

## SO<sub>2</sub> TRAINING MANUAL

### GLOSSARY

**Absorption** - The operation in which one or more soluble components of a gas mixture are dissolved in a liquid.

**Acid Rain** - Precipitation containing harmful amounts of nitric and sulfuric acids formed primarily by nitrogen oxides and sulfur oxides released into the atmosphere when fossil fuels are burned. Acid rain has a pH below 5.6 which is slightly acidic.

**Additive** - Substance added to a liquid or gas stream to cause a chemical or physical reaction to enhance SO<sub>2</sub> sorption.

**Adipic Acid** – An organic acid used as a performance enhancing chemical in absorber towers.

**Adsorption** - The operation in which a solid substance retains on its surface a layer of gaseous or liquid substance by which gas molecules are selectively removed from a gas stream.

**Allowance** - One SO<sub>2</sub> allowance permits one ton of SO<sub>2</sub> emissions.

**Anthracite** - A hard, black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of fixed volatile matter. Anthracite contains approximately 22 million to 28 million Btu per ton.

**Apex** – The tip, point, vertex; the narrowest point at the bottom of a hydroclone or thickener.

**Ash** - Impurities consisting of silica, iron, alumina, and other noncombustible matter that are contained in coal. Ash content is measured as a percent by weight of coal on an "as received" or a "dry" (moisture-free, usually part of a laboratory analysis) basis.

**Baghouse (Fabric Filter)** - A fabric filter that collects the dry particulate matter as the cooled flue gas passes through the filter material

**Ball Mill** - Equipment used for pulverizing limestone as well as for slaking of lime. It consists of a rotating cylindrical or conical casing charged with metal balls or slugs along with water and the material to be pulverized or slaked.

**Bituminous Coal** - The most common coal. It is dense and black (often with well-defined bands of bright and dull material). Its moisture content usually is less than 20 percent. It is used for generating electricity, making coke, and space heating. The contents of bituminous coal range from 19 million to 30 million Btu per ton.

**Blinding** – Having no opening, closed at one end (such as covering the pores in a porous material).

**Boiler** - A device that generates steam for power. Heat from an external combustion source is transmitted to a fluid contained within the tubes in the boiler shell. This fluid is delivered at a desired pressure, temperature and quality.

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**Breeching** – The rectangular opening in a chimney wall where a duct enters the chimney.

**Btu (British Thermal Unit)** - A standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

**Buffering** – When a substance in solution has the ability to react with and neutralize large amounts of acid, thus preventing the pH from changing substantially with small additions of acid.

**By-product** - Saleable or usable product that has some economic value.

**Cake** – The layer of solids left on a filter cloth once the liquid has been drawn out of a slurry using vacuum.

**Calcination** – To change or burn to a powder using heat, such as changing limestone into lime in a kiln.

**Centrifuge** – A device which separates the phases in a composite fluid stream by applying centrifugal motion to the stream and forcing the higher density component to the outside wall of the device where it is collected.

**Chimney Rain-out** – A condition where moisture droplets leave a chimney plume and fall to the ground in the area around the chimney.

**Clarifier** – A large tank where slurries can be separated into a liquid stream and a solid stream. This is usually accomplished because the clarifier has a large volume that allows the dense solid particles to settle under the influence of gravity. The liquid steam exits the top of the clarifier and the more dense solid slurry is drawn from the bottom of the tank.

**Coal - Low-sulfur** - The EIA sulfur content category of coal with less than 0.60 pounds of sulfur per million Btu. Less than or equal to 1%.

**Coal - Medium-sulfur** - The EIA sulfur content category of coal with 0.60 to 1.67 pounds of sulfur per million Btu. Greater than 1% and less than or equal to 3%.

**Coal - High-sulfur** - The EIA sulfur content category of coal with greater than 1.67 pounds of sulfur per million Btu. Greater than 3%.

**Colloidal** – Having very small, insoluble, nondiffusible particles larger than molecules but small enough so that they remain suspended in a fluid medium without settling to the bottom.

**Continuous Emission Monitor (CEM)** - A device that approximates a continuous measurement of certain characteristics of a gas by making separate measurements frequently. For compliance with the CAAA90, the measurements must be taken at least every 15 minutes. Two common types are an Extractive Continuous Emission Monitor and an In Situ Continuous Emission Monitor.

**Cyclone** - A free vortex centrifugal separator that removes solids from liquids by combination of centrifugal force and liquid shear. Used in some systems to replace the liquid thickener/clarifier.

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**DBA (Dibasic Acid)** – A mixture of organic acids (adipic acid, succinic acid, glutaric acid) used as a performance enhancing chemical in absorber towers.

**Dead Band** – In control circuits, the zone between the start of an action and when the action is reversed. This prevents the control action from cycling back and forth too quickly. In a home, the furnace starts when the temperature reaches a certain point. It continues to run until the temperature rises several degrees. This range of temperature is the dead band of the furnace control.

**Density** – The weight of a material divided by the volume of the material.

**Dolomite** – A mineral composed of calcium carbonate and magnesium carbonate found in limestone deposits. It has the chemical formula  $\text{CaMg}(\text{CO}_3)_2$ .

**Dry FGD** - An FGD process comprised of contacting a sulfur oxide containing flue gas with an alkaline material without saturating the flue gas and producing a dry waste product or dry by-product.

**Durometer** – A device for measuring the firmness of a material. A spring forces a small diameter foot into the material being tested. The amount of force required to push the foot down until the material is exerting the same force back is the Durometer reading measured on a scale specified by the size of the foot. Rubber is typically measured using the Shore A scale.

**Electrostatic Precipitator (ESP)** - A unit comprised of a series of parallel vertical plates through which the flue gas passes. It electrically charges the ash particles in the flue gas to collect and remove them.

**Energy** - Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatt-hours, while heat energy is usually measured in British thermal units.

**Exothermic** – A chemical change in which there is a liberation of heat, as in combustion.

**Ex situ oxidation (wet FGD)** - Forced oxidation that occurs outside of the scrubber and is used to produce FGD gypsum.

**Extractive Continuous Emission Monitor** - A CEM that draws exhaust gas away from the combustion system to the measurement equipment through special ducts.

**Federal Energy Regulatory Commission (FERC)** - A quasi-independent regulatory agency within the Department of Energy having jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification.

**FGD Material** - This wet thixotropic sludge from limestone-based reagent wet scrubbing process is predominantly calcium sulfate dihydrate, which is gypsum. This material readily dewater, and there are systems in use where the slurry is transported to a pond and construction equipment is used to excavate and stockpile the gypsum.

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**Filter Cake** - The material produced by filtering equipment such as vacuum filters for dewatering wet FGD material.

**Fixation** - A process of stabilization of sludge involving the addition of reagents causing chemical reactions with the sludge, generally of a cementitious nature.

**Flocculant** - Charged polymers used in industry for clarifying suspensions. They cause suspended colloidal matter to aggregate, forming particles that are large enough to settle out under gravity.

**Flue Gas Desulfurization Unit (Scrubber)** - Equipment used to remove sulfur oxides from the combustion gases of a boiler plant before discharge to the atmosphere.

**Fluoroelastomers** - A class of synthetic rubber which provide extraordinary levels of resistance to chemicals, oil and heat, while providing useful service life above 200°C. The outstanding heat stability and excellent oil resistance of these materials are due to the high ratio of fluorine to hydrogen, the strength of the carbon-fluorine bond, and the absence of unsaturation.

**Fly Ash** - Particulate matter from coal ash in which the particle diameter is less than .0001 meter. This is removed from the flue gas using flue gas particulate collectors such as baghouses and electrostatic precipitators.

**Flywheel** - A heavy wheel for regulating the speed and uniformity of motion of the machine to which it is attached.

**Fossil Fuel** - Any naturally occurring organic fuel, such as petroleum, coal, and natural gas.

**Fouling** - The formation of high temperature bonded deposits on convective heat absorbing surfaces.

**Generating Unit** - Any combination of physically connected generator(s), reactor(s), boiler(s), combustion turbine(s), or other prime mover(s) operated together to produce electric power.

**Generation - Gross** - The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

**Generation - Net** - Gross generation less the electric energy consumed at the generating station for station to station use.

**Generator Nameplate Capacity** - The full-load continuous rating of a generator, prime mover, or other electric power production equipment under specific conditions as designated by the manufacturer.

**Gigawatt (GW)** - One billion watts of capacity.

**Greenfield Unit** - A newly constructed generating unit.

**Grits** - The hard, coarse particles that will not dissolve in a lime slaker and must be removed and disposed

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of.

**Gypsum** - Formed from forced oxidation in a calcium-based FGD process. Also, a precipitated gypsum formed through the neutralization of sulfurous acid (H<sub>2</sub>SO<sub>3</sub>) in FGD process at coal-fired power plants. This gypsum can vary in purity, which is defined as the percentage of CaSO<sub>4</sub>•2H<sub>2</sub>O, and generally is over 94% for use in wallboard manufacturing.

**Hardgrove Grindability Index (HGI)** - A measure of the relative ease with which coal can be pulverized or ground. Higher grindability indicates coal which are easier to grind.

**Hydrated Crystal** – The natural form of many crystalline materials. Some water has been chemically combined in the crystal matrix.

**Hydrated Lime** – Calcium Hydroxide (Ca(OH)<sub>2</sub>) that is formed by reacting quicklime and water in a lime slaker.

**Hydroclone** - A device for separating particles of varying densities in a liquid stream by spinning the liquid rapidly in a cyclonic manner and drawing off product streams at various locations in the cyclonic profile.

**Hydrogen Sulfide** – H<sub>2</sub>S is a colorless highly toxic gas that is heavier than air and has a “rotten eggs” odor.

**Hydroxyl Group** - The term used to describe the functional group -OH when it is a substituent in an organic compound. Organic molecules containing a hydroxyl group are known as alcohols and have the formula C<sub>n</sub>H<sub>(2n+1)</sub>-OH, the simplest of which is methyl alcohol (CH<sub>3</sub>-OH)

**Hygroscopic** – Attracting or absorbing moisture from the air.

**In Situ Continuous Emission Monitor** - A CEM that makes measurements directly in the flue or exhaust pipe.

**In Situ Oxidation (wet FGD)** - A process in which both SO<sub>2</sub> absorption and oxidation are carried out within the scrubber.

**Kiln** – A furnace or oven for drying, burning, or baking something.

**Kilowatt (kW)** - One thousand watts of capacity.

**Kilowatt-hour (kWh)** - One thousand watthours.

**Landfill** - A site for the disposal of all conducive wastes. Landfill configuration may be heaped, side hill or valley fill.

**L/G** - Liquid to gas ratio which is defined as the recirculated absorbent liquid flow rate (gpm) divided by the absorber outlet gas flow rate (acfm/1000).

**Lignite** - A brownish-black coal of low rank with high inherent moisture and volatile matter (used almost exclusively for electric power generation). It is also referred to as brown coal. Lignite contains

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approximately 9 million to 17 million Btu per ton.

**Low-NO<sub>x</sub> Burners** - Burners that utilize special arrangements of fuel and air injection ports, which reduce the formation of NO<sub>x</sub> during combustion.

**Maintenance Costs** - Maintenance costs are the portion of operating expenses consisting of labor, materials, and other direct and indirect expenses incurred for preserving the operating efficiency and/or physical condition of utility plants used for power production, transmission, and distribution of energy.

**Mandrel** – A large rotating circular form used as a core around which glass fiber covered with resin is wound creating a cylinder of fiberglass reinforced plastic (FRP)

**Megawatt (MW)** - One million watts of capacity.

**Megawatt-hour (MWh)** - One million watt-hours of electric energy.

**Mist Eliminator** - That part of an absorber designed to remove entrained liquid droplets from the exiting gas stream.

**Nacolite** – A natural mineral form of sodium carbonate used in sodium scrubbing or converted into Soda Ash.

**Non-Regenerable FGD** - Process that consumes the sorbent.

**Opacity** - The degree of imperviousness to the passage of light.

**Operations Costs** - Operations costs are the components of power production that incur cost for operations that are directly related to producing electricity. The major item is almost always fuel that has to be burned to generate electricity.

**Oxidation** - When oxygen is added to a material to chemically transform it into a different material.

**Oxidation - Forced** - An additional unit operation to a wet FGD process that intentionally oxidizes the sulfite specie to sulfate by the introduction of supplemental air or catalysts or both.

**Oxidation - Natural** - That which results from the reaction of absorbed sulfite specie with dissolved oxygen originating from flue gas and incidental contact with atmospheric oxygen.

**Permeability** – The property of being open to the passage or penetration of gas or liquid through a material.

**pH** - A measure of acidity or alkalinity that ranges from 0 to 14. A pH measurement of 7 is regarded as neutral. Measurements below 7 indicate increased acidity, while those above indicate increased alkalinity.

**Pitting** – An extremely localized form of corrosion that leads to the formation of small holes in metal.

**Plant-Use Electricity** - The electric energy used in the operation of a plant.

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**Plume Rise** – As flue gas exits a chimney, it is desirable for it to be buoyant and continue to rise rather than fall back towards the chimney creating a mushroom shaped cloud. Heat is sometimes added to increase buoyancy or a restriction at the chimney exit is added to increase exit velocity and insure proper plume rise.

**PPM** – The concentration of one material mixed with another material expressed in parts per million. A 3 ppm solution of salt in water would be 3 pounds of salt added to one million pounds of water.

**Precipitate** – To cause a slightly soluble substance to become insoluble and separate out of a solution.

**Pulverizers** - Mills of various designs used to finely grind the coal which is swept from the mills by air for pneumatic transport directly to the burners.

**Quarry** – A place where stone is excavated.

**Quicklime** – Calcium Oxide (CaO) that has been produced by a calcination process where crushed limestone is fed through a kiln and the heat of the kiln drives the carbon dioxide (CO<sub>2</sub>) from the limestone (CaCO<sub>3</sub>).

**Reagents** – Pure forms of chemicals that are added to a process to react with other chemicals in the process to form reaction byproducts.

**Reduction** - When oxygen is removed from a material to chemically transform it into a different material.

**Regenerable FGD** - Process that regenerates and recycles the sorbent.

**Reheat** - A heat transfer process by which the absorber outlet flue gas temperature is increased for the purpose of increasing plume buoyancy, reducing a visible plume, or preventing downstream corrosion.

**Residence Time** - The time period for a given volume of liquid or gas throughput to pass through a vessel. When referred to an absorber, it is defined as the absorber's internal volume through which gas passes (cu. ft.) divided by the absorber outlet flue gas flow rate (acfs).

**Retention Tank** - Provides residence time for the absorbent recirculation flow for the purpose of allowing sufficient time to complete chemical reactions.

**Scale** – Any thin, flaky or plate like layer or coating which forms on the inside of metal containers.

**SCFM** - Gas flow rate in terms of cubic feet per minute measured at the standard conditions of 70°F and one atmosphere pressure.

**Scrubber** - Any of several forms of chemical/physical devices that remove sulfur compounds formed during coal combustion and especially from coal-fired power plants.

**Scrubber Sludge** - Another name for wet FGD material

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**Set Point** – In a control circuit, the value when an action by the control system will be initiated.

**Sinusoidal** - Moving in simple harmonic motion according to the function  $A \sin(2\pi ft)$  where A is the amplitude of the wave, f its frequency, and t is time.

**Slagging** - The formation of molten, partially fused resolidified deposits on furnace walls or other surface exposed to radiant heat.

**Slaker** – A device to mix quicklime and water in such a manner as to cause a chemical reaction producing calcium hydroxide.

**Slurry** - A mixture of liquid suspended solids (e.g. recycle slurry, lime slurry).

**Soda Ash** – The manufactured form of sodium carbonate used in sodium based scrubbing.

**Soluble** – Can be dissolved; capable of passing into solution.

**Specific Gravity** – The ratio obtained by taking the density of a volume of a material and dividing it by the density of the same volume of water.

**Stabilization** - The addition of fly ash, soil or other similar material to induce physical changes without chemical interaction between the additive and the sludge.

**Stoichiometry** - The ratio of how much lime or limestone was added to the scrubber to remove a quantity of SO<sub>2</sub> divided by the theoretical amount of lime or limestone that should have been used to remove that same quantity of SO<sub>2</sub>.

**Sub bituminous Coal** - A dull black coal of rank intermediate between lignite and bituminous. The contents of sub bituminous coal ranges from 16 million to 24 million Btu per ton.

**Sulfate Reducing Bacteria** - A group of anaerobic bacteria (i.e. don't need oxygen) that obtain energy from iron or sulfur and generate hydrogen sulfide (H<sub>2</sub>S).

**Sulfate Saturation** - The maximum concentration of the sulfate ion per unit volume of slurry or solution, above which the sulfate specie crystallizes as an alkali or earth alkali salt.

**Sulfur** - One of the elements present in varying quantities in coal which contributes to environmental degradation when coal is burned.

**Tadpole Tape** – A gasket material that has a flat cross section with a large bulbous section attached to one edge. It gets its name since this cross section looks like a tadpole.

**Temperature - Adiabatic Saturation** - The temperature, below which for a given mixture of gas and vapor, no additional vapor can be added at specified conditions (partial pressure of vapor is equal to vapor pressure of the liquid at the gas-vapor mixture temperature).

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**Temperature - Approach** - The difference between the actual temperature of a given gas-vapor mixture and the adiabatic saturation temperature of that gas-vapor mixture.

**Temperature - Spray Down** - The difference between the inlet and outlet temperature of flue gas passing through an absorber.

**Thickener** – A large diameter vessel with a conical bottom used to separate solids from a liquid using the principal of gravity settling in a large still volume of liquid.

**Thiosulfate** – The ion S<sub>2</sub>O<sub>3</sub> which is a strong reducing agent. In the photographic process, it dissolves the silver salts and is known as a fixer in developing films and prints.

**Thixotropic** – A thixotropic material is one that becomes more liquid as higher shear stresses are applied to it. When the stresses are removed, the material behaves more like a solid.

**Trona** – A natural mineral form of sodium carbonate used in sodium scrubbing or converted into Soda Ash.

**Utilization** - A measure of the extent to which the alkali added to the absorber reacts with SO<sub>2</sub>.

**Vacuum Filter** - A mechanical continuous dewatering device, usually of a rotary drum design, which draws air and filtrate through a filter cloth coated with cake or sludge to be dewatered.

**Valeric Acid** – An organic acid produced by the degradation of dibasic acid in an absorber tower. Valeric acid can have a noticeably unpleasant odor.

**Viscosity** – The internal fluid resistance of a substance, caused by molecular attraction, which makes it resist a tendency to flow. Water has a low viscosity, tar has a high viscosity.

**Vulcanization** - A chemical process in which individual polymer molecules are linked to other polymer molecules by atomic bridges. The end result is that the springy rubber molecules become locked together to a greater or lesser extent. This makes the bulk material harder, much more durable and also more resistant to chemical attack. It also transforms the surface of the material from a sticky feel to a smooth soft surface which does not adhere to metal or plastic substrates.

**Waste Product** - Waste material that has little or no economic value and must be disposed.

**Watt-hour (Wh)** - An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

**Wet/Dry Interface** – The zone at the absorber tower inlet where the hot flue gas first comes in contact with the slurry droplets.

**Wet FGD** - An FGD process comprised of contacting a sulfur oxide containing flue gas with a SO<sub>2</sub> sorbent liquid, saturating the flue gas, and producing a wet waste product or wet by-product.