MAGNETROL®

AMETEK®
SENSORS, TEST & CALIBRATION

LEVEL AND FLOW

# INSTRUMENTS FOR FLUE GAS DESULFURIZATION

SPECIAL APPLICATION SERIES

# FGD: An Industry Perspective

The reduction of air pollution has been mandated by several Clean Air Acts beginning in 1963 and followed by major revisions and amendments throughout the successive decades. The Amendments of 1990 specifically addressed acid rain caused by sulfur dioxide ($SO_2$) emissions from fossil-fueled electric power plants and, to a lesser extent, from other industrial sources. The more stringent Phase II of this Act went into effect in 2000.

With the new emissions standards arriving at a time when energy prices and global warming dominate the news, Flue Gas Desulfurization (FGD) technology has become the hot topic of power generation. The number of FGD units operating between 1971 and 2001 grew from 40 in two countries to over 700 in 30 countries. Power plants in the U.S. are expected to spend $200 billion for FGD systems between 2005 and 2020. Of the 2.2 million megawatts of coal-fired plants in operation by 2020, two-thirds will be equipped with FGD systems.

Though many variations in the FGD process exist, approximately 85% of the units installed in the U.S. today are the wet scrubber variety. With up to 99% $SO_2$ removal efficiency, wet scrubber technology is the only practical method for treating boiler gas generated from the combustion of medium to high sulphur coal. With all the coal-fired power plants now in existence and the number of new plants in planning stages around the world, the market for FGD systems is growing rapidly.

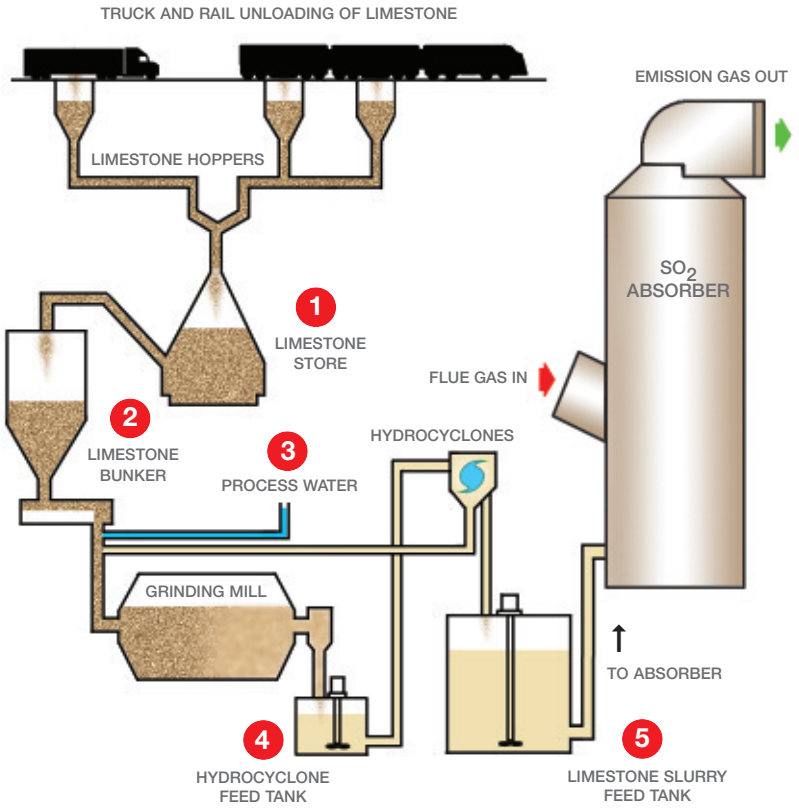
# The Wet FGD Process

Flue Gas Desulfurization is widely acknowledged as today's state-of-the art technology for removing sulfur dioxide from the exhaust flue gas in coal- and oil-fired power plants. In the "wet limestone-gypsum" form of FGD, an aqueous slurry of finely ground limestone is introduced into an absorber tower and contacted with the flue gas. The interaction results in the conversion of $SO_2$ in the gas stream into calcium sulfate, or gypsum, with carbon dioxide ($CO_2$) being routed up the stack.

As diagrammed at right, a typical FGD system consists of four units operating simultaneously: (1) Limestone Processing; (2) Gypsum Recovery; (3) Wastewater Treatment; and (4) $SO_2$ Scrubbing (or Absorption). The level and flow control applications found in these units are discussed in the pages ahead.

# 1. Limestone Processing

Limestone is the most extensively used reagent in today's utility industry. Limestone arrives by truck and train and is transferred from the limestone bunker to the ball mill where it is ground into a fine powder. The ground limestone is then transferred to the hydrocyclone feed tank where makeup water is added. The slurry proceeds to the limestone slurry storage tanks from where it enters the $SO_2$ absorber tower. There the flue gas is contacted by the limestone slurry resulting in the conversion of $SO_2$ in the flue gas to calcium sulfate, or gypsum. The gypsum is typically recovered for resale.




## Level and Flow Applications for Limestone Processing

❶ **Limestone Store** Limestone is delivered either as crushed stone or pre-ground powder. Unground limestone from road or rail hoppers is conveyed to the limestone store for storage. A limestone reclaim machine operates within this vessel.
**Point Level:** Solitel® Vibrating Rod Level Switch for bulk solids.

❷ **Limestone Bunker** Unground limestone is transferred from the limestone store to a bunker prior to its conveyance to the ball mill for grinding. The bunker is a day silo containing a 16- to 24-hour supply.
**Point Level:** Solitel Vibrating Rod Level Switch for bulk solids

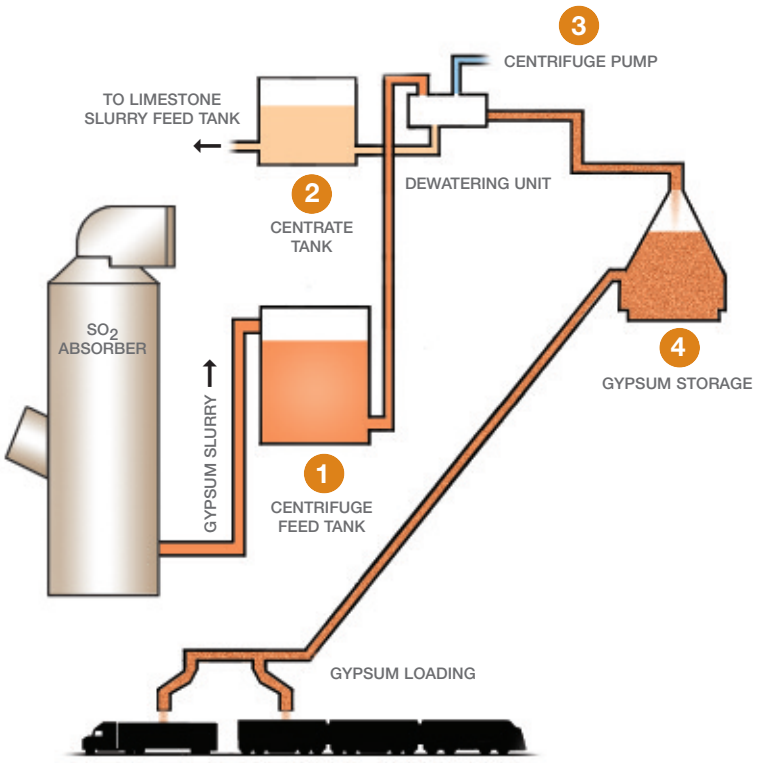
❸ **Pump Protection** Process water is added to limestone between the bunker and the grinding mill and again in the hydrocyclone feed tank. A flow switch positioned along the pump's discharge piping will actuate an alarm and shut down the pump when liquid flow drops below the minimum flow rate.
**Flow Alarm:** Thermatel® TD1/TD2 Switch for low flow cutoff

❹ **Hydrocyclone Feed Tank** Hydrocyclones separate solid-liquid suspensions through centrifugal sedimentation. An agitated hydrocyclone feed tank supplies the separator.
**Continuous Level:** Pulsar® Thru-Air Radar; Eclipse® Guided Wave Radar (GWR); or Echotel® Ultrasonic Transmitters
**Point Level:** Thermatel TD1/TD2 Switch with Spherical Tip for Hi/Low Alarm

❺ **Limestone Slurry Feed Tank** Hydrated lime stored in steel or poly tanks is kept in suspension with a slow speed mechanical agitator. The slurry fed to the absorber serves as the scrubbing reagent.
**Continuous Level:** Pulsar Thru-Air Radar; Eclipse GWR; or Echotel Ultrasonic Transmitters
**Point Level:** Thermatel TD1/TD2 Switch for Hi/Low Alarm

# 2. Gypsum Recovery

Although the FGD process was originally established for environmental purposes, a large amount of high quality, synthetic gypsum is created as a by-product of the scrubbing process. Gypsum is widely used as a source material for manufacturing wallboard and as a conditioner for agricultural soils. Because of its commercial value, most FGD systems incorporate equipment to recover, dewater and store gypsum for resale. The gypsum slurry pumped from the absorber is fed to the centrifuge feed tank. The centrifuge reduces the gypsum slurry to a dewatered cake containing less than 10 percent moisture by weight.




## Level and Flow Applications for Gypsum Recovery

❶ **Centrifuge Feed Tank** The gypsum slurry is pumped from the absorber to the centrifuge feed tank. Centrifuge operation is initiated by a level controller located in the centrifuge feed tank.
**Continuous Level:** Eclipse GWR; or Pulsar Thru-Air Radar Transmitters

❷ **Centrate Tank** The gypsum slurry stream (centrate) produced in the gypsum dewatering operation is routed for residence in a centrate tank prior to its introduction into the limestone slurry feed tank to serve as an additive.
**Continuous Level:** Eclipse GWR; Pulsar Thru-Air Radar; Echotel Ultrasound; Kotron® RF Capacitance; or E3 Modulevel® Displacer Transmitters
**Point Level:** Echotel Ultrasonic Switch; Kotron RF Capacitance Switch; or Float and Displacer Switches

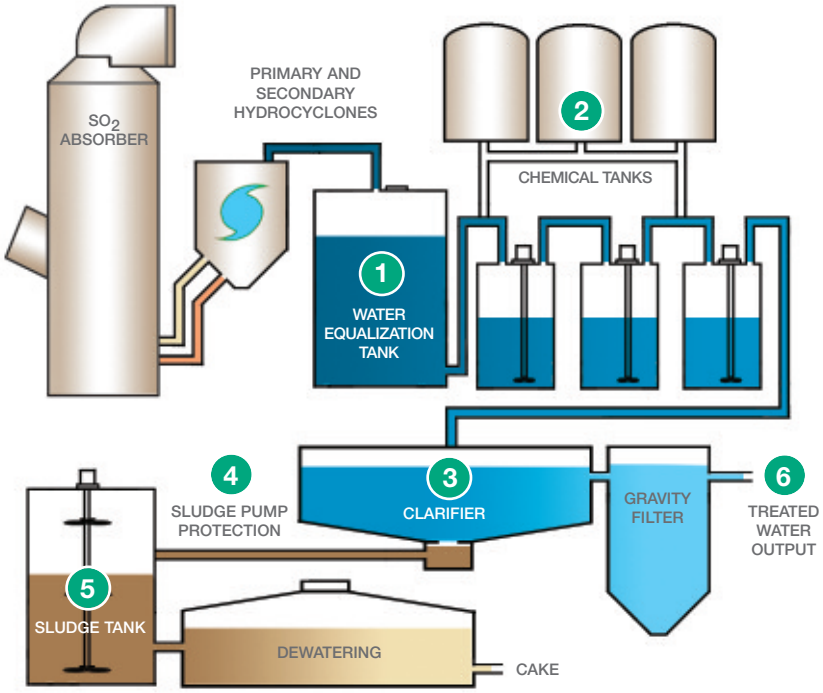
❸ **Centrifuge Pump Protection** Process water is added to the gypsum dewatering centrifuge. A flow switch along the pump's discharge piping will actuate an alarm and shut down the pump when liquid flow drops below the minimum flow rate.
**Point Level:** Thermatel TD1/TD2 or F10 Mechanical Flow Switch

❹ **Gypsum Storage** Dewatered gypsum is transferred to a gypsum storage vessel equipped with a gypsum reclaim machine. The gypsum may later be transferred to a storage shed.
**Point Level:** Solitel Vibrating Rod Level Switch for bulk solids

A front-end loader fills a dump truck with gypsum.

# 3. Wastewater Treatment

A dedicated wastewater facility properly integrated with the FGD scrubber operation is typically required to meet the very strict wastewater discharge requirements that ensure water returned to the source will meet quality standards set by the regulatory authority. A well-designed treatment facility includes a number of technologies such as lime neutralization, gypsum desaturation, clarification, filtration, biological treatment, and sludge thickening and dewatering.




## Level and Flow Applications for Wastewater Treatment

❶ **Water Equalization Tanks** Wastewater is held in the equalization tank to allow solids to begin settling and to help maintain a more constant flow rate through the treatment unit.
**Continuous Level:** Eclipse GWR; Pulsar Thru-Air Radar; Echotel Ultrasound; Kotron RF Capacitance; or E3 Modulevel Displacer Transmitters
**Point Level:** Echotel Ultrasonic Switch; Kotron RF Capacitance Switch; or Float and Displacer Switches

❷ **Chemical Storage Tanks** An array of chemicals are added from feed tanks to facilitate processing, adjust water quality and chemistry, and inhibit corrosion, scaling, or other conditions.
**Continuous Level:** Eclipse GWR; Pulsar Thru-Air Radar; Echotel Ultrasound; Kotron RF Capacitance; Enhanced Jupiter® Magnetostrictive; or E3 Modulevel Displacer Transmitters
**Point Level:** Echotel Ultrasonic Switch; Kotron RF Capacitance Switch; or Float and Displacer Switches

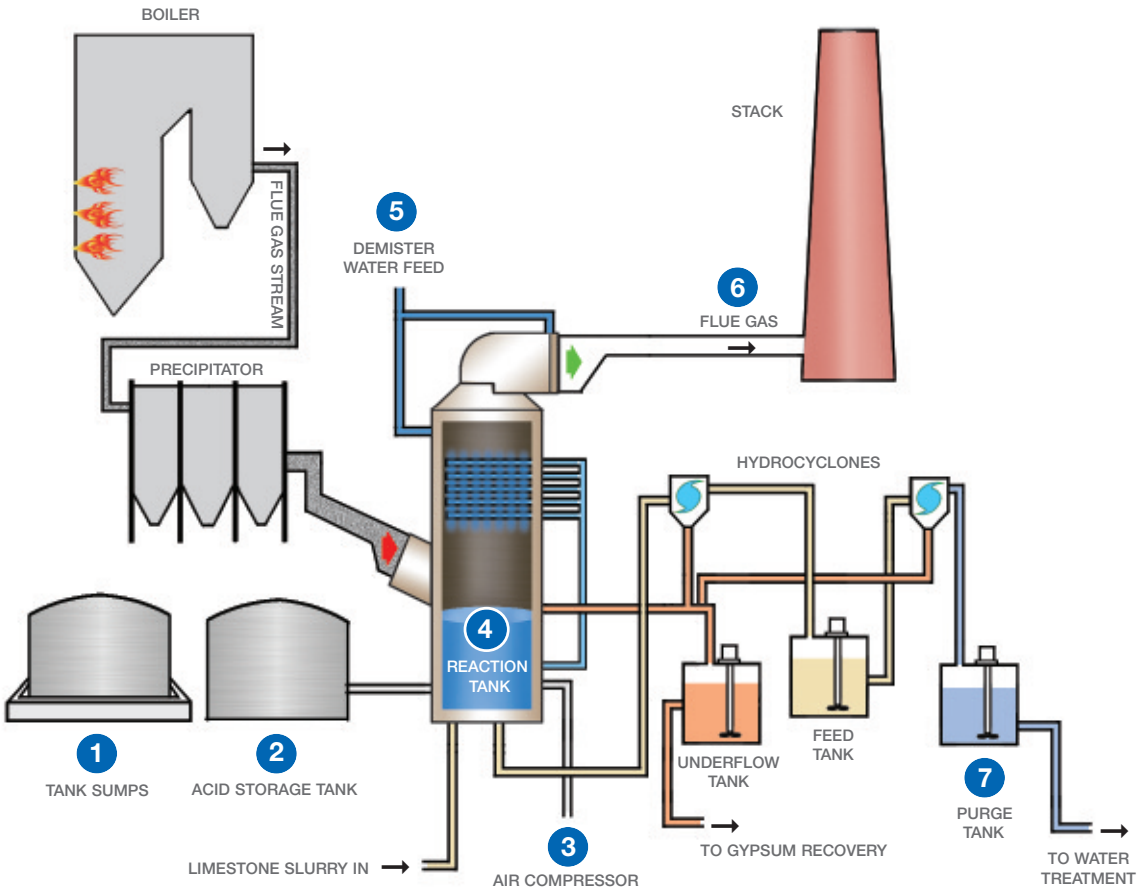
❸ **Clarifier Level** Wastewater influent slowly passes through clarifiers where sludge settles and floating material can rise to the surface to be skimmed off. The sludge is pumped away for further treatment.
**Continuous Level:** Echotel Ultrasonic; Kotron RF Capacitance; or Echotel Non-Contact Transmitters

❹ **Sludge Output Pump Protection** A flow switch along the pump's discharge piping will actuate an alarm and shut down the sludge pump when liquid flow drops below the minimum flow rate.
**Flow Alarm:** Thermatel TD1/TD2 Switches

❺ **Sludge Tank Level** Sludge that settles at the bottom of the clarifier is pumped to a sludge tank where level is monitored to control against incomplete discharge or dilution of the sludge.
**Continuous Level:** Eclipse GWR; or Echotel Ultrasonic Transmitters

❻ **Treated Water Output** Flow measurement is accomplished by a transmitter programmed to convert a level reading into "units of volume per time" as liquid passes through a flume or weir in an open channel.
**Continuous Level:** Echotel Non-Contact Ultrasonic Transmitters

# 4. $SO_2$ Absorption




## $SO_2$ Absorption System

The $SO_2$-laden boiler flue gas stream passes through the electrostatic precipitators and into the absorber column. Inlet wash water used to prevent a buildup of solids in the inlet duct cools the flue gas as it enters the absorber.

The $SO_2$ absorption process begins as the flue gas is scrubbed by the recirculating limestone slurry that also washes out the remaining pulverized fuel ash. (When particulate content of the gas is very high a venturi scrubber may be necessary to remove residual particles.) The reagent suspension used in the scrubbing process is water containing approximately 20% fine-grained limestone. The slurry is pumped from the bottom of the absorber and is sprayed downward from nozzles arranged at separate levels in the absorber tower. Process chemistry transforms the recirculating slurry into gypsum and a portion of it is continuously pumped away to the primary and secondary hydrocyclones for separation and dehydration.

Water removed from the scrubber purge stream is then pumped to the water treatment unit.

## Level and Flow Applications for the $SO_2$ Absorption System

❶ **Sump Overflow and Leak Detection** Small sumps are positioned under tanks plantwide to contain leaks or spills. Sumps also contain leaks from pumps, valves, and pipelines.
**Point level:** Top Mounting Displacer Switch; Echotel Ultrasonic Switch; Float-actuated Flood Level Switch; Thermatel TD1/TD2 Switch with a Spherical Tip; or Kotron RF Capacitance Switch

❷ **Dibasic Acid (DBA) Storage Tank** Organic acid additives improve scrubbing efficiency and reliability, and reduce tower operating cost. DBA is typically stored in a heated, agitated tank from where the acid is fed into a limestone slurry tank or directly into the scrubber.
**Continuous Level:** Pulsar Thru-Air Radar with a 4-inch horn; or Eclipse Guided Wave Radar

❸ **Oxidation Air Compressor** The FGD absorber is equipped with an oxidation air system to provide oxidation air for the absorber vessel.
**Continuous Flow:** Thermatel TA2 Mass Flow Transmitter
**Flow Alarm:** Thermatel TD1/TD2 Switch; or Model F10 Mechanical Flow Switch for low flow cutoff

❹ **Absorber Reaction Tank** The recycle slurry falls from the spray zone into the reaction tank located at the base of the absorber. This tank is sized to provide sufficient residence time for all of the gypsum precipitation and limestone dissolution reactions to take place.
**Continuous Level:** Pulsar Thru-Air Radar equipped with a 4- or 6-inch horn and mounted within a 30- to 40-foot stilling well; Eclipse GWR with a flexible probe; or Kotron RF Capacitance with a flexible probe (least recommended, but commonly used on this application).

❺ **Demister Water Feed** Process water flow to the demister affects the continuous and reliable running of the FGD system. Interrupted water feed can not only stop the FGD system but also shut down the power generating unit.
**Flow Alarm:** Thermatel TD1/TD2 Switch or Model F10 Mechanical Flow Switch for low flow cutoff

❻ **Flue Gas** Treated gas passes from the absorber through outlet dampers and into the chimney where the off-gases are discharged directly to the atmosphere. A mass flow meter may be used to measure the treated gas flow.
**Continuous Flow:** Thermatel TA2 Mass Flow Transmitter

❼ **Absorber Purge Tank and Wastewater Outlet** After the slurries pass through the hydrocyclones, wastewater is purged in the absorber purge tank to avoid accumulation of impurities in the system. The wastewater is then routed to water treatment for processing.
**Continuous Level:** Eclipse GWR; Pulsar Thru-Air Radar; Echotel Ultrasound; Kotron RF Capacitance; Jupiter Magnetostrictive; or E3 Modulevel Transmitters.
**Point Level:** Float and Displacer Level Switches
**Flow Alarm:** Thermatel TD1/TD2 Switch; or Model F10 Mechanical Flow Switch

# Special Application Series

## **Instrumentation** from Magnetrol®

### 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, this leading-edge transmitter provides measurement performance well beyond that of many traditional technologies. Available with HART®, FOUNDATION fieldbus™ and PROFIBUS® outputs

### Thru-Air Radar

Pulsar Pulse Burst Radar level transmitters are the latest generation of loop-powered, 24 VDC, liquid level transmitters. They offer lower power consumption, faster response time and are easier to use than most loop-powered radar transmitters. Pulsar is available in a dielectric rod or horn antenna style.

### Float & Displacer

Float-actuated switches are available in top-mount and side-mount styles for high or low level alarm, interface, and pump control applications.Top-mounting displacer type level switches offer the industrial user a wide choice of alarm and control configurations. Displacer based electronic and pneumatic transmitters offer 4-20 mA or HART output.

### Ultrasound

Echotel contact and non-contact ultrasonic level transmitters and switches are available in a range of models to provide users with the features and options suitable for their specific application. The Models 961 single point and 962 dual point switches are available with relay or current shift electronics.

### Thermal Dispersion

Thermatel Models TA1 and TA2 Mass Flow Transmitters provide reliable mass measurement for air and gas flow applications. Thermatel switches provide a high level of performance in flow, level and interface applications for air, gas and liquids. A hygienic version of the TD2 switch is available for sterile, Clean-In-Place applications.

### Visual Indication

Atlas™, Aurora® and Gemini are magnetically coupled liquid level indicators precision engineered and manufactured to provide accurate, reliable, and continuous visual level indication. Aurora provides redundant control with both a float and an Eclipse Guided Wave Radar transmitter.

### RF Capacitance

Kotron RF Capacitance level switches and transmitters are available in various models providing a wide range of features to suit a wide array of applications and process media.

### Vibrating Rod

Solitel Vibrating Rod Level Switches provide reliable level detection of powders and bulk solids. This compact, integral switch is suitable for high or low level detection in hoppers or silos.

### Magnetostriction

The Enhanced Jupiter magneto-strictive transmitter provides a 4-20 mA output proportional to the level being measured or Foundation fieldbus™ output. May be externally mounted to a MLI or inserted directly into the process vessel.

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

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