AquaProbe
Insertion Type
Electromagnetic Flowmeters

Installation Manual

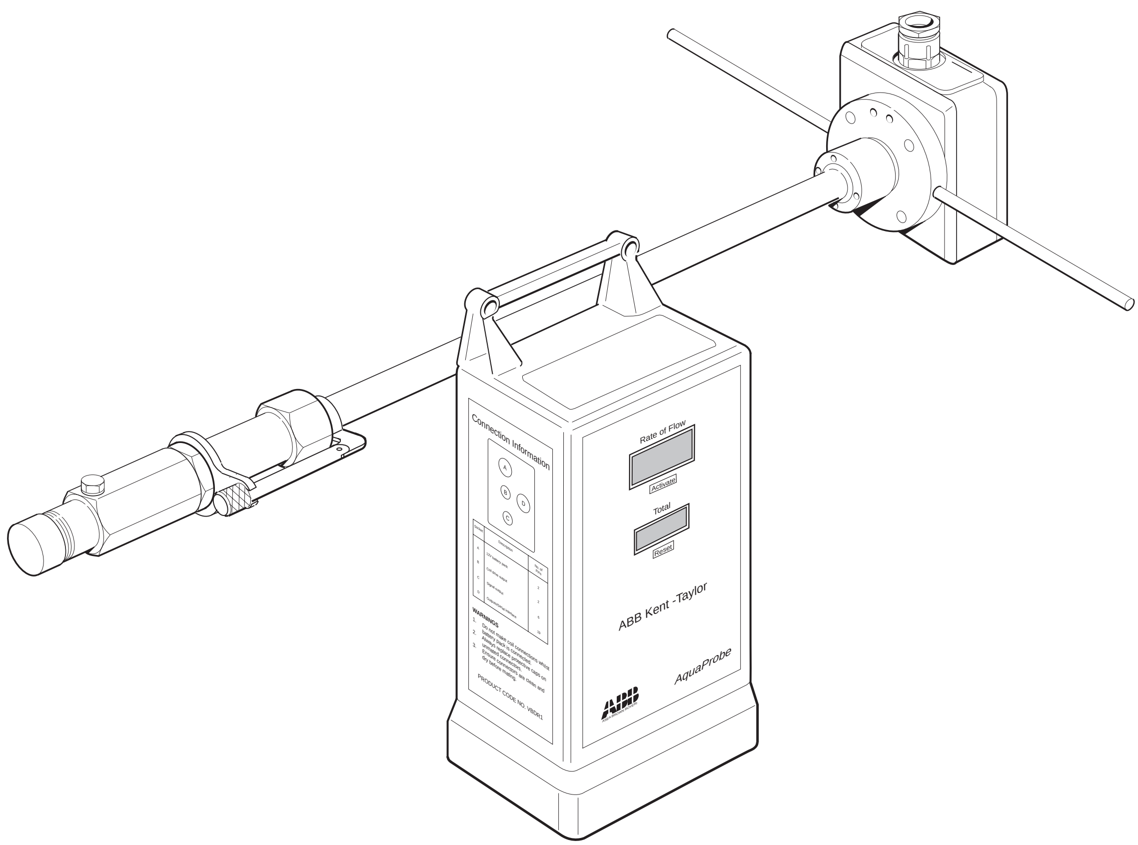

ABB Kent-Taylor

ABB KENT-TAYLOR

The Company

ABB Kent-Taylor is 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 NAMAS Calibration Laboratory No. 0255(B) is just one of the ten flow calibration plants operated by the Company, and is indicative of ABB Kent-Taylor's dedication to quality and accuracy.

BS EN ISO 9001

St Neots, U.K. – Cert. No. Q5907
Stonehouse, U.K. – Cert. No. FM 21106

UNI EN 29001 (ISO 9001)

Lenno, Italy – Cert. No. 9/90A

Stonehouse, U.K. – Cert. No. 0255

Use of Instructions

Warning.
An instruction that draws attention to the risk of injury or death.

Note.
Clarification of an instruction or additional information.

Caution.
An instruction that draws attention to the risk of damage to the product, process or surroundings.

Information.
Further reference for more detailed information or technical details.

Although **Warning** hazards are related to personal injury, and **Caution** hazards are associated with equipment or property damage, it must be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process system performance leading to personal injury or death. Therefore, comply fully with all **Warning** and **Caution** notices.

Licensing, Trademarks and Copyrights

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 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.

1.1 System Schematic – Fig. 1.1

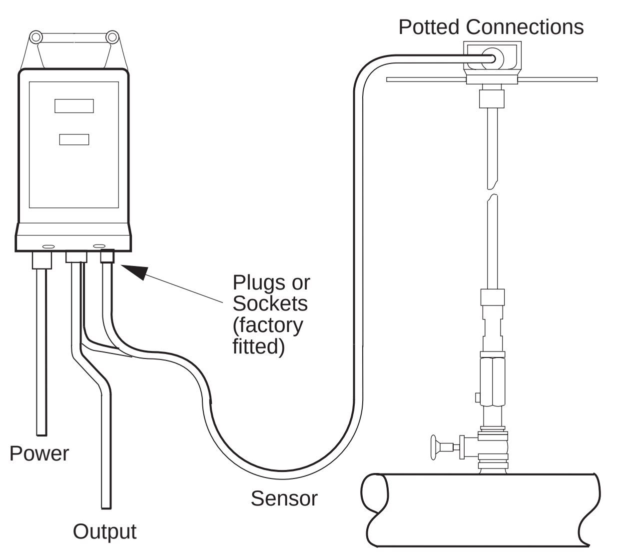


Fig. 1.1 System Schematic

2 PREPARATION

2.1 Checking the Code Number – Fig. 2.1

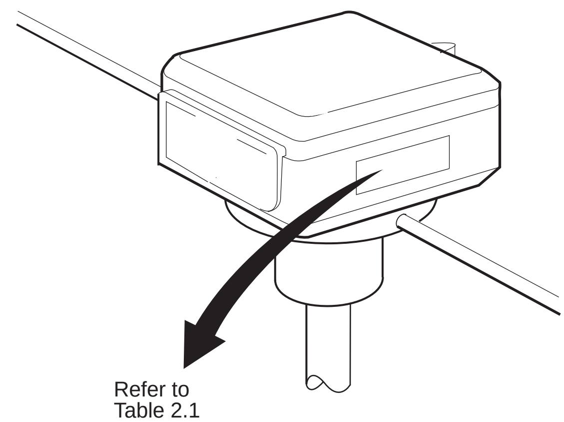


Fig. 2.1 Checking the Code Number

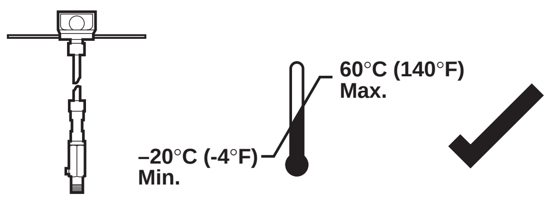
AquaProbe Product Code													**Transmitter**						
			Sensor																
AquaProbe		MF/A	XXX	X	1	0	1	0	X	XX	0	AA	X	3	0	0	1	0
Length	No probe 300mm (12in) 500mm (20in) 700mm (27in) 1000mm (39in)		000 301 501 701 102															
Sliding Joint Connection	Not required 1.0in BSP, with ⅛ in BSP pressure tapping 1.5in BSP, with ⅛ in BSP pressure tapping 1.0in NPT, with ⅛ in NPT pressure tapping			0 1 2 3														
Calibration	Un-calibrated Standard 3 point 8 point Witnessed 8 point								0 1 2 4									
Cabling	Not fitted or potted 3m 10m } Fitted to sensor and potted 30m									00 03 10 30								
Power Supply	Battery pack Power supply cable												4 6					

Table 2.1 Code Number Identification

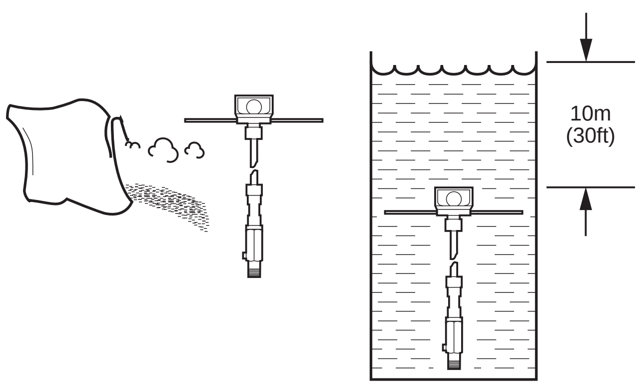
3 MECHANICAL INSTALLATION

3.1 Location – Environmental Conditions

3.1.1 AquaProbe – Fig. 3.1

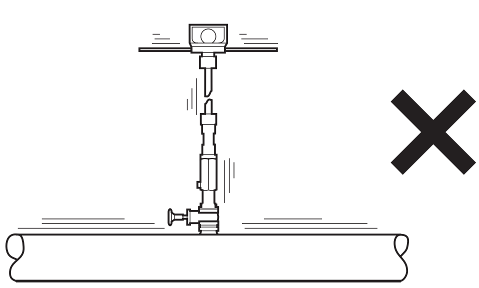


A – Within Temperature Limits



IP68 (NEMA 6)

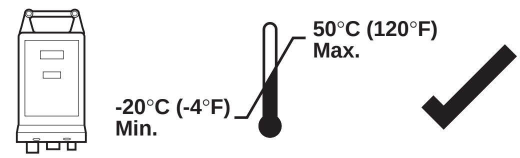
B – Within Environmental Rating



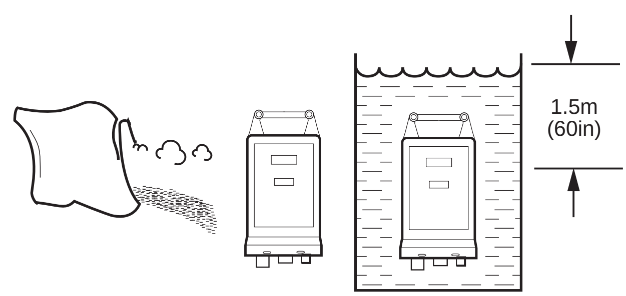
C – Avoid Excessive Vibration

Fig. 3.1 Environmental Requirements – AquaProbe

3.1.2 Transmitter – Fig. 3.2

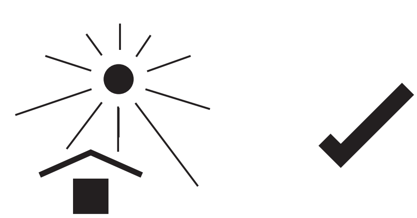


A – Within Temperature Limits



IP68 (NEMA 6)

B – Within Environmental Rating



C – Shade from Heat

Fig. 3.2 Environmental Requirements – AquaProbe Transmitter

3.2 Location – Flow Conditions

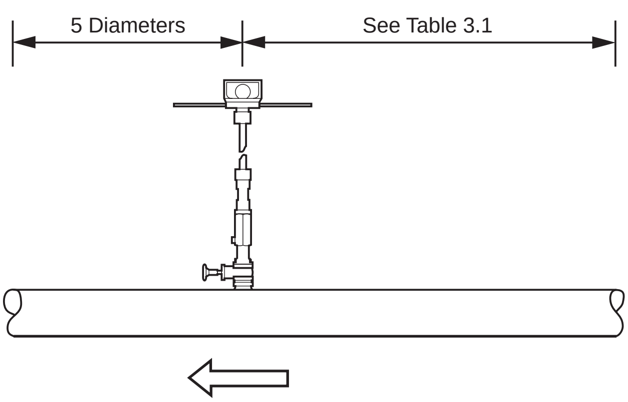
The probe may be installed in one of two positions in the pipe; either on the centre line or at the mean axial velocity point ($^1/_8$ pipe diameter). It may also be traversed across the pipe to determine the velocity profile.

3.2.1 International Standard for Flow Measurement

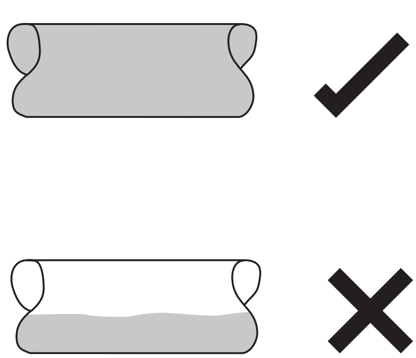
ISO 7145 '(BS 1042) Measurement of fluid flow in closed conduits' Part 2 'Velocity area methods' describes methods of calculating volumetric flow from velocity measurements.

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.

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 Straight Pipe Lengths

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.

i **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.

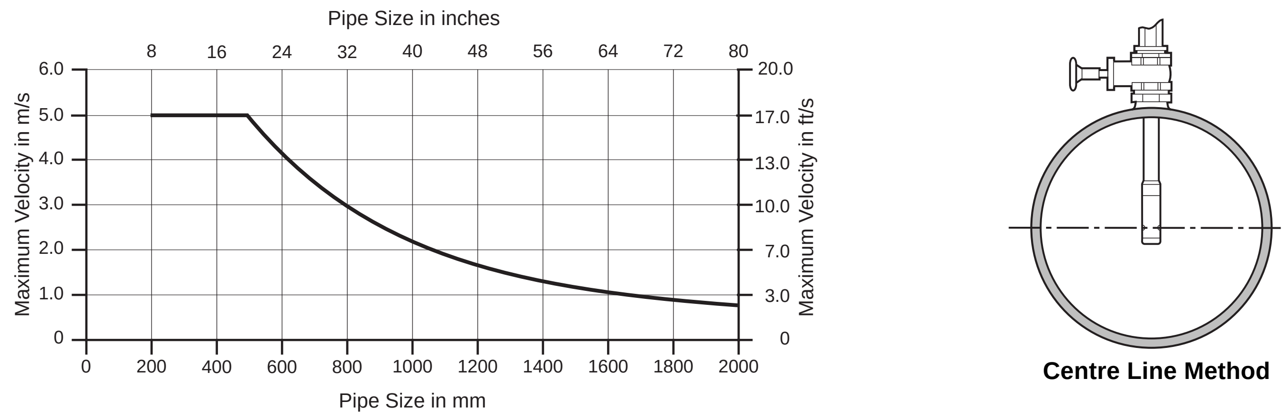


Fig. 3.4 Maximum Permissible Velocity for different Pipe Sizes

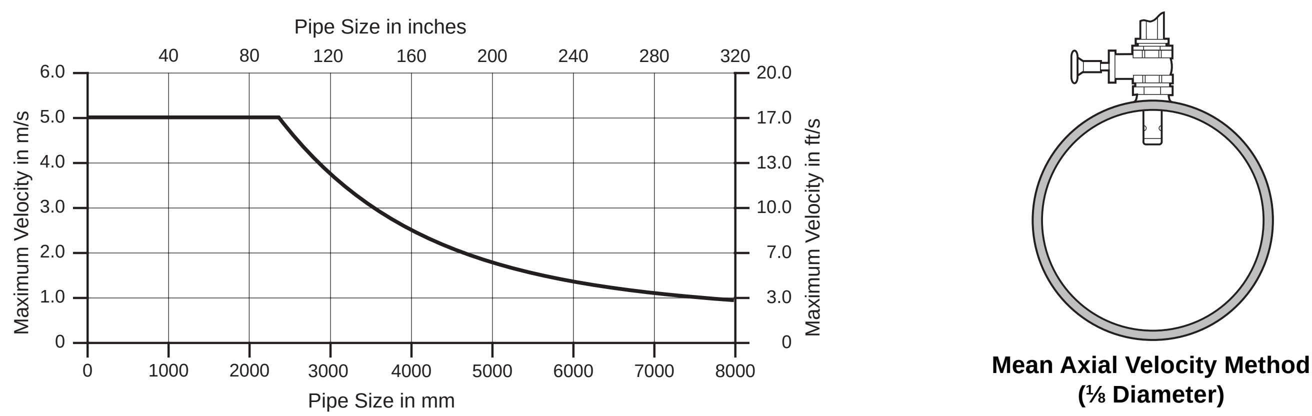


Fig. 3.5 Maximum Permissible Velocity for different Pipe Sizes

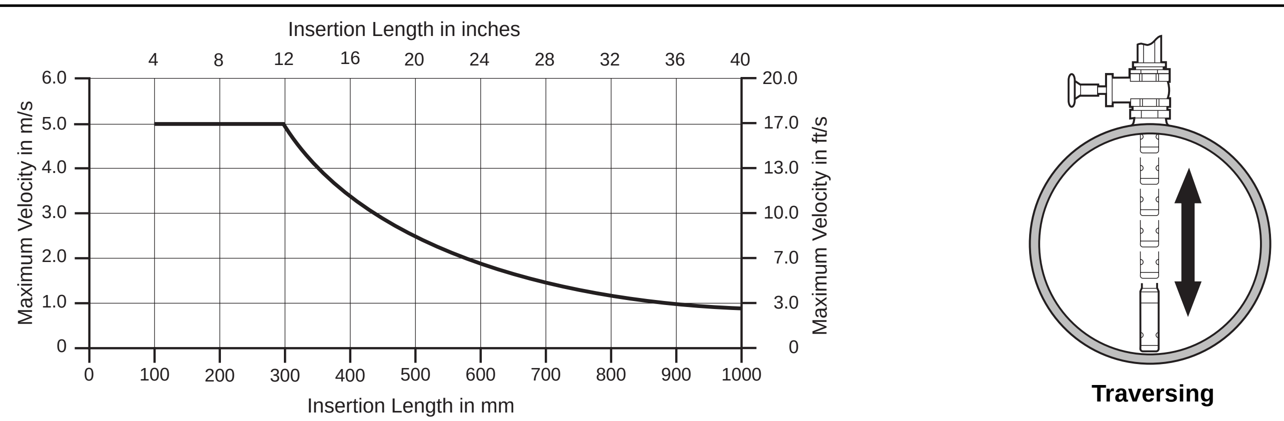


Fig. 3.6 Maximum Permissible Velocity for different Insertion Lengths

3.3 Location – Mechanical

3.3.1 AquaProbe – Fig. 3.7

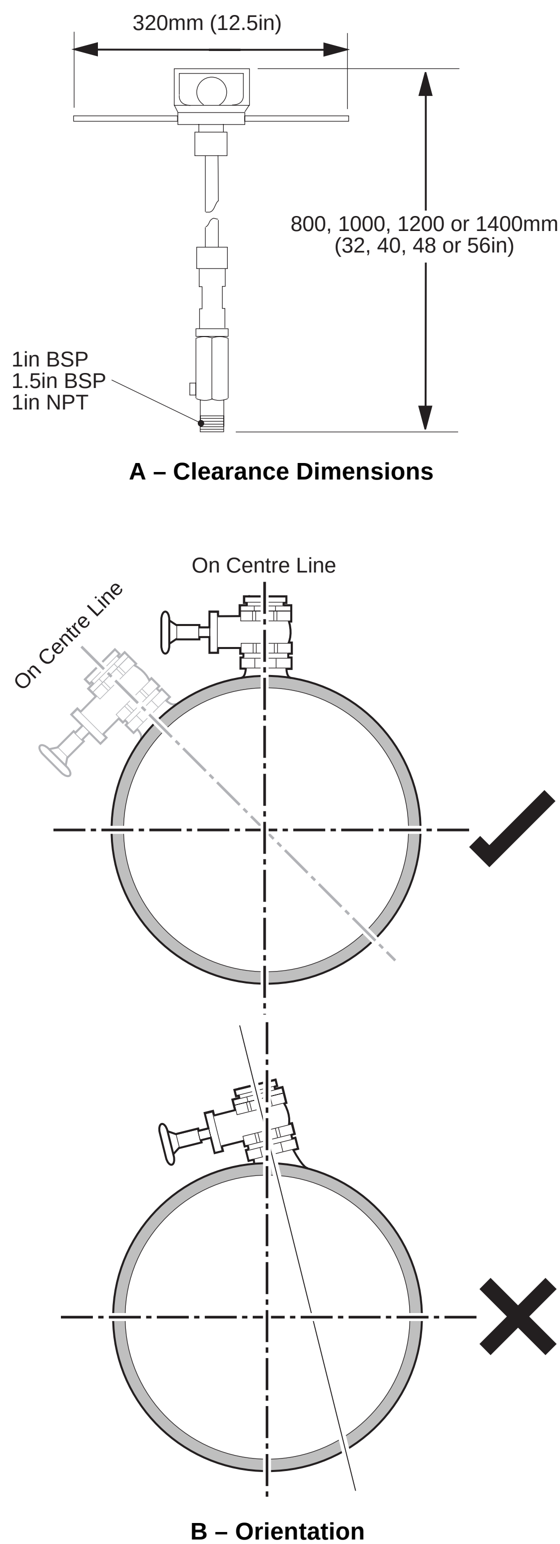


Fig. 3.7 Mechanical Requirements – AquaProbe

3.3.2 Transmitter – Fig. 3.8

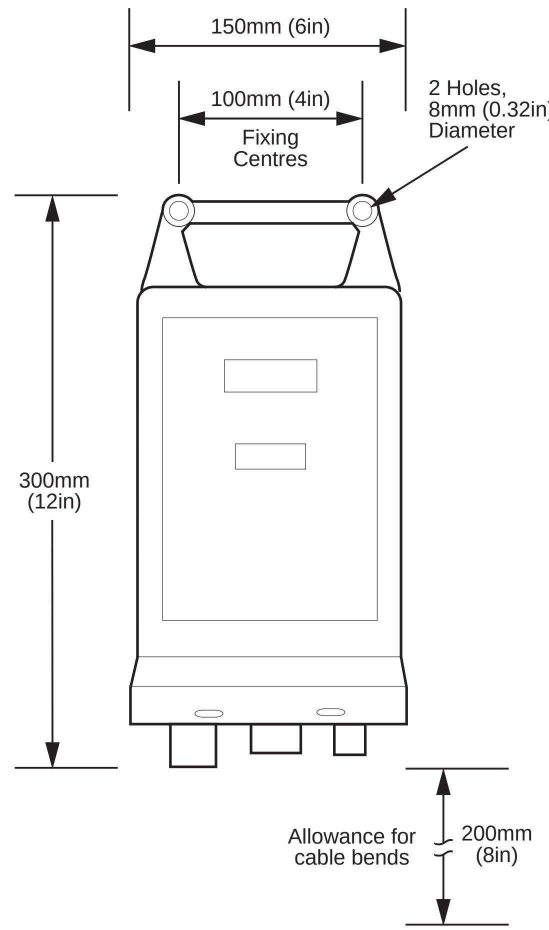
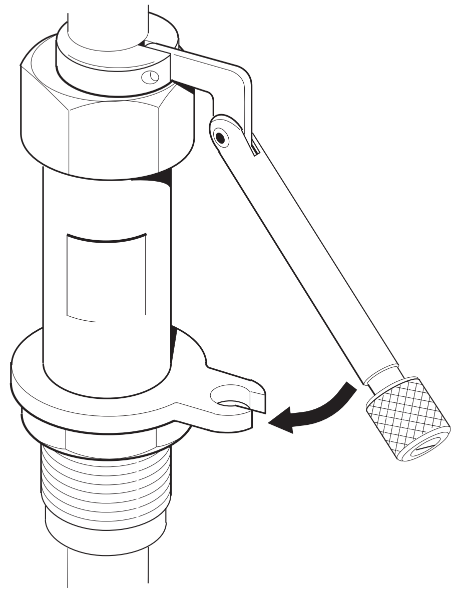


Fig. 3.8 Clearance Dimensions – Transmitter

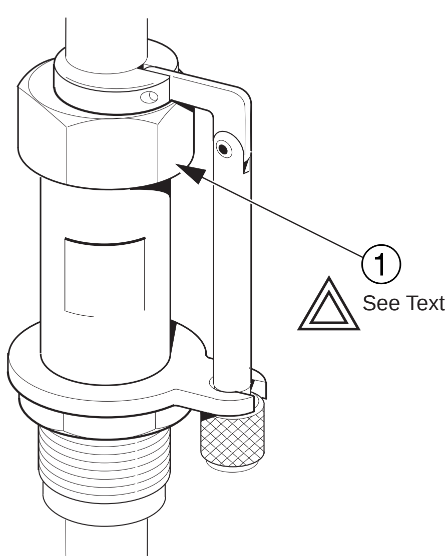
3.4 Safety – Fig. 3.9

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.



A – Unsecured



B – Secured

Fig. 3.9 Safety Mechanism

3.5 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.

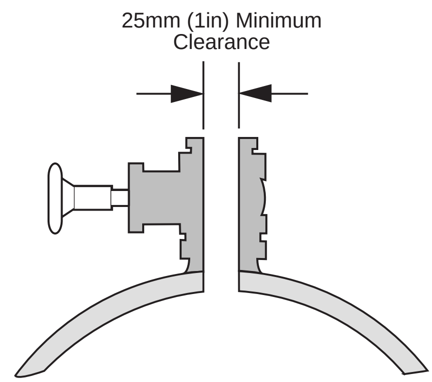


Fig. 3.10 Insertion Bore Clearance

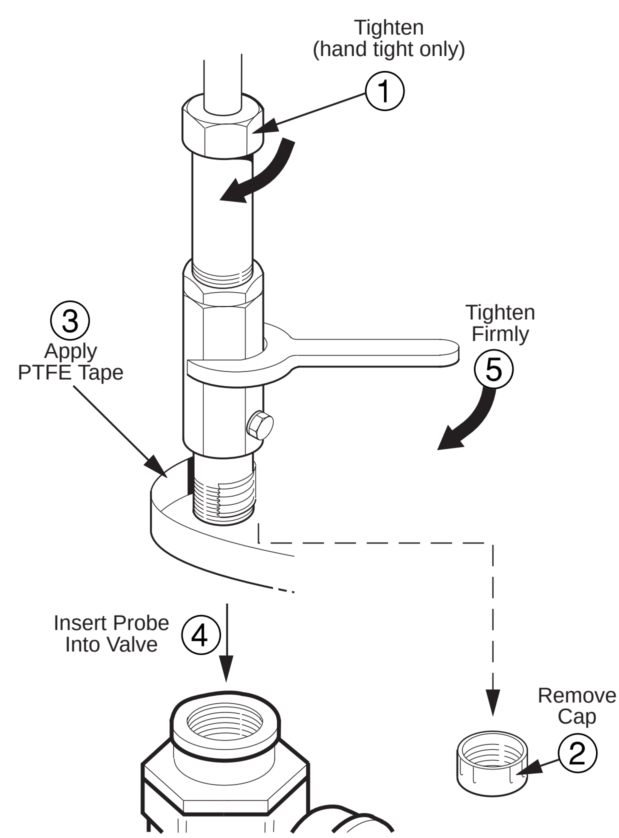


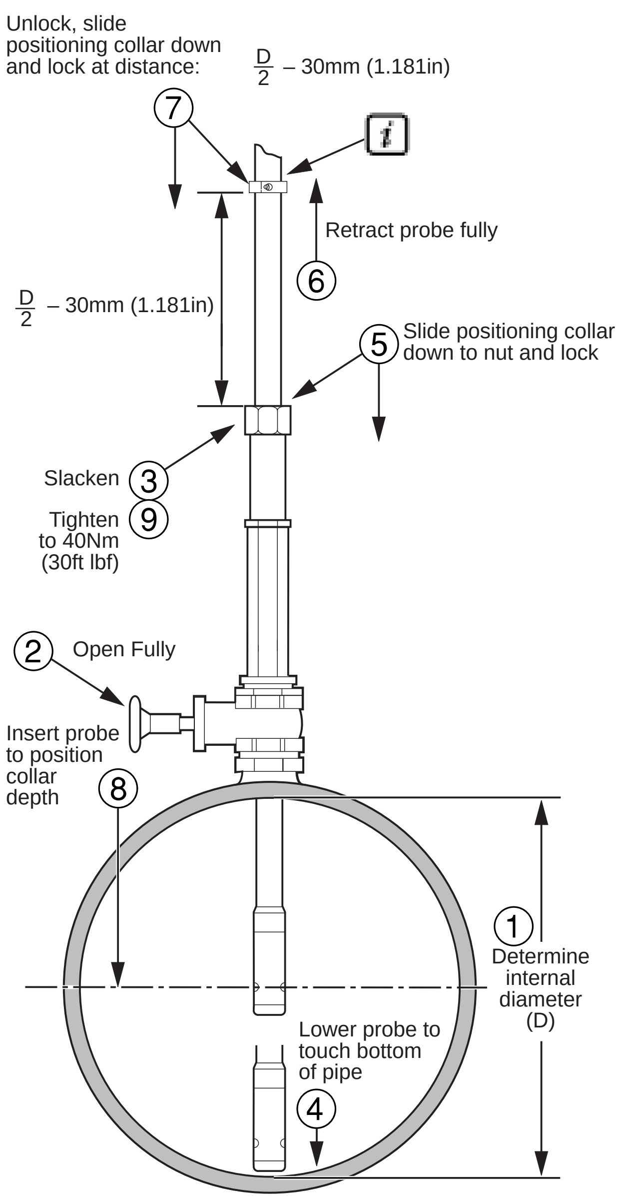
Fig. 3.11 Installing the AquaProbe

3.6 Setting the Insertion Depth

3.6.1 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.



3.6.2 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.

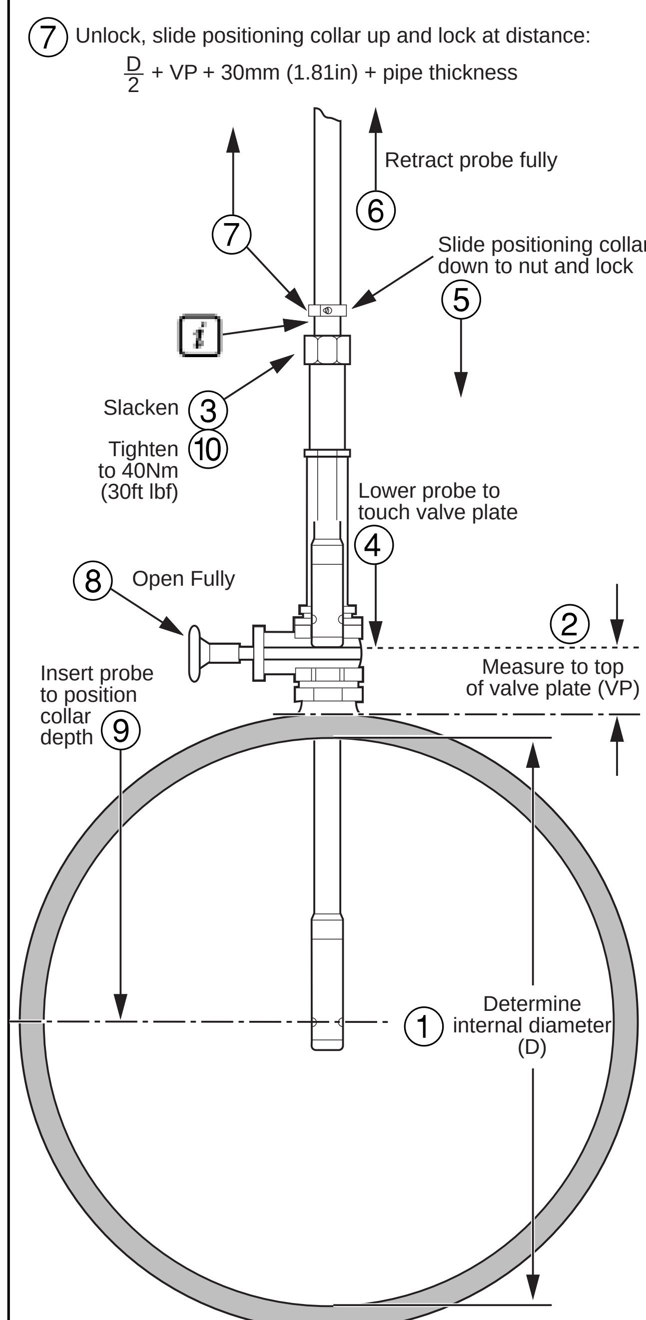


Fig. 3.13 Setting the Insertion Depth – Centre Line Method for Pipe Diameters >1m ≤2m (>40in ≤80in)

3.6.3 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.

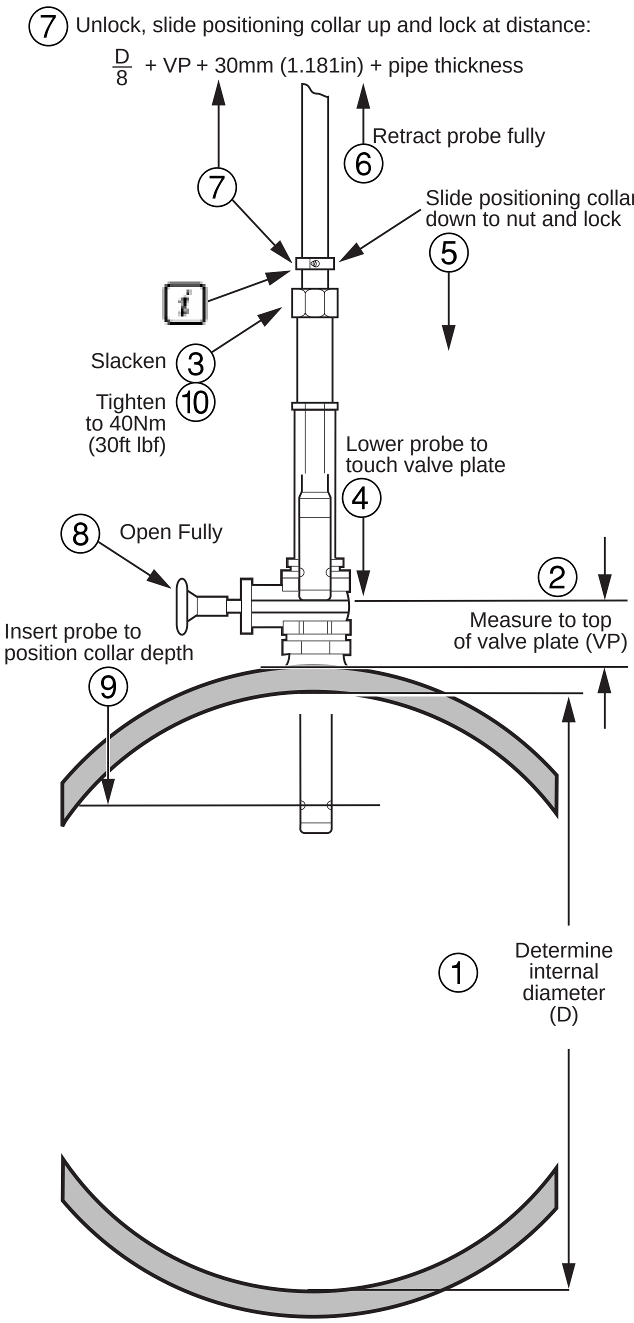


Fig. 3.14 Setting the Insertion Depth – Mean Axial Velocity Method

3.7 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.

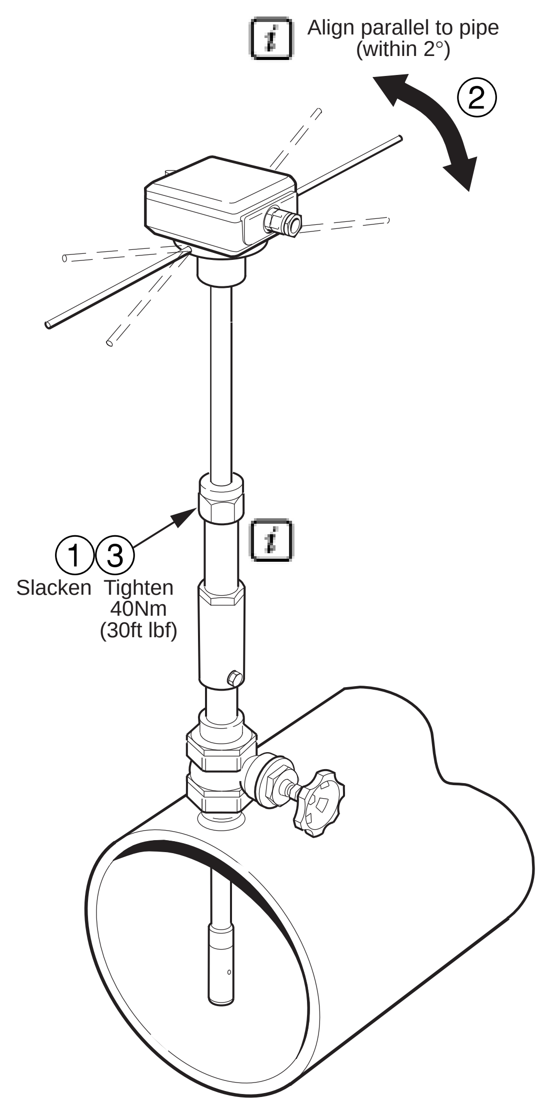


Fig. 3.15 Probe Alignment

4 ELECTRICAL INSTALLATION

AquaProbe is usually supplied with an integral cable and potted terminal box. The cable is fitted with the necessary plugs for connection to the AquaProbe transmitter. In some cases however the lead assembly (complete with plugs) is supplied unattached to the AquaProbe and connections to the probe head are necessary. A battery may be supplied, with integral plug and connector. If required an optional cable, with the required connector, is available for any output function.

4.1 AquaProbe Transmitter Socket Identification – Fig. 4.1

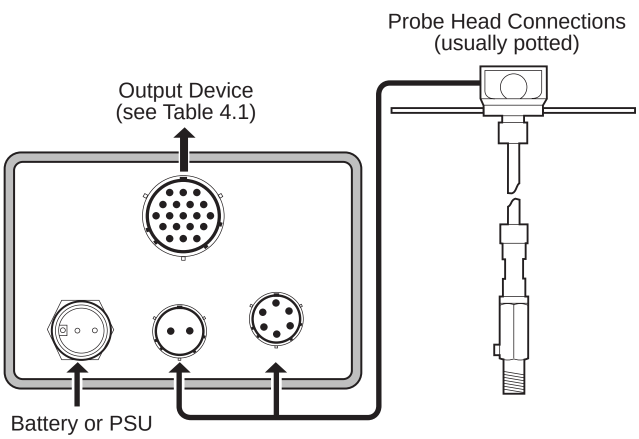


Fig. 4.1 – AquaProbe Transmitter Connections

4.2 Grounding

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

4.3 Input and Output Connections – Table 4.1

Caution. Ensure that all external connections and are suitably protected against moisture or flooding.

Note. When connecting cables to the transmitter unit, correctly align the plug with the keyway to ensure correct insertion, and turn the locking ring fully clockwise to secure.

Pin	Name	Function	Colour (Output cable)
A	B –	Internally wired to battery connector –ve (= GND)	Black
B	B +	Internally wired to battery connector +ve (= +12V)	Red†
C	A +	Equivalent to B+ (+12V), forces CONTINUOUS MODE when powered.	Pink
D	x1F	Forward pulse output, standard resolution	Orange
E	x10F	Forward pulse output, high resolution	White/Orange
F	x1R	Reverse pulse output, standard resolution	Blue
G	GND	Internally wired to battery connector –ve	Drain Wire
H	x10R	Reverse pulse output, high resolution	White/Blue
J	RESET	Resets internal totaliser when connected to GND	White
K	ACTIVATE	Equivalent to 'ACTIVATE' (connect to GND)	Violet
L	RXD	Receive data (serial input connection)	Turquoise
M	TXD	Transmit data (serial output connection)	Brown
N	—	Not used	
P	—	Not used	
R	—	Not used	
S	GND	Internally wired to battery connector –ve	Grey
T	RSTSW	Connects to GND when 'RESET' operated with magnetic wand	Yellow
U	—	Not used	
V	GND	Internally wired to battery connector –ve	Green

† This wire is directly connected to the battery connector +ve and must be adequately insulated to prevent shorting to other connections, as this may cause damage or fire.

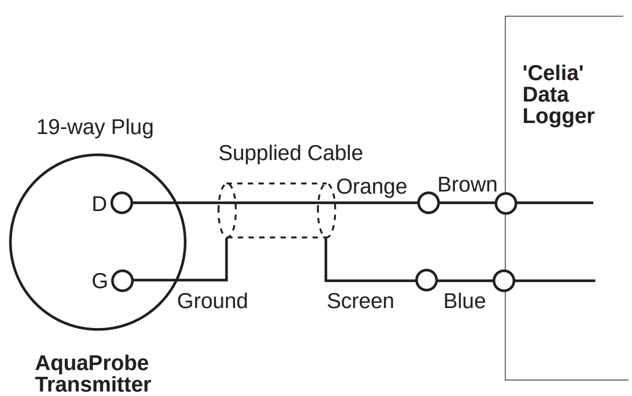
Table 4.1 Input/Output Connection Details

4.4 Data Logger Connections – Figs. 4.2 to 4.5

If required, the transmitter may be connected to a data logger using suitable cables – see Section 8.1. Additional connection details are shown in Table 4.1 (previous page).

> ⚠ **Caution**. When connecting to remote receiving equipment take care to ensure that large earth currents are prevented as a result of the common zero volt connections. Failure to observe this precaution may result in inaccurate or unreliable operation.

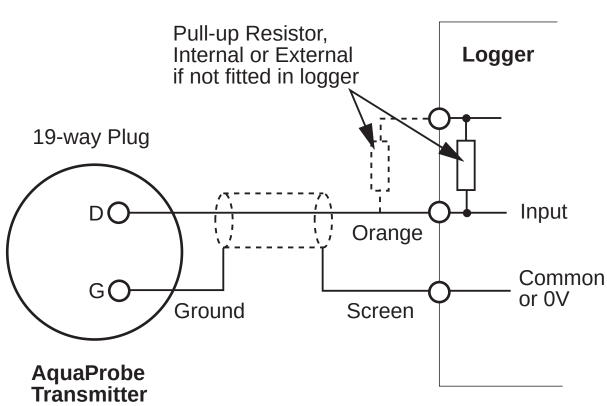
4.4.1 Celia Isolated Logger – Fig. 4.2



✶ For reverse flow and/or x10 resolution see Table 4.1

Fig. 4.2 – Connection to 'Celia' Isolated Data Logger (x1 Forward Flow Connected)

4.4.2 Data Logger Configured for Contact Closure – Fig. 4.3



✶ For reverse flow and/or x10 resolution see Table 4.1

Fig. 4.3 Connection to Contact Closure Configured Logger (x1 Forward Flow Signal Connected)

4.4.3 Bi-directional Data Logger – Fig. 4.4

Where an AquaProbe is replacing an existing electro-mechanical probe the following circuitry may be required.

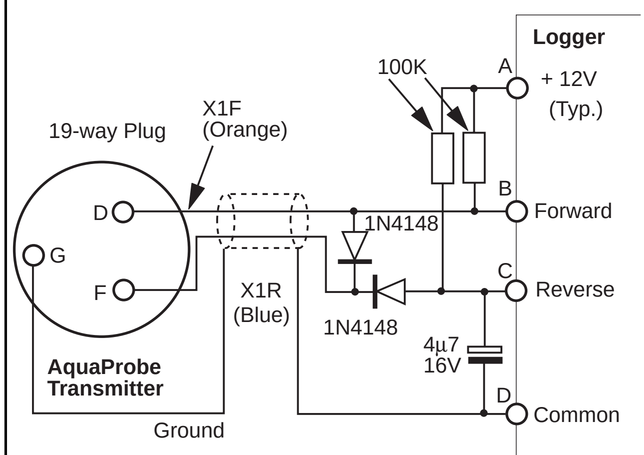


Fig. 4.4 Connection to Bi-directional Data Logger

4.4.4 Cervelec WS2 Telemetry System – Fig. 4.5

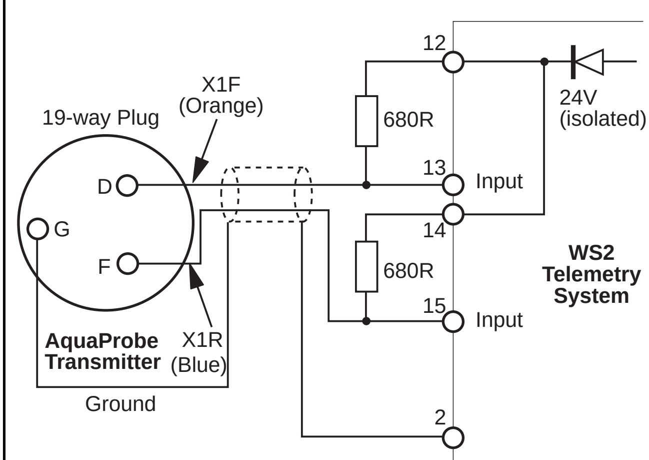


Fig. 4.5 Connection to WS2 Telemetry System

4.5 Cable Type and Preparation – Figs. 4.6 and 4.7

If the cable assembly is supplied independent of the AquaProbe the cable end must be prepared as detailed in Fig. 4.7 before connection to the probe head.

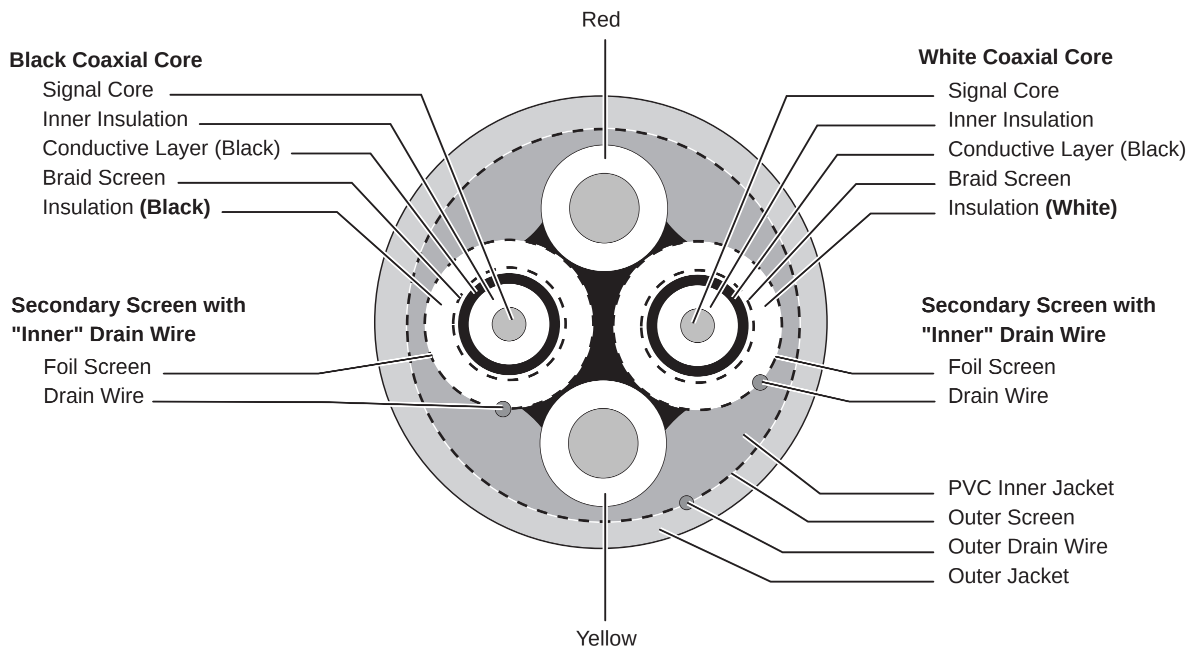
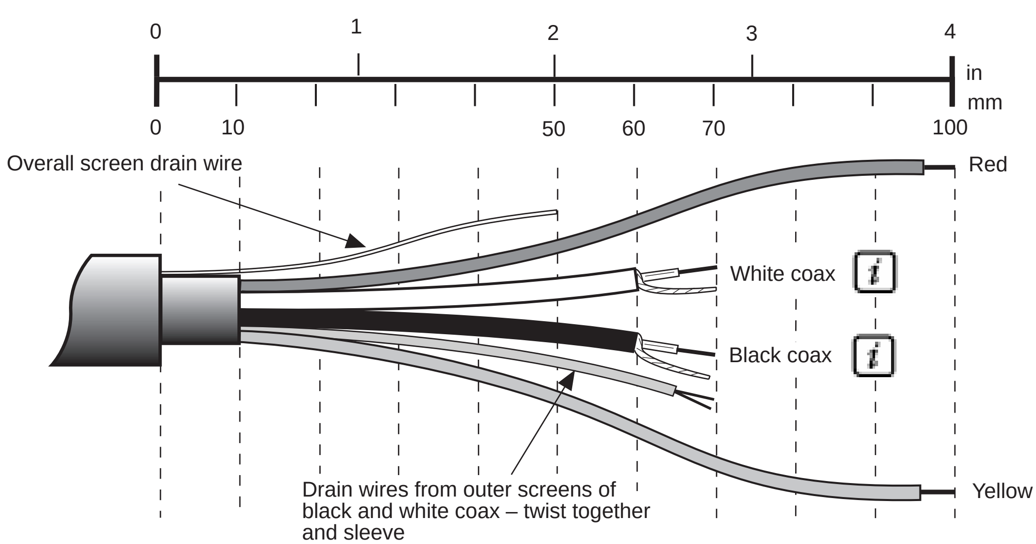


Fig. 4.6 Cable Identification



Information. Remove black conductive layer from clear insulation of inner core.

Fig. 4.7 Cable Preparation

4.6 Probe Head Connections – Fig. 4.8

The probe head connections must potted immediately on completion to prevent ingress of moisture – refer to Appendix A2.

4.7 Power Supply Unit

A 12V power supply unit may be connected to the AquaProbe transmitter instead of the battery pack. A power supply lead is available for this purpose – see Section 8.1.

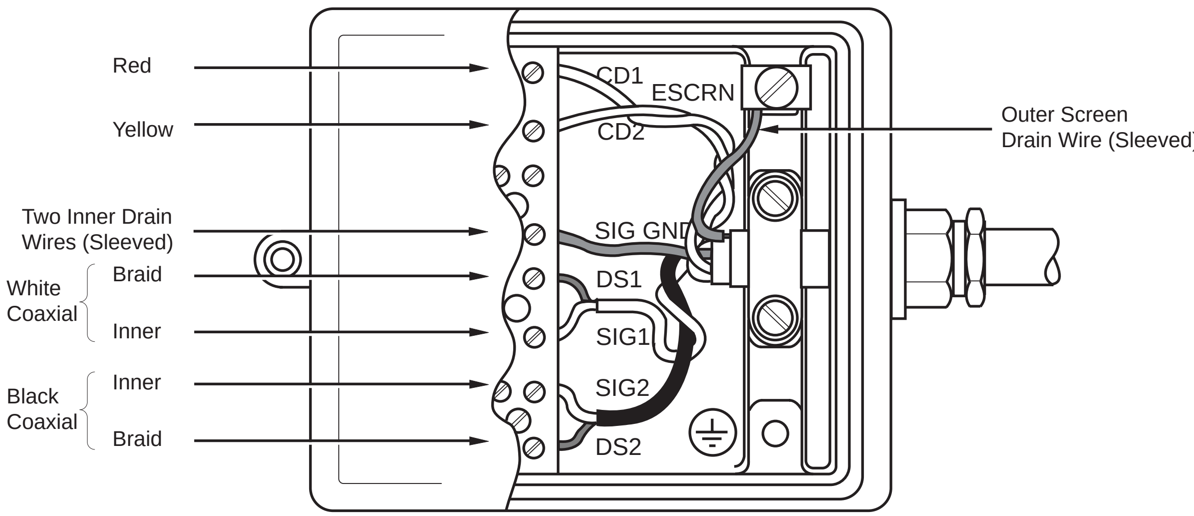


Fig. 4.8 Probe Head Connections

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.

> ✶ **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

5.2 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. 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 (⅛ 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 $F_i = \left[1 + \dfrac{12.09}{D} + \dfrac{1.3042}{\sqrt{D}}\right]$

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 AquaProbe Transmitter Set-up

The AquaProbe Transmitter can be set up to display point velocity, mean velocity or flow rate, as required. For full programming details refer to the AquaProbe Transmitter Configuration Manual.

For velocity measurement set:

VU to 1.000
TU to 1.000
BL to $F_i \times F_p$

For flow rate (in any units):

a) Calculate the volume units VU using

$$VU = \frac{\pi}{4} \times \left(\frac{D}{1000}\right)^2 \times L$$

Where D is the internal pipe diameter in mm
L is the number of volume units in a cubic metre

b) Enter TU for the time display units required, i.e. 1 (per second) 60 (per minute) etc.

Example – for a pipe diameter of 593mm (23.35in) and flow rate display in L/m (litres per minute) using centre line method:

$$VU = \frac{\pi}{4} \times \left(\frac{593}{1000}\right)^2 \times 1000$$

VU = 276.2

and

TU = 60

$BL = F_i \times F_p$

$BL = 1.021 \times 0.861$

BL = 0.879

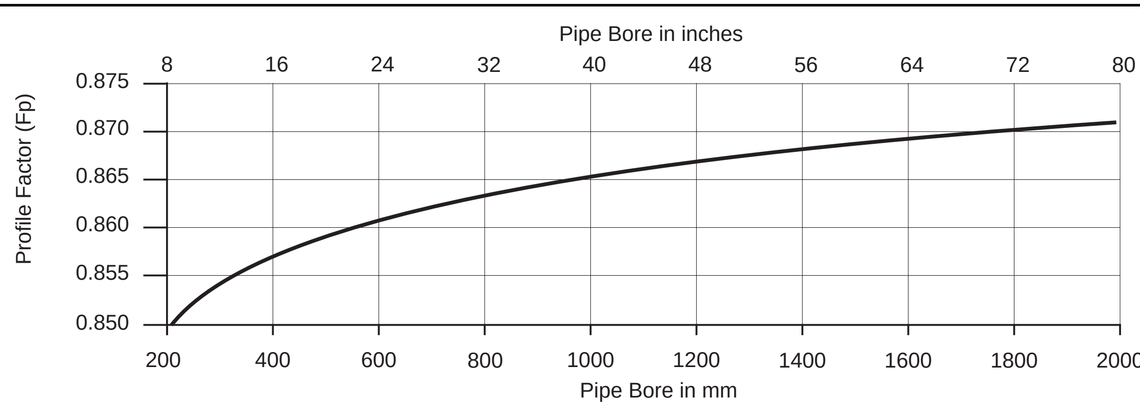


Fig. 5.1 Profile Factor vs Velocity for Pipe Sizes 200 to 2000mm (8 to 80in)

6 OPERATION

For full details of operation and displays refer to the AquaProbe Transmitter Configuration Manual (IM/AQUAPB-CM).

6.1 Start-up and Operation – Fig. 6.1

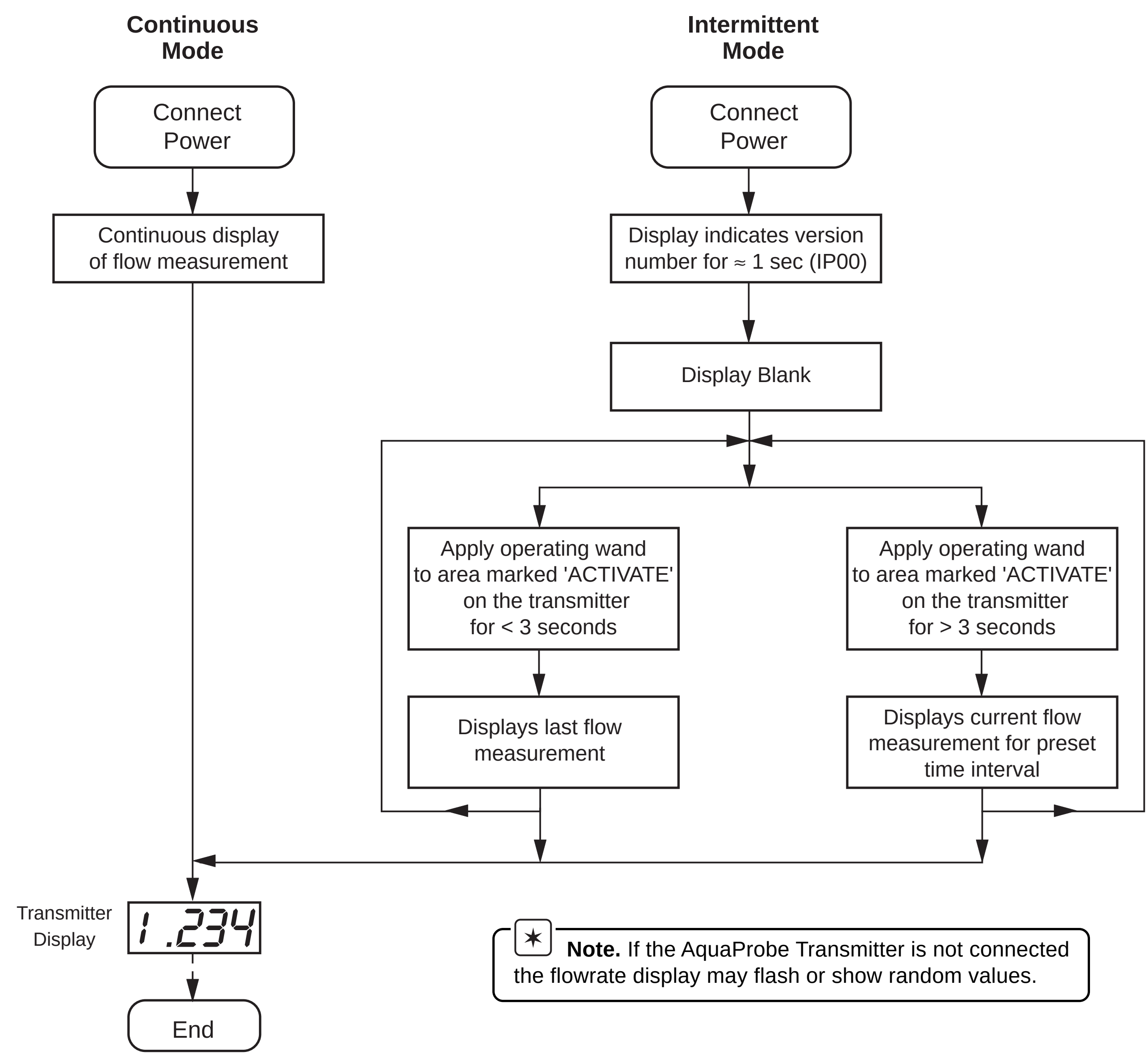
Ensure connections have been made correctly, connect power and follow the sequence of operation detailed in Fig. 6.1. To change between continuous and intermittent mode refer to the AquaProbe Transmitter Configuration Manual.

6.2 Battery Pack Replacement

The totaliser display is maintained for approximately one minute after removal of power to enable the battery pack to be changed. The count is typically stored for a further 2 to 3 minutes after which time a random totaliser value is displayed on restoration of power.

The battery pack must be replaced annually on systems using the 15 minute measurement interval in intermittent mode and proportionally more often for other measurement intervals.

Caution. Ensure that the battery connector locking ring is not cross-threaded and tighten connector firmly by hand.



Note. If the AquaProbe Transmitter is not connected the flowrate display may flash or show random values.

Fig. 6.1 AquaProbe Operation

7 FAULT FINDING

Refer to Fig. 7.1 for fault diagnosis procedure. If a fault is found which cannot be resolved using the procedure detailed in Fig. 7.1, return the AquaProbe Transmitter to The Company.

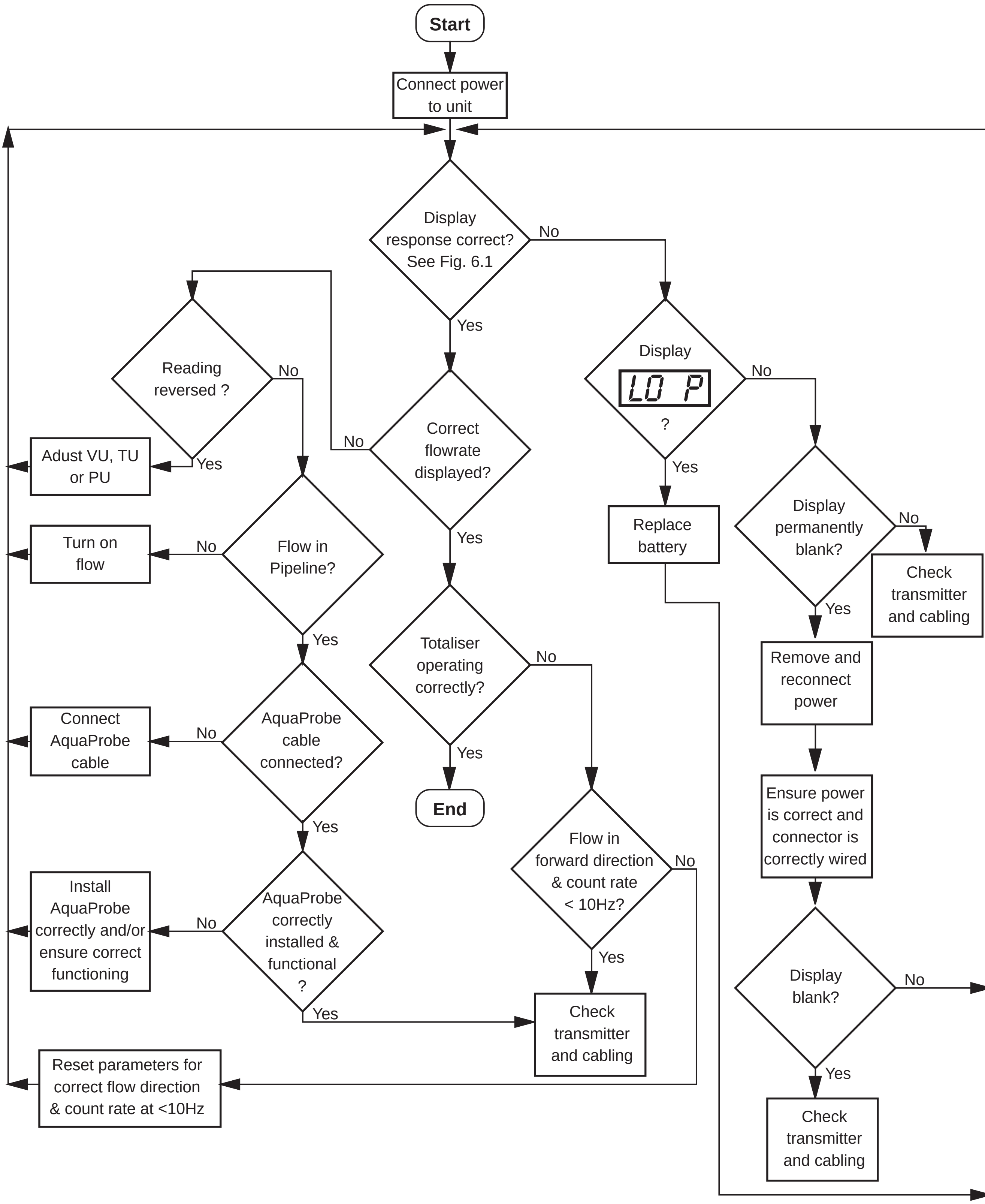


Fig. 7.1 Fault Diagnosis

8 SPARES

8.1 Accessories – Fig. 8.1

A	Communications adaptor (to connect to Psion Organiser etc.)	WEBC 0004
B	Serial Data Lead (to connect PC to 'A' above)	WEBC 0003
C	Output Cable Assembly (14 core plus screen)	MVBX 99147
D	Power Supply Lead	STT 3162
E	Battery Pack	STT 3201
F	Display Operating Wand	MEBX9902

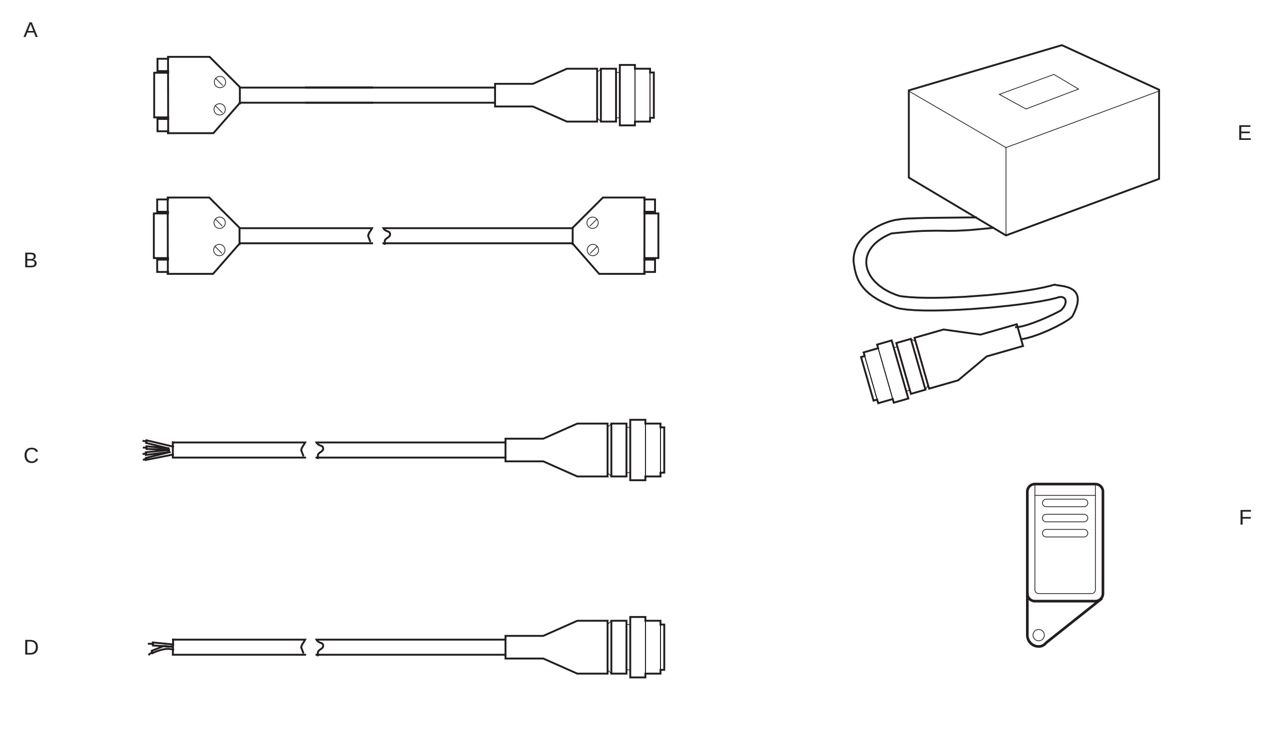


Fig. 8.1 Accessories

8.2 Replacement Parts – Fig. 8.2

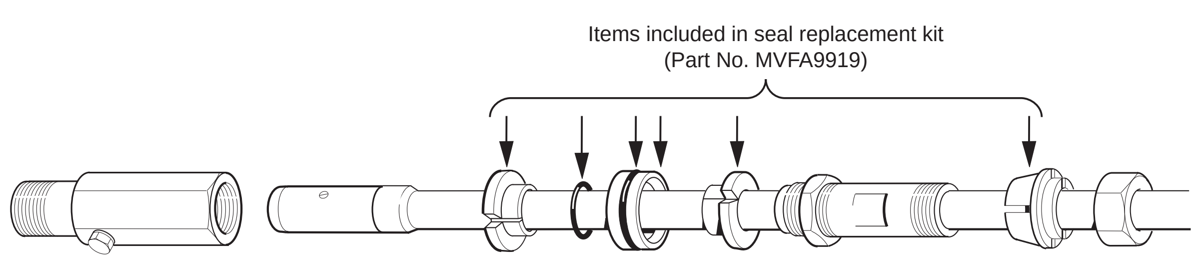


Fig. 8.2 Replacement Parts

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 ⅛ and ⅞ 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 ⅛ 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 ⅞ 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 ⅛ the pipe diameter through the original mounting boss.

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 ⅛ 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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