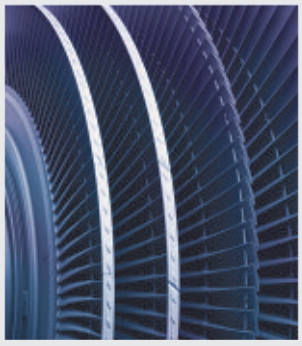
Magnetrol®

LEVEL INSTRUMENTATION FOR STEAM GENERATION

SPECIAL APPLICATION SERIES

Steam is today's utility player in the industrial energy arena. It cleans and sterilizes, dries and concentrates, separates and evaporates. In cookery, it preserves flavor, texture, and retains nutrients. In chemistry, it fosters reactions by controlling process pressure and temperature. In biotechnology, it's essential for growing production organisms. Steam ranges in purity from boiler grade for routine tasks, to culinary grade "Clean Steam" for food and dairy, and graduates up to super pure, pyrogen-free steam for biopharmaceutical use.



Steam can drive a simple pump or generate hundreds of megawatts of electricity. It cures rubber, and puts the corrugated furrows in cardboard. It adds heat, humidity and air conditioning to buildings and is a fire suppressant, too. In frigid oil & gas fields, steam heat-traces tanks and pipelines to keep processes moving. Steam is so essential to industry that 83% of the total energy used by the pulp and paper segment is for generating it (57% for chemicals and 42% for refining). From massive petrochemical complexes to the local microbrewery, steam is the tool for getting things done.

Steam is ubiquitous because it's industry-friendly. It's intrinsically safe, flexible, economical, aseptic, and environmentally benign. Steam can arise from fossil fuels, biomass or biogas. Its high efficiency is due to its ability to return a significant portion of condensate to the generation cycle. With proper maintenance, a steam plant can last for decades.

This brochure focuses on the industrial steam boiler (the massive electricity-generating utility boilers are addressed in our Power Gen and Nuclear brochures). The Magnetrol® relationship with steam systems dates back to the 1930s, when, as a new Chicago-based manufacturer of boiler systems, we needed a boiler level controller. Rather than acquiring one, we invented one, and the success of that initiative put our young company on a path toward becoming the level and flow specialist that we are today.

Steam: With all its versatility, is it any wonder that steam is essential to so many industries? ■

It all begins with water, the essential medium for steam generation. Conditioning water properly can increase boiler efficiency and extend the boiler's operating life. Improper or nonexistent feed water treatment is the major cause of boiler failure.

All natural sources of fresh water require varying degrees of treatment prior to boiler use. Boiler feed water treatment prevents scale and deposits, removes dissolved gases, protects against corrosion, eliminates water and steam carry-over, and optimizes boiler efficiency and minimizes maintenance costs.

Feed water is treated and conditioned in three phases: (1) Raw make-up water is treated before entering the deaerator; (2) Treated make-up water and return condensate merge in the deaerator for removal of dissolved gases; and (3) De-oxygenated and heated feed water enters the boiler where it is further treated with chemicals.

Feed water treatment requirements vary greatly. In rare cases, raw make-up water only needs filtering. More commonly, some form of external treatment is needed, as in the typical process units shown below.

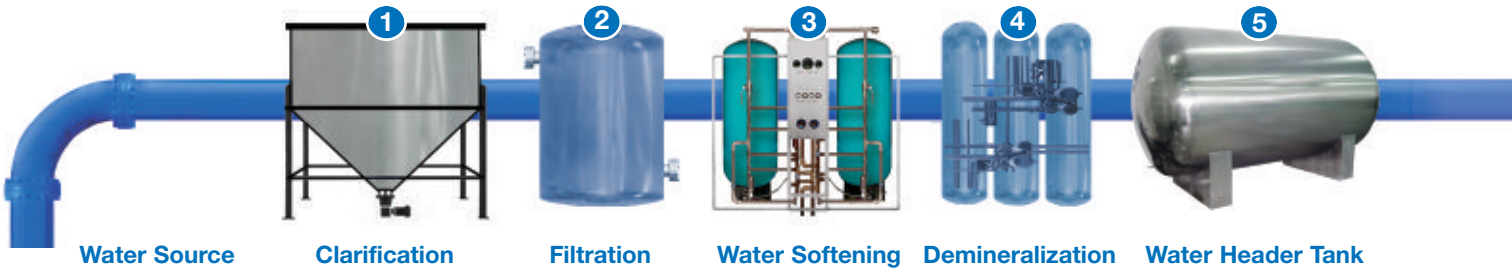


Fig. 1. Make-up Water Treatment Applications

❶ **Clarification** Raw water with sediments may require a settling tank with the addition of chemicals to foster precipitation of the suspended matter. Clarified water is then drawn off at a surface outlet.

Continuous Level: Eclipse® Enhanced 705 Guided Wave Radar (GWR); Echotel® Model 355 Non-contact Ultrasonic Transmitter; Kotron® Models 82CE, 804 or 805 RF Capacitance Transmitters.

❷ **Coarse and Fine Filtration** Suspended solid impurities are reduced or eliminated by passing make-up water through a filter. If the suspended solids are very fine, a flocculation step may be required.

Continuous Level: ECHOTEL Model 355 Non-contact Ultrasonic Transmitter; Pulsar® R95 Thru-air Radar Transmitter; Model R82 Thru-air Radar Transmitter; ECHOTEL 344/345 Non-Contact Ultrasonic Transmitter.

❸ **Water Softening** Calcium and magnesium are hard scale forming minerals that build up on boilers and steam-related equipment resulting in costly repairs, increased energy consumption, and plugged equipment. Softening occurs as hardness minerals attach to the softening resin and "exchange" for sodium.

Continuous Level: PULSAR R95 Thru-Air Radar Transmitter; ECLIPSE Enhanced 705 Guided Wave Radar; Atlas™ or Aurora® Magnetic Level Indicators (MLIs).

Point Level: ECHOTEL 961 Ultrasonic Level Switch; Model T20 Single Stage Float Level Switch.

❹ **Demineralization** Demineralization is typically an ion exchange process whereby minerals or mineral salts are removed from water. Chemical treatment or a Feed Water Evaporator can be used as alternative methods, the latter using extraction steam to remove impurities in raw water.

Continuous Level: ECLIPSE Enhanced 705 GWR; Digital E3 Modulevel® Electronic Transmitter.

Point Level: Models T5x and T6x Float-based Level Switches.

❺ **Header Tank** The treated make-up water is routed for storage in a Cold Water Header Tank. From there the water passes on demand through a flash tank for heating and on to the deaerator for degassing.

Continuous Level: Model R82 Non-contact Radar Transmitter; ECLIPSE Enhanced 705 GWR; ECHOTEL Model 344/345 Non-contact Ultrasonic Transmitter; PULSAR R95 Thru-air Radar Transmitter.

STEAM LOOP: 2. Feed Water Deaeration

Because boiler and steam systems are made primarily of steel and the heat transfer medium is water, the potential for corrosion is very high. Dissolved oxygen is the major cause of boiler system corrosion.

Oxygen and other gases are removed from both feed water streams—treated make-up water and return condensate feed water—when they merge in the deaerator. Deaerators remove non-condensable gases from feed water streams by steam heating and by aggressively agitating incoming water. The deaerator's storage section is typically designed to hold enough water for ten minutes of boiler operation at full load.

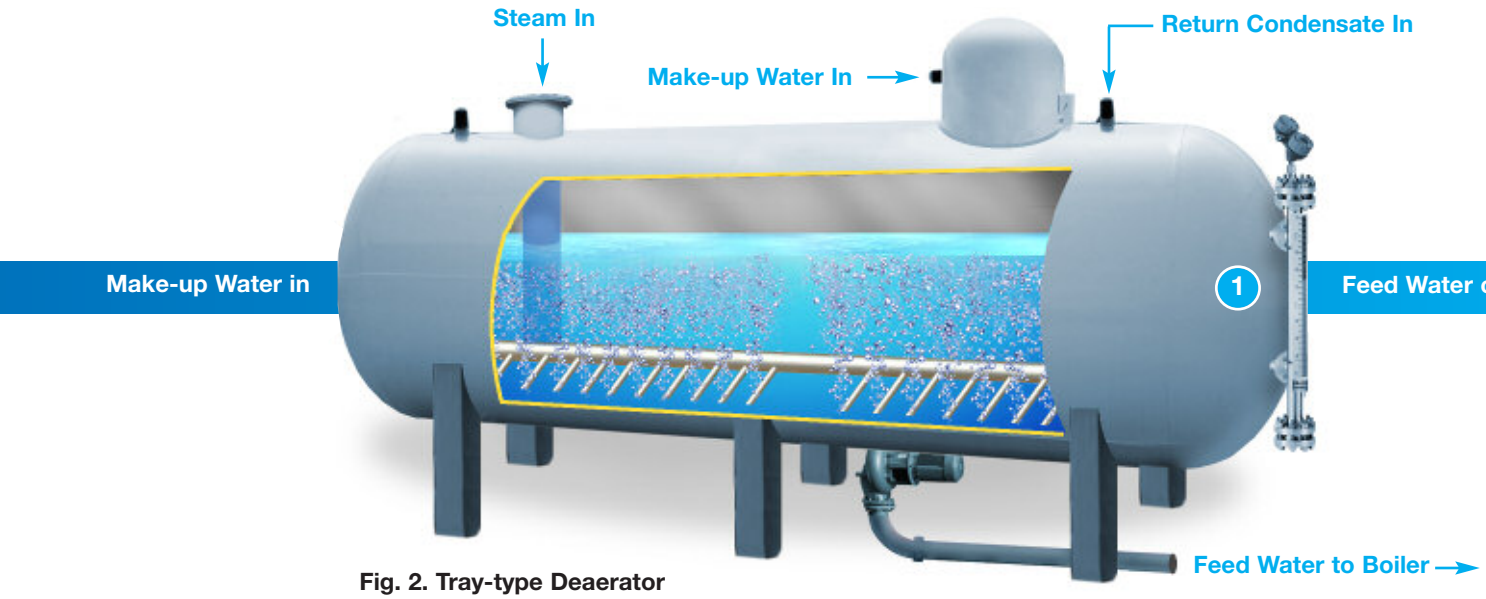


Fig. 2. Tray-type Deaerator

❶ **Deaerator** Level control on a deaerator typically measures the level in the storage tank and modulates a control valve on feed water streams to maintain tank level at the desired set points.

Continuous Level: ECLIPSE Enhanced 705 Guided Wave Radar; ATLAS or AURORA Magnetic Level Indicators.

Point Level: Series 3 ASME B31.1 External Caged Liquid Level Switch.

STEAM LOOP: 3. Boiler Feed Water Treatment

For higher boiler efficiencies, the feed water is further conditioned prior to and upon entering the boiler. First, the water is preheated by an economizer (Figure 3) using the boiler's hot exhaust gas streams. Next, water treatment inside the boiler reduces foaming, eliminates adherence of suspended matter to boiler internals, further prevents corrosion and scaling by eliminating residual oxygen. Chemical feed systems are employed for both Internal Boiler Treatment and in the Make-up Water Treatment unit.

❶ **Chemical Feed Systems** Liquid treatment chemicals in storage tanks, day tanks, or injection skids require stringent level monitoring to ensure ongoing chemical treatment of make-up and feed water.

Continuous Level: ECLIPSE Enhanced 705 Guided Wave Radar; ATLAS or AURORA Magnetic Level Indicators; PULSAR R95 Thru-air Radar Transmitter; Model R82 Thru-air Radar Transmitter.

Point Level: ECHOTEL 910, 961/962 Ultrasonic Level Switches; Tuffy® II Side-mounted Float Level Control.

Feed water routed to the boiler is heated in an economizer before being chemically treated upon entering the boiler. After heat converts the water into steam, the steam is routed to its applications.

Boiler drum level control must maintain water level within critical set points. Ancillary boiler systems requiring level control include fuel storage, flash tanks and the boiler's blowdown tank.

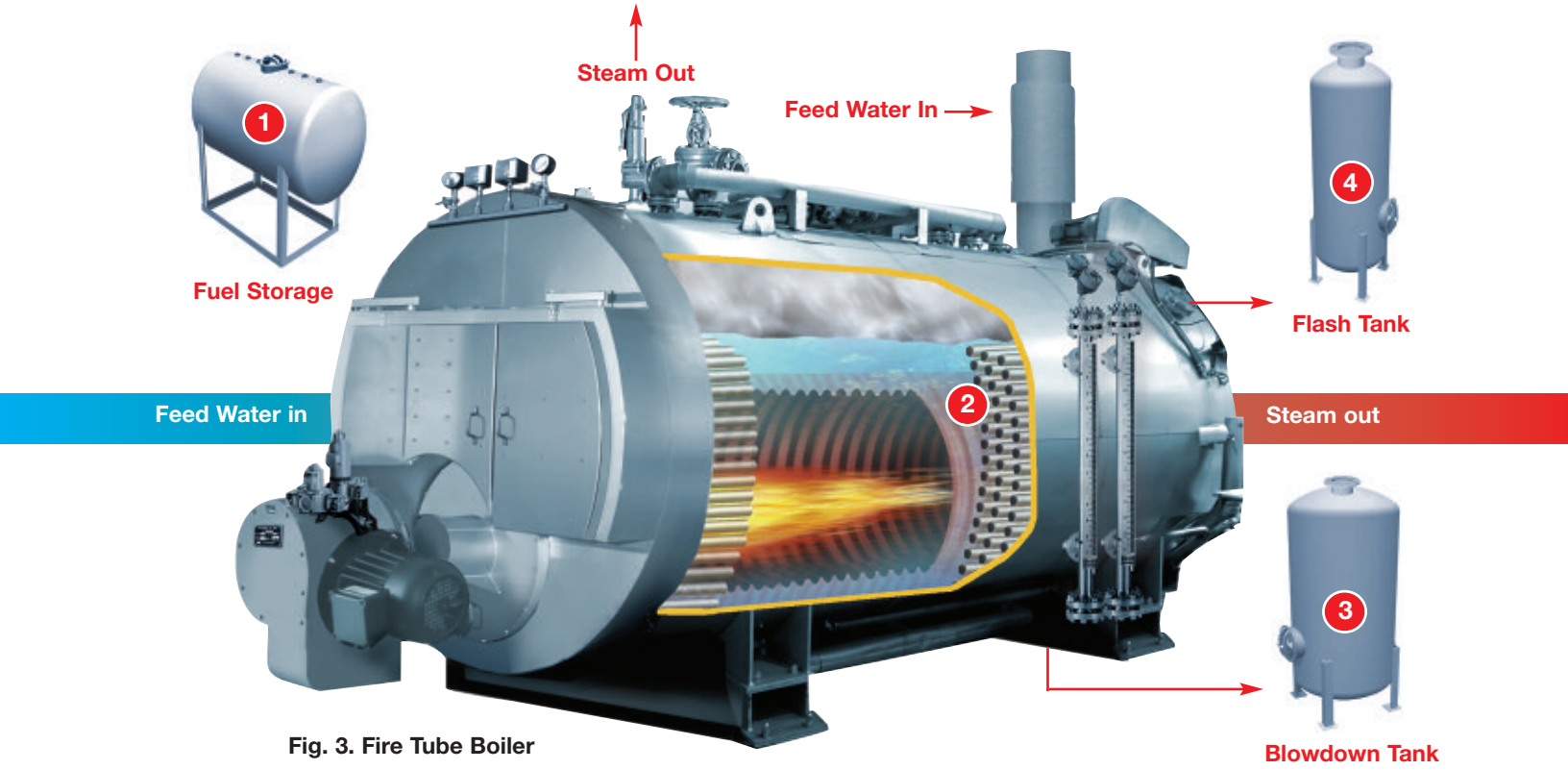


Fig. 3. Fire Tube Boiler

❶ **Fuel Storage** A boiler can be fueled by natural gas, propane, fuel oil, coal, biomass or biogas. Storage of liquid fuel oils with low flash points requires safety-certified controls due to the hazardous location.

Continuous Level: ECLIPSE Enhanced 705 Guided Wave Radar; PULSAR R95 Thru-air Radar Transmitter; Model R82 Thru-air Radar Transmitter; ECHOTEL Model 355 Non-contact Ultrasonic Transmitter.

Point Level: Model B10/B15 Dual Stage Displacer Level Switch.

Granulated Biomass: Solitel® Vibrating Rod Level Switches detect ground biomass levels in hoppers and silos.

❷ **Boiler Drum** Low water level can cause severe, even catastrophic, damage. If necessary, level controls add feed water or shut-down the burner operation. Excessive high level can cause damaging carryover and priming in which a large, rapidly applied load results in a sudden reduction in steam pressure that pulls boiler water into piping. In this event, the level control actuates a valve to throttle down feed water supply.

Continuous Level: ECLIPSE Enhanced 705 Guided Wave Radar; Digital E3 MODULEVEL Electronic Transmitter; APM MODULEVEL Pneumatic Transmitter; ATLAS or AURORA Magnetic Level Indicators.

Point Level: Series 3 ASME 31.1 External Caged Level Switch; Model B40 HT/HP External Caged Level Switch.

❸ **Blowdown Tank** Undesirable solids in boiler water can be reduced through a continuous purge or blow down system. Blowdown tanks allow the blowdown to cool before it is discharged into the sewer system.

Continuous Level: ECLIPSE Enhanced 705 Guided Wave Radar; Digital E3 MODULEVEL Electronic Transmitter.

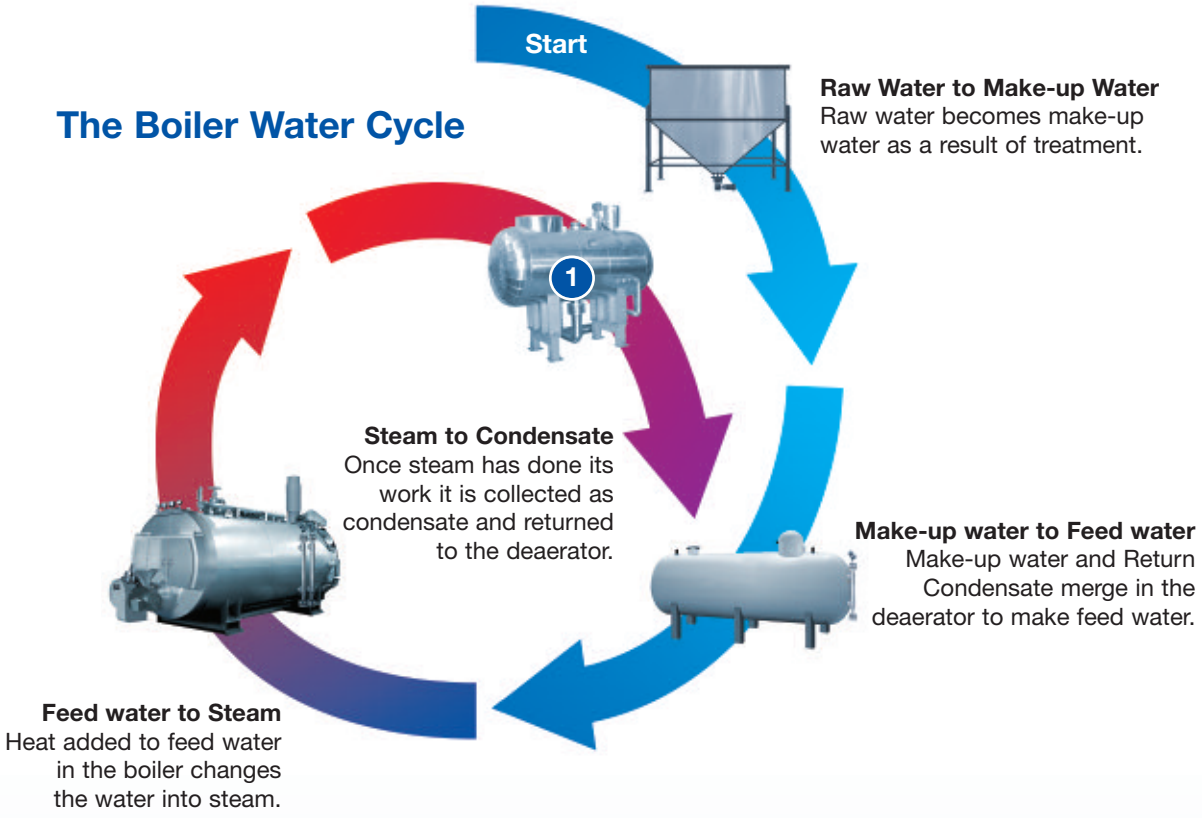
❹ **Flash Tank** Boiler water blowdown can be used to heat process streams. Boiler water blowdown heat recovery systems use flash steam from the flash tank for deaeration. The blowdown from the flash tank is passed through an exchanger and used to preheat the boiler make-up water.

Continuous Level: ECLIPSE Enhanced 705 Guided Wave Radar; ATLAS or AURORA Magnetic Level Indicators.

Point Level: Model B40 HT/HP External Caged Liquid Level Switch.

STEAM LOOP: **5. Condensate Return System**

After steam does its work it condenses to water and is collected in the Condensate Return System for reuse in the boiler plant. Since condensate has already been treated with chemicals and has been through the steam system, it will take far less resources to turn it back into steam than it would to make steam from an equal quantity of cold water. A condensate return unit thus provides a significant savings in make-up and the associated water treatment chemicals.



❶ **Condensate Receiver Tank** Level controls in receiver tanks ensure that water is returned to the boiler house for reuse. When the control senses the upper level in the receiver tank it will actuate a pump to route the condensate to the deaerator. Typically, these tanks range from 65 to 1,800 gal. (250 to 7,000 L).

Continuous Level: ECLIPSE Enhanced 705 GWR; Digital E3 MODULEVEL Electronic Transmitter; ATLAS MLI.

Point Level: Thermatel® TD1/TD2 Flow/Level/Interface Switch; ECHOTEL Model 961 Single Point Ultrasonic Level Switch; Sealed External Caged Level Switch; Model B40 External Caged Liquid Level Switch.

ALL STEAM LOOPS: **Flow Control Applications**

❶ **Pump Protection** A flow switch positioned along the pump's discharge piping will actuate an alarm and shut down the pump when liquid flow drops below the minimum flow rate.
Flow Alarm: THERMATEL TD1/TD2 Level/Flow/Interface Switch for High/Low Alarm.

❷ **Burner Fuel Gas Flow.** Natural gas and biogas are the most common gaseous forms of boiler fuel. Natural gas is primarily methane, and biogas is typically 65% methane and 35% carbon dioxide. Flaring and venting biogas is giving way to energy harvesting technologies with the economic advantage of creating heat, electricity, fuel or feed stocks while also reducing carbon emissions.

Continuous Flow: THERMATEL TA2 Mass Flow Transmitter.

Flow Alarm: THERMATEL TD1/TD2 Level/Flow/Interface Switch for High/Low Alarm.

MAGNETROL Instrumentation for Boiler Drum Level Measurement and Control

Perhaps the single most critical level control in the steam loop is boiler drum measurement and control. This application requires a high degree of accuracy, reliability and temperature tolerance—attributes the instruments below have been engineered to provide.

ECLIPSE Guided Wave Radar

ECLIPSE is a two-wire, loop-powered, 24 VDC level transmitter based on Guided Wave Radar (GWR) technology. Available in coaxial, twin rod and single rod probes, ECLIPSE is offered with HART®, PROFIBUS® and FOUNDATION fieldbus™ outputs. Of special note is the Model 7xS Coaxial Steam Probe optimized to effectively measure levels in saturated steam applications. The 7xS withstands the high temperature, high pressure and corrosive nature of steam applications. A patented steam compensation feature of the probe protects against measurement errors that are common to this application.

Eclipse® with 7xS Steam Probe

PULSAR Thru-Air Radar

PULSAR Pulse Burst Radar Level Transmitters are the latest generation of loop-powered, 24 VDC, liquid level transmitters. Offering lower power consumption, faster response time and simplified operation, PULSAR performance is not process dependent (changing specific gravity and dielectric have no effect). Its operating frequency offers superior performance in the tougher applications that include turbulence, foam, and heavy vapors.

Pulsar® with Horn Antenna

Pulsar® with Dielectric Rod Antenna

TUFFY and MODULEVEL Float & Displacer Controls

Float-actuated switches are ideal for level alarm, interface, and pump control applications. **Top-mounting displacer switches** offer a wide choice of alarm and control configurations. **MODULEVEL displacer transmitters** offer digital 4-20 mA or HART output. Specifically designed for boiler service, the Model APM MODULEVEL Pneumatic Transmitter provides output signals in direct proportion to changes in liquid level.

APM Pneumatic Modulevel®

Digital E3 Modulevel®

Tuffy® II

AURORA and ATLAS Visual Indicators

Orion Instruments® Magnetic Level Indicators (MLIs) are robust visual indicators offering single or redundant level measurement. **ATLAS** is the basic MLI with float-based visual indication. **AURORA** provides redundant control with both float and ECLIPSE Guided Wave Radar. **ORION INSTRUMENTS** MLIs are ideal for water treatment systems, deaerators, chemical feed systems, steam boiler drums, flash tanks and condensate tanks.

Atlas™ **Aurora®**

KOTRON RF Capacitance

KOTRON RF Capacitance level switches and transmitters are available in nine different models to provide a wide range of features suitable to a broad range of applications and process media. KOTRON RF Capacitance probes are offered in many different configurations to suit the user's unique application conditions.

MODEL 804 **MODEL 805**

Enhanced JUPITER® Magnetostriction

The **JUPITER** Magnetostrictive level transmitter provides 4-20 mA output, proportional to the level being measured, or FOUNDATION fieldbus output. It is designed to attach quickly to **ORION INSTRUMENTS** MLIs or to be directly inserted into a process vessel. JUPITER offers precision accuracy and high linearity at a reasonable price.

Jupiter®

Special Application Series

*Other industry and special application brochures from **MAGNETROL** include:*

- ***Chemical***
- ***Crude Oil Processing***
- ***Flue Gas Desulfurization***
- ***Food & Beverage***
- ***Interface Level Measurement***
- ***Life Science***
- ***Mass Flow Measurement***
- ***Modular Skid Systems***
- ***Natural Gas Processing***
- ***Nuclear Power***
- ***Petroleum Refining***
- ***Power Generation***
- ***Pulp & Paper Mills***
- ***Renewable Energy***
- ***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.

Magnetrol

Worldwide Level and Flow Solutions[sm]

CORPORATE HEADQUARTERS
5300 Belmont Road • Downers Grove, Illinois 60515-4499 USA
Phone: 630-969-4000 • Fax: 630-969-9489
magnetrol.com • info@magnetrol.com

EUROPEAN HEADQUARTERS
Heikensstraat 6 • 9240 Zele, Belgium
Phone: 052 45.11.11 • Fax: 052 45.09.93

BRAZIL: Av. Dr. Mauro Lindemberg Monteiro, 185, Quadrante 16 • CEP 06278-010 • Osasco • São Paulo
CANADA: 145 Jardin Drive, Units 1 & 2 • Concord, Ontario L4K 1X7
CHINA: Plant 6, No. 191, Huajin Road • Minhang District • Shanghai 201108
DEUTSCHLAND: Alte Ziegelei 2–4 • D-51491 Overath
DUBAI: DAFZA Office 5EA 722, P.O. Box 293671 • Dubai, United Arab Emirates
INDIA: C-20 Community Centre • Janakpuri, New Delhi 110 058
ITALIA: Via Arese, 12 • 20159 Milano
SINGAPORE: 33 Ubi Avenue 3 • #05-10 Vertex • Singapore 408868
UNITED KINGDOM: Regent Business Centre • Jubilee Road • Burgess Hill, West Sussex RH15 9TL

Bulletin: 41-183.0 • Effective: January 2010