot over it.

8 Secure the bottom section with the 3 screws and secure the feed-through wire under the wire clamp.

Feedthrough Wire

A pressure seal on the Feedthrough Wire is obtained using a rubber gland and clamping nut and washer, parts 10, 9 and 8. Should the wire become damaged it can be replaced using the following procedure:-

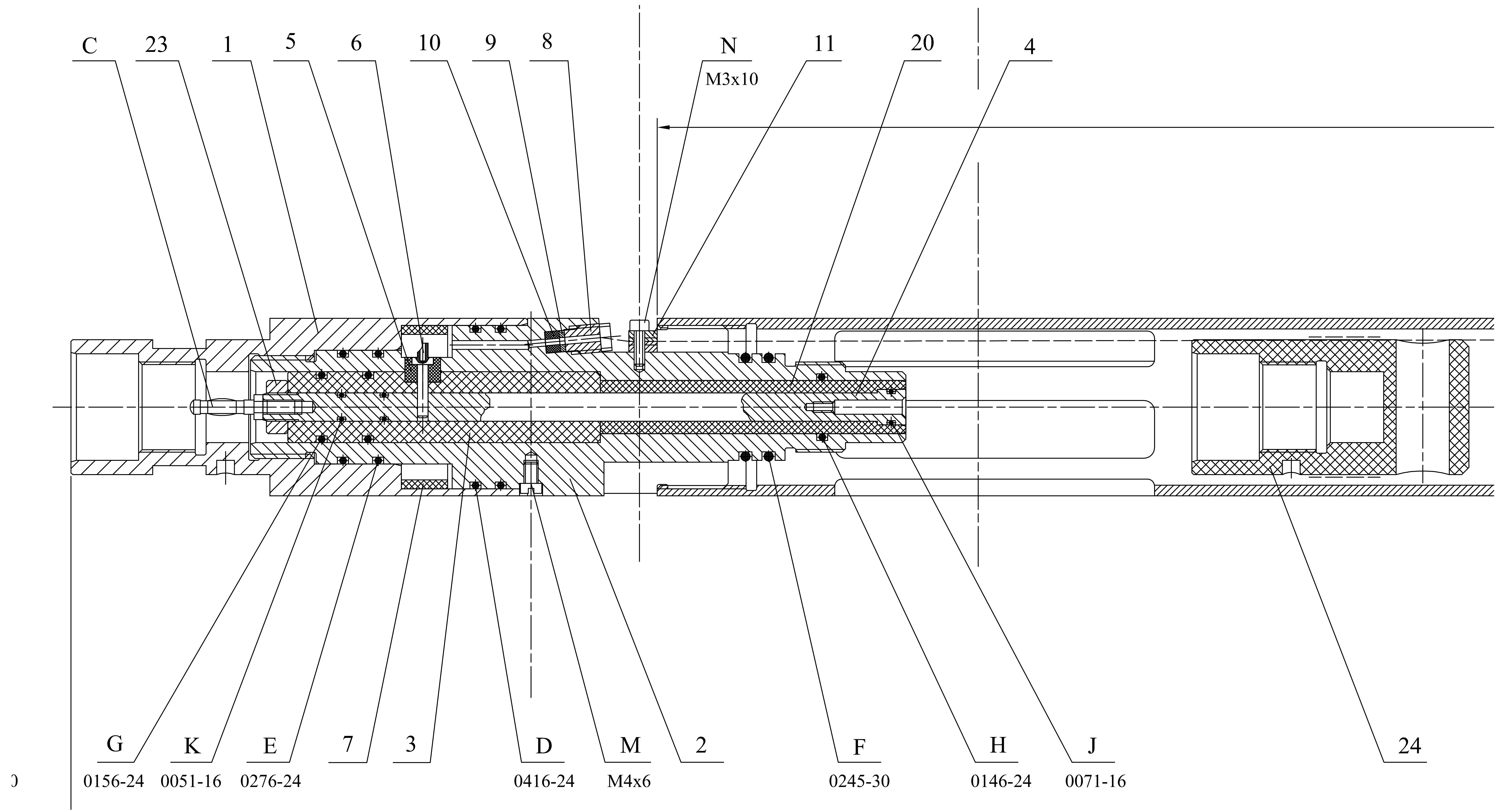
1) Remove the anti-rotation screw part M and unscrew the upper sub body, part 1 from part 2.



2) Unsolder the Feedthrough wire from the Line solder terminal part 6.
3) Unscrew and completely remove the clamping nut part 8.
4) Solder the replacement wire onto the end of the old wire and use the old wire to pull the new wire through the rubber gland.
5) Solder the new wire back onto the Line terminal.
6) Refit the clamping nut ensuring that it is firmly tightened against the rubber gland to create a pressure seal.
7) Refit the upper sub body and anti-rotation screw.

A suitable replace wire is PTFE 19/0.2 with an OD of 1.8mm. A similar wire can be used providing the OD is 1.8mm this is important for the Feedthrough and rubber gland seals.

New rubber seals and O rings are available from GeoVista.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