



LIQUID INTERFACE LEVEL MEASUREMENT



SPECIAL APPLICATION SERIES

The Need for Interface Measurement

The need for interface measurement arises whenever immiscible liquids—those incapable of mixing—reside within the same vessel. The lighter material rises to the top and the heavier material settles at the bottom. In oil production, for example, water or steam is used to extract oil from a well. Well fluids then route to production separators where they settle into their primary constituent parts as a water-hydrocarbon interface. Water may also be used as a transport medium or a cleaning agent and forms an interface with an allied material which is later extracted.

Interfaces are most commonly found in the diverse separation processes that are essential to every industry. Separation recovers additives, catalysts or solvents, extracts impurities, and routes media into different processing channels.

Though our emphasis is on liquid/liquid interface, interfaces also form between liquid and solids, liquid and foam, or liquid and a gas—such as gases (other than air) that are used in tank blanketing.

Immiscible liquids meet along an interface layer where they undergo some amount of emulsification. This emulsion layer (also called a rag layer) may form a narrow and precise boundary; but more frequently it is a broader gradient of mixed liquids—or liquids mixed with particles that form a slurry. Generally, the thicker the emulsion layer, the greater will be the measurement challenge.

Knowing the position of a process interface is necessary for maintaining product quality and operations efficiency. The interface is measured and controlled by precision level switches and transmitters. Though at least 20 different types of liquid level measurement devices are in service today, only a very few are suitable for accurate and reliable interface measurement.

The five leading interface measurement technologies in use today are discussed in the pages ahead. Grouped by their operating technologies, these include Buoyancy (Floats and Displacers), RF Capacitance, Thermal Dispersion, Radar, and Redundant Technologies (those combining two measurement technologies in one instrument). ■

The Emulsion Layer

Interface Measurement Technology

Principal Applications

Petroleum and Gas

- Separators
- LPG Dehydrators
- Heater Treaters
- Crude Desalters
- Free-water Knock-out
- Regenerators
- Coalescers
- Crude Dewatering
- Acid Settling Tanks
- Alkylation Tanks
- Coking Drums

Other Industrial

- Liquid Oxygen and Nitrogen production
- Digester Vessels
- Extractors & Separators
- Grease Traps
- Pulp and Paper
- Mining and Quarrying
- Food and Beverage
- BioPharmaceutical
- Chemical Plants
- Storage Facilities

Water & Wastewater

- Settlement Tanks
- Clarifiers
- Sludge Thickeners
- Filtration Systems
- Final Effluent Monitoring



Types of Interface

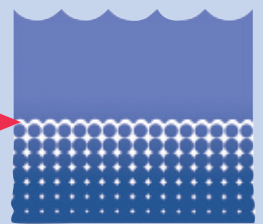
Liquid/Liquid Interface

- The liquid/liquid interface—including classic oil/water products—is found in separation, purification, catalysis, extraction and other processes.



Liquid/Solids Interface

- These interfaces are common in Water and Wastewater Treatment, Pulp and Paper, Mining and Quarrying, and Chemical Processing.



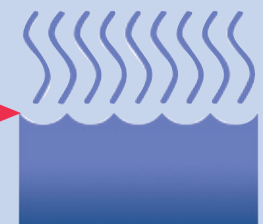
Foam/Liquid Interface

- Interface detection between immiscible fluids can be calibrated in some controls to alarm when the liquid changes to foam.



Vapor/Liquid Interface

- The phase change of a vapor to a liquid is detected in storage tanks, tank cars and process systems. Interfaces between vapor and foam can also be detected.



ECLIPSE®
706GWR

GWR TECHNOLOGY:

An Eclipse® Model 706 Guided Wave Radar (GWR) transmitter is capable of measuring both an upper liquid level and the interface level:

- Two-wire, 24 VDC, loop-powered
- Not effected by changing specific gravity
- Probe-based GWR is subject to less signal dispersion and attenuation.
- Easy configuration without changing level
- Quick connect/disconnect probe coupling
- No moving parts—Maintenance free!

GWR MEASUREMENT PRINCIPLE:

ECLIPSE is based on Time Domain Reflectometry. TDR transmits pulses of electromagnetic energy down the wave guide, or probe. When a pulse reaches a liquid surface that has a higher dielectric constant than the air in which it is traveling (dielectric constant of 1), the pulse is reflected. Ultra high-speed timing circuitry provides an accurate measure of liquid level. Even after the pulse is reflected from the upper surface, some of the energy continues along the length of the probe through the upper liquid. The pulse is again reflected when it reaches the higher dielectric lower liquid.

GWR INTERFACE MEASUREMENT:

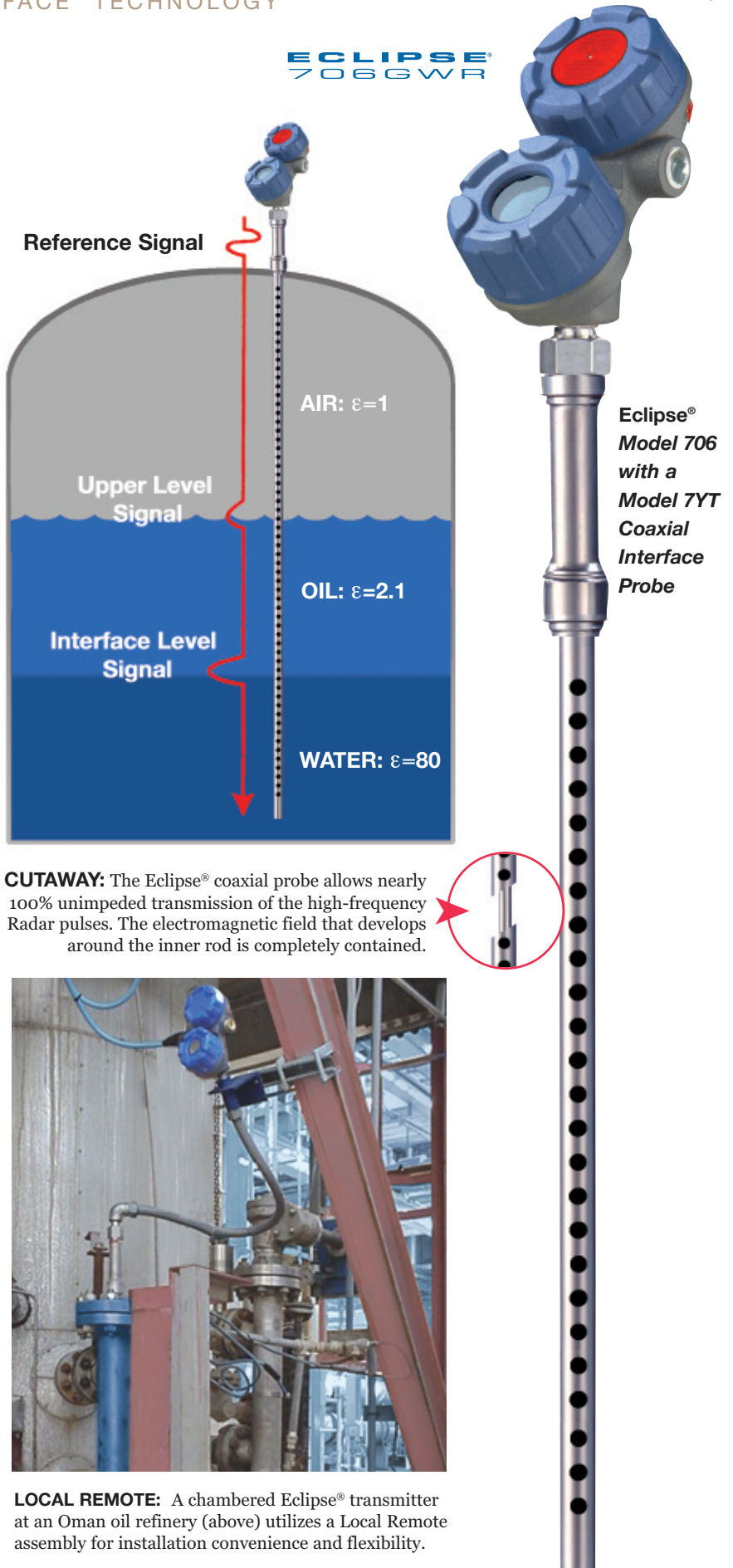
The dielectric constant (ϵ) of the interface media is critically important for GWR. As shown in the illustration at right, the upper dielectric should be between 1.4 and 5, and the lower dielectric should be greater than 15. The typical oil and water interface application shows the upper, nonconductive oil layer being 2, and the lower, very conductive water layer being 80. ECLIPSE measurement is suitable where the interface is clean and distinct and the depth of the emulsion layer is shallow.

GWR PROCESS CAPABILITIES:

- Max Pressure:** 5000 psig @ +70 °F
- Min Pressure:** Full vacuum
- Max Temperature:** +750 °F @ 270 psig
- Min Temperature:** -40 °F @ 2000 psig
- Sensitivities:** Probe coating or buildup, foam, dielectric constant, deep emulsion layer.

GWR TRANSMITTER OPTIONS:

- HART®, FOUNDATION fieldbus™ or Modbus digital communications
- Hastelloy® and Monel® construction
- Local Remote assembly
- Eight-character LCD and three-button keypad



LOCAL REMOTE: A chambered Eclipse® transmitter at an Oman oil refinery (above) utilizes a Local Remote assembly for installation convenience and flexibility.

MAGNETIC LEVEL INDICATION

REDUNDANT INTERFACE TECHNOLOGY

MLI TECHNOLOGY:

Flagship of the Orion Instruments® product line, the **Aurora®** Magnetic Level Indicator (MLI) combines ECLIPSE Guided Wave Radar and float technology into a truly redundant measurement system. The AURORA chamber houses both an ECLIPSE probe and a float:

- Single-chamber redundancy in a compact, precision fabricated chamber
- The ECLIPSE probe is mounted off-center within the chamber permitting the float to rise and fall as level changes
- Ideal for low specific gravity applications and low-dielectric media such as propane, butane, and hexane

MLI MEASUREMENT PRINCIPLE:

The ORION INSTRUMENTS AURORA combines the operating system of a conventional float-based MLI with an all-electronic ECLIPSE Guided Wave Radar transmitter for true level measurement redundancy in a single-chamber design.

MLI PRODUCTS:

ORION INSTRUMENTS products are applicable to a wide range of services and offer either level or continuous interface measurement (or both).

In addition to AURORA, **Atlas™** is the ideal replacement for sight and gauge glass instruments and suitable for the most demanding high pressure and temperature applications.

Twin chamber **Gemini™** features a Guided Wave Radar, Magnetostrictive or Capacitance transmitter set into its secondary chamber.

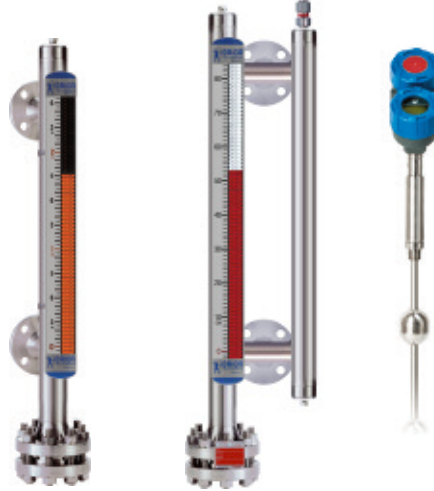
Jupiter® utilizes Magnetostrictive technology for reliable level and interface measurement.

MLI PROCESS CAPABILITIES:

- Max Pressure:** 4500 psig
- Min Pressure:** Full Vacuum
- Max Temperature:** +1000 °F
- Min Temperature:** -320 °F
- Sensitivities:** Variable S.G., media buildup

MLI TRANSMITTER OPTIONS:

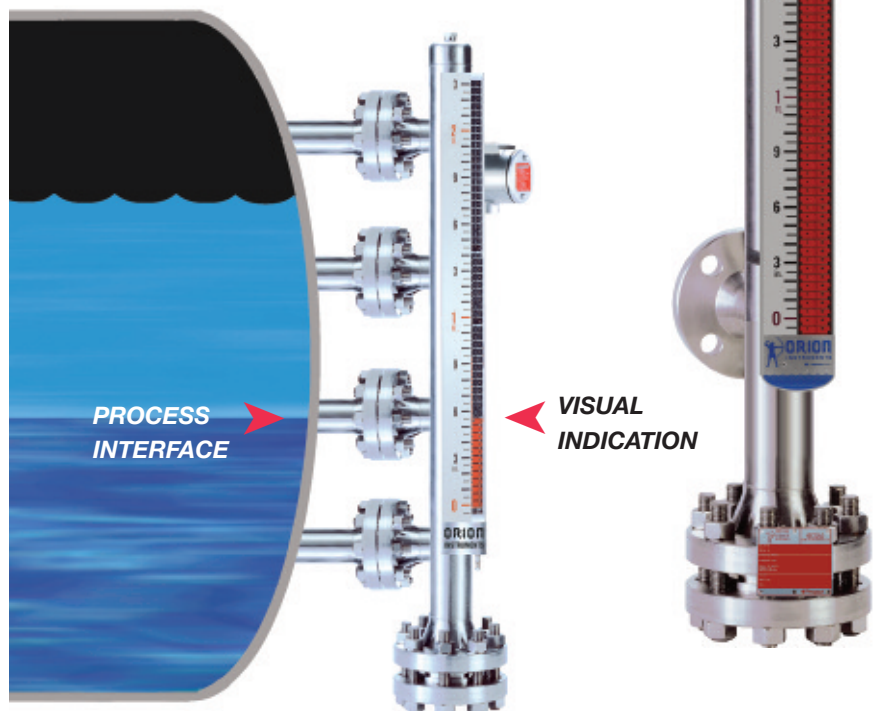
- HART® digital communication
- FOUNDATION fieldbus™ communication
- MLI options include flag-type or shuttle indicator, scales, switches and transmitters, blankets, steam or electric heat tracing, and frost extensions. A wide selection of materials, pressure classes, process connections, and instrument configurations is offered.



Atlas® Gemini® Jupiter®

ESSENTIAL MLIs: ATLAS is designed for side and top mounting. JUPITER mounts to the side of the MLI gauge or directly into a secondary chamber or vessel. GEMINI and AURORA MLIs are side-mounted on vertical, horizontal or spherical vessels.

VISUAL INDICATION: A side-mounted ATLAS with a reed switch (below) measures a tank's true interface level. Rising or falling tank fluid corresponds to a similar change within the Atlas chamber. In response to this movement, the float moves up or down accordingly and registers the interface level on a flag-type (or shuttle style) indicator.



Aurora®



Float Switches

MEASUREMENT PRINCIPLE:

A float calibrated for interface service must be heavy enough to penetrate the upper liquid yet buoyant enough to float on the lower liquid.

PROCESS CAPABILITIES:

Max Pressure:

3000 psig @ +697 °F

Min Pressure: Full Vacuum

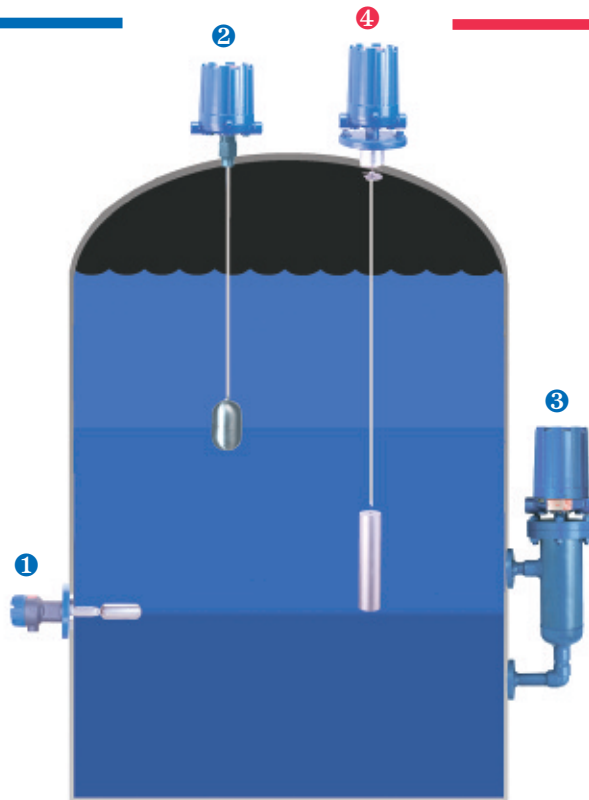
Max Temperature: +1200 °F

Min Temperature: -150 °F

Sensitivities: 0.1 is the minimum difference allowable between the S.G.s of the upper and lower liquids. As S.G. difference approaches this limit, very large floats are required.

INSTRUMENT OPTIONS:

Float-type switches available for top, side mounting, and external cage applications. A wide range of dry contact, hermetically sealed, pneumatic, and vibration-resistant switch mechanisms are offered.



- ① The Tuffy® side-mount, float-type switch is compact and economical.
- ② A simple and reliable T20 top-mount switch.
- ③ One of the many float or displacer, external cage switches by Magnetrol®.
- ④ Displacement-type controls are well-suited for simple or complex interface applications.

Displacer Switches

MEASUREMENT PRINCIPLE:

Interface level movement changes the buoyancy force on a displacer suspended from a range spring. The force change on the spring causes it to extend or compress, moving an attraction sleeve into or out of the field of the switch magnet, actuating the switch.

PROCESS CAPABILITIES:

Max Pressure:

5000 psig @ +300 °F

Min Pressure: Full Vacuum

Max Temperature:

+500 °F @ 2665 psig

Min Temperature: -150 °F

Sensitivities: Wider deadbands than float; entire displacer must be submerged in interface service.

INSTRUMENT OPTIONS:

Top-mounting displacer switch options include electric or pneumatic switch mechanisms and enclosures; Proof-er® ground check; and a wide range of connections.

Displacer Controllers & Transmitters

MEASUREMENT PRINCIPLE:

Movement of the interface level along the length of the displacer causes the precision range spring to extend or compress. This causes the movement of the core within a linear variable differential transformer in the electronic **Modulelevel®** resulting in a digital or analog output. In the Pneumatic **MODULELEVEL**, this causes the movement of a magnetic ball which guides the magnet carriage resulting in a pneumatic output change.

INTERFACE MEASUREMENT:

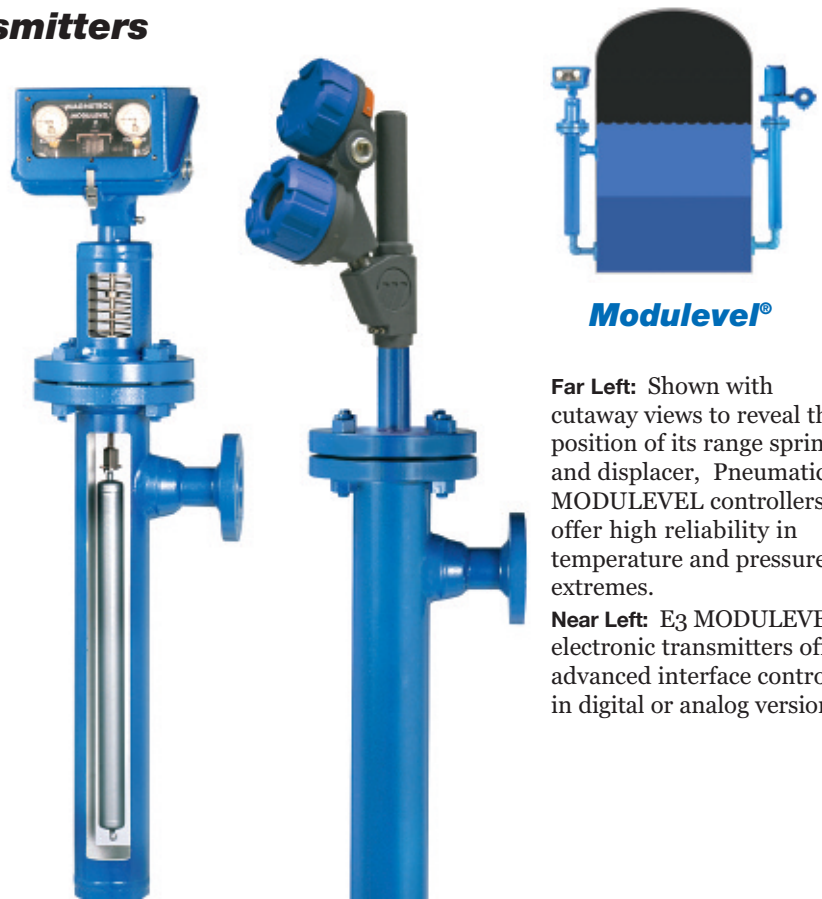
This technology is widely used for interface service because it is unaffected by emulsions and will accurately track the middle of the emulsion layer.

PROCESS CAPABILITIES (Electronic Models):

Steam Applications: -20° F to +500 °F

Non-Steam Applications: -20° F to +600 °F
(with carbon steel chambers)

Process Pressure: Up to 5100 psig @ +100 °F



Far Left: Shown with cutaway views to reveal the position of its range spring and displacer, Pneumatic **MODULELEVEL** controllers offer high reliability in temperature and pressure extremes.

Near Left: E3 **MODULELEVEL** electronic transmitters offer advanced interface control in digital or analog versions.

THERMAL DISPERSION INTERFACE TECHNOLOGY

TD TECHNOLOGY:

Thermatel® switches offer a new level of interface performance and reliability in thermal dispersion technology (see product-specific features in grey box below right):

- Accurate, fast-responding technology
- Easy, quick calibration
- Not affected by temperature, pressure or viscosity.
- No moving parts—Maintenance free!

TD MEASUREMENT PRINCIPLE:

Switches using thermal dispersion technology detect heat transfer which reduces the temperature difference between the switch's two sensors; one sensor is for reference and the other is heated to a temperature above the process temperature. The temperature difference is greatest in air, then decreases when cooling occurs due to a change in media. The electronics compare the electrical signal from the sensor against the set point and provide a relay actuation.

TD INTERFACE MEASUREMENT:

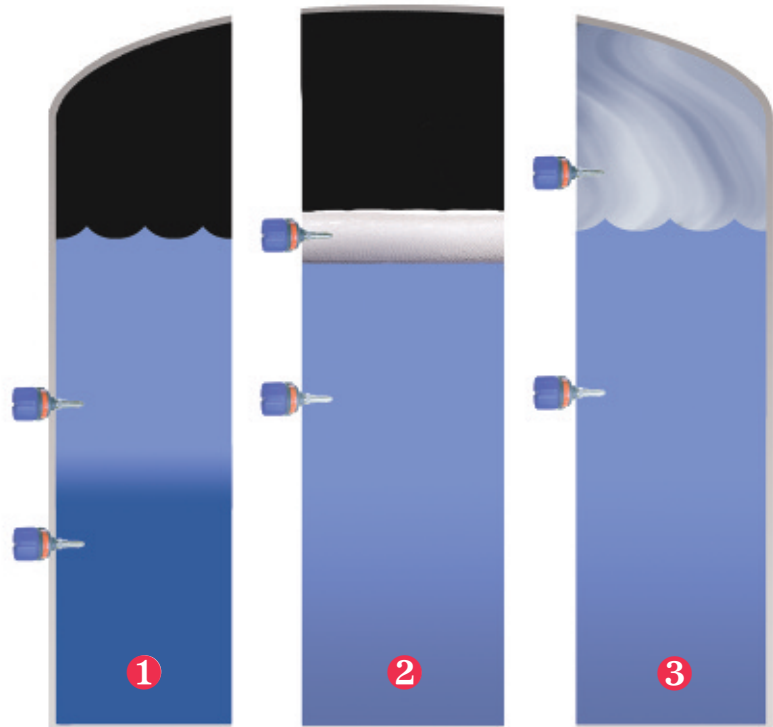
The THERMATEL TD1/TD2 and TG1 switches have been designed and engineered for level, flow or interface detection. When used as an interface detection switch, the set point can be adjusted to detect the difference in media between two fluids that have different thermal conductivity. Water has a very high thermal conductivity while organic materials (oil) have a much lower thermal conductivity. THERMATEL detects the difference in media due to the temperature difference which will be greater in the organic layer than in the oil layer.

TD PROCESS CAPABILITIES:

- Max Pressure:** 6000 psig @ +100° F
- Min Pressure:** Full vacuum
- Max Temperature:** +850 °F @ 3380 psig
- Min Temperature:** -100 °F @ 6000 psig
- Sensitivities:** Condensing environments

TD SWITCH OPTIONS:

- Available in explosion-proof version
- Intrinsically safe design
- Available in threaded, flange, hygienic and adjustable length connections
- Viewable alarm status window
- Integral or remote electronics
- Hot tap retractable probe



Three Interfaces detectable by Thermatel® Switches:

- ① Liquid/Liquid ② Foam/Liquid ③ Vapor/Liquid

Switches

TD1/TD2



TG1

FEATURES:

- Continuous diagnostics; fault indication
- Temperature compensated to provide repeatable alarm under varying temps
- Narrow hysteresis and fast response
- Non-linear mA output signal for trending, diagnostics & repeatable level indication
- Hygienic design option
- NACE construction option
- Window to view alarm status option
- Integral or remote electronics

FEATURES:

- Two-wire, intrinsically safe circuit between the probe and the remote din rail enclosure
- LEDs provide visual indication
- 24 VDC input power
- Adjustable set point and time delay
- SPDT Alarm relay
- mA output signal for diagnostics and repeatable level indication
- NACE construction option

RF TECHNOLOGY:

Kotron® RF (Radio Frequency)

Capacitance-type electronic controls offer many interface measurement advantages:

- Up to 150-foot measurement range
- Conductive and non-conductive liquids
- Corrosive and abrasive media resistance
- Extensive sensor probe selection
- No moving parts—Maintenance free!

RF MEASUREMENT PRINCIPLE:

As media rise and fall inside a tank, the amount of capacitance developed between the sensing probe and the ground reference rises and falls. In RF switches, this change is sensed by the electronics and converted into a relay operation. In RF transmitters, the electronics convert the capacitance change into a continuous level measurement.

RF INTERFACE MEASUREMENT:

The dielectric constant (ϵ) of the process medium is critically important. The higher the difference between the dielectric constants of the process material and the area of the two layers the easier the interface measurement will be.

RF PROCESS CAPABILITIES:

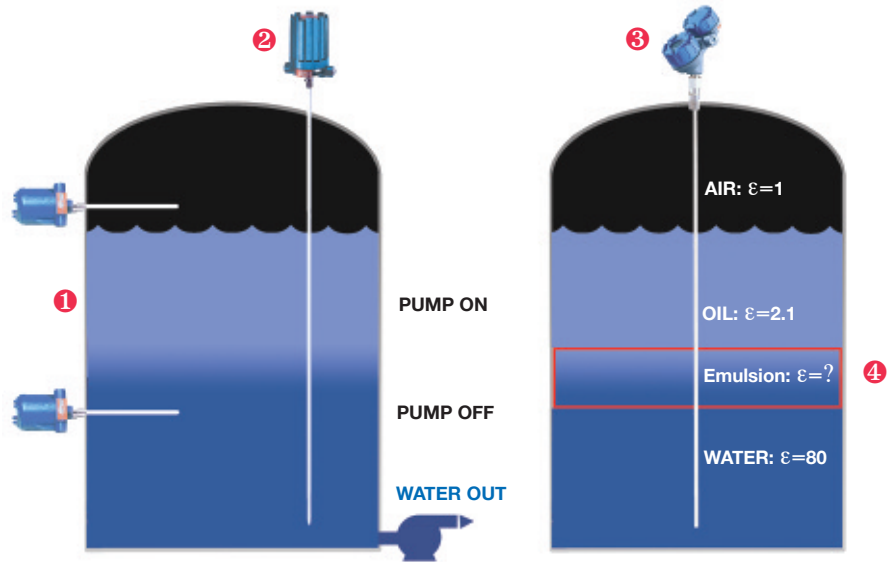
- Max. Pressure:** 2000 psig @ +100 °F
- Min. Pressure:** Full vacuum
- Max. Temperature:** +400 °F @ 200 psig
- Min. Temperature:** -40 -°F @ 3000 psig
- Sensitivities:** Variable dielectrics and conductive coating.

RF SWITCH OPTIONS:

- Single-point and multi-point
- Integral or remote location
- Field selective fail-safe setting
- Intrinsically safe probe circuitry
- Narrow or wide differential
- Easy calibration models

RF TRANSMITTER OPTIONS:

- 4-20 mA, 20-4 mA output
- Integral or remote location
- Self diagnostics
- FM and CSA approvals
- Up to four control relays
- LCD display and keypad options
- Two-wire, 24 VDC, loop-powered
- HART® digital communication



Switches: 1 In the oil and water interface above, RF Point Switches provide instantaneous detection of the dielectric difference between the two media. **2** The Model 811 Point Switch can use one unit for pump control.

Transmitter: 3 A Capacitance transmitter will measure total vessel capacitance. Since water has a high dielectric, most capacitance is generated by the water. **4** The dielectric (ϵ) in the rag layer (red box) changes from 2.1 to 80. As water mixed in the oil increases conductivity, the emulsion layer will appear to be more like water than oil.

Switches

811



Transmitters

805

082



SPECIAL APPLICATION SERIES

Other industry and special application brochures from MAGNETROL include:

- **Chemical**
- **Crude Oil Processing**
- **Flue Gas Desulfurization**
- **Food & Beverage**
- **Life Science**
- **Mass Flow Measurement**
- **Modular Skid Systems**
- **Natural Gas Processing**
- **Nuclear Power**
- **Petroleum Refining**
- **Power Generation**
- **Pulp & Paper Mills**
- **Renewable Energy**
- **Steam Generation**
- **Tank Bridle Level Measurement**
- **Tank Overfill Prevention**
- **Understanding Safety Integrity Level (SIL)**
- **Water & Wastewater**

PLEASE NOTE: The instruments recommended in these brochures are based on field experience with similar applications and are included as a general guide to level and flow control selection. Because all applications differ, however, customers should determine suitability for their own purposes.



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