Installation Manual
IM/AP/MM–IM_2

Insertion-Type Electromagnetic Probe Flowmeters

AquaProbe and MagMaster™ Transmitter

ABB

The Company

EN ISO 9001:2000

Cert. No. Q 05907

EN 29001 (ISO 9001)

Lenno, Italy – Cert. No. 9/90A

Stonehouse, U.K.

0255

We are an established world force in the design and manufacture of instrumentation for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

The UKAS Calibration Laboratory No. 0255 is just one of the ten flow calibration plants operated by the Company and is indicative of our dedication to quality and accuracy.

Electrical Safety

This instrument complies with the requirements of CEI/IEC 61010-1:1993 "Safety requirements for electrical equipment for measurement, control, and laboratory use". If the instrument is used in a manner NOT specified by the Company, the protection provided by the instrument may be impaired.

Symbols

One or more of the following symbols may appear on the instrument labelling:

	Warning – Refer to the manual for instructions
	Caution – Risk of electric shock
	Protective earth (ground) terminal
	Earth (ground) terminal

	Direct current supply only
	Alternating current supply only
	Both direct and alternating current supply
	The equipment is protected through double insulation

Health and Safety

To ensure that our products are safe and without risk to health, the following points must be noted:

1. The relevant sections of these instructions must be read carefully before proceeding.
2. Warning labels on containers and packages must be observed.
3. Installation, operation, maintenance and servicing must only be carried out by suitably trained personnel and in accordance with the information given.
4. Normal safety precautions must be taken to avoid the possibility of an accident occurring when operating in conditions of high pressure and/or temperature.
5. Chemicals must be stored away from heat, protected from temperature extremes and powders kept dry. Normal safe handling procedures must be used.
6. When disposing of chemicals ensure that no two chemicals are mixed.

Safety advice concerning the use of the equipment described in this manual or any relevant hazard data sheets (where applicable) may be obtained from the Company address on the back cover, together with servicing and spares information.

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1 INTRODUCTION

The AquaProbe electromagnetic insertion flowmeter is designed for measurement of the velocity of the velocity of electrically conductive fluids.

The flowmeter, available in four standard lengths, can be installed in any pipeline of internal diameter from 200mm (8in) to 8000mm (360in), through a small tapping.

The AquaProbe has been designed for use in survey applications such as leakage monitoring and network analysis and in permanent locations where cost or space limitations preclude the use of conventional closed pipe meters.

1.1 System Schematic – Fig. 1.1

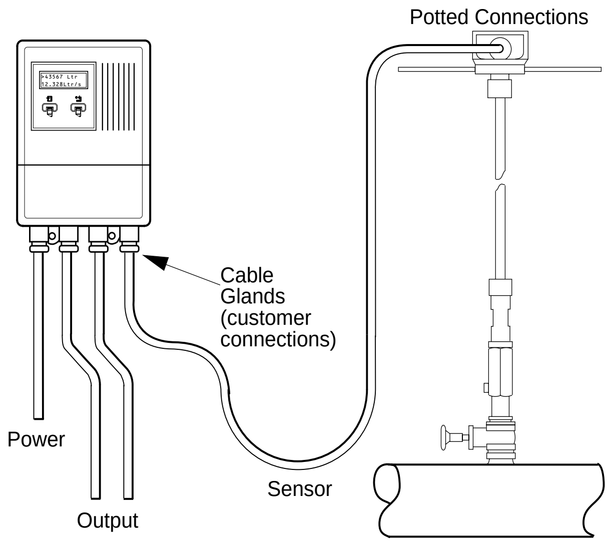


Fig. 1.1 System Schematic

2 PREPARATION

2.1 Checking the Code Number – Fig. 2.1

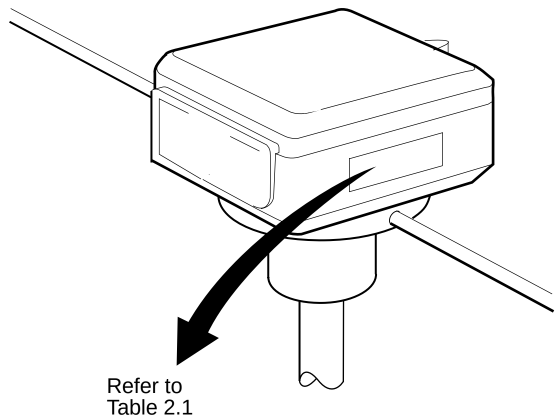


Fig. 2.1 Checking the Code Number

AquaProbe Product Code		Sensor										Transmitter					
AquaProbe	MF/A	XXX	X	1	0	1	0	X	XX	X	ER	X	X	X	1	X	X

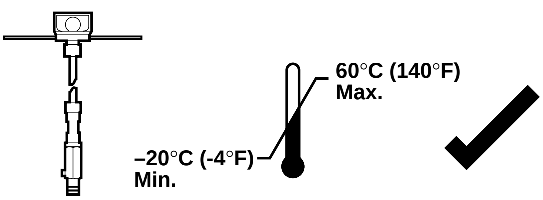
Length	No probe	000
	300mm (12in)	301
	500mm (20in)	501
	700mm (27in)	701
	1000mm (39in)	102
Sliding Joint Connection	Not required	0
	1.0in BSP, with 1/8 in BSP pressure tapping	1
	1.5in BSP, with 1/8 in BSP pressure tapping	2
	1.0in NPT, with 1/8 in NPT pressure tapping	3
Calibration	Un-calibrated	0
	Standard 3 point	1
	8 point	2
	Witnessed 8 point	4
Cabling	Not fitted or potted	00
	3m	03
	10m Fitted to sensor and potted	10
	30m	30
Glanding and Armoured Cable Options	Standard sensor interconnection cable with 20mm plastic glands	1
	Armoured sensor interconnection cable with two brass glands for sensor connection; remaining three transmitter glands in plastic	2
	Armoured sensor interconnection cable with 20mm brass glands	3
	North American option, 0.5in NPT drilling on terminal box	4
Power Supply	85 to 265V A.C.	1
	11 to 40V D.C.	3
Display	None	0
	Standard	3
Output Options	Standard output	0
	Dual current output	1
	RS423/422 serial communications	4
	RS423/422 serial communications + dual current	5
Meter Orientation	Standard	1
	+ 90°	2
	+180	3
	+270°	4
Language	English	1
	French	2
	German	3
	Spanish	4
	Italian	5

Table 2.1 Code Number Identification

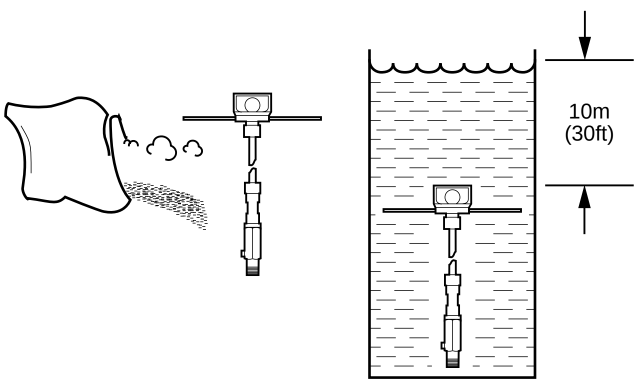
3 MECHANICAL INSTALLATION

3.1 Location – Environmental Conditions

3.1.1 AquaProbe – Fig. 3.1

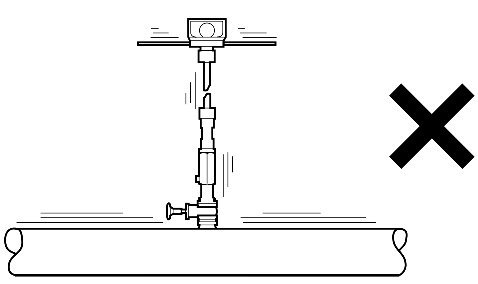


A – Within Temperature Limits



IP68 (NEMA 6)

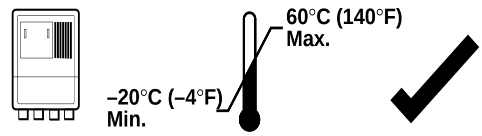
B – Within Environmental Rating



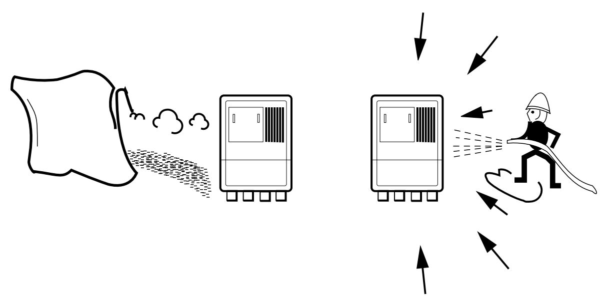
C – Avoid Excessive Vibration

Fig. 3.1 Environmental Requirements – AquaProbe

3.1.2 Transmitter – Fig. 3.2

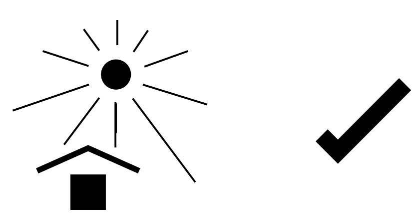


A – Within Temperature Limits



IP68 (NEMA 4)

B – Within Environmental Rating



C – Shade from Heat

Fig. 3.2 Environmental Requirements – AquaProbe Transmitter

3.2 Location – Flow Conditions

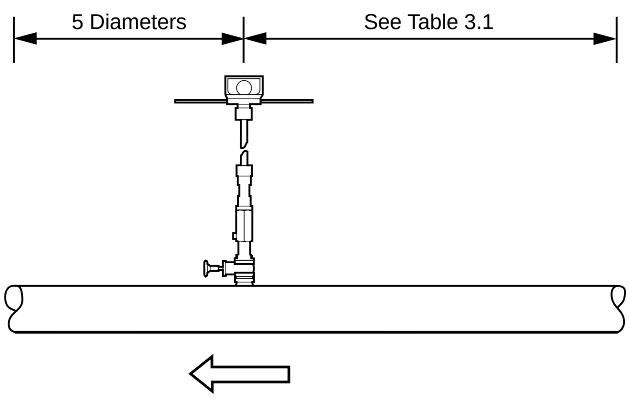
The probe may be installed in one of two positions in the pipe; either on the centre line or at the mean axial velocity point ($^1/_8$ pipe diameter). It may also be traversed across the pipe to determine the velocity profile.

3.2.1 International Standard for Flow Measurement

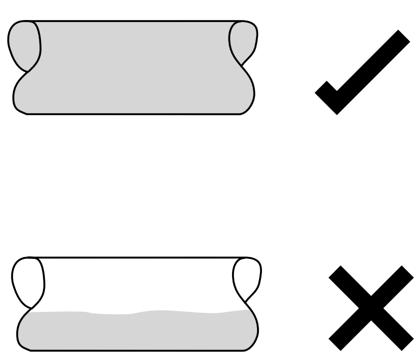
ISO 7145 '(BS 1042) Measurement of fluid flow in closed conduits' Part 2 'Velocity area methods' describes methods of calculating volumetric flow from velocity measurements.

Section 2.2: 1982 'Method of measurement of velocity at one point of a conduit of circular cross section' describes the inference of volumetric flow from measurement of velocity at a single point. Several conditions must be fulfilled to validate the method, which uses calculations based on empirical data.

Where the validating conditions can be met, the method described in Section 2.2 is the most practical. It is possible to measure the velocity either on the centre line, which reduces sensitivity to positional errors, or at the assumed point of mean flow velocity.



A – Flow Direction



B – Fluid Level

Fig. 3.3 Flow Conditions

Type of disturbance upstream from the measuring cross-section	Minimum upstream straight length*	
	For a measurement at the point of mean axial velocity	For a measurement on the axis of the conduit
90° elbow or a t-bend	50	25
Several 90° coplanar bends	50	25
Several 90° non-coplanar bends	80	50
Total angle convergent 18 to 36°	30	10
Total angle divergent 14 to 28°	55	25
Fully opened butterfly valve	45	25
Fully opened plug valve	30	15

* Expressed in multiples of the diameter of the conduit.

Table 3.1 Straight Pipe Lengths

Downstream from the measurement cross-section, the straight length shall be at least equal to five duct diameters whatever the type of disturbance.

Table 3.1 is an extract from ISO 7145 (BS 1042): Section 2.2: 1982 and is reproduced with the permission of BSI. Complete copies of the standard can be obtained by post from BSI Publications, Linford Wood, Milton Keynes, MK14 6LE.

Information. Where the above ideal conditions cannot be achieved, the flow profile must be tested for symmetry in order to obtain reliable flow results.

3.2.2 Velocity Limitations – Figs. 3.4 to 3.6

All insertion probe devices are susceptible to the vortex shedding effect which can cause severe vibration of the probe, resulting in damage and/or measurement instability. Electromagnetic devices with no moving parts, such as AquaProbe, are less susceptible to this effect than mechanical devices.

The graphs below show the maximum permissible velocities, depending the probe's location.

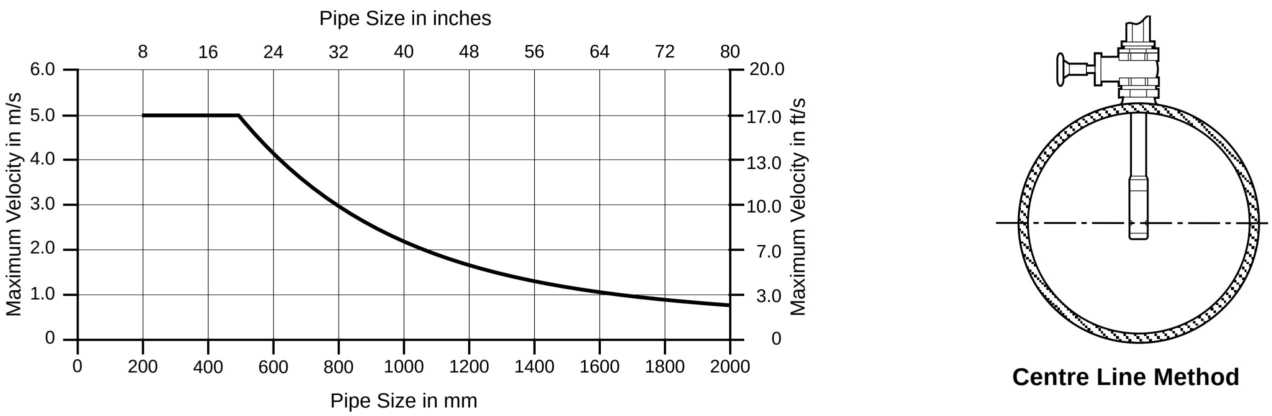


Fig. 3.4 Maximum Permissible Velocity for different Pipe Sizes

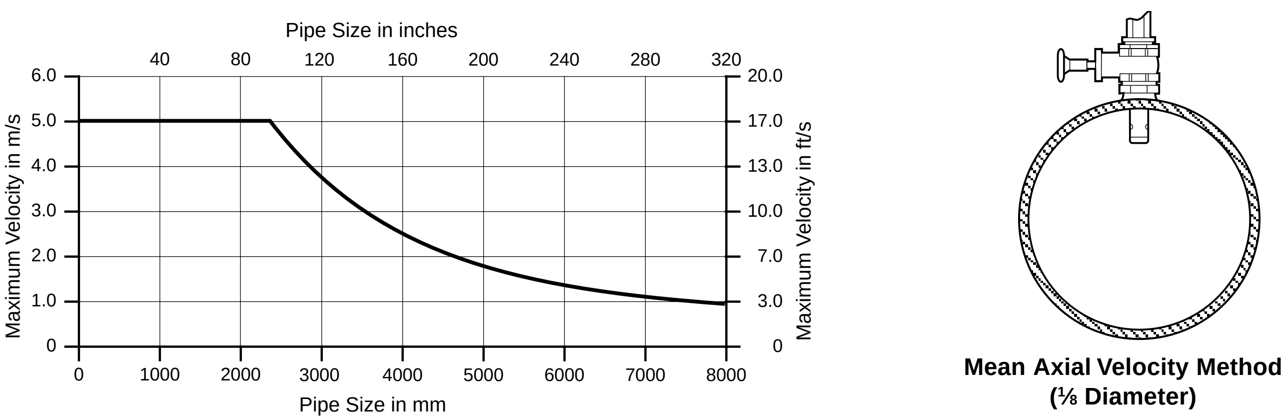


Fig. 3.5 Maximum Permissible Velocity for different Pipe Sizes

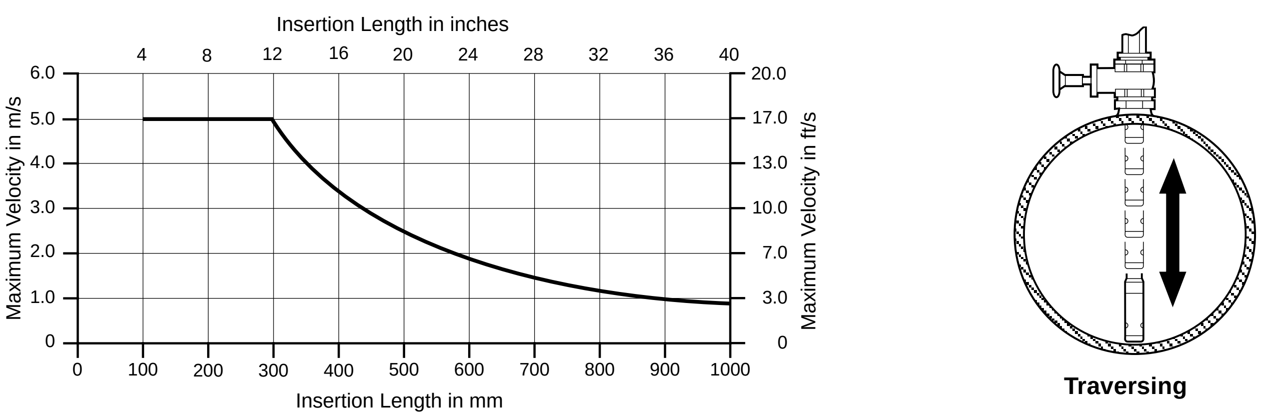


Fig. 3.6 Maximum Permissible Velocity for different Insertion Lengths

3.3 Safety – Fig. 3.9

Warning. The Aquaprobe is provided with a safety mechanism (see Fig. 3.9) which should be attached to its securing collar as shown in Fig. 3.9B. This prevents rapid outward movement by the probe if the nut 1 is released.

Note. To ensure maximum safety, the positioning collar **MUST** be tightened in place using a 4mm hexagon key

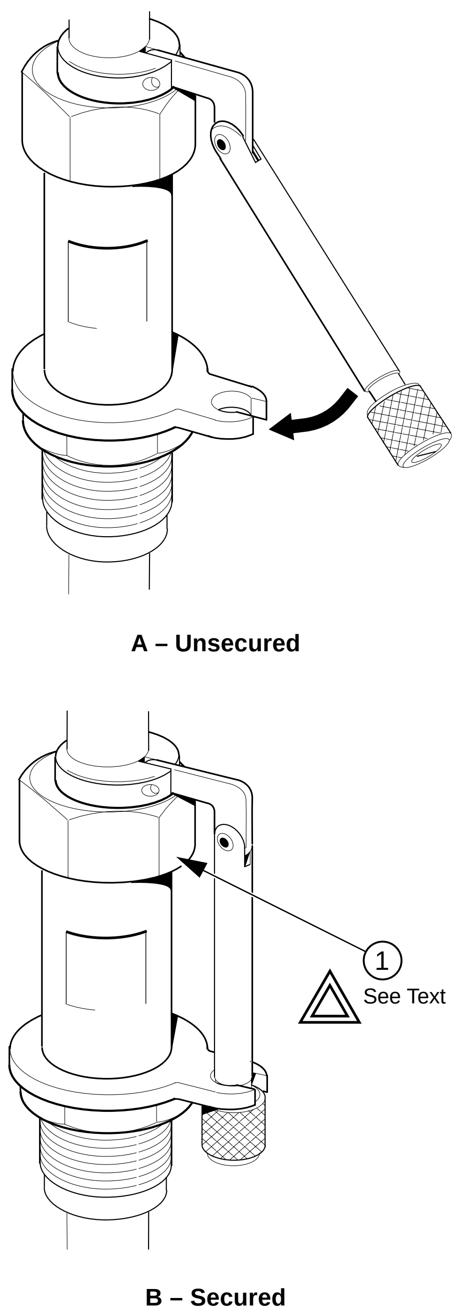


Fig. 3.9 Safety Mechanism

3.4 Installing the AquaProbe – Figs. 3.10 and 3.11

Warning. When inserting or removing the AquaProbe suitable restraining equipment must be used to prevent the probe being forced out under pressure.

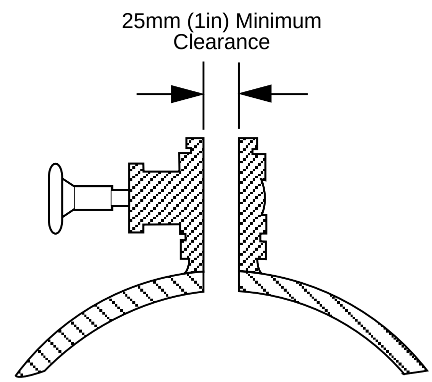


Fig. 3.10 Insertion Bore Clearance

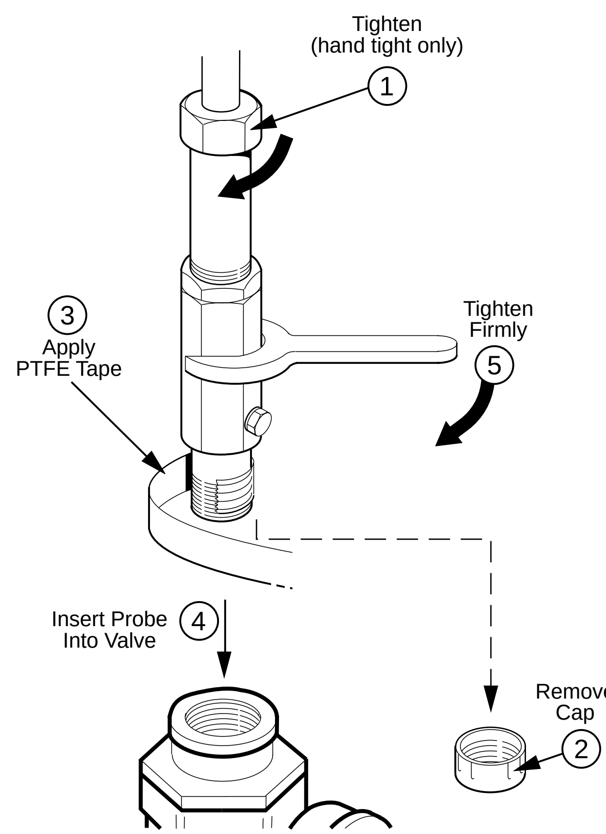


Fig. 3.11 Installing the AquaProbe

3.5 Setting the Insertion Depth

3.5.1 Centre Line Method for Pipe Diameters ≤1m (≤40in) – Fig. 3.12

Warning. When inserting or removing the AquaProbe suitable restraining equipment must be used to prevent the probe being forced out under pressure.

Information. Safety restraint omitted for clarity.

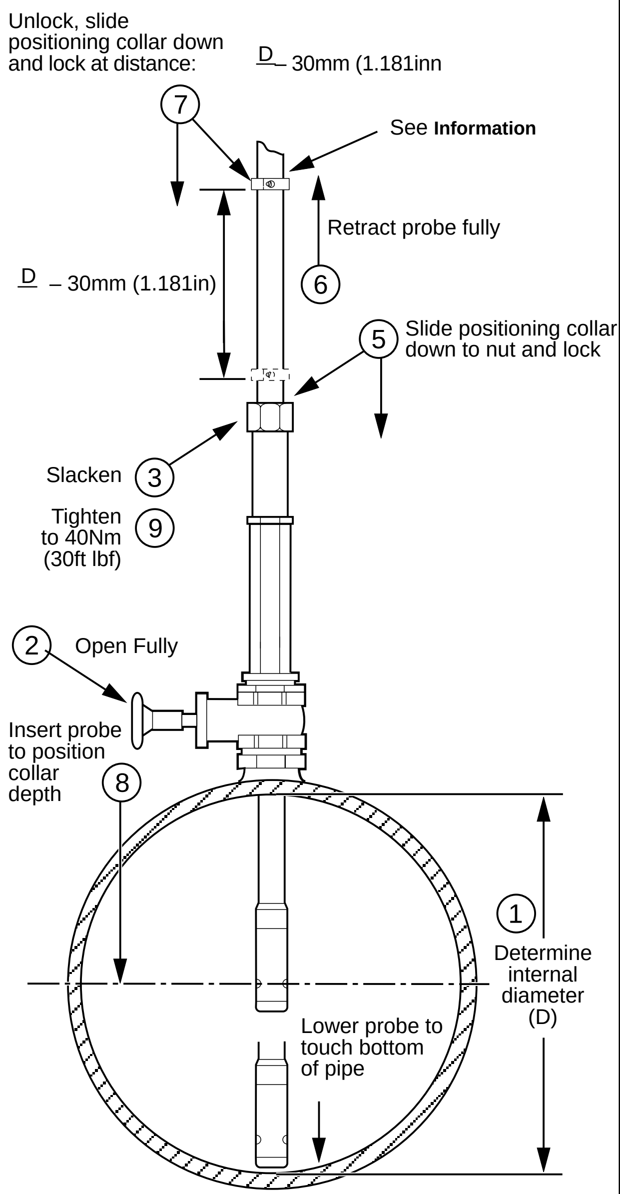


Fig. 3.12 Setting the Insertion Depth – Centre Line Method for Pipe Diameters ≤1m (≤40in)

3.5.2 Centre Line Method for Pipe Diameters >1m ≤2m (>40in ≤80in) – Fig. 3.13

Warning. When inserting or removing the AquaProbe suitable restraining equipment must be used to prevent the probe being forced out under pressure.

Information. Safety restraint omitted for clarity.

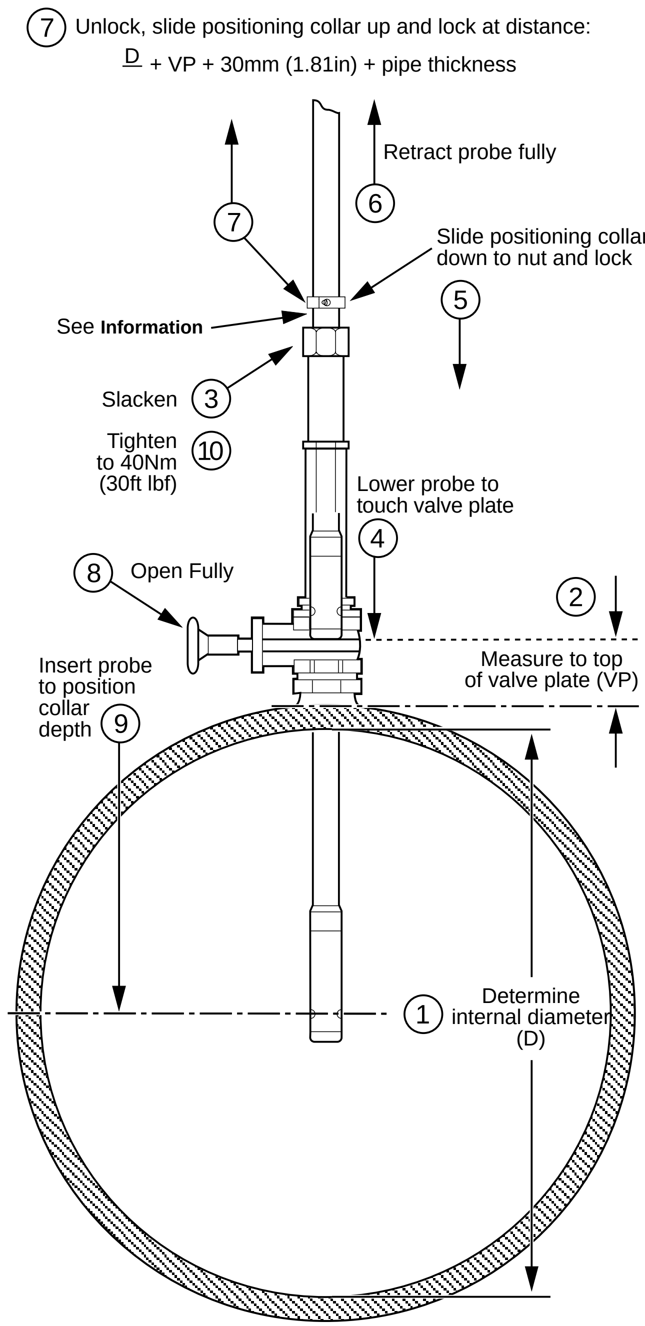


Fig. 3.13 Setting the Insertion Depth – Centre Line Method for Pipe Diameters >1m ≤2m (>40in ≤80in)

…Setting the Insertion Depth

3.5.3 Mean Axial Velocity Method – Fig. 3.14

Warning. When inserting or removing the AquaProbe suitable restraining equipment must be used to prevent the probe being forced out under pressure.

Information. Safety restraint omitted for clarity.

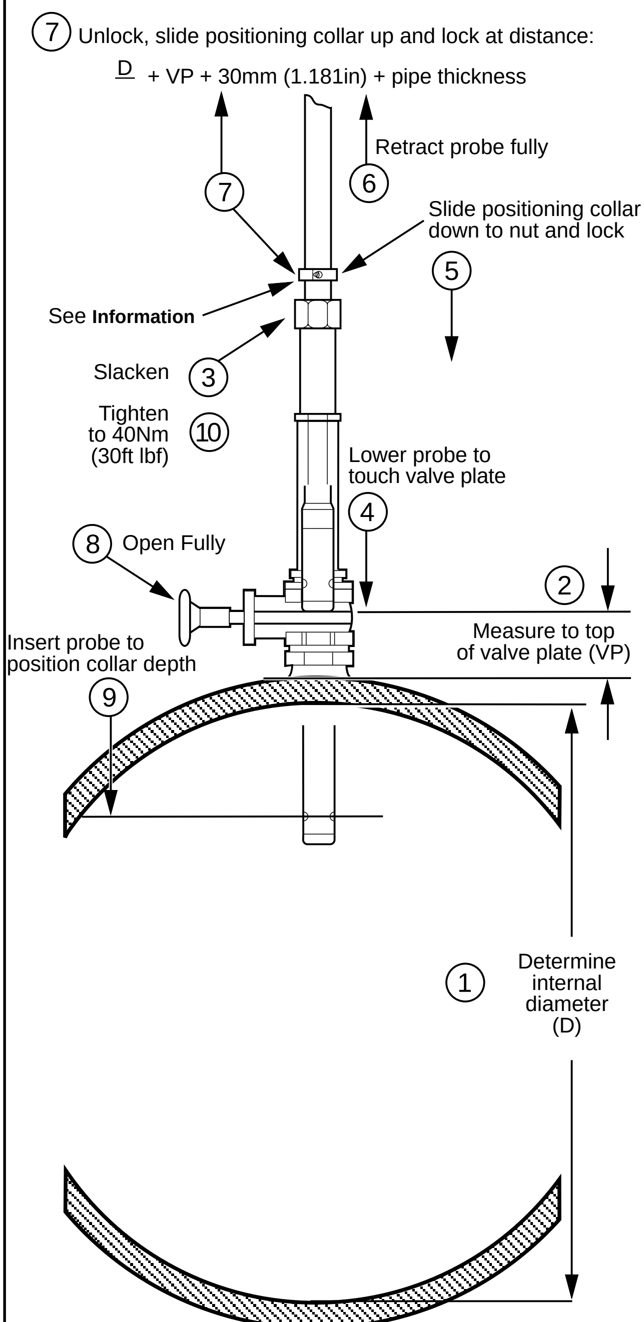


Fig. 3.14 Setting the Insertion Depth – Mean Axial Velocity Method

3.6 AquaProbe Alignment – Fig. 3.15

Warning. When inserting or removing the AquaProbe suitable restraining equipment must be used to prevent the probe being forced out under pressure.

Information. Measurement error due to misalignment is <0.15%.

Information. Safety restraint omitted for clarity.

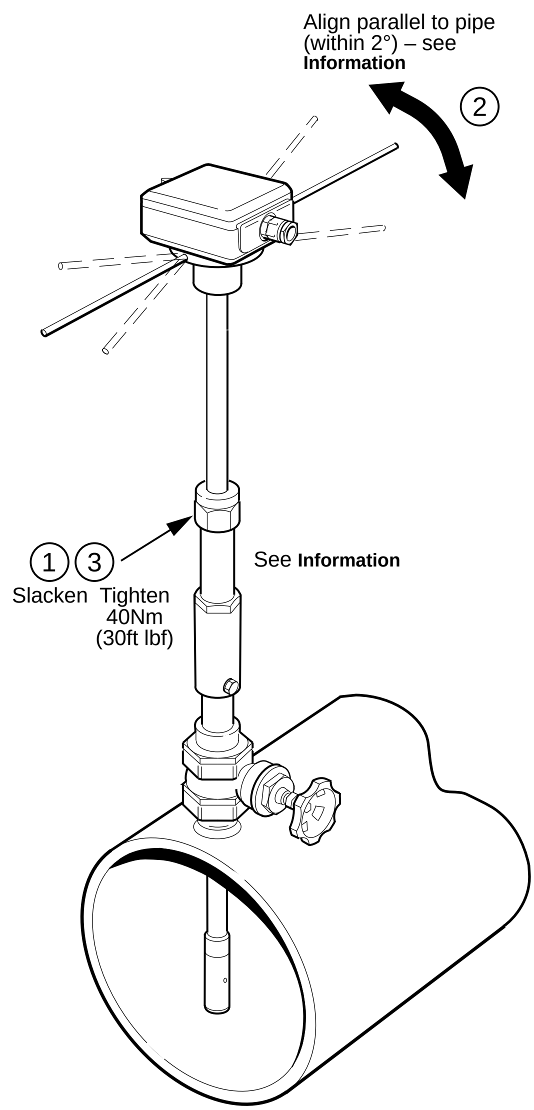


Fig. 3.15 Probe Alignment

4 ELECTRICAL INSTALLATION

AquaProbe is usually supplied with an integral cable and potted head connections. The transmitter end of the AquaProbe cable, the power supply and any output cables must be prepared and connected as detailed in the relevant parts of this section. If the AquaProbe has been supplied unpotted, connections must also be made to the probe head (Figs. 4.17 and 4.18) and then potted on completion.

4.1 Access to Terminals – Figs. 4.1 and 4.2

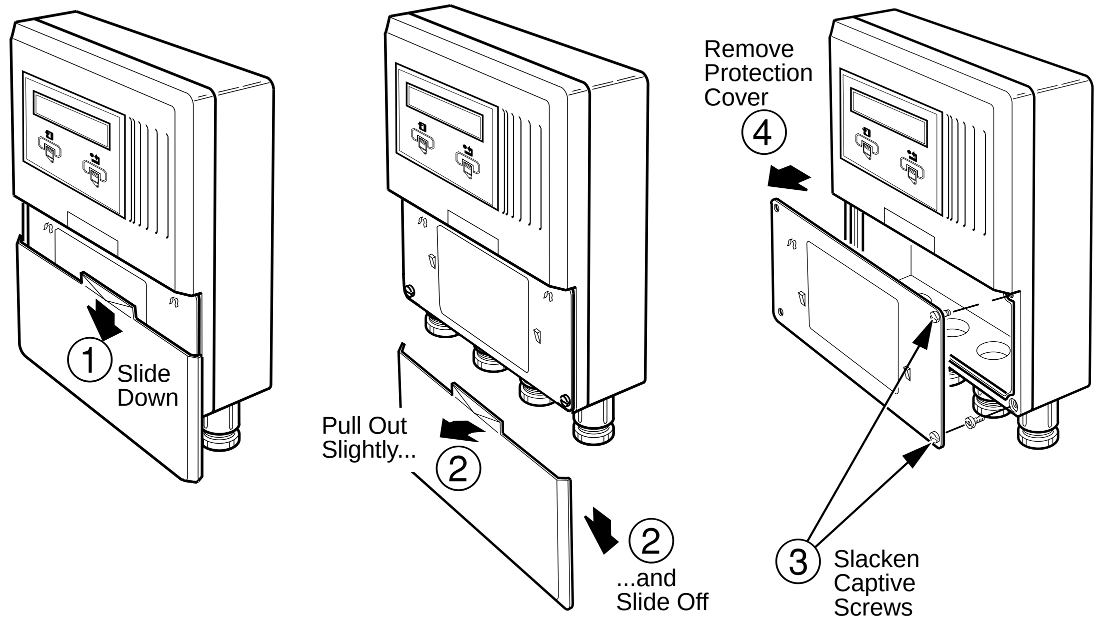


Fig. 4.1 Connection Terminal Access

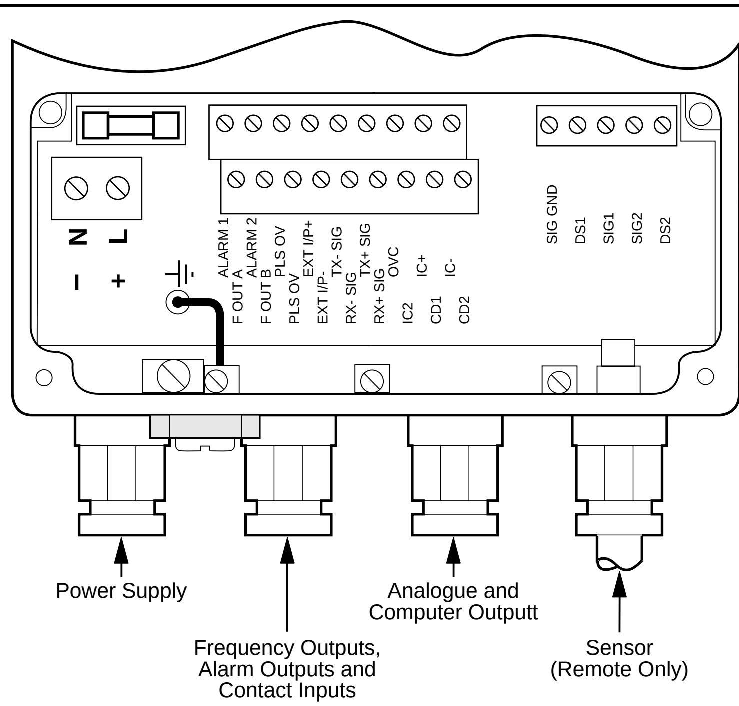


Fig. 4.2 Cable/Conduit Entries

4.2 Cable Types and Preparation

4.2.1 Cable Type Identification (IEC Installation Practice) – Fig. 4.3

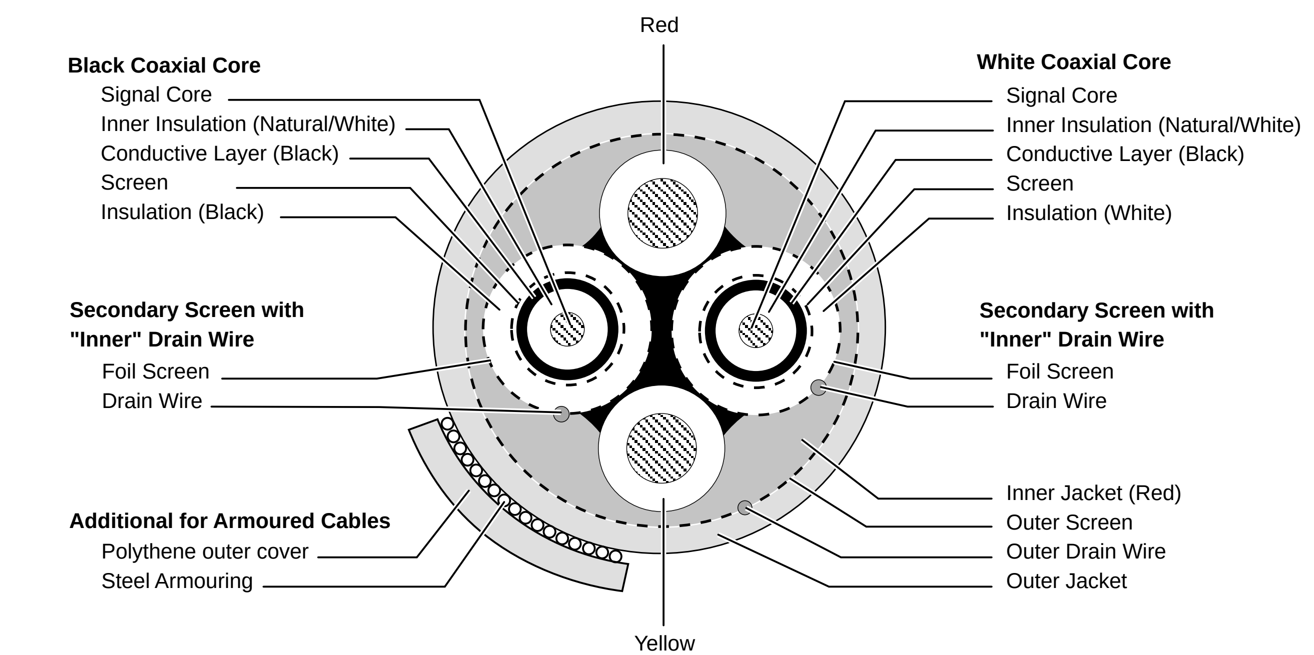
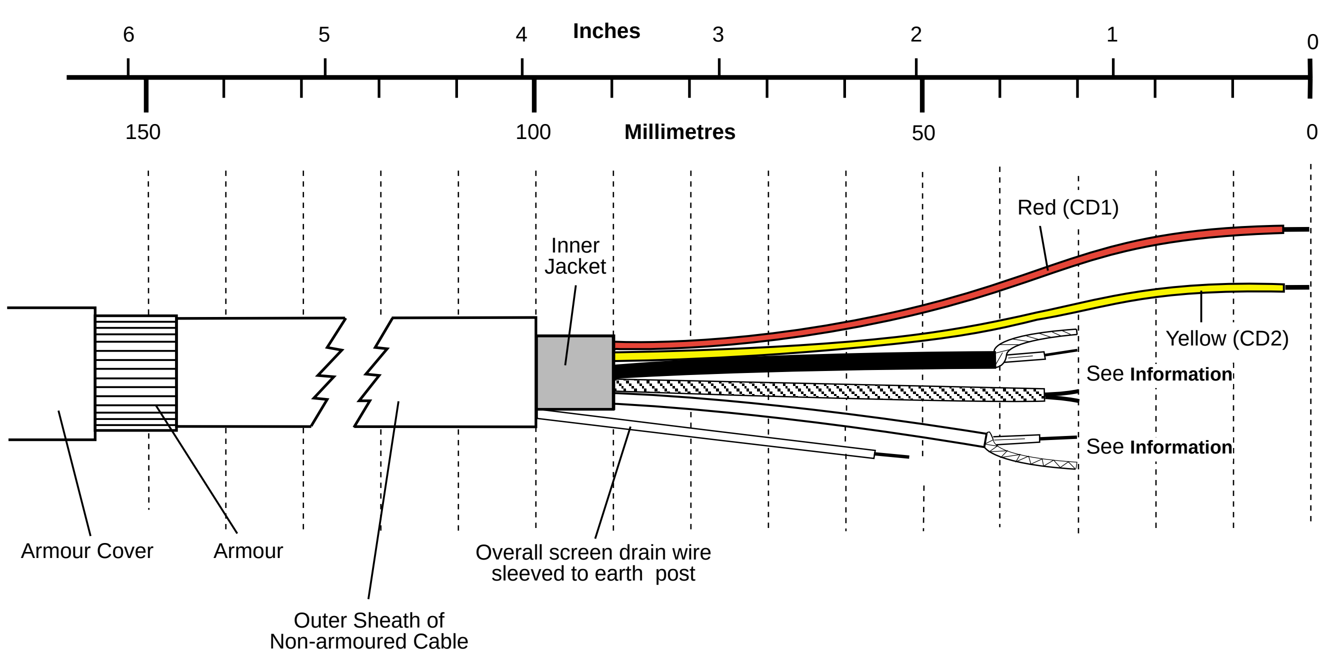


Fig 4.3 Cable Type Identification (IEC Installation Practice)

4.2.2 Cable Preparation (IEC Installation Practice) – Fig. 4.4



Information. Remove all exposed black conductive layer from coaxial inners.

Fig 4.4 4-Core Cable Preparation (IEC Installation Practice)

...Cable Types and Preparation

4.2.3 Cable Type Identification (North American Installation Practice) – Fig. 4.5

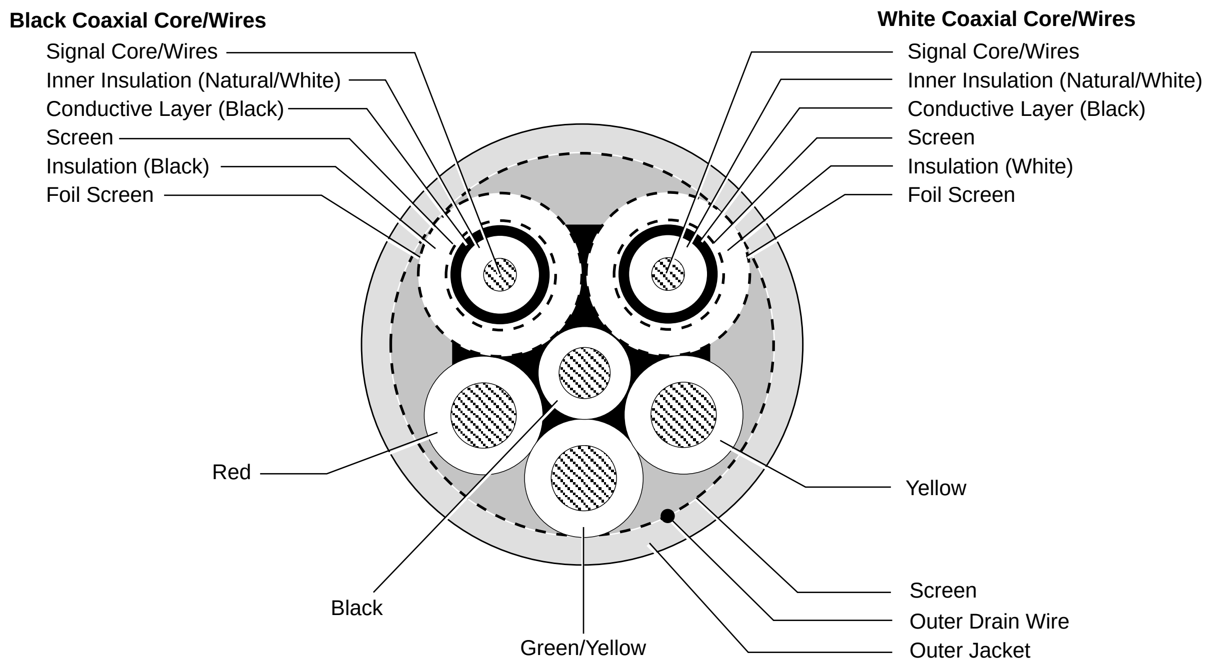
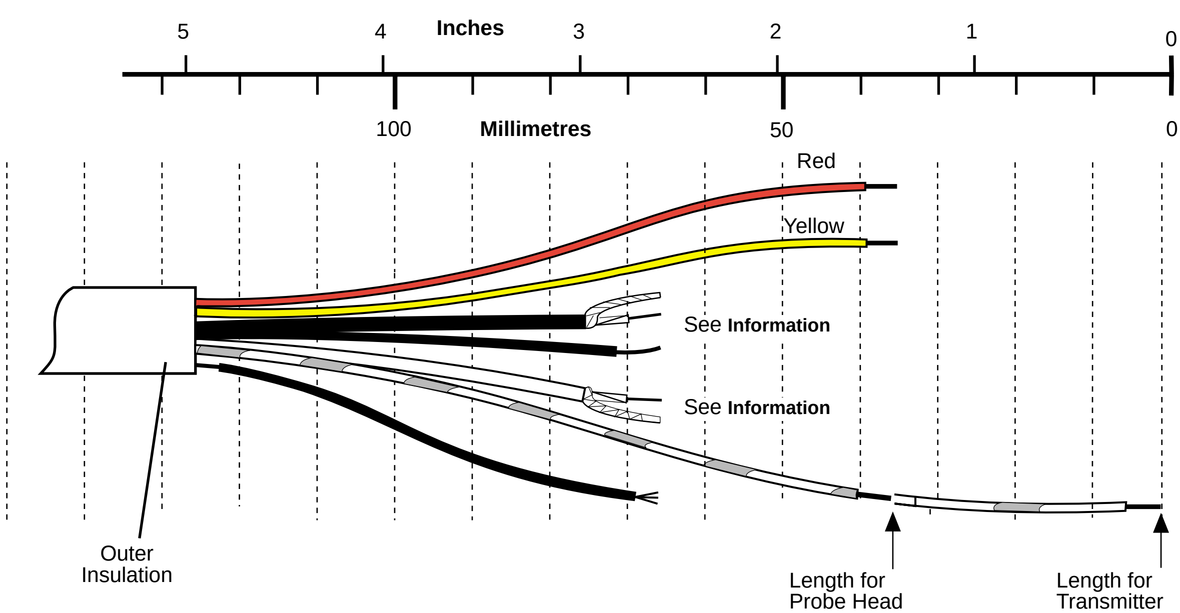


Fig 4.3 Cable Type Identification (North American Installation Practice)

4.2.4 Cable Preparation (North American Installation Practice) – Fig. 4.6



Information. Remove all exposed black conductive layer from coaxial inners.

Fig 4.6 6-Core Cable Preparation (North American Installation Practice)

4.3 Cable Glands and Conduit Fixings

4.3.1 Cable Glands (IEC Installation Practice) – Fig. 4.7

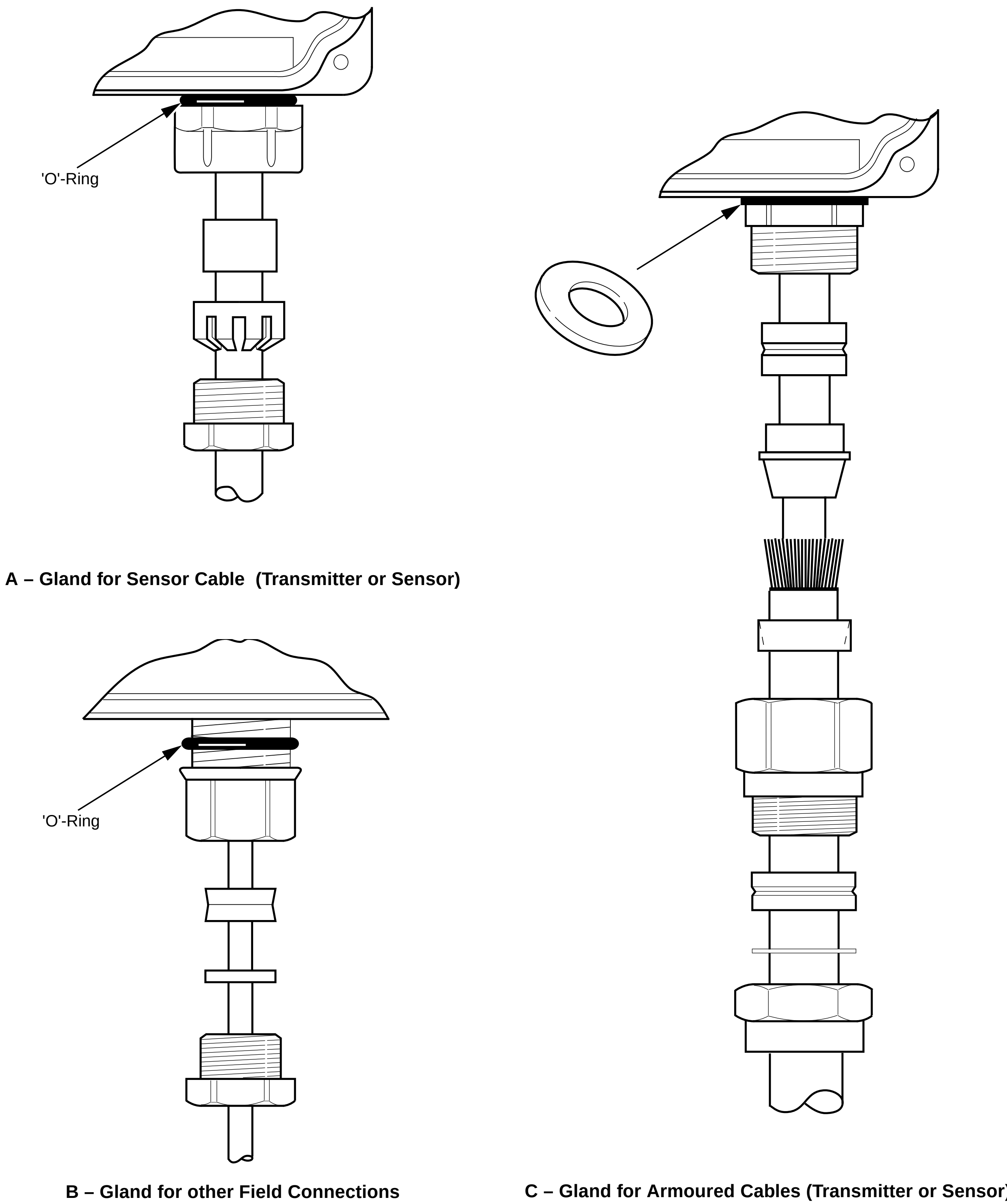


Fig. 4.7 Cable Glands (IEC Installation Practice)

...Cable Glands and Conduit Fixings

4.3.2 Cable Glands (North American Installation Practice) – Fig 4.8

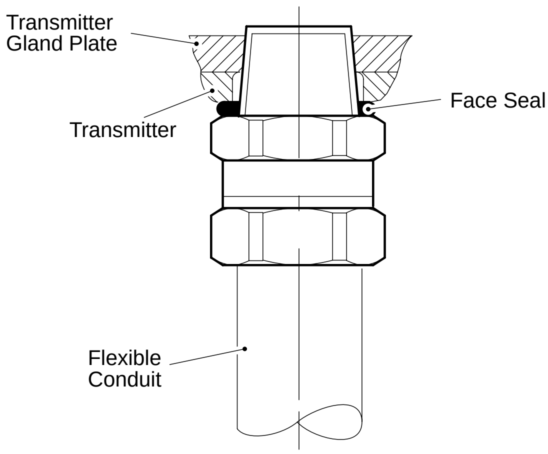


Fig 4.8 Cable Gland (North American Installation Practice)

4.3.3 Conduit Fitting (North American Installation Practice) – Fig 4.9

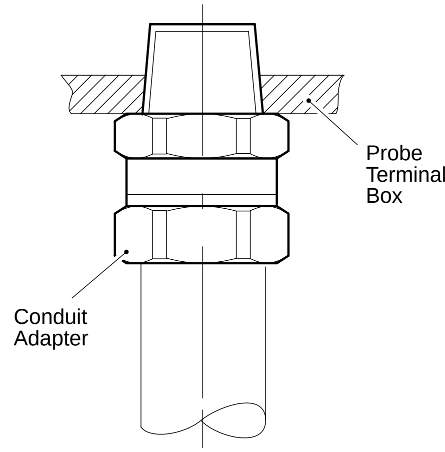


Fig. 4.9 Conduit Fitting (North American Installation Practice)

Note. Appleton* ST-50 plus STG-50 or STB-50 plus STG-50 O.Z. Gedney 4Q-50, 4Q50T or 4Q-50TG.

* Appletonadaptors are not reusable without the use of a replacement ferrule (STF-50).

Always fit NEW face seals with any of the above adaptors.

4.4 Transmitter Connections

4.4.1 AquaProbe Cable – Fig 4.10

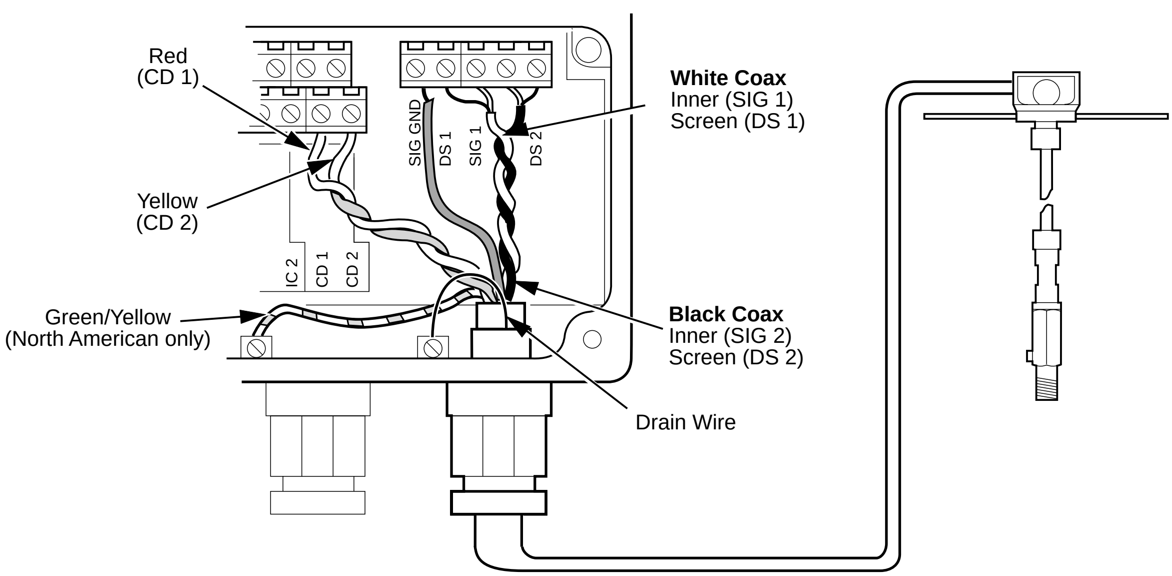
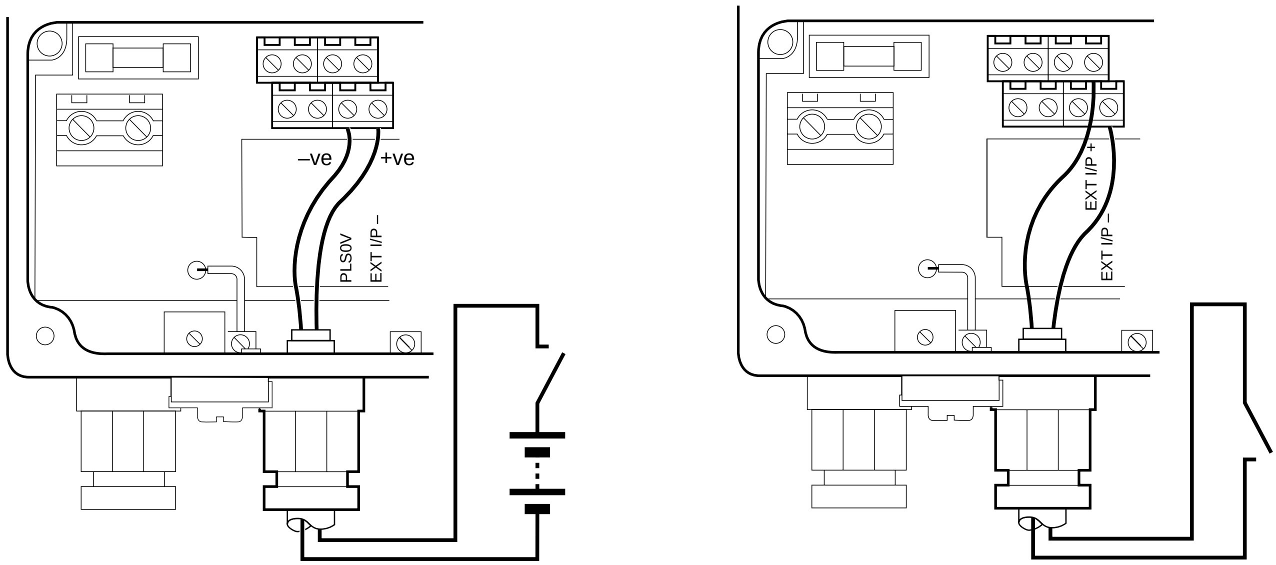


Fig 4.10 AquaProbe Cable Connections

...Transmitter Connections

4.4.2 Contact Inputs – Fig. 4.11

Information. The inputs can be programmed for different functions – refer to the MagMaster Configuration Manual.



A – Voltage Signal **B – Volt-free Contacts**

Fig 4.11 Contact Inputs

4.4.3 Alarm Outputs – Fig. 4.12

Information. Relay, lamp, electromagnetic counter or other suitable electronic device.

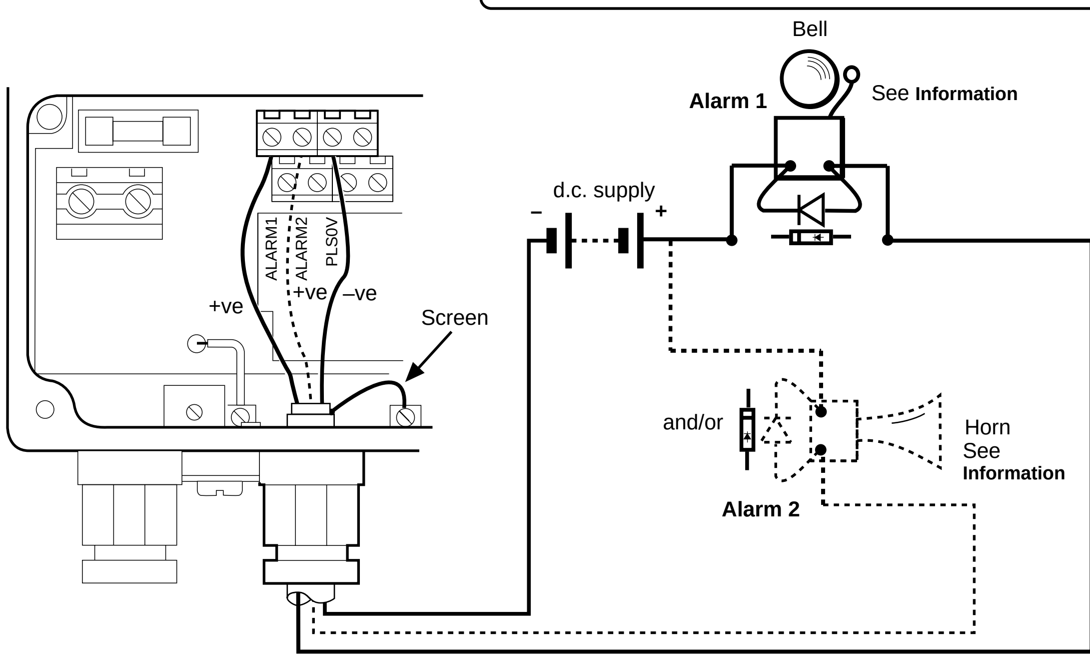


Fig 4.12 Alarm Outputs from MagMaster

...Transmitter Connections

4.4.4 Frequency Outputs – Fig. 4.13

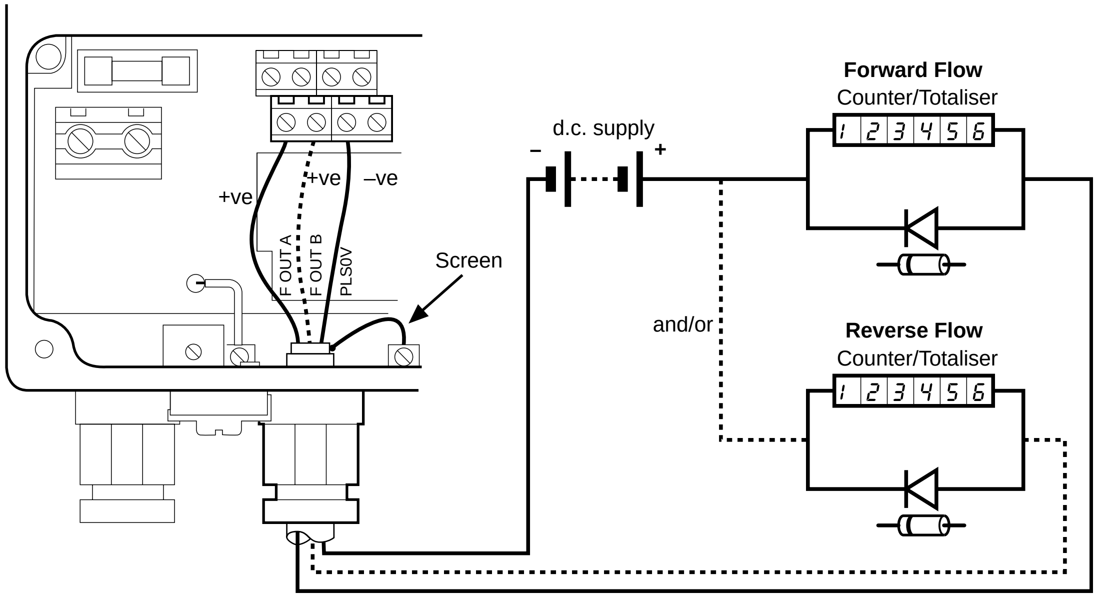


Fig. 4.13 Frequency Outputs from MagMaster

4.4.5 Analogue Outputs – Fig. 4.14

Information. Current output range(s) are programmable, 0 to 22mA

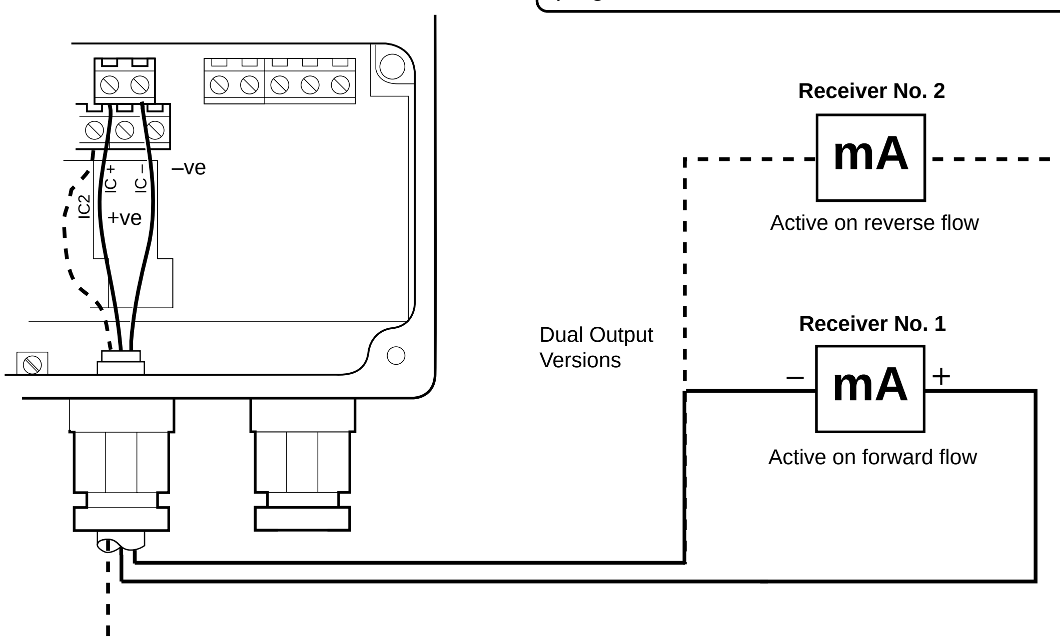


Fig. 4.14 Analogue Outputs from MagMaster

...Transmitter Connections

4.4.6 Computer Connection (RS422) – Fig. 4.13

Information. Use four-core screened cable with two twisted pairs

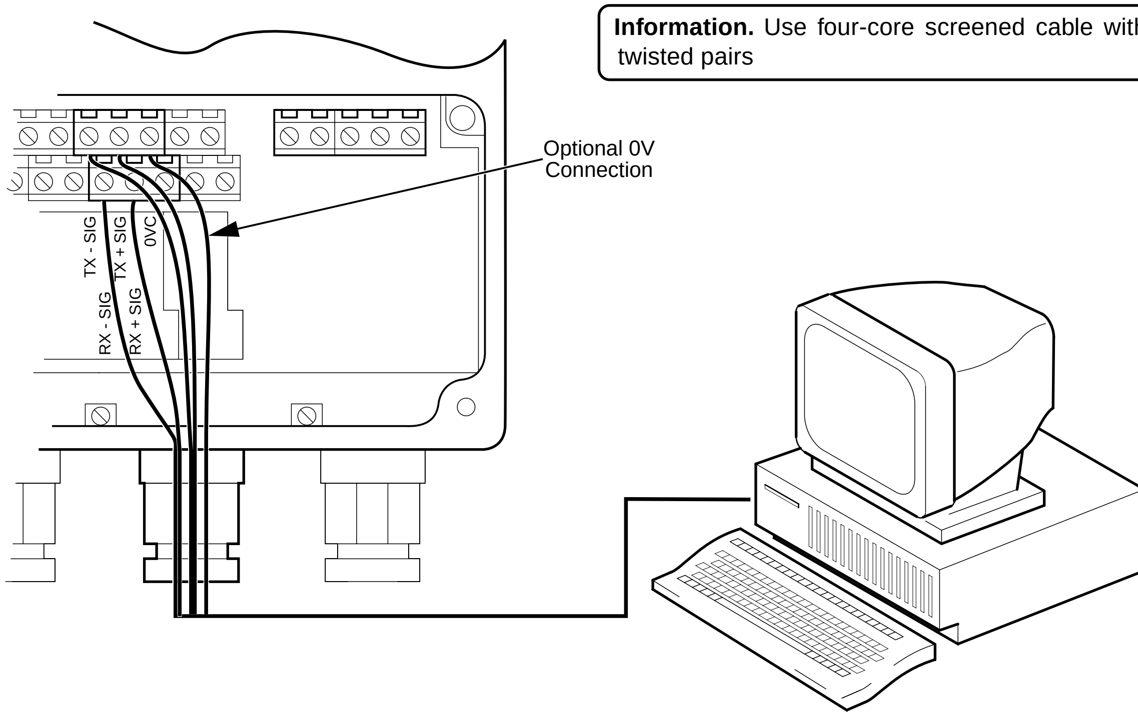


Fig. 4.15 Computer Connection to Transmitter – RS422

4.4.7 Computer Connection (Single Ended or RS232 Connection) – Fig. 4.16

Information. Use four-core screened cable with two twisted pairs

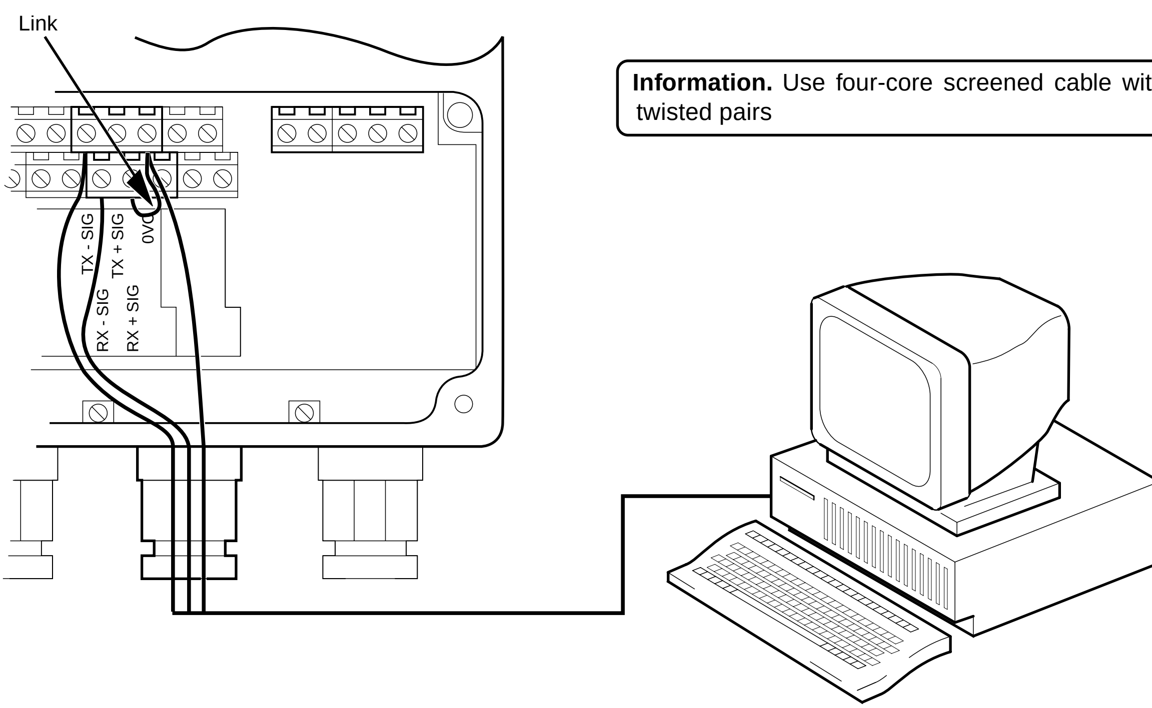


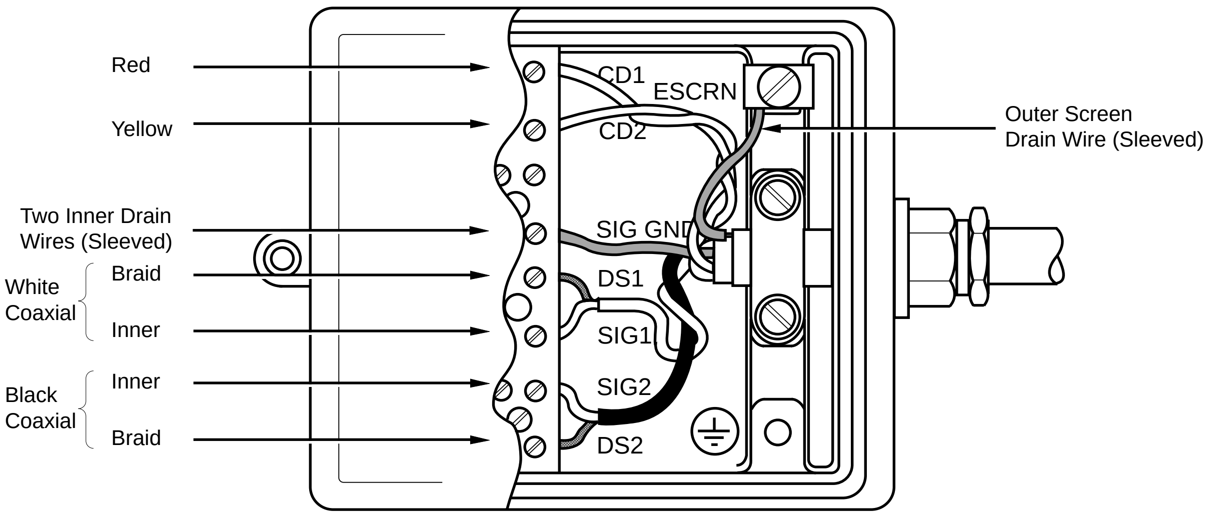
Fig 4.16 Computer Connection to Transmitter

4.5 Probe Head Connections

Caution. The probe head connections must be potted immediately on completion, to prevent ingress of moisture – refer to Appendix A2 for full procedure.

The cable must be prepared as shown in Fig. 4.4 or 4.6, as applicable. Sleeve all bare wiring and remove the black conductive layer from under the coaxial braids.

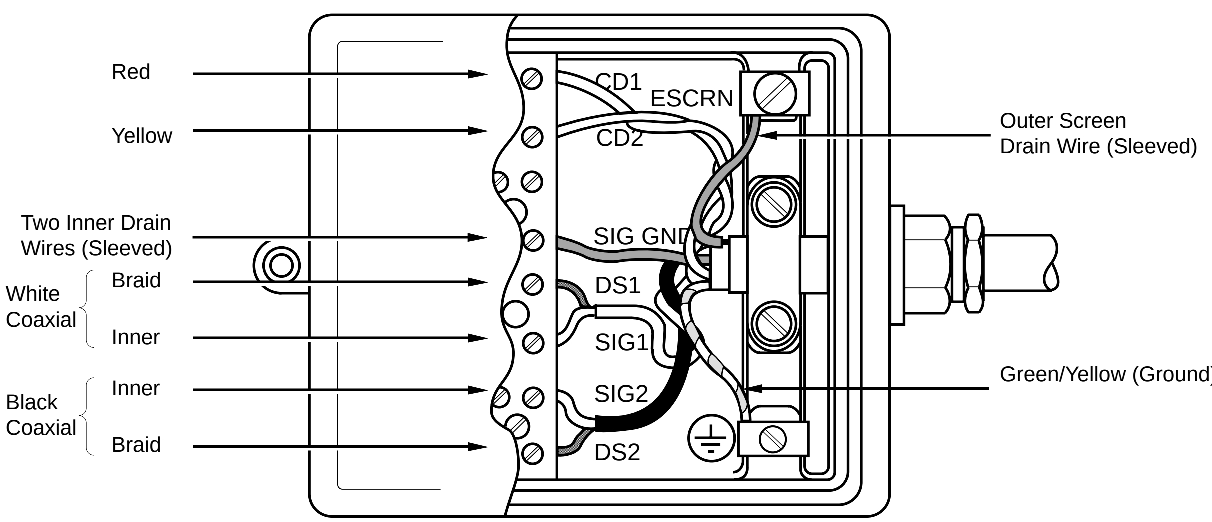
4.5.1 IEC Installation Practice – Fig 4.17



Information.
- Twist Red and Yellow cores lightly together
- Twist White and Black coaxial cores lightly together

Fig. 4.17 Probe Head Connections

4.5.2 North American Installation Practice – 4.18



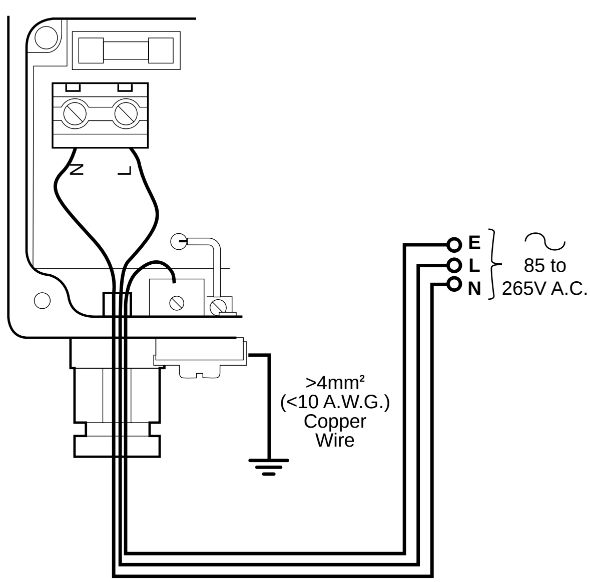
Information.
- Twist Red and Yellow cores lightly together
- Twist White and Black coaxial cores lightly together

Fig 4.18 Probe Head Connections (North American Installation Practice)

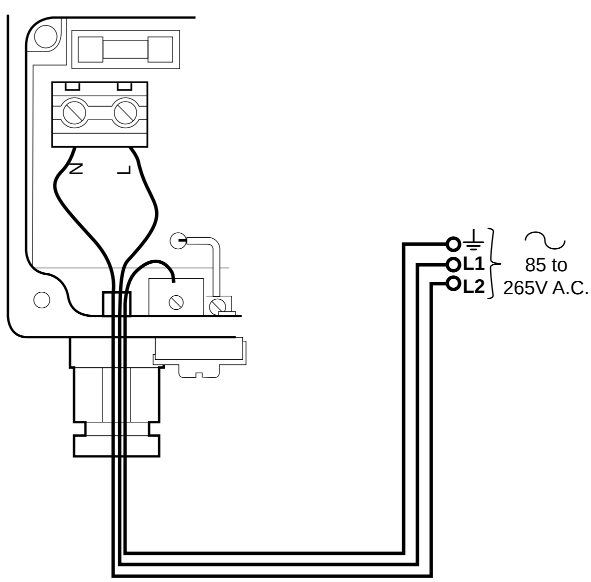
4.6 Grounding

Caution. All earth bonding (grounding) must be in accordance with relevant national and local standards.

4.7 Power Supply Connections – Figs. 4.19 and 4.20



A – IEC Installation Practice



B – North American Installation Practice

Fig. 4.19 – Power Supply Connections (A.C.)

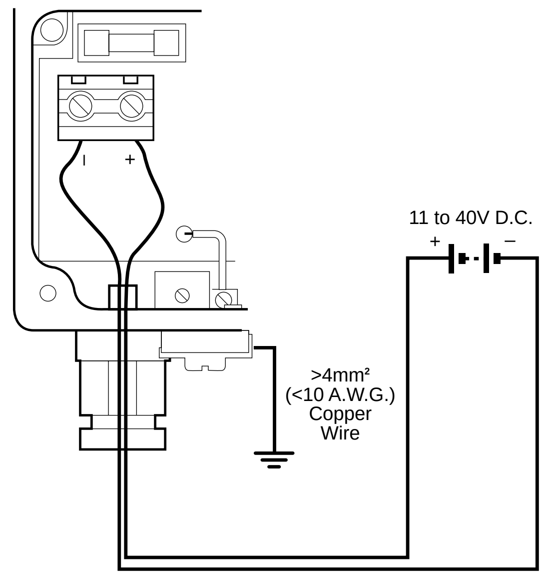


Fig. 4.20 – Power Supply Connections (D.C.)

5 SETTING UP

5.1 Introduction

The basic equation for volume measurement using AquaProbe is:

$$Q = A \; F_i \; F_P \; V$$

Where:
- Q = flow rate,
- F_i = insertion factor
- F_p = profile factor
- V = velocity
- A = area

The pipe diameter, profile factor and insertion factor must be determined as detailed in Sections 5.2 to 5.3, as applicable.

5.2 Centre Line Method

a) Determine the internal diameter D of the pipe, in millimetres, by the most accurate method available.

> **Note.** Due to software configuration, all calculations are in metric units. Therefore if using an imperial pipe, the diameter **MUST** be converted into millimetres (1in = 25.4mm) i.e. a 36in pipe = 914mm

b) Determine the profile factor F_p from Fig. 5.1.

c) Calculate the insertion factor $F_i = \dfrac{1}{1 - (38/\pi D)}$.

Example – for a pipe of internal diameter 593mm (23.35in):

F_p = 0.861 (derived from Fig. 5.1)

$$F_i = \frac{1}{1 - (38/593\pi)}$$

F_i = 1.021

5.3 Mean Axial Velocity Method (1/8 Diameter)

a) Determine the internal diameter D of the pipe, in millimetres, by the most accurate method available.

> **Note.** Due to software configuration, all calculations are in metric units. Therefore if using an imperial pipe, the diameter **MUST** be converted into millimetres (1in = 25.4mm) i.e. a 36in pipe = 914mm

b) A profile factor F_p of 1 must be used.

c) Calculate the insertion factor $F_i = \left[1 + \dfrac{12.09}{D} + \dfrac{1.3042}{\sqrt{D}}\right]$

Example – for a pipe of internal diameter 593mm (23.35in):

F_p = 1

$$F_i = \left[1 + \frac{12.09}{593} + \frac{1.3042}{\sqrt{593}}\right]$$

F_i = 1.074

5.4 Partial Velocity Traverse

Refer to the Appendix A1 for procedure.

5.5 Transmitter Set-up

For full programming details refer to the MagMaster Transmitter Configuration Manual. Refer to the **Parameter Tree Structure** (Appendix B in the Configuration Manual) and proceed as follows.

a) Enter the internal diameter D in parameter B3 **'Snsr Size'**

b) Enter the value of F_i in parameter 461 **'Flow Probe Ins'**

c) Enter the value of F_p in parameter 462 **'Flow Probe Prof'**

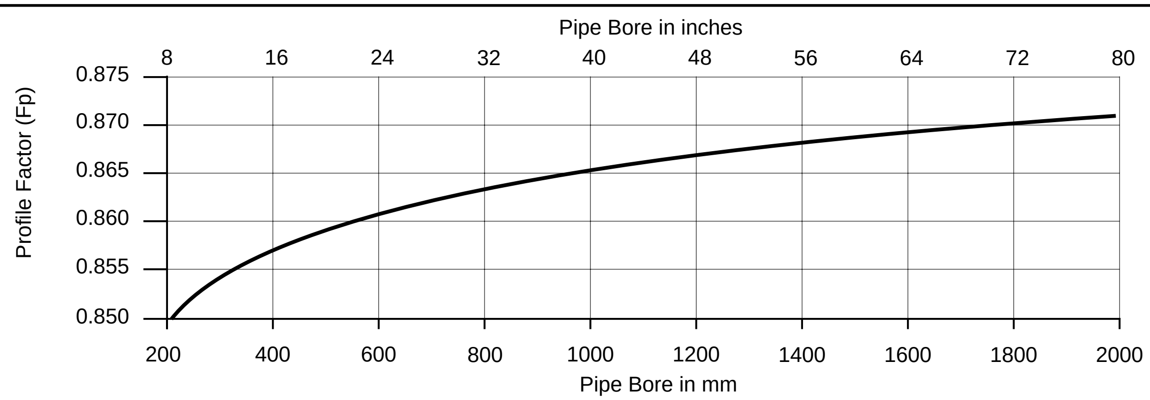


Fig. 5.1 Profile Factor v Velocity for Pipe Sizes 200 to 2000mm (8 to 78in.)

6 OPERATION

6.1 Start-up – Fig. 6.1

Switch on the power supply and, if a MagMaster Transmitter with display has been ordered, the flow rate is displayed on the lower display line.

> **Note.** If using a MagMaster Transmitter without a display refer to the MagMaster Configuration Manual (IM/MAGMAS-CM).

6.2 Upper Display Line – Fig. 6.1

Repeated appliction of the wand to the left hand icon in the transmitter display area steps the upper display through the following sequence:

`>`	–	forward flow total value
`<`	–	reverse flow total value
`*`	–	nett flow (total value)
`Alm Clr`	–	if no alarms are activated
`Vel`	–	Velocity
`%`	–	% full scale flow

Any additional alarms are displayed sequentially.

6.3 Lower Display Line – Fig. 6.1

The lower display line normally indicates flow rate in the chosen units. If an alarm is active the display alternates between the alarm indication signal and the flow rate. For full details of alarm indication signals refer to Section 7.2.

6.4 Resetting the Flow Total – Fig. 6.1

application of wand to the right hand icon resets the flow total if parameter "`Tot ClrEn`" (parameter 73), is set to '1' – see MagMaster Configuration Manual.

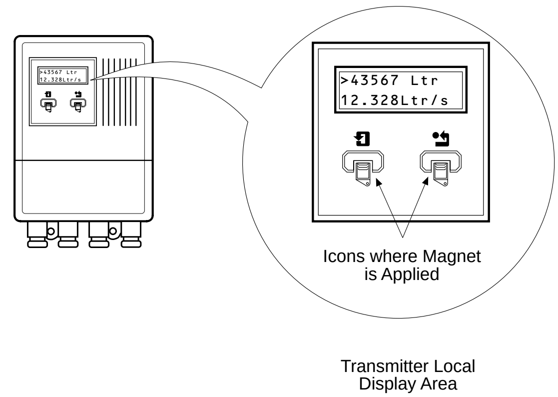


Fig. 6.1 MagMaster Display and Controls

7 FAULT FINDING

7.1 Basic Fault Finding

If the MagMaster fails to operate, check the connections, power supply and fuse (located in the terminal compartment). If necessary, replace the fuse with one of the correct rating (500mA, T Type).

7.2 Alarm Indication Signals – Table 7.1

The MagMaster Transmitter has built-in diagnostics for the alarm conditions detailed below.

Display	Alarm
Mtsnsr	Empty Sensor
Hi	High flow
Lo	Low flow
Anlg	Analogue over range
Pls	Pulse frequency limited
Coil	Sensor Coil open circuit
19, 20, 21	Refer to MagMaster Configuration Manual

Table 7.1 MagMaster Diagnostic Messages

8 SPARES

8.1 Replacement Parts – Fig. 8.1

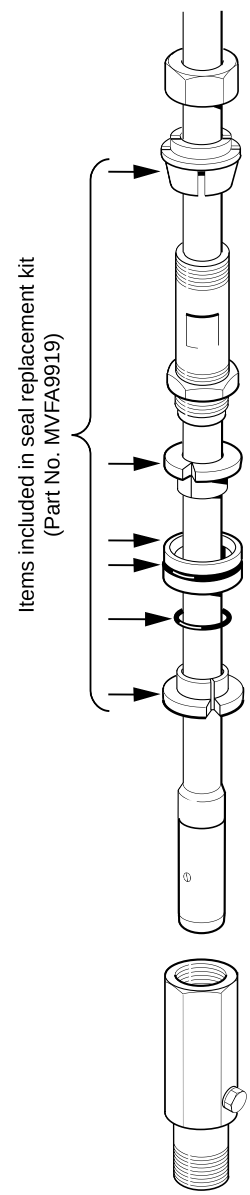


Fig 8.1 Seal Replacement Kit

A1 Testing the Flow Profile for Symmetry

If there is any doubt as to the symmetry of the flow profile (see Section 3.2), a Partial Velocity Traverse should be carried out. This procedure involves comparing the value of velocity at two points at equal distances from the centre line.

It is normal to compare the flow velocities at insertion depths of $\frac{1}{8}$ and $\frac{7}{8}$ of the pipe diameter as these points are always on the 'knee' of the profile.

A1.1 Partial Velocity Traverse

Determine the internal diameter D of the pipe, in millimetres, by the most accurate method available. If the AquaProbe insertion length is greater than the internal diameter of the pipe, proceed with the **Single Entry Point Method** detailed in Section A1.2. If the AquaProbe insertion length is less than the internal diameter of the pipe, proceed with the **Dual Entry Point Method** detailed in Section A1.3.

A1.2 Single Entry Point Method

a) Insert the probe to a depth of $\frac{1}{8}$ the pipe diameter – see Fig. 3.14 on page 9.

> **Note.** Due to software configuration, all calculations are in metric units. Therefore if using an imperial pipe, the diameter **MUST** be converted into millimetres (1in = 25.4mm) i.e. a 36in pipe = 914mm.

b) Calculate the insertion factor $F_i = \left[1 + \frac{12.09}{D} + \frac{1.3042}{\sqrt{D}}\right]$.

c) Refer to the AquaProbe Transmitter Configuration Manual and enter a Blockage Factor (BL) of value equal to F_i.

d) Record the flow velocity reading.

e) Insert the probe to a depth of $\frac{7}{8}$ the pipe diameter.

f) Calculate the insertion factor $F_i = \left[1 + \frac{12.09}{D} - \frac{1.3042}{\sqrt{D}}\right]$.

g) Refer to the AquaProbe Transmitter Configuration Manual and enter a Blockage Factor (BL) of value equal to F_i.

h) Record the flow velocity reading.

i) Calculate the ratio of the two values recorded.

If the ratio is between 0.95 and 1.05 the flow profile is acceptable and the procedure detailed in section 5.2 can be used. If outside this ratio the AquaProbe should be resited for optimum accuracy.

A1.3 Dual Entry Point Method

Refer to Section 3.5 and fit a second mounting boss directly opposite the one already fitted.

> **Note.** Due to software configuration, all calculations are in metric units. Therefore if using an imperial pipe, the diameter **MUST** be converted into millimetres (1in = 25.4mm) i.e. a 36in pipe = 914mm.

a) Insert the probe to a depth of $\frac{1}{8}$ the pipe diameter through the original mounting boss.

b) Calculate the insertion factor F_i = .

c) Refer to the AquaProbe Transmitter Configuration Manual and enter a Blockage Factor (BL) of value equal to F_i.

d) Record the flow velocity reading.

e) Insert the probe to a depth of $\frac{1}{8}$ the pipe diameter through the second mounting boss.

f) Record the flow velocity reading.

g) Calculate the ratio of the two values recorded.

If the ratio is between 0.95 and 1.05 the flow profile is acceptable and the procedure detailed in Section 5.2 can be used. If outside this ratio the AquaProbe should be resited for optimum accuracy.

A2 Potting the Probe Head Connections

> **Warnings**.
>
> - Potting materials are toxic – use suitable safety precautions
> - Read the manufacturer's instructions carefully **before** preparing the potting material.

> **Notes.**
>
> - The probe head connections must be potted immediately on completion, to prevent ingress of moisture.
> - Check all connections before potting – see Section 4.
> - Do not overfill or allow the potting material to come into contact with the 'O' ring or groove.

NOTES

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United States of America

ABB Inc.
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Fax: +1 215 674 7183

Client Warranty

Prior to installation, the equipment referred to in this manual must be stored in a clean, dry environment, in accordance with the Company's published specification.

Periodic checks must be made on the equipment's condition. In the event of a failure under warranty, the following documentation must be provided as substantiation:

1. A listing evidencing process operation and alarm logs at time of failure.
2. Copies of all storage, installation, operating and maintenance records relating to the alleged faulty unit.

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Printed in UK (08.04)

IM/AP/MM–IM Issue 2

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