1. INTRODUCTION

1.1 General Information and References

Refer to the following documents for detailed information such as the process flow rates, instrument tag numbers and alarm set points.

Description	Document Number
PFD's	100319-93020010-12
P&ID Drawing List	100319-94900001
P&I D's, SCR Systems	100319-94900002-00090
P&I D's, Turbosorp Systems	100319-104900070-00099
Functional Description, SCR Reactor	100319-9022000
Functional Description, Ammonia Unloading and Storage	100319-9022100
Functional Description, Ammonia Injection	100319-9022200
Functional Description, E-Stop	100319-9022600
Functional Description, Sonic Horns	100319-9022800
Functional Description, Turbosorp System	100319-100201110
Functional Description, Hydrated Lime	100319-100201130
Functional Description, Process Water	100319-100201140
Functional Description, Baghouse	100319-100201150
Functional Description, Product Recirculation and Disposal	100319-100201160
Functional Description, Booster Fan	100319-100241000
Manual Valve List	100319-10490410
Actuated Valve List	100319-10490411
Instrument List	100319-10490420
Alarm List	100319-10490480
Functional Description, SCR Reactor	100319-100201110
Functional Descriptions, Turbosorp Systems	100319-100201140
Analog Logic Drawing List	100319-94915000
Analog Logic Drawings, SCR Systems	100319-94915014-16014
Analog Logic Drawings, Turbosorp Systems	100319-104915011-15064
Binary Logic Drawing List	100319-94920000
Binary Logic Drawings, SCR Systems	100319-94920004-27020
Binary Logic Drawings, Turbosorp Systems	100319-1049221005-21092
Vendor O&M Manuals	

1.2 Multi-Pollutant Control System Overview

The Westover Unit 8 Multi-Pollutant Control System (MPCS) is designed to reduce SO_2 and acid gas emissions by 95%, while reducing the outlet NO_X concentration to 0.10 lb/MBtu, and particulate concentration to 0.015 lb/MBtu. The MPCS consists of a Selective Catalytic Reduction (SCR) system for NO_X removal, a Turbosorp® Circulating Dry Scrubber(CDS) for removal of SO_2, SO_3, HCl, and HF,. and a baghouse for particulate removal. The system is shown on Process Flow Diagrams, Drawings 100319-93001010 and 100319-93001011.

Aqueous ammonia solution is injected into the flue gas downstream of the economizer and distributed uniformly in the flue gas using the Delta Wing® static gas mixing system. The flue gas then passes through two layers of catalyst in the SCR reactor. The ammonia and NO_x react to nitrogen and water within the catalyst.

The Turbosorp® CDS system is located downstream of the air heater. Flue gas entering the reactor is cooled with a water spray, and dry hydrated lime is injected pneumatically into the reactor. The system includes the reactor vessel, hydrated lime storage and injection, water injection, product recycle, and a flue gas recycle.

The dust-laden flue gas from the Turbosorp® reactor flows through the bag house. The dust is collected in two air slide conveyors under the bag house. Most of the ash and lime is recycled back into the Turbosorp® reactor vessel via the air slide conveyors. A dosage valve is used to control the ash recycle rate, based on the pressure drop across the Turbosorp® reactor. The excess ash for disposal is transferred to surge bins and then pneumatically conveyed to the existing main plant storage silo.

A booster fan after the baghouse offsets the additional system pressure drop due to the SCR, the Turbosorp® reactor, and the baghouse. At reduced loads a portion of flue gas from the booster fan outlet is recycled to the Turbosorp® reactor vessel inlet, to maintain minimum fluidization velocity. The discharge of the booster fan is connected to the suction of the existing ID fans.

1.3 Operation Modes

Automatic Operation - Equipment to be operated in automatic operation mode will be selected and controlled from the control room DCS operator station. In this mode, regulation of all control loops, start-ups, and shutdowns are done by the DCS with all permissives and interlocks in place.

Manual Operation - Equipment to be operated in a manual operation mode will be selected and operated from the control room DCS operator station. The operator will regulate and supervise the start-up and shutdown operation of the equipment via the control room DCS operator station unless otherwise noted. In this mode, while the operator manually carries out each step of the operating sequence or control loop, the safety permissives and interlocks only will remain in effect via the DCS system.

2. Process Chemistry

2.1 NOx Removal

The Selective Catalytic Reduction process converts the NO_x contained in the flue gas into nitrogen (N_2) and water (H_2O) with the use of ammonia (NH_3) as the reduction agent. The basic reactions are the following:

1. $4NO + 4NH_3 + O_2 \text{ ---> } 4N_2 + 6H_2O$
2. $2NO_2 + 4NH_3 + O_2 \text{ ---> } 3N_2 + 6H_2O$

The following side reactions may occur on a small scale:

3. $4NH_3 + 3O_2 \text{ ---> } 2N_2 + 6H_2O$
4. $4NH_3 + 5O_2 \text{ ---> } 4NO + 6H_2O$

2.2 SO_2 Removal

In the Turbosorp® dry scrubber system, the acidic constituents of the flue gas, primarily SO_2 and SO_3, and to a lesser extent CO_2, HCl and HF, are removed by reaction with hydrated lime. The dominant Turbosorp® equations are as follows:

$$Ca(OH)_2 + SO_2 \leftrightarrow CaSO_3 * \tfrac{1}{2}H_2O + \tfrac{1}{2}H_2O \qquad (1)$$

$$Ca(OH)_2 + SO_3 \leftrightarrow CaSO_4 * \tfrac{1}{2}H_2O + \tfrac{1}{2}H_2O \qquad (2)$$

$$CaSO_3 * \tfrac{1}{2}H_2O + \tfrac{1}{2}O_2 \leftrightarrow CaSO_4 * \tfrac{1}{2}H_2O \qquad (3)$$

$$Ca(OH)_2 + CO_2 \leftrightarrow CaCO_3 + H_2O \qquad (4)$$

$$Ca(OH)_2 + 2HCl \leftrightarrow CaCl_2 + 2H_2O \qquad (5)$$

$$Ca(OH)_2 + 2HF \leftrightarrow CaF_2 + 2H_2O \qquad (6)$$

To assure a high level of removal and lime utilization, the solid products exiting the Turbosorp® reactor vessel: flyash, adsorbent, activated carbon, and reaction products $CaSO_3$, $CaSO_4$, $CaCO_3$, $CaCl_2$ and CaF_2, are separated from the flue gas in the baghouse and recycled to the vessel inlet at a high ratio to the inlet solids.

3. Subsystem Process Description

3.1 Selective Catalytic Reduction

3.1.1 Aqueous Ammonia Tank

The aqueous ammonia system is comprised of truck loading station and an aqueous ammonia storage system to store 19 wt.% ammonia. It includes one (1) ASME Section VIII 15,000 gallon storage tank that is sized for a minimum of 10 days usage. The ammonia is delivered to the process using 2 x 100% pumps. The pumps supply ammonia to an injection skid that meters the ammonia and atomizing air to the dual fluid nozzle injection system and provides safety trip protection for the system. The ammonia is injected into nozzles which incorporate added heated air enhancing water evaporation minimizing local ash build-up at the nozzle penetrations. The flow control regulates the ammonia injected to the SCR reactor based on demand using the difference of inlet and outlet NO_x measurements, flue gas flow rate and removal rate set point..

3.1.1 Flue Gas and SCR Reactor

The catalyst bed is a titanium-tungsten-based material that is highly reactive to NO_x with a high geometric surface area per unit volume. The catalyst is assembled in steel modules that are arranged in the down flow SCR reactor to efficiently contact the flue gases during operation. The Westover Station design has a single SCR reactor with two catalyst modules layers both in a 9 x 3 two-layer arrangement. The catalyst selected for the project has an overall SO_2 to SO_3 conversion rate of 0.6% with both layers full. The outlet NO_x concentration of the SCR reactor is 0.10 lb/MMBtu is emission for 30day rolling average.

To prevent ash buildup on top of each of the two catalyst layers are two sonic horns per layer. Comprising four (4) sonic horns in total.

3.2 Turbosorp® Flue Gas Desulfurization (FGD)

3.2.1 Turbosorp® Reactor Vessel

The Turbosorp® Dry Scrubber is installed down stream of the air heater. In this system, the acidic constituents of the flue gas, primarily SO_2 and SO_3 and to a lesser extent, CO_2, HCl and HF, are removed by reaction with hydrated lime. To assure a high level of removal and lime utilization, the solid products exiting the Turbosorp® reactor vessel (flyash, adsorbent, and reaction products) are separated from the flue gas downstream in the baghouse and recycled to the vessel inlet at a high ratio to the inlet solids.

At the inlet of the Turbosorp® reactor vessel, flue gases pass through a horizontal duct and a 90° turn in gas path. At this bend at the bottom of the Turbosorp a flyash hopper collects any ash that may fall out. Once flowing in the vertical direction the flue gas passes through a Venturi nozzle, which serves to accelerate the flue gas just prior to the injection of high-pressure water, recycled solids and adsorbent. Water is added to bring the flue gas closer to the saturation temperature where the SO_2 absorption is most effective. The reactor acts as a fluidized bed, assuring maximum contact between the pollutants in the flue gas and the adsorbent solids.

3.2.2 Adsorbent Storage and Injection

Hydrated lime $Ca(OH)_2$) is the adsorbent used in the Turbosorp® process. Hydrated lime of required quality is delivered by truck periodically.

A storage silo is provided to receive hydrated lime pneumatically using the truck's unloading system. From the storage silo, the hydrated lime is conveyed pneumatically to the Turbosorp® vessel.

The amount of fresh adsorbent sent to the Turbosorp® is controlled by the inlet and outlet SO_2 monitors. As SO_2 concentrations increase at the inlet, more lime is added to the reactor. The process is fine-tuned by a feedback control loop that narrows the process conditions to the desired outlet SO_2 emissions.

3.2.3 Water Injection

Atomized water is injected into the Turbosorp® FGD Reactor. This atomization is accomplished by means of a high-pressure back flow nozzle, which is supplied by high-pressure pumps that increase the pressure of the water to more than 500 psi. The amount of water injected is controlled by the flue gas mass flow rate and Turbosorp® inlet temperature.

3.3 Particulate Removal

3.3.1 Baghouse

The dust-laden flue gas from the Turbosorp® reactor flows through the baghouse, where the dust is collected on the filter bags. The flue gas flows horizontally through the inlet plenum, through the filter bags and to the outlet plenum.

The particulate is collected on the outside of the bags. The filter bags are cleaned automatically, causing the accumulated ash to fall to the hoppers.

3.3.2 Ash Recycle and Disposal

The particulate that falls into the baghouse hoppers is collected in a product recycle hoppers. Each of the two air slide conveyors is used to recycle the ash back to the Turbosorp® reactor. The conveyor consists of a sloped piece of ductwork with a thick fabric material dividing the top portion of the duct from the lower half. A blower provides air along the lower half of this air slide that fluidizes the solids and permits them to flow by gravity back toward the reactor vessel. A significant portion of the ash and lime is recycled back into the Turbosorp® reactor vessel. A dosage valve is used to control the ash recycle rate, based on the pressure drop across the Turbosorp® reactor. The excess particulate for disposal is removed from the recycle hopper to-a surge bins, and then pneumatically conveyed to the existing ash handling silo system.

3.4 Booster Fan

A booster fan is provided to serve two functions. It provides the additional motive force to overcome the additional pressure drop imposed on the system by the addition of the SCR, the Turbosorp® system and the Baghouse. It also allows the Turbosorp® system to operate at reduced Unit loads by recycling a portion of flue gas from the Baghouse outlet to the Turbosorp® reactor vessel inlet thereby keeping the solids bed in the vessel fluidized. The discharge of the booster fan is connected to the suction of the existing ID fans.