AUTOFLAME®
Combustion Management Systems

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گروه مهندسی فیاماک
نماینده انحصاری شرکت اتوفلیم
در ایران

AUTOFLAME
LEVEL SENSING CONTROL
GUIDE

Fiammac

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1. Ways of Level Sensing

1.1 Overview

Water level control requires a minimum of two water level sensing devices, one of which must be an analogue device (capacitance probe or external level sensing device).

The MM will show the capacitance probe reading(s), the external level sensor reading, and a combined reading of the optioned analogue sensing devices, as well as the 2nd low probe and auxiliary alarm inputs status.

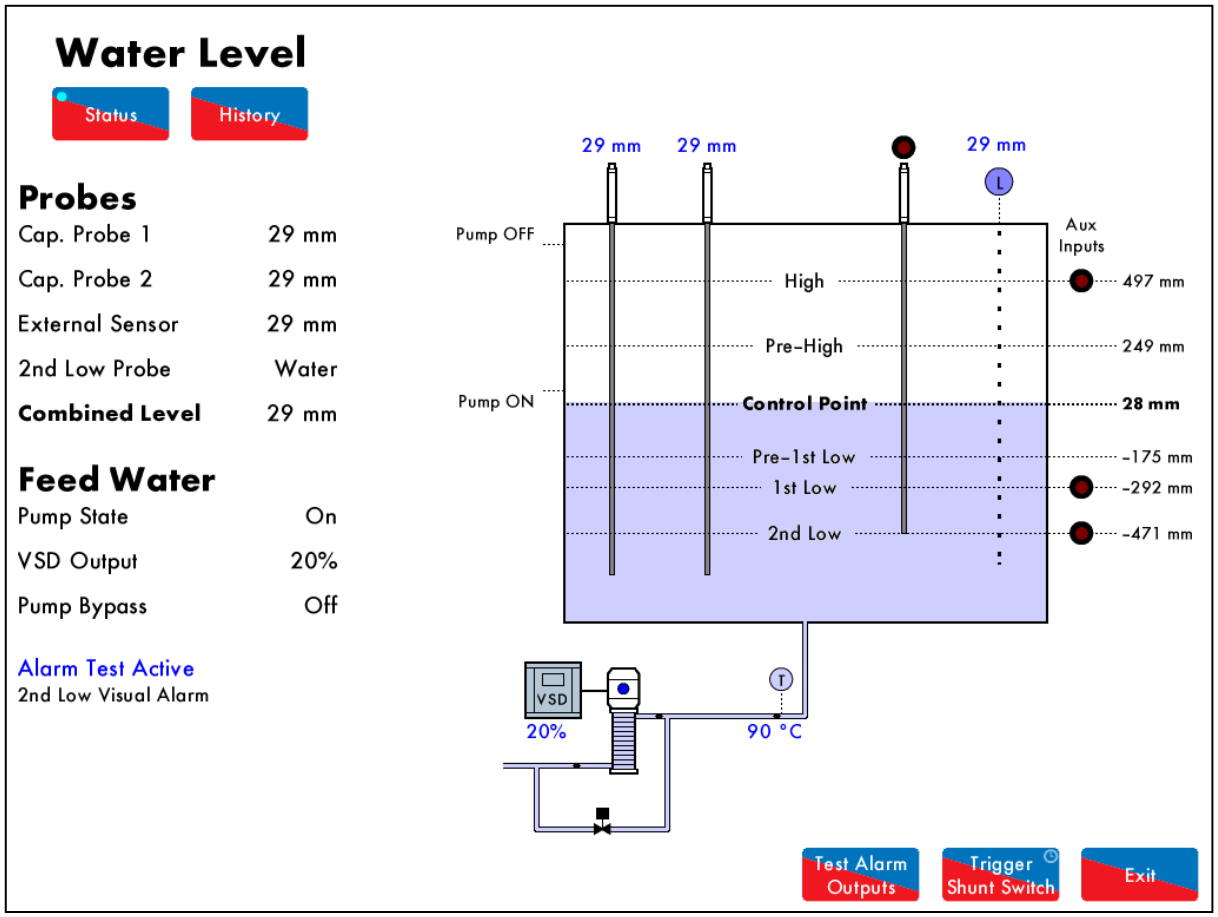


Figure 1.1.i Water Level Status – Combined Level Sensing

1.2 Configuration

The following tables show the expansion options which need to be set on the Mk8 MM for the different ways of water level detection.

Expansion Option	Description	Setting
1. One capacitance probe, external level sensor		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

2. One capacitance probe, external level sensor, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

3. One capacitance probe, external level sensor, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

4. One capacitance probe, external level sensor, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

5. One capacitance probe, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

6. One capacitance probe, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

7. One capacitance probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

8. Two capacitance probes		
1	Water level control function	1
3	Capacitance probes	2
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

9. Two capacitance probes, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

10. Two capacitance probes, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	2
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

11. Two capacitance probes, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

12. Two capacitance probes, external level sensor		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

13. Two capacitance probes, external level sensor, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

14. Two capacitance probes, external level sensor, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

15. Two capacitance probes, external level sensor, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

16. External level sensor, auxiliary alarm inputs		
1	Water level control function	1
4	External level sensor	1
5	Auxiliary alarm inputs	1
30	External level sensor scaling	As required
31	External level sensor filter time	As required

17. Auxiliary alarm inputs, 2nd low probe		
1	Water level control function	1
5	Auxiliary alarm inputs	1
6	Second low probe	1

18. External level sensor, 2nd low probe		
1	Water level control function	1
4	External level sensor	1
30	External level sensor scaling	As required
31	External level sensor filter time	As required

1.3 Capacitance Probes

1.3.1 Overview

The Autoflame capacitance probes can be used in conjunction with the Mk8 MM to detect the water level in the boiler. The system safety is guaranteed as the level measurement is managed by two identical capacitance probes both of which measure and control to the level switching points entered at the time of commissioning.

The capacitance probes are designed to work with steam boilers where the chemical treatment is maintained to the limits stated within these standards and guidelines. When the chemical treatment is maintained to levels under the maximum limits as stated in the standard's tables, the water level probes will work as expected.

When using two capacitance probes, the water level is read to a resolution of less than 1mm in still water. This resolution is maintained during normal operation by Autoflame's patented "wave signature and turbulence management" software. The patented movement detection of water feature ensures that no static value can be accepted, i.e. the probes are in turbulent water. The swell management feature prevents intermittent shutdowns from the 1st low being switching due to increases in steam requirements. The Mk8 MM knows the firing rate and boiler pressure and accommodates for this transient condition by increasingthe 'control point' level.

The capacitance probes are high integrity self-checked and continuously monitored by the Autoflame MM control system.

Figure 1.3.1.i Capacitance Probe

Movement Detection of Water

When the burner is running it is expected that a wave turbulence signature of in excess of 20Hz / 1mm will always be present (due to vibration of thermal energy). Both probes are checked for this value. This feature ensures that either probe cannot read a still water condition when the burner is running. This safety check ensures no static or stuck value can be accepted, thereby checking that the probes are in water.

Swell Management

When there is a sudden drop in boiler pressure an increase in water level will be observed. This is due to the expansion of the steam bubbles in the water causing the water level to increase. It follows that the water feed would then turn off or go to a low flow condition. The Autoflame system identifies this ambiguous condition by monitoring the sudden increase in burner firing rate to meet the load demand and increases the "required water level" by up to 50% of the distance between normal "required level" and "high water level". When normal conditions are reinstated and the boiler firing rate stabilises, the "required level" returns to the normal setting. This stops spurious shutdowns due to 1st low being switched during these transient conditions. The Autoflame system knows what the firing rate and boiler pressure is at any one time and uses this information to identify the above condition. This feature is one of the main elements in the patent claim.

1.3.2 Operation

Capacitance is a measurement of how much a body can store electrical charge. The capacitance ismeasured between the surface area of the probe and the surface area of the boiler shell. As the water level changes the surface area of the boiler shell covered will change, so a change in the capacitance will be detected. The measured capacitance will increase as the water level in the boiler rises, as the surface area covered with water will be bigger with more water in the boiler.

The capacitance readings are constantly checked between both probes, the commissioned value and an internal hardware reference capacitor (to account for long term drift and temperature variations). Both probes control typically “high level”, “required level”, “first low” and “second low”. The actual water level readings taken from both probes are constantly compared and checked against each other, as well the commissioned water levels. When controlling the required level this data stream is combined with a PI algorithm which controls either the two-port feed water control valve or the variable speed drive to the feed water pump. Eachprobe is self-checked for electrical and mechanical integrity by hardware references and self-checking software routines. Each probe and its control electronics are compensated for ambient temperature variations and component drift, guaranteeing absolute safety of operation.

By our method the probes control the required level by learning the wave signature and managing the turbulence within the boiler shell. This “wave signature management” takes into account the changes in burner firing rate and any variance in pressure in the boiler shell. Incorporated within the system hardware are all necessary electronic switching functions to control audible alarms, mute/reset and indication lights required to meet standard North American and European codes. Safety, accuracy and integrity are guaranteed.

1.3.3 Specification

Part No.	Length (Metric)	Length (Imperial)
WLCP500	500mm	20”
WLCP750	750mm	30”
WLCP1000	1000mm	40”
WLCP1250	1250mm	50”
WLCP1500	1500mm	60”

Custom length capacitance probes available upon request.

Specifications	Metric	Imperial
Supplied flying lead	2m	6ft
Probe connection– quick connect	½” NPT Tapered Tread	
Ingress Protection	IP 68	NEMA 6P
Temperature rating of housing	0 - 70°C	32 - 158°F
Nominal Size of Line	15mm	½”
Maximum Allowable Pressure	16 Bar	232 PSI
Maximum Allowable Temperature	200°C	392°F
Test Pressure	40 Bar	870 PSI
Material	Stainless Steel	
Coating	PTFE coated	

Note: The probes must not be cut. If the probes are cut this will act as a short between the positive and negative plates of the capacitor and will stop the probes from working.

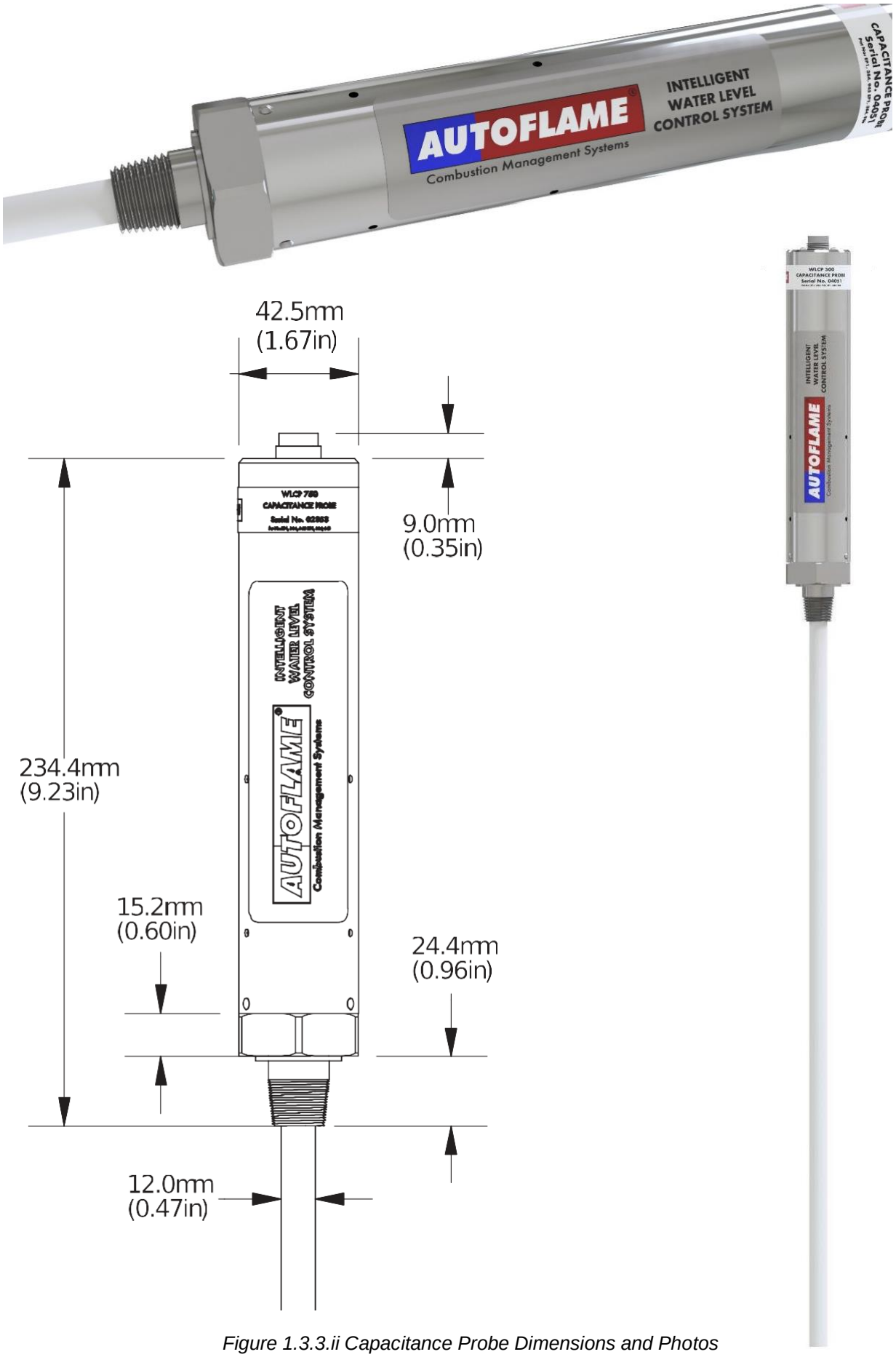


Figure 1.3.3.ii Capacitance Probe Dimensions and Photos

1.3.4 Installation Safety Guidelines

The notes and mechanical executions implicit in the following diagrams for capacitance probe installation are to be used for guidance purposes only. Local, state and national codes must be adhered to in all cases. It is important to use only qualified and experience installation personnel who have been factory trained.

Under all boiler operation codes that Autoflame is aware of, it is not permitted to install only two capacitance probes without an additional water level detection device. When the capacitance probes are installed on a boiler application in this way, the boiler must be protected using a separate auxiliary low water cut-off device.

For fire tube steam boilers, a sight gauge glass must be installed to visually indicate the level of the water in the boiler. The water in the sight gauge glass is considerably colder than the water in the boiler and does not contain bubbles or current effects.

Installation diagrams:

Figure 1.3.4.A: Capacitance Probe – Externally Mounted Pots

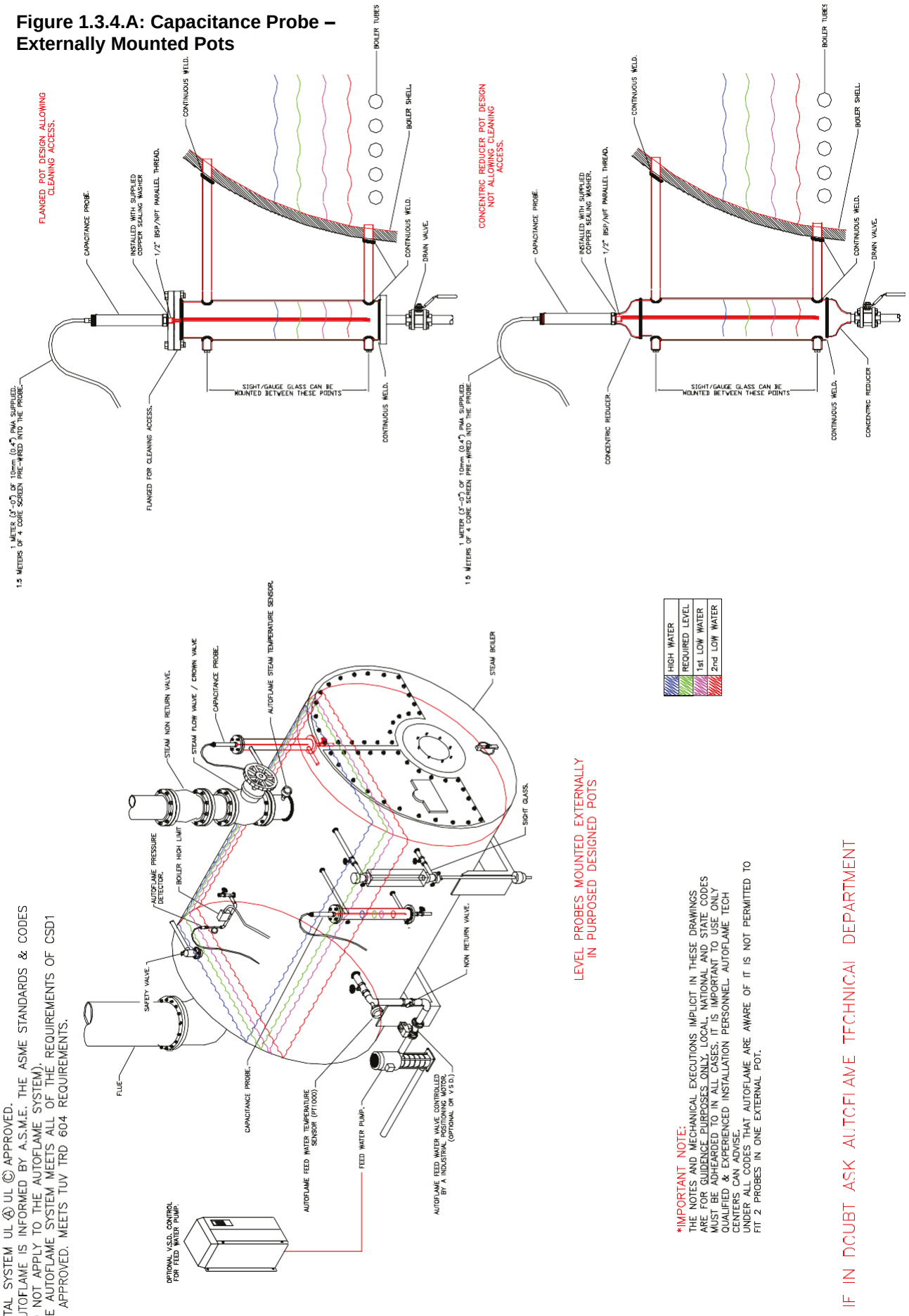


Figure 1.3.4.B: Capacitance Probe – Internally Mounted Pots

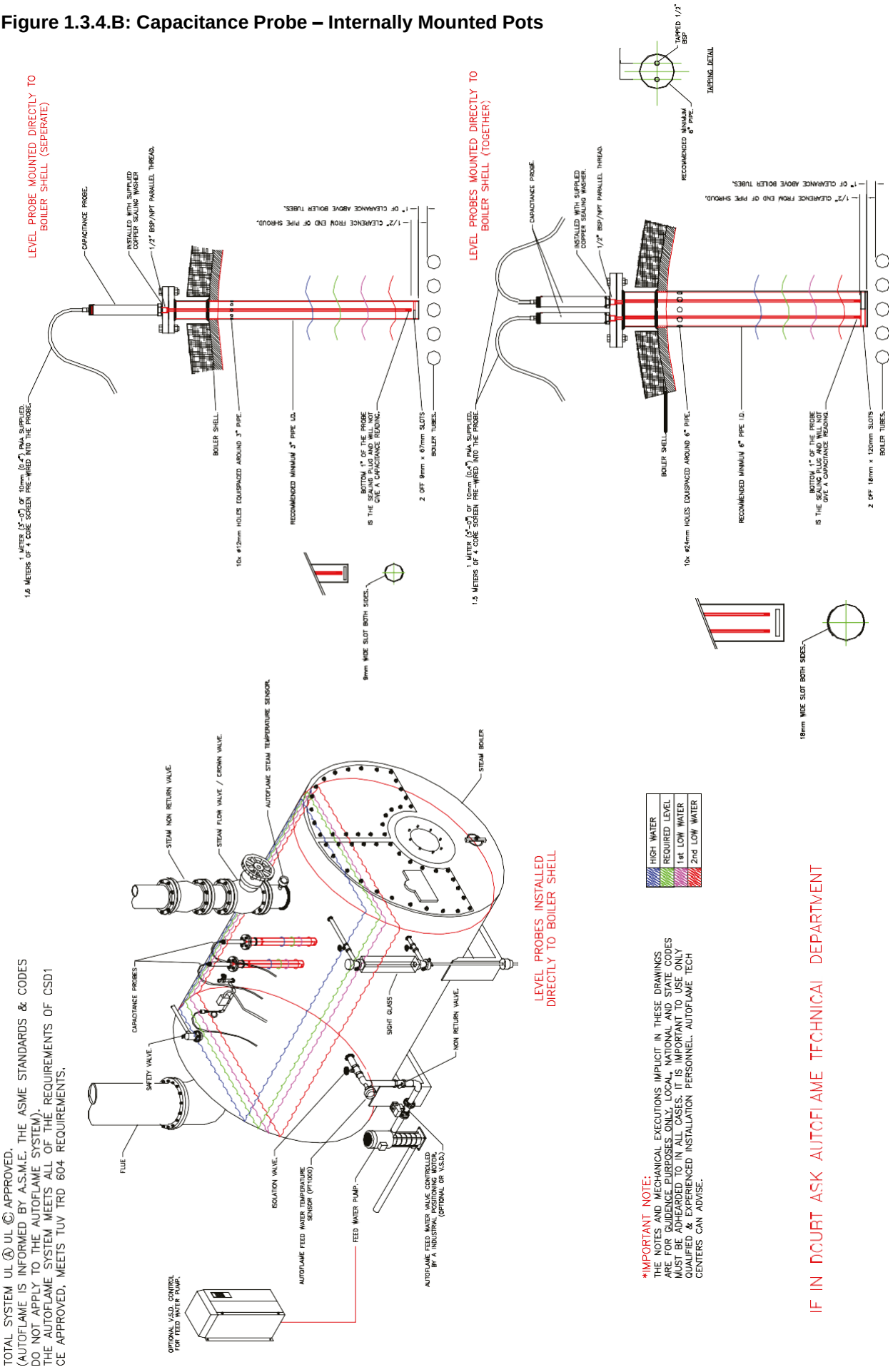


Figure 1.3.4.C: Capacitance Probe –Installation for a Water Tube Boiler

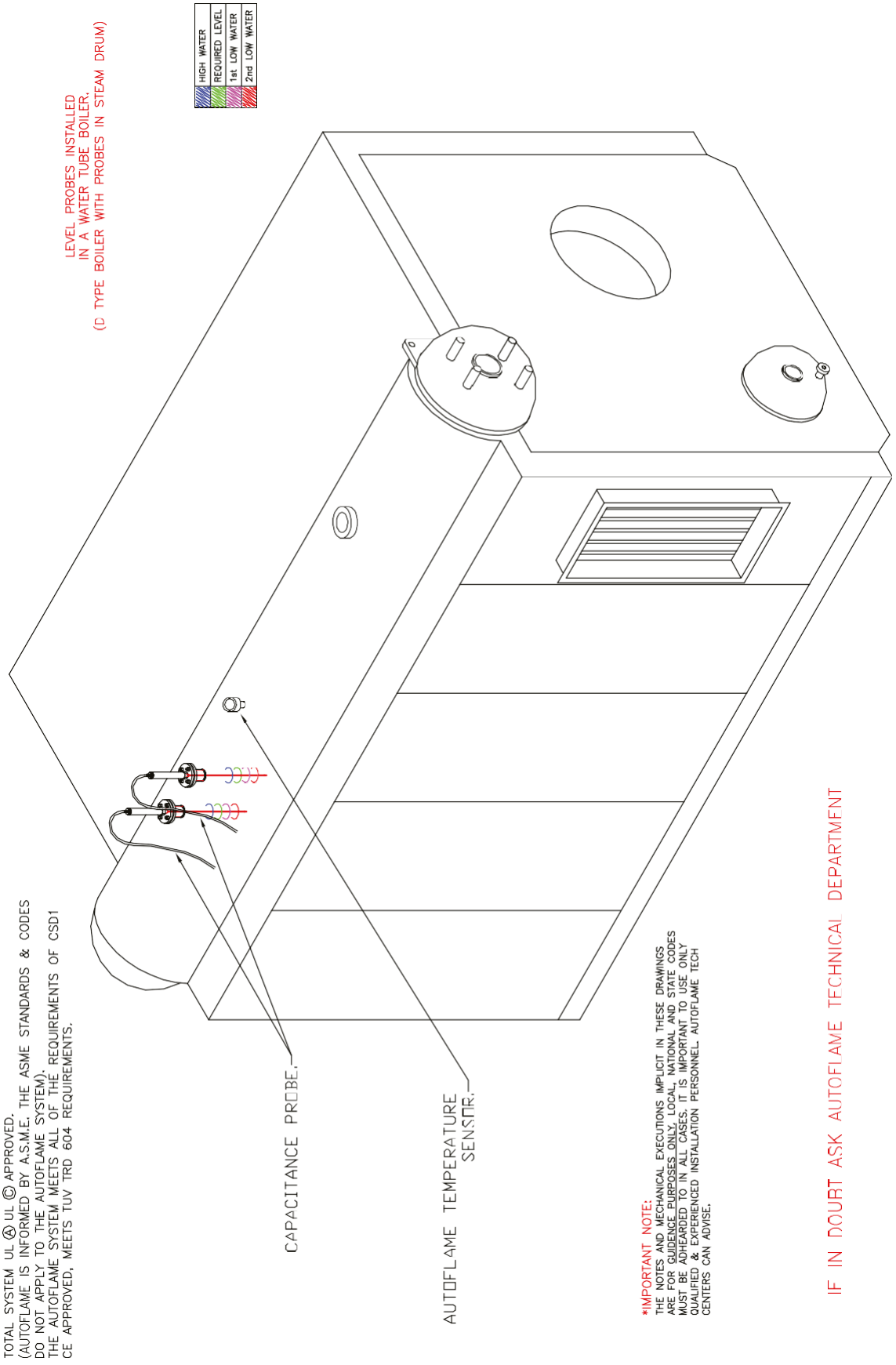
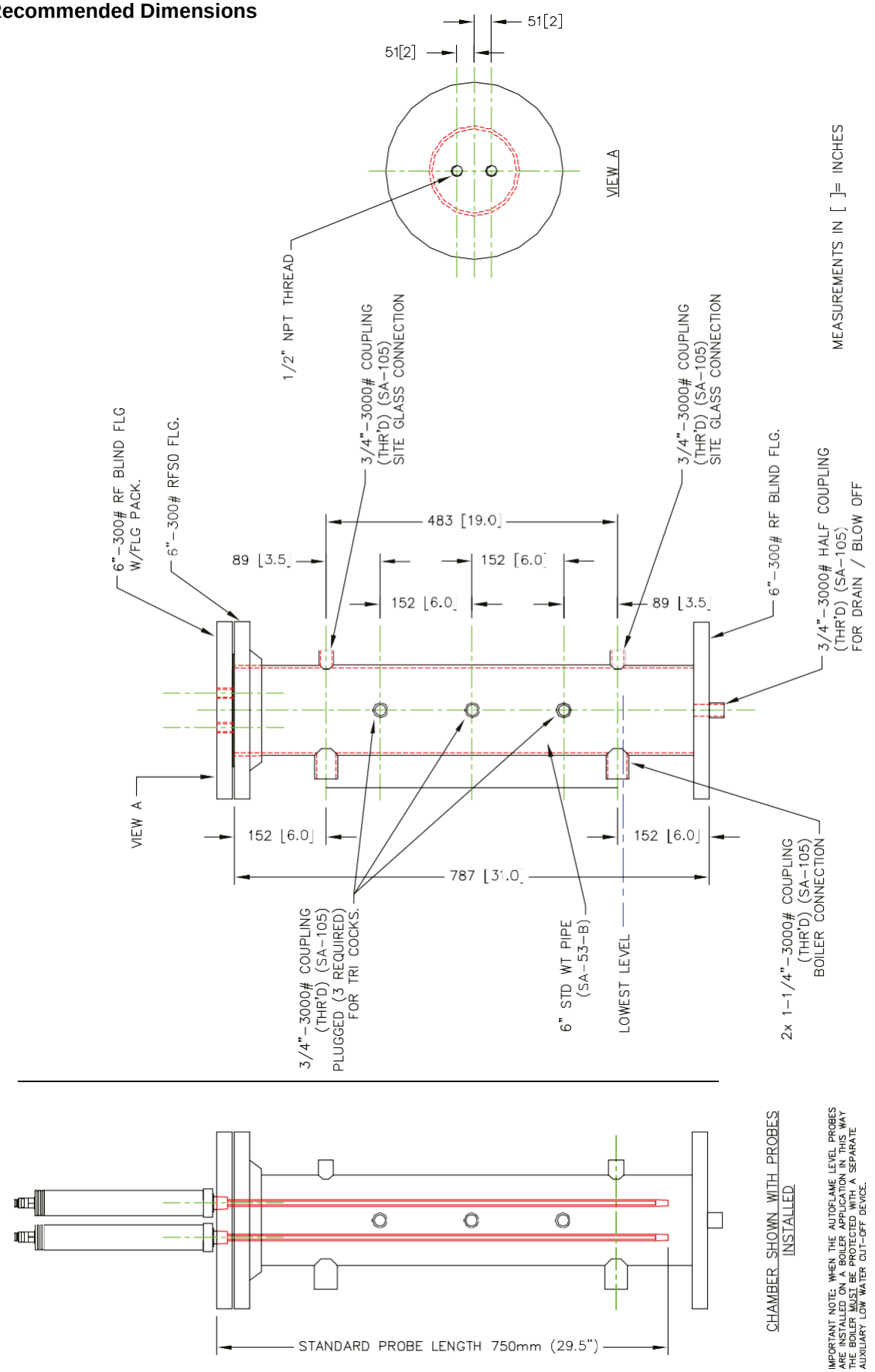


Figure 1.3.4.D: External Probe Chamber – Recommended Dimensions



1.3.5 Configuration

The table below shows the terminals allocated on the MM for the capacitance probes.

Terminal	Description
1P+	+9V supply to capacitance probe 1
1P-	0V supply to capacitance probe 1
1T+	Digital communications connections from capacitance probe 1
1T-	Digital communications connections from capacitance probe 1
2P+	+9V supply to capacitance probe 2
2P-	0V supply to capacitance probe 2
2T+	Digital communications connections from capacitance probe 2
2T-	Digital communications connections from capacitance probe 2

When wiring the capacitance probes, the screen is connected through the casing of the lead and through the probe; therefore, the flying lead should be connected to the MM without a screen. The screen should be carried through until the connection to the MM; the screen should not be connected to the S terminal.

The table below shows the expansion options to be set when using capacitance probes with the MM for water level detection.

Expansion Option	Description	Setting
1	Water level control function	1
3	Capacitance probes	1 or 2
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

1.3.6 Capacitance Probes Maintenance

When carrying out a boiler service, the capacitance probes must be cleaned and checked for correct and safe operation. Use nonabrasive cleaning method and a PTFE surface cleaning detergent to clean the probe. Care must be taken to ensure that the PTFE coating on the surface of the probes is not damaged. After cleaning the probes, the water levels commissioned for those probes must be checked.

If the probes are mounted directly into the boiler shell it is important to lag the flanges in order to avoid overheating of the electronics. It is recommended that the probes are not installed too close to the steam off-take and safety valve connection, but also not too close to the boiler end plates. If possible, they should be installed near the sight gauge glass.

1.4 2nd Low Probe

1.4.1 Overview

The 2nd low probe is a conductivity probe, and its purpose is to act as an additional 2nd low water cut-offwhen the water falls too low in the boiler. The conductive technology with safe electronic control has been granted a worldwide patent for its continuous electrical and mechanical self-checking software.

If the water level in the boiler falls below the end of the probe, then a 2nd low water level alarm will occur.The water level may be low due to insufficient water in the feed water tank, feed water pump failure, feed water line isolated and/or the level controls have failed. If there is not enough water in the boiler, the heated tubes will be left exposed and unable to cool down as there is no longer water to transfer the heat to. If the burner were to continue firing, the temperature of the tubes would be rapidly increase, reducing the metal strength, and could cause a collapse or explosion. On the MM system the 2nd low water level alarm will shut down the burner.

1.4.2 Operation

The water level detection probes use capacitance technology, whereas the 2nd low safety probe uses conductive technology. Following basic electric circuit theory, when the probe is in the water in the boiler and an electrical voltage is applied, the current will flow; when water level drops below the probe, no current will flow. This is the basic principle of the 2nd low safety probe, if the water levels drop below the cut-length of the probe, then a 2nd low water alarm will occur on the MM or for standalone mode, the volt-free connection will open to indicate this alarm. When used with an MM, the 2nd low water alarm requires a manual reset.

1.4.3 Specifications

Specifications	Metric	Imperial
Part number	SLP70001	
Compatible with	Mk8 MM and Mk7 MM	
Standalone usage	Yes	
Internal relay	Self-checking	
Technology	Conductivity	
Material	Stainless Steel	
Coating	PTFE coated	
Integration with external safety devices and circuits	Volt free contacts	
Thread type	NPT	
Standard probe length*	750mm	30”
Supplied flying lead	2m	6ft
Probe connection– quick connect	½” NPT Tapered Tread	
Ingress Protection	IP 68	NEMA 6P
Temperature rating of housing	0 - 70°C	32 - 158°F
Nominal Size of Line	15mm	½”
Maximum Allowable Pressure	16 Bar	232 PSI
Maximum Allowable Temperature	200°C	392°F
Test Pressure	40 Bar	580 PSI

*The 2nd low probe can be cut to length to suit application

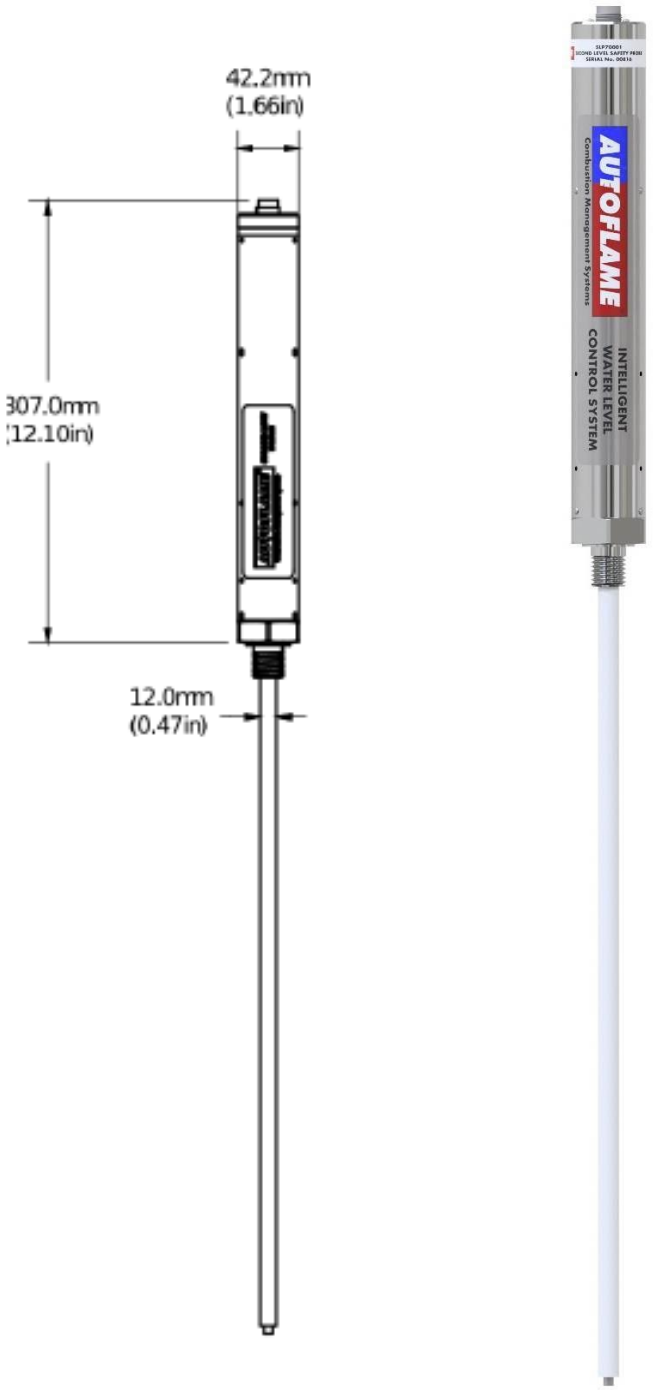
2nd Low Probe Flying Lead

The 2nd low probe is supplied with a 2m (6ft) flying lead, which has quick-connect multi-pin end.
The cable shield is connected to the probe body.

Description	Wire	MM Terminal
Optional ground connection (not used)	Black	
0V Power (DC or AC)	Blue	4P-
12V Power (DC or AC)	Red	4P+
RS485 Comms -	Yellow	5T-
RS485 Comms +	Green	5T+
Volt-free connection 1 (250mA max)	Brown	
Volt-free connection 2 (250mA max)	Purple	

If using the 2nd low probe for standalone operation, then the volt-free connections must be used; the volt-free connection will be closed when water is detected and there is no system fault.

Dimensions



1.4.4 Installation and Safety Guidelines

The 2nd low probe's length must be equivalent to the 2nd low water level in the boiler as recommended by the boiler's manufacturer; this length should match the commissioned 2nd low level of the capacitance probes or external level sensing device.

The 2nd low probe can be cut to the required length using pression cutting equipment. If this is not available, please order the exact probe length from Autoflame.

The 2nd low probe should not be installed in the same pot as the capacitance water level probes. Any blockages in the line will affect the levels; therefore the 2nd low probe should be fitted in a pot with a separate line to the water level probes line. If the water level probes are installed in a pot externally mounted to the boiler as shown in section 3.5.4, the 2nd low probe can either be fitted in a separate pot, or internallymounted pot directly into the boiler. If the water level probes are installed in internally mounted pots asshown in section 3.5.4, the 2nd low probe can also be installed in an internally mounted pot directly into the boiler.

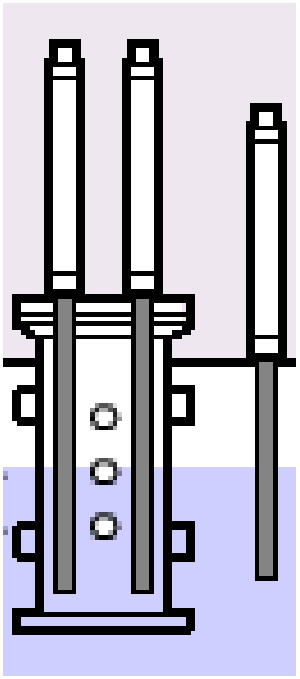


Figure 1.4.4.i Capacitance Probes and 2nd Low Probe displayed on the main Mk8 MM screen

1.4.5 Configuration

The table below shows the Mk8 MM terminals allocated for the 2nd low safety probe.

Terminal	Description
5T+	Digital communication connections from 2nd low resistance probe
5T-	Digital communication connections from 2nd low resistance probe
4P+	+12V supply to 2nd low resistance probe
4P-	0V supply to 2nd low resistance probe

The screen is connected through the casing of the flying lead supplied with the 2nd low safety probe. When connecting the flying lead to the MM, do not wire the screen at the MM.

The table below shows the expansion options to be set when using the 2nd low probe with the MM.

Expansion Option	Description	Setting
1	Water level control function	1
6	Second Low Probe	1

Note: 2nd low probe can only be used in conjunction with an analogue sensing device such as twocapacitance probes or one capacitance and an external level sensor at minimum; please see section 3.3 Ways of Level Sensing for more information.

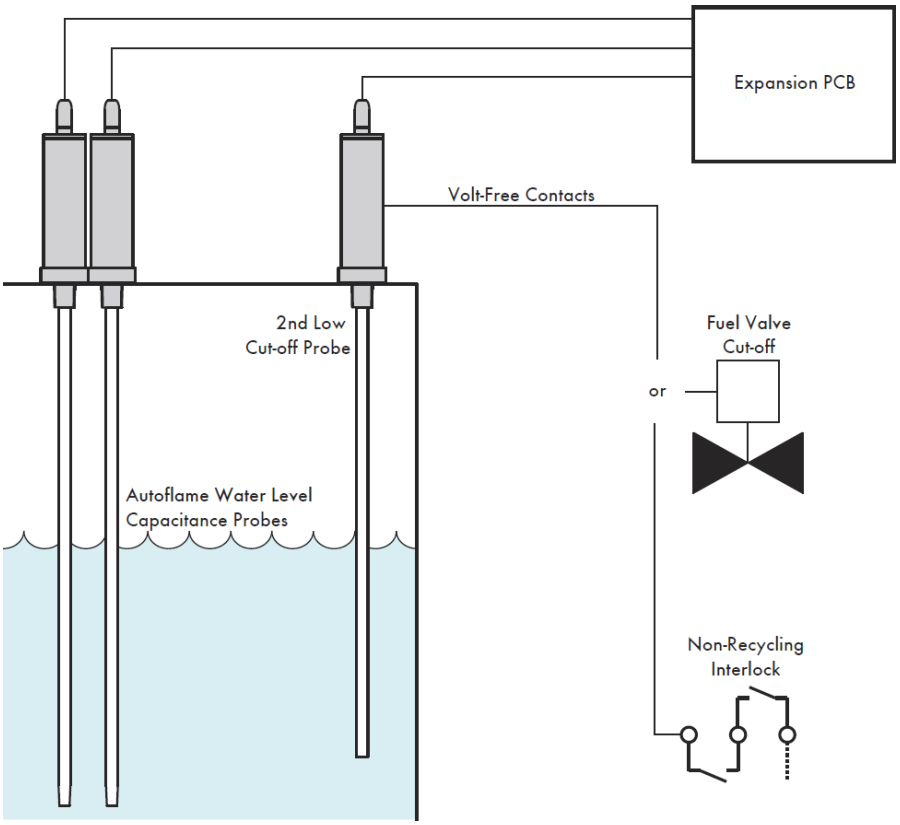


Figure 1.4.5.i 2nd Low Probe Installation Example

To install the 2nd low probe, no commissioning is required; just simply option the probe in expansion option 6. The bottom of the 2nd low probe should be at the capacitance probes/external level sensor commissioned 2nd low level or higher.

1.5 Analogue Water Level

An external level sensor (4-20mA input) can be used for water level detection on the Mk8 MM. This sensor will give an analogue signal to the MM to indicate level across a 4-20mA input range. The water levels commissioned for the external level sensor are the same for the capacitance probes which are HIGH, CONTROL POINT, 1st LOW, 2nd LOW and END OF PROBE.

The table below shows the terminals allocated on the MM for an external level sensor.

Terminal	Description
EX-	Common for terminal EX+
EX+	Current input, 4-20mA for external water level probe (or fuel flow feedback)

The table below shows the expansion options to be set to for using external level sensor on the MM.

Expansion Option	Description	Setting
1	Water level control function	1
4	External level sensor	1
30	External level sensor scaling	As required
31	External level sensor filter time	As required

Note: An additional water level safety device such as 2nd low probe or an auxiliary alarm input is required as minimum with the analogue water level detection device

Note: The external level sensor cannot be used with 4-20mA input for the fuel flow feedback, see option 57.

1.6 Auxiliary Alarm Inputs

For additional safety, it is possible to retain the site's existing float type level controls by using auxiliary alarm inputs. The schematic below shows an example of how to wire such alarm inputs.

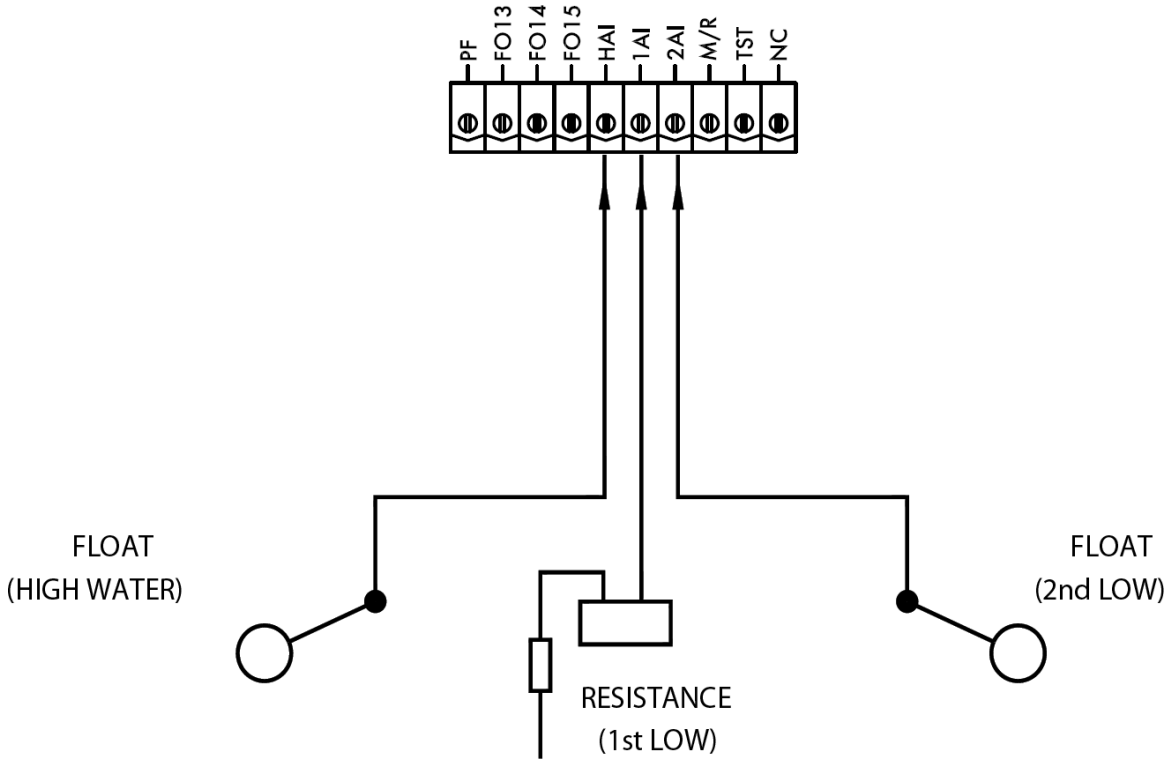


Figure 1.6.i Wiring Auxiliary Alarm Inputs

Note: If any of the three alarms are not being used when an auxiliary alarm inputs have been enabled, a line voltage input should be connected to the corresponding terminals to stop a fault occurring.

The table below shows the expansion options to be set on the MM for the auxiliary alarm inputs.

Expansion Option	Description	Setting
1	Water level control function	1
5	Auxiliary alarm inputs	1

Note: Auxiliary alarm inputs can only be used in conjunction with an analogue sensing device such as two capacitance probes or one capacitance and an external level sensor at minimum. please see section 3.4 for Ways of Level Sensing for more information.

1.7 Related Item Part Numbers

Item No.	Mk8 MM Unlockable Software Features	Kgs	Part No
1	Autoflame Water Level		MK8001
2	Analogue Water Level (requires Autoflame Water Level)		MK8002
	Steam Boiler Capacitance Probes		
3	Capacitance Probe 20" (500mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	WLCP500
4	Capacitance Probe 30" (750mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	WLCP750
5	Capacitance Probe 40" (1000mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	WLCP1000
6	Capacitance Probe 50" (1250mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	WLCP1250
7	Capacitance Probe 60" (1500mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	WLCP1500
	Additional capacitance probe lengths are available upon request. Please contact Autoflame for price and availability.		
	2nd Low Probe		
8	2nd Level Probe (750mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	SLP70001
9	2nd Level Probe (1000mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	SLP70001/1000
10	2nd Level Probe (1500mm) *Supplied with 2m (6ft) Plug-in Lead*	1.50	SLP70001/1500
	Water Level Spares		
11	Water Level Probes Flying Leads *Replacement Flying Leads for Water Level Probes, Length 2m (6ft)*	0.05	AUTO/0005
12	Water Level Probes Flying Leads *Replacement Flying Leads for Water Level Probes, Length 10m (32ft)*	0.05	AUTO/0005/10

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