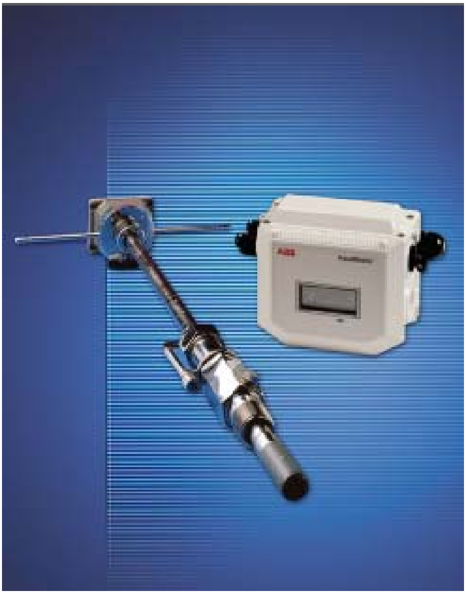
Installation Guide

IM/AQP/SF_2

Insertion-Type Electromagnetic Probe Flowmeter

AquaProbe



ABB

The Company

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.

EN ISO 9001:2000

Cert. No. Q5907

EN 29001 (ISO 9001)

Lenno, Italy – Cert. No. 9/90A

Electrical Safety

This equipment complies with the requirements of CEI/IEC 61010-1:2001-2 "Safety requirements for electrical equipment for measurement, control, and laboratory use". If the equipment is used in a manner NOT specified by the Company, the protection provided by the equipment may be impaired.

Symbols

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

	Warning – Refer to the manual for instructions		Direct current supply only
	Caution – Risk of electric shock		Alternating current supply only
	Protective earth (ground) terminal		Both direct and alternating current supply
	Earth (ground) terminal		The equipment is protected through double insulation

Information in this manual is intended only to assist our customers in the efficient operation of our equipment. Use of this manual for any other purpose is specifically prohibited and its contents are not to be reproduced in full or part without prior approval of the Technical Publications Department.

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.

CONTENTS

1 INTRODUCTION

The AquaProbe electromagnetic insertion flowmeter is designed for measurement of the velocity of water.

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.

2.1 Location – Environmental Conditions

2.1.1 AquaProbe – Fig. 2.1

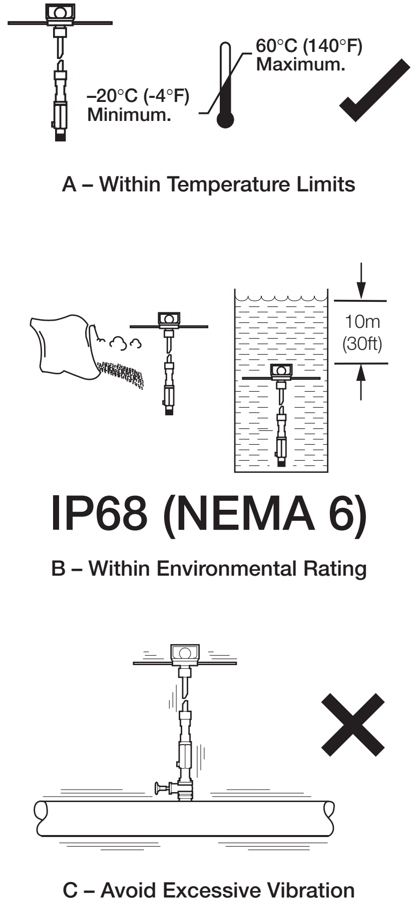


Fig. 2.1 Environmental Requirements – AquaProbe

2.1.2 Transmitter – Fig. 2.2

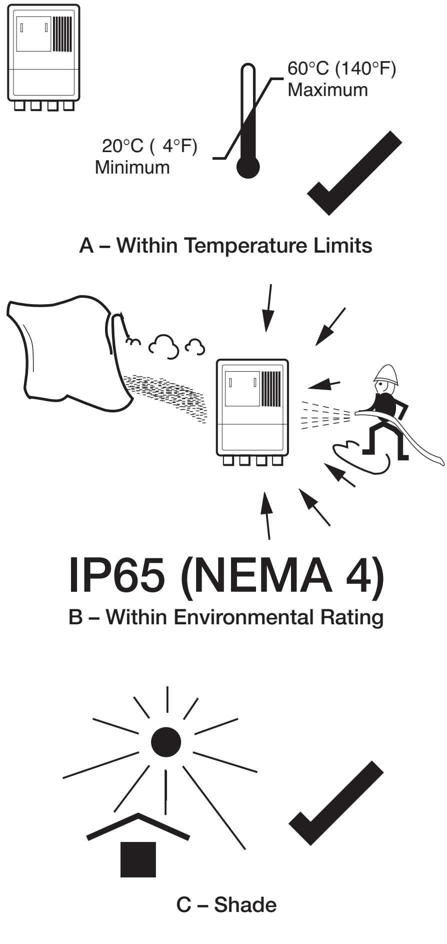


Fig. 2.2 Environmental Requirements – MagMaster Transmitter

2.2 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.

Note. Ensure that the sensor is installed in the pipe with the flow direction arrow on the probe case matching the pipe flow.

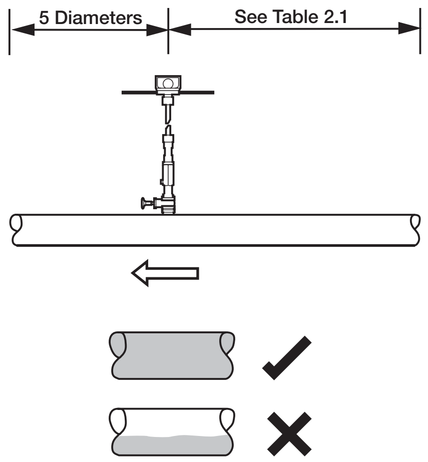


Fig. 2.3 Flow Conditions

2.2.1 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.

Table 2.1 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.

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

Table 2.1 Straight Pipe Lengths

2.2.2 Velocity Limitations – Figs. 2.4 to 2.6

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 on the probe's location.

This information is provided as a guide only. Some installations may experience unwanted vibration resonance which may further limit the maximum velocity at which the AquaProbe may be used.

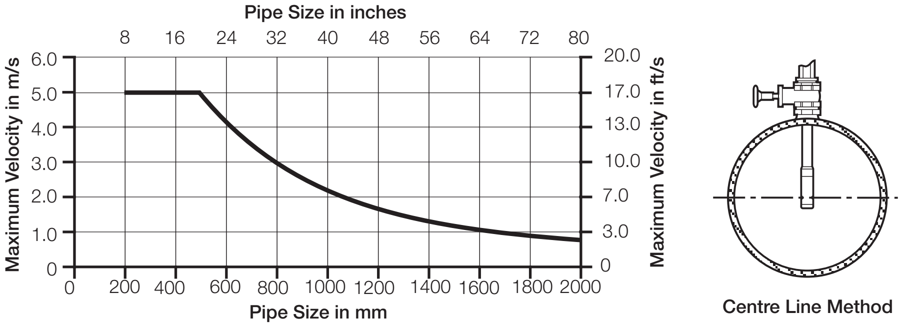


Fig. 2.4 Maximum Permissible Velocity for different Pipe Sizes

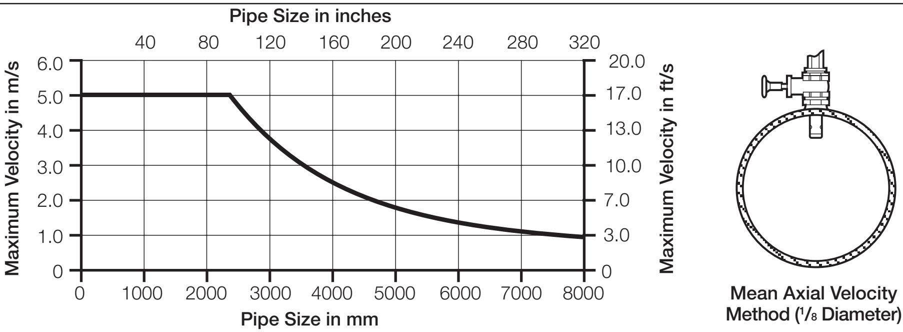


Fig. 2.5 Maximum Permissible Velocity for different Pipe Sizes

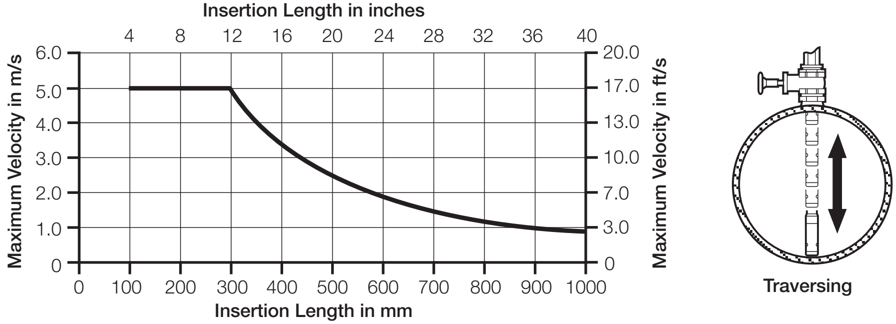
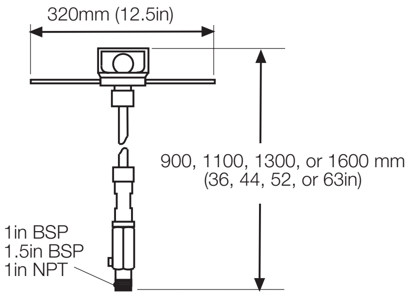


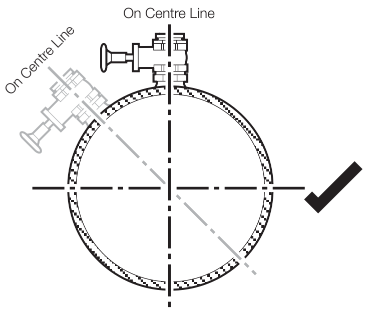
Fig. 2.6 Maximum Permissible Velocity for different Insertion Lengths

2.3 Location – Mechanical

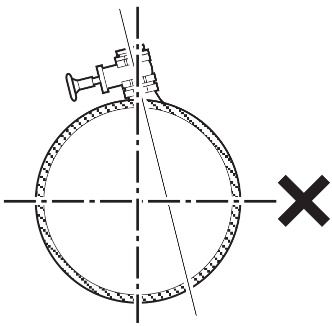
2.3.1 AquaProbe – Fig 2.7



A – Clearance Dimensions



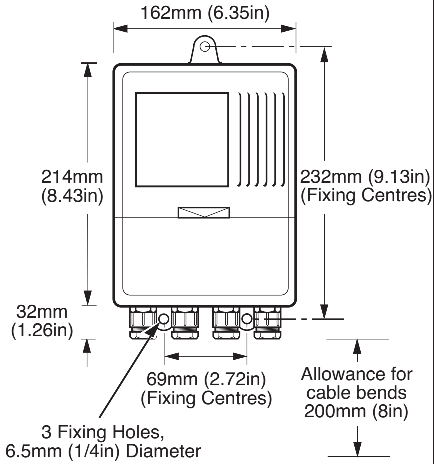
Note. Pipeline recommended to be metal for electrical screening.



B – Orientation

Fig. 2.7 Mechanical Requirements – AquaProbe

2.3.2 Transmitter – Fig 2.8



Caution. Do not overtighten the fixings, especially on an uneven surface.

Fig. 2.8 Clearance Dimensions – Transmitter

2.4 Safety – Fig. 2.9

Warning. The AquaProbe is provided with a safety mechanism (see Fig. 2.9A) which should be attached to its securing collar as shown in Fig. 2.9B. 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

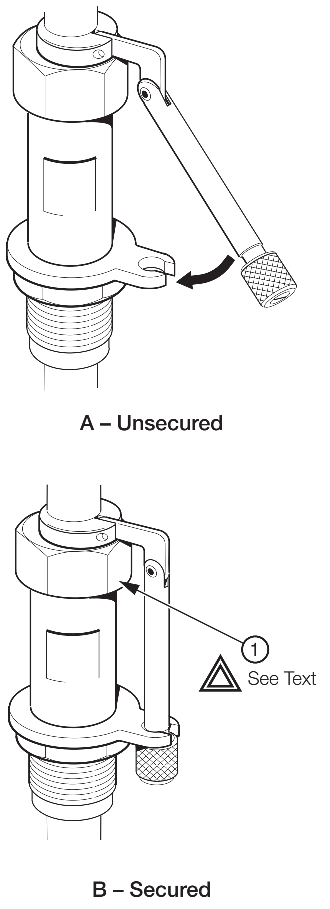


Fig. 2.9 Safety Mechanism

2.5 Installing the AquaProbe – Figs 2.10 and 2.11

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

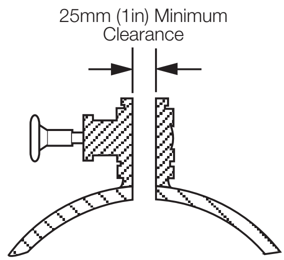


Fig. 2.10 Insertion Bore Clearance

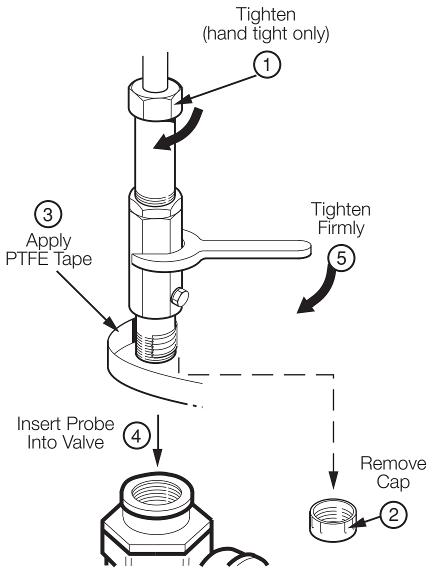


Fig. 2.11 Installing the AquaProbe

2.6 Setting the Insertion Depth

2.6.1 Centre Line Method for Pipe Diameters ≤1m (≤40in) – Fig. 2.12

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.

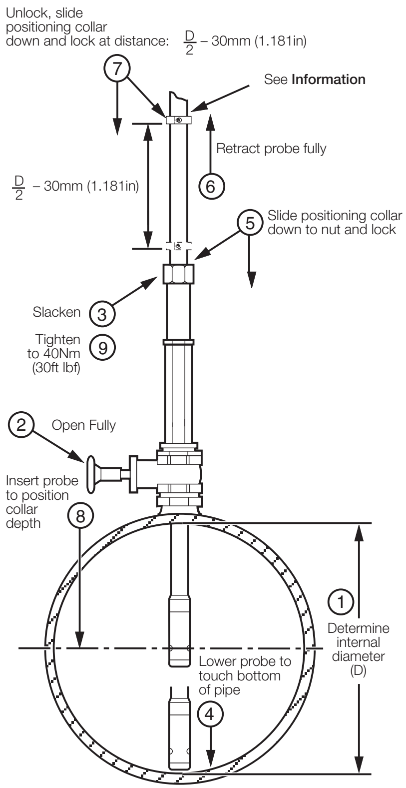


Fig. 2.12 Setting the insertion Depth – Centre Line Method for Pipe Diameters 1m (40in)

2.6.2 Centre Line Method for Pipe Diameters >1m ≤2m (>40in ≤80in) – Fig 2.13

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.

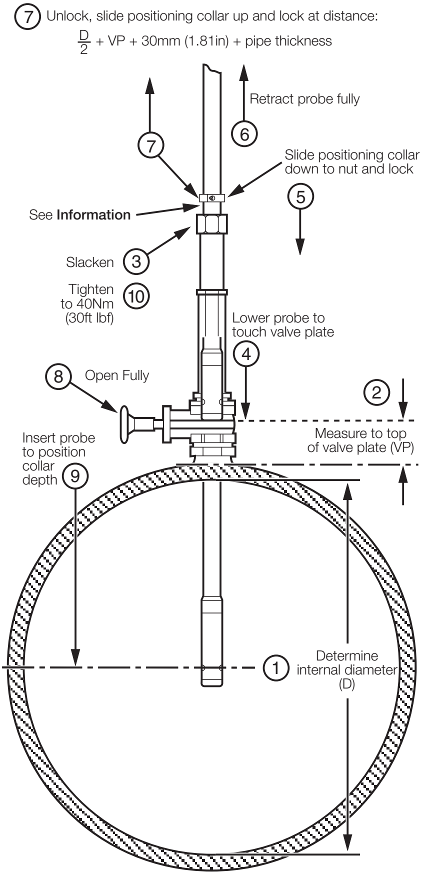


Fig. 2.13 Setting the Insertion Depth – Centre Line Method for Pipe Diameters >1m 2m (>40in 80in)

2.6.3 Mean Axial Velocity Method – Fig. 2.14

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.

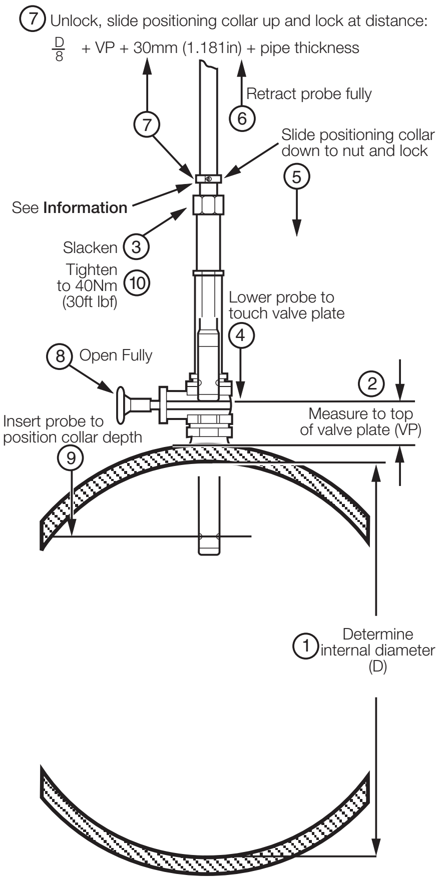


Fig. 2.14 Setting the Insertion Depth – Mean Axial Velocity Method

2.7 AquaProbe Alignment – Fig. 2.15

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.

Information. Measurement error due to misalignment (of <2) is <0.15%.

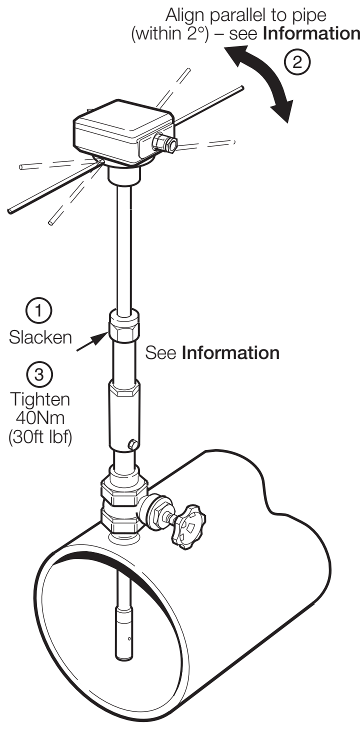


Fig. 2.15 Probe Alignment

3 ELECTRICAL INSTALLATION

3.1 Sensor Terminal Box Connections (Remote Versions only)

Caution. (Remote versions)
- Make connections only as shown.
- Remove foil screens.
- Twist the three screen wires together and sleeve them.
- Twist cable pairs together.
- Maintain Environmental Protection at all times.
- Conduit connections must provide cable entry sealing.

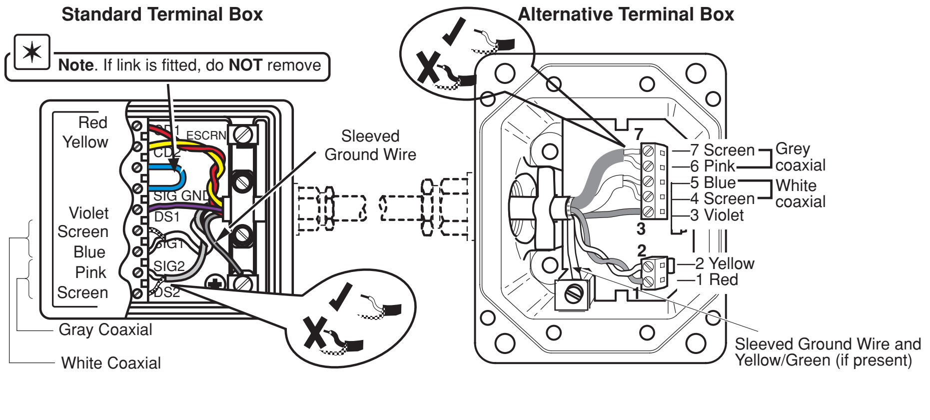


Fig. 3.1 Sensor Terminal Box Connections (Remote Version)

3.1.1 Environmental Protection

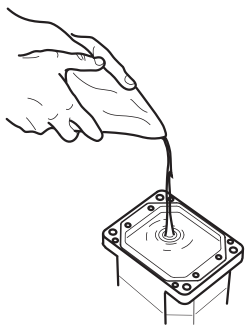


Fig. 3.2 Potting the Terminal Box

Warning.
- Potting materials are toxic – use suitable safety precautions.
- Read the manufacturers instructions carefully before preparing the potting material.
- The remote sensor terminal box connections must be potted immediately on completion to prevent the ingress of moisture.
- Check all connections before potting – see ELECTRICAL INSTALLATION.
- Do not overfill or allow the potting material to come into contact with 'O' rings or grooves.
- Do not let potting material enter conduit, if used.

3.2 Transmitters (All versions)

Caution. Unused cable entries must be blanked with the permanent blanking plugs supplied with the transmitters.

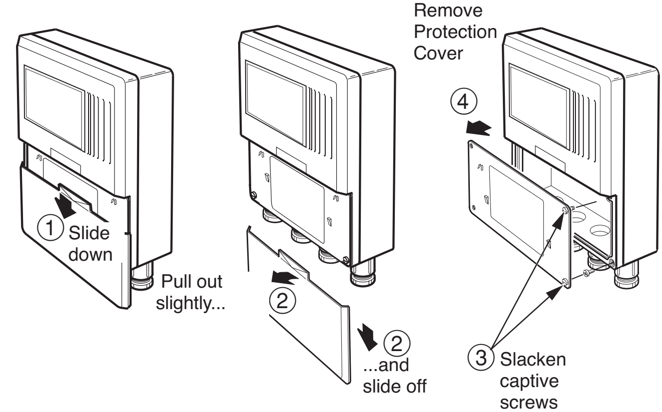


Fig. 3.12 Transmitter Connection Terminal access

Caution.
- Remove any exposed black conductive layer from the inner insulation of both coaxial cables.
- Substitute sensor cable of any kind is not acceptable.
- Do not make connections except as shown.
- Twist cable pairs together as shown.
- Sleeve ALL bare wires.
- Sensor cable may only be joined using company supplied junction box - available separately.

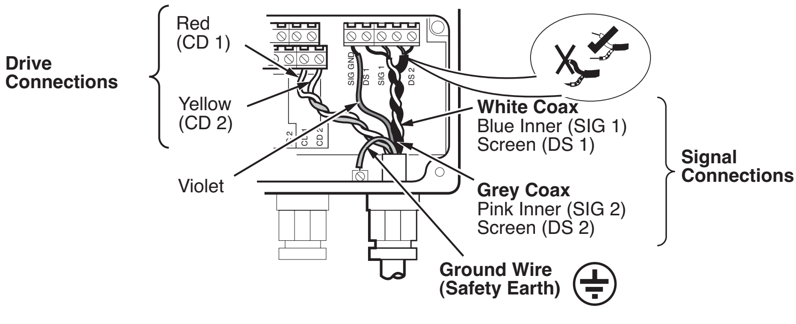


Fig. 3.13 Sensor Cable Connections at the Transmitter (Remote version)

3.2.1 North American Wiring Practice

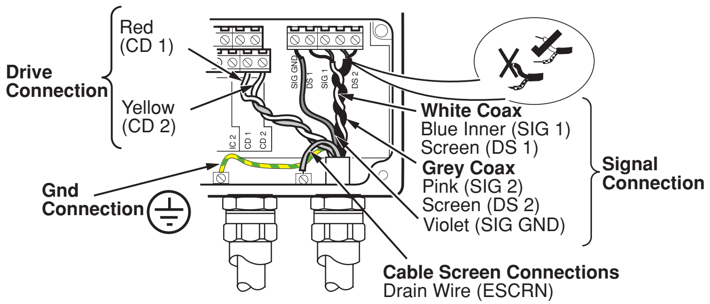
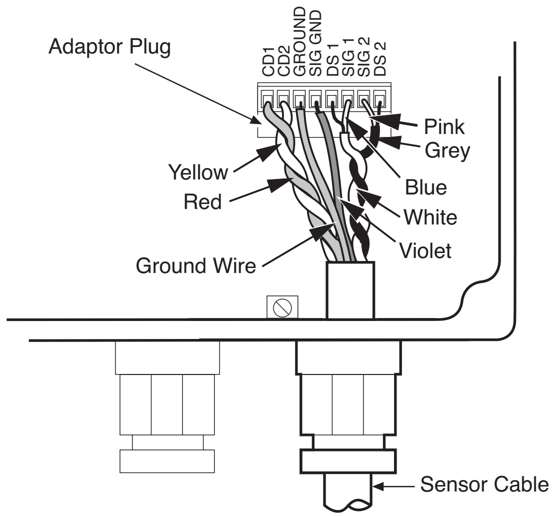


Fig. 3.14 Sensor Cable Connections at the Transmitter (North American Wiring Practice)

3.2.3 Alternate Wiring Configuration

Some later transmitters have an alternative plug-and-socket sensor wiring configuration (see Fig. 3.15)

To wire the adaptor plug, carefully pull off the plug from the adaptor board, connect the wires, using only a screwdriver with a 2.5mm blade to tighten the terminal screws, and replace the plug.



Caution. Remove any exposed black conductive layer from the inner insulation of both coaxial cables

Fig 3.15 Fitting the Sensor Wiring onto the Adaptor

3.3 Input/Output Connections

Caution.
- Refer to SPECIFICATION SHEET for Input/Output ratings.
- Inductive loads must be suppressed or clamped to limit voltage swings.
- Capacitive loads must be inrush current limited.
- Hazardous area requirements are not considered in the following pages.

Note. The connection terminal markings in the metal housed transmitter are identical to those in the standard transmitter as shown in this section. However, the supply connection in the former is made using a non-reversible plug (provided).

3.3.1 Frequency Outputs – Fig. 3.16

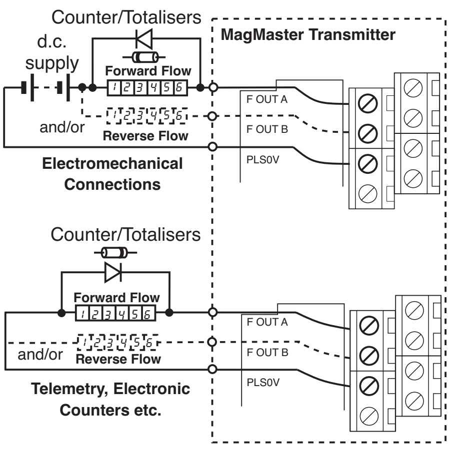


Fig. 3.16 Frequency Output Connections

3.3.2 PLC Interface – Fig. 3.17

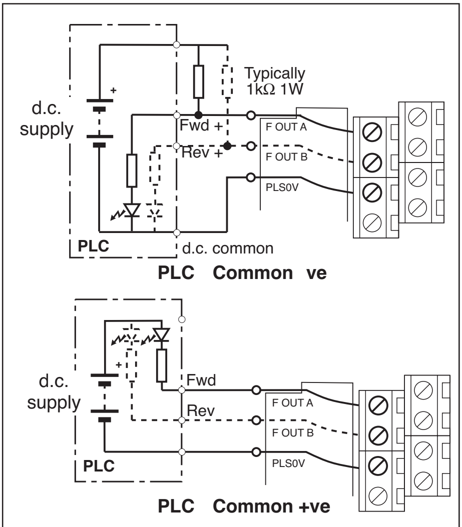


Fig. 3.17 Frequency Output Connections

3.3.3 Alarm Outputs – Fig. 3.18

Information.

- Inductive loads may be suppressed by diodes (D) – 1N4004 or similar.
- Inrush currents are limited to 1 Amp by resistor R – e.g. 27Ω 1W for 24V systems.
- Operation of outputs is programmable – see Configuration Manual for details.
- Frequency and Alarm outputs share a common return with contact input.
- External isolators not normally required, as the pulse, alarm and contact circuits are electrically separated from all other Magmaster connections.

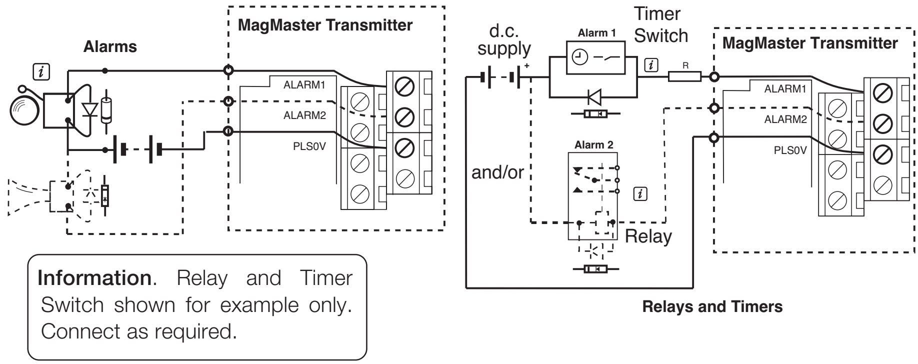


Fig. 3.18 Alarm Output Connections

3.3.4 Contact Input – Fig 3.19

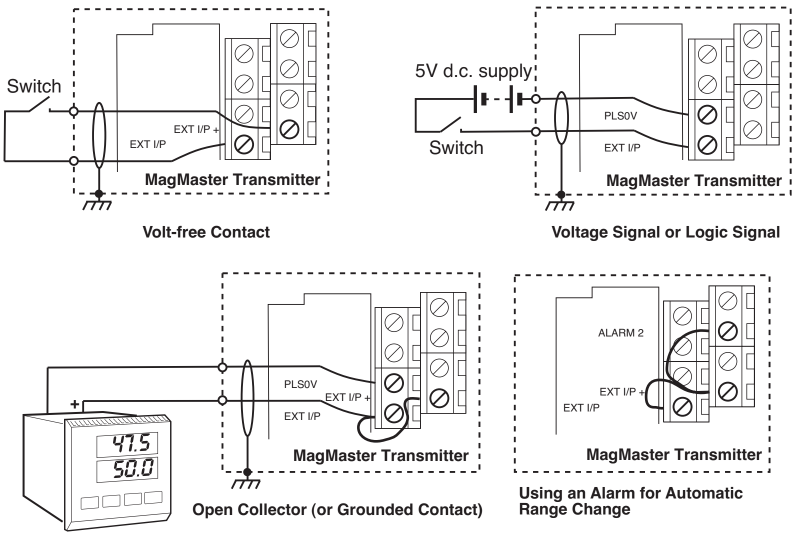
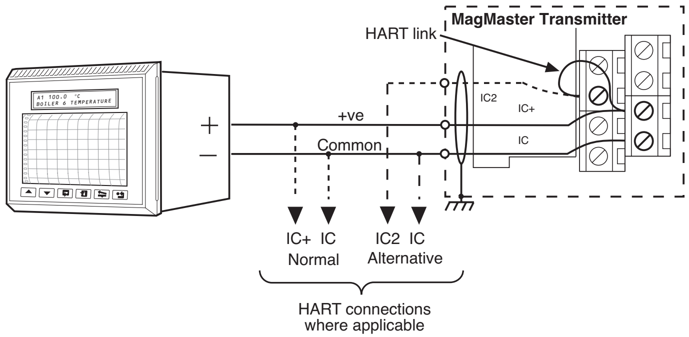


Fig. 3.19 Contact Input Connections

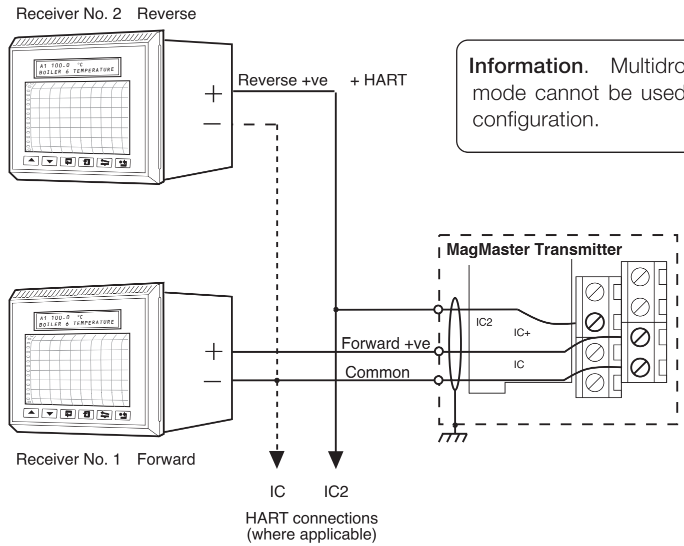
3.3.5 Current Output – Fig. 3.20 and 3.21

Information.
- Output is fully programmable – see Programming Guide.
- Output is electrically separated from all other MagMaster connections.
- External isolators are not normally required and may significantly limit accuracy if used.



Information. For Multidrop HART installations, remove 'HART Link' and connect HART systems directly to IC2: this allows the analog output function to be retained.

Fig. 3.20 Current Output Connections: Standard



Information. Multidrop HART mode cannot be used with this configuration.

Fig. 3.21 Current Output Connections: Dual Current Option

3.3.6 Computer Connection – Fig. 3.22 and 3.23

Information. RS422/423 option is electrically isolated from all other MagMaster connections.

MagMaster TERMINALS		RS422 Connection NAME	APPLE Connector (8 Pin MC)
TX-SIG	CONNECT TO	RX DATA -	5
TX+SIG		RX DATA +	8
RX-SIG		TX DATA -	3
RX+SIG		TX DATA +	6
0VC		SIGNAL GROUND	4
		DCD } Link	7 } Link
		DTR } together	1 } together
		DSR }	2 }

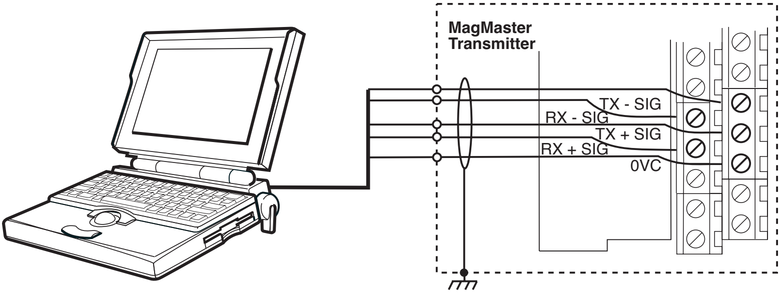


Fig. 3.22 RS 422 Connections (Balanced)

MagMaster TERMINALS		RS232 Name	9-Pin PC Connector	25-Pin PC Connector	Hygienic Adaptor Cable
TX-SIG	CONNECT TO	RXD	2	3	Red
TX+SIG					
RX-SIG		TXD	3	2	Blue
RX+SIG		GND	5	7	Yellow
0VC		(linked)	(linked)	(linked)	Green
		DTR } link	4 } link	20 } link	
		DSR } together	6 } together	6 } together	
		RTS } link	7 } link	4 } link	
		CTS } together	8 } together	5 } together	

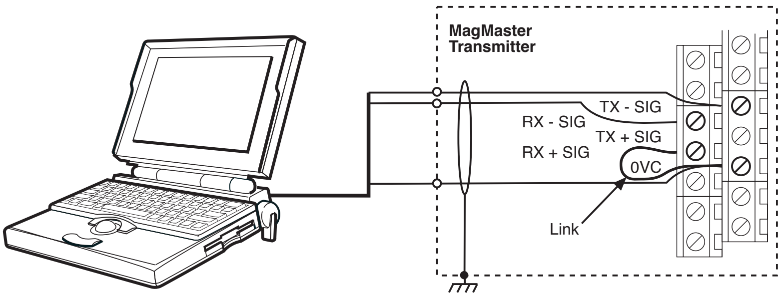


Fig. 3.23 RS 423 Connections (Single Ended or RS 232)

3.3.7 Power Supply Connections – Fig. 3.24 and 3.25

Warning.

- DISCONNECT THE SUPPLY FROM ANY CABLES BEING TERMINATED ON THE TRANSMITTER.
- Electrical installation and earthing (grounding) must be in accordance with relevant national and local standards.
- Ensure that the cover of the metal housed transmitter is never cross threaded. The threads are greased (as supplied).
- Ensure that the grease is in good condition when fitting the cover, and replenish as required with a grease suitable for aluminium threads.

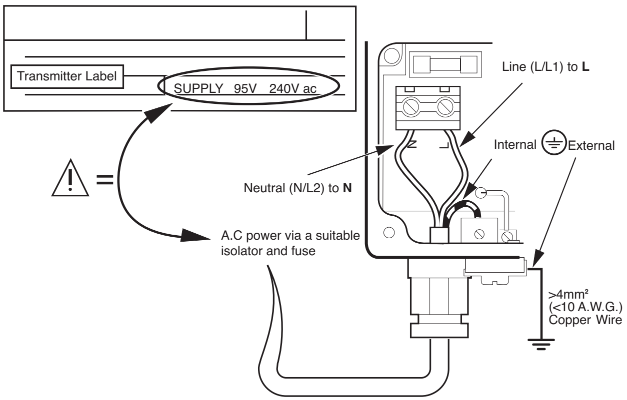


Fig. 3.24 Power Supply Connections (A.C. Version Transmitter)

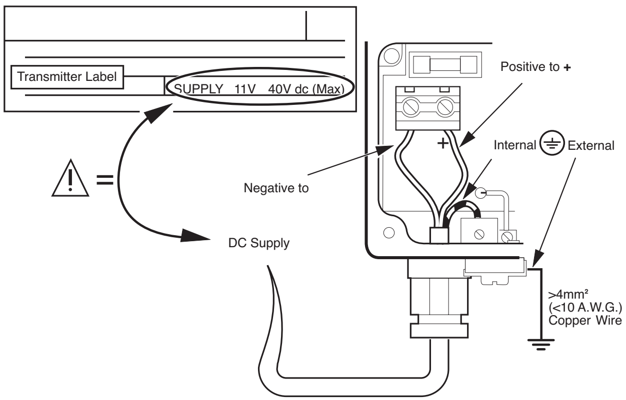


Fig. 3.25 Power Supply Connections (D.C. Version Transmitter)

4 SETTING UP

4.1 Introduction

The basic equation for volume measurement using AquaProbe is:

$$\mathbf{Q = A \;\; F_i \;\; F_P \;\; V}$$

Where: Q = flow rate,

Fi = insertion factor

Fp = 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.

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

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4.2 Partial Velocity Traverse

Refer to the Appendix A1 for procedure.

4.3 Centre Line Method

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

b) Determine the profile factor F_p from Fig. 4.1.

c) Calculate the insertion factor

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

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

Fp = 0.861 (derived from Fig. 4.1)

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

Fi = 1.021

4.4 Mean Axial Velocity Method (1/8 Diameter)

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

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

c) Calculate the insertion factor

$$F_i = +1\left[\frac{12.09577}{d} + \frac{1.3042118}{\sqrt{d}} + \frac{146.3077892}{d^2}\right]$$

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

Fp = 1

$$F_i = +1\left[\frac{12.09577}{d} + \frac{1.3042118}{\sqrt{d}} + \frac{146.3077892}{d^2}\right]$$

Fi = 1.074

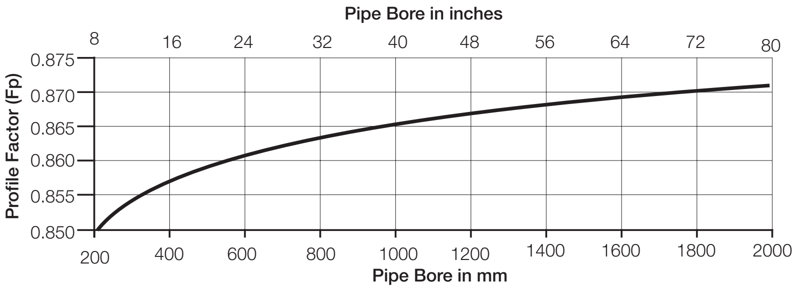


Fig. 4.1 Profile Factor vs Velocity for Pipe Sizes 200 to 2000mm (8in to 80in)

5 START UP AND OPERATION

Warning.
- Ensure Plant Safety while configuring, at all times.
- The 9-way D-Type Serial Link is not isolated. Ensure that it is NOT connected to power earth (ground), with cathodically protected systems.

5.1 Startup

Switch on the power supply to the flowmeter, and if a transmitter with display has been ordered, the flow rate will be shown on the display as shown in Fig. 5.1 or 5.2, overleaf.

Sequential application of the provided magnetic wand to the left hand icon in the transmitter display area, or by pressing the button on the keypad versions or the remote display, steps the display through the following sequence:

% (Flow Rate % of Range)

> (Forward flow total value)

< (Reverse flow total value)

* (Net flow total value)

Alm (Active alarms)

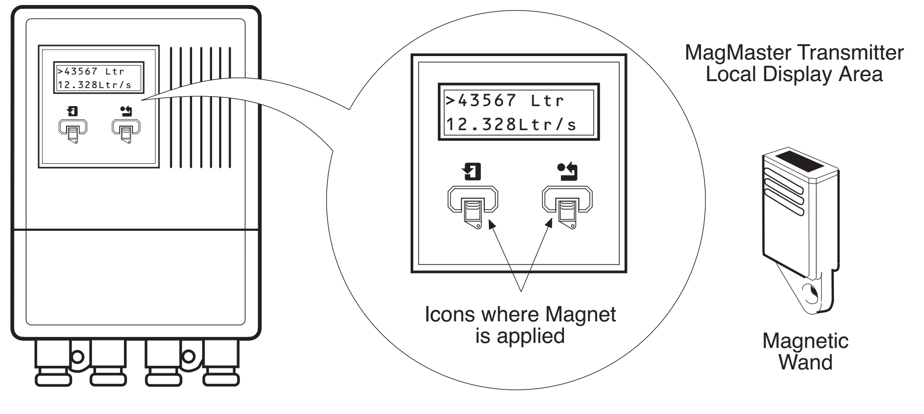
Vel (Flow Velocity in m/s or ft/s)

Any alarms are displayed sequentially if more than one alarm is present.

Application of the wand to the right hand icon, or pressing the keypad button, resets the totaliser display, if this facility is enabled.

Information.
- For the use of local or remote serial communication, and configuration, see the Quick Reference Programming Guide or the main MagMaster manual.
- For all versions supporting HART™, see the main MagMaster manual.

...Start up



5.1 Location of Controls (Non-Keypad Version)

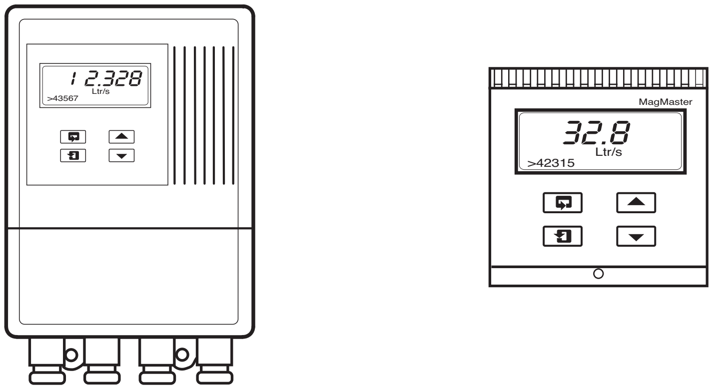


Fig. 5.2 Location of Controls (Keypad Versions)

A1 Testing the Flow Profile for Symmetry

If there is any doubt as to the symmetry of the flow profile (see Section 2.2), 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 $^1/_8$ and $^7/_8$ 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 $^1/_8$ the pipe diameter – see Fig. 2.14.

> **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

$$F_i = +1\left[\frac{12.09577}{d} + \frac{1.3042118}{\sqrt{d}} + \frac{146.3077892}{d^2}\right]$$

c) Refer to the AquaMaster Quick Reference Guide. Enter the value of F_i into Insertion Factor and enter a value of 1.00 into Profile Factor.

d) Record the flow velocity reading.

e) Insert the probe to a depth of $^7/_8$ the pipe diameter.

f) Calculate the insertion factor

$$F_i = +1\left[\frac{12.09577}{d} + \frac{1.3042118}{\sqrt{d}} + \frac{146.3077892}{d^2}\right]$$

g) Refer to the AquaMaster Quick Reference Guide. Enter the value of F_i into Insertion Factor and enter a value of 1.00 into Profile Factor.

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 4.2 can be used. If outside this ratio, resite the AquaProbe for optimum accuracy.

A1.3 Dual Entry Point Method

Refer to Section 2.5 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 $^1/_8$ the pipe diameter through the original mounting boss.

b) Calculate the insertion factor

$$F_i = +1\left[\frac{12.09577}{d} + \frac{1.3042118}{\sqrt{d}} + \frac{146.3077892}{d^2}\right]$$

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.

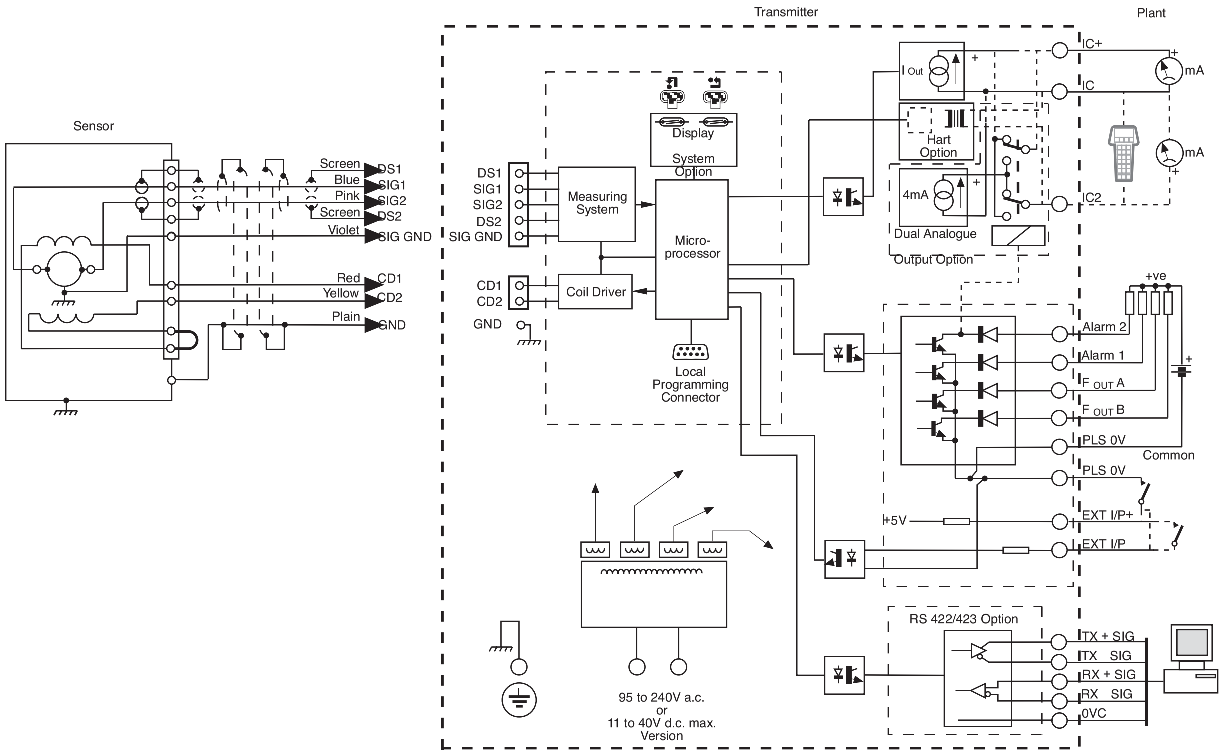
e) Insert the probe to a depth of $^1/_8$ the pipe diameter through the second mounting boss.

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 4.2 can be used. If outside this ratio the AquaProbe should be resited for optimum accuracy.

APPENDIX B – MAGMASTER BLOCK DIAGRAM



NOTES

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- ***Zirconia oxygen analyzers, katharometers, hydrogen purity and purge-gas monitors, thermal conductivity.***

Customer Support

We provide a comprehensive after sales service via a Worldwide Service Organization. Contact one of the following offices for details on your nearest Service and Repair Centre.

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United States of America
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Instrumentation Division
Tel: +1 215 674 6000
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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