

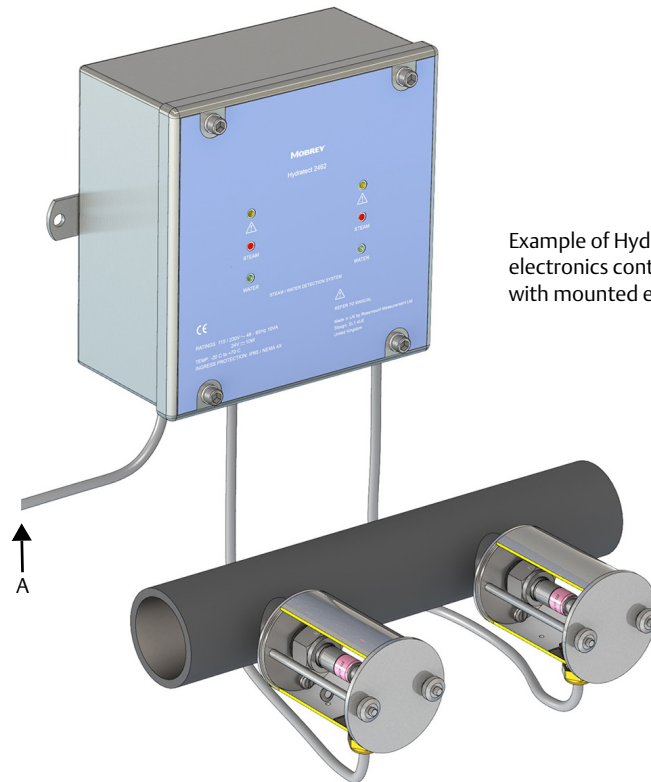
Mobrey Hydratect Steam and Water Detection System

1.1 Introduction

Mobrey Hydratect 2462 system is an electronic alternative to conventional water level switches on steam raising plant. A Hydratect system contains a compact, two-channel electronic control unit connected to a pair of electrodes mounted in the plant pipe-work (Figure 1-1 on page 1).

The electronics control unit provides drive, signal processing, and output for two electrodes. A high temperature electrode cable is used to connect each electrode to the electronics in a control unit. Each electrode cable contains four wires – two wires for connection to the electrode and two wires for connection to plant ground.

Figure 1-1. Example Hydratect 2462 System



Example of Hydratect 2462 system with the electronics control unit, and horizontal pipe run with mounted electrodes and covers.

A. Status and alarm signal outputs.

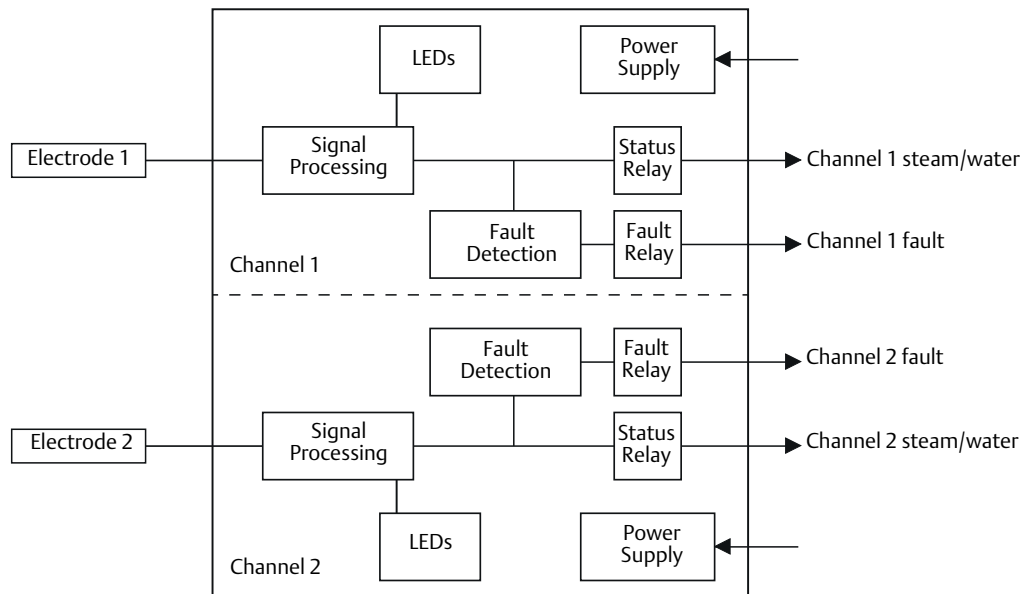
Each electrode channel is completely independent, having separate transformer, power supply, signal processing, fault detection, and output circuitry (Figure 1-2 on page 2).

The outputs from each of the two channels are:

- Status LEDs for water, steam and fault indication (red LED to indicate steam, a green LED to indicate water, and an amber LED to indicate fault conditions).
- Configurable fail-safe status relay for output of water or steam condition.
- Fail-safe fault output relay.

Electronics continuously perform a resistance measurement between the insulated tip of each electrode and the cell wall (i.e manifold wall). The resistance measured in water is substantially less than that measured in steam, and this is used to detect the presence or absence of water. Typical applications are low or high level alarms and trips on steam drums, feed heaters, de-aerators, etc. and turbine water induction prevention systems (TWIPS) on steam lines.

Figure 1-2. Electronics Block Diagram



1.2 How electrodes operate

1.2.1 The signal returned by the electrode

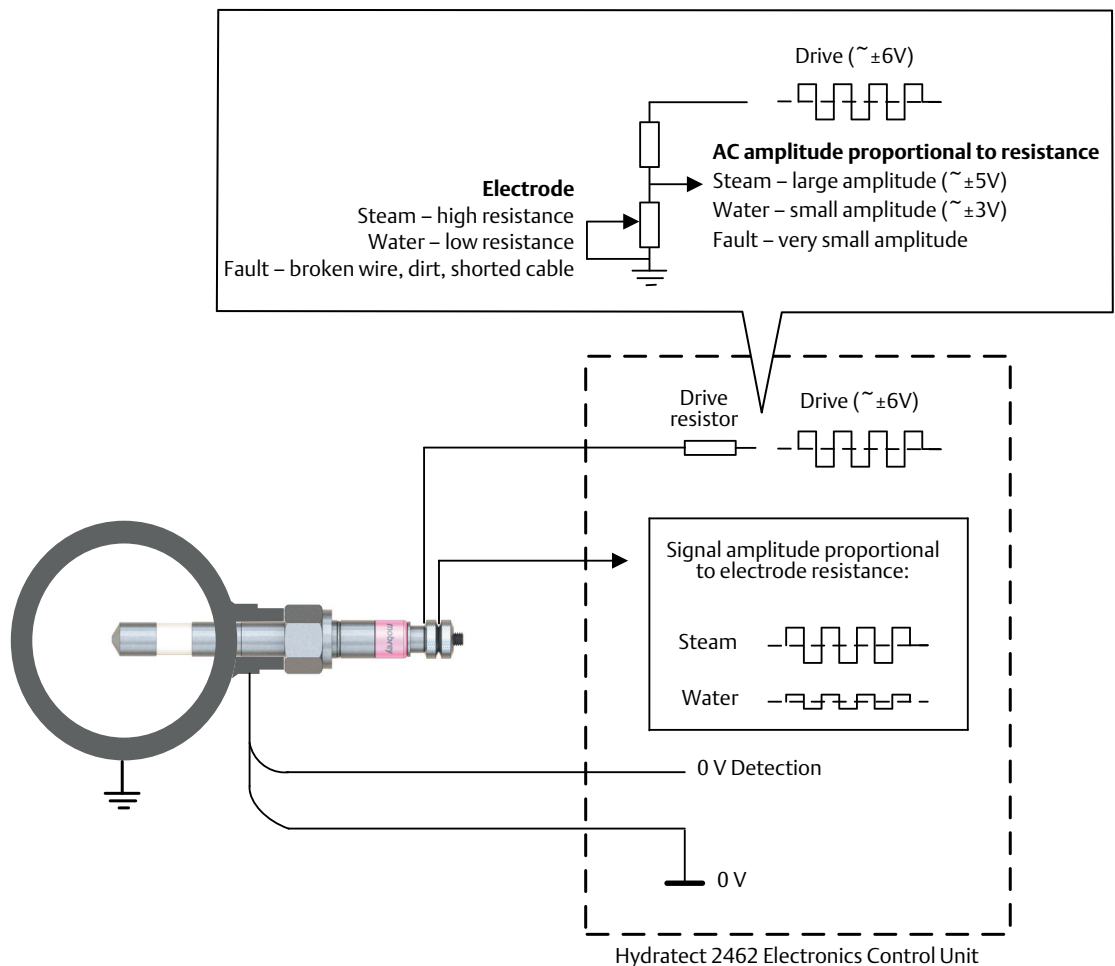
Two wires are connected to each electrode, one for the signal drive and one for the signal return. A low frequency alternating current (ac) square wave is used to drive the electrodes through drive resistors. A further wire is used for the signal return from the electrode and two further wires are used for the ground connection.

When the electrode is in steam, a high resistance to ground (insert in wall, [Figure 1-3 on page 3](#)) is presented, and therefore a large signal is returned.

When the electrode is in water, a low resistance to ground is presented and, therefore, a small signal is returned. If no signal is returned or only a very small amplitude is returned, either a short circuit to ground is present or a wire has been broken or disconnected.

A large signal is returned (equivalent to steam) if a ground connection becomes broken or disconnected. A separate circuit is used to detect the broken or disconnected wire.

Figure 1-3. Electrode Returned Signal



1.2.2 Conductivity and resistance values of steam and water

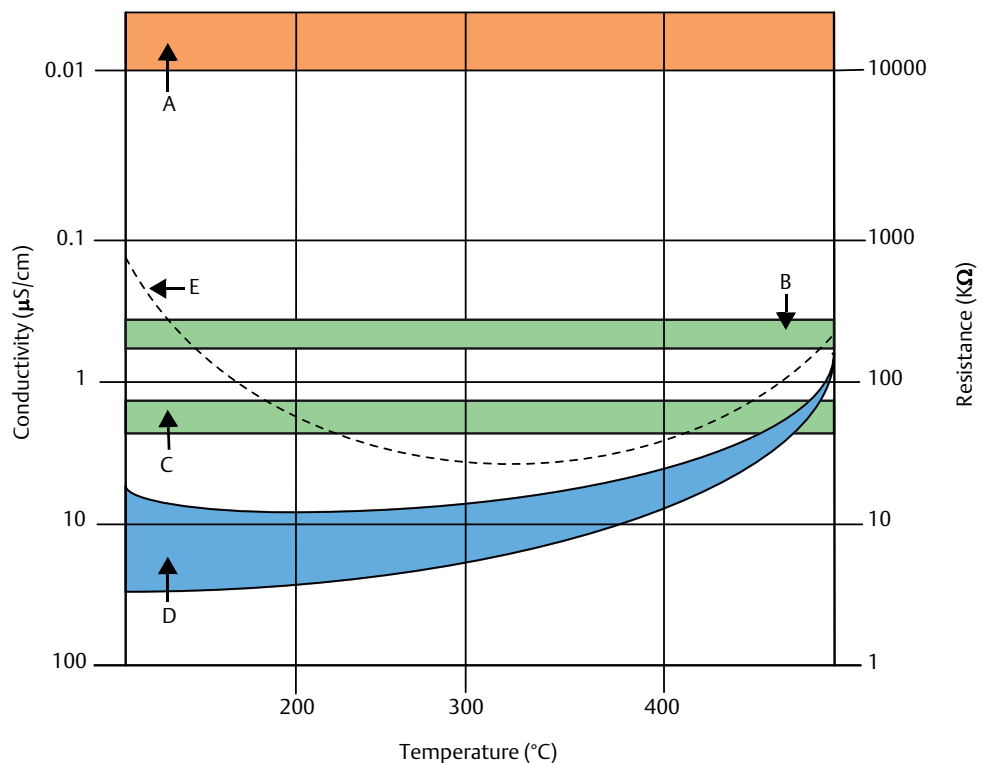
Figure 1-4 on page 4 shows conductivity and resistance values of steam, pure water, and typical boiler water. The significant difference between the resistance of steam and boiler water allows the Hydratect system to differentiate between the two.

The cell constant for the electrode and the surrounding insert is such that typical boiler water (conductivity between 1 $\mu\text{S}/\text{cm}$ and 50 $\mu\text{S}/\text{cm}$) has a resistance value of between 2 $\text{K}\Omega$ and 100 $\text{K}\Omega$, while the typical steam value is greater than 10 $\text{M}\Omega$. A short circuit or broken wire fault is declared if a resistance of less than 960 Ω (conductivity greater than 104 $\mu\text{S}/\text{cm}$) is measured. An alternate value of 333 Ω (300 $\mu\text{S}/\text{cm}$) is also available.

The drive to the electrode is true alternating current (ac) to prevent electrolytic action, and low frequency for the electrode cable capacitance to not affect the resistance measurement.

The normal steam/water switching threshold is set at 0.6 $\mu\text{S}/\text{cm}$. An alternative threshold of 1.6 $\mu\text{S}/\text{cm}$ is also available where wet steam conditions are likely e.g. at relatively low temperatures of under 200 $^{\circ}\text{C}$.

Figure 1-4. Conductivity and Resistance of Steam and Water



- A. Typical steam values.
- B. Hydratect switching band (0.6 $\mu\text{S}/\text{cm}$ setting).
- C. Hydratect switching band (1.6 $\mu\text{S}/\text{cm}$ setting).
- D. Typical boiler water
- E. Pure water.

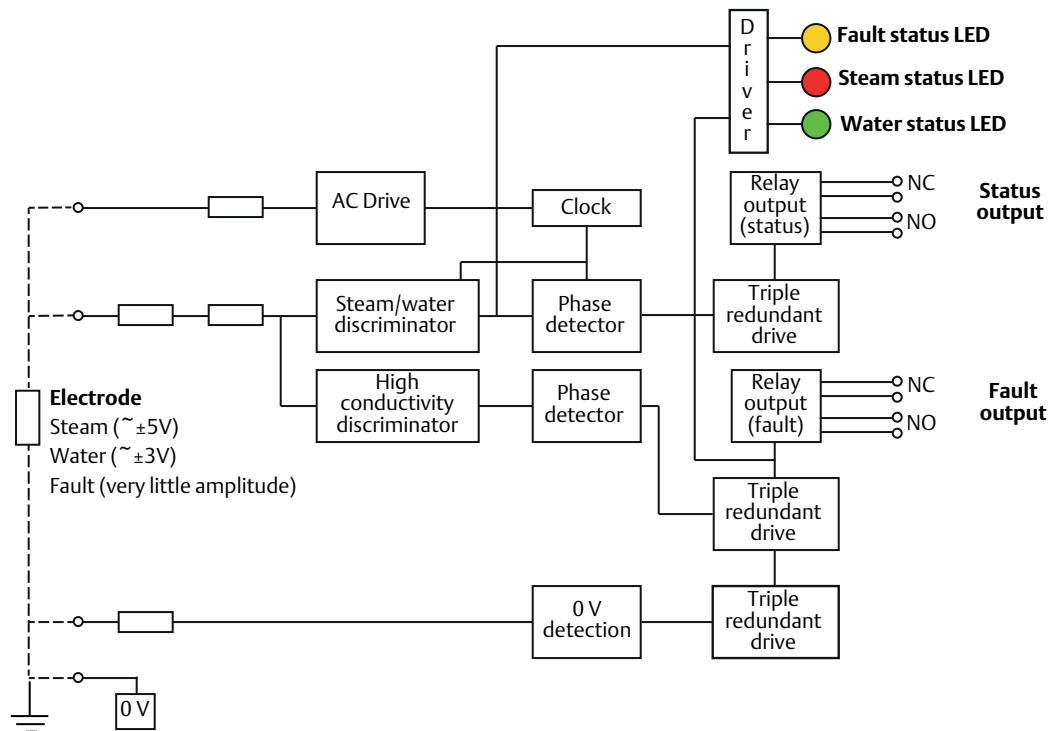
1.3 Design philosophy

The Mobrey Hydratect system has been designed to comply with the requirements of prEN50156. Any failure that could adversely affect the operation of the unit will be detected and cause the 'status' or 'fault' relay to de-energize (i.e go to the safe condition). The design philosophy behind the circuitry is fail-safe, such that any component failure will cause the circuit to default to the selected safe condition.

With this design philosophy, 'validation' circuitry, whose primary purpose is to detect short circuit and internal faults, is not required. Validation of the signals for trip purposes can be performed by connecting the status relays in the required configuration (i.e '1 out of 2' or '2 out of 2' output).

The design concept relies on the circuit oscillating in a pre-determined phase for the normal operating state. Oscillation in the correct phase then energizes a relay via triple redundant circuitry. The relay can be considered fail-safe if operated within 60% of its rating and capable of 3×10^6 cycles (defined by prEN50156). If the input changes to the abnormal state (i.e for low level trip, the normal condition will be water, the abnormal state will be steam) the output stops oscillating, de-energizing the relay to the safe condition. Any component failure or track break causes the circuit output to stop oscillation, which will de-energize the relay (i.e safe condition). The exception to this are the areas of circuitry that are triple redundant, where the circuit will continue to operate and provide the correct output with up to two component failures.

Figure 1-5. Validation Circuitry Blocks



The circuit is configured so that the status relay is energized in the preferred (water-normal or steam-normal) condition. The fault relay is energized in the 'no-fault' state. The ac drive provides a balanced square wave drive to the electrode via a drive wire. A return wire from the electrode provides a turn signal to the steam/water discriminator. The steam/water discriminator determines if the electrode is in steam or water and provides an ac output if the electrode is in the normal condition or a dc output if the electrode is in the abnormal condition.

The normal steam/water switching threshold is set at $0.6 \mu\text{S}/\text{cm}$. A second threshold of $1.6 \mu\text{S}/\text{cm}$ is also available where wet steam conditions are likely (i.e at relatively low temperatures under 200°C). The high conductivity discriminator provides an ac output if the conductivity is below the set threshold of $104 \mu\text{S}/\text{cm}$ (960Ω) or $300 \mu\text{S}/\text{cm}$ (333Ω).

The circuitry detects contamination (low resistance or short circuit to ground) faults and broken connections to the electrode. If the return signal from the electrode is less than the fault threshold then the output from the high conductivity discriminator will be dc. The output of each phase detector will be a.c only if its input is oscillating in the correct phase and at the correct frequency. That is, if the electrode is in the normal state and the conductivity is above the fault threshold. If the input is any else other than in phase ac, the output will be dc.

The triple redundant drive provides energization for its relay only if its input is ac. Under normal operating conditions, both 'status' and 'fault' relays are energized.

1.4 Circuit description

The circuit in [Figure 1-6 on page 7](#) can be considered as a number of blocks; a discriminator block, phase detection block, and relay drive block. These blocks operate as described below.

The electrode is driven with a low frequency square wave (clock) via resistor R1, forming a potential divider with R1. The signal amplitude returned via resistor R2 and resistor R3 is dependent on the electrode resistance.

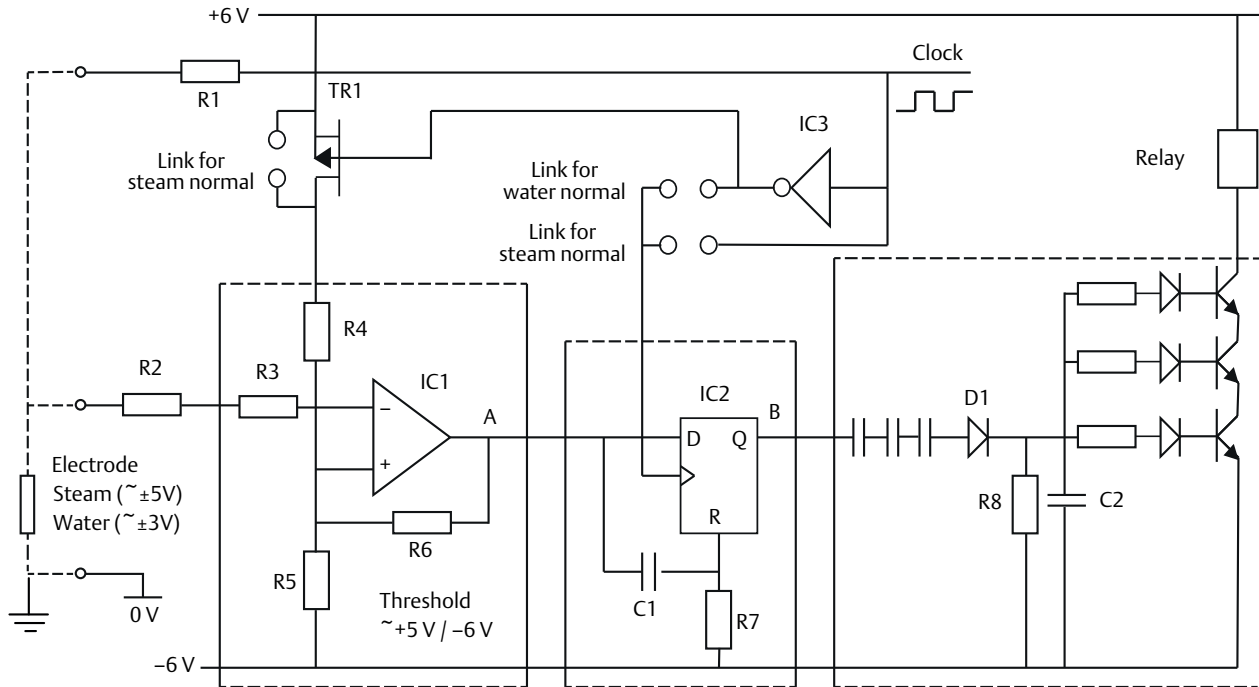
IC1 is the steam/water discriminator and IC2 the phase detector. The output of the phase detector (B) then drives a triple redundant relay drive. If the signal at B is alternating current (ac), the relay is energized,. If the signal at "B" is direct current (dc), the relay is de-energized.

The output from the steam/water comparator (A) under normal conditions (e.g. water in a water-normal set-up) oscillates in phase with the clock (for water-normal) or anti-phase with the clock (for steam-normal). A change to an abnormal state (e.g steam in a water-normal set-up) causes the steam/water comparator (A) output to stop oscillating. Any component failure or track break in the circuit path before "A" causes the oscillating to stop or start oscillating in an altered manner (incorrect frequency or phase).

The phase detector output (B) is an alternating current (ac) if "A" is oscillating at the correct frequency and the correct phase; this energizes the relay via the triple redundant relay drive circuitry. If "A" is a direct current (dc) or oscillating in the incorrect manner, the phase detector (B) output is dc and the relay is then de-energized to the safe condition. The relay drive circuitry uses an ac detector circuit to drive the relay.

During the negative cycle of the signal B, the drive transistors are held on by capacitor C2 being charged during the positive cycle. The size of C2 is chosen such that the relay is de-energized within five clock cycles of B becoming d.c.

Figure 1-6. Circuit Block Details



1.5 System state tables

Table 1-1. Water-normal Configuration

System state	Front panel LEDs			Relays	
	!	Steam	Water	Fault	Status
No fault, electrode in water	Off	Off	On	Energized	Energized
No fault, electrode in steam	Off	On	Off	Energized	De-energized
Power supply loss	Off	Off	Off	De-energized	De-energized
Electrode contamination / short circuit	On	Off	On	De-energized	Energized
Broken electrode connection (wire)	On	Off	On	De-energized	Energized
Broken ground connection (wire)	On	Off ⁽¹⁾	On ⁽¹⁾	De-energized	Energized ⁽¹⁾
Component failure (signal path)	On ⁽²⁾	Off	On	De-energized ⁽²⁾	De-energized ⁽²⁾

1. Status LED and relay state depends on which ground wire is broken.

2. One or both of the output relays will be de-energized depending on where the failure has occurred.

Table 1-2. Steam-normal Configuration



System state	Front panel LEDs			Relays	
	!	Steam	Water	Fault	Status
No fault, electrode in steam	Off	On	Off	Energized	Energized
No fault, electrode in water	Off	Off	On	Energized	De-energized
Power supply loss	Off	Off	Off	De-energized	De-energized
Electrode contamination / short circuit	On	Off	On	De-energized	Energized
Broken electrode connection (wire)	On	Off	On	De-energized	Energized
Broken ground connection (wire)	On	On ⁽¹⁾	Off ⁽¹⁾	De-energized	Energized ⁽¹⁾
Component failure (signal path)	On ⁽²⁾	Off	On	De-energized ⁽²⁾	De-energized ⁽²⁾

1. Status LED and relay state depends on which ground wire is broken.

2. One or both of the output relays will be de-energized depending on where the failure has occurred.

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