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Executive Summary

Results of an 800 Hertz Mid Frequency Power Supply Field Test on a Recovery Boiler Electrostatic Precipitator *by Peter Aa, Redkoh Industries*

The results of an installation of a Mid Frequency Power Supply on the Inlet of a Recovery Boiler electrostatic precipitator clearly shows significant increases in precipitator current and reduction in precipitator sparking on the Inlet and Center fields, while also increasing the stability of operation for all fields. ***Full Story….***

Portable Dry Bulk Sorbent Injection Considerations for Utility and Industry Fossil Fuel-Fired Generating Facilities *by Jerry VanDerWerff, Nol-Tec Systems*

A Portable dry sorbent injection system allows facilities with solid fuel boilers to test for mitigation efficiencies prior to installing a permanent system. The following, highlights some of the requirements of the portable system. ***Full Story….***

Operation of the Holly Refining's FCC SCR Unit in Tulsa, OK

by Joseph Merle Fritz, Holly R&M, Dr. Kevin Linfield, Airflow Sciences Corporation, Dennis I. Salbilla, Haldor Topsoe, Inc.

An SCR unit was installed on the Holly Tulsa FCCU. The existing ESP was removed from service resulting in a "high dust" content flue gas SCR design. This required a custom SCR catalyst that would withstand the erosive environment and still perform well over a 5–year continuous run. The FCCU SCR unit has been in service for over 1 year without any maintenance outages. NOx reduction is excellent with outlet NOx values below 20 ppmvdc at 0% O_2 and this is achieved without ammonia injection. Apparently, the amount of NH_3 formed in the Regenerator is in ~1:1 proportion with NOx. Pressure drop across each of the two separate SCR catalyst layers is less than 1.5 IWC. ***Full Story….***

Liquid/Gas Ratio for Wet Scrubbers *by Ron Richard, RE Consulting*

Just as SCA is a number that helps one compare the overall design performance of electrostatic precipitators, the liquid/gas ratio L/G is a number that helps one compare the overall design performance of FGD absorber towers. ***Full Story….***

An "Old School" Approach Modernized for Today's Air Pollution Challenges – Particle Size Distribution Testing in "Wet" Gas Streams Using In-Situ Cascade Impactors

by Jim Guenthoer, Clean Air Engineering

This article provides a brief overview of particle size distribution testing using in-situ cascade impactor sampling devices. The special considerations necessary to do particle size testing in "wet" gas streams are examined. Examples of generated data from this type of testing are presented as well as post test analyses of the collected samples using SEM and EDX analytical procedures. . ***Full Story….***

Air Pollution Control Solution for Smaller Power Boilers *by Gordon Maller and Jonas Klingspor, URS*

With the advent of current and future regulations for control of hazardous air pollutants, utilities are faced with the decision of what to do with their older and smaller (<300 MW) un-scrubbed generating units. In some cases, the older units will be retired. However, there is a need within the industry for a low cost and reliable scrubbing system for the units which must continue to operate. This article describes the development of such a system which is designed to achieve performance levels of new systems installed on larger generating units but at a significantly lower capital cost. ***Full Story….***

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WORLDWIDE POLLUTION CONTROL ASSOCIATION

Results of an 800 Hertz Mid Frequency Power Supply Field Test on a Recovery Boiler Electrostatic Precipitator

By Peter Aa, Redkoh Industries (peter.aa@redkoh.com)

Introduction

A mid Frequency Power Supply is a Switch Mode Power Supply operating at 800 Hertz rather than at a conventional 50/60 Hz. Switch Mode Power Supplies are used to improve power input to Electrostatic Precipitators, primarily through the reduction of ripple on the ESP voltage. This reduction in ripple allows the average voltage value to approach the peak value providing a higher average voltage than with a 60 Hz system.

Recovery Boiler Experience

Recently, a Mid Frequency Power Supply (MFPS) operating at 800 Hz was installed on an inlet field of a Recovery Boiler electrostatic precipitator. The installation of this new MFPS required a new controller to be installed in place of the existing 60 Hz controller. However, on this plant, the MFPS did not require a new high frequency transformer rectifier (TR), the existing TR was reused, along with existing power and signal cabling. This not only reduced the cost of the equipment required, but reduced installation time as well.

The graphs on the next pages show the TR secondary (precipitator) voltage, current, and spark rate recorded prior to and after the installation of the MFPS. The first graphs show the operation of the Inlet, Center, or Outlet fields operating at 60 Hz prior to the installation of the MFPS. The following graphs show the operation of the Inlet, Center, or Outlet fields operating at 800 Hz after installation of the Mid Frequency Power Supply.

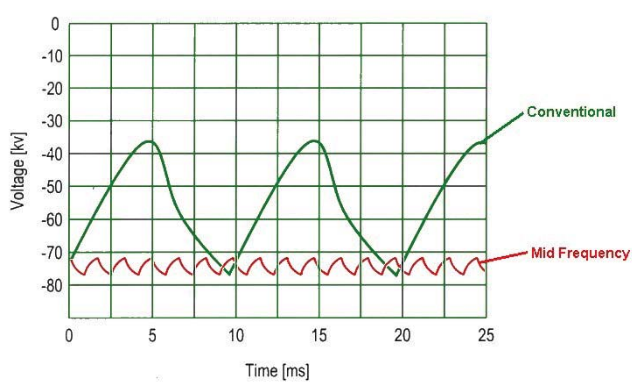


Figure 1: Ripple Comparison Between Conventional and Mid Frequency Secondary Voltage

It can easily be seen that under the 60 Hz operation:

- The Inlet field precipitator current collapses with increased black liquor flow.
- Current is suppressed due to Inlet field sparking.
- The Inlet field can only sporadically reach current limit.
- The Center field current drops when the Inlet field drops.
- The Outlet field has a small degree of instability.

With the Inlet field operating at 800 Hz:

- The Inlet field precipitator current no longer collapses with increased liquor flow rate and remains at a higher and more stable level regardless of liquor flow rate.
- Inlet field sparking is significantly reduced.
- The Center field current operates at a fairly constant current limit regardless of liquor flow rate.
- The Outlet field current and voltage are extremely steady regardless of liquor flow rate.

Summary

In summary, the data shows that a significant increase in the Inlet and Center field power, as well as more stable operation of all fields in the direction of gas flow, resulted from operation at 800 Hz. The simple replacement of the Controller and SCR block with the Redkoh IGBT Inverter assembly allowed the field current (ma) to achieve the current limit and corona density of the original design.

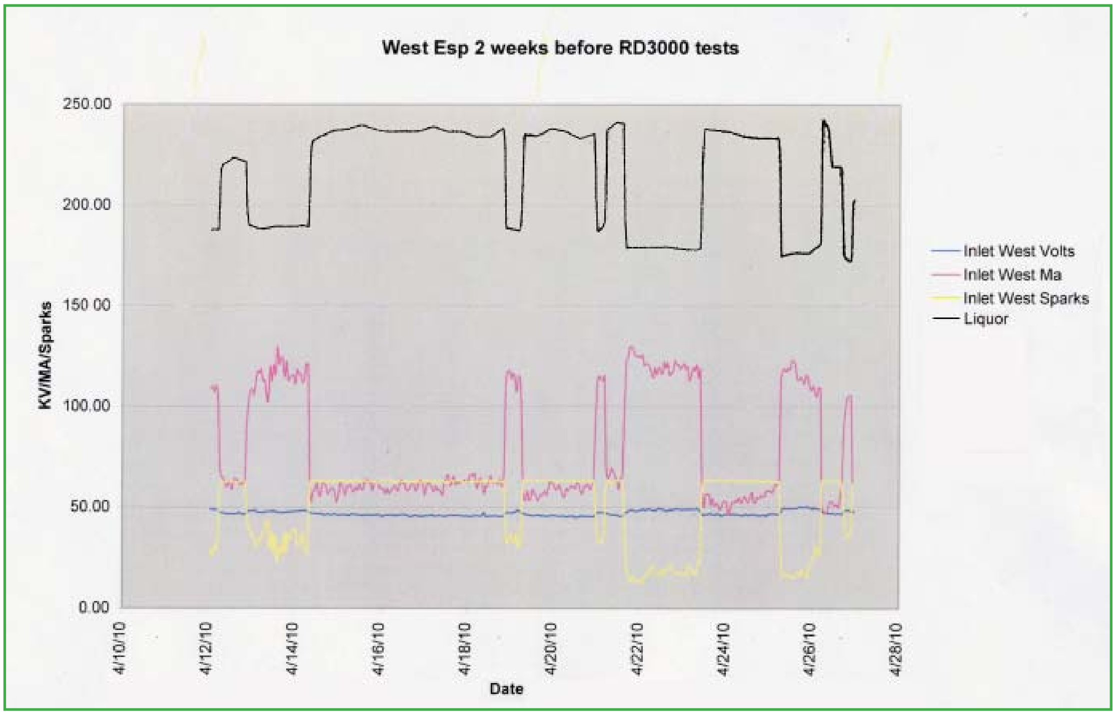


Figure 2: Inlet field operating at 60 Hz

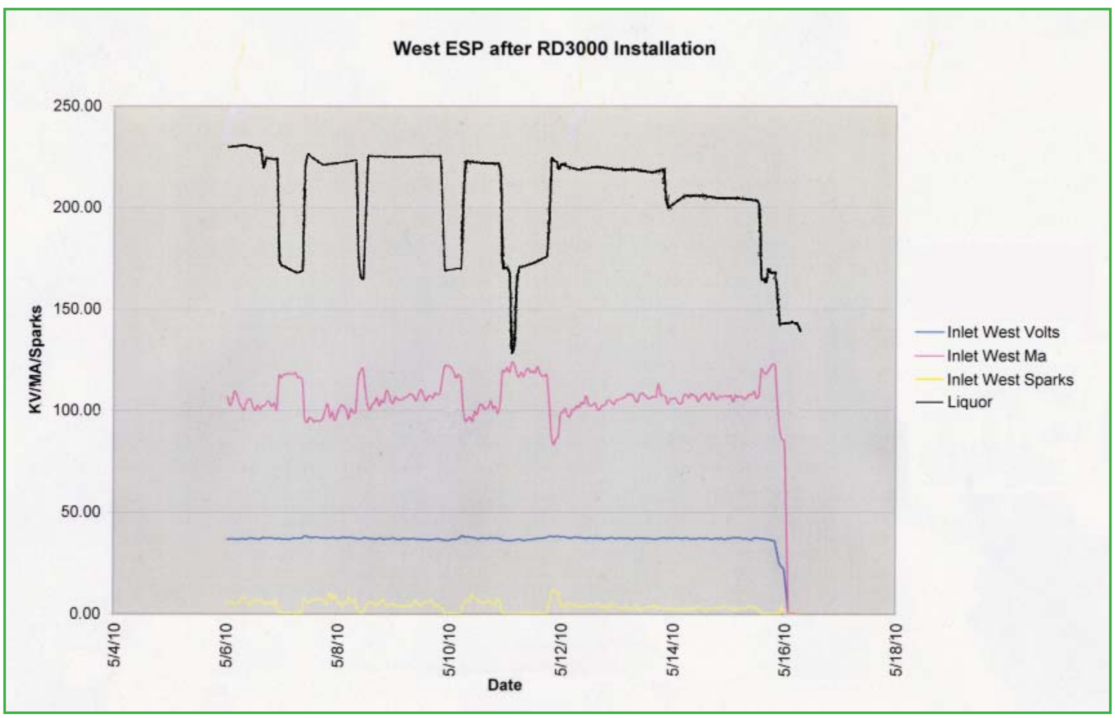


Figure 3: Inlet field operating at 800 Hz

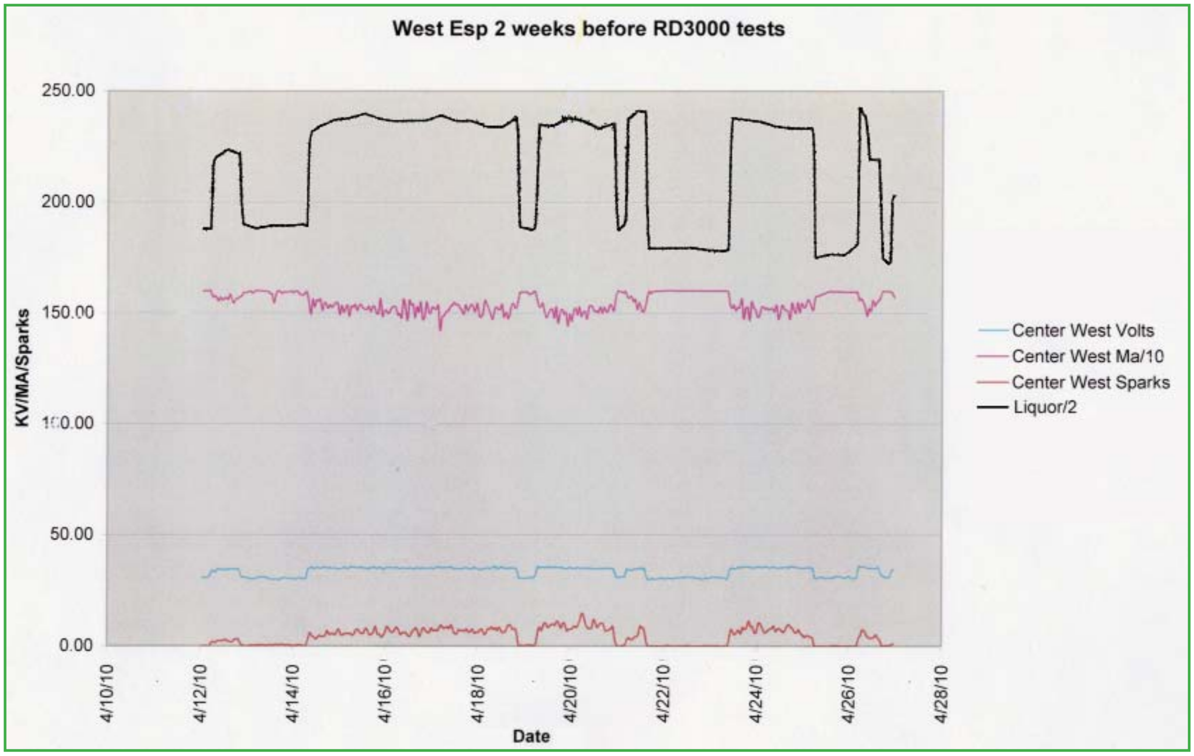


Figure 4: Center field operating at 60 Hz

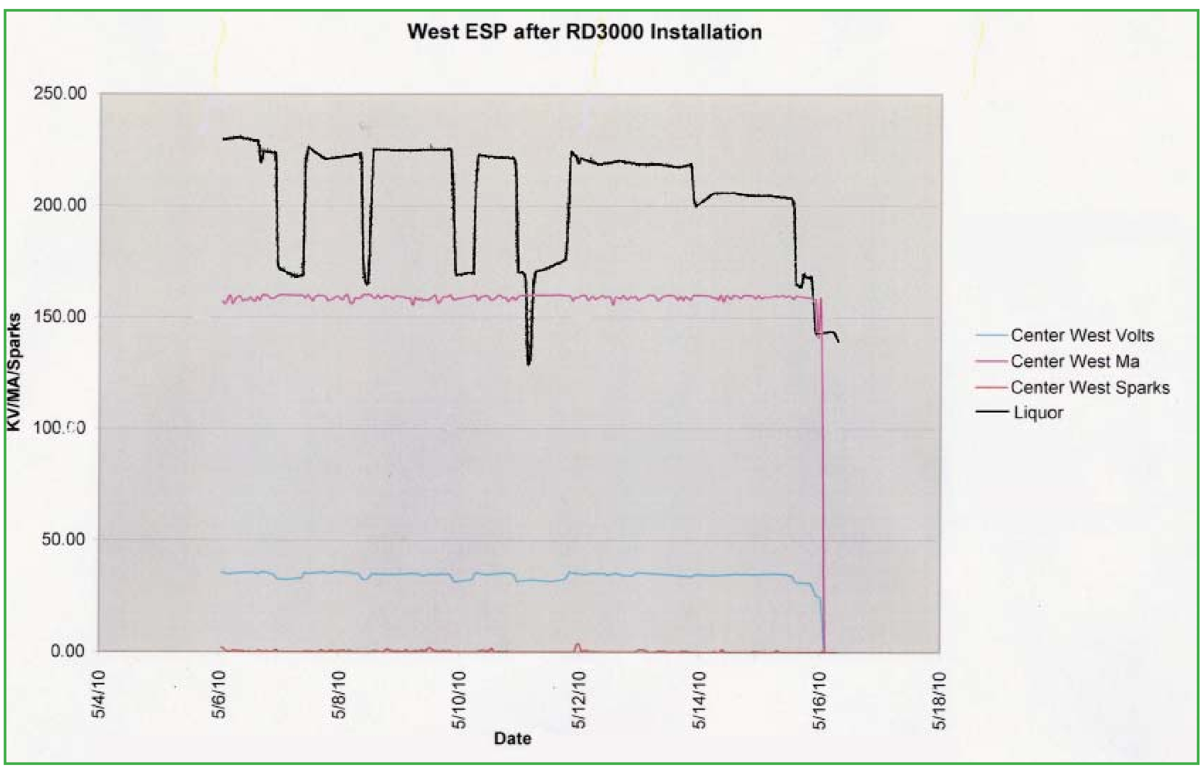


Figure 5: Center field operating at 800 Hz

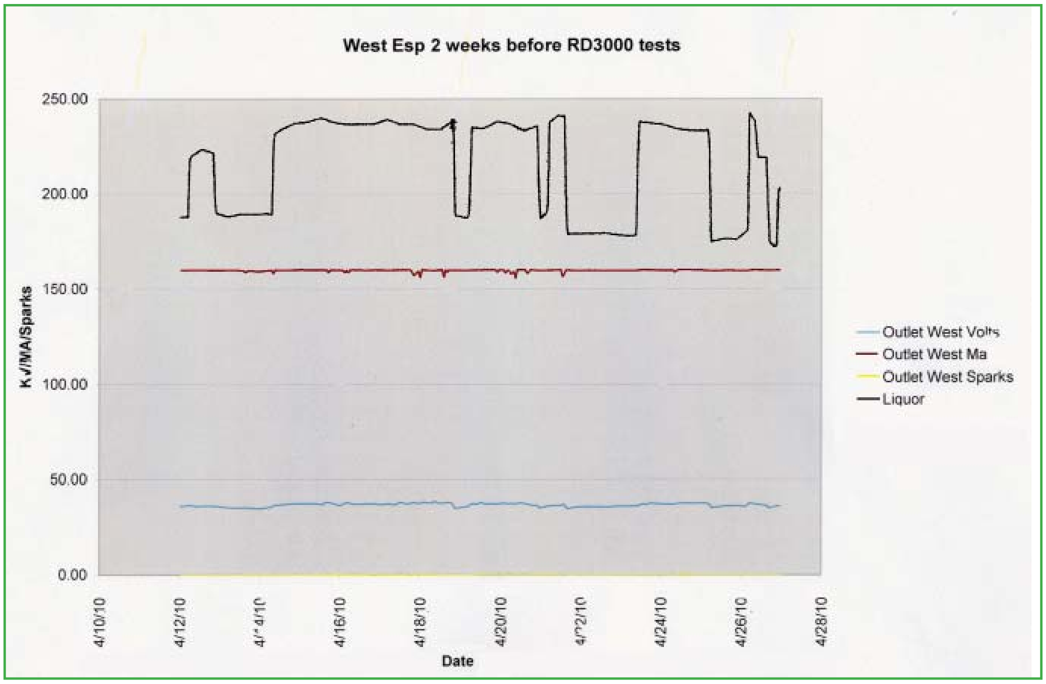


Figure 6: Outlet field operating at 60 Hz

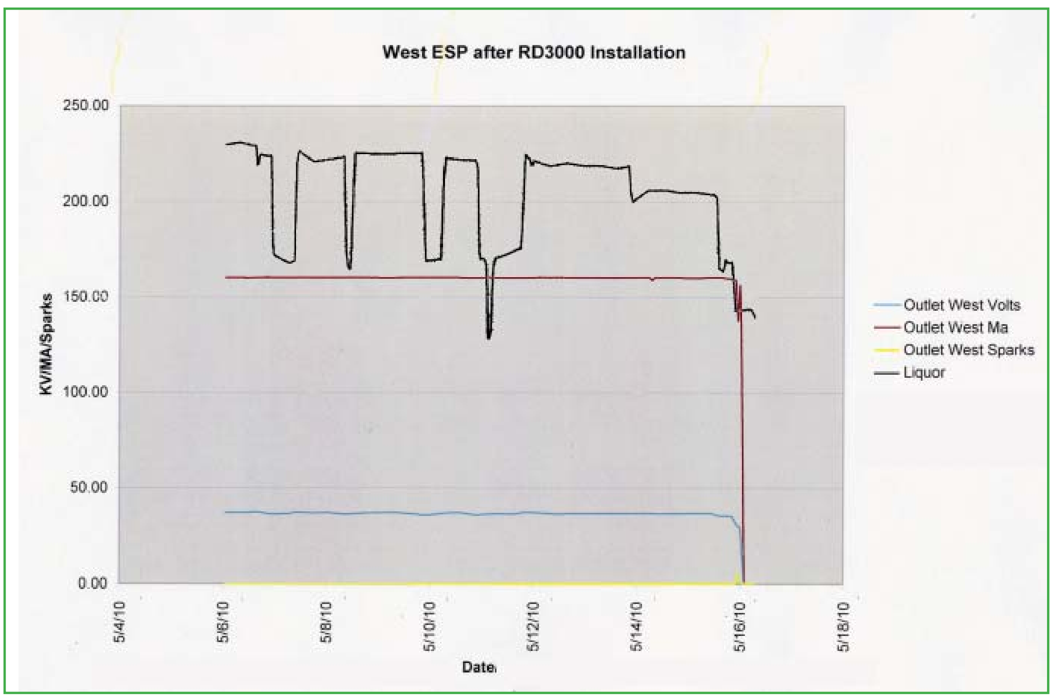
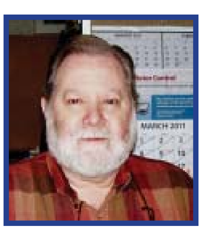


Figure 7: Outlet field operating at 800 Hz



Peter Aa is a graduate of NY Institute of Technology. He worked at Research-Cottrell for 30 years with various positions from Field Service Engineer to Manager of Aftermarket Services, and Manager of Electrical Engineering. Peter has presented several papers relating to ESP operation and maintenance. He has also been published in "Chemical Engineering Magazine". Presently he is the Manager of Customer Services at Redkoh Industries. He consults, advises, evaluates, and trains on all facets of electrostatic precipitator operation and maintenance. **Visit Redkoh at www.redkoh.com.**

Portable Dry Bulk Sorbent Injection Considerations for Utility and Industry Fossil Fuel-Fired Generating Facilities

*by Jerry VanDerWerff, Nol-Tec Systems (*jerryvanderwerff@nol-tec.com)

Introduction

To determine the validity of and accurate planning for permanent emissions mitigation technology for public and private sector fossil fuel-fired electric generating plants/industrial boilers, portable dry bulk sorbent injection is a proven tool to help meet HAP emissions control requirements.

When a facility no longer meets emission control standards, determining the proper path to compliance is essential. Dry scrubbing is one of the technologies available. If the decision is made to investigate the use of dry scrubbing, specifically dry sorbent injection, a dry bulk sorbent injection testing protocol becomes an indispensible tool for measuring critical factors concerning types and quantity of sorbent necessary to meet verifiable emission control compliance standards. Compliance standards and testing protocol may vary by group (industrial vs. utility boiler operations), type of boiler, type of fuel (coal/oil/biomass), type of pollutant, and age of plant ("Grandfathered" existing facility versus new plant). However, compliance standards are required by all such plants.

Mitigation equipment can be an expensive proposition, but the costs for the sorbent materials themselves often outweigh those of hardware. Due to the custom nature of each plant's design and operation it is imperative that the selected mitigation technology be "proven" for any given facility to maximize the efficient utilization of sorbent materials. The best way to prove the technology (prior to actual purchase of a permanent solution) is to conduct full scale demonstration testing at the facility.

Dry Sorbent Injection Testing Objectives

A typical dry sorbent injection system transfers the sorbent material from a storage silo into the effluent gas duct between the boiler and the particulate control device. The sorbent material reacts with the given pollutant in the gas stream and in the particulate control device. For a given installation it is imperative that the following be determined from the dry sorbent testing:

- Sorbent Type – determination of the best sorbent to reduce each HAP in a cost effective manner.
- Sorbent Injection Location- determination of the most effective injection location(s) in the duct for maximum sorbent efficiency

Figure 8: A self-erecting portable sorbent storage silo moved into position and then using self-contained hydraulics rising into a fully erect posture.

- Sorbent Quantity-determination of the quantity of a given sorbent to obtain a desired result

Satisfying these three required elements is where portable dry sorbent injection technology becomes an essential issue.

Criteria for evaluating portable dry sorbent injection solutions

Dry sorbent injection testing at a given facility is an essential step in the process of evaluating the cost of a permanent mitigation solution. However, while this step is essential, it is important to minimize the amount of disruption to daily operations while the tests are being set up, conducted and taken down. In the process of selecting a vendor to conduct dry sorbent injection testing, it is important to consider the following criteria in the design of the test equipment:

- Portability of complete system with minimal impact to existing structure
- Ease of installation
- Minimal disruption
- Comprehensive onsite testing – accurate and verifiable

Essential design considerations of portable dry bulk sorbent injection systems

How "Portability" is best satisfied impacts all the facility owner/operators evaluative criteria in selecting dry bulk sorbent injection support in advance of a permanent facility enhancement.

Look for the most economically attractive mode of portability – typically on wheels; preferably transported via conventional semi truck to keep the cost reasonable.

The same transportability allows for equipment placement close to the boiler facility, thus facilitating "*Ease of Installation*." Look for a self-erecting sorbent storage silo, preferably with adjustable leveling supports. When the storage silo can be erected without a crane, it makes the installation much easier and less costly. System installation that avoids use of cranes also reduces cost of additional equipment rental and possible permit fees.

In addition, the portable system must include all essential ancillary components, with ability to incorporate modular enhancements for alternating sorbent types for testing purposes.

Assurance of "*Minimal Disruption*" to plant operation during the evaluative sorbent testing period requires selecting a portable dry bulk sorbent injection system that avoids major modifications to existing facilities and support structures.

"*Comprehensive Testing*" requires the ability to test a variety of sorbents, including hydrated lime, trona, sodium bicarbonate and powdered activated carbon. In addition, testing must include evaluating proper sorbent injection locations, taking into account variants in sorbent efficiencies influenced by temperature of stack gases at various locations.

Weigh Accuracy

When it comes to getting all you can from sorbent materials, weigh accuracy is the name of the game. There are several methods to weigh sorbents with each method delivering varying degrees of accuracy.

Weigh the silo – Often, the sorbent storage silo itself is load cell equipped. This requires a load capacity range in tons versus hundredweight or pounds and does not easily contribute to a wide range of metering rates by weight (referred to as Loss-In-Weight (or LIW) metering) of sorbent into the process.

Separate weigh hopper – The range of LIW metering rates can be improved by discharging sorbent from the storage silo to a weigh hopper that can then more accurately meter by weight sorbent into the process. The weigh hopper is more accurate because the quantity of material being weighed and metered is much smaller than the thousand or so cubic feet of material in the storage silo. The load cell configuration is calibrated for this smaller load and the metering accuracy is improved.

Multiple weigh hoppers – For ultimate accuracy and maximum efficiency in sorbent use, multiple weigh hoppers are

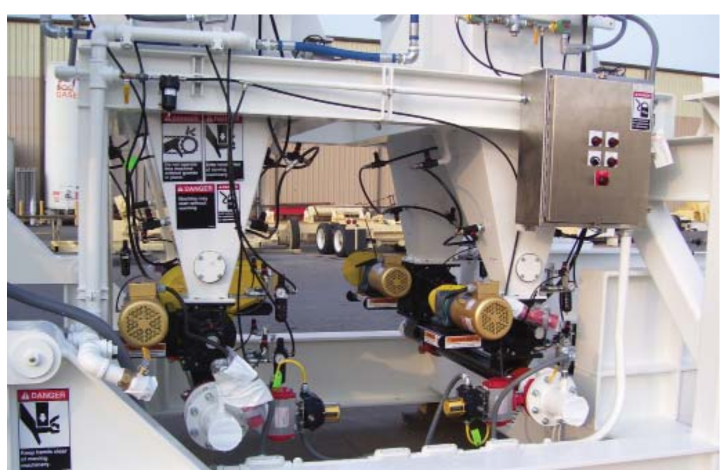


Figure 9: Example of a multiple weigh hopper assembly utilizing dual RAL discharge feeders on each convey line.

the best choice. Look for a sorbent injection technology that allows multiple LIW discharge into the individual convey lines.

Testing Scope and Flexibility

Turndown ratio – The greater the range of available turndown ratio, the more accurate and flexible the sorbent injection system. A 100:1 turndown ratio is desirable and as such delivers a greater ability to meter all sorbents in a more precise manner for a wide range of HAP. Watch for this because turndown ratio is critical for sorbent injection rate accuracy. An added design benefit is seen if the testing module can utilize multiple conveying lines, thus allowing injection into more locations at the same time.

Typical Sorbent Materials

- Hydrated Lime
- Trona
- Sodium Bicarbonate
- Powdered Activated Carbon

Effectiveness of various sorbents – Different HAP responds differently to different sorbents. During testing the portable dry bulk sorbent injection system has to have the flexibility to easily switch from one type of sorbent to another. This improves overall testing results for all HAPs requiring necessary compliance measures, saves time and money during the evaluative process.

Maximizing sorbent efficiencies

Testing requires continuous sorbent supply. Some pollutants such as SO_2 require significant amounts of continuously injected sorbent during testing periods. Failure to maintain continuous sorbent injection defeats the test and results in loss of measurable results, loss of time and added expense to make up for both.

To protect your test from these problems, the portable sorbent injection system must allow repeated sorbent storage silo refilling during the testing period without adversely affecting the Loss-In-Weight metering accuracies of the system. Again, this is best assured by a configuration of multiple weigh hoppers separate from the sorbent storage silo.

Mill advantage – Mitigation of HAP using trona and sodium bicarbonate is greatly enhanced when these sorbents are milled to a smaller particle size. Smaller particle size greatly enhances the available sorbent surface area improv-

Figure 10: An example of an in-line blow through variable speed rotary pin mill used to improve removal of SO_2 and SO_3.

ing reaction of pollutants and maximizing sorbent efficiency. Basically, finer sorbent particle size results in less sorbent required.

In summary

Portable dry bulk sorbent injection technologies are valuable tools to aid in the decision making process of meeting EPA and state regulatory HAP emissions control requirements. Key characteristics of dry bulk sorbent injection testing systems include:

- Transportability of complete system to the plant site
- Ease of installation with minimal plant operation disruption
- Sorbent storage facility of sufficient capacity
- LIW (Loss-In-Weight) metering operation
- Multiple weigh hoppers for superior accuracy
- A broad turndown ratio for multiple sorbent testing

These requirements result in portable sorbent injection emissions mitigation technology that provides both private and public sector fossil fuel fired boiler facilities methodology for determining optimum design of permanent sorbent injection systems and assured verifiable HAP emissions control compliance.

Jerry VanDerWerff is the national sales manager for Sorb-N-JectTM Technology provided by Nol-Tec Systems, Inc. of Lino Lakes, MN. He has been with Nol-Tec Systems for 22 years.

Visit Nol-Tec Systems at www.nol-tec.com

Operation of the Holly Refining's FCC SCR Unit in Tulsa, OK

By: Merle Fritz, Holly R&M, Dr. Kevin Linfield, Airflow Sciences Corporation (klinfield@airflowsciences.com), *Dennis L. Salbilla, Haldor Topsoe, Inc.*

Background

In January 2008, Sinclair entered into a Consent Decree with the U.S. Environmental Protection Agency. The refiner agreed to reduce NOx emissions from the Holly Tulsa refinery's Fluid Catalytic Cracking Unit (FCCU) to 20 ppmvdc on a 365 – day rolling average and 40 ppmvdc (parts per million volume dry correct) on a 7 day rolling average, both at 0% reference O_2. Reductions in SOx emissions were also agreed at 25 ppmvdc on a 365 – day rolling average and 50 ppmvdc on a 7 – day rolling average, again based at 0% O_2.

In order to achieve these emission targets, Sinclair installed an SCR Unit for NOx reduction immediately upstream of a Wet Gas Scrubber, which removes particulates and SOx. An existing ESP was removed from service and dismantled prior to the installation of the new SCR and Wet Gas Scrubber.

It was decided that the ESP was expendable based on the High Dust SCR unit offered by Haldor Topsoe and the state of the art Flue Gas Scrubber offered by MECS.

Design

The design of a FCCU SCR comes with some unique challenges. These include:

- Two – phase flow as FCCU catalyst fines are entrained in the flue gas
- Continuous operation targeting a 5 year run life
- Low pressure drop in a dusty operating environment

Selective Catalytic Reduction (SCR) is an end of pipe technology used for NOx destruction characterized by high single – pass removal efficiency. Ammonia is injected into the flue gas at slightly above the molar equivalent ratio as its NOx concentration to react on the catalyst producing nitrogen and water. Ammonia flow is automatically controlled by feedback control measuring outlet NOx downstream of the SCR catalyst.

Haldor Topsoe's design philosophy for FCCU SCR applications calls for a vertical down flow unit. This takes advantage of gravity to address the catalyst fines entrained in the flue gas. Turning vanes are required to prevent uneven stratification of the solids and maintain a uniform velocity profile leading up to the inlet face of the SCR catalyst.

The Holly Tulsa FCCU SCR unit has these characteristics, as shown in Figure 11. Two catalyst layers each containing 20 modules with 1 meter deep of DNX – 958 catalyst are

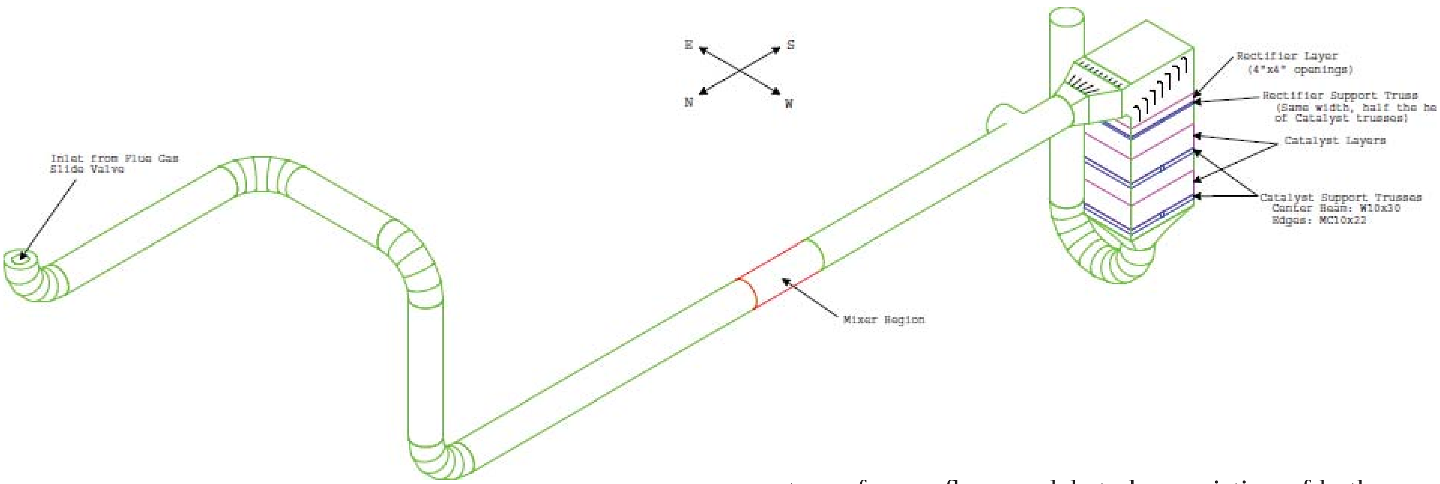


Figure 11: Overview of SCR System

employed. The size of one module is approximately 2 meters wide by 1 meter high by 1 meter deep in the flow direction. A set of static mixers along with the NH_3 injection lances are located well upstream of the SCR Catalyst, to provide adequate mixing time for the ammonia to blend completely with the flue gas prior to reaction on the catalyst surface.

The Haldor Topsoe DNX – 958 catalyst utilizes a tri –modal pore size distribution containing Macro pores, Meso pores and Micro pores for activity retention in this dust laden environment. FCCU catalyst entrained in the flue gas is typically fines having an average particle size below 10 microns as well as full range catalyst, with an average particle size of 70 microns during an upset. The fines are able to fill the Macro pores similar to how marbles fill a vase. At some point, the Macro pores accept the maximum amount of catalyst dust yet NOx and NH_3 in the flue gas can still diffuse into these pores through the remaining void space and complete the reduction reaction of the active sites of the catalyst surface.

After deciding on a catalyst and determining the required volume configured in two identical layers, computational fluid dynamics is used to further develop the design. Root Mean Square maldistribution for flue gas flow, NH_3:NOx and temperature are quantified and corrected within acceptable tolerances, +/- 15%, +/-10% RMS, and +/- 20 deg F, respectively. Turning vanes, static mixers and adequate mixing time enable the even distribution of flow and NH3 prior to entering the first layer of SCR catalyst.

Flow Modeling

In order to optimize the design of the SCR, Haldor Topsoe contracted Airflow Sciences Corporation of Livonia, Michigan to perform a flow model study consisting of both computational fluid dynamics (CFD) and physical flow modeling. These tools were used to develop optimal flow control devices that targeted the following design objectives across the specified load range:

- uniform gas velocity distribution upstream of the AIG,
- uniform gas velocity distribution upstream of the first catalyst layer,
- uniform ammonia distribution upstream of the first catalyst layer,

Figure 12: Physical Flow Model

- maintain less than 10% flow angularity from vertical at the first catalyst level,
- locate, document, and minimize particulate accumulations on all surfaces, and
- minimize system pressure loss.

The CFD model was the main tool used to develop flow control devices throughout the system. Major internal elements, such as the mixers and turning vanes, are represented precisely in the model. Model results detailed the 3-D velocity flow field, pressure, and ammonia distribution.

Since the entire geometry can exist virtually within the computer, there are no scaling limitations. All elements are modeled full scale. Actual flow conditions such as temperature, density, viscosity, etc. are implemented so matching of important flow parameters, i.e. Reynolds Number, is attained.

The physical flow model, shown in Figure 12, duplicated the geometry at 1:12 scale and was made mainly of clear acrylic to facilitate flow visualization. Results included the velocity flow field at the planes of interest, pressure, ammonia concentration, dust drop-out and re-entrainment testing, and flow visualization (via smoke flow).

The ultimate objective of the flow modeling was to design the FCCU SCR with a wide operating window that is able to perform at 116% of design throughput and at a turndown of 66%. The flue gas velocity upstream of the AIG ranged from 75 – 95 feet per second (fps) and defined the inlet velocity of the SCR. The first priority was to achieve uniform flue gas flow distribution, using a pair of Sulzer Chemtech static mixers, prior to entering the transition duct from round to square.

A series of simulations were performed to develop design modifications to meet the project goals. The final flow control devices consisted of two sets of flow directing vanes with 60% open flow distribution grids.

The flow models are then used to validate the distribution of ammonia. The ammonia is injected well upstream of the SCR Reactor to allow for adequate time to mix and achieve even distribution within the stream. A pair of Sulzer Chem-

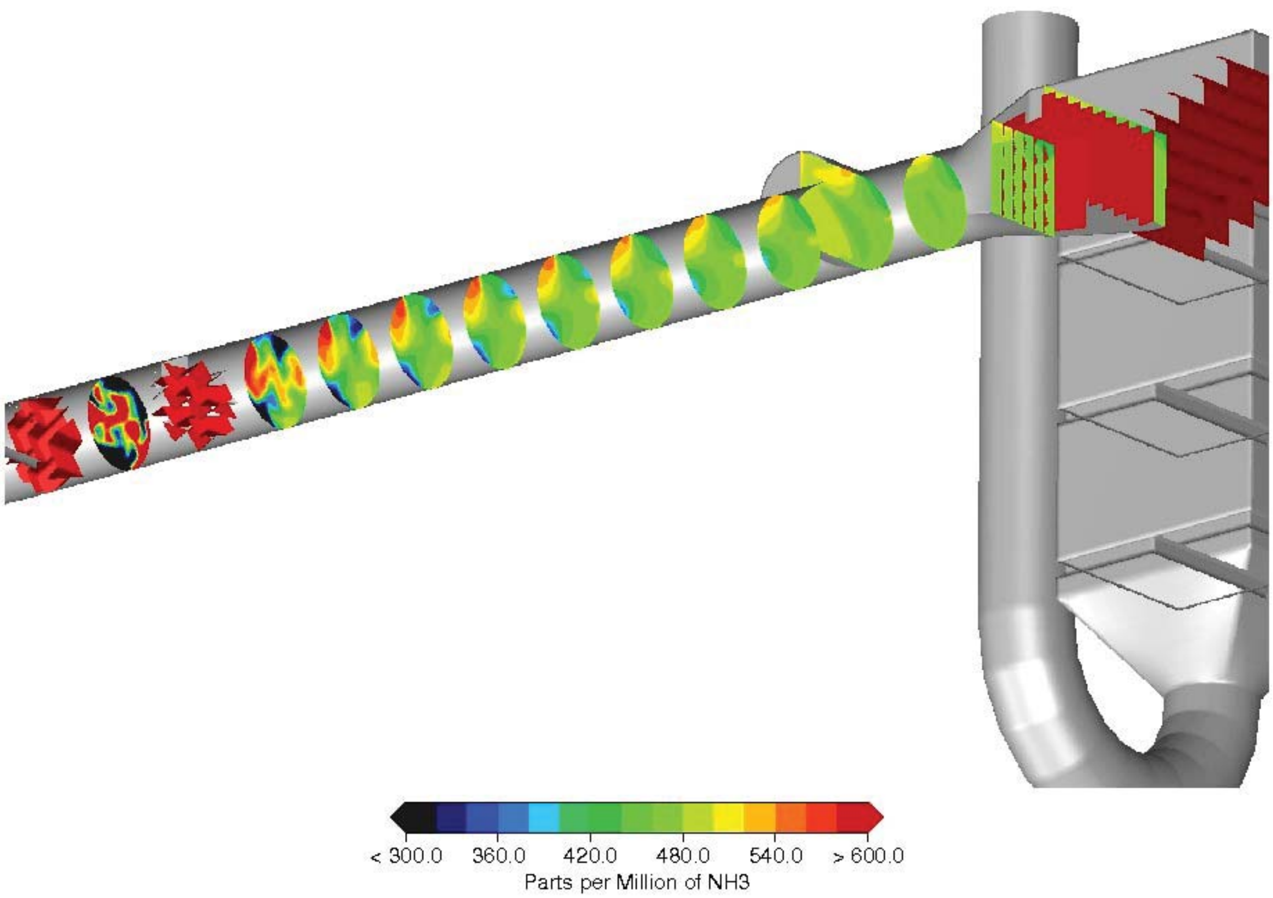


Figure 13: CFD Results of Ammonia Distribution

tech static mixers were installed immediately downstream of the ammonia injection point to facilitate mixing. From both the CFD and physical model results, a uniform concentration of ammonia is achieved by the time the flue gas reaches the turning vanes thus defining the ideal location (minimum distance upstream from the SCR Reactor) of the ammonia injection point as well as locations of the static mixers. This is evident in Figure 13.

The flow modeling continues through the SCR Reactor to ensure an even distribution of ammonia within the system. Uniform ammonia concentration coupled to even flue gas velocity, i.e. flow distribution, are characteristics of a well-designed SCR unit. The consequences of large deviations in ammonia concentrations include NOx breakthrough in some areas of the SCR catalyst bed as well as high NH_3 slip in other areas. The same occurs as a result of poor distribution of flue gas, i.e. stream velocity variance.

Once the flow model work is finished and accepted, mechanical drawings of the equipment commences. From these drawings, fabrication of the actual equipment is built to these specifications.

Construction of the Holly Tulsa FCC SCR

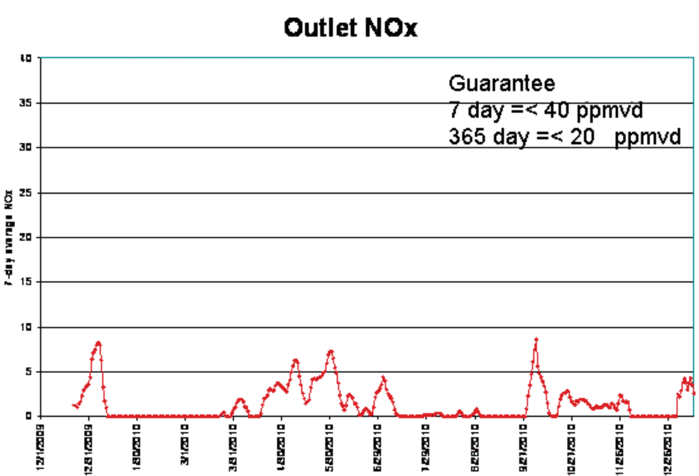
The FCC SCR at Holly Tulsa, shown in Figure 14, was built and started up for the first time in November 2009. The ideal space to build the SCR and Flue Gas Scrubber was almost 100 yards away from the FCC Reactor and regenerator behind an old brick stack. The existing electrostatic precipitator, one of the first to be placed in FCC service, was retired and replaced with a Flue Gas Scrubber downstream of the SCR.

Figure 14: Construction of the SCR

Operational Performance

The SCR reactor has performed well on every design parameter. Both Consent Decree NOx requirements have been met since the unit startup. The 365-day rolling average NOx limit has been met and is currently below 10 ppm. The 7-day rolling average limit has also been met; however, startup and shutdown procedures were modified because the 550°F minimum temperatures, required for ammonia injection, is no longer a concern. The SCR has a total system design maximum pressure drop of 5 IWC (inches water column) and catalyst bed pressure drop of 1.5 IWC per layer.

The total system pressure drop, which includes the ammonia injection grid, flow rectifiers, turning vanes, soot blow-



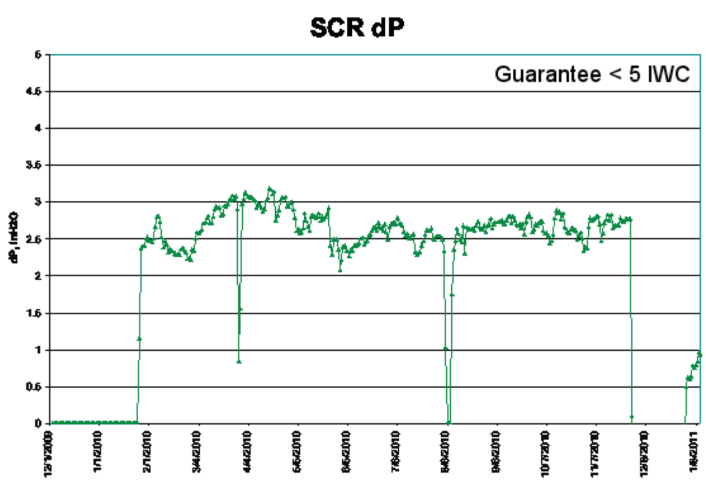


Figure 15: Outlet NOx ; Figure 16: SCR Pressure Loss

ers and catalyst bed, is measured at 3-3.5 IWC. This is very close to the model predictions of 3.3 IWC and well below the design value of 5 IWC. The pressure drop across each catalyst bed is measured at 1.5 IWC, which is also significantly below the design value of 2.5 IWC.

The SCR has not been run for extended periods of time at low temperatures. The minimum design temperature is 550°F; however, the SCR reactor inlet temperature is rarely less that 600°F.

The unit has, however, operated at a wide variety of flow rates with no adverse effect on NOx reduction or ammonia slip. Additionally, the unit has operated at low flow rates for extended periods of time (weeks) with no detrimental effects on pressure drop even when the rate is restored to maximum. Therefore, at reduced rates the turndown flow is well-distributed preventing particulate buildup and plugging. (see Figures 15 and 16)

Airflow Sciences Corporation

Questions regarding this article can be addressed to Dr. Kevin Linfield at Airflow Sciences Corporation.

Dr. Kevin W. Linfield, P.E., Engineering Director, has been with Airflow Sciences Corporation since January 2000. He has many years experience managing and working on a range of flow modeling projects using CFD, laboratory, and field testing skills. Applications include HRSGs, fabric filters, electrostatic precipitators, scrubbers, SCRs, flow mixing devices, and fossil fuel boilers. He received his Bachelors, Masters, and Doctorate degrees in aerospace engineering at the University of Toronto. He is a registered Professional Engineer in Ontario and Michigan.

Dennis Salbilla works for Haldor Topsoe's SCR Group in Houston, TX as the Sales Manager of Industrial Processes. He has over 20 years experience working with Fluid Catalytic Cracking Units start with U.O.P. in the late 1980's. He has authored and published several articles on FCC in Oil & Gas Journal. He holds a U.S. Patent on preventing fouling in FCCU Slurry Exchangers. Dennis earned a Bachelors of Science degree from the University of Illinois and a MBA from the University of Houston.

Merle Fritz is a Senior Process Engineer for the Holly Refining and Marketing - Tulsa LLC refinery. He is responsible for the process technical support of refinery operations and capital projects in the Fluid Catalytic Cracking area of the plant. He holds a BS degree in Chemical Engineering from the University of Nebraska-Lincoln and has over 35 years of experience in the refining industry.

Visit Airflow Sciences at www.airflowsciences.com

Liquid/Gas Ratio for Wet Scrubbers

(excerpt from the Reinhold Environmental Scrubber Training Manual)

by Ron Richard, RE Consulting (Ron.Richard@reconsulting.info)

Liquid/Gas ratio is a number that can quickly allow someone to compare a scrubber's design against others just like SCA is used in precipitator designs. The liquid portion is the gallons per minute of slurry being recirculated through the absorber tower. The gas portion is the actual cubic feet per minute of wet cool flue gas exiting the absorber tower expressed in units of 1000 ACFM. So the liquid/gas ratio is in units of gallons/1000 ft^3.

An absorber tower that has a slurry recirculation flow of 10,000 GPM and a gas flow of 100,000 ACFM would have a liquid/gas ratio (10,000/100) or 100 gallons/1000 ft^3. Or in more common terms one would say the tower has an L/G of 100.

A scrubber using very reactive sodium chemistry might be designed with an L/G of 10. Scrubbers using lime chemistry are typically designed with an L/G in the 30 – 40 range. Early limestone scrubbers were designed with an L/G in the 80 – 100 range. With the desired increase in SO_2 removal to meet current environmental regulations, limestone scrubbers are being designed with an L/G as high as 150.

The L/G ratio sets the size of the slurry recirculation pumps on the tower based on the flue gas flow that will be passing through the tower. The higher the L/G, the bigger the pumps and the higher the capital costs. The operating costs will also be higher because of the higher horsepower requirements. The size of the absorber tower will also be larger to accommodate more slurry spray nozzles and spray levels. Again this adds to the capital cost.

A design with a higher L/G will have more slurry in contact with the flue gas at any given instant. This is necessary for limestone since it has a much slower dissolution and reaction rate than the other chemicals, so there are less reactive sites in each droplet. It takes more droplets in contact with the gas to have the same number of reactive sites in contact with the gas. Some designers design the absorber tower with a smaller L/G based on feeding performance enhancing chemicals with the limestone. This can save some capital and operating costs. A utility has to decide whether to choose this design or insist on a design with the higher L/G and without the performance enhancing chemicals. This saves the option of adding the chemicals at a later time in case the original design falls a little short or in case a higher removal percentage is required by future regulations.

An absorber tower will have a better removal efficiency as boiler load is reduced. This is because with the same number of pumps operating and lower flue gas flow, the L/G will be higher. That is why it is possible to take slurry recirculation pumps out of service during sustained low boiler load operation and still maintain the required SO_2 removal.

RE Consulting

Ron Richard of RE Consulting is a chemical engineer with 32 years of utility experience at Cinergy (now Duke Energy) including design and construction of wet FGD and SCR systems, as well as procurement of catalysts for NOx removal. In addition, Ron is knowledgeable of engineering, testing and maintenance of water treatment and lime handling systems, coal analysis procedures and practices for ASTM compliance, piping design and installation of bearing cooling water systems.

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An "Old School" Approach Modernized for Today's Air Pollution Control Challenges --Particle Size Distribution Testing in "Wet" Gas Streams Using In-Situ Cascade Impactors

By Jim Guenthoer, Clean Air Engineering (jguenthoer@cleanair.com)

Introduction

Driven by the filterable and condensable particulate matter (PM) control requirements of the Maximum Achievable Control Technology (MACT) standards for Industrial and Utility Boilers as well as the $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS), there has been a renewed interest in understanding wet particle size distribution in flue gas streams.

The intent of this article is to discuss how wet particle size distribution testing using in-situ cascade impactors can be a viable and valuable diagnostic tool for determining particle size distribution, as well as particle chemistry, for developing control strategies or to ascertain if particulate matter emissions are the result of unentrained particles passing through or particulate matter laden water droplet emissions from wet scrubbers and other wet devices

Cascade impactors

Cascade impactors are static mechanical devices which are used, most often in-situ, to obtain a multi-size particle distribution of the filterable particulate matter in a gas stream. Unlike a cyclone which provides a single size "cut," diameter, an impactor can provide multiple size fraction results in a single device. They can provide size distributions that range from tens of microns to less than 0.1 microns within a single test run. However, these devices have seldom been used in "wet" sources, wet meaning those with liquid droplets present. In most impactors the large (tens of microns) water drops would flood the device rendering the collection of a viable sample impossible. This can be overcome with special accommodations to the impactor to successfully test in saturated gas streams containing liquid droplets and provide clients valuable, heretofore unavailable information.

Particle Sizing Fundamentals

The fundamentals of particle size distribution determination entail filterable particulate matter being withdrawn isokinetically from the source and segregated by size in an in-situ cascade impactor at the sampling point exhaust conditions of temperature, pressure, etc. Cascade impactors separate the sampled aerosol particles into size increments by inertial impaction of the particles on to a collection surface, which can be a greased steel foil, ultrapure quartz microfibre filter paper, Teflon™, or some other type of appropriate substrate material. This occurs at successive stages through the impactor, hence the name “cascade.” The resulting index of the measured particle size is traditionally separated by the particle diameter collected with 50% collection efficiency by each jet stage, and this diameter is usually called the “cut diameter” and is characterized by the symbol “D50.” The aerodynamic cut diameter is the diameter of an equivalent unit density sphere which would be collected with 50% efficiency by the specific impactor jet stage.

The Stokes diameter is similar but employs the known density of the material rather than assigning it a value of one as with the aerodynamic diameter. The mass of each size fraction is determined gravimetrically. Depending on the end user’s data needs, further laboratory analysis such as size specific chemical speciation or scanning electron microscopy can be performed after the weight gain determination.

Particle size determination testing varies from standard mass testing in that too much material can be collected, voiding the sample, as well as too little material, so there is no set test length. We pretest target a minimum total sample catch of 50-100 milligrams, depending on which model of impactor is being used. CleanAir recommends utilizing Pilat, University of Washington, Mark III (7 stage) and Mark V (11 stage) cascade impactors which have been long recognized in the industry as providing very accurate particle sizing data. The range of sample rates for particle sizing with these impactor models is 0.1 to 1.0 cubic feet per minute (cfm) with the typical sample rate in the 0.3 to 0.5 cfm range. Depending on the PM concentration this can equate to sample runs of less than a minute to several hours long.

The point was made earlier that impactors are not traditionally used in wet gas streams. There is however a real need to understand wet ESP and scrubber performance as relates to droplet carryover/emission from these types of devices. The particulate matter born by a wet gas stream is not distributed in the same manner as the gas upstream of a wet collection device. There are fine particles that are moving along in the gas stream independent of the water droplets. Along with these fine particles there are water droplets of tens of microns in size that contain entrained fine particulate matter of a much smaller actual size. This is the reason EPA will not allow compliance testing using PM_{10} and $PM_{2.5}$ cyclones at the exhaust from wet devices because what may be removed from the gas stream as a greater than PM_{10} water drop may contain 1 micron particulate matter that will be released when the plume evaporates in the atmosphere.

Particle Sizing In A Wet Gas Stream

When evaluating how to attempt to perform particle size distribution testing on a wet gas stream the intent of the data needs to be clearly understood. Is it desired to evaluate the size of the PM that will be released to the atmosphere after the plume has evaporated? Do we want to understand what the downstream equipment is “seeing” in the actual gas stream? In the first case the gas stream needs to be heated and the droplets evaporated, releasing any droplet entrained particulate matter before entering the impactor in a dry sample stream which can be accomplished following an addendum to California Air Resources Board Method 501, that was developed by Southern Research Institute that addresses this mode of sampling. The second case is more technically challenging because we want to size the droplets as they exist in the gas stream as well as any unentrained particulate matter.

To address the exigencies of wet gas stream particle size distribution testing, necessary modifications need to be made to the sampling method. To prevent the possibility of condensation occurring in the impactor when it is first placed in the duct/stack, it is heat soaked immediately prior to testing for one hour to a temperature 20°F above stack gas temperature. If the stack/duct being sampled is not sufficiently large enough to allow the entire impactor to remain within the gas stream, external heating is supplied to the device and a thermocouple is used to monitor the impactor exhaust gas temperature and maintains it at approximately 20°F above the gas stream temperature by controlling the heat wrap.

Because of sample port diameter constraints and sample port length, most cascade impactor sampling is performed using an inlet device that enables sampling at right angles to the gas stream and still allows specific particle size determination to be made in that configuration. The most commonly used right angle pre-cutter head, developed by Dr. Joe McCain at Southern Research Institute, which acts as the inlet section of the impactor is normally an empty, dry collection device. The Pollution Control Systems Corporation (PCSC) pre-cutter, developed by Mr. Jim Guenthoer in cooperation with the late Mr. Don Russell of Russell Engineering, Inc., is a modified version of the original SRI device that has an interior diameter that can accept a CleanAir proprietary liner for wet particle sizing that absorbs the large (relative to the PM size) water drops that enter the impactor and keeps them from shattering and flooding the lower stages of the impactor. In order to assist in differentiating between water entrained and gas-borne particulate matter, the impactor substrates are weighed "wet" onsite as they are removed from the impactors. The substrates then undergo normal post test drying protocol to derive a dry weight of collected particulate matter. A graphic comparison of wet weights and dry weights from a sample collected at the outlet of an FGD mist eliminator that shows the significant import of the data is presented in Figure 17.

The dMdLogD plot presents the mass concentration with respect to particle size on the Y-axis. The particle size is on the logarithmic X-axis. By using a linear scale for the Y-axis the area under the curve between two particle sizes equals the total concentration between the diameters. This type of plot is frequently used to demonstrate where the mass of material is with respect to particle size which affects the necessary control equipment design to achieve emissions limits. The wet plot shows what appears to be a bimodal distribution of almost equal masses of particles around 20 microns size and 0.4 microns size. However, when the samples are dried and reweighed the "large" particle concentration has diminished significantly with respect to the smaller particles whose magnitude in the total sample remains essentially the same. This indicates that the large wet peak was composed of largely of water with a smaller relative fraction of entrained particulate matter residue that remains after the water is removed. The small size diameter peak reflects untrained particulate matter that was wet, then dried but did not alter the relationship between the samples as exemplified by the larger peak. The lesson learned here of course is that if the mist eliminator

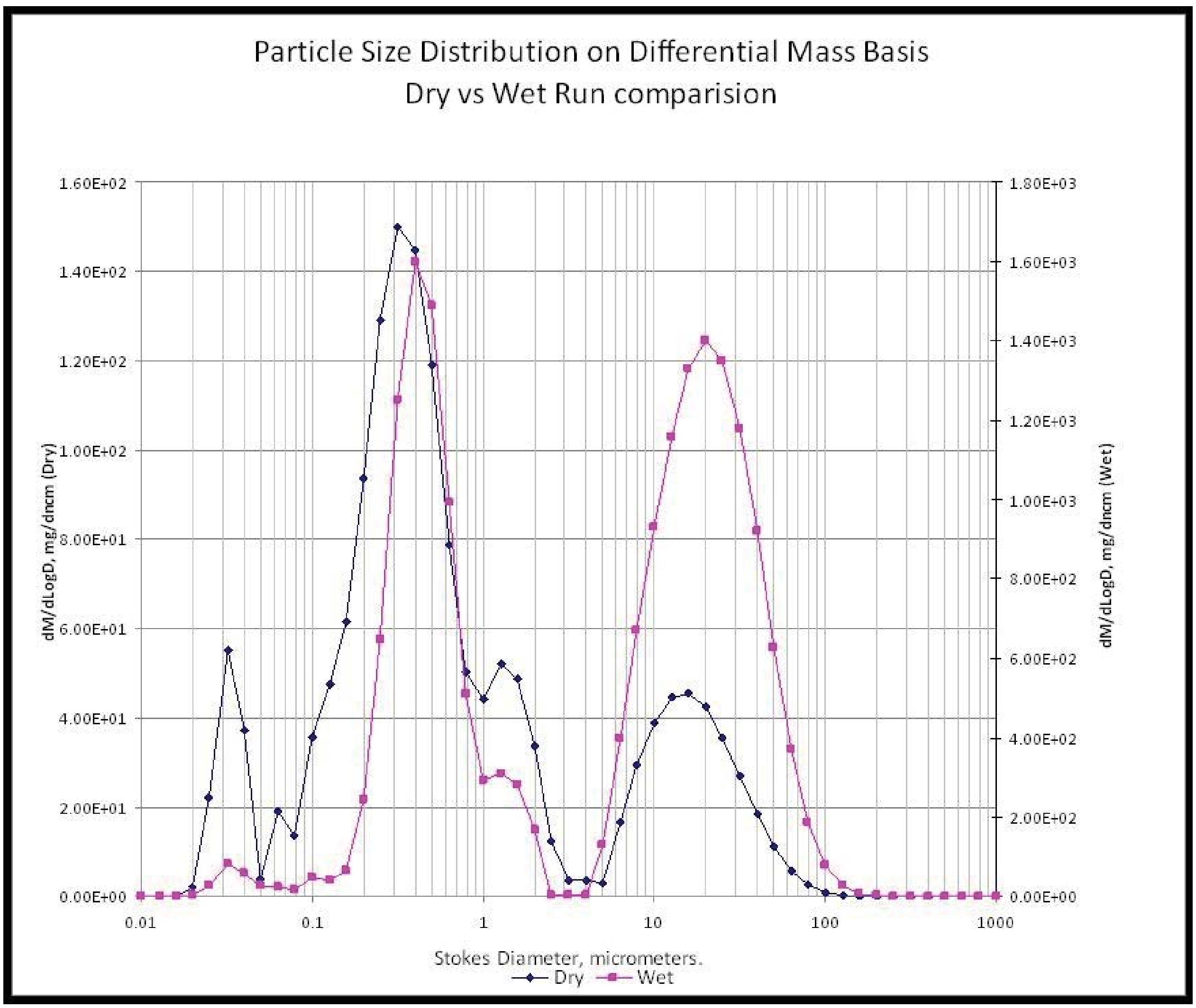

Figure 17: Wet versus Dry Particle Size Distribution Samples

was not allowing those drops to be re-entrained in the gas stream that particulate matter residue would not be in the gas stream affecting any downstream hardware and being emitted from the stack as particulate matter.

Figure 18 is a photograph of a pre-cutter liner that was used on an FGD outlet particle size distribution test. You can see the dark particulate matter residue deposited when the water drops struck the liner and were absorbed.

Figure 18: Pre-cutter liner from FGD outlet test

Post Sampling Particle Characterization Analysis

Additional analytical tools that are useful in evaluating a particle size distribution sample are scanning electron microscopy (SEM) to determine the morphology of the sample and energy dispersive spectroscopy (EDS) to identify the elemental composition of a sample. These techniques can be used on size specific samples to differentiate those that have the morphology and elemental composition of flyash versus those that show the influence of scrubber water carryover. To illustrate this, an SEM photograph and an EDS analysis of one of the individual deposits on a particle size distribution substrate collected at an FGD outlet are shown in Figures 19 and 20. The D50 of this sample was approximately one micron.

Conclusion

With the proper sampling equipment, technical expertise and experience, wet particle size distribution testing using in-situ cascade impactors can prove to be a viable and valuable diagnostic tool for assessing the operation of wet scrubbers and other wet air pollution control devices to determine if particulate matter emissions are the result of unentrained particles passing through or particulate matter laden water droplet emissions from the control devices.

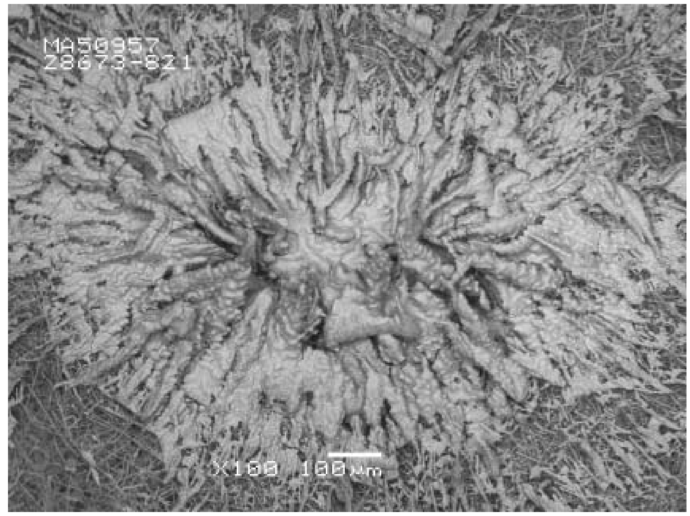

Figure 19: FGD outlet test substrate deposit

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Questions regarding this article can be addressed to Jim Guenthoer, M.S.E., QSTI, Sr. Environmental Engineer at Clean Air Engineering.

Jim Guenthoer has over 30 years of experience in the field of air emissions testing and consulting. Prior to joining Clean Air Engineering, he worked at several other engineering consulting firms as well as air pollution control and source testing equipment manufacturers. While at those firms his roles included project management and field testing, as well as design, manufacture, technical service, and sales of in-situ cascade impactor particle sizing devices. While at one firm he was involved with research and development studies of novel particulate control technologies using enhanced electrostatics. He earned his BS Degree from Juniata College and an M.S.E. in Environmental Engineering from the University of Washington.

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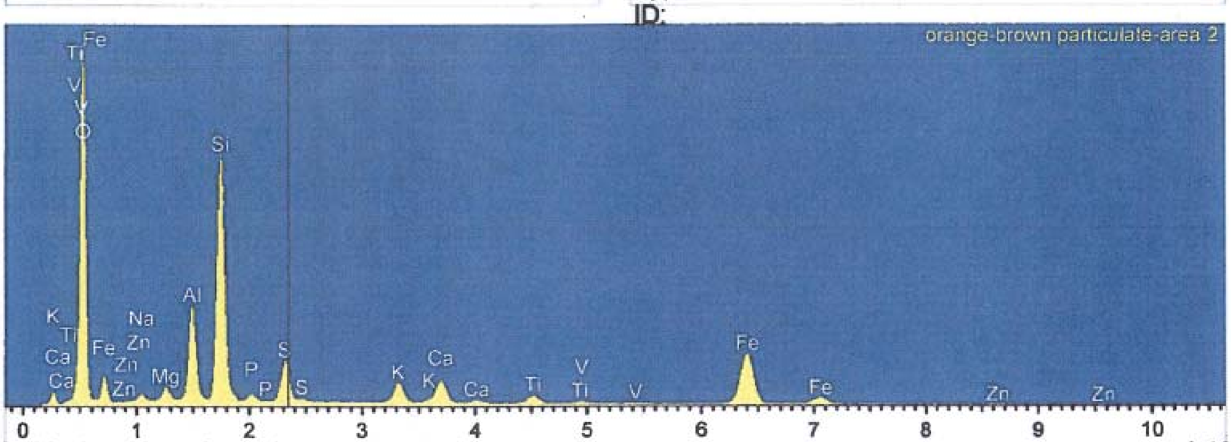
MA50957 3/22/2011 7:25:35 AM

Project: MA50957
Owner: INCA
Site:

Sample: Orange-brown particulate Filter 28673-821
Type: SFS
ID:



Full Scale 23237 cts Cursor: 2.343 (2196 cts)

Spectrum processing :
No peaks omitted

Processing option : All elements analyzed (Normalised)
Number of iterations = 4

Standard :
O SiO2 1-Jun-1999 12:00 AM
Na Albite 1-Jun-1999 12:00 AM
Mg MgO 1-Jun-1999 12:00 AM
Al Al2O3 1-Jun-1999 12:00 AM
Si SiO2 1-Jun-1999 12:00 AM
P GaP 1-Jun-1999 12:00 AM
S FeS2 1-Jun-1999 12:00 AM
K MAD-10 Feldspar 1-Jun-1999 12:00 AM
Ca Wollastonite 1-Jun-1999 12:00 AM
Ti Ti 1-Jun-1999 12:00 AM
V V 1-Jun-1999 12:00 AM
Fe Fe 1-Jun-1999 12:00 AM
Zn Zn 1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	75.12	1.0425	56.23	0.16	73.54
Na K	0.55	0.6446	0.67	0.05	0.61
Mg K	0.73	0.6272	0.91	0.03	0.78
Al K	5.10	0.7415	5.36	0.05	4.16
Si K	14.94	0.7900	14.75	0.08	10.99
P K	0.71	1.0266	0.54	0.03	0.37
S K	3.18	0.8104	3.06	0.04	2.00
K K	2.22	1.0183	1.70	0.03	0.91
Ca K	2.60	0.9753	2.08	0.04	1.09
Ti K	1.08	0.8337	1.01	0.03	0.44
V K	0.21	0.8340	0.20	0.03	0.08
Fe K	14.17	0.8374	13.21	0.10	4.95
Zn K	0.29	0.7952	0.28	0.07	0.09
Totals			100.00		

Figure 20: EDS analysis of Figure 3 sample

Air Pollution Control Solutions for Smaller Power Boilers

By Gordon Maller and Jonas Klingspor, URS Corporation (gordon_maller@urscorp.com)

Coal-fired boilers supply almost half of the U.S. electricity demand, more than the combined total of natural gas and nuclear. Higher-cost renewable options, such as solar and wind, only provide around 3% of the country's electricity needs. As a result, we will continue to rely on the availability of inexpensive electricity from coal to keep our economy strong and growing.

Over half of the current fleet of coal-fired generating units are comprised of smaller sized (<300 MW) boilers, most of which are un-scrubbed. Current and proposed regulations and the recent adoption of the new MACT Regulations for small boilers mean that many utilities will soon face a decision of either adding pollution control equipment to these smaller boilers or shut the units down. There is a need in the industry for a low-cost, high efficiency pollution control system that can be easily and quickly retrofit on the smaller boilers and capable of controlling emissions levels for SO_2 and the other HAP's covered under the new MACT rules.

There are a number of options available for controlling SO_2 emissions from smaller boilers and a number of examples where these technologies have been employed. Of course, conventional FGD systems, such as wet or dry scrubbers can be down-sized and installed on a small boiler. These systems are well understood within the industry and are capable of providing high removal performance and high reliability. The key disadvantage with these systems is high capital costs, especially in this application. Stated another way, when installed on a small boiler, an FGD system that was originally designed to be used on a large boiler suffers from the economy of scale factor in reverse. It is true that quite often a plant will include a number of small boilers that can all be scrubbed in a single absorber module, however, doing this makes planning a maintenance outage for the FGD system particularly challenging.

If only moderate levels of SO_2 removal are required, there are several low capital cost options. The two most common are furnace injection of lime or limestone, and duct sorbent injection of lime, trona or soda ash. For furnace injection, removal rates in the 30% to 60% can be achieved. This technology can be characterized as having very low capital costs, but may result in an increase in slagging and negative impacts to boiler heat rates and fly ash quality. In duct injection is also very low in capital costs but will generally require a higher cost reagent to be effective. These systems can achieve SO_2 removal rates in the 50% to 70% range. Potential problems that have been observed with this technology include duct deposits and scaling, impacts to fly ash quality, and negative impacts to ESP performance.

Circulating dry FGD technology, such as the Turbosorp or NID systems, may offer another attractive option for small boilers, especially if PM control is required in addition to SO_2 control. These systems are capable of very high removal efficiencies for both SO_2 and PM and are well suited for control of the other key HAPs such as mercury. They also produce a dry byproduct. They do have higher capital costs, relative to some of the other available options, and will impose a high (10 to 14") pressure loss on the system. As a result new fans or, at a minimum, an upgrade to existing fans will be required.

Small Boiler FGD Systems

FGD technology providers are in the process of designing and developing FGD systems to specifically service the small boiler market. The systems they design must be significantly lower in capital costs, on a dollar per kW basis, than conventional large boiler FGD systems, must be able to be installed on older units where space is typically very limited, must be able to be up and running on a very short schedule, and must be able to match performance and reliability levels of conventional larger systems. An example of such a system is the Co-FloTM wet FGD system. This system was specifically developed from the ground up as a low-cost, high performance system for the aging smaller coal-fired boiler population. A view of a Co-FloTM scrubber is shown in Figure 21.

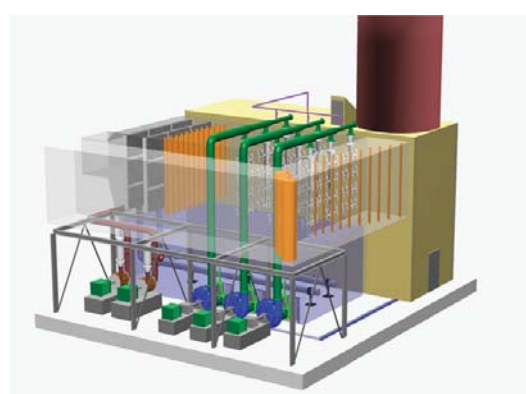


Figure 21: Typical Co-FloTM FGD System Design

The main features of the system include:

- Absorber vessel, reagent preparation, and byproduct dewatering are integrated into one compact process island;
- Limited number of rotating equipment;
- About half the cost of a conventional dry or wet FGD system;
- High performance, equal to new conventional wet FGD systems;
- Forced oxidation process producing a byproduct suitable for reuse or easy disposal;
- Zero pressure drop for the absorber and associated inlet and outlet ductwork due to use of co-current spray headers;
- Zero liquid discharge by blending fly ash and the FGD system byproduct; and
- Short 24-month project execution duration due to standardization, modularization, and off-site fabrication of key components.

The system integrates all process functions on one single foundation within one single integrated structure. Recycle pumps and air compressors are located inside the building attached to the front side of the absorber vessel. The building attached to the backside of the absorber vessel includes the limestone storage and feed system and the dewatering system. The back side building includes two levels and provides access to the absorber internals from the second level via 2 ft by 4 ft quick connect access doors.

A key component of the FGD system is the horizontal absorber vessel. The absorber vessel is equipped with traditional spray headers with some key distinctions: (1) the spray headers are oriented such that the recycle slurry is sprayed co-currently with the flue gas flow, and (2) the velocity of the droplet leaving the spray nozzles is considerably higher than the surrounding flue gas velocity. This allows for a pressure rise to be created across the absorber module and the absorber module to operate at full load without assistance of a fan.

Three stages of mist eliminators are installed in the absorber outlet including a roughing mist eliminator followed by two stages of conventional horizontal flow mist eliminators. The roughing mist eliminator consists of two rows of 8 inch half pipes. The two rows are offset to maximize liquid collection while minimizing the pressure drop.

Below the horizontal absorber vessel is an integrated reaction tank. Sparge headers are located at the bottom of the reaction tank to allow air to be sparged into the reaction tank slurry to oxidize absorbed SO_2 and produce a gypsum byproduct. The reaction tank sparge headers are designed such that the introduction of air is sufficient to agitate the solids in the tank without the need of mechanical agitators. Possible configurations for the equipment bay on the backside of the absorber vessel include:

- A dry limestone feed system and a dewatering system to produce a gypsum byproduct for reuse or disposal illustrated in Figure 22; and
- A dry limestone feed system and a dewatering system to produce a stabilized byproduct by mixing gypsum, fly ash and possibly lime to allow operation with zero liquid discharge (Figure 23).

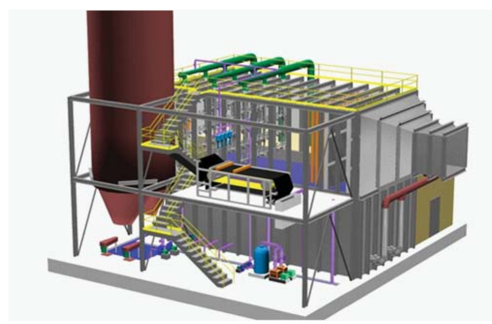


Figure 22: Limestone Storage and Gypsum Dewatering to Produce a Gypsum Byproduct

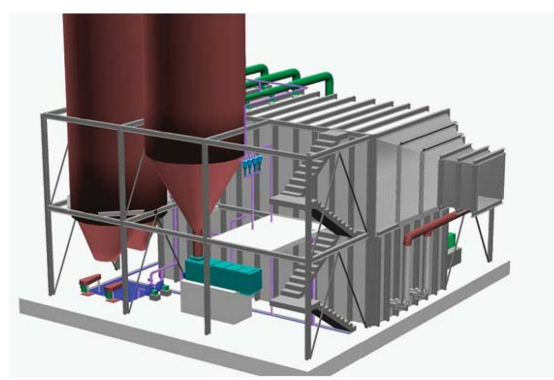


Figure 23: Limestone Storage and Byproduct Stabilization with Fly Ash and Lime

Pre-ground powder limestone is stored in a single silo equipped with two outlet hoppers for redundancy.

Option 1 includes a hydrocyclone system followed by a horizontal belt filter for production of a cement grade or wallboard grade gypsum quality.

Option two includes a second silo for fly ash storage, a hydrocyclone system and a pug mill for production of a stabilized byproduct.

Absorber Design

The close proximity of the process bays and associated buildings and the absorber vessel has allowed a tight integration of the overall structural design. An overview of the structural design approach is shown in Figure 24.

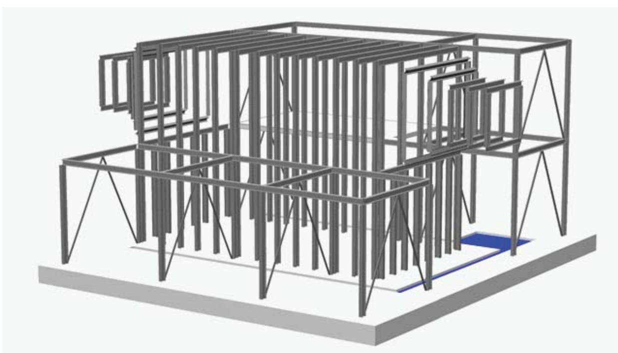


Figure 24: Integrated Structural Design

The structural steel for the two buildings attached to the absorber vessel is integrated with the absorber vessel. Therefore, the structural steel required for the absorber vessel is minimized resulting in a lower cost.

A typical design for the absorber includes four spray headers, with three operating and one spare. The first spray header is made of a higher-grade alloy such as Al6XN as it is exposed to the wet / dry interface zone while the last three headers are made from a lower-grade alloy suitable for the expected chloride and expected corrosion levels. As the first spray header is located in the quench area and sees hot flue gas on one side and saturated flue gas on the other side, buildup can potentially be experienced over time on the leading edge through recirculation of slurry droplets from the spray nozzles.

In order to keep the first spray header clean from deposits, a wash header is located immediately upstream. The wash header operates intermittently in manner similar to a mist eliminator wash header to manage the water balance. The spray headers are spaced 10 ft apart to avoid any header-to-header erosion as the spray nozzles operate at 25 psi and the spray nozzle exit velocity is elevated. The total spray zone is 50 ft long providing more than 3 seconds of flue gas residence which is sufficient to induce the level of droplet and flue gas mixing required to achieve an SO_2 removal efficiency of 98 percent or higher.

Spray Header Design

The role of the spray header in the scrubber is twofold:

(1) to transfer momentum from the injected slurry droplets to the surrounding flue gas in order to generate a pressure rise and

(2) to create an intimate contact between injected slurry droplets and the flue gas to promote mass transfer and achieve the desired SO_2 removal efficiency.

When properly designed, the Co-FloTM scrubber will provide the same removal efficiency as a counter current spray header. The determining factor of the spray header efficiency, all other design parameters being equal, is the relative velocity between the flue gas and the slurry droplets. For a co-current spray header arrangement to have the same relative velocity as a countercurrent spray header arrangement, the nozzle exit velocity must be increased. This is accomplished by operating the spray header at a higher pressure, e.g. 25 psi, compared to 8 to 10 psi typical of countercurrent spray headers. A typical spray header design is shown in Figure 25.

Co-current spray headers operating with high pressure nozzles have dramatic impact on the pressure profile across the absorber tower. Slurry droplets that enter the absorber at velocities higher than the flue gas will transfer their momentum to the flue gas as the drag between the droplets and the flue gas slows them down. As a result, co-current spray headers will generate a pressure rise across the absorber module.

Double hollow cone spray nozzles are used for the spray headers to provide improved performance. The double hollow cone nozzles generate a high amount of nozzle-to-nozzle interaction through collision among droplets from within each nozzle and between adjacent double-hollow cone nozzles. This contributes to an increase in efficiency of up to 40 percent compared to traditional nozzles. The increased removal is due to the high internal turbulence within the slurry and the high degree of droplet collisions that occur as the slurry exits the spray nozzle and within the first 1.5 feet. This results in smaller and more reactive droplets because the turbulence and collisions tend to bring fresh reagent to the surface of the droplets. Data has shown that 70% of removal occurs in this region. The double hollow cone spray nozzles are shown and the droplet to droplet interactions are illustrated in Figure 26.

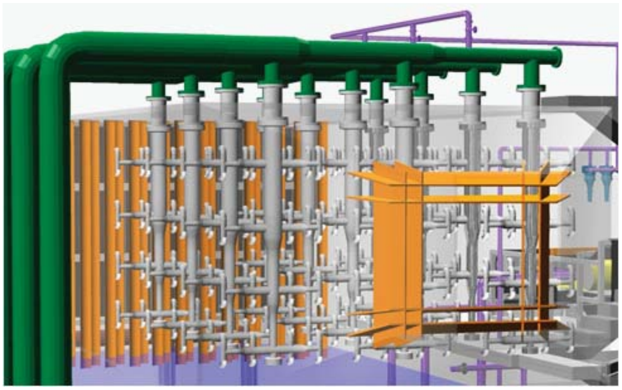


Figure 25: Spray Header Design

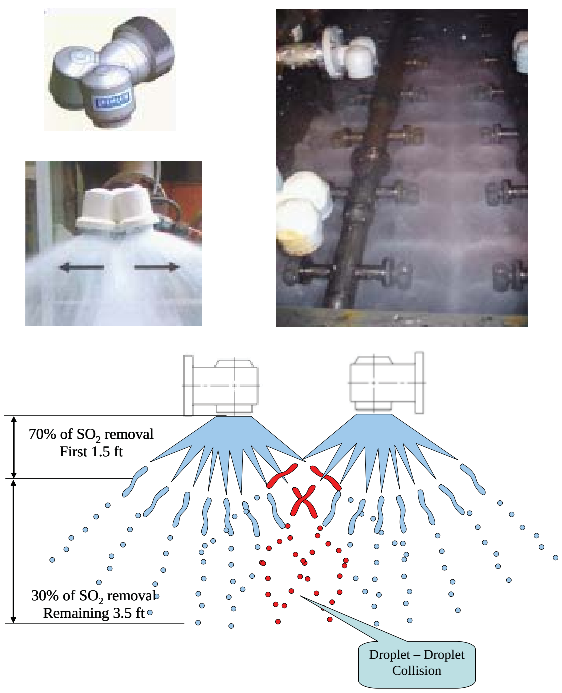


Figure 26: Performance of Double Hollow Cone Spray Nozzles

Forced Oxidation System

A key cost saving feature of the system is the fact that the forced oxidation system is used to provide both oxidation air to produce a gypsum byproduct and agitation to keep solids in the reaction tank suspended. Air is injected into the reaction tank by air spargers which run the length of the reaction tank.Each sparge header has two rows of sparge holes located 30 degree on both sides of vertical pointing downward towards the absorber floor. This approach generates a double helix recirculation inside the tank sufficient to keep the tank agitated and avoid need for mechanical agitators. The oxidation system is illustrated in Figure 27.

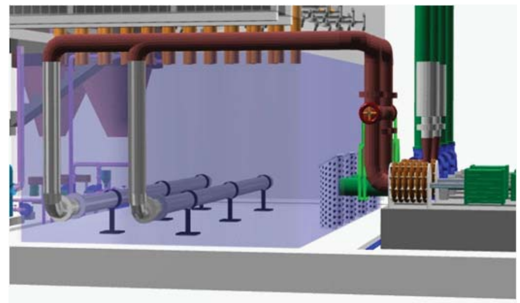


Figure 27: Forced Oxidation System

FGD ID Fan

A FGD system typically requires a fan that can accommodate 5 to 15 inch of pressure drop depending on type and FGD design approach such as wet versus dry FGD systems and open spray towers versus tray towers. A unique feature of a co-current spray headers is the fact that they generate a pressure rise. The accomplished pressure rise depends on several factors such as the absorber liquid-to-gas ratio, absorber bulk velocity, and the spray nozzle spray angle and pressure drop. A noteworthy characteristic of the co-current absorber design is that for a given SO_2 removal efficiency, a higher sulfur coal generates a higher pressure rise across the absorber module. Similarly for a given coal sulfur level, a higher SO_2 removal efficiency generates a higher pressure rise.

The pressure rise feature of the co-current spray headers is illustrated in the computational fluid dynamics (CFD) modeling shown in Figure 28.

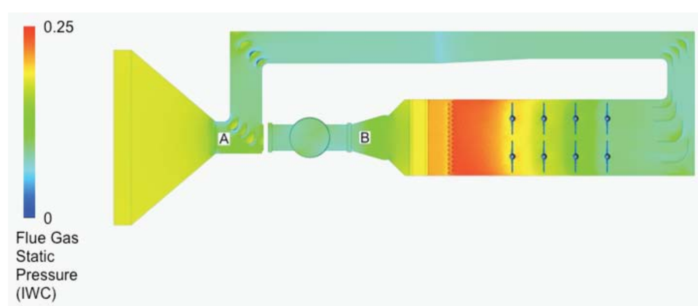


Figure 28: Pressure Drop Profile Across Co-FloTM FGD System

For the particular system and ductwork configuration that was analyzed, the pressure rise across the absorber is 0.8 in-wg with 3 spray headers in operation and full load conditions. When the pressure drop across the four 90-degree turns is added in, the overall pressure drop for the system from point B to point A is 0.35 inches.

Project Schedule

The FGD system described above is designed to be installed and operating within 24 months including all design, procurement and construction activities. A key feature that makes this possible is the modular design of the system utilizing pre-fabricated absorber panels. In addition, there are fewer interface points and interface issues to be resolved as a result of the integrated design of the absorber module and support systems.

Conclusion

Recent and pending regulations such as the Utility MACT rules will require utilities to make decisions on what to do with their smaller and older un-scrubbed coal-fired units. In many cases it will not be possible, due to market demands for power, to retire these units requiring the utility to make an investment in pollution control equipment. There is a need within the industry for FGD systems specifically designed for the smaller and older boilers that will remain in service. These systems will need to be lower in cost than conventional scrubbers and will need to be able to be placed in service quickly to be able to meet the pollution control requirements of the current and future regulations.

URS

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Gordon Maller serves as a Business Development Manager and Project Manager in the Air Pollution Control Technology area of URS Corporation. In this capacity, he develops business opportunities, directs projects, manages resources, and directs engineers and scientists in programs aimed at designing, optimizing, and upgrading air pollution control processes. He also has performed and directed numerous projects aimed at gaining a better understanding of air pollution control process technology. Mr. Maller joined Radian Corporation, a URS legacy company, in 1980 after receiving a BS degree in chemistry.

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Is a bi-annual newsletter sponsored by and for the Worldwide Pollution Control Association www.wpca.info

Purpose

To foster new ideas and greater awareness concerning pollution control in the energy industry

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For more information on the WPCA Please visit our website at
www.wpca.info

WPCA

IL Regional Seminar

September 13-15, 2011
Marriott Bloomington-Normal Hotel
Bloomington-Normal, Il

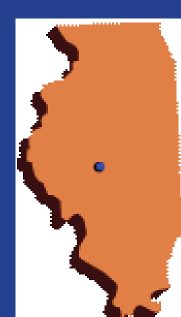
Solutions
U-MACT
Regulation Update
O&M Troubleshooting

Training
Networking
User Meetings
Technical Exchange

Worldwide Pollution Control Association

WPCA IL Regional Seminar

- Date: 9/13/11 to 9/15/11
- Location: Marriott Bloomington-Normal Hotel & Conference Center
- Cost: one day fee - $100; 3 day fee - $250
- Three day seminar - Each day is devoted to a different technology
  - Tuesday - NOx control / Hg control / SO_3 Mitigation
  - Wednesday - Particulate control and O&M / SO_3 mitigation
  - Thursday - Scrubbers: dry and wet / Hg control
- Each day starts with a 2 hour Users Group Meeting
- Each day will have a panel discussion on Utility MACT



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