

Mobrey™ Ultrasonic Liquid Level Detection Systems for Interface Applications

User Manual



Control unit types:
MCU201 and MCU203

Ultrasonic gap sensor types:
433SD, 402SD, and 442SD

General safety precautions

The equipment described in this manual has been designed in accordance with EN61010 “Safety requirements for electrical equipment for measurement, control and laboratory use”, and has been supplied in a safe condition.

To avoid injury to an operator or service technician, the safety precautions given below, and throughout the manual, must be strictly followed whenever the equipment is operated, serviced or repaired.

For specific safety details, please refer to the relevant sections within the manual. The equipment is designed solely for electronic measurement and should be used for no other purpose. Delta Mobrey accepts no responsibility for accidents or damage resulting from failure to comply with these precautions.

Grounding

To minimise the hazard of electrical shock, it is essential that the equipment be connected to a protective ground whenever the power supply, measurement or control circuits are connected, even if the equipment is switched off. The electronics unit must be connected to ground using the marked case stud before control or signal leads are connected. The ground connections must have a current rating of 25 A.

AC supply

Never operate the equipment from a line voltage or frequency in excess of that specified. Otherwise, the insulation of internal components may break down and cause excessive leakage currents. To allow the electronics unit to be isolated from the ac supply, the supply must be routed through a switch (or circuit breaker). The switch (or circuit breaker) must be within easy reach of the operator and must be clearly identified as the means of supply isolation. The maximum current drawn from the supply must be limited by a fuse or trip, to a maximum of 13 A.

Fuses

Before switching on the equipment, check that the fuses accessible from the interior of the equipment are of the correct rating. The rating of the ac line fuse must be in accordance with the voltage of the ac supply. If any fuse continually blows, do not insert a fuse of a higher rating. Switch the equipment off, clearly label it “unserviceable” and inform a service technician.

Explosive atmospheres

Never operate the equipment, or any sensors connected to the equipment, in a potentially explosive atmosphere. It is not intrinsically safe and could possibly cause an explosion.

Safety symbols

For the guidance and protection of the user, the following safety symbols appear on the equipment:

Symbol:

Meaning:



Fault indicator. Refer to the user manual for detailed instructions of use.



Hazardous voltages

Avoid unsafe equipment

The equipment may be unsafe if any of the following statements apply:

- Equipment shows visible damage
- Equipment has failed to perform an intended operation
- Equipment has been subjected to prolonged storage under unfavourable conditions
- Equipment has been subjected to severe physical stress.

Live conductors

Do not open the electronics unit when it is energised.

When the equipment is connected to its' supply, the opening of covers or removal of parts could expose live conductors. The equipment must be disconnected from all power and signal sources before it is opened for any adjustment, replacement, maintenance or repair. Adjustment, maintenance and repairs must be done by qualified personnel.

Equipment modification

To avoid introducing safety hazards, never install non-standard parts in the equipment, or make any unauthorised modification. To maintain safety, always return the equipment to Delta Mobrey for service and repair.

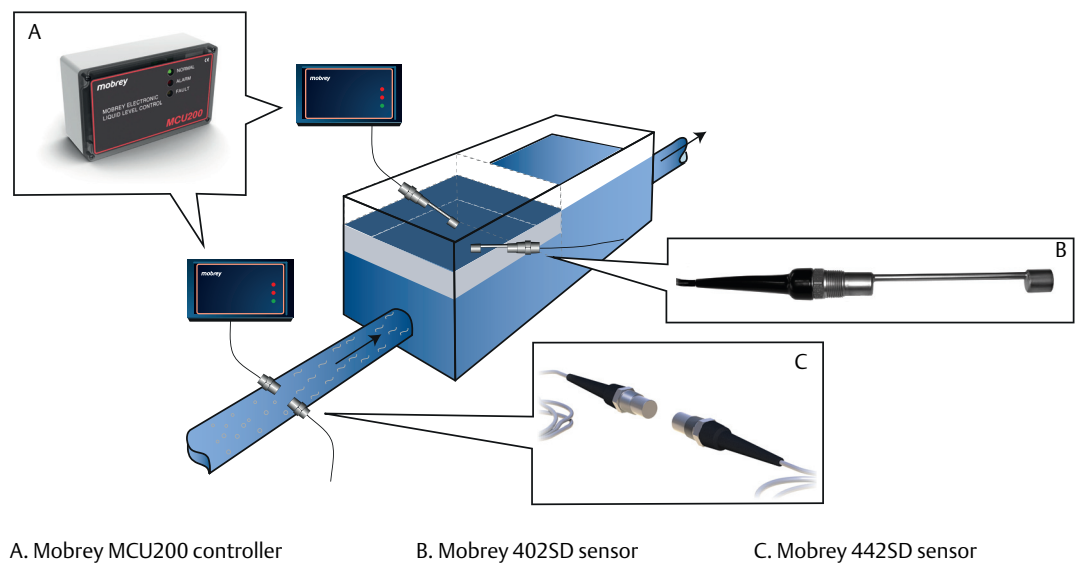
If in any doubt as to the serviceability of the equipment, don't use it. Get it properly checked out by a qualified service technician.

1. Introduction

Delta-Mobrey level control systems for sludge blanket and interface detection applications require a Mobrey MCU200 Series control unit and a Mobrey ultrasonic sensor ([Figure 1](#)).

The start of this manual shows how to install the control unit and supported sensors to form control systems. This is followed by application information for configuration and operation of the control unit. Finally, there is the maintenance, spare parts, and specifications information.

Figure 1. Typical application with Mobrey 442SD and 402SD ultrasonic Gap Sensors



2. Sensor installation

2.1 Safety matters

Review all the safety information at the front of this manual.

2.2 How ultrasonic gap sensors work

Each Mobrey ultrasonic sensor contains two piezoelectric crystals. A high frequency signal (1 MHz or 3.7 MHz) is generated by the control unit and transmitted to one of the piezoelectric crystals by coaxial cable. This crystal converts the electrical signal into an ultrasonic oscillation.

The sensor design allows the ultrasonic oscillation to pass from the transmitter crystal to the receiver piezoelectric crystal ([Figure 2](#)) through a gap. When the gap is in liquid, the signal reaches the receiver due to the low ultrasonic attenuation of the liquid. When the gap is filled with air, no ultrasonic signal can pass from transmitter to receiver.

Figure 2. Sensor in clear water and sludge

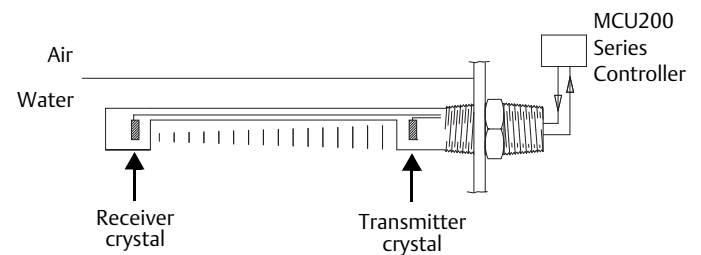
Sensor in sludge

The ultrasonic beam is attenuated and will not reach the receiver crystal.



Sensor in clear water

The ultrasonic beam reaches the receiver crystal with a strong signal.



When the gap is filled with liquid, the piezoelectric receiver crystal converts the ultrasonic wave into an electrical signal, which is transmitted back to the control unit using a second coaxial cable. Usually the two coaxial cables to the sensor are in one overall sheath.

The control unit circuitry is a feedback amplifier, which oscillates when the sensor is wet and is quiescent when the sensor is dry. The “oscillating” and “non-oscillating” sensor states determine the output relay states of the control unit.

For sludge blanket or interface detection the sensor “oscillates” in a clear liquid and is “non-oscillating” in the sludge or at the interface. An amplifier gain adjustment determines the sludge density for the change between these two states. See [“Interface detection” on page 12](#).

2.3 Switching levels and orientation

Mobrey gap sensors are mounted with the sensor faces vertical. This is to avoid a build-up of solids on the sensor faces on either side of the gap. In this orientation, the switching level is half-way up the sensor face. If the sensor is mounted from the side of the tank, the switching level is normally on the centreline of the cylindrical body.

2.4 Installation of the sensor

The sensor must be handled with care - it is a measuring instrument. Before installation, check that sensor, cable and control unit have not been damaged in transit. If necessary, drill and tap a hole with a suitable thread. It is advisable to use a boss or similar on thin walls. The sensor has a tapered thread. Use PTFE tape or similar to seal the thread. Mark the sensor hexagon to identify the gap orientation of the sensor, if appropriate. Take care not to damage the sensor cable during tightening.

The cable should be laid on cable trays and separated from any high voltage or mains cables. The normal cable termination is a plastic gland (to fit the MCU200 control box drilled hole) and crimped terminal pins to suit the MCU200 terminals.

2.5 Extension cables

Extension cables up to 50 metres long can be fitted to most Mobrey ultrasonic sensors in the factory to special order, but a better site arrangement is to have a separate extension cable. When a double coaxial cable needs to be extended, two sets of coaxial plugs and sockets will be needed; one set for transmit, and one receive. Care must be taken that the connectors are not earthed, or shorted together in any way, to prevent cross-talk or pick-up. The coaxial connections must be made in a waterproof junction box. Terminal blocks should not be used. The extension cable needs to be of 50ohm characteristic impedance. Suitable dual coaxial extension cables can be purchased from Delta Mobrey (Part No. K178).

For extensions over 50 metres, it is recommended that two runs of single coaxial low-loss cable is used, with the transmit and return cable runs separated by 0.15 metres to minimise cross-talk. If several sensor cables are being run together then all the transmit cables (those connected to E2) should be grouped together and all receive cables (those connected to 1E) grouped together maintaining the separation specified above.

3. Control unit installation

3.1 Safety matters

Review the safety information provided at the beginning of this user manual.

3.2 Mechanics

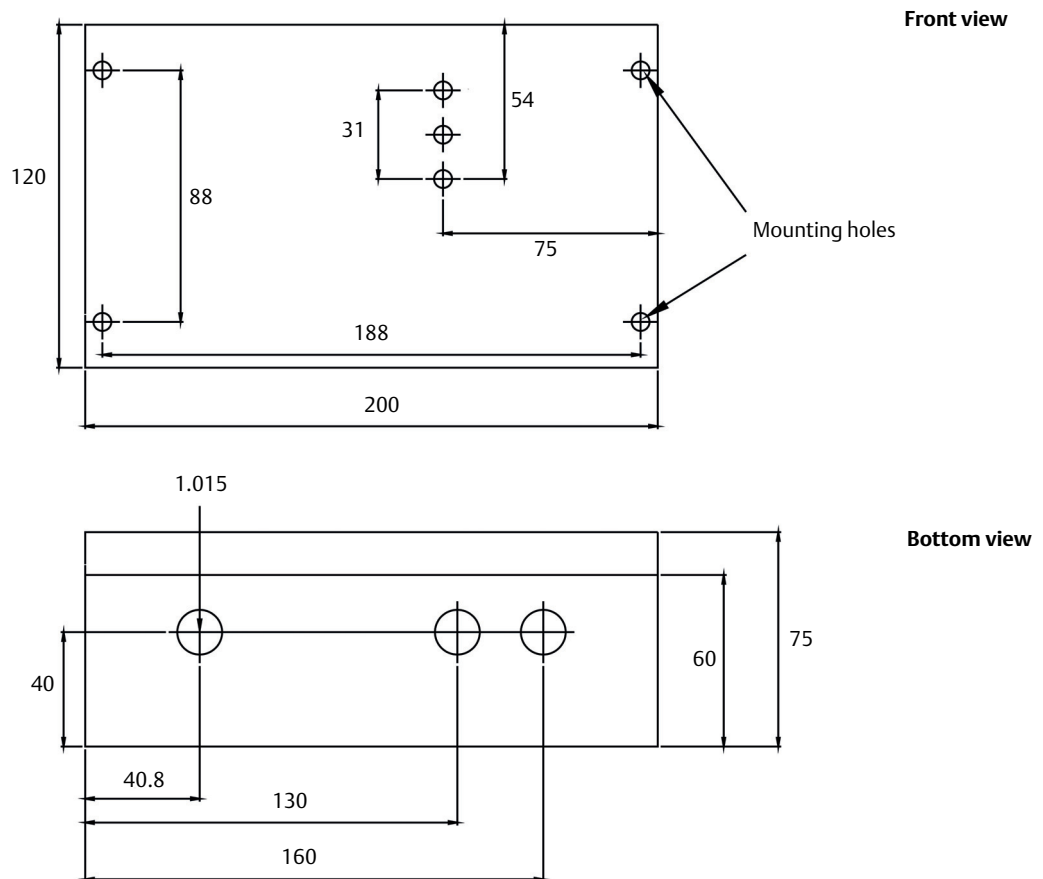
The control unit is supplied with three holes drilled in the bottom (longer) side of the box. Two glands are supplied for the power input cable and relay output cable. The sensor is normally supplied fitted with a suitable gland on the cable. Two further holes can be drilled in the bottom side of the box should these be needed: it is recommended that the circuit board is removed whilst drilling extra gland holes.

Determine suitable mounting location with regards to:

- Surface composition / load bearing capacity
- Cable length restrictions
- Accessibility for servicing

All cable connections are made to the terminal blocks along the bottom edge of the PCB (see fig.5). Release the terminal screw before inserting the wire.

Figure 3. MCU200 housing dimensions



3.3 External connections

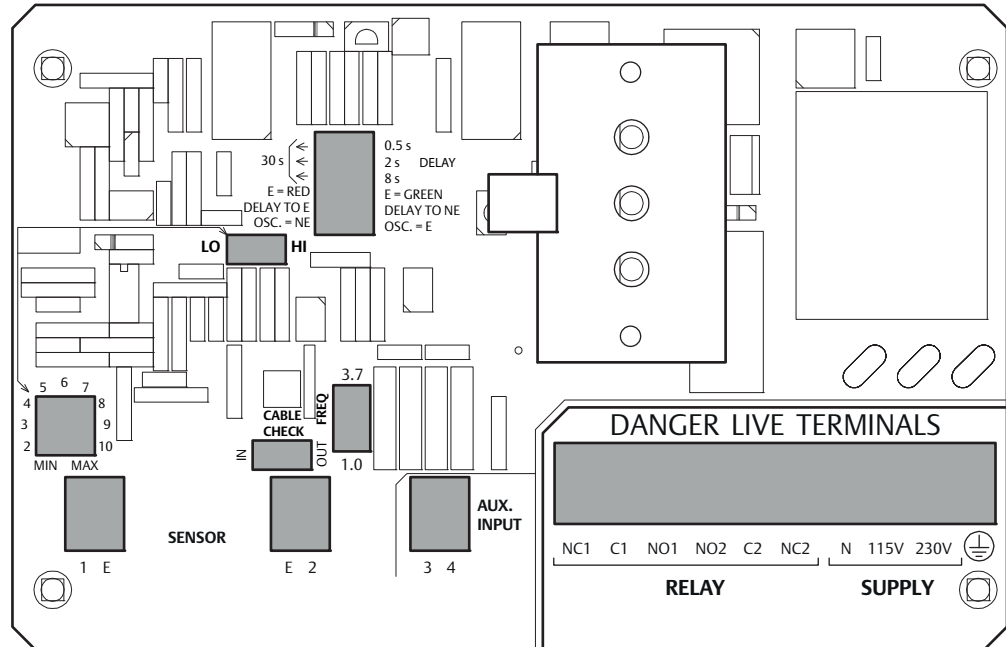
Two cables are required per sensor. The RG178 should be used where the cable itself is subject to temperatures exceeding 74 °C.

Note

Protection for permanently installed equipment:

This equipment is regarded as permanently installed equipment and must be wired up using suitable cable for the current and voltage specified. A suitable switch or circuit breaker must be included in the installation and this should be in close proximity to the equipment and marked as its disconnecting device. A suitable fuse rated at 3 A must be fitted in the supply. Each relay circuit must be protected by a fuse not exceeding the maximum rated current for the relay as specified in the manual. As S/C current on the transformer secondary is in the order of 70 mA and the transformer thermal fuse will not operate for at least 17 minutes (as tested), a smaller value mains fuse (63 mA) should be agreed upon.

Figure 4. PCB for MCU201



Supply connection

The AC mains supply is connected to the “N” terminal for neutral and one of the “115V” or “230V” terminals (depending on the voltage supply available).



The terminal not connected externally will be “live” once the transformer is powered via the other terminals.

PE (Protective Earth) connection

The protective earth must be used in all applications.

DPCO (Double-Pole-Change-Over) relay connections

There are two sets of contacts:

Set 1:	NC1	Normally closed
	C1	Common
	NO1	Normally open
Set 2:	NC2	Normally closed
	C1	Common
	NO2	Normally open



If the relay is connected to hazardous live (mains) circuits:
External circuits (e.g. signal circuits) with accessible parts, or only basic insulation, must not be connected to the relay.

Ultrasonic gap sensor connections

The sensor connections on the PCB are labelled “1”, “E” for the receiver crystal and “E”, “2” for the coax cable to the transmitter crystal. The screens of these coax cables must be connected to the terminals marked “E”.

Auxiliary Input connection

The Auxiliary Input is a terminal which can be connected to a “push- to-reset” button to achieve a latching alarm, or connected to another Mobrey control unit for pump control from the MCU200 relay output.

If a short-circuit is connected between terminals 3 and 4, the MCU200 relay, when de-energised, is held de-energised. Even if the sensor attached to the MCU200 changes state, to that which should energise the output relay, this relay will not energise until the link between terminals 3 and 4 is broken in the circuit external to the MCU200.

3.4 Internal switch settings

Gain switch (and potentiometer)

See “Applications” on page 11.

Frequency selection

This slide-switch is labelled “FREQ” and is located between the sensor terminal block “E 2”, and the “Aux. Input” terminals. This switch selects the operating frequency of the MCU200 oscillator, which is either 3.7 MHz (switch in the ‘up’ position) or 1 MHz, (switch in the ‘down’ position).

The setting required is dependent on the sensor type connected to the control unit. Usually these are:

3.7 MHz sensors
40*S, 43*S, 44*S

Mobrey sludge sensors type 433 and 448 with the suffix M1, built after S/No 9001, can operate at both 1 MHz and 3.7 MHz. The MCU201 selection switch determines the operating frequency.

Note

Where any sensor is built to operate at non-standard frequency, it will have the suffix M1 or M3 at the end of the type number.

Cable check option selection

This single slide-switch is labelled “Cable Check” and is located directly above the sensor terminal block “E 2”. The ex-factory setting is “OUT” i.e. with the slide-switch to the right.

By sliding this switch to the left, the cable-check circuitry is enabled. This circuitry monitors the continuity of the screens of the two coaxial cables attached to the sensors. Normally, these cable screens are connected at the sensor-end to the metal body of a fitting (or to each other in

the case of non-metallic sensors). If this continuity is broken, the control unit illuminates the “FAULT” LED to indicate the sensor cable is damaged and changes the output relay to the “ALARM” state.

Note

The separated nature of sensor types 442S and or 448S usually make this cable check unreliable.

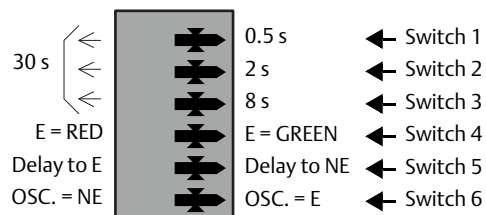
Relay output and LED logic selection

A bank of six slide-switches is located towards the top of the PCB (Figure 4 on page 8). Each switch is numbered and labelled to give brief function information (Figure 5).

The switches are used to set:

- The relay output state logic (relative to the sensor state).
- Associated time delays for state changes and LED colours.

Figure 5. Relay output and LED logic switch



Ex-factory position is to the right for all switches.

OSC = sensor oscillating.

E = relay energised.

NE = de-energised.

Note

Slide-switches are adjustable using a pencil. Ex-factory settings are with all switches to the right.

Procedure for setting the switches.

1. Set the top three switches first. Examples are in Figure 6.
2. Set the remaining switches in the following order, starting at the bottom and working upwards.

- a. Switch number 6.

If the MCU200 relay is to be energised (E) when the sensor is oscillating (OSC), set the No. 6 blue switch to the right (OSC=E). This is the preferred setting, to give a de-energised relay in the ALARM state for a gap sensor as a low level alarm.

The opposite setting might be used for a sludge blanket detector, when an oscillating sensor (OSC), which occurs in clear liquids, might preferably cause the relay to de-energise (OSC=NE).

- b. Switch number 5.

This selects the relay change which is subject to the time delay selected on the top switches. When the No.5 green switch is set to the right, the delay occurs between the sensor changing state and the relay de-energising or becoming “not energised” (NE). This time delay is a minimum of 0.5 seconds, (achieved by switching the top BROWN switch to the right) and is used to prevent relay chatter at the changeover point. Longer time delays are selected on the top three slide switches as follows:

The relay change in the opposite direction is immediate (within 50 milliseconds).

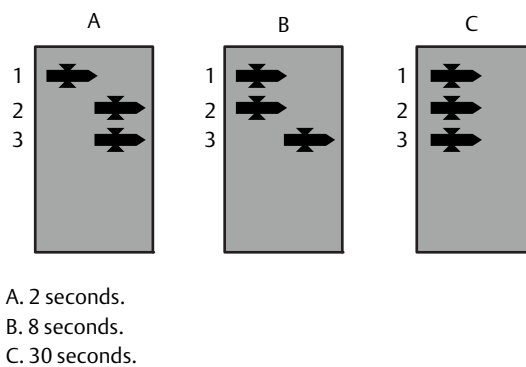
c. Switch number 4.

Only one of the GREEN or RED LEDs will be illuminated at any one time. These LEDs show the state of the MCU200 output relay.

The RED LED is labelled “ALARM” and the GREEN LED is labelled “NORMAL”.

The Switch 4 slide switch (Number 4) determines which LED will be illuminated when the relay is energised (E). It is usual to have the GREEN/NORMAL condition occur with the relay energised, i.e. with switch number 4 to the right (E=GREEN).

Figure 6. Example time delays for state changes



4. Applications

4.1 Gain adjustment

Correct adjustment of the gain is essential for proper operation of any ultrasonic sensor system. The HI/LO switch and potentiometer adjusts the gain of the amplifier feedback in the control unit, which produces oscillation of the sensor when the coupling between the ultrasonic crystals is sufficient. Therefore, the higher the gain setting, the lower the coupling needed to produce an oscillating sensor.

The MCU201 and MCU203 operate with many Mobrey gap sensors. Correct settings for a particular sensor and application should be found on-site by experiment, if possible. This approach takes account of particular site conditions like RF coupling between extension cables, which can affect the maximum allowed gain.

Other liquid characteristics, such as the presence of suspended solids or air bubbles, can mean that the control unit gain must be set as high as possible for reliable operation. This can overcome future solids build-up, but it should be at least one potentiometer division below the maximum allowed level to ensure temperature and component-ageing stability. With sludge

blanket sensors, the gain-adjustment changes the density of sludge at which the system will switch, increased gain giving increased solids levels.

The particular procedures outlined below for gain adjustments give the mid point gain settings, which may need to be adjusted to meet specific site/sensor future requirements as indicated above.

4.2 Interface detection

Suspended Solids blanket sludge discharge detection

The Mobrey MCU200 Series control unit can be used with a Mobrey 433SD sensor to provide sludge-blanket level detection in a settling tank, and assist with the control of an automatic de-sludging process. The Mobrey 433SD sensor is normally suspended in the settling tank.

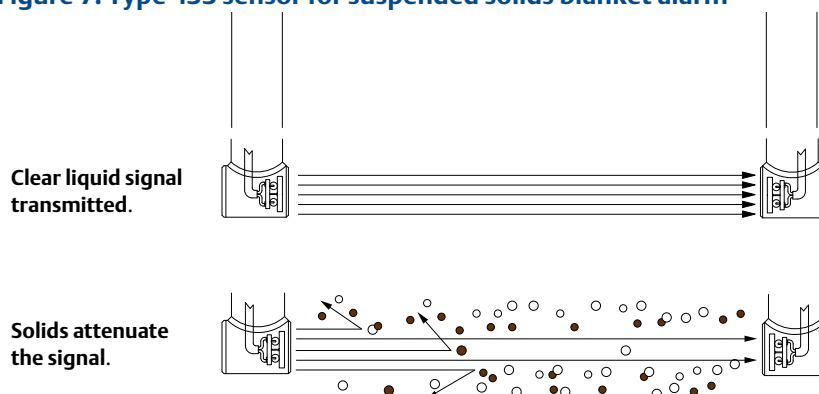
Similarly, the control unit can be used with a Mobrey sludge pipe and a pair of 488S sensors to control the end of a de-sludge cycle when thin solids are discharged.

Figure 7 shows the operation of a Mobrey 433SD sensor. In a clear liquid, the ultrasonic signal is carried across the gap and the sensor “oscillates”. In a dirty liquid - one containing high levels of suspended solids - the signal cannot cross the gap and the oscillation ceases.

Note

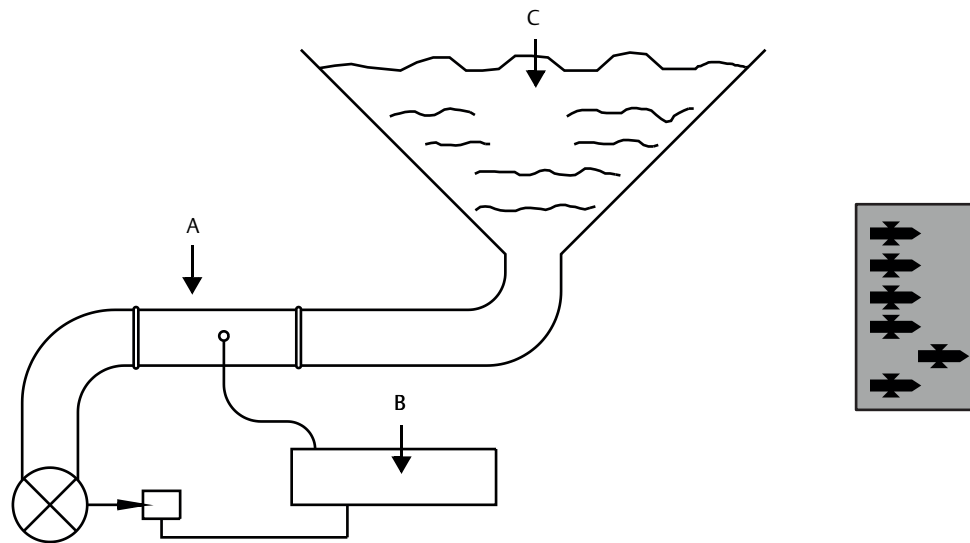
The same attenuation occurs when the sensor is in air.

Figure 7. Type 433 sensor for suspended solids blanket alarm



An alternative sensor type is the Mobrey sludge pipe, which is installed on the sludge discharge line from the settling tank. In this application, it is essential to install the pipe section below the bottom of the tank and close to the tank discharge (Figure 8).

Figure 8. Sludge discharge control



A. Mobrey pipe section
B. MCU200 Series control unit
C. Sludge

This maintains the hydraulic pressure on the sludge to prevent release of dissolved gases. Any such air entrained will give a false “thick sludge” indication.

The application of [Figure 8](#) shows a control valve opening on a timed basis to discharge the sludge. After sludge is flowing along the line, the control valve can be closed by the MCU200 when sludge with a low density is detected.

The gain potentiometer on the control unit allows the percentage of solids to be adjusted to a level that trips the output relay. A clockwise rotation of the gain increases the percentage.

Settled sludge discharge control

- Reduce the time delay setting to make adjustments easier. See [“Relay output and LED logic selection” on page 10](#) for details.
- Set the operating frequency on the control unit to 1 MHz if the sensor is to operate at this frequency. See [“Frequency selection” on page 9](#) for details.
- With a sensor or pipe in relatively clean water (supernatant), set the gain switch to the “LO” position and reduce the potentiometer gain until the LED changes. See [“Gain switch \(and potentiometer\)” on page 9](#) for details.

Note this point on the potentiometer as the switching point for 0% suspended solids.

- For a 1 MHz sensor on a 150 mm or 200 mm ID pipeline or sensor gap, working on primary sewage sludge, each division increase on the potentiometer above the 0% switching point represents approximately 1% suspended solids.
 - Increase the potentiometer gain to the desired level, remembering a 2-division overlap between “LO” and “HI” gain ranges.

- Check the setting in practice by taking a sludge sample at the switching point, and adjust as necessary. Increasing the gain makes the switching point occur at a higher percentage of suspended solids.
- For different ID (Internal Diameter) pipelines or sensor gaps, of dimensions 'D' mm, each division on the potentiometer represents approximately $(180, D) \% \text{solids}$.
- In a 3.7 MHz system, on a 150mm gap sensor each division on the potentiometer represents 0.25% solids: for sensor gaps D mm the divisions are $(38, D) \% \text{solids}$ typically.

Overflow alarm or fine solids detection

- Set the operating frequency on the control unit to 3.7 MHz if the sensor is suitable. This will improve the sensitivity.
- Reduce the time delay setting and use the potentiometer gain to locate the position for the switching point of 0% solids.
- Assume the potentiometer gain adjustment is $(90, D) \% \text{solids}$ per division increase to set initial switch point.

Interface detection between two dissimilar liquids

Viscous liquids, emulsions and liquids containing solid particles have a greater ultrasonic attenuation than clear liquids. This technique is used to detect which liquid is present at the sensor e.g. the separation of oil and water. For this application, Mobrey 402SD or 433SD sensors operating at 3.7 MHz are used to produce the maximum ultrasonic difference between two liquids monitored. An alternative technique for pipelines is the use of a Mobrey sludge pipe section with Mobrey 448SD type sensors.

The gain potentiometer on the PCB of the control unit is adjustable for the sensor to oscillate only in the liquid with a lower ultrasonic attenuation. This liquid in the example of [Figure 9](#) is usually clear, e.g. water.

Note

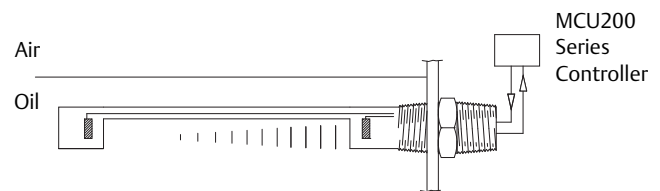
The signal when oil is present in the sensor gap will be the same as that for air in the gap, and that emulsion layers give a very high attenuation.

- Reduce the gain (potentiometer) with the sensor immersed in one of the liquids until a "false dry" indication is obtained. Note the position of the potentiometer.
- Repeat for the sensor immersed in the other liquid.
- Set the potentiometer half-way between these two values. Correct performance requires a total difference between the two set points of at least 3 divisions.

Figure 9. Mobrey 402 sensor as oil/water interface

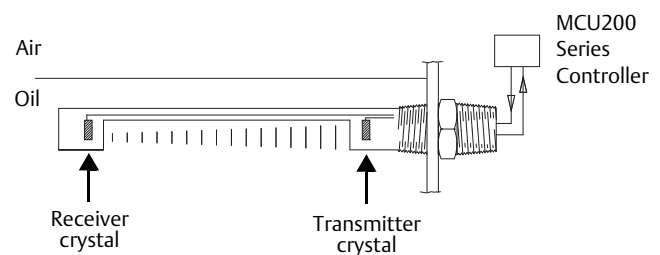
Sensor in oil

The ultrasonic beam is attenuated and will not reach the receiver crystal.



Sensor in water

The ultrasonic beam reaches the receiver crystal.



Interface detection between two similar immiscible liquids

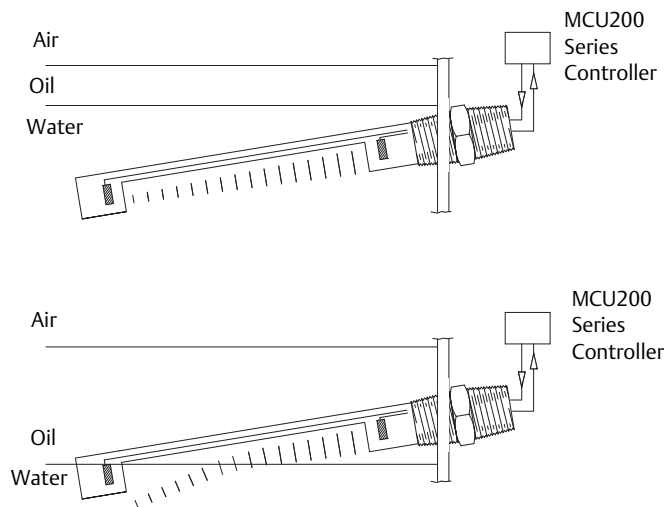
When liquids are ultrasonically very similar e.g. paraffin and water, the procedure in the section [“Interface detection between two dissimilar liquids” on page 14](#) produces very little difference between the two “false dry” points. In this case, the “reflection” method for interface detection is used ([Figure 10 on page 16](#)).

If an ultrasonic beam is transmitted from one liquid to another at a suitable angle (10°), it is split at the interface into reflected and a refracted beams, so that it does not reach the receiver crystal. If there is no interference in the gap, but only one liquid, the beam is received and the sensor oscillates.

The gain adjustment is made so that the gain is 3 divisions higher than the highest false dry position obtained. Performance at the interface should then be checked.

Note that the non-oscillating state of the sensor, at the interface, also occurs throughout any emulsion layer at the interface and when the sensor is in air.

Figure 10. Interface detector by reflection method



5. Maintenance

Safety maintenance: This is limited to periodic inspection by a qualified person to ensure that the installation including wiring and equipment housing is safe.

6. Fault finding

- At least one LED should always be illuminated.
 - If none are illuminated, check the power supply to the control unit.
- If the Fault LED is illuminated while the sensor is connected, check the coaxial cable to the sensor for incorrect wiring or damage.
 - Particularly check the continuity of extension cables, connection of crimped connectors on cable ends.
 - For other types of sensor, change the cable check switch to the “OUT” position (see [“Internal switch settings” on page 9](#)). The PCB can be then checked by linking the two terminals (both labelled as “E”) on the sensor terminals. This should stop the Fault LED illuminating.
- If the sensor is giving incorrect indications, check the gain (see [“Applications” on page 11](#)).
 - For a gap sensor giving a false dry indication, this could be due to aeration or solids in the liquid. This problem can be overcome by increasing the gain, slightly, to a maximum of X-2. This increases the sensitivity and is appropriate for high level alarms.
 - For a gap sensor giving false indication, this could be due to cross-talk between cables. Check that all junctions use coaxial connectors with the outer casings isolated. Separate the two coaxial cables for long cable runs. A ‘false wet’ indication can also be caused by viscous liquids clinging to the sensor: sensitivity can be decreased slightly by reducing the gain to X-6 minimum and then checking for reliable operation in the liquid.

- Check for correct sensor operation whenever the gain is adjusted away from the normal set point. Assume an overlap of 2 divisions between the “LO” and “HI” gain ranges.
- Check the incorrect operation has not been produced by incorrect setting of the frequency selection switch or an external short circuit on the auxiliary input terminals.
- The electronics PCB can be checked by linking the sensor terminals 1 and 2 with a wire, to simulate an oscillating sensor.

7. Specifications

7.1 MCU201

Power supply

110/120 \pm 10%, 220/240 \pm 10%, 50/60 Hz

Installation categories

II-IEC60664 for 230 Vac supply.

III-IEC60664 for 115 Vac supply.

Pollution degree

2-IEC60664

Power consumption

6 VA at 240 Vac.

7.2 MCU203

Power supply

24 Vdc (20 V minimum, 30 V maximum).

Supply must be floating or have negative earth.

Current consumption

Maximum of 0.1 A.

7.3 General

Relay

DPCO, 5A at 230 Vac.

Normal state selectable energised/de-energised.

0.5, 2, 8, or 30 seconds selectable delay.

- Operates for change of relay state in one direction only. 50 ms in other direction.

LED

Indicators: Red for alarm, green for normal, yellow for a cable fault.

State: Green or red indication is selectable for either sensor state.

Sensors

All Mobrey ultrasonic gap sensors are supported.

A switch on the PCB selects the electronics to operate at 1 MHz or 3.7 MHz.

Cable check option is supported for some sensors.

External input

Available for keeping the relay de-energised to provide pump control.

Dimensions

Box size is 200 x 120 x 75 mm

Fixing centres are 188 x 88 mm

Holes for glands

3 off Ø16 mm

Ingress protection

IP65 polycarbonate (clear lid)

Temperature

-40 °C to 55 °C, ambient

EMC

EN61326

Safety

EN61010-1


Net weight


0.700 Kg


Head Office

Delta Mobrey Limited

Riverside Business Park, Dogflud Way
Farnham, Surrey, GU9 7SS

 +44 (0)1252 729140

 +44 (0)1252 729168

 mobrey@delta-mobrey.com

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