AN INTRODUCTION TO THE
WAHLCO SO_3 FLUE GAS CONDITIONING SYSTEM

The Wahlco SO_3 Flue Gas Conditioning (FGC) System allows plants to use existing precipitators to clean flue gas generated from burning low-sulfur coal – eliminating the need to install larger and more costly precipitators.

Overview

The Process

When coal is burned the sulfur component combines with oxygen in the air to form sulfur dioxide. A small percentage of this sulfur dioxide is further oxidized in the boiler to sulfur trioxide. Sulfur trioxide combines with moisture in the flue gas to form sulfuric acid, which condenses on the surface of the fly ash particles. The sulfuric acid forms a conductive film on the fly ash surface that lowers its' resistivity, which is required for efficient precipitator operation.

With high sulfur coals the amount of sulfur trioxide formed is sufficient for effective precipitator collection. However, when low sulfur coal is burned, the fly ash produced has an excessively high resistivity — reducing precipitator efficiency below acceptable levels. This requires the installation of either larger precipitators or a more cost-effective SO3 flue gas conditioning system that adds a controlled amount of sulfur trioxide to the flue gas stream thus reducing the fly ash resistivity to an optimum level for maximum precipitator efficiency.

Basic Site Requirements

The plant provides saturated steam, electrical power, instrument air, Wahlco designed interconnection piping (requirements vary per installation), and a boiler load signal that is proportional (0-100%) to the rate of coal combustion.

The Wahlco Molten Sulfur SO_3 FGC System

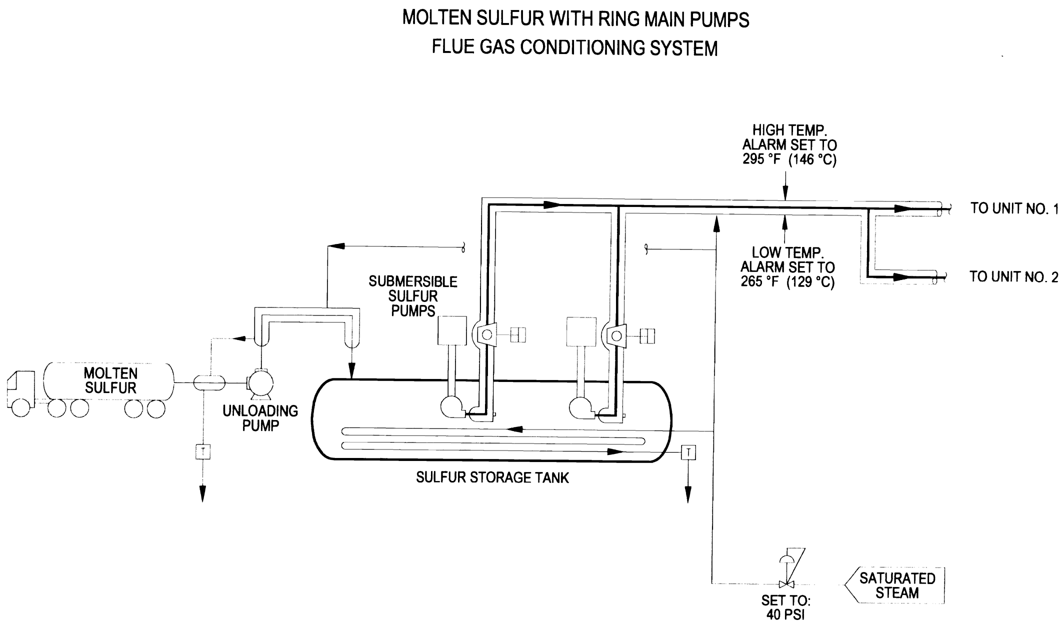
The basic FGC system consists of three main sub-systems:

- Molten Sulfur Storage and Pumping System
- Sulfur Metering, Burning and Sulfur Trioxide Generation System
- Flue Gas Duct SO_3 Delivery and Injection Grid System

Automated system components are controlled by an Allen-Bradley Logic Controller (SLC/PLC), with local operator control and monitoring through a Human Machine Interface (HMI) system capable of station DCS interface communications.

Molten Sulfur Storage and Delivery sub-system

This sub-system consists of a steam-heated storage tank and equipment to safely unload, monitor, and deliver sulfur to the individual unit system skids.



Sulfur Unloading

Sulfur is unloaded from the delivery truck through a 3-inch steam-jacketed ball valve and fill-line that connects to an entry point on the top of the sulfur storage tank. Molten sulfur is unloaded by either a steam-jacketed positive displacement gear pump or by pressurizing the delivery truck tank.

Typically, the sulfur delivery tanker supplies a flexible hose with a 3-inch ACME fitting for connection to the storage tank fill point. An optional steam-jacketed unloading hose is available from Wahlco. A 3/4" steam supply hose is connected between the storage tank steam supply valve and the tanker.

The unloading process is monitored by a Level Transmitter that provides the control system with Sulfur Storage Tank level information. To prevent sulfur overflow, a high-level alarm activates whenever the tank level reaches a pre-set limit — a local alarm horn sounds to alert unloading personnel and a 4-20 mA signal is sent to the control system for monitoring.

Sulfur Storage

Unloaded sulfur is stored in a horizontal cylindrical tank that has a covered vent, two submersible sulfur feed pumps, a level indicator, a steam (fire extinguisher) line, and an access manway. Four steam coils (includes 100% spare design capacity) that use plant supplied saturated steam provide heat to keep the sulfur in a molten state. Access to these internal steam coils is located at one end of the tank.

A temperature indicator is used to locally monitor the tank temperature, while thermocouples provide the system with temperature signals for remote monitoring and control.

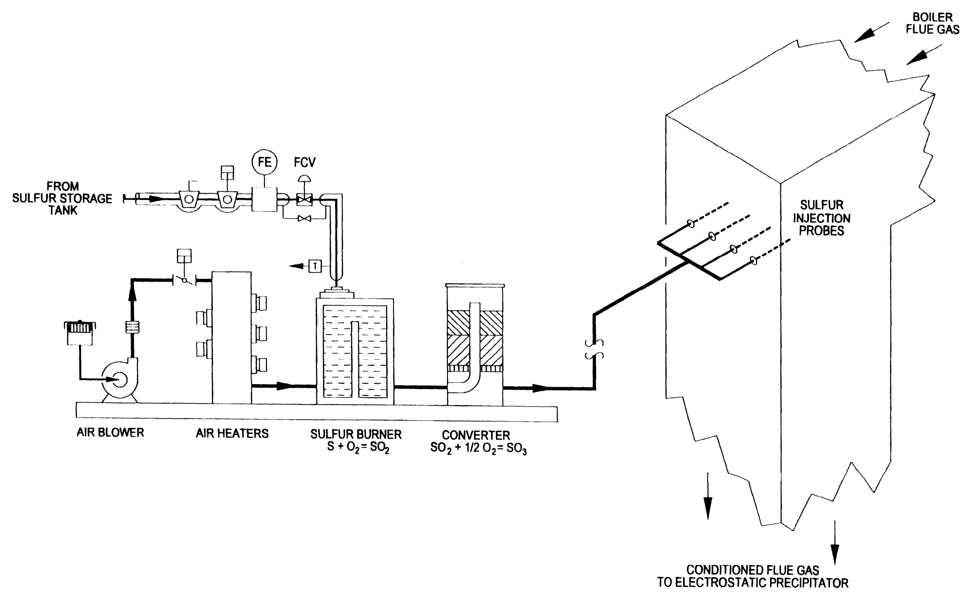
Sulfur Delivery

The molten sulfur in the storage tank is pumped through steam-jacketed piping to multiple system skids, using one of the two submersible-centrifugal feed pumps mounted on top of the storage tank. Both pumps are sized to provide a flow rate above the requirements for all units — resulting in faster startups.

Either pump can be started or stopped via system controls. One pump is designated a “duty pump,” while the other remains on stand-by. Each pump has an assoiated three-position switch (hand, off, and auto) that allows the stand-by pump to be manually operated for verification without interrupting operations. An orifice at each pump’s discharge casing continuously bleeds the minimum flow of molten sulfur required for proper pump operation — the pumps can be run “dead-head” without any flow demand.

Each pump is driven by a simple 3-phase AC constant speed motor. The drive shaft connecting the pump head and motor assembly is steam-jacketed to keep the molten sulfur at the correct temperature. Each pump has an automatic isolation valve that is directly connected to that pump’s motor starter; when the pump is started, the associated valve opens to allow sulfur to flow from the storage tank to the system skid(s).

SULFUR BURNER SKID
SO_3 FLUE GAS CONDITIONING SYSTEM



Metering and Sulfur Trioxide Generation sub-system (System Skid)

Each System Skid provides molten sulfur flow-metering, SO_2 generation through oxidation (burning) of Sulfur, and SO_3 generation through further oxidation of generated SO_2, using the following major components:

- Sulfur Flow Metering (Coriolis mass flow meter, flow control valve, and shut-off valve)
- SO_2 Generation (Forced Air Blower / Heater and Sulfur Burner Box)
- SO_3 Generation (Catalytic Converter)

All sulfur piping is steam-jacketed and thermally insulated. The sulfur flow meter and control valve are steam-jacketed to maintain proper molten sulfur temperature.

Sulfur Flow Metering

Molten sulfur is pumped to the system skid under constant pressure, where a steam-jacketed Coriolis mass flow meter, flow control valve, and an automated shut-off valve control the rate of flow of molten sulfur to the burner box.

Process control uses either an operator set input value (% of unit design sulfur flow) or an SO_3 ppmv setpoint. When the system is in auto mode (using an SO_3 setpoint), the control system calculates the sulfur flow rate using a plant supplied "linear" signal multiplied by the desired SO_3 injection concentration (ppmv). This supplied "linear" signal is essentially the system flue gas flow rate; i.e.: as the flue gas flow rate changes, the actual SO_3 ppmv remains constant. When plant conditions require changes in the injection rate, the unit control system automatically limits the rate at which a change can be made thus preventing a system upset.

Optional biasing control is available for adjusting the desired SO_3 ppmv as a function of flue gas SO_2 content and/or temperature. Biasing provides increase metering accuracy in installations that have unique conditions or special operational requirements.

Process Air Flow and Heating

A multi-stage constant speed centrifugal blower forces air through a heater box, the sulfur burner box, and converter, eventually delivering SO_3 to the flue gas duct. The heater box heats the air using Thyristor-controlled electric heaters.

The blower is driven by a simple 3-phase AC constant speed motor. An inlet filter/silencer reduces airborne contaminants and noise. The blower bearings are greased or oil lubricated.

The air heater box is a welded internally insulated fabrication unit that stands vertically on the skid. Five(5) horizontally opposing electrical heating units are flange mounted in the heater box. Air forced through the heater box is heated to the pre-set SO_3 converter inlet control temperature. The heaters are regulated by a solid state Thyristor that maintains the converter inlet temperature at the setpoint regardless of the sulfur feed rate.

Air flow is automatically controlled using an air flow transmitter and modulating control valve.

Sulfur Burning

The molten sulfur burning box is downstream from the air heater box. The burner box outer shell is constructed of carbon steel and the interior is lined with 2600 °F firebrick.

The molten sulfur enters from the top of the burner box and strikes a leveled firebrick splash block, which is located in the upper part of a firebrick constructed "checker work." The checker work below creates turbulence to assure total combustion of the sulfur/air mixture. A viewing port is provided to visually monitor sulfur flame as the molten sulfur falls onto the splash block.

Hot air from the air heater box raises the burner box temperature above the auto-ignition point of sulfur. At this point, sulfur burns and forms the first oxidation product — sulfur dioxide. As the sulfur burn rate increases, the heater output decreases. When the heater output is zero and the sulfur burn rate continues to increase, the temperature is controlled by increasing the air flow (air quenching).

Once the sulfur burning process has started, sulfur will continue to burn as long as air (oxygen) and a source of heat are available. Shutdown of the unit is gradual and requires as much as a half-hour to burn the residual sulfur in the burner box.

Sulfur Trioxide Generation

The last stage before injection is the conversion of the generated sulfur dioxide into sulfur trioxide. This final conversion process is accomplished using a vanadium Pentoxide dual-layer catalytic converter that provides ample residence time and active sites for SO_2 to SO_3 an exothermic conversion reaction. The dual layer catalyst material is contained within a fixed bed in the 304 stainless steel converter vessel. The vessel is thermally insulated to minimize heat loss. When in full operation, the catalytic converter has a minimum overall efficiency (SO_2 to SO_3) of 95%.

Hot Gas Piping Purge System

A hot gas pipe purge valve with a pneumatic actuator and dual limit switches is located at the converter outlet. The purpose of the purge air is to keep the injection probe nozzles clear of ash build-up when the system is not running. The purge valve will open when the system is shut down — allowing ambient air to flow through the injection piping. With flue gas ducts operating at positive pressure, the purge system is supplied with a small purge blower to assure air flow through the hot gas piping and injection probe nozzles.

Sulfur Trioxide Hot Gas Piping and Injection Grid sub-system

The final component of the Wahlco Flue Gas Conditioning System is the Injection Grid. At the injection grid, the SO_3 is uniformly injected into the boiler flue gas stream via specifically designed and spaced 304 stainless steel injection probes.

Since the system is designed to deliver SO_3 to the flue gas duct well above the condensation point of SO_3, the sulfur trioxide/air mixture is transported through a 304 stainless steel hot gas piping and manifold system. The piping is thermally insulated to minimize heat loss and prevent the formation of sulfuric acid condensate, which could cause corrosion. This hot gas piping complies with the ANSI B31.3 Piping Code at operating temperatures.

All injection probes are supplied with duplex thermocouples. The thermocouple cables from the injection probes are routed to the unit's System Skid Control Panel for injector probe temperature monitoring.

WAHLCO ADVANTAGES

- Quick startup
- Precision metering and delivery of molten sulfur
- Internally insulated air heater boxes - reduces structural heat stress
- Flexible control system design – operates with virtually any PLC or plant DCS system
- High SO3 conversion efficiency – utilizes low S02 concentrations (3.75% max) and a unique internal gas path (inlet gas travels up through the center of the vessel)

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