



CLEAN AIR FOR A BETTER TOMORROW

AIR POLLUTION CONTROL



ENGINEERED SUCCESS

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**ENGINEERED
SUCCESS**

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Working hand in hand with the environment

ANDRITZ is a leading global supplier of innovative air pollution control technologies. Our product range combines 30+ years' experience with the specific knowledge gained from over 200 installations around the world. ANDRITZ offers high-end technologies and is a partner you can rely on.

Thanks to our wide portfolio of flue gas cleaning technologies and extensive experience in executing projects, ANDRITZ is more than capable of handling all of the challenges involved in your project. We are reliable and innovative – an ideal partner to help you meet your environmental and financial goals. Maintaining the energy efficiency of your processes, complying with the most stringent environmental regulations and developing tailor-made solutions for your plant are the cornerstones of our approach. With offices in the USA, Europe, South America, and Asia, ANDRITZ is able to provide well-proven solutions for each respective market and has the dedicated personnel to meet all clients' needs.

AIR POLLUTION CONTROL TECHNOLOGY APPLICATIONS FOR

- Utility Power Industry
- Waste to Energy / Sludge Incineration
- Pulp&Paper
- Mining & Metals Industry
- Oil & Refinery Industry
- Marine Industry



Clean air is the basis of a healthy life. Air pollution causes discomfort or harm to human beings and other living organisms. It is our mission to prevent air pollution from power generation and industrial processes.

recognized partners and universities are the foundations of our work. Early identification of each client's needs help us make a long-term contribution to clean air and a clean environment.

Even with heavy subsidies and incentives, renewable and environmentally friendly energy sources will only meet part of the world's future demand for power. Reliance on thermal power stations will continue to be important for the future. With this reality, it is critical to make thermal power generation cleaner and more sustainable. It is our mission to allow power plants to continue in long-term operation without impacting the environment.



ANDRITZ delivers environmentally friendly flue gas cleaning solutions, tailored to the needs of our clients and their operating environments. We are an environmental technology pioneer with a history in air pollution control spanning 30+ years. Our products range from flue gas scrubbers and SCRs for power stations to complex flue gas cleaning systems for waste-to-energy and industrial plants. Use of cutting-edge engineering tools and global R&D collaboration with a network of



From single systems to turnkey plants

Several design options are available to choose from depending on the upstream processes and potential pollutants to be filtered out, including tailored solutions for industrial applications. Our goal is the removal of acid gases (SO_x, HCl, HF), particulate matter, mercury (Hg), heavy metals and nitrogen oxides (NO), dioxins and furans.

WET FLUE GAS CLEANING

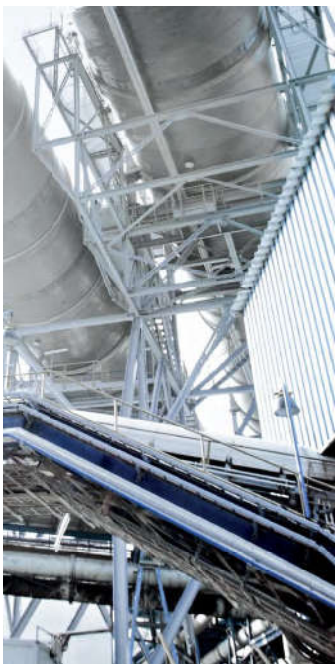
ANDRITZ offers wet limestone flue gas desulphurization (WFGD) scrubbers with high reliability and availability based on a wellknown principle of washing flue gas with a limestone slurry and generating gypsum as a saleable end product. We have enhanced this basic process and now offer the most advanced scrubbing technology (FGDplus).

DRY FLUE GAS CLEANING

ANDRITZ dry flue gas scrubbing processes are based on circulating fluidized bed technology and offer an ideal solution for flue gas cleaning downstream of conventional thermal power stations, biomass incineration plants, RDF-fired boilers (Refuse Derived Fuels), or waste-to-energy plants and other industrial applications.

DeNOx SYSTEMS – SCR

ANDRITZ offers Selective Catalytic Reduction (SCR) technology for the de-nitrification of flue gas. High- and low-dust as well as tail-end configurations are available. Dioxins and furans can also be removed with the SCR tail-end configuration.



- POWER STATION APPLICATIONS**
- Wet limestone FGD
 - FGDplus
 - Mercury Control
 - Seawater FGD
 - Post Carbon Capture/CO₂ Absorption

- INDUSTRIAL APPLICATIONS**
- Wet flue gas cleaning (calcium and sodium based)
 - Multi-stage scrubber
 - Combined system
 - Mercury Control
 - SeaSO_x, open/closed/hybrid loop



- POWER STATION APPLICATIONS**
- Dry sorption
 - Turbo-CDS/TurboSorp
 - Mercury control
 - Particulate control

- INDUSTRIAL APPLICATIONS**
- Dry sorption
 - TurboSorp
 - Particulate control
 - Spray Absorption
 - Mercury Control
 - SeaSO_x, dry



- POWER STATION APPLICATIONS**
- SCR (high-dust, low-dust, or tail-end application)
 - SCR for combined cycle power plants (CCPP)

- INDUSTRIAL APPLICATIONS**
- SCR (low dust and tail end application)
 - SNCR

Wet flue gas desulphurization systems – Highly efficient processes for low emissions

Limestone flue gas desulphurization systems (FGDs) are well-proven and cost-effective. They have been in use in power stations since the 1970s. Over the years, we have created an advanced scrubber design with outstanding reliability and excellent availability. Plant economics have also been optimized, ensuring low capital and operating costs.



LIMESTONE FGD: A NEW DIMENSION
 ANDRITZ has set a new global standard of excellence with its wet limestone FGD design, featuring the world's largest wet scrubbers at the Neurath power plant (2x1,100 MW). These two scrubbers (with diameter of 23.6 m / 77.4 ft) have been operating successfully since 2008, and each one can accommodate a flue gas flow of 4.75 million m³/h or 2.8 million ACFM.

The unique scrubber design combined with optimum use of our technology to meet our customers' needs has become our trademark. Technical and economic optimization guarantees lower capital and operating costs.

KEY FEATURES

- Outstanding for all fuels (lignite, hard coal, oil, biomass, waste)
- SO₂ removal > 99%
- Maximum HCl and HF removal levels
- Gypsum as a saleable end product
- Flue gas volume flows of up to 5 million m³/h [stp, wet] per scrubber
- Limestone as a favorably priced absorption agent
- Low operating costs and power consumption
- Open spray tower, low pressure loss
- Options for materials of construction (high-alloy carbon steel with rubber lining, concrete with PP-lining, glass fiber reinforced plastics)

Wet limestone scrubbing process World's largest absorber in Neurath, Germany

LIMESTONE FGD: ADVANCED SCRUBBER DESIGN
 The nucleus of our design is the scrubber, which is an open spray tower that has been enhanced using computerized simulation techniques. We have been conducting intensive development work in this field since 1995 and today enjoy a leading position that not only allows us to simulate flow and temperature profiles, but also to calculate the distribution of SO₂ concentrations in the scrubber.

During comparisons of simulator data with actual plant measurements, the flow and temperature profiles have verified our design parameters. Compared to traditional scrubbers, the result is a scrubber that is substantially smaller than conventional designs and features adaptable scrubber inlet and outlet geometry, as well as optimum layout of the spray nozzles and spray banks. This results in a uniform SO₂ profile in combination with the highest possible gas velocity in the scrubber – removing the most pollutants while utilizing the least power.

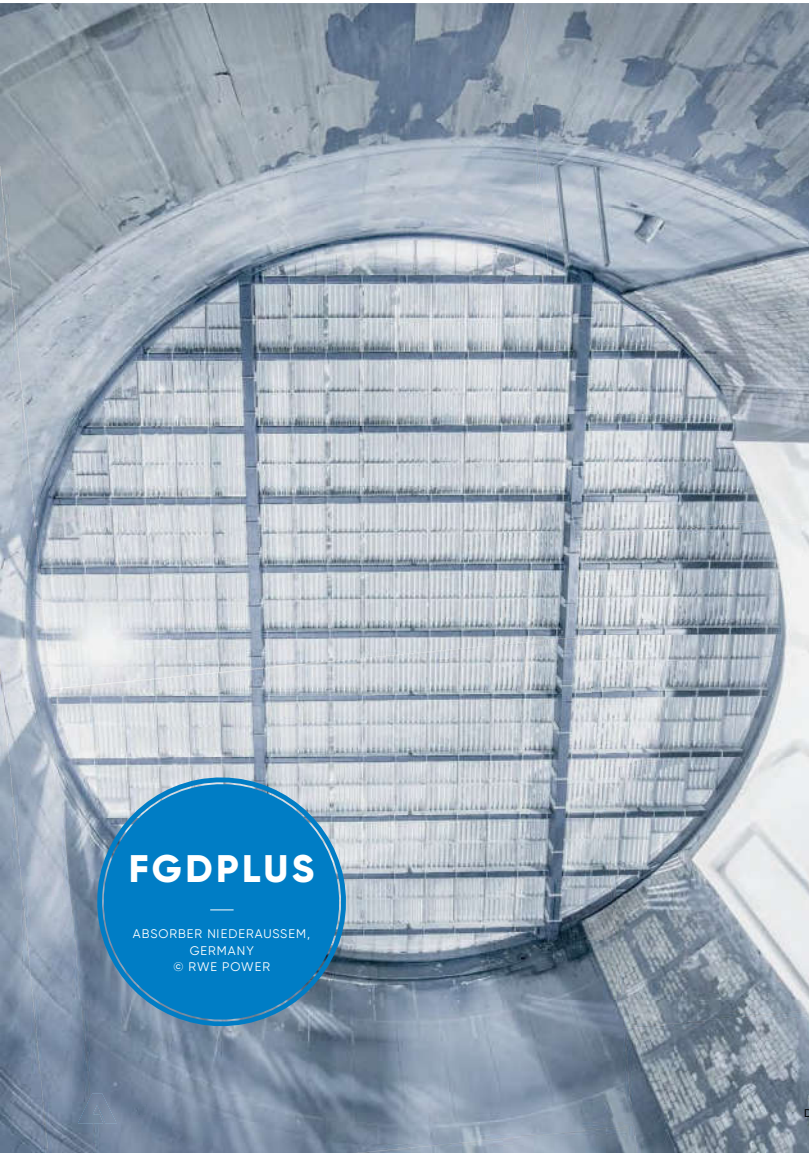
The scrubber also benefits from use of the latest materials and construction methods. Fiber reinforced plastic (FRP) absorbers and reinforced concrete absorbers with polypropylene linings are used in addition to the proven stainless steel and alloy absorbers as well as carbon steel absorbers with a variety of inner linings.



Scrubber at Neurath Power Plant, Germany



World's largest absorber in Neurath, Germany



FGDplus

The optimized mass transfer upgrade for improved removal of SO_x, dust, and aerosol. The drivers for process development in the field of flue gas cleaning technologies are no longer limited to more stringent, country-specific emission limits.

Meanwhile, there are other drivers, such as optimization of the separating efficiency in order to improve input of energy and resources. Another determining factor is the need to minimize the maintenance effort over the entire lifecycle of a flue gas desulphurization plant (FGD plant).

A new type of FGD technology based on the proven ANDRITZ limestone wash technology meets these new requirements. The patented FGDplus technology from ANDRITZ is based on an optimized "tracked mass transfer" inside the scrubber. With this system, an optimized combination of different absorption regimes leads to improved SO_x, dust, and aerosol removal, which helps to improve the efficiency of any installed system.

Especially in high sulphur applications, these advantages are outstanding. Existing open spray tower scrubbers can be retrofitted easily to a new level of

performance with this innovation, where the design will be optimized to meet the requirements on site. Influence on the existing design of the scrubber sump and the recirculation system is minor.

Challenging implementation time and special maintenance requirements will also favor the FGDplus system. A very robust and reliable FGD system was introduced with the FGDplus design. Based on long term investigations on lab and pilot scale, but especially with an industrial size pilot plant at a lignite-fired power plant in Germany, a new and innovative design was developed. The first applications and long-term experience in Germany and Asia confirm these findings and show a clear advantage over comparable designs on the market.

KEY FEATURES

- Optimized combination of favorable mass transfer regimes from inlet to outlet of absorber
- Easy to implement and update existing systems
- Short implementation time
- Robust design, absolutely blocking resistant
- Minimized operation and maintenance costs
- Designed for optimized removal of SO_x, dust, and aerosol

Seawater Flue Gas Desulphurization (FGD)

Process with low operating and maintenance costs for use in coastal regions. ANDRITZ has developed the seawater FGD process by taking full advantage of the cooling water circuit downstream of the condenser of power plants in coastal areas.

IDEAL SOLUTION FOR COASTAL PLANT

ANDRITZ's seawater FGD system is able to work without additional absorbent, and there are no by-products or waste created that need further treatment or disposal. Raw flue gas enters the scrubber and is cleaned in counter-current by seawater. The principle applied here is similar to the limestone process. Depending on the application at re-nat-em haruntiat etur?

ANDRITZ offers an FGD scrubber based on the well proven open spray tower technology, combined with an FGDplus system. In addition, ANDRITZ also has experience with a packed tower design for seawater FGD systems. These systems are beneficial in optimizing the plant's footprint and efficiency at high SO₂ inlet concentrations.

WISE PRINCIPLE

The principle of our process is to make use of the natural alkalinity of seawater instead of using limestone solution to absorb acidic substances in the flue gas. The SO₂ is first converted into sulphite. Then the sulphite is oxidated to form sulphate in the CFD-optimized aeration basin in order to maintain the pH, raise the DO (dissolved oxygen), and reduce the COD (Chemical Oxygen Demand). In the meantime, CO₂ formed by the neutralization reaction is stripped by aeration membranes, and the pH value is increased consequently to meet legal requirements.

FLEXIBLE ARRANGEMENT

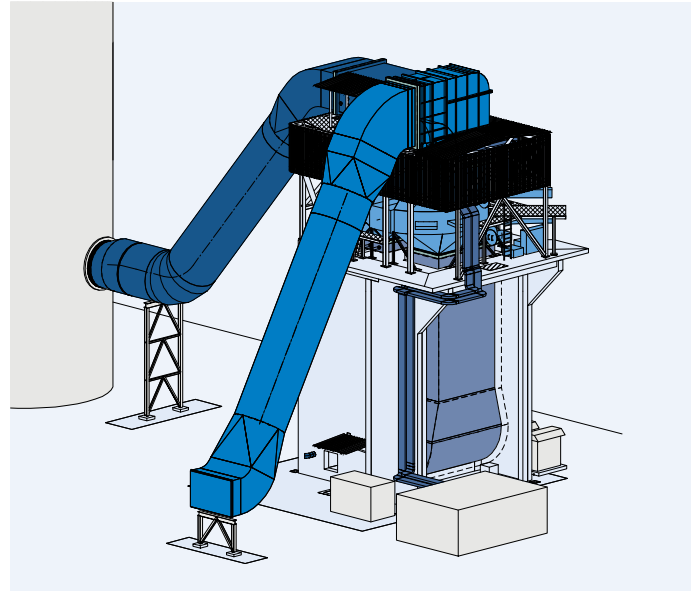
ANDRITZ is able to provide customized seawater FGD design and planning to suit the general power plant arrangement



Seawater FGD at Vung Ang power plant, Vietnam

KEY FEATURES

- Outstanding for various fuels (lignite, hard coal, oil, and biomass)
- Up to 99% SO₂ removal
- No by-products
- Seawater as absorbent
- Open spray tower technology and packed tower design
- Low operating and maintenance
- High availability
- Options for materials of construction (high-alloy carbon steel with rubber lining, concrete with PP-lining, glass fiber reinforced plastics)



Turbo-CDS – Multi-pollutant control for utility power plants

ANDRITZ Turbo-CDS technology is the ideal solution for flue gas cleaning downstream of boilers fired with fossil fuels and other energy sources. It is an optimum one-step solution that has demonstrated not only high efficiency in removal of SO_x and particulate, but also of HCl, HF, heavy metals like mercury, and other hazardous pollutants.

PROCESS

ANDRITZ's Turbo-CDS system based on the well-proven circulating fluid bed (CFB) technology. It has shown excellent performance as a multi-pollutant control system in just one step. The flue gas flows through a cylindrical apparatus (CFB scrubber). The scrubber inlet uses multiple venturi nozzles to increase gas velocity in order to support the fluidized bed. The bed material in the fluidized bed consists of unreacted lime, which is injected as a dry powder, reaction by-products, and fly ash. These materials are recirculated between the scrubber and the connected filter. In addition, process water is injected separately into the scrubber in order to enhance the desulphurization capacity of the process. Wastewater from other processes can be used as process water, which is beneficial if waste water disposal is desired or if fresh water availability is limited on site. To collect particulate matter exiting the scrubber, either a fabric filter or an electrostatic precipitator may be used. The separated material is recirculated back into the scrubber by means of fluidized "air slide" conveyors. This recirculation system also regulates disposal of the by-product, which is a dry powder that can be landfilled or used beneficially as structural fill or in agricultural applications. Other equipment has also been optimized and designed especially for the ANDRITZ Turbo-CDS. The lime hydrator, for example, can be made an integrated part of the overall ANDRITZ technology so that pebble (or "burnt") lime (CaO) can be used as the reagent, which is less expensive than using hydrated lime.

ADVANTAGES

ANDRITZ Turbo-CDS has been optimized for a minimum footprint requirement and is, therefore, an excellent solution for retrofits where space for the necessary plant is limited. With this system, no wastewater is generated. Also the short implementation time, and the low investment and maintenance costs are clear advantages over comparable systems. The ANDRITZ Turbo-CDS has demonstrated its high availability in multiple applications around the world.

KEY FEATURES

- Focus on optimized SO_x and dust removal (> 99%) – high reliability and flexibility
- Up to 99% SO₂ removal
- Multi-pollutant control in one step, suitable for an expanded set of pollutants newly regulated in the US, the EU, and China
- CFD modelling used as an engineering tool – optimization of fluid dynamics
- In-house lime hydration design, optimized for ANDRITZ Turbo-CDS



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Dry flue gas cleaning systems Effective and compact – in one step

ANDRITZ dry flue gas cleaning systems meet the requirements for complying with the world's strictest emissions legislation, the desire for low consumption of additives, the need for minimal residues, and the installation simplicity of a compact design.

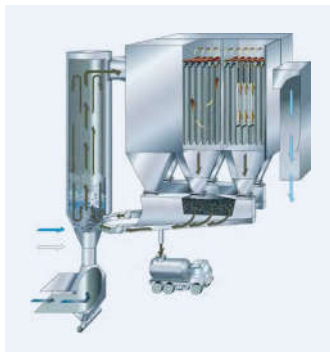
Activated carbon can be used to achieve excellent removal of mercury, heavy metals, and dioxin/furan. As a result of advanced process management in terms of operating temperature, solids recirculation, and the dosage of additives, material consumption and generation of waste are kept to a minimum. The by-product of the process is a dry, powdery residue, which – depending on its composition – can be landfilled or used as a filler (e.g. road construction).

LOW INVESTMENT AND MAINTENANCE COST

ANDRITZ CDS systems are noteworthy for their compact designs. This allows for easier installation in a plant. Fluidized bed technology does not use rotating or wear parts, reducing the initial investment cost and the ongoing maintenance costs. Due to the simplicity of the design of the system components, very high levels of availability are achieved.

DRY SORBENT INJECTION (DSI)

In certain cases, especially for smaller plants, dry sorbent injection is used for removal of SOx and /or HCl, and even as a multi-pollutant control system. DSI has been optimized for a minimum footprint requirement and is, therefore, an excellent solution for retrofits where space is limited and plant upgrades are necessary. Hydrated lime neutralizes the acid components in the flue gas, whereas activated carbon injection can be used for heavy metal and dioxin/furan removal. A downstream bag filter is usually used for particulate removal, where dust and by-products are collected.



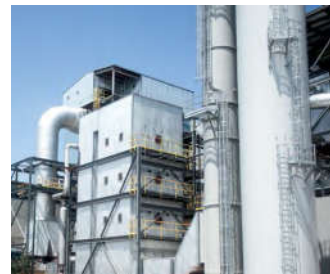
TurboSorp, Fabric Filter, SCR, Moerdijk, Netherlands

SODIUM BICARBONATE

The sodium bicarbonate process is used wherever waste production must be kept to a minimum. Due to the very high reactivity of sodium bicarbonate, only a small amount of sorbent is required. The process is independent as long as the temperature is high enough. This technology is also compatible with low temperature SCR, where no reheating is required.

TURBOSORP

Similar to the Turbo-CDS technology, the TurboSorp process consists of a CFB scrubber connected to a bag filter, where the product is circulated multiple times before it is released from the process. The TurboSorp process is designed to optimize the footprint and keep the installation time to a minimum. Due to product recirculation and water injection, the sorbent consumption is minimized.



Dry Sorbent Injection and Tail-End SCR, Conyers (GA), Pratt, USA

KEY FEATURES

- Proven technology know-how with excellent references
- Dry sorbent technologies optimized for any onsite conditions, with a focus on multi-pollutant control solutions:
 - SOx, HCl, HF removal
 - Dust and particulate matter
 - Heavy metal including mercury, organic, and other pollutants like dioxins/furans
- Low investment costs
- Low maintenance, high availability
- Wastewater free

Particulate removal technologies

Pulse Jet Fabric Filters (PJFFs) and Electrostatic Precipitators (ESPs). ANDRITZ Pulse Jet Fabric Filter technology has been developed through the design and installation of more than 80 fabric filter systems worldwide.

PULSE JET FABRIC FILTERS (PJFF)

These fabric filters treat approximately 54 million m³/h (32 million ACFM) of flue gas, primarily at coal-fired boiler power plants (over 7,000 MW capacity), but also including waste incinerators, biomass, and other industrial processes.

ANDRITZ fabric filters are used to meet the most stringent particulate emissions requirements, but also for ash recirculation and collection, as well as the adsorption or absorption of partially gaseous pollutants in conjunction with the ANDRITZ CFB scrubbers or Dry Sorbent Injection (DSI) systems.

KEY FEATURES

- Modular fabric filter (PJFF) designs available up to 150 MW
- Structural designs up to 500 MW in a single fabric filter
- As many as 1,800 bags per compartment
- ASME stamped pulse headers with multiple pulse valve designs
- High- and medium-pressure cleaning system designs
- Filter bags up to 10 meters (32.8 ft) in length
- Multiple filter bag and cage designs to suit any application
- Filter bag life in excess of five years
- Low pressure drop on stand-alone filters as well as downstream of CFB scrubbers
- Ideal solution for dry scrubber applications low sulphur, and PRB coals
- > 99.9% particulate removal, with demonstrated emissions less than 0.005 lb/MMBtu



A Cleco, USA
B Hoppers for the pulse jet fabric filter – Big Stone – Otter Tail



Otter Tail Power, USA

WET ELECTROSTATIC PRECIPITATOR (WESP)

Extensive experience with wet-type electrostatic precipitators that are now operating worldwide. The WESP is used to collect sub-micron particulate and aerosols (PM10) from gas streams.

DRY ELECTROSTATIC PRECIPITATORS

Dry electrostatic precipitators are offered as part of our Circulating Fluid Bed (CFB) scrubber system as well as on integrated air quality control system projects.

KEY FEATURES

- No emission of aerosol
- Dust removal down to PM2.5 and <1 mg/m³ [stp]
- Reduction of heavy metals
- High velocity operation up to 4 m/s

KEY FEATURES

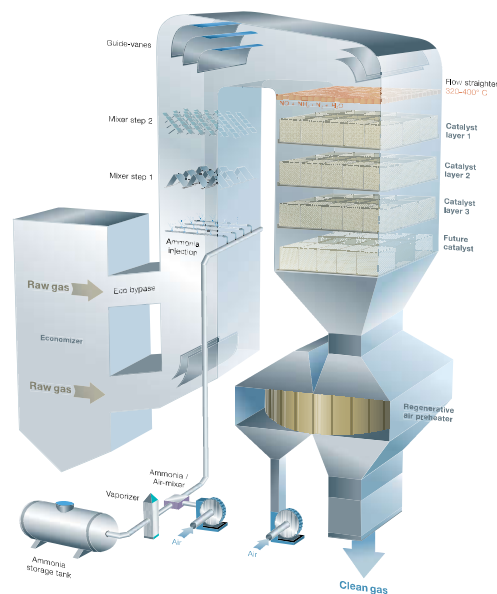
- Dust removal down to 10 mg/m³ [stp, dry]
- Retrofit of existing ESP

DeNOx plants – Selective Catalytic Reduction (SCR)

ANDRITZ was among the first companies in Europe to use SCR technology successfully.

The company has numerous references in the DeNOx/SCR sector encompassing a variety of applications. In addition to use in power plants (high- and low-dust configuration), we have also used SCR technology successfully for waste incineration and other industrial processes.

We are able to select specific operating parameters, catalyst geometry, and composition, thus ensuring optimum operation.



The location of the DeNOx/SCR system within the flue gas cleaning process depends on the type of fuel involved. Our tailend configuration has proved to be highly effective in waste incineration and biomass-fired plants. The active centers of the catalyst are only exposed to a minimum of catalyst poisons, resulting in a longer lifetime.

Due to the necessity of a reheating system, the investment and operating costs are higher for the tail-end

configuration, which is thus mainly used in industrial applications. The high-dust configuration is preferred for power plants (coal, gas, oil), as the costs for reheating can be avoided. ANDRITZ has an extensive database on catalyst life for a variety of fuels. Consequently, we are able to optimize and minimize the catalyst volume for every application.

KEY FEATURES

- Aqueous ammonia direct injection
 - Latent heat of flue gas used to vaporize reagent
- Injection of pre-vaporized ammonia with optimized Ammonia Injection Grid (AIG)
 - Optimum NOx to ammonia distribution at minimum pressure drop
- Experience with wide fuel range
 - Most coal types (PRB, subbituminous, bituminous, and lignite)
 - Oil refinery wastes, lean gas, natural gas
 - MSW, industrial sludge, biofuels, sewage sludge
- Experience with various SCR arrangements
 - High dust; Low dust and Tail end
- SCR cleaning devices
 - Soot blowers and sonic horns



ANDRITZ DENOX/SCR SYSTEMS ARE USED IN THE FOLLOWING PLANTS.

- Power plants
 - Gas-fired
 - Oil-fired
 - Coal-fired
 - Biomass-fired
- Waste incineration plants
 - Household waste
 - Hazardous waste
 - Hospital waste
- Industrial plants
 - Steel industry
 - Oil industry
 - Pulp and paper industry



High-dust configuration at Hoosier Energy Merom Power Station, Units 1 & 2, Sullivan (IN), USA

Multi-stage / combined flue gas cleaning – Compliance with lowest emission values

ANDRITZ has the competence to combine and optimize systems for special requirements.

Current legislation regarding waste disposal and emission levels requires state-of-the-art flue gas cleaning systems. Selective pollutant removal is required, which not only aims to achieve minimum emissions in tandem with low operating costs, but also enables the recovery of recyclable by-products and a linked reduction in the volume of highly pollutant residues. ANDRITZ is the perfect partner for tailored solutions meeting both environmental and procedural requirements. We accompany our clients through the whole investment process, beginning with project development through plant commissioning, and then service support for the lifetime of the system.

Our flue gas cleaning systems are designed in modules. This helps us to configure and combine technologies in order to meet specific requirements:

- Dry flue gas cleaning
- DeNOx/SCR systems
- Multi-stage wet scrubbing
- Particulate control
- Spray absorption
- Activated carbon

KEY FEATURES

- Process /project development for complex, unique process requirements
- As an experienced EPC contractor, knowledge of the complex project set-up throughout the entire project lifetime
- Focus on holistic project setup – minimizing operation costs, recovery of recyclable by-products
- Process know-how, experience from tip to toe for multiple industry sectors



Recirculation pumps, Pfaffenau, Austria



SCR, SPRAY DRYER, FABRIC FILTER, TWO-STAGE WET SCRUBBER / Mainz, Germany

Mercury control – Holistic approach to minimize mercury emissions

Of the several processes for removing mercury from the emissions of coal-fired power stations, the most preferred are those that have synergy with existing air pollution control equipment.

Mercury is a potentially deadly neuro-toxin. Mercury emissions from coal-fired power stations are a major environmental concern due to the toxicity and persistence of mercury that accumulates in our waterways.

Stringent mercury emission limits in the USA and upcoming BAT and IED regulations in Europe present a

significant challenge. To meet these limits, ANDRITZ follows a holistic approach by taking not only the various oxidation reactions in the flue gas pathway, but also the processes within the wet FGD system and downward streams into account. We expect that this issue will become a main topic worldwide for coal-fired boilers within the next few years. If the conventional

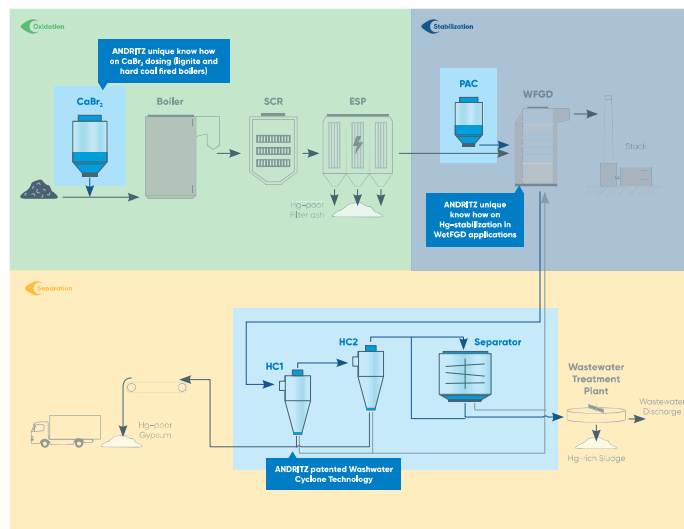
oxidation in the gas phase, based on the gas condition and process set-up, is not sufficient to meet the emission limits, ANDRITZ offers a well proven calcium bromide oxidation system. Dosing calcium bromide into the boiler is an adequate and easy way to oxidize the greater part of the mercury originating within the boiler. Other process steps within the flue gas path are crucial for any further mercury oxidation downstream of the boiler as well. For instance, any enhanced oxidation within an existing SCR unit has to be considered for any process developments. Finally, the oxidized mercury will be caught at the FGD scrubber. ANDRITZ considers all the important process steps and the gas composition in order to optimize the mercury emission control system implemented.

ANDRITZ has long-term experience with wet and dry FGD systems. A well designed dry flue gas cleaning system will help to minimize the additional additive costs. ANDRITZ has introduced and constantly improved the TurboSorp Circulation Dry Scrubbing (CDS) system.

which could render the FGD product useless as a resource for the drywall industry. Secondly, the gypsum whiteness will deteriorate and hence be unattractive for commercial use.

With conventional hydrocyclone systems, the specifically bound mercury cannot be removed efficiently from the gypsum. Thus, ANDRITZ offers a patented hydrocyclone design that clearly separates the mercuryloaded particles (e.g. PAC) from the gypsum and thereby reduces the mercury content in the FGD product to a minimum. This system is easy to implement and has a clear advantage for any upgrade of existing FGD installations. In order to enhance the mercury transfer to the waste water treatment plant and also to prevent an increase of the mercury concentration within the scrubber, ANDRITZ offers an upgrade of any mercury reduction system with a clear mercury sink within the FGD system. ANDRITZ can draw on long-term experience with any dewatering technology. Thus, a controlled mercury sink is created.

The wet FGD is not only a very efficient way of separating acidic components from the flue gas stream, it is also highly efficient when it comes to removal of the oxidized mercury species. However, inconsistencies in the wet scrubber chemistry can be linked to re-emissions of mercury that has already been captured. In order to avoid any reemissions from the FGD process, ANDRITZ focuses particularly on binding and stabilizing the dissolved mercury in the limestone slurry. If, for instance, PAC (powdered activated carbon) injection is applied to inhibit re-emission, the main mercury sink in the conventional process chain will be the FGD by-product – the gypsum. This is unacceptable for two major reasons if the plant management is targeting beneficial use of the FGD product. Firstly, it greatly increases the mercury content in the gypsum,



- KEY FEATURES**
- Offering a complete, holistic mercury reduction system including flue gas path and FGD by-products
 - Proven system for mercury removal in the flue gas path
 - Easy to implement and to upgrade existing systems
 - Defined mercury sink within the waste water plant



Making your plant fit for upcoming, stringent emission limits

Increasingly stringent emission limits worldwide for dust, NO_x, SO_x, mercury, and other flue gas pollutants, but also further overall plant efficiency standards (guidelines) require individual solutions (solution approaches) for existing facilities.

In order to find the best suitable solution (for the individual frame conditions), ANDRITZ can draw from an extensive pool of knowhow and a variety of test and measurement facilities, as well as offering full support for modernization of the air pollution control systems of older power plants and industrial facilities. Together with our own measurement and laboratory team, ANDRITZ has gathered extensive know-how for all of the flue gas pollutants mentioned. Within the past few years, we have analyzed several existing facilities in order to pinpoint different pollution tracks on several different process parameters. After a first facility

process check with our modernization specialists, we aim to gain a detailed insight into the whole process chain, from the boiler to the stack. In combination with our simulation models, developed and tested in-house, like our Computational Fluid Dynamics (CFD) model, we find the most suitable solution together with our clients. With the CFD model, we can provide local and/or time-resolved visualization of flow and transport processes in multi-phase processes. For example, pollutant concentrations in apparatus can be pinpointed locally and temporarily.

KEY FEATURES

- Increasingly stringent flue gas emission limits for dust (down to 5 mg/m³ [stp, dry]), NO_x (< 75 mg/m³ [stp, dry]), SO_x (< 35 mg/m³ [stp, dry]), mercury (< 3 µg/m³ [stp, dry]), and other pollutants
- We analyze specimens in our laboratory and our own measurement team conducts the measurements
- We develop and implement optimization concepts for your plant
- We identify the most cost-effective solution for your specific challenges with respect to both investment and operating expenses
- We take care of the planning and execution from project development to plant commissioning, to support during the warranty period



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Exhaust gas cleaning – ANDRITZ SeaSOx technology

Exhaust gas cleaning for shipping is a challenge that can be solved perfectly with the know-how ANDRITZ has gained by designing and optimizing hundreds of installations around the world.

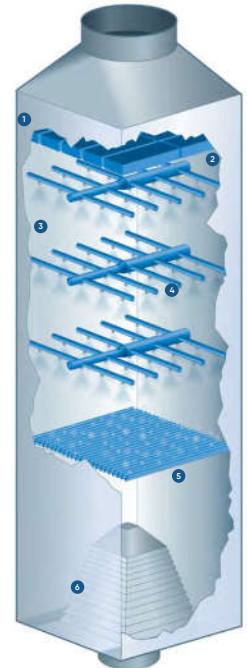
Keeping in mind the demand for high availability, the simple but effective scrubber system is the ANDRITZ solution for efficient and reliable exhaust gas desulfurization on board ships. By identifying each client's needs at an early stage, we can make a long-term contribution towards cleaner air and a clean environment. With offices in the USA, Europe, South America, and Asia, ANDRITZ is able to provide our well-proven solutions globally and has the dedicated personnel to meet all clients' needs. A global service network is available for all of our products, so wherever you are – we are available to provide support to our clients.



Advanced SeaSOx_{wet} scrubber

Designed on the basis of more than 35 years of experience in scrubber design and using the most highly developed CFD models to simulate and optimize flow distribution and SOx mass transfer, the scrubber offers some decisive benefits:

- 1 **SCRUBBER MATERIAL CONCEPT**
Scrubber shell and internals made of alloys with a high Cr, Ni, and Mo content. Perfectly resistant to high chlorine content and high temperatures in the inline operating mode.
- 2 **MIST ELIMINATOR CLEANING SYSTEM**
Lamella plates minimize droplet emissions.
- 3 **RECTANGULAR DESIGN**
Due to optimum use of space on ships, ANDRITZ decided to use a rectangular cross section as standard.
- 4 **SPRAY BANK**
The position of the spray nozzles is determined by CFD modeling. The nozzles and spray banks are made of an alloy containing Cr, Ni, and M.
- 5 **FGDplus LAYER**
The patented FGDplus technology from ANDRITZ has proven its advantage over conventional mass transfer systems for power plants up to 600 MWel. For small FGD systems, it shows excellent performance, with the focus on flow equalization in general.
- 6 **ABSORBER INLET DUCT**
Either side entry or central entry is possible, depending on layout constraints.



ANDRITZ SeaSOx_{wet} Process description

OPEN LOOP MODE

In open loop mode, seawater is used as a washing medium to clean the exhaust gas. This simple process makes use of the natural alkalinity of the seawater in chemical absorption of the SOx. For this reason, the washing medium is pumped from sea chests to the

absorber, where the absorption process takes place by means of spray scrubbing. The treated exhaust gas can then be released to the environment, and the effluent is also discharged. Both the exhaust gas and the effluent have to meet several critical, environmental constraints, which are validated by continuous emission monitoring.

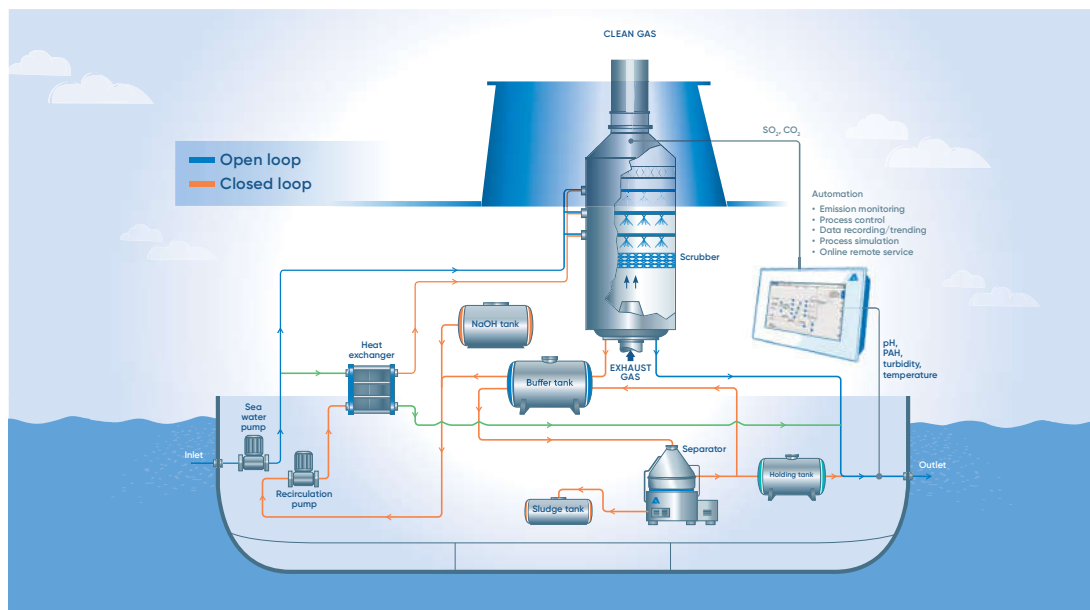
CLOSED LOOP MODE

If the natural alkalinity is too low or discharging of effluent is not allowed, SOx scrubbing is performed in closed loop mode. In this mode, the washing medium is recycled, and a neutralizing agent (50% wt. NaOH, Na₂CO₃) is added in metered doses to obtain a certain

absorption capacity. In order to control the absorption temperature and maintain the water balance, an inline heat exchanger is provided on request to cool the washing medium down. Consequently, the effluent has to be cleaned periodically depending on the engine load, the ship's route, and its fuel specification. For this application, a washing water treatment unit is installed to separate the particles and salts from the washing medium, in accordance with the MARPOL Convention, before it is discharged into the sea. The sludge generated is collected in a separate tank, while the treated washing water is either stored in the holding tank or discharged into the sea, depending on local discharging restrictions.

HYBRID MODE

A combination of open and closed loop operations is called hybrid mode. In hybrid mode, it is possible to switch between these two processes depending on the predominant basic conditions (seawater alkalinity, discharge restrictions, etc.). This option provides high flexibility and enables customers to choose the best process, both economically and technically.



ADVANTAGES

- Simple and robust design suitable for inline and by-pass installation.
- Substantial noise reduction: The silencer can be removed if operated in the inline mode.
- Exhaust gas can pass through safely, even when the absorber pumps are not operating.
- Highest removal efficiencies with lowest operating costs, combining ANDRITZ proprietary FGDplus technology and optimized spray bank design.
- Multiple inlets possible.
- Smallest footprint due to rectangular design.

ANDRITZ SeaSOx_{dry} Process description

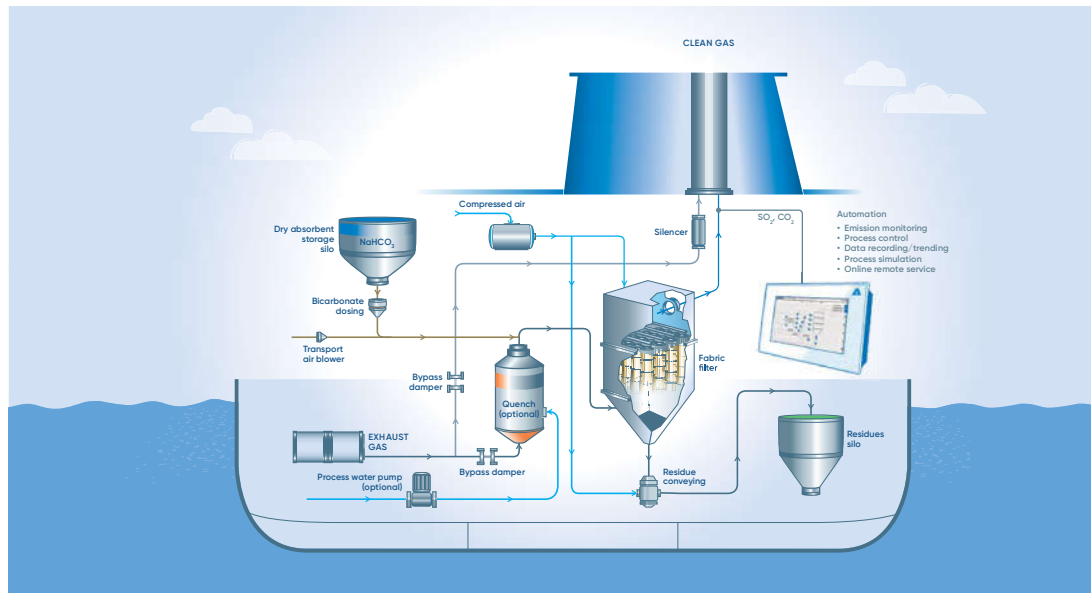
DRY DESULPHURIZATION PROCESS

In the dry desulphurization process, sodium bicarbonate (NaHCO₃) is injected as a dry powder into the existing exhaust pipe. Due to the prevailing high temperature and adequate residence time, the NaHCO₃ particle is activated, which increases the reactive surface by many times. This activation is necessary for

the NaHCO₃ to react with the sulfur components. Such a process requires a temperature of at least 150°C. If the temperature of the exhaust gas stream from the engines is higher than 250°C, a quench is connected upstream, which brings the exhaust gas to the desired temperature by means of evaporative cooling. At the downstream dust filter, on which other particles

(e.g. dust, soot ...) are also deposited in addition to the sodium bicarbonate, a filter cake builds up on the filter cloth, and this is where the decisive chemical reaction takes place. SO₂ reacts with NaHCO₃ to form Na₂SO₄, which is also present as a powder. After a defined period of time or due to the maximum allowed pressure loss, the dust filter is cleaned by means of a pulse-jet

process. During operation, a short stream of air is introduced at high pressure into the bag filter, whereby the filter cake peels off and drops into a collecting funnel. From there, the product is carried off by compressed air and stored in a silo.



ADVANTAGES

- Low CAPEX (low-cost equipment, little installation work necessary)
- SO₂ removal to leave only 0.1 or 0.5% S possible
- Low pressure drop (< 15 mbar)
- No waste water
- No plume due to hot process (tail-end SCR possible)
- No harmful sorbents (NaHCO₃ is also known as baking soda)
- Additional particulate removal > 99 %
- No pumps, waste water treatment equipment, heat exchangers, filters, or tanks have to be installed in the engine room
- Multiple inlets possible

Selected References



NEURATH F/G, GERMANY
Wet limestone FGD
Customer: RWE Power
Capacity: 2 × 1,100 MWel,
2 × 4,850,000 m³/h [stp, wet]
Fuel: Lignite
Start-up: 2011



RYBNIK, POLAND
Wet limestone FGD
Customer: Elektroenergia Rybnik
Capacity: 4 × 200 MWel,
2 × 1,320,000 m³/h [stp, wet]
Fuel: Hard coal
Start-up: 2008



KARLSRUHE, GERMANY
Wet limestone FGD
Customer: EnBW
Capacity: 910 MWel,
2,500,000 m³/h [stp, wet]
Fuel: Hard coal
Start-up: 2011



TUSIMICE II, CZECH REPUBLIC
Wet limestone FGD
Customer: CEZ
Capacity: 4 × 200 MWel,
2 × 1,780,000 m³/h [stp, wet]
Fuel: Lignite
Start-up: 2009/2010



VIRGINIA CITY, VA, USA
CFB scrubbers, PJFF and ESP
Customer: Dominion Energy
Capacity: 2 × 335 MWel,
2 × 1,046,000 acfm
Fuel: Waste coal, biomass
Start-up: 2011



GUACOLDA, CHILE
Turbo-CDS and SCR plant
Customer: Empresa
Electrica Guacolda
Capacity: 3 × 140 MW,
3 × 560,000 m³/h [std, wet]
Fuel: Coal
Start-up: 2015-2016



LINZ 04-05, AUSTRIA
SCR DeNOx
Customer: VA STAHL
Capacity: 2 × 150,000 m³/h [stp, wet]
Fuel: Blast furnace gas,
coke oven gas
Start-up: 2004-2005



SANDOW, TEXAS COUNTY, USA
Wet limestone FGD
Customer: RWE Power
Capacity: 2 × 1,100 MWel,
2 × 4,850,000 m³/h [stp, wet]
Fuel: Lignite
Start-up: 2011



TA LAUTA, GERMANY
Wet limestone FGD
Customer: RWE Power
Capacity: 2 × 1,100 MWel,
2 × 4,850,000 m³/h [stp, wet]
Fuel: Lignite
Start-up: 2011



MOERDIJK, NETHERLANDS
TurboSorp PJFF, ESP
and SCR/DeNOx
Customer: BMC Moerdijk
Capacity: 250,000 m³/h [stp, wet]
Fuel: Poultry litter
Start-up: 2008



HAIKOU, CHINA
Turbo-CDS WTE power plant
Customer: CPI New Energy Holding
Capacity: 1 × 600 t/d,
2 × 108700 Nm³/h
Sorbent: Ca(OH)₂
Start-up: 2012



LÜNEN, GERMANY
Wet limestone FGD
Customer: Trianel
Capacity: 1 × 800 MWel,
1,965,000 m³/h [stp, wet]
Fuel: Hard coal
Start-up: 2012



YUNUS EMRE, TURKEY
Turbo-CDS and ESP
Customer: Vitkovice, Adularya
Capacity: 2 × 145 MWel,
2 × 610,000 m³/h [stp, wet]
Fuel: Lignite
Start-up: 2013



**CENTRAL POWER PLANT #6,
VENEZUELA SEAWATER FGD**
Customer: Beijing Boqi Electric Power
Sci-tech Co., Ltd
Capacity: 1 × 600 MW,
1 × 1,973,209 Nm³/h
Sorbent: Seawater
Start-up: 2014



TURCENI, ROMANIA
Wet limestone FGD
Customer: S.C. Complexul
Energetic Turceni S.A.
Capacity: 4 × 330 MWel,
4 × 1,723,000 m³/h [stp, wet]
Fuel: Lignite
Start-up: 2011



GLÜCKSTADT, GERMANY
Dry FGC (TurboSorp)
Customer: HKWG Glückstadt
Capacity: 160,000 m³/h [stp, wet]
Fuel: RDF, sludge, coal
Start-up: 2009



LUKE, MD, USA
Pulse Jet Fabric Filter (PJFF)
Customer: New Page
Capacity: 1 × 179900 and
1 × 349,800 m³/h [stp, wet]
Fuel: Eastern bituminous coal
Start-up: 2007



MELLACH, AUSTRIA
SCR DeNOx
Customer: Siemens,
Verbund ATP
Capacity: 2 × 400 MWel,
2 × 2,100,000 m³/h [stp, wet]
Fuel: Natural gas
Start-up: 2011



CLEAN ENVIRONMENT FOR A BETTER TOMORROW

ANDRITZ is a leading global supplier of innovative air pollution control technologies. Our product range combines 30+ years' experience with the specific knowledge gained from over 200 installations around the world. ANDRITZ offers high-end technologies and is a partner you can rely on. Contact us all over the world.

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TERMS AND CONDITIONS OF SALE AND/OR SERVICE**1. TERMS APPLICABLE**

(a) These Terms and Conditions of Sale and/or Service are the only terms which govern the sale of the products, equipment, or parts and/or the provision of services ("Products" and "Services") pursuant to the quotation or acknowledgement of the Andritz entity supplying the same ("Seller" or Buyer's purchase order or other written document issued by Buyer. These Terms and Conditions of Sale and/or Service control, supersede and replace any and all other additional and/or different terms and conditions of Buyer, and Seller hereby objects to and rejects all such terms and conditions of Buyer without further notification, except to the extent Seller expressly agrees to such conditions in writing. Buyer's authorization for Seller to commence work under the Agreement or Buyer's acceptance of delivery of or payment for any Products or Services covered by this Agreement, in whole or in part, shall be deemed Buyer's acceptance of these Terms and Conditions of Sale and/or Service. The term "Agreement" as used herein means (1) these Terms and Conditions of Sale and/or Service, (2) Seller's quotation or acknowledgment together with any attachment thereto and any documents expressly incorporated by reference, and (3) Buyer's purchase order or other written document issued by Buyer, together with any attachment thereto and any documents expressly incorporated by reference (but excluding any Buyer terms and conditions attached thereto or incorporated therein by reference). In the event of a conflict between any documents forming the Agreement, such documents shall be construed in the above-listed order of precedence.

(b) Prior to Buyer's acceptance of any Seller quotation in which these Terms and Conditions of Sale and/or Service are incorporated, in the event that the introduction of new tariffs, levies, duties, taxes, regulation, or any type of legislation by a domestic or foreign government has the effect of increasing the price of the quoted Products and/or Services, Seller reserves its right to adjust its quoted price in order to reflect these increases in cost. Nothing in this document, or any of the applicable contractual documentation shall be construed as a waiver of this right.

2. DELIVERY OR PERFORMANCE; RISK OF LOSS AND TITLE

(a) Delivery or performance dates are good faith estimates and do not mean that "time is of the essence." Buyer's failure to promptly make advance or interim payments, supply technical information, drawings and approvals will result in a commensurate delay in delivery or performance. If the parties have agreed to liquidated damages in this Agreement for Seller's delay in achieving certain milestones, (i) the parties acknowledge and agree that Buyer's damages for Seller's delay are difficult to predict with any certainty, and such liquidated damages are not a penalty but a reasonable estimate of Buyer's delay damages; (ii) such liquidated damages shall not exceed an aggregate value of five percent (5%) of the Agreement price and shall be Buyer's exclusive remedy for any delay by Seller in performing any of its obligations under this Agreement; and (iii) Buyer agrees Seller shall not be liable for liquidated damages if Seller's delay in achieving a milestone subject to liquidated damages has not delayed Buyer's ability to use the applicable Products, Software and/or Services.

(b) Upon and after delivery, risk of loss or damage to the Products shall be Buyer's. Delivery of the Products hereunder will be made on the terms agreed to by the parties as set forth in this Agreement, according to INCOTERMS 2020. If no delivery term is agreed elsewhere in the Agreement, delivery of the Products will be made FCA shipping point (INCOTERMS 2020). Title to the Products shall transfer to Buyer upon final payment therefor.

3. WARRANTY

(a) **Product Warranty.** Seller warrants to Buyer that the Products manufactured by it will be delivered free from defects in material and workmanship. This warranty shall commence upon delivery of the Products and shall expire on the earlier to occur of 12 months from initial operation of the Products and 18 months from delivery thereof (the "Warranty Period"). If during the Warranty Period Buyer discovers a defect in material or workmanship of a Product and gives Seller written notice thereof within 10 days of such discovery, Seller will, at its option, either deliver to Buyer, on the same terms as the original delivery was made, according to INCOTERMS 2020, a replacement part or repair the defect in place. Any repair or replacement part furnished pursuant to this warranty are warranted against defects in material and workmanship for one period of 12 months from completion of such repair or replacement, with no further extension. Seller will have no warranty obligations for the Products under this Paragraph 3(a): (i) if the Products have not been stored, installed, operated and maintained in accordance with generally approved industry practice and with Seller's specific written instructions; (ii) if the Products are used in connection with any mixture or substance or operating condition other than that for which they were designed; (iii) if Buyer fails to give Seller such written 10 day notice; (iv) if the Products are repaired by someone other than Seller or have been intentionally or accidentally damaged; (v) for corrosion, erosion, ordinary wear and tear or in respect of any parts which by their nature are exposed to severe wear and tear or are considered expendable; or (vi) for expenses incurred for work in connection with the removal of the defective articles and reinstallation following repair or replacement.

(b) **Services Warranty.** Seller warrants to Buyer that the Services performed will be free from defects in workmanship and will conform to any mutually agreed upon specifications. If any failure to meet this warranty appears within 12 months from the date of completion of the Services, on the condition that Seller be promptly notified in writing thereof, Seller as its sole obligation for breach of this warranty will correct the failure by re-performing any defective portion of the Services furnished. Seller does not warrant the accuracy of, or performance results of, any conclusions or recommendations provided, nor that any desired objective will result from the Services provided and Seller shall not be liable for any loss of use or any production losses whatsoever.

(c) **THE EXPRESS WARRANTIES SELLER MAKES IN THIS PARAGRAPH 3 ARE THE ONLY WARRANTIES IT WILL MAKE. THERE ARE NO OTHER WARRANTIES, WHETHER STATUTORY, ORAL, EXPRESS OR IMPLIED. IN PARTICULAR, THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**

(d) The remedies provided in Paragraphs 3(a) and 3(b) are Buyer's exclusive remedy for breach of warranty.

(e) With respect to any Product or part thereof not manufactured by Seller, Seller shall pass on to Buyer only those warranties made to Seller by the manufacturer of such Product or part which are capable of being so passed on.

4. LIMITATION OF LIABILITY

Notwithstanding any other provision in this Agreement, the following limitations of liability shall apply:

(a) In no event, whether based on contract, tort (including negligence), strict liability or otherwise, shall Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies be liable for loss of profits, revenue or business opportunity, loss by reason of shutdown of facilities or inability to operate any facility at full capacity, or cost of obtaining other means for performing the functions performed by the Products or Software, loss of future contracts, claims of customers, cost of money or loss of use of capital, in each case whether or not foreseeable, or for any indirect, special, incidental or consequential damages of any nature resulting from, arising out of or connected with the Products, Services, Software or this Agreement or from the performance or breach hereof.

(b) The aggregate liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, for all claims of any kind for any loss, damage, or expense resulting from, arising out of or connected with the Products, Services, Software or this Agreement or from the performance or breach hereof, together with the cost of performing make good obligations to pass performance tests, if applicable, shall in no event exceed the Agreement price.

(c) The limitations and exclusions of liability set forth in this Paragraph 4 shall take precedence over any other provision of this Agreement and shall apply whether the claim of liability is based on contract, warranty, tort (including negligence), strict liability, indemnity, or otherwise. The remedies provided in this Agreement are Buyer's exclusive remedies.

(d) All liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, resulting from, arising out of or connected with the Products, Services or this Agreement or from the performance or breach hereof shall terminate on the third anniversary of the date of this Agreement.

(e) In no event shall Seller be liable for any loss or damage whatsoever arising from its failure to discover or repair latent defects or defects inherent in the design of goods serviced (unless such discovery or repair is normally discoverable by tests expressly specified in the scope of work under this Agreement) or caused by the use of goods by the Buyer against the advice of Seller. If Seller furnishes Buyer with advice or assistance concerning any products or systems that is not required pursuant to this Agreement, the furnishing of such advice or assistance will not subject Seller to any liability whether in contract, indemnity, warranty, tort (including negligence), strict liability or otherwise.

5. CHANGES, DELETIONS AND EXTRA WORK.

Seller will not be required to make changes in the Products or Services unless Buyer and Seller have executed a written change order for such change. Any such change order will include an appropriate adjustment to the Agreement price and/or schedule. If the change impairs Seller's ability to satisfy any of its obligations to Buyer, the change order will include appropriate modifications to this Agreement. Seller shall be entitled to a change order adjusting the Agreement price, schedule and/or any affected obligations of Seller if after the effective date of this Agreement (a) a change in applicable law, tariffs, levies, duties, taxes, regulations or ordinances or (b) any act or omission of Buyer or any other party for whom Buyer is responsible, or any error or change in Buyer-provided information should require a change in the Products or Services or cause an increase in the cost or change in the schedule to supply the Products or Services.

6. TAXES

Seller's prices do not include any sales, use, excise or other taxes. In addition to the price specified herein, the amount of any present or future sales, use, excise or other tax applicable to the sale or use of the Products, Software or Services shall be billed to and paid

by Buyer unless Buyer provides to Seller a tax-exemption certificate acceptable to the relevant taxing authorities.

7. SECURITY INTEREST

Seller shall retain a purchase money security interest and Buyer hereby grants Seller a lien upon and security interest in the Products until all payments hereunder have been made in full. Buyer acknowledges that Seller may file a financing statement or comparable document as required by applicable law and may take all other action it deems reasonably necessary to perfect and maintain such security interest in Seller and to protect Seller's interest in the Products.

8. SET OFF

Neither Buyer nor any of its affiliates shall have any right to set off claims against Seller or any of its affiliates for amounts owed under this Agreement or otherwise.

9. PATENTS

Unless the Products or any part thereof are designed to Buyer's specifications or instructions and provided the Product or any part thereof is not used in any manner other than as specified or approved by Seller in writing or modified by Buyer without the written consent of Seller, (i) Seller shall defend against claims made in a suit or proceeding brought against Buyer by an unaffiliated third party that any Product infringes a device claim of a patent issued as of the effective date of this Agreement in the country in which the Product will be operated, and limited to the field of the specific Products provided under this Agreement; provided Seller is notified promptly in writing and given the necessary authority, information and assistance for the defense of such claims; (ii) Seller shall satisfy any judgment (after all appeals) for damages entered against Buyer on such claims so long as such damages are not attributable to willful conduct or sanctioned litigation conduct; and (iii) if such judgment enjoins Buyer from using any Product or a part thereof, then Seller will, at its option: (a) obtain for Buyer the right to continue using such Product or part; (b) eliminate the infringement by replacing or modifying all or part of the Products; or (c) take back such Product or part and refund to Buyer all payments on the Agreement price that Seller has received for such Product or part. The foregoing states Seller's entire liability for patent infringement by any Product or part thereof.

10. SOFTWARE LICENSE, WARRANTY, FEES

If Buyer and Seller have not entered into a separate license agreement, the following Software Terms and Conditions apply to any embedded software produced by Seller and furnished by Seller hereunder:

(a) The Software, as described in the Agreement ("Software"), and all written materials or graphic files that are fixed in any tangible medium and that relate to and support the Software ("Documentation"), and all present and future worldwide copyrights, trademarks, trade secrets, patents, patent applications, mask work rights, moral rights, contract rights, and other proprietary rights recognized by the laws of any country inherent therein, including all changes and improvements requested or suggested by Buyer in the support and maintenance of the Software are the exclusive property of Seller ("Seller's Intellectual Property Rights"). All rights in and to the Software not expressly granted to Buyer in the Agreement are reserved by Seller. Nothing in this Agreement will be deemed to grant, by implication, estoppel, or otherwise, a license under any of Seller's existing or future patents. Software will not include any upgrades, new versions, releases, enhancements, or updates to the Software, unless agreed to by Seller in writing and at its sole discretion. To the extent any upgrades, new versions, releases, enhancements, or updates to the Software are provided by Seller, the term "Software" shall be deemed to include such upgrades, new versions or releases, enhancements or updates. To the extent any ownership right arises in Buyer with respect to the above, Buyer hereby assigns all of its right, title, and interest in and to any intellectual property embodied in in the Seller's Intellectual Property Rights, including enforcement rights, to Seller without the payment of any additional consideration thereof either to Buyer, or its employees, agents, or customers and agrees to execute any documents Seller deems necessary to effect such assignment.

(b) Seller hereby grants to Buyer a non-exclusive, non-transferable, non-sub-licensable, revocable license to install, run, and use the Software, and any modifications made by Seller thereto only in connection with configuration of the Products and operating system for which the Software is ordered hereunder, and for the end-use purpose stated in the Documentation. Buyer agrees that neither it nor any third party shall modify, reverse engineer, decompile or reproduce the Software, except Buyer may create a single copy for backup or archival purposes in accordance with the Documentation (the "Copy"). Buyer's license to use the Software and the Copy of such Software shall terminate upon any breach of this Agreement by Buyer. All copies of the Software, including the Copy, are the property of Seller, and all copies for which the license is terminated shall be returned to Seller, or deleted from Buyer's computer systems, with written confirmation after termination.

(c) Seller warrants that, on the date of shipment of the Software or the Products containing the Software to Buyer: (1) the Software media contain a true and correct copy of the Software and are free from material defects; (2) Seller has the right to grant the license hereunder; and (3) the Software will function substantially in accordance with the related Seller operating documentation. In no event does Seller warrant that the Software is error free or that Buyer will be able to operate the Software without impairments or interruptions. In addition, due to the continual development of new techniques for intruding upon and attacking networks,

Seller does not warrant that the Software or any equipment, system, or network on which the Software is used will be free of vulnerability to intrusion or attack.

(d) If within 12 months from the date of delivery of the Products containing the Software, Buyer discovers that the Software is not as warranted above and notifies Seller in writing prior to the end of such 12 month period, and if Seller determines that it cannot or will not correct the nonconformity, Buyer's and Buyer's Seller-authorized transferee's exclusive remedies, at Seller's option, are: (1) replacement of the nonconforming Software; or (2) termination of this license and a refund of a pro rata share of the Agreement price or license fee paid.

(e) If any infringement claims are made against Buyer arising out of Buyer's use of the Software in a manner specified by Seller, Seller shall: (i) defend against any claim in a suit or proceeding brought by an unaffiliated third party against Buyer that the Software violates a registered copyright or a confidentiality agreement to which Seller was a party, provided that Seller is notified promptly in writing and given the necessary authority, information and assistance for the defense and settlement of such claims (including the sole authority to select counsel and remove the Software or stop accused infringing usage); (ii) Seller shall satisfy a final judgment (after all appeals) for damages entered against Buyer for such claims, so long as such damages are not attributable to willful conduct or sanctioned litigation conduct; and (iii) if such judgment enjoins Buyer from using the Software, Seller may at its option: (a) obtain for Buyer the right to continue using such Software; (b) eliminate the infringement by modifying the Software or replacing it with a functional equivalent (in which case, Buyer shall immediately stop use of the allegedly infringing Software), or (c) take back such Software and refund to Buyer all payments on the Agreement price that Seller has received. However, Seller's obligations under this Paragraph 10 shall not apply to the extent that the claim or adverse final judgment relates to: (1) Buyer's running of the Software after being notified to discontinue; (2) non-Seller software, products, data or processes; (3) Buyer's alteration of the Software; (4) Buyer's distribution of the Software to, or its use for the benefit of, any third party not approved in writing by Seller; or (5) Buyer's acquisition of confidential information (a) through improper means; (b) under circumstances giving rise to a duty to maintain its secrecy or limit its use; or (c) from a third party who owed to the party asserting the claim a duty to maintain the secrecy or limit the use of the confidential information. Buyer will reimburse Seller for any costs or damages that result from actions 1 to 5.

THE FOREGOING PROVISIONS OF THIS SECTION 10(e) STATE THE ENTIRE LIABILITY AND OBLIGATIONS OF SELLER AND THE EXCLUSIVE REMEDY OF BUYER, WITH RESPECT TO ANY VIOLATION OR INFRINGEMENT OF ANY PROPRIETARY RIGHTS UNDER SECTION 10, INCLUDING BUT NOT LIMITED TO PATENTS AND COPYRIGHTS, BY THE SOFTWARE OR ANY PART THEREOF.

(f) This warranty set forth in subparagraph (c) above shall only apply when: (1) the Software is not modified by anyone other than Seller or its agents authorized in writing; (2) there is no modification in the Products in which the Software is installed by anyone other than Seller or its agents authorized in writing; (3) the Products are in good operating order and installed in a suitable operating environment; (4) the nonconformity is not caused by Buyer or a third party; (5) Buyer promptly notifies Seller in writing, within the period of time set forth in subparagraph (c) above, of the nonconformity; and (6) all fees for the Software due to Seller have been timely paid. **SELLER HEREBY DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WITH REGARD TO THE SOFTWARE, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, COURSE OF DEALING AND USAGE OF TRADE.**

(g) Buyer and its successors are limited to the remedies specified in this Paragraph 10.

(h) Any subsequent modifications or enhancements to the Software made by Seller are, at Seller's option, subject to a fee.

11. SITE RISKS

(a) Site Conditions. The parties acknowledge and agree that as to conditions at the project site, Seller is relying upon information provided by Buyer. If Seller becomes aware of any subsurface, concealed, or differing condition, environmental hazard or violation of any environmental law or regulation, Seller will immediately suspend performance of the work in the affected area and notify Buyer. Buyer acknowledges that it will assume the risk of any increased costs and changes to the schedule that may result from such conditions. If Buyer does not immediately remediate such conditions, Seller may either suspend performance of all work or terminate this Agreement.

(b) Environmental Remediation. Buyer acknowledges that Seller is not an expert in environmental remediation and shall not be directed by change order or otherwise to perform any environmental remediation as part of the Services, including but not limited to asbestos and lead paint removal. If any environmental remediation becomes necessary, Buyer will contract directly with a qualified third party to perform such work.

12. TERMINATION

(a) Buyer may terminate this Agreement upon breach by Seller of a material obligation hereunder and Seller's failure to cure, or to commence a cure of, such breach within a reasonable period of time (but not less than 30 days) following written receipt of notice of the same from Buyer.

(b) Buyer may only terminate this Agreement for Buyer's convenience upon written notice to Seller and upon payment to Seller of Seller's termination charges, which shall be specified to Buyer and shall take into account among other things expenses (direct and indirect) incurred and commitments already made by Seller, overhead, and an appropriate profit. In case of such termination, the licenses granted in Paragraphs 10 and 13 hereof shall terminate.

(c) Seller shall have the right to suspend and/or terminate its obligations under this Agreement if payment is not received within 30 days of due date. In the event of the bankruptcy or insolvency of Buyer or in the event of any bankruptcy or insolvency proceeding brought by or against Buyer, Seller shall be entitled to terminate any order outstanding at any time during the period allowed for filing claims against the estate and shall receive reimbursement for its cancellation charges.

13. INTELLECTUAL PROPERTY; CONFIDENTIALITY

(a) All intellectual property embodied in the Products, Services and Software provided to Buyer is the property of Seller, and any intellectual property developed, at least in part, by Seller under this Agreement is and remains the sole and exclusive property of Seller. Further, Seller shall have the right to collect and use data generated by the Products, Software or Services supplied hereunder.

(b) Buyer acknowledges that the information that Seller submits to Buyer in connection with this Agreement and the performance hereof is Seller's confidential and proprietary information. Buyer agrees not to disclose such information to third parties without Seller's prior written consent. Seller grants to Buyer a non-exclusive, royalty-free, non-transferrable license to use Seller's confidential and proprietary information for the purpose of the installation, operation, maintenance and repair of the Products that are the subject of this Agreement only; provided, however, that Buyer further agrees not to, and not to permit any third party to, analyze, measure the properties of, or otherwise reverse engineer the Products or any parts thereof, fabricate the Products or any parts thereof from Seller's drawings or to use the drawings other than in connection with this Agreement. Buyer will defend and indemnify Seller from any claim, suit or liability based on personal injury (including death) or property damage related to any Product or part thereof which is fabricated by a third party without Seller's prior written consent and from and against related costs, charges and expenses (including attorneys' fees). All copies of Seller's confidential and proprietary information shall remain Seller's property and may be reclaimed by Seller at any time in the event Buyer is in breach of its obligations under this Paragraph 13, or in case of Buyer's termination pursuant to Paragraph 12(b).

14. END USER

If Buyer is not the end user of the Products sold hereunder (the "End User"), then Buyer will use its best efforts to obtain the End User's written consent to be bound to Seller by the provisions hereof. If Buyer does not obtain such End User's consent, Buyer shall defend and indemnify Seller and Seller's agents, employees, subcontractors and suppliers from any action, liability, cost, loss, or expense for which Seller would not have been liable or from which Seller would have been indemnified if Buyer had obtained such End User's consent.

15. FORCE MAJEURE

(a) Force Majeure Defined. For the purpose of this Agreement "Force Majeure" will mean all events, whether or not foreseeable, beyond the reasonable control of either party which affect the performance of this Agreement, including, without limitation, acts of God, acts or advisories of governmental or quasi-governmental authorities, laws or regulations, strikes, lockouts or other industrial disturbances, acts of public enemy, wars, insurrections, riots, epidemics, pandemics, outbreaks of infectious disease or other threats to public health, lightning, earthquakes, fires, storms, severe weather, floods, sabotage, delays in transportation, rejection of main forgings and castings, lack of available shipping by land, sea or air, lack of dock lighterage or loading or unloading facilities, inability to obtain labor or materials from usual sources, serious accidents involving the work of suppliers or sub-suppliers, thefts and explosions.

(b) Suspension of Obligations. If either Buyer or Seller is unable to carry out its obligations under this Agreement due to Force Majeure, other than the obligation to make payments due hereunder, and the party affected promptly notifies the other of such delay, then all obligations that are affected by Force Majeure will be suspended or reduced for the period of Force Majeure and for such additional time as is required to resume the performance of its obligations, and the delivery schedule will be adjusted to account for the delay.

(c) Strikes On-Site. Notwithstanding anything herein to the contrary, in the event a strike, lockout, blockage, slowdown, labor, union or other industrial disturbance at Buyer's site affects, delays, disrupts or prevents Seller's performance of this Agreement, Seller shall be entitled to a change order containing an appropriate adjustment in the Agreement price and delivery schedule.

16. INDEMNIFICATION AND INSURANCE

(a) Indemnification. Seller agrees to defend and indemnify Buyer from and against any third-party claim for bodily injury or damage to tangible property ("Loss") arising in connection with the Products or the Services provided by Seller hereunder, but only to the extent such Loss has been caused by the negligence, willful misconduct or other legal fault ("Fault") of Seller. Buyer shall promptly tender the defense of any such third-party claim to Seller. Seller shall be entitled to control the defense and resolution of such claim, provided that Buyer shall

be entitled to be represented in the matter by counsel of its choosing at Buyer's sole expense. Where such Loss results from the Fault of both Seller and Buyer or a third party, then Seller's defense and indemnity obligation shall be limited to the proportion of the Loss that Seller's Fault bears to the total Fault.

(b) Insurance. Seller shall maintain commercial general liability insurance with limits of \$2,000,000 per occurrence and in the aggregate covering claims for bodily injury (including death) and physical property damage arising out of the Products or Services. Seller shall also provide workers' compensation insurance or the like as required by the laws of the jurisdiction where the Services will be performed, and owned and non-owned auto liability insurance with limits of \$1,000,000 combined single limit. Seller will provide a Certificate of Insurance certifying the existence of such coverages upon request.

17. EXPORT CONTROL AND ECONOMIC SANCTIONS COMPLIANCE

(a) Buyer recognizes that any Products and Software that are the subject of this Agreement and originate in the U.S. remain subject to U.S. export control and economic sanctions laws and regulations even after such Products are exported from the U.S. (if applicable), and even though such Products and Software have been purchased in and, if applicable, exported from Canada. Buyer certifies that such Products and Software will not be diverted, transshipped, re-exported, or otherwise transferred in contravention of any applicable export control and economic sanctions laws and regulations, nor will it allow the Products or Software to be incorporated into other products or used to make direct products thereof that are exported, re-exported, used, or transferred in violation of U.S. export control and economic sanctions laws and regulations. Buyer further affirms that such Products and Software will not be used, directly or indirectly, in any application involving missile technology, nuclear proliferation, or chemical and biological weapons proliferation. Without limiting the foregoing, Buyer will not, nor will it allow third parties to, export, re-export, or transfer any Products or Software to any person or entity that is the target of U.S. sanctions or is in Crimea, Cuba, Iran, North Korea, or Syria, or any other country or territory in violation of U.S. sanctions.

(b) Buyer shall be responsible for any breach of this provision by it, and its successors and permitted assigns, as well as its parents, affiliates, employees, officers, directors, partners, members, shareholders, customers, agents, distributors, resellers, or vendors ("Buyer Parties") and shall indemnify and hold harmless Seller from and against any claim, proceeding, action, fine, loss, cost, damages, and penalties arising out of or relating to any non-compliance with U.S. export control and economic sanctions laws and regulations by any Buyer Party.

(c) Buyer shall, upon request of Seller, promptly provide all information necessary for Seller to ensure compliance with U.S. export control and economic sanctions laws and regulations, including but not limited to information related to end-users, end-uses, and destination countries.

18. SPECIAL CONDITIONS FOR PRESSURE VESSELS

For installation, repair, or maintenance Services on existing pressure vessels, piping and equipment, the following shall apply:

(a) Unless otherwise agreed and stated in the Agreement, Buyer shall be responsible for: (i) physically disconnecting and isolating vessels and equipment being repaired from existing piping and electrical power before Seller or any of its subcontractors start the Services, and take adequate precautions that re-connection and resumption of use does not take place until the Services are completed, and (ii) emptying the vessels and piping and freeing them from any toxic or harmful substances before the Services begin so that the vessels and piping are safe for Services to begin. Buyer shall maintain the area entirely free of combustible, toxic and asphyxiant substances and provide fire protection service until the Services are completed;

(b) If the Services are on an existing vessel or existing piping, the Buyer is responsible for determining the prior condition of the portion of the vessel or piping not involved in the Services, and its ability to withstand the Services and any tests that may be necessary;

(c) Buyer shall also be responsible for evaluating the effects of prior use of the vessel or piping upon structural adequacy, and the suitability of the vessel or piping for the service intended when the Services are completed;

(d) Seller has no obligation to provide any inspections or tests, and Buyer takes full responsibility for all necessary inspections and tests, including but not limited to, selection of testing personnel, type, location, frequency, and severity of any inspections and tests and all test results at any stage of the Services;

(e) Upon request of Seller, Buyer shall provide Seller with the history of the vessel, a statement of the tests to be performed and a statement of the proposed use of the vessel after completion of the Services, and

(f) If repairs are required: (i) Buyer will provide an Authorized Inspector ("AI") who will determine the scope of the Services to be done; (ii) Seller will provide Buyer with a proposed Quality Control ("QC") package specifying the methods and procedures that Seller will follow in performing the Services specified by the Buyer; (iii) the proposed QC package is subject to approval by the Buyer, and such approval must be provided before Services commence; (iv) after approval of the QC package, the Services shall be done in accordance with the QC package. At the option of the AI, hold points may be established for inspection during the course of the Services; and (v) upon completion of the Services, the AI shall inspect the

Services and provide a signed acceptance that they have been completed in accordance with the QC package. Such acceptance by the AI shall establish completion of the Services.

19. TECHNICAL ASSISTANCE

Technical Assistance means that Seller's technician(s) and or engineer(s) will assist Buyer during the performance of Buyer's site work in the interpretation of the related procedures provided by Seller. When providing Technical Assistance, Seller will not be required to supervise or coordinate Buyer's work force, perform measurements, complete or ensure the accuracy of quality control documents, or ensure the orderly sequencing of the site work, but Seller will advise Buyer of any non-conformances as recorded on the quality control documentation completed by Buyer, and counter sign such quality control documentation to confirm correction of such non-conformances. Notwithstanding the above or any other provision of the applicable Purchase Order, Seller shall have no authority, responsibility, liability or control over Buyer's work, schedule and labor force. Therefore, Seller will not be responsible for the installation labor and Seller will not be liable for the quality and/or workmanship of the site work.

20. GENERAL

(a) Seller represents that any Products or parts thereof manufactured by Seller will be produced in compliance with all applicable federal, state and local laws applicable to their manufacture and in accordance with Seller's engineering standards. Seller shall not be liable for failure of the Products to comply with any other specifications, standards, laws or regulations.

(b) This Agreement shall inure only to the benefit of Buyer and Seller and their respective successors and assigns. Any assignment of this Agreement or any of the rights or obligations hereunder, by either party without the written consent of the other party shall be void.

(c) This Agreement contains the entire and only agreement between the parties with respect to the subject matter hereof and supersedes all prior oral and written understandings between Buyer and Seller concerning the Products and/or Services and any prior course of dealings or usage of the trade not expressly incorporated herein.

(d) This Agreement may be modified, supplemented or amended only by a writing signed by an authorized representative of Seller. Seller's waiver of any breach by Buyer of any terms of this Agreement must also be in writing and any waiver by Seller or failure by Seller to enforce any of the terms and conditions of this Agreement at any time, shall not affect, limit or waive Seller's right thereafter to enforce and compel strict compliance with every term and condition hereof.

(e) All terms of this Agreement which by their nature should apply after the cancellation, completion or termination of this Agreement, including, but not limited to, Paragraphs 4, 13, 17 and 19, shall survive and remain fully enforceable after any cancellation, completion or termination hereof.

(f)(i) If Seller's office is located in the United States, this Agreement and the performance hereof will be governed by and construed according to the laws of the State of Georgia.

(ii) If Seller's office is located in Canada, this Agreement and the performance hereof will be governed by and construed according to the laws of the Province of New Brunswick...

(g) (i) In the circumstances of f(i) above, any controversy or claim arising out of or relating to this Agreement, or the breach hereof, or to the Products or the Services provided pursuant hereto, shall be definitively settled by arbitration, to the exclusion of courts of law, administered by the American Arbitration Association ("AAA") in accordance with its Construction Industry Arbitration Rules in force at the time this Agreement is signed and to which the parties declare they will adhere (the "AAA Rules"), and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction over the party against whom enforcement is sought or having jurisdiction over any of such party's assets. The arbitration shall be conducted in Atlanta, Georgia by a panel of three members, one of whom will be appointed by each of Buyer and Seller and the third of whom will be the chairman of the panel and will be appointed by mutual agreement of the two party appointed arbitrators. All arbitrators must be persons who are not employees, agents, or former employees or agents of either party. In the event of failure of the two party appointed arbitrators to agree within 45 days after submission of the dispute to arbitration upon the appointment of the third arbitrator, the third arbitrator will be appointed by the AAA in accordance with the AAA Rules. In the event that either of Buyer or Seller fails to appoint an arbitrator within 30 days after submission of the dispute to arbitration, such arbitrator, as well as the third arbitrator, will be appointed by the AAA in accordance with the AAA Rules.

(ii) In the circumstances of f(ii) above, any controversy or claim arising out of or relating to this Agreement, or the breach hereof, or to the Products or the Services provided pursuant hereto, shall be definitively settled under the auspices of the Canadian Commercial Arbitration Centre ("CCAC"), by means of arbitration and to the exclusion of courts of law, in accordance with its General Commercial Arbitration Rules in force at the time the Agreement is signed and to which the parties declare they will adhere (the "CCAC Rules"), and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction over the party against whom enforcement is sought or having jurisdiction over any of such party's assets. The arbitration shall be conducted in Saint John, New Brunswick by a panel of three arbitrators, one of whom will be appointed by each of Buyer and Seller and the third of whom will be the chairman of the arbitral tribunal and will be appointed by mutual

agreement of the two party-appointed arbitrators. All arbitrators must be persons who are not employees, agents, or former employees or agents of either party. In the event of failure of the two party-appointed arbitrators to agree within 45 days after submission of the dispute to arbitration upon the appointment of the third arbitrator, the third arbitrator will be appointed by the CCAC in accordance with the CCAC Rules. In the event that either of Buyer or Seller fails to appoint an arbitrator within 30 days after submission of the dispute to arbitration, such arbitrator, as well as the third arbitrator, will be appointed by the CCAC in accordance with the CCAC Rules.

(h) In the event this Agreement pertains to the sale of any goods outside the United States or Canada, the parties agree that the United Nations Convention for the International Sale of Goods shall not apply to this Agreement.

(i) The parties hereto have required that this Agreement be drawn up in English. Les parties aux présentes ont exigé que la présente convention soit rédigée en anglais.

Jahn, Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Friday, July 1, 2022 4:52 AM
To: Jahn, Mario
Subject: RE: Preliminary Building Requirements

Follow Up Flag: Follow up
Flag Status: Completed

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Mario,

Yes, the monorail / hoist is small – 2 tons is about right. Regarding operators our experience is that with retrofit CDS projects of this type no additional operators are added. If we had on site lime hydration then this might add an operator per shift as that is a complex system but this project does not have that system (or lime injection of any kind). Without a lime feed system this is essentially a glorified baghouse, with some water injection. The only items that require routine attention are the water nozzles but these are typically not pulled more than once a week, usually every 2 or 3 weeks. Typically the existing plant rovers can just add this to their normal rounds, checking local gauges, etc. as well. This is a main advantage of CDS technology over SDA or WFGD. Thanks

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, June 30, 2022 4:44 PM
To: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Preliminary Building Requirements

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Thanks Paul. That elevation helps get a good visual. I'm assuming that the monorail for the top door isn't too big of a system? Maybe 2Tons?

Any chance that you have a good feel on how many additional operators the plant would need for the CDS system?

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Wednesday, June 29, 2022 5:11 AM

To: Jahn, Mario <JahnMario@stanleygroup.com>

Subject: RE: Preliminary Building Requirements

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mario,

Yes, you are looking at the dimensions correctly. The side EL. I have for the reference project is not quite what you would get here as the design was a bit customized and there is a lot of balance of plant that obscures things a bit. I am attaching a drawing for one of our standard six compartment designs that better shows you what the side EL looks like including platform elevations etc. You will see there is an overall height dimension given to the baghouse roof structure, which is used to mount the monorail for the top door removal. The monorails could be mounted on the underside of the building roof so that dimension (30,303 mm to the top of the steel) would be a conservative value to use for your building height. The overall elevation for the 6 compartment design shown vs a four compartment design as you will need here is not much – perhaps 0.5m shorter.

In short, a nominal 30m value is accurate within a foot or two one way or the other. Thanks.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>

Sent: Tuesday, June 28, 2022 3:48 PM

To: Petty Paul <Paul.Petty@andritz.com>

Subject: Preliminary Building Requirements

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Paul,

See attached PDF that was provided by Andritz as part of the CDS quote. Is it safe to assume that the elevations in this drawing start at “zero”? With this installation being in Fairbanks, Alaska, we want to put this equipment in a building and want to make sure that they building is tall enough. In the lower left view in the drawing, the elevation given for the top of the reactor platform is at 27.2 meters. We would size a building at roughly 30 meters to enclose this last platform. I want to confirm the height since we don’t have an elevation view in the drawing.

Thanks in advance for your help.

Regards,
Mario

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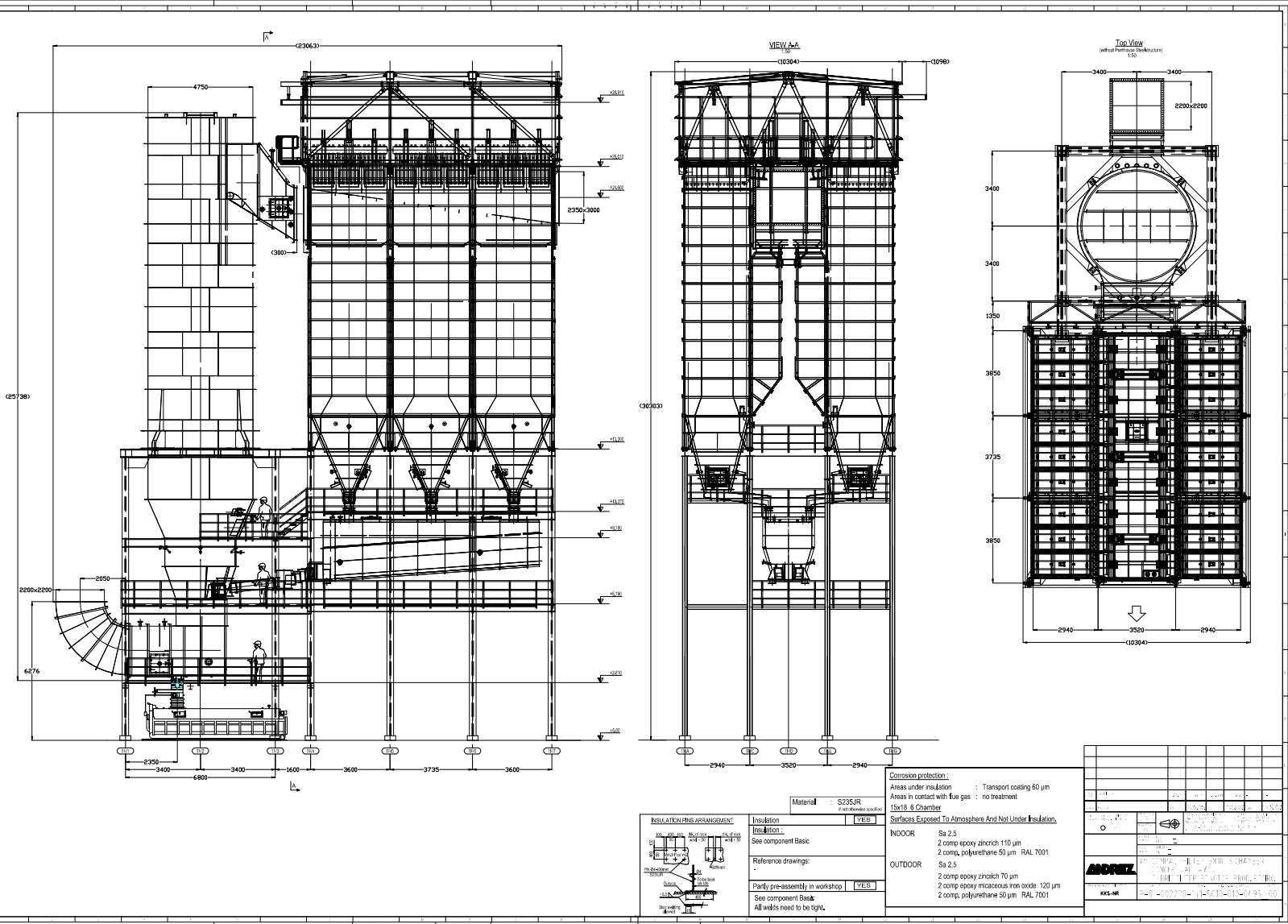
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Thank you

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Thank you



Jahn, Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Wednesday, June 15, 2022 7:02 AM
To: Jahn, Mario; Prieler Harald
Cc: Verreault Ron; Solan, John; Payne, Mark
Subject: RE: Cost Estimating Support for Desulfurization Technologies

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mario,

We have never provided a CDS for a baghouse that is at grade and am not aware of any utility retrofit project of that type. I am sure you have asked them the question of “where have they done this before”. For more on this topic, there are two possible approaches to reuse of the baghouse

Ash pumps

Given the cost of support steel required to elevate a baghouse we have looked a number of times over the years for ways to use a baghouse at grade. Here are the issues:

- The main problem is how to get the required amount of ash recycled back to the scrubber in a dry state. The amount of recycle is enormous, so conventional pneumatic conveying is not feasible – for a large project these would be medium voltage driven blowers or multiple lines of pneumatic system. We did find a type of system referred to as an “ash pump” that is in the vein of a very dense phase pneumatic system but had concerns about the reliability and O&M costs for such a system. Also they were expensive and power hungry and when we compared the cost for our standard design to a design with a baghouse at grade with an ash pump system we found no cost benefit.
- The other issue is that the dust loading from scrubber outlet to the baghouse is VERY high – on the order of 300 gr/acf – and therefore the duct from the scrubber to the baghouse needs to be highly sloped towards the baghouse at all times or dust will build up quickly. For the baghouse to be reused the CDS must be close coupled to the baghouse.
- Also, the existing baghouse inlet manifold almost certainly has a flat floor. This will cause deep dust buildups esp. at lower loads, very quickly. Baghouse inlet manifolds for use on CDS scrubbers are customized as compared to a normal baghouse, with the floors sloped towards the hoppers at all points to allow dust to “drain” into the hoppers. Use of an existing inlet manifold is not possible, it would need to be replaced. With our design there are no surfaces anywhere between the CDS outlet and the baghouse hopper that are not highly sloped.

With the above, given the technical risks to use such a design we never offered such a design. I am not aware of any CDS OEM who has tried such an approach. For a retrofit project, the other issue with the above approach is the enormous outage time required to demolish the existing baghouse inlet manifold and dust system and to install this new ash pump system and inlet manifold.

Pre-collector

There is a second approach. For projects with at grade existing baghouses where reuse of the baghouse was absolutely required by our client our approach has been to add a small ESP (elevated, to allow recycle) downstream of the CDS to

collect the dust required for the scrubber and to reduce the dust loading to the baghouse to “normal” levels where traditional ash disposal systems can be used for the baghouse. We have bid such a system 4 or 5 times but so far do not have such a system in service. We have considered and rejected use of a cyclone for this due to concerns about turndown and pluggage. Usually we are asked to turn down to 30% MCR or so and at those velocities the cyclone efficiency drops off and this means not enough dust can be recycled back to the scrubber to maintain the proper bed density. At that point wall wetting and corrosion occurs. The wall wetting can be severe to the point where the bed cannot be maintained due to large concrete buildups in the vessel, with an outage required to remove the buildups. Beds that are too thin also at some point impact SO2 removal rates. On scrubber projects with chronically thin beds this wetting / corrosion / buildup / low SO2 removal is a recurring problem and is a severe operational and reliability problem. The other issue with a cyclone is scalability – for larger projects two cyclones per scrubber (with maybe even multiple scrubber per boiler) are required, with 50% flow and dust distribution to each. In the real world it is not possible to have a true 50/50 split so one cyclone is always more heavily loaded than the other and this cannot be controlled. Getting proper dust recycle back to the scrubber is absolutely critical for CDS scrubbers to operate. For these reasons we have offered small ESPs rather than cyclones for this type of situation. As a secondary issue, the pressure drop of a cyclone is significantly higher than an ESP (maybe 5” more).

It may be that your other supplier has proposed something like the second idea above, with an ESP or cyclone to reduce dust loading prior to the baghouse. We would be willing to offer something like this but the cost savings of reusing the existing baghouse are partially offset by the need to add a small elevated ESP. If the baghouse is old or in bad repair, the savings may not be worth it. Use of a cyclone in particular adds considerable technical risk to the project and this is not our preference.

In short, we would advise strongly against using a baghouse at grade and sending the full dust loading of the scrubber to the baghouse. We could however propose an approach with partial removal of the dust upstream of the baghouse for use as recycle material and to reduce the dust loading to the baghouse to near current levels. Let me know if this answers your question.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Tuesday, June 14, 2022 4:13 PM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>; Payne, Mark <PayneMark@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Good Afternoon Paul,

We recently received a CDS quote from another vendor, and they stated that they can provide a CDS system that reuses the existing baghouse (ie, not provide an elevated baghouse). I’m not familiar with this type of system as I’ve only seen the elevated baghouse system in the past.

1. Does Andritz offer this type of CDS system?
 - a. If not, do you have any information why an elevated baghouse is a better design than a CDS system reusing the existing baghouse? We are trying to justify on whether this technology is actually something that has been proven for utility grade coal fired boilers.

Any feedback and information that you can provide would be appreciated.

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Thursday, June 9, 2022 5:11 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Mario,

As a very rough rule of thumb mechanical, electrical and insulation and lagging (but not civil) erection should cost roughly 75-85% of my material price if the project is non-union and 85% to 95% of my price if union for a typical union area and higher if this is Chicago, New York ,St. Louis, etc.

Using that ratio gives you a price from a general contractor bidding directly to you or your client. If they were a subcontractor to us we'd have to mark it up – I assume you would buy this directly.

This is a rough value but is the right order of magnitude certainly. Hope this helps. Thanks.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, June 8, 2022 3:57 PM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul,

Do you have any internal installation numbers or costs that you could share with us for a unit this size? That would help us tremendously.

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Friday, May 20, 2022 4:26 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: Re: Cost Estimating Support for Desulfurization Technologies

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Mario

We were not planning on bidding the other two technologies as to us for a CFB boiler application we think a CDS is a slam dunk choice, mostly because the CDS will not need any fresh lime addition as it can use residual active calcium coming from the boiler. Please see my email to Mark below from March 21 for more details. Let us know if that doesn't answer your questions. Thanks.

Paul Petty
Andritz Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Friday, May 20, 2022 5:25:28 PM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul/Harald,

I'm looking thru the RFQ documentation that Mark Fritz sent to you in February and noticed that we had also asked for pricing of a WFGD and SDA. Is this pricing coming at a future time or was pricing not provided for these technologies for another reason?

Thanks,



Mario Jahn, Mechanical Engineer
STANLEYCONSULTANTS, 8000 South Chester Street Suite 500, Centennial, CO 80112
T: 303.649.7895 | M: 303.725.1361 | stanleyconsultants.com

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Friday, May 20, 2022 10:41 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Mario,

Understood, thank you for the update, that helps frame this as “near term” or “not near term”. Thanks again

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Friday, May 20, 2022 11:32 AM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul,

Thanks for the info.

Viability: We are still performing the BACT analysis. Final viability will be determined by the EPA based on the findings of the BACT analysis.

Timing: My best guess at this moment in time is that we would have direction from the EPA around Q1, 2023.

Hope that helps.

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Friday, May 20, 2022 9:03 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Mario,

Please see attached for a preliminary I/O list. Our "typical" list has been checked vs. the scope for project and preliminary corrections made to match but there are a few items that would need to be confirmed such as what SO₂, PM, CEMS etc. type signals are available for use. This does not include any scope by others like any pneumatic conveying system to disposal of the byproduct or the instrument air compressors.

Is there any update you can provide us on the project in terms of viability and timing? Thanks.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Friday, May 20, 2022 8:57 AM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul,

Sounds good. We appreciate the support on this.

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Thursday, May 19, 2022 5:48 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Mario,

Email received, we'll get back with you shortly with the I/O count. No, we had not heard that Mark retired from Stanley. We look forward to working with you on the project going forward. Thanks.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, May 18, 2022 7:34 PM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Good Afternoon Paul and Harald,

I'm not sure if you are aware, but Mark Fritz retired from Stanley last week. I'll be your contact moving forward for this project. I've been coming up to speed with the information that was provided by Andritz. I do apologize if my question was previously asked and answered, but I was wondering if you had a preliminary count of I/O for a project this size.

Thanks in advance for your help.

Regards,



Mario Jahn, Mechanical Engineer
STANLEYCONSULTANTS, 8000 South Chester Street Suite 500, Centennial, CO 80112
T: 303.649.7895 | M: 303.725.1361 | stanleyconsultants.com

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Tuesday, April 26, 2022 6:47 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Hello Mark,

I thought I would check in to see if you could provide any update and "next steps" for the below project. Thanks again,

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Petty Paul

Sent: Monday, March 21, 2022 2:03 PM

To: Fritz, Mark <FritzMark@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>

Cc: Verreault Ron <Ron.Verreault@andritz.com>

Subject: RE: Cost Estimating Support for Desulfurization Technologies

Mark,

Please find attached our budgetary proposal for a TurboCDS scrubber and baghouse for your U of A Fairbanks project. A few notes about this proposal

1. As this is a CFB Boiler project, we are not offering the SDA or limestone WFGD options at this time. This is due to the following factors:
 - a. Regarding WFGD, experience is clear that WFGD would not make economic sense for a project this small, with such a low inlet SO₂ value. A WFGD would be higher in capital cost than a DFGD and will require a liquid waste stream to be disposed of. Typically, therefore, the project needs to be large enough that a high amount of SO₂ is being removed from the flue gas so that the much lower reagent costs of limestone type WFGD systems can over time result in a lower NPV for the project. For this project our quoted DFGD system actually requires no sorbent (see below) and so a WFGD will have no advantage, other than reuse of the baghouse. The existing baghouse could be reused but note that to offer any PM emissions guarantees new bags and cages would need to be installed and this offsets a significant portion of that benefit. We are confident that even with the existing baghouse this is a higher capital / NPV cost
 - b. Regarding SDA the capital cost is usually similar to a CDS but in this case the SDA will require a slaking system where the CDS will have no lime injection system of any kind (see below) so the capital cost will be higher for the SDA. As with the WFGD the existing baghouse can likely be reused but this benefit is offset by the need for new bags and in the case of an SDA modified inlet duct as well. Also, we are not clear what outlet SO₂ emissions rate is required but guarantees below about 0.06 #/MMBTU for SO₂ are difficult for an SDA. A CDS can achieve much lower values, equal to WFGD performance but at lower cost. In short, the CDS will have superior SO₂ performance and the capital cost of the SDA, with a reused baghouse, is likely similar to the CDS with a new baghouse. The NPV will favor the CDS due to the lack of lime consumption costs for the CDS and lower operating/maintenance costs due to the lack of a slaking system.
2. As mentioned above, the TurboCDS is an excellent fit for use with a limestone fired CFB Boiler. This is because a portion of the limestone injected into the boiler is calcined to CaO but does not react with acid gases in the boiler before exiting the economizer. A portion of this CaO is still chemically active and once it enters the TurboCDS it is hydrated into Ca(OH)₂ where it again becomes chemically active and is effective at reducing SO₂. Andritz has a number of CFB/CDS installations in the US, including Luminant Sandow, CLECO Rodemacher, Dominion Virginia City and Georgia Pacific Port Hudson. Some discussion would need to take place to confirm the Ca/S of the boiler but experience indicates that for a design boiler SO₂ outlet value of 0.2 #/MMBTU it is highly likely that enough active CaO will exit the boiler to allow Andritz to guarantee zero fresh lime addition in the scrubber for 90% removal to 0.02 #/MMBTU. This also eliminates the need for a lime silo and feed system.
3. Note that Andritz assumes 0.01 #/MMBTU PM guarantees and 0.02 #/MMBTU SO₂ guarantees are acceptable as none were specified. Please advise if different values are desired.
4. We assume you require the emissions to be met with one baghouse compartment out of service, as is typical. If this is not the case we can make the baghouse significantly smaller or consider use of alternate technologies.

Thank you for your interest in Andritz. Hopefully this is responsive to your request. Please let us know if you have any questions. Thanks again.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 9, 2022 3:05 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Harald,

No problem. It had been a while since we talked and I wanted to touch base to see if there had been any changes in the end of March date.

Thanks,

Mark

From: Prieler Harald <Harald.Prieler@andritz.com>
Sent: Wednesday, March 9, 2022 12:44 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Hello Mark

as mentioned in my previous email, we are busy with some other proposal and project work at the moment, but we believe being able to provide you some information on the project by end of March.

Hoping this Works for you.

Thanks and

Best regards,

Harald Prieler
Regional Manager Americas
Air Pollution Control

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 9, 2022 3:19 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Harald,

When is a good time to discuss this proposal? Project was temporary delayed but is back on track.

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

From: Prieler Harald <Harald.Prieler@andritz.com>
Sent: Tuesday, February 8, 2022 12:23 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Thanks Mark.

As a matter of fact, we are working on several firm proposals at the momento, therefore it will be difficult to provide you something before end of March.

We are trying our best to do it earlier, but I do not want to provoke wrong expectations.

Hoping, this is ok for you.

Best regards,

Harald Prieler
Regional Manager Americas
Air Pollution Control

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Tuesday, February 8, 2022 1:05 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Harold,

Yes existing baghouse is downstream of the boiler. Have attached a few layout drawings. Do you have a idea of when we might see some of the requested information? If you need any further information, please ask.

Regards,

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

From: Prieler Harald <Harald.Prieler@andritz.com>
Sent: Thursday, February 3, 2022 4:41 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: FW: Cost Estimating Support for Desulfurization Technologies

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Mark

confirming that we have received your inquiry.
We'll assess it and let you know, how we can Support you on this project.

Following quick clarifications:

- the attached baghouse data sheet is for an existing BHF downstream the boiler – please confirm.
- A layout of the CHPP would be very helpful to assess the different alternatives.

Thanks and br
Harald

Best regards,

Harald Prieler
Regional Manager Americas

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, February 2, 2022 6:15 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Subject: Cost Estimating Support for Desulfurization Technologies

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Harold,

See attached for the Scope and additional information we discussed on the phone. I have tried to minimize the requested information and provide just what we need to finish the cost estimate. Please do not hesitate to call to discuss further, or if there is additional information you require.

Regard,

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

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Thank you

Stanley Consultants University of Alaska – Fairbanks Project Andritz TurboCDS / Compact Filter DeSOx System

BUDGETARY TECHNICAL AND COMMERCIAL PROPOSAL

Proposal No.: Later
Version No.: 0

Inquiry No.: Email dated February 2, 2022
Date: March 23, 2022



Customer: Stanley Consultants
Attention: Mr. Mark Fritz
Principal Mechanical Engineer
p: 563-607-1430
fritzmark@stanleygroup.com

Contact: ANDRITZ Inc.
Division: Air Pollution Control, North America
Project Manager: Paul Petty
p: 667-351-8872
paul.petty@andritz.com

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TECHNICAL PROPOSAL

1 INTRODUCTION

ANDRITZ, Inc. is a leading international supplier of air pollution control technology for power stations and industrial plants. The ANDRITZ product portfolio ranges from large scale wet flue gas desulfurization to dry flue gas cleaning based on hydrated / slaked lime or dry sodium sorbents, and SCR (selective catalytic reduction for NO_x removal) systems. Other market segments for the ANDRITZ APC division are the cement, metal, petrochemical, and waste to energy sectors. ANDRITZ offers customized design concepts and is a „one-stop-shop“ for flue gas cleaning solutions. To view our extensive experience in the field of flue gas cleaning, please refer to our attached reference lists.

The subject of this proposal is a dry type flue gas desulfurization plant, the Andritz TurboCDS CFB SCRUBBER and Compact Filter pulse jet fabric filter system. It shall be installed to remove acid gases and particulate matter from a coal fired CFB Boiler. Andritz has extensive experience with installations of CDS type scrubbers downstream of CFB Boilers, including both the TurboCDS type scrubber and also the NID scrubber, now part of the Andritz technology portfolio due to Andritz's acquisition of the air pollution control group of General Electric. Of the two types of CDS Andritz is proposing the TurboCDS type design although in a later firm bid we may also assess a NID approach. At this time we believe the TurboCDS to be the more competitive offering.

ANDRITZ's dry flue gas desulfurization process consists of a TurboCDS Circulating Fluid Bed (CFB) technology reactor and an ANDRITZ designed downstream Compact Filter for particulate removal. With this process, particulate, harmful acid compounds such as SO₂, HCl, and SO₃/H₂SO₄ are separated from the flue gas at a high removal and low sorbent consumption rate. The final product of the desulfurization process is a dry residue that may be disposed of easily.

The main advantages of the TurboCDS CFB Scrubber process are:

- Ability to utilize calcium products in the fly ash instead of fresh lime
- Easy operation and high reliability
- Low capital cost
- Low maintenance cost
- Minimal rotating equipment
- Excellent turndown characteristics
- Reduction of components subject to wear
- Waste water free system
- No reheating necessary
- High removal rate of particulate / flyash
- High removal rate of SO₂
- High removal rate of SO₃/H₂SO₄

2 PROCESS DESCRIPTION

2.1 PROCESS OVERVIEW

The TurboCDS Circulating Fluid Bed Scrubber (CFB) process represents a proven alternative to wet scrubbing. The process can achieve greater than 99% SO₂ capture on high (>6%) sulfur fuels with greater reliability and less maintenance than either the wet or semi-dry spray dryer (SDA) systems. The process is totally “dry”, meaning it not only produces a dry free flowing disposal product but also introduces the lime reagent as a dry free flowing powder.



Flue gas is directed into the bottom of the CFB vessel where it is turned upwards and passes through a grid of venturis (1 to 7 venturis, depending on size). The lime reagent is introduced below the venturi level where it mixes with the flue gasses and is evenly dispersed in the vessel via the mixing that occurs in the lower vessel. Above the venturis, cooling water is added totally independently from the introduction of fresh reagent and recirculated by-product. The CFB is completely empty and has no special internals that can be eroded or plugged. All vessel materials of construction are carbon steel. The utilization of reagent (calcium) is vastly improved over previous “dry” processes by evaporative cooling of the flue gas to typically 30°-35° F of adiabatic saturation and retaining the calcium in the process for a typical average of 30 minutes of contact with the SO₂. Thus a totally dry process is successfully applied to higher sulfur dioxide concentrations than the semi-dry SDA process with demonstrated performance capabilities equivalent to “wet” FGD processes. Improved reliability and availability has been achieved by eliminating equipment requiring routine maintenance such as ball mills, slurry pumps, agitators, high-speed rotary atomizers, thickeners, and sludge dewatering equipment. By-product that is generated as a result of the CFB process is collected in a downstream electrostatic precipitator or fabric filter. The by-product is metered from the collector hoppers onto air slides that are designed to recirculate back into the scrubber vessel. A portion of this material is diverted from the hoppers and flows via gravity to product surge bins, located at grade, and then into the ash handling system.

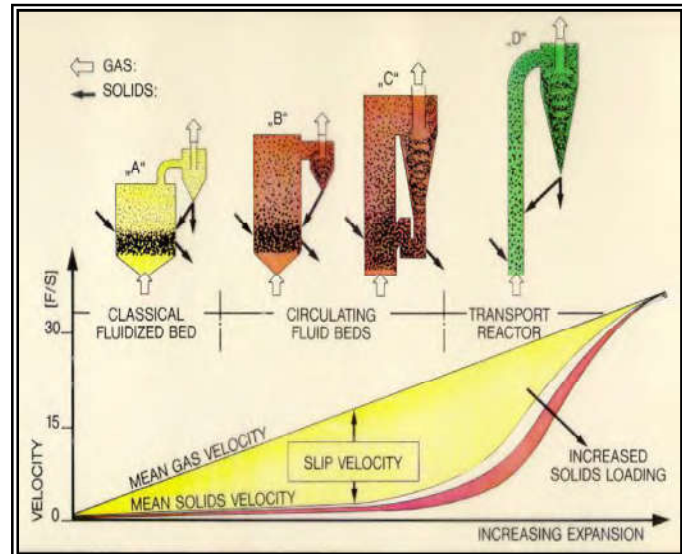
As is shown, the CFB operates not only as a chemical reactor for absorbing gaseous contaminations but also as an evaporator. Surface humidity of solids within the CFB is held nearly constant by maintaining the introduction of water completely independent of the recirculated solids and fresh lime. This eliminates the potential for scaling that exists in wet and semi-dry processes.

The excellent heat and mass transfer is achieved by maximizing the slip velocity between the solid particles and the flue gas (differential velocity).

For classical or bubbling flue fluidized beds the particle velocity is very close to the main gas velocity with which the bed is fluidized. Therefore, the “slip” is relatively small.

Transport reactors also operate with minimal slip velocity. The gas velocity is so high that the particles are entrained as nearly independent individual single particles. The particle and transport gas velocities differ only by the particle suspension velocity. Therefore the slip velocity is minimal.

In the expanded circulating fluid bed scrubber the slip between the average solids velocity and the fluidizing gas is a maximum. For fluidizing gas velocities in between the bubbling bed and transport reactor and at a sufficient solid loading, the particles are forming chains. This creates a different aerodynamic resistance and allows the solid chains to move contrary to the fluidizing gas until the slip velocity is so high that the chains will be destroyed and the single particles will again be entrained by the fluidizing gas. That explains the typical pulsation of an expanded CFB where the particles are continuously tumbling within the gas-solid suspension.



Typical CFB characteristics are:

- *High mass transfer rate within the lime particles*, which have an average particle diameter of 5 to 10 microns.
- *Extremely long solids retention time* that allows high concentrations of gaseous pollutants to be absorbed with very efficient lime utilization.
- *Continuous abrasion of the lime particle surface*, removing inactive CaSO_4 surfaces which cover active lime particle cores.
- *Operating temperatures with a close approach to the water dew point* can be achieved which gives a high utilization of the reagent.
- *Wastewater can be used for water injection*, which improves desulphurization and dust collection. The water injection is independent from the reagent feed required for desulphurization.
- *The natural turndown ratio* is from 100% to 60% of the gas flow to the scrubber. Operation below this can be achieved through the use of clean-gas recirculation, or other means.

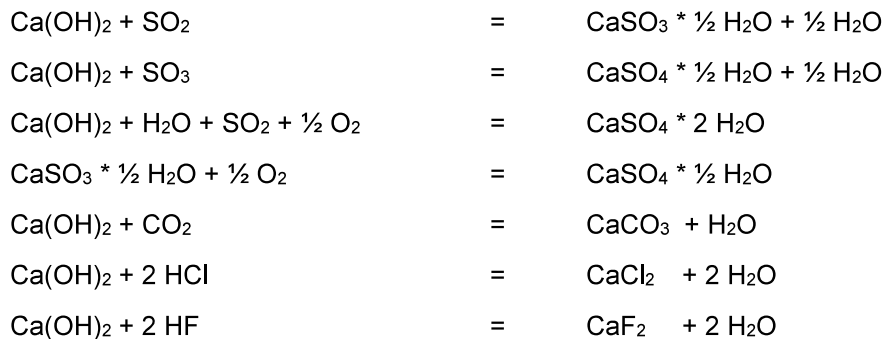
The simplified process control effectively consists of only three major control circuits for fully automatic operation. This process is in principle very simple and reliable.

- SO₂ Control:
 - The feed of hydrated lime is controlled by the amount of SO₂ in the flue gas which sets the basic predetermined lime rate for the absorber corrected by the SO₂ clean gas concentration.
- Temperature Control:
 - The gas temperature leaving the absorber controls directly the amount of water that will be injected via high-pressure return flow nozzles into the bottom of the absorber. Repositioning the return flow valve will cause a change in the amount of water being sprayed into the CFB.
- Solids Discharge:
 - The solids loading of the absorber control the amount of dry by-product discharged from the system. This is measured by the pressure loss along the absorber height and is kept on a constant value. The solids loading, or the hold up, divided by the solids feed (product and dust) gives the solids retention time of the absorber. It can be varied over wide ranges limited by the draft capability of the fan for the maximum value.

The reagent can be in the form of either powdered hydrated lime or pebble lime. For hydrated lime, the only equipment required is a storage bin, gravimetric feeder and an air slide conveyor. For systems that use pebble lime a hydrator that mixes the pebble lime with water is required. For this project use of hydrated lime is proposed. For this specific project, which uses a CFB Boiler with limestone addition, it may be possible to eliminate the need for fresh lime addition of any kind as CaO exiting the boiler as fly ash can be utilized by the scrubber. Please see below for more information on this advantage.

2.2 ACID GAS EQUATIONS

The following reactions are essential for the dry desulfurization process in the nominal temperature range which corresponds to a temperature that is typically near a 30°F approach to adiabatic saturation (the given formulae are cumulative formulae and do not reflect the true course of the reactions in individual steps):



3 SCOPE OF PROPOSAL

ANDRITZ Inc. is pleased to offer one (1) TurboCDS scrubber system, consisting of the following equipment:

3.1 ANDRITZ CIRCULATING FLUID BED SCRUBBER (CFB)

ANDRITZ will design, fabricate and deliver to the jobsite:

- One (1) TurboCDS type Circulating Fluid Bed Scrubber (CFB) for scrubbing acid gases from the waste gas stream. The CFB Scrubber will be nominally 12'-7-1/2" in diameter and shall include a venturi section to maintain the solids in suspension (i.e. fluidized bed) within the reaction chamber.
- Waste gas entering the CFB Scrubber shall be humidified with water sprays as required to achieve the required acid gas removal efficiency. Water sprays shall be controlled based on the CFB Scrubber outlet temperature, and will maintain an optimum approach temperature to saturation.
- Equipment necessary to re-circulate the majority of the reacted lime and byproducts exiting the CFB, so as to improve the efficiency of the scrubber and to minimize the lime consumption including all lime discharge, handling and conveying equipment.
- CFB Scrubber byproduct discharge system to dispose of ash or dust. The system consists of shear bottom conveyors and a screw conveyor, which allows for transport to a downstream conveying system and silo or disposal bin (by others)
- Design and specification (supply of materials by others) of thermal insulation and cladding as necessary to prevent internal acid/water vapor condensation.
- All steel required for support of the various components of the CFB Scrubber to provide a minimum clearance as shown on the proposal GA drawings
- Steel required for equipment access, including stairs, platforms, walkways and caged ladders to provide safe access to the equipment, instrumentation, etc.

3.2 HYDRATED LIME SYSTEM

No lime storage or injection system is required as the Andritz TurboCDS utilizes the unreacted calcium present in the fly ash leaving the boiler very effectively and the proposed SO₂ emissions rate can be achieved without the need for a dedicated lime system. This assumes typical CFB Boiler Ca/S ratios bed temperatures and SO₂ removal rates. If desired a small system can be added to „trim“ the SO₂ emissions.

3.3 CFB SCRUBBER AND FABRIC FILTER SYSTEM DUCTWORK

ANDRITZ will design, fabricate and deliver to the jobsite:

- Flanged ductwork from the outlet of the CFB Scrubber vessel to the inlet of the Fabric Filter, complete with stiffeners and access door.

3.4 FABRIC FILTER SYSTEM (BAGHOUSE)

ANDRITZ will design, fabricate and deliver to the jobsite:

- One (1) Andritz Compact Filter Pulse Jet Fabric Filter (PJFF) system designed for negative pressure, constructed of four (4) compartments of a top-door design. Each compartment will be provided with 270 16 osy PPS/PTFE filter bags, each nominally 5" in diameter by 26' – 3" long. Carbon steel cages are also supplied.
- All required bag cleaning components, including ASME pulse headers, double diaphragm pulse valves, blow pipes, and timer control panels, all shop assembled.
- Fabric filter pulse pipes and large bore air piping downstream of the supplied air receiver.
- Instrumentation and controls necessary to monitor and operate the baghouse equipment, including bag cleaning, material handling, leak detection, module and overall pressure drop, gas temperature, and hopper level. Main process controls shall be via DCS (by others). No local PLCs are required nor supplied.
- Automatically operated baghouse outlet flap dampers (via pneumatic actuators) to allow for isolating a compartment for maintenance, while the other compartments remain in operation.
- Automatically operated baghouse inlet flap dampers (via pneumatic actuators), that allow for isolating a compartment for maintenance, while the other compartments remain in operation.
- Access steel required for safe operation and maintenance of the various baghouse system equipment, including stairs and/or ladders to various access platforms, handrails and walkways to the extent indicated on the attached proposal GA drawings.
- Steel required for supporting the baghouse and all supplied auxiliary equipment systems.
- Supply of all heating required to prevent acid/water vapor condensation on the baghouse hopper surfaces, including pad type hopper heaters.

3.5 ASH AND BYPRODUCT RECIRCULATION HANDLING SYSTEM

ANDRITZ will design, fabricate and deliver to the jobsite:

- All required material handling system equipment within the specified terminal points, including recycling of material to the circulating fluidized bed scrubber (CFB) and transporting the waste product from the Fabric Filter to terminal points on the provided airslides where the byproduct will be disposed of by others (via dumpster or pneumatic system and silo).
- The material recirculation system includes main by-product air-slides under each pair of fabric filter modules with rotary air lock valves, "dosing" valves (used to meter the byproduct back to the scrubber vessel, air slide fluidization heater/blower system and miscellaneous scope such as expansion joints, slide gates and required local instruments).

3.6 INSTRUMENTATION AND CONTROLS

- ANDRITZ will provide all required instrumentation required to monitor and control the Dry Flue Gas Desulfurization equipment, including temperature transmitters, pressure transmitters, flow transmitters, level transmitters, etc. Note that no outlet SO₂ monitor is included at this time. Use of outlet SO₂ monitor or CEMS (by others) is assumed. Andritz will provide an inlet SO₂ monitor for feed forward control purposes.
- ANDRITZ shall provide control system design engineering, including all P&IDs, detailed Functional Control Specification documents, logic diagrams, control loop concept development, alarms, and set points.
- Owner shall provide a DCS to control the operation of the Dry Flue Gas System equipment. All DCS programming and configuration will be supplied by others. ANDRITZ will assist with the HMI screen requirements and on-site consultation during commissioning.
- All instrumentation and controls will be supplied in accordance with the applicable sections of the specification.
- Additional controls will be provided for auxiliary equipment as appropriate.

3.7 BALANCE OF PLANT EQUIPMENT AND SERVICES

- ANDRITZ shall supply a shop applied prime and finish coat paint system per Andritz standards specifications to protect the equipment being supplied from the elements as appropriate
- ANDRITZ shall flow model the equipment via CFD to determine the optimum flow distribution and pressure drop characteristics of the gas path from the APH outlet to the fabric filter outlet.
- ANDRITZ will provided qualified field personnel to consult in the erection of the equipment, provide commission services, providing training in the operation of the equipment and witness the performance testing of the equipment. The amount of this support is identified in detail below.
- ANDRITZ shall transport the equipment to site using truck deliveries, DAP/DDP jobsite.

3.8 TECHNICAL OPTIONS

- No technical options are offered at this time.

4 EQUIPMENT AND PROCESS DESCRIPTIONS

4.1.1 PROCESS DESCRIPTION

The flue gases coming from the upstream process enter into the CFB Scrubber for pollution control. The flue gas ducts will utilize the draft created by the new ID fan (by Others) to induce the flow into the Circulating Fluid Bed Scrubber, where the flue gas enters horizontally at the bottom of the vessel. The flue gas turns vertically upwards, passing through one or more venturis, into a vertical tower. In order to raise the reactivity, the flue gas is cooled down in the vessel to an appropriate operating temperature by water injection.

In the reactor vessel, the flue gas also comes into contact with recirculated by-product from the Compact Filter Fabric Filter. As this project includes a CFB Boiler with limestone addition, this by-product contains significant usable calcium and this is used to remove flue gas SO₂. The treated flue gas leaves the CFB reactor at the top and immediately turns towards the Compact Filter Fabric Filter where the particulate and reacted/unreacted sorbents will be separated from the gas stream.

After the ID fan (by others), the flue gas flows through the outlet duct (by others) to the stack (by others) for discharge to the atmosphere. A flue gas recirculation ductwork system (with damper) is also supplied by ANDRITZ to connect the outlet duct of the ID fan to the inlet duct of the CFB Scrubber in order to allow for sufficient flue gas velocity in the scrubber during low load operation.

4.2 CIRCULATING FLUID BED SCRUBBER (CFB)

4.2.1 CFB SCRUBBER SCOPE OF SUPPLY

ANDRITZ will design, fabricate and deliver to the jobsite one (1) 12'-7-1/2" nominal diameter single venturi scrubber vessel including:

- Flue gas inlet box, 1/4" thick
- By-product discharge system consisting of bottom scraper and conveyor system (downstream disposal to silo or dumpster by others)
- Expansion joints between the scrubber exit and the fabric filter inlet
- Air slide penetrations for by-product recirculation
- Hinged access doors above and below venturi
- Nozzles for measuring equipment (pressure, temperature, flow)
- Supporting steel structure, A36 / A992 and/or A572 Grade 50

4.3 GAS HUMIDIFICATION SYSTEM

ANDRITZ will design, fabricate and deliver to the jobsite one (1) process water tank with a storage capacity of nominally one hour at MCR case design conditions and will be fed by a process water stream from the plant. The tank is equipped with a continuous filling level measurement system and an additional minimum level alarm in order to protect the pumps.

The atomization of water in the reactor vessel is achieved by means of high pressure dual fluid type nozzles after the water has been pressurized by a relatively low pressure water pump. An additional pump will be used as a back-up. A control valve installed in the water piping continuously controls the outlet temperature of the CFB Scrubber by adjusting the injected amount of water to maintain the outlet set point at the optimum temperature.

4.3.1 WATER SYSTEM SCOPE OF SUPPLY

ANDRITZ will design, fabricate and deliver to the jobsite:

- Design and supply of one (1) process water tank
- Two (2) high pressure process water pumps (1 total operating, 1 total stand-by), at nominally 500 to 600 psig
- Two (1 operating + 1 stand-by) injection lances
- Connection piping and ring pipe
- Dual basket strainers for each pump
- One (1) water flow control valve per scrubber with pneumatic actuator and positioner
- Pumps are base mounted and piping, including pipe supports, are field erected

4.4 COMPACT FILTER PULSE JET FABRIC FILTER SYSTEM

The second stage of the flue gas cleaning system is the Fabric Filter, used for maximum removal efficiency of the particulate in the flue gas (Typically 99.9%+ filterable particulate removal).

The Compact Filter Fabric Filter is comprised of four (4) independent compartments. Each compartment can be isolated from the other utilizing the pneumatically actuated flap type dampers.

The heavily laden particulate (typically ~300 to 400 gr./acf) and flue gas mixture is directed to the compartments via a central plenum in such a way that optimal gas distribution occurs within the Fabric Filter as well as the individual compartments, and low Air to Cloth Ratios and upward can velocities within the compartments are achieved.

The gas flows through the filter medium from the outside to the inside, such that the solids carried over by the gas are trapped on the outside of the filter bag. These particles form a layer of filter cake, which allows for a "barrier filtration" process to occur at the bag surface, and contributes to the very high filtration efficiency

To avoid excessive flow resistance across the filter bags, compressed and dried air (instrument quality to -40°F dew point) from the compartment pulse reservoirs is used for regular cleaning of the bags, and is distributed into the bags via a pulse pipe above each row of bags. These pulses of pressurized air (nominally 60-100 psig at the pulse pipe) are blown into the filter bags, causing the bag to expand and the filter cake to peel off and fall down into the hoppers.

The cleaning frequency and the length of the pulse valve opening periods can be adjusted using the supplied control system.

The flyash and reaction by products are removed from the hoppers into a fluidized ash recirculation system from where the majority of the ash is recirculated into the CFB Scrubber reactor, and the remainder is discharged into the downstream disposal system (by others).

The Fabric Filter hoppers are electrically heated (which is important in case of plant standstills or at start-up) and the hoppers are also equipped with hinged access doors, strike plates, poke tubes, level detectors and fluidizing air system.

The clean flue gas leaves the filtration system via the outlet poppet dampers and the clean gas manifold duct to the ID fans and then to the stack.

4.4.1 FABRIC FILTER SYSTEM DESCRIPTION

ANDRITZ will design, fabricate and deliver to the jobsite:

- Heavy duty, well-stiffened compartment casing, 1/4" thick A36 / A992.
- Supporting structure, designed for maximum dead, wind, snow, pressure and seismic load combinations as required by state and appropriate local building codes.
- Robust 1/4" A36 / A992 stiffened, plasma or laser cut tube sheets, seal welded and dye penetrant tested in the shop
- PPS (with PTFE membrane) filter bags with supporting mild steel cages.
- Automatic cleaning system for filter bags using compressed air pulses from individual ASME-stamped compartment pulse headers, controlled with shop assembled and wired double diaphragm and solenoid valves
- Heavy duty gas inlet and outlet manifolds 1/4" thick A36 / A992, with pneumatic flap type inlet and outlet gas dampers for separating individual filter compartments for off line cleaning and/or maintenance
- Dust hoppers fabricated of 1/4" thick A36 / A992 steel, designed for maximum structural ash loading, with connections for level detection, pad type heaters, poke tubes, provisions for vibrators, fluidizing air and ash discharge isolation valves
- Large bore air distribution piping, including pulse pipes and couplings
- Necessary hinged access doors, one per hopper and one per walk in plenum
- Level detection in hoppers, 1 per hopper
- Local instruments including thermocouples, pressure transmitters, tube sheet delta pressure gauges, and limit switches for position feedback on all dampers
- Hopper heating
- 2% spare bags
- 1% spare cages
- One (1) monorail with electric hoist and manual trolley for bag removal.
- Grounding pads
- Black light power
- Pre-coat material

- One (1) broken bag detector per compartment
- Local instruments as required
- Access platforms as indicated on the attached drawings

4.4.2 FABRIC FILTER SYSTEM SPECIFICATIONS

- | | |
|---|---|
| • Number of fabric filters | One (1) |
| • Number of filter compartments each | Four (4) |
| • Filter surface area per compartment | 8,580 ft ² Effective |
| • Number of filter bags per compartment | 270 |
| • Filter bag diameter | 5 inch nominal |
| • Filter bag length | 26'-4" nominal |
| • Filter bag material | PPS 16 oz./yd ² nominal with PTFE |
| • Bag cage material | 11 gage carbon steel |
| • Cage type | 12 vertical wires, 3 piece |
| • Gross A/C ratio | 2.36 ft ³ /ft ² /min effective (MCR case) |
| • Net A/C ratio | 3.14 ft ³ /ft ² /min effective (MCR case) |

4.5 REAGENT STORAGE AND INJECTION SYSTEMS

No reagent system is required or supplied.

4.6 PRODUCT RECIRCULATION SYSTEM

The fabric filter hoppers serve to provide an inventory of ash and by-product for feeding and maintaining the fluidized bed in the reactor vessel. The majority of these buffered solids are recirculated into the reactor vessel via fluidizing (air-slide) conveyors and dosing valves. Thus, the content of particulate in the flue gas between the CFB Scrubber reactor vessel and the Fabric Filter can increase up to ~300 to 400 gr./acf. The fluidizing air for the conveyors and related systems is generated by positive displacement fluidizing air blowers, with 2 x 100% redundancy.

The regulation of the amount of recirculated solids being introduced back into the CFB Scrubber reactor is based on the measured differential pressure between the reactor vessel inlet and outlet, and the flue gas volumetric flow. The control scheme maintains the pressure drop caused by the fluidized bed at a constant level.

4.6.1 FABRIC FILTER HOPPERS WITH AIR SLIDES

The Fabric Filter hoppers with air slides are situated below the Fabric Filter bags. Each Fabric Filter is equipped with 2 rows of 2 hopper each. Each hopper is equipped with a manual shut off gate valve, and chute where the product is introduced into the main product recirculation slide. One (1) product

recirculation slide collects the dry product of each row of Fabric Filter hoppers.

4.6.2 FLUIDIZATION AIR BLOWERS

The fluidization air is supplied by one set of PD type blowers with heaters. Each scrubber has two (2) blowers (one operating and one spare) and a bank of heaters that contain one spare element.

The fluidization air blowers are encapsulated with a sound protection hood in order to minimize noise emission. All blowers are situated below the Fabric Filter.

4.6.3 PRODUCT RECIRCULATION SCOPE OF SUPPLY

ANDRITZ will design, fabricate and deliver to the jobsite:

- Two (2) Dosing valves, for by-product recirculation
- Two (2) medium pressure Fluidization Air Blowers (one standby) including piping and pneumatic actuators
- One (1) medium pressure heater bank with four (4) elements (3 operating, 1 spare)
- All required instrumentation and relief valves
- Design of insulation and trace heating of the recirculation hoppers and air slides
- All required interconnecting large bore (=> 2-1/2") piping

4.7 DUCTWORK AND EXPANSION JOINTS

ANDRITZ will supply the interconnecting ductwork between the scrubber outlet to the Fabric Filter inlet complete with stiffeners. High temperature expansion joints at the outlet of the scrubber and the inlet of the Fabric Filter are also supplied. The supports for this transition ductwork are included.

ANDRITZ will also supply the flue gas recirculation ductwork including supports, expansion joints and control damper, assuming the ID fan to be local to the baghouse outlet.

4.8 SUPPORTING STEEL AND ACCESS PLATFORMS

The supporting steel structure for the CFB Scrubber reactor, Fabric Filter, and the product recirculation system is included. This includes all stairs, ladders, platforms and access ways indicated on the attached general arrangement drawings for inspection and maintenance of the proposed equipment.

4.9 ELECTRICAL SYSTEMS

ANDRITZ is responsible for supply of all locally mounted motors, drives, actuators, etc., required for operation of the equipment. ANDRITZ will provide a complete electrical drawing package showing the method and size of wiring required for each consumer. Wiring provided by ANDRITZ will be limited to pre-wired equipment sent to the site as part of the overall scope of supply.

Others are responsible for the main power supply, motor control centers, motor starters, contactors, breakers, and all field cables, wiring, conduit, supports, etc., for a complete electrical installation. Others are also responsible for permanent area lighting, electrical outlets, welding receptacles, and local disconnects, as required.

4.10 CONTROL AND INSTRUMENTATION SYSTEM

ANDRITZ will provide all local instrumentation required to monitor and operate the FGD system (other than inlet SO₂ monitor, stack CEMS and COMS). The instrumentation scope will also include temperature transmitters, thermocouples, pressure transmitters, level detection, flow transmitters, zero speed switches, etc., to monitor and verify the proper operation of the system. ANDRITZ will provide all related engineering, including P&ID's, functional control descriptions, loop diagrams, and set points for operation and alarm.

Others shall provide a central DCS based control and monitoring system, and associated Human Machine Interface (HMI), for taking signals from ANDRITZ's instruments and operating the equipment. Others will be responsible for all programming and screen development as part of their DCS work.

4.11 PIPING

Within the identified scope boundaries, ANDRITZ will design and supply the large bore ($\geq 2\text{-}1/2"$) piping, prefabricated (spooled) including supports, valves, regulators and filters. Also included is large bore isometric drawings and orthographic "suggested routing" drawings for small bore ($<2\text{-}1/2"$) pipe. Small bore piping, valves, fitting and supports are by others.

4.12 PAINTING

The painting system for interior and exterior exposed structural and miscellaneous steel will include surface preparation of SSPC-SP6 and a 2-3 mil inorganic zinc prime coat and an epoxy finish coat.

The painting system for handrails, guardrails, toe plates, ladders cages and stair stringers will include surface preparation of SSPC-SP6 and a 2-3 mil inorganic zinc prime coat and an epoxy finish coat.

The painting system for uninsulated large bore piping will include surface preparation of SSPC-SP6 and a 2-3 mil inorganic zinc prime coat and an epoxy finish coat.

Grating and stair treads will be hot-dip galvanized.

Field touch-up will be by others.

4.13 MODEL STUDY

ANDRITZ will perform a CFD model from a suitable point in the ductwork (to be mutually agreed) upstream of the scrubber inlet to the ID fan inlet(s) for purposes of determining turning vane details.

5 BATTERY LIMITS

5.1 MECHANICAL

5.1.1 FLUE GAS

Begin: CFB Scrubber Inlet Flange, downstream of joint

End: Fabric Filter Outlet Flange, upstream of joint

5.1.2 REAGENT SYSTEMS

Begin: N/A

End: N/A

5.1.3 PROCESS WATER

Begin: Valve on inlet of process water storage tank

End: Within scope

5.1.4 FGD BY-PRODUCT

Begin: Within scope.

End: ANSI flanges on ash disposal flange at each airslide and flange at scrubber ash outlet

5.1.5 PRESSURIZED AIR

Begin: Outlet of air receiver (by others), local to the scrubber system at grade

End: In scope (for large bore piping only)

5.2 ELECTRICAL

5.2.1 ELECTRICAL SUPPLY

Begin: Others will provide power to each power consumer's terminals

5.2.2 PROCESS CONTROL SYSTEM

Begin: Others will provide wiring to each instrument or device provided by ANDRITZ

5.3 CIVIL AND STRUCTURAL

5.3.1 BUILDING AND STRUCTURE WORK

Begin: At top of Others' foundations (anchor bolts and grout by Others)

End: within scope

5.4 SUPPLY EXCLUSIONS

- Receiving, unloading and storage of all equipment
- Erection labor, equipment and consumables
- Design and supply of Q decking, elevated concrete deck, foundations, anchor bolts and grouting (if any)
- Design and supply of scrubber inlet ductwork and fabric filter outlet ductwork including all expansion joints and supports
- Any interior coatings for the scrubber inlet and bottom
- Design and supply of ID fans and related subsystems
- Design and supply of stack including stack platform and test ports
- Design and supply of small bore piping
- Design and supply of field wire, conduit, junction boxes and all other erection materials related to electrical erection including cable, cable tray and/or conduit routing schedules or drawings
- Design and supply of light fixtures, convenience receptacles and welding receptacles
- Design and supply of plant communications (“Gaitronics” and similar) system, if any.
- Design and supply of lighting and receptacles
- Design and supply of heat tracing, if required
- Design and supply of motor starters, MCC’s, switchgear, power distribution panels, and other power distribution equipment such as medium or high voltage transformers
- Heat insulation, lagging, flashing and any other accessories related to I&L erection
- Design and supply of ash removal system including waste ash silo
- Field finish and/or touch-up painting
- Elevators, if any
- Design and supply of any PLC, DCS and/or field I/O racks and any communications interfacing hardware. This includes but is not limited to general DCS design, screen/graphics creation (except as noted above), programming, testing (including FAT) documentation.
- Design and supply of sub surface grounding system
- Demolition and/or hazardous material identification and abatement, if any
- Design and supply of fire detection/protection system and emergency (UPS) power supply, if any
- Design and supply of stack CEMS and/or stack SO₂ monitor.
- Lightning protection, if any, and above grade equipment grounding to sub surface grid
- Performance testing including preliminary performance testing
- Securing of all permits and licenses, including engineering activities required to secure same
- Creation of turnover packages, if any
- Consumables (sorbents, water, power, etc.) for commissioning, testing and operation

- P.E. Stamps other than for support steel
- 3-D modeling, if any
- Non process piping systems such as any vacuum system, convenience service air, water and potable water
- Eyewash stations and safety showers
- Spare parts other than start-up spares
- Air compressors, receivers and dryers
- Enclosures for any supplied system
- Supplies and services which are not expressly mentioned in the scope of supplies and services

6 DESIGN AND PERFORMANCE DATA

6.1 DESIGN BASIS – CODES AND STANDARDS

Parameter	Unit	Value
Location / Building Codes	Fairbanks, AK	IBC assumed
Altitude above sea level	ft	446 assumed
Ambient temperature (min - max)	°F	Later, assumed indoors
Relative humidity	%	100 max
Ambient pressure	Inch Hg	As per elevation
Maximum wind speed	mph	ASCE 7 Assumed
Snow Load (ground)	psf	ASCE 7 Assumed
Seismic Load	g	ASCE 7 Assumed
Seismic Design	IBC 2012	ASCE 7 Assumed
Operating Pressure	Inches W.C.	-8" assumed
Design Pressure @ Allowable Design Stress	Inches W.C.	+35 / -35 Scrubber +35 / -35 PJFF
Volumetric Dust Density	Lbs/Cu.Ft.	By-product - 60
Structural Dust Density	Lbs/Cu.Ft.	By-product - 90

6.2 FLUE GAS DATA AT BATTERY LIMIT

Full load inlet flue gas conditions are per the „Boiler Data.pdf“ file for the „MCR“ condition, as supplemented by the „UAF Exhaust Gas Data.doc“ file. Minimum load conditions are assumed to be per the „40%“ design case with other chemistry similar to that specified for the „MCR“ condition.

6.3 FLUE GAS DATA AT FABRIC FILTER OUTLET

Please refer to the attached PFD data information for the MCR Load conditions for expected Fabric Filter outlet information.

6.4 REAGENT QUALITY – HYDRATED LIME

Not applicable

6.5 PROCESS WATER QUALITY

Parameter	Unit	Value
Chlorides (Cl ⁻)	mg/l	<200 ppm
Sulfates (SO ₄ ²⁻)	mg/l	<200 ppm
Total suspended solids (TSS)	mg/l	Per Others design for water tank use (TSS to be removed as needed to not drop out in Andritz tank)
Temperature	°F	Ambient

6.6 GUARANTEES

6.6.1 EMISSIONS AND OTHER “MAKE RIGHT” GUARANTEES

Except as noted, ANDRITZ guarantees the following emission limits at the stack as a 3 hour (minimum) average:

Parameter	Units	Value	Test Method	Test Duration
Sulfur dioxide (SO ₂)	%	≥ 90%	EPA Method 6 or 6C	Three 1-hr runs
Particulate (Filterable)	#/MMBTU	≤ 0.01	EPA Method 5	Three 1-hr runs

Preconditions and Notes:

1. Emissions guarantees are offered with one fabric filter compartment out of service
2. EPA Methods 1-4 shall be run in parallel with all other above specified EPA methods.
3. CEMS, if used, to be certified, by others.
4. No other guarantees, express or implied, are offered and are hereby disclaimed. All other performance data is provided for informational purposes only.
5. In the event after testing in accordance with agreed-upon testing procedures and subject to Owner's achievement of all preconditions, the Emissions Guarantees set forth above have not been met, Andritz shall promptly investigate the cause of the failure and perform modification to achieve the Emissions Guarantees. Owner agrees to provide Andritz reasonable access to the Equipment to allow diagnosing, modification and re-testing. Andritz shall only be required to demonstrate achievement of each of the Emissions Guarantees one time during a contractually proper test. After any subsequent failed performance test, Andritz shall take the necessary remedial (make good) actions to achieve the Emissions Guarantees, at Andritz's cost. This Section sets forth Andritz's total liability, and Owner's exclusive remedy, for failure to achieve the Emissions Guarantees.

6.7 SYSTEM PERFORMANCE VALUES

System Performance Values are estimated to be as follows (expected values only):

Parameter	Units	“MCR“ Operating Case
Hydrated Lime Consumption	#/hr	0
Pressure Drop, gross condition	Inch W.C.	15
Power Consumption	kW-hr/hr	175
By-product disposal rate (includes fly ash from boiler)	#/hr	2,798
Water consumption	gpm	17
Air Consumption	scfm	250 at 90 psig

6.8 WARRANTY

ANDRITZ offers a general warranty for Andritz supplied equipment. Please refer to Andritz’s attached standard terms and conditions for details.

7 PROPOSAL ATTACHMENTS

The following technical drawings and documents are attached in the appendix of this proposal:

1. Preliminary General Arrangement Drawings
2. Andritz AQCS Brochure
3. Andritz Standard Terms and Conditions

ANDRITZ COMMERCIAL PROPOSAL

8 PRICING

8.1 BASE BID PRICING (+/- 20%)

Andritz Inc. will design, supply, and deliver per the INCOTEMS specified in 8.3.3 below, one (1) DeSOx system as described in the referenced technical proposal for the sums listed below:

TOTAL Base Bid Price	\$8,475,000
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8.2 OPTIONAL FIELD SERVICES PRICE (+/- 20%)

Pending better definition of the project schedule and desired amount of training, etc. required by Stanley, at this time as an option an allowance of 9 man-months is quoted for all field services of all types (erection advisor, field engineer, training, test witnessing, etc.). This optional price is listed below:

Optional Price, 9 man-month field services	\$Incl. In Base Bid Price
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8.3 PRICE BASIS

8.3.1 CURRENCY AND ESCALATION

Price is quoted in US Dollars.

The following provisions apply, noting current uncertainty regarding COVID related impacts to the supply chain:

The quoted price in this proposal/order has been calculated based on the current market prices required to manufacture the quoted equipment and services pursuant to regulations, duties and law in effect as of the date of this proposal. The quoted price shall be subject to the following. "In the event that the introduction of new tariffs, levies, duties, taxes, regulations, or any type of legislation by a domestic or foreign government has the effect of increasing the price of the quoted equipment or services, Andritz reserves its right to adjust its quoted price in order to reflect these increases in cost. Nothing in this document, or in any of the applicable contractual documentation shall be construed as a waiver of this right."

The delivery dates and prices, including but not limited to freight prices, in this proposal do not account for the present and future cost and schedule impacts of the COVID-19 pandemic, including, but not limited to, those associated with resuming normal sourcing, manufacturing, and transportation. Notwithstanding anything in this proposal or any contract based hereon to the contrary, in the event that developments related to the pandemic, whether initiated prior to or after the date of this proposal, including but not limited to travel advisories, steps taken to protect the health and safety of employees, Government orders, delays or lack of availability of common carriers, and temporary facility shutdowns, increase the cost or time for delivery, Andritz shall be entitled to adjust the price and delivery dates herein to reflect these impacts. Nothing in this proposal or any contract based hereon shall be construed as a waiver of this right.

8.3.2 TAXES, DUTIES AND BUYER CREDIT RATING

Other than as required by the quoted INCOTERM, Supplier's prices do not include value added tax, customs or any other taxes, duties, levies and fees in the state or country of destination. Supplier's price includes customary payroll taxes only. Price assumes adequate creditworthiness of Buyer to ensure timely payments to Supplier.

8.3.3 TERMS OF DELIVERY AND DELIVERY TIME

The equipment shall be delivered "DDP jobsite" per the latest INCOTERMS. The Supplier shall commence its works – and thus the delivery time will commence – when the Customer's Purchase Order has been received and acknowledged by Supplier.

8.3.4 TERMS OF PAYMENT

Payment terms shall be net 30, conceptually cash neutral and mutually agreed upon.

8.3.5 VALIDITY OF THE PROPOSAL


This proposal, being budgetary, is not valid for acceptance.


8.3.6 TERMS AND CONDITIONS


Andritz's proposal is conditioned upon use of the attached "TERMS AND CONDITIONS OF SALE AND/OR SERVICE"


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Designation:		Status:		Rev1													
Customer:																	
Country:		USA															
The number of I/O's per typical are based on standard-typicals and have to be proofed by PURCHASER										Signal type: BUS = BUS I/O AO = Analog output DO = Digital output		AI = Analog input DI = Digital input					
ID-No.	Description Position	Functy	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
01 Flue Gas System PID Q-01-xxxxxx-141-0003-017-1301																	
1	01 Flue Gas System PID	AI	Analysis Raw Gas 2	Flue Gas Analyzer (HCl, H2O, CO, SO2) before Turboreactor	DCS	4		5									
2	01 Flue Gas System PID	CF	Cable Feeder	Cable Feeder Flue Gas Analyzer (HCl, H2O, CO, SO2) before Turboreactor	DCS	1											
3	01 Flue Gas System PID	CF	Cable Feeder	Cable Feeder Flue Gas Analyzer (HCl, H2O, CO, SO2) before Turboreactor	DCS	1											
7	01 Flue Gas System PID	FI	Flow	Flow after Fabric Filter	DCS			1									
8	01 Flue Gas System PID	TI	Temperature	Temperature after Fabric Filter	DCS			1									
9	01 Flue Gas System PID	PI	Pressure Safety	Pressure after Fabric Filter	DCS								1				
9_1	01 Flue Gas System PID	PI	Pressure Safety	Pressure after Fabric Filter	DCS								1				
9_2	01 Flue Gas System PID	PI	Pressure Safety	Pressure after Fabric Filter	DCS								1				
10	01 Flue Gas System PID	AI	Analysis Raw Gas 2	Flue Gas Analyzer (SO2, H2O, HCl) after Fabric Filter	DCS	4		5									
11	01 Flue Gas System PID	CF	Cable Feeder	Cable Feeder Flue Gas Analyzer (SO2, H2O, HCl) after Fabric Filter	DCS	1											
12	01 Flue Gas System PID	CF	Cable Feeder	Cable Feeder Flue Gas Analyzer (SO2, H2O, HCl) after Fabric Filter	DCS	1											
13	01 Flue Gas System PID	M	MCC - Automatic	Clean Gas Damper	DCS	6	2										
14	01 Flue Gas System PID	GS	Position Switch	Position Switch Clean Gas Damper Position OPEN	DCS	1											
15	01 Flue Gas System PID	GS	Position Switch	Position Switch Clean Gas Damper Position CLOSE	DCS	1											
16	01 Flue Gas System PID	M	MCC - Automatic	Raw Gas Damper	DCS	6	2										
17	01 Flue Gas System PID	GS	Position Switch	Position Switch Raw Gas Damper Position OPEN	DCS	1											
18	01 Flue Gas System PID	GS	Position Switch	Position Switch Raw Gas Damper Position CLOSE	DCS	1											
39	01 Flue Gas System PID	AI	Analysis CEMS	CEMS CO2 Measurement	DCS					1							
43	01 Flue Gas System PID	AI	Analysis CEMS	CEMS HCl Measurement	DCS					1							
44	01 Flue Gas System PID	AI	Analysis CEMS	CEMS O2 Measurement	DCS					1							
45	01 Flue Gas System PID	AI	Analysis CEMS	CEMS H2O Measurement	DCS					1							
46	01 Flue Gas System PID	AI	Analysis CEMS	CEMS CO Measurement	DCS					1							
47	01 Flue Gas System PID	AI	Analysis CEMS	CEMS SO2 Measurement	DCS					1							
48	01 Flue Gas System PID	AI	Analysis CEMS	CEMS Dust Measurement	DCS					1							
49	01 Flue Gas System PID	AI	Analysis CEMS	CEMS Flow Measurement	DCS					1							
50	01 Flue Gas System PID	AI	Analysis CEMS	CEMS Temperature Measurement	DCS					1							
51	01 Flue Gas System PID	AI	Analysis CEMS	CEMS Pressure Measurement	DCS					1							
52	01 Flue Gas System PID	AI	Analysis Emi-System	CEMS	DCS					20							


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FGC Plant		Rev1		FGC Plant													
USA																	
<div style="border: 1px solid red; padding: 2px; color: red; font-weight: bold;"> The number of I/O's per typical are based on standard-typicals and have to be proofed by PURCHASER </div>				Signal type: BUS = BUS I/O AI = Analog input AO = Analog output DI = Digital input DO = Digital output													
ID-No.	Description Position	Func'ty	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
53	01 Flue Gas System PID	CF	Cable Feeder	Cable Feeder Extractive Clean Gas Emission Monitoring System (normal)	DCS	1											
54	01 Flue Gas System PID	CF	Cable Feeder	Cable Feeder Extractive Clean Gas Emission Monitoring System (UPS)	DCS	1											
no of I/O's:						30	4	12		30			3				
01 Turboreactor PID Q-01-xxxxxx-141-0003-017-1305																	
55	01 Turboreactor PID	PI	Pressure	Pressure Raw Gas before Turboreactor	DCS			1									
55_1	01 Turboreactor PID	PI	Pressure	Pressure Raw Gas before Turboreactor	DCS			1									
57	01 Turboreactor PID	TI	Temperature	Temperature Raw Gas before Turboreactor	DCS			1									
58	01 Turboreactor PID	PI	Pressure	Pressure after Turboreactor	DCS			1									
58_1	01 Turboreactor PID	PI	Pressure	Pressure after Turboreactor	DCS			1									
60	01 Turboreactor PID	TI	Temperature	Temperature after Turboreactor	DCS			1									
60_1	01 Turboreactor PID	TI	Temperature	Temperature after Turboreactor	DCS			1									
61	01 Turboreactor PID	OS	Valve	Valve Service Air to Water Injection Lance	DCS	2	1										
61_1	01 Turboreactor PID	OS	Valve	Valve Service Air to Water Injection Lance	DCS	2	1										
63	01 Turboreactor PID	M	MCC - DOL	Air Fan to Water Injection Lance	DCS	2	1										
65	01 Turboreactor PID	M	MCC - DOL	Hydraulic Pump	DCS	2	1										
66	01 Turboreactor PID	M	MCC - DOL	Oil Tank Heater	DCS	2	1										
67	01 Turboreactor PID	LS	Level Switch	Level MIN Oil tank Hydraulic Station	DCS	1											
69	01 Turboreactor PID	TS	Temperature Switch	Temperature MAX Oil tank Hydraulic Station	DCS	1											
72	01 Turboreactor PID	HS	Hydraulic Valve	Hydraulic Station	DCS		1										
72_1	01 Turboreactor PID	HS	Hydraulic Valve	Hydraulic Station	DCS		1										
73	01 Turboreactor PID	GS	Position Switch	Position Hydraulic Cylinder Turboreactor Floor	DCS	1											
73_1	01 Turboreactor PID	GS	Position Switch	Position Hydraulic Cylinder Turboreactor Floor	DCS	1											
73_2	01 Turboreactor PID	GS	Position Switch	Position Hydraulic Cylinder Turboreactor Floor	DCS	1											
73_3	01 Turboreactor PID	GS	Position Switch	Position Hydraulic Cylinder Turboreactor Floor	DCS	1											
74	01 Turboreactor PID	GZ	E-Stop	E-Stop Byproduct Transport System	DCS						1						
75	01 Turboreactor PID	M	MCC - REV	Screw Conveyor	DCS	3	2										
76	01 Turboreactor PID	SS	Speed Switch	Speed MIN Screw Conveyor	DCS	1											
77	01 Turboreactor PID	HTR	TRACE HEATING Thermostat	Trace Heating Screw Conveyor	DCS	1											
78	01 Turboreactor PID	XS	Interface Motor Control Panel	Local Control Panel Screw Conveyor	DCS	2											
79	01 Turboreactor PID	HTR	TRACE HEATING Thermostat	Trace Heating Turboreactor	DCS	1											
79_1	01 Turboreactor PID	HTR	TRACE HEATING Thermostat	Trace Heating Turboreactor	DCS	1											


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Country:		USA																
<div style="border: 1px solid red; padding: 5px; color: red;"> The number of I/O's per typical are based on standard-typicals and have to be proofed by PURCHASER </div>								Signal type: BUS = BUS I/O AI = Analog input AO = Analog output DI = Digital input DO = Digital output										
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						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus			
79_2	01 Turboreactor PID	HTR	TRACE HEATING Thermostat	Trace Heating Turboreactor	DCS	1												
						no of I/O's:												
01 Fabric Filter PID Q-01-xxxxxx-141-0003-017-1308																		
80	01 Fabric Filter PID	LS	Level Switch	Level MAX Hopper Chamber 1	DCS	1												
81	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 1	DCS			1										
81_1	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 1	DCS			1										
82	01 Fabric Filter PID	HTR	TRACE HEATING Thermostat	Trace Heating Hopper Chamber 1	DCS	1												
83	01 Fabric Filter PID	OS	Valve	Raw Gas Damper Chamber 1	DCS	2	1											
84	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 1	DCS	2	1											
84_1	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 1	DCS	2	1											
84_2	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 1	DCS	2	1											
85	01 Fabric Filter PID	LS	Level Switch	Level MAX Hopper Chamber 2	DCS	1												
86	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 2	DCS			1										
86_1	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 2	DCS			1										
87	01 Fabric Filter PID	HTR	TRACE HEATING Thermostat	Trace Heating Hopper Chamber 2	DCS	1												
88	01 Fabric Filter PID	OS	Valve	Raw Gas Damper Chamber 2	DCS	2	1											
89	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 2	DCS	2	1											
89_1	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 2	DCS	2	1											
89_2	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 2	DCS	2	1											
90	01 Fabric Filter PID	LS	Level Switch	Level MAX Hopper Chamber 3	DCS	1												
91	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 3	DCS			1										
91_1	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 3	DCS			1										
92	01 Fabric Filter PID	HTR	TRACE HEATING Thermostat	Trace Heating Hopper Chamber 3	DCS	1												
93	01 Fabric Filter PID	OS	Valve	Raw Gas Damper Chamber 3	DCS	2	1											
94	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 3	DCS	2	1											
94_1	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 3	DCS	2	1											
94_2	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 3	DCS	2	1											
95	01 Fabric Filter PID	LS	Level Switch	Level MAX Hopper Chamber 4	DCS	1												
96	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 4	DCS			1										
96_1	01 Fabric Filter PID	TI	Temperature	Temperature Hopper Chamber 4	DCS			1										
97	01 Fabric Filter PID	HTR	TRACE HEATING Thermostat	Trace Heating Hopper Chamber 4	DCS	1												


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Customer:		USA															
<div style="border: 1px solid red; padding: 2px; color: red; font-weight: bold;"> The number of I/O's per typical are based on standard-typicals and have to be proofed by PURCHASER </div>								Signal type: BUS = BUS I/O AI = Analog input AO = Analog output DI = Digital input DO = Digital output									
ID-No.	Description Position	Func	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
98	01 Fabric Filter PID	OS	Valve	Raw Gas Damper Chamber 4	DCS	2	1										
99	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 4	DCS	2	1										
99_1	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 4	DCS	2	1										
99_2	01 Fabric Filter PID	OS	Valve	Clean Gas Damper Chamber 4	DCS	2	1										
100	01 Fabric Filter PID	POI	Difference Pressure	Diff Pressure Fabric Filter	DCS			1									
101	01 Fabric Filter PID	AI	Analysis Clean Gas	Dust Measurement after Fabric Filter	DCS	4		1									
102	01 Fabric Filter PID	CF	Cable Feeder	Cable Feeder Dust Measurement after Fabric Filter	DCS	1											
						no of I/O's: 45 16 10											
01 Fabric Filter Cleaning System PID Q-01-xxxxxx-141-0003-017-1309																	
103	01 Fabric Filter Cleaning System PID	PI	Pressure	Pressure Service Air to Fabric Filter Cleaning System	DCS			1									
105	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 1 to DCS	DCS	2	2										
105_1	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 1 to DCS	DCS	2	2										
105_2	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 1 to DCS	DCS	2	2										
106	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 1	DCS	1											
106_1	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 1	DCS	1											
106_2	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 1	DCS	1											
107	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_1	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_2	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_3	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_4	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_5	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_6	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_7	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_8	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_9	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_10	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_11	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_12	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_13	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_14	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										

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ID-No.	Description Position	Func'ty	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
107_15	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_16	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
107_17	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 1	BB Sequencer		1										
109	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 2 to DCS	DCS	2	2										
109_1	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 2 to DCS	DCS	2	2										
109_2	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 2 to DCS	DCS	2	2										
110	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 2	DCS	1											
110_1	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 2	DCS	1											
110_2	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 2	DCS	1											
111	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_1	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_2	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_3	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_4	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_5	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_6	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_7	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_8	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_9	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_10	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_11	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_12	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_13	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_14	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_15	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_16	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
111_17	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 2	BB Sequencer		1										
113	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 3 to DCS	DCS	2	2										
113_1	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 3 to DCS	DCS	2	2										
113_2	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 3 to DCS	DCS	2	2										

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ID-No.	Description Position	Func'ty	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
114	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 3	DCS	1											
114_1	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 3	DCS	1											
114_2	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 3	DCS	1											
115	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_1	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_2	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_3	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_4	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_5	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_6	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_7	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_8	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_9	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_10	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_11	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_12	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_13	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_14	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_15	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_16	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
115_17	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 3	BB Sequencer		1										
117	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 4 to DCS	DCS	2	2										
117_1	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 4 to DCS	DCS	2	2										
117_2	01 Fabric Filter Cleaning System PID	XS	Interface Fabric Filter Cleaning	Interface Sequencer Chamber 4 to DCS	DCS	2	2										
118	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 4	DCS	1											
118_1	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 4	DCS	1											
118_2	01 Fabric Filter Cleaning System PID	CF	Cable Feeder	Cable Feeder Sequencer Chamber 4	DCS	1											
119	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer		1										
119_1	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer		1										
119_2	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer		1										

Project:		Draw. No. Andritz:		Q-01-xxxxxx-141-8020-0003		Basic I/O - List											
Project No:		Date:		5/20/2022		for											
Designation:		Status:		Rev1		FGC Plant											
Customer:		Country:		USA													
<div style="border: 1px solid red; padding: 5px; color: red; font-weight: bold;"> The number of I/O's per typical are based on standard-typicals and have to be proofed by PURCHASER </div>						Signal type: BUS = BUS I/O AI = Analog input AO = Analog output DI = Digital input DO = Digital output											
ID-No.	Description Position	Func	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
119_3	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_4	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_5	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_6	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_7	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_8	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_9	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_10	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_11	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_12	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_13	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_14	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_15	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_16	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
119_17	01 Fabric Filter Cleaning System PID	OS	Valve 3	Cleaning Valve Chamber 4	BB Sequencer	1											
						no of I/Os:	36	96	1								
01Product Recirculation System PID Q-01-xxxxxx-141-0003-017-1311																	
120	01Product Recirculation System PID	M	MCC - DOL	Fluidization Air Blower 1	DCS	2	1										
122	01Product Recirculation System PID	M	MCC - DOL	Fluidization Air Blower 2	DCS	2	1										
124	01Product Recirculation System PID	PI	Pressure	Pressure Fluidization Air Distributer	DCS			1									
127	01Product Recirculation System PID	LS	Level Switch	Level MAX Recirculation Hopper	DCS	1											
128	01Product Recirculation System PID	LS	Level Switch	Level MIN Recirculation Hopper	DCS	1											
129	01Product Recirculation System PID	TI	Temperature	Temperature Product Recirculation Hopper	DCS			1									
129_1	01Product Recirculation System PID	TI	Temperature	Temperature Product Recirculation Hopper	DCS			1									
130	01Product Recirculation System PID	HTR	TRACE HEATING Thermostat	Trace Heating Product Recirculation Hopper	DCS	1											
130_1	01Product Recirculation System PID	HTR	TRACE HEATING Thermostat	Trace Heating Product Recirculation Hopper	DCS	1											
133	01Product Recirculation System PID	CV	Control Valve	Dosing Roller Recirculation Air Slide 1	DCS	2		1	1								
134	01Product Recirculation System PID	OS	Valve	Dosing Roller Recirculation Air Slide 1	DCS	2	1										
135	01Product Recirculation System PID	HTR	TRACE HEATING Thermostat	Trace Heating Recirculation Air Slide 1	DCS	1											
138	01Product Recirculation System PID	CV	Control Valve	Dosing Roller Recirculation Air Slide 2	DCS	2		1	1								
139	01Product Recirculation System PID	OS	Valve	Dosing Roller Recirculation Air Slide 2	DCS	2	1										

Project:	FGC Stanley	Draw. No. Andritz:	Q-01-xxxxxx-141-8020-0003		Basic I/O - List												
Project No.:	Q-01-xxxxxx-141	Date:	5/20/2022														
Designation:	FGC Plant	Status:	Rev1		for												
Customer:	USA			FGC Plant													
<div style="border: 1px solid red; padding: 2px; color: red; font-weight: bold;">The number of I/O's per typical are based on standard-typicals and have to be proofed by PURCHASER</div>					Signal type: BUS = BUS I/O AI = Analog input AO = Analog output DI = Digital input DO = Digital output												
ID-No.	Description Position	Func'ty	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
140	01Product Recirculation System PID	HTR	TRACE HEATING Thermostat	Trace Heating Recirculation Air Slide 2	DCS	1											
no of I/O's:						18	4	5	2								
01 Residue Transport System Turbo Reactor PID Q-01-xxxxxx-141-0003-017-1314																	
144	01 Residue Transport System Turbo Reactor PID	OS	Valve	Valve Service Air to Residue Crusher	DCS	2	1										
145	01 Residue Transport System Turbo Reactor PID	M	MCC - DOL	Residue Crusher	DCS	2	1										
146	01 Residue Transport System Turbo Reactor PID	EI	Current	Current Residue Crusher	DCS			1									
147	01 Residue Transport System Turbo Reactor PID	HTR	TRACE HEATING Thermostat	Trace Heating Residue Crusher	DCS	1											
148	01 Residue Transport System Turbo Reactor PID	SS	Speed Switch	Speed MN Residue Crusher	DCS	1											
149	01 Residue Transport System Turbo Reactor PID	OS	Valve	Valve Residue from Residue Crusher to Residue Pneumatic Conveyor	DCS	2	1										
no of I/O's:						8	3	1									
01 Residue Transport System Fabric Filter PID Q-01-xxxxxx-141-0003-017-1315																	
161	01 Residue Transport System Fabric Filter PID	OS	Valve	Dosing Valve Residue to Residue Pneumatic Conveyor	DCS	2	1										
162	01 Residue Transport System Fabric Filter PID	M	MCC - VSD	Rotary Feeder before Residue Pneumatic Conveyor	DCS	2	1	1									
163	01 Residue Transport System Fabric Filter PID	SIC	Speed	Speed Rotary Feeder before Residue Pneumatic Conveyor	DCS			1	1								
164	01 Residue Transport System Fabric Filter PID	SS	Speed Switch	Speed MN Rotary Feeder before Residue Pneumatic Conveyor	DCS	1											
no of I/O's:						5	2	2	1								
01 Process Water Tank Q-01-xxxxxx-141-0003-017-1355																	
245	01 Process Water Tank	GS	Position Switch	Position OPEN Flap before Process Water Pump 1	DCS	1											
246	01 Process Water Tank	M	MCC - DOL	Process Water Pump 1	DCS	2	1										
247	01 Process Water Tank	GS	Position Switch	Position OPEN Flap before Process Water Pump 2	DCS	1											
248	01 Process Water Tank	M	MCC - DOL	Process Water Pump 2	DCS	2	1										
249	01 Process Water Tank	FI	Flow	Flow Process Water to Turbo Reactor	DCS			1									
250	01 Process Water Tank	PI	Pressure	Pressure Process Water to Turbo Reactor	DCS			1									
252	01 Process Water Tank	OS	Valve	Discharge Valve after Process Water Pump 1-2	DCS	2	1										
253	01 Process Water Tank	CV	Control Valve	Control Valve Process Water from Turboreactor	DCS	2		1	1								
254	01 Process Water Tank	FI	Flow	Flow Process Water from Turboreactor	DCS			1									
256	01 Process Water Tank	HTR	TRACE HEATING Thermostat	Trace heating Process Water Pipe	DCS	1											
256_1	01 Process Water Tank	HTR	TRACE HEATING Thermostat	Trace heating Process Water Pipe	DCS	1											
no of I/O's:						12	3	4	1								
01 Instrument and Service Air Distribution Q-01-xxxxxx-141-0003-017-1361																	
257	01 Instrument and Service Air Distribution	PI	Pressure	Pressure after Instrument Air Receiver	DCS			1									

Project:	FGC Stanley	Draw. No. Andritz:	Q-01-xxxxxx-141-8020-0003	Basic I/O - List													
Project No:	Q-01-xxxxxx-141	Date:	5/20/2022														
Designation:	FGC Plant	Status:	Rev1	for													
Customer:				FGC Plant													
Country:	USA																
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ID-No.	Description Position	Funct	Description Function	Description Loop	processed by	Control System					Safety PLC					Remark	Rev
						DI	DO	AI	AO	Bus	DI	DO	AI	AO	Bus		
259	01 Instrument and Service Air Distribution	PI	Pressure	Pressure after Service Air Receiver	DCS			1									
					no of I/O's:			2									
					total no of I/O's:	180	137	44	4	30	1		3				
I/O-Summary of Control Systems:																	
DCS		FGC Plant Control System				180	65	44	4	30	1		3				Spare I/O's according contract have to be added!
BB Sequencer		Fabric Filter Cleaning Sequencer Card					72										
BB Filter Cleaning		Black Box Silo Dedusting Filter Cleaning															
Rev:	Rev. Date	Created:	Checked:	Description of Revision	Creation Date:	5/20/2022											
					Created:	Fahrberger											
					Checked:	Schloegl											

B&W CDS

Jahn, Mario

From: Pon, Ronald T <rtpon@babcock.com>
Sent: Wednesday, February 9, 2022 11:50 PM
To: Fritz, Mark
Cc: Solan, John; Frances Isgrigg; Walukiewicz, Henry D; Mitchell, Joseph M; Perkins, Sharon D
Subject: RE: AQCS Cost Estimate for UAF

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mark,

Sorry for the delay in getting back to you as I've been on the road this week.

The pricing for the engineering review is based on simultaneous evaluation each of the four technologies at 40 hours for each evaluation along with an additional 15 hours for project management and report writing. The Hourly Rate for the engineering to support this effort averages to \$200 per hour.

Best regards,
Ron



Ronald Pon
Account Manager
Email: rtpon@babcock.com
Desk: 707.265.1055
Mobile: 925.451.4272
FAX: 707.265.1000
710 Airpark Road
Napa, CA 94558
www.babcock.com • NYSE BW
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TARGET ZERO - To finish each and every day injury- and incident-free

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Thursday, February 3, 2022 7:24 AM
To: Pon, Ronald T <rtpon@babcock.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>; Frances Isgrigg <fisgrigg@alaska.edu>
Subject: EXTERNAL: RE: AQCS Cost Estimate for UAF

Ron,

Can you provide a breakdown of your costs and make the attached SOW part of the proposal?

Mark

From: Pon, Ronald T <rtpon@babcock.com>
Sent: Tuesday, February 1, 2022 10:25 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>; Hensel, Ryan D <rdhensel@babcock.com>; Mitchell, Joseph M <JMMitchell@babcock.com>; Perkins, Sharon D <sdperkins@babcock.com>
Subject: RE: AQCS Cost Estimate for UAF

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mark,

The Babcock & Wilcox Company (B&W) is pleased to offer Proposal P-082524 to perform an engineering review of the available SO₂ control technologies (Wet Flue Gas Desulfurization (WFGD), Circulating Dry Scrubber (CDS), Spray Dry Absorbers (SDA), and Dry Sorbent Injection (DSI)) for the University of Alaska Fairbanks (UAF). The study will consist of finding a similarly sized application in B&W's experience for each technology to provide high level values for expected pricing and performance.

Due to the criticality of this request and quick turnaround, B&W respectfully requests that a PO be issued as quickly as possible if this is something that Stanley and UAF would like to proceed.

Please feel free to contact me with any questions or comments.

Best regards,
Ron



Ronald Pon
Account Manager
Email: rtpon@babcock.com
Desk: 707.265.1055
Mobile: 925.451.4272
FAX: 707.265.1000
710 Airpark Road
Napa, CA 94558
www.babcock.com • NYSE BW
Follow Us on Social Media

TARGET ZERO - To finish each and every day injury- and incident-free

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, January 26, 2022 12:01 PM
To: Pon, Ronald T <rtpon@babcock.com>
Cc: Hensel, Ryan D <rdhensel@babcock.com>; Mitchell, Joseph M <JMMitchell@babcock.com>
Subject: EXTERNAL: RE: AQCS Cost Estimate for UAF

Ron,

Yes, the proposed time will work for me.

Mark

From: Pon, Ronald T <rtpon@babcock.com>
Sent: Wednesday, January 26, 2022 1:50 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Hensel, Ryan D <rdhensel@babcock.com>; Mitchell, Joseph M <JMMitchell@babcock.com>
Subject: Re: AQCS Cost Estimate for UAF

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mark

Sorry for the delay in getting back to you

Would you be available to do a call Friday at 7 am, PDT / 8 am, MDT / 9 am, CDT / 10 am, EDT

Ron

Get [Outlook for iOS](#)

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Thursday, January 13, 2022 7:34:17 AM
To: Pon, Ronald T <rtpon@babcock.com>
Subject: EXTERNAL: RE: AQCS Cost Estimate for UAF

Ron,

I have simplified our requested information. Please call to discuss or let me know when you are available to discuss.

Mark

From: Fritz, Mark
Sent: Wednesday, January 5, 2022 9:38 AM
To: Pon, Ronald T (rtpon@babcock.com) <rtpon@babcock.com>
Subject: AQCS Cost Estimate for UAF

Ron,

See attached for the preliminary scope of work to support our cost estimating work for UAF CHPP. Please call to discuss.

I have left the schedule blank for now. We can discuss after you get a chance to review the scope of work.

My current schedule for this week

Today – Open except 1:00 – 2:00 PM CST

Thursday - open

Friday - PM is open.

Mark



Mark Fritz, Principal Mechanical Engineer

STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657

T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

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February 1, 2022

Attn: Mr. Mark Fritz, Principal Mechanical Engineer
Stanley Consultants

Subj: UAF SO₂ Control Evaluation Study

Dear Mark,

The Babcock & Wilcox Company (B&W) is pleased to offer Proposal P-082524 to perform an engineering review of the available SO₂ control technologies (Wet Flue Gas Desulfurization (WFGD), Circulating Dry Scrubber (CDS), Spray Dry Absorbers (SDA), and Dry Sorbent Injection (DSI)) for the University of Alaska Fairbanks (UAF). The study will consist of finding a similarly sized application in B&W's experience for each technology to provide high level values for expected pricing and performance. The results of the study will be presented as a summary of findings report, and this report will include the following information for each technology option:

- Typical achievable removal efficiencies
- Budgetary pricing for material scope only, which will be defined for each technology
- Approximate size of enclosure for equipment
- Evaluation of existing baghouse for each technology
- Typical impacts to liquid or solid waste (including typical composition of waste stream for WFGD option) and fly ash (byproduct)
- Typical utility consumptions
 - Power
 - Reagent consumption rates
 - Water
 - Air
 - Expected equipment pressure drop

SCHEDULE:

It is anticipated that the summary of findings report will be provided 2 weeks after acceptance of a purchase order

PRICING:

The above scope can be provided for a firm price of \$40,000.

VALIDITY, PAYMENT & TERMS:

This proposal is open for acceptance for 7 days from the letterhead date. Invoices would be due Net 30 days. Invoices would be issued based on 100% on Receipt of an Order

Any contract would be according to the attached B&W standard terms for engineering studies

We appreciate this opportunity and if I can be of further assistance please do not hesitate to contact me via phone at (707) 265-1055 or via email at rtpon@babcock.com.

Sincerely,

Ronald Pon
Account Manager
The Babcock & Wilcox Company

Cc: J. Solan – Stanley
R. D. Hensel – B&W, Akron
S. D. Perkins – B&W, Akron

Babcock Power CDS

EXAMPLE PROPOSAL

TO:

Stanley Group

FOR:

Circulating Dry Scrubber

AT:

**University of Alaska
Fairbanks**

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7.0 PROJECT SCHEDULE ERROR! BOOKMARK NOT DEFINED.

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9.0 APPENDICES..... ERROR! BOOKMARK NOT DEFINED.

 9.1 CIRCULATING DRY SCRUBBER SELLER DATA SHEETS 1 – 7 **ERROR! BOOKMARK NOT DEFINED.**

 9.2 DRY FLUE GAS DESULFURIZATION SYSTEM - EXTENT OF FABRICATION & SHOP ASSEMBLY - 07-05-17 **ERROR! BOOKMARK NOT DEFINED.**

 9.3 PRELIMINARY GENERAL ARRANGEMENT DRAWING **ERROR! BOOKMARK NOT DEFINED.**

 9.4 PRELIMINARY PROCESS FLOW AND PIPING AND INSTRUMENTATION DIAGRAMS **ERROR! BOOKMARK NOT DEFINED.**

 9.5 MATERIAL BALANCE **ERROR! BOOKMARK NOT DEFINED.**

 9.6 PRELIMINARY LOAD LIST **ERROR! BOOKMARK NOT DEFINED.**

 9.7 GUARANTEES AND CORRECTION CURVES **ERROR! BOOKMARK NOT DEFINED.**

 9.8 PRELIMINARY SCHEDULE..... **ERROR! BOOKMARK NOT DEFINED.**

 9.9 ISO 9001-2008 CERTIFICATE **ERROR! BOOKMARK NOT DEFINED.**

 9.10 QSM-1.001 REV 13, QUALITY SYSTEM MANUAL **ERROR! BOOKMARK NOT DEFINED.**

 9.11 BABCOCK POWER ENVIRONMENTAL TECHNICAL CLARIFICATIONS AND EXCEPTIONS 07-07-17.....**ERROR! BOOKMARK NOT DEFINED.**

 9.12 RILEY POWER FY 2017 PER DIEM RATE SHEET..... **ERROR! BOOKMARK NOT DEFINED.**

 9.13 PROJECT MEMBER RESUME **ERROR! BOOKMARK NOT DEFINED.**

 9.14 PRO-SOP-106-F06-PURCHASE AGREEMENT 2017 SUBCONTRACT (RPI REDLINE 7-7-17)**ERROR! BOOKMARK NOT DEFINED.**

 9.15 RFP 7863-011102 - (DFGD SYSTEM) - RESPONSE PACKAGE BPE FILL-IN 07-07-17 **ERROR! BOOKMARK NOT DEFINED.**

 9.16 MILESTONE PAYMENT SCHEDULE **ERROR! BOOKMARK NOT DEFINED.**

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1.0 EXECUTIVE SUMMARY

Babcock Power Environmental Inc. (BPE), an ISO 9001 certified full-service OEM for complete environmental systems, is pleased to offer to Stanley Group an example proposal for a Circulating Dry Scrubber (CDS) for University of Alaska Fairbanks. Our offering provides Stanley Group with indicative, example scope and pricing representative of this type of system for a unit of similar size. This proposal was not generated specifically for Stanley Group or the University of Alaska Fairbanks boiler and should not be considered an offer to provide material or perform services.

With our superior environmental equipment technology, technical expertise and demonstrated project execution capabilities, BPE provides optimum technical solutions to the utility and industrial markets. These solutions address both current and potential future emission regulations and are competitive from both a capital and operational cost perspective.

BPE Experience

BPE is a leading supplier of Air Quality Control System technology, equipment, and services, with more than 30 Wet and Dry FGD systems in operation on utility and industrial applications throughout the US. This extensive operating base promotes confidence in our process design, reliability, and the ultimate performance of our systems.

BPE offers the most advanced Circulating Dry Scrubber (CDS) available in the world and strongly believes that this technology is the clear choice for this project. Our offering is in compliance with your specifications.

BPE has internally developed our own high-level technology and competency through the design, construction and commissioning of multiple CDS installations in the U.S. In addition, BPE has extensively modeled the behavior of fluid beds utilized in all CDS technologies. These are physical models which include gas and solids, and the information obtained correlates directly with field observations. This modeling effort has identified several key factors allowing us to develop and offer an advanced CDS design.

BPE has the experience to ensure your installed system meets the specified emissions levels while optimizing hydrated lime stoichiometry, system pressure drop and electrical power consumption.

The Best Technology

Key technical differentiators and advantages of BPE CDS systems are:

- Ash recirculation above the venturi as opposed to below. This results in consistent performance and greatly reduced maintenance.
- Lower lime consumption compared to other dry scrubber technologies
- Generates less byproduct for disposal
- Single venturi design to minimize pressure drop, resulting in reduced power consumption.
- Minimal moving parts compared to other designs, resulting again in greatly reduced maintenance.
- Simple process control philosophy allowing stable operation with minimal operator intervention.
- Equipment arrangements, similar on all three units that can be used to optimize engineering, spare parts, and maintenance costs.

- Work with SEFA to design common equipment such as baghouse and fans utilizing the same vendors and design considerations to optimize pricing and minimize spare part requirements.

Guaranteed Performance and High Reliability

BPE is fully confident that our system will achieve high removal and reliability levels. All our Air Quality Control Systems (AQCS) have met or exceeded all specified performance and reliability guarantees.

The design of the BPE CDS is based on extensive experience acquired over many years of field operation on utility-grade installations. The process is inherently simple with, thus contributing to its high reliability and low operating and maintenance costs.

Constructability

BPE has designed our system to provide an optimum level of modularization, balancing shop and field fabrication costs, shipping and logistics and schedule to minimize overall installed cost.

The Babcock Power Environmental Team

Low Overall Evaluated Life Cycle Cost: BPE's advanced CDS system provides the maximum benefit by achieving the minimum total evaluated life cycle cost. The benefits are the result of our CDS system's low pressure drop, stoichiometry and power consumption.

Successful CDS Experience: BPE is well experienced in the successful design, supply, start-up and performance of CDS projects, with 10 years successful operation on CDS reactors and fabric filter installations in the US (See Table 1.)

Experienced in Environmental Projects: BPE has completed many complex environmental programs with other major U.S. utility clients, on time, with high quality and achieving all performance guarantees. We have the technical knowledge, engineering expertise, project management team experience and construction expertise to successfully execute programs of this scope and complexity.

Financial Strength: BPE has developed and maintained solid financial strength through its diverse lines of products and services for the U.S. utility and industrial markets. BPE has more than adequate resources to complete this project on time and within budget, while meeting all contract requirements.

Summary

BPE, as a leading supplier of AQC systems, has successfully executed many complex, multi-unit, multi-site projects. Based on this experience, we have developed a project execution plan utilizing a highly experienced and capable team for this project. BPE will provide the greatest certainty of success by providing superior technology, solid financial security, and strong, comprehensive project execution capabilities.

Table 1- 1 Hours of CDS operation

Plant	Greenidge	Westover	Mt. Tom	Deerhaven	Nearman
2007	7,789	-	-	-	
2008	8,447	1,316	-	-	
2009	6,037	4,214	1,092	5,778	
2010	8,303	4,414	5,260	7,794	
2011	1,757	236	1,179	6,715	
2012	-	-	1,785	7,429	
2013	-	-	1,297	5,925	
2014	-	-	-	6,510	
2015	-	-	-	6,517	
2016				6,368	
2017					2,009
Total	32,332	10,180	10,613	53,036	2,009

2.0 PRICING PREAMBLE

The below pricing is indicative of what a similar sized unit cost in 2017 dollars. No escalation/inflation has been taken into account. This pricing is for design and supply only.

\$7,500,000.00

Scope

As described in section 3.0 of this proposal.

Taxes

The prices shown do not include taxes

Pricing Validity

None.

Site Services

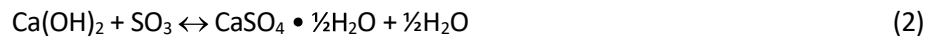
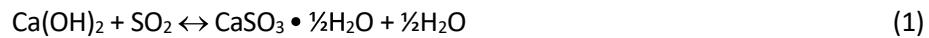
Site Services for Technical Representative, Commissioning, Start-Up and Optimization, and Technical Training are included with this offer. Site services additional to this offer are available on a per diem basis.

3.0 BPE CDS Design and Technology

3.1 Process Description

3.1.1 BPE's Circulating Dry Scrubber

A CDS removes the acid gas constituents of flue gas, primarily SO₂ but also SO₃, HCl, and HF by reacting the acid gases with hydrated lime, Ca(OH)₂. The CDS reactions are as follows:



Equation (4) has little effect on flue gas CO₂ concentration but does consume a portion of the hydrated lime making it unavailable for the other reactions. The CDS system also removes a high percentage of mercury in the flue gas.

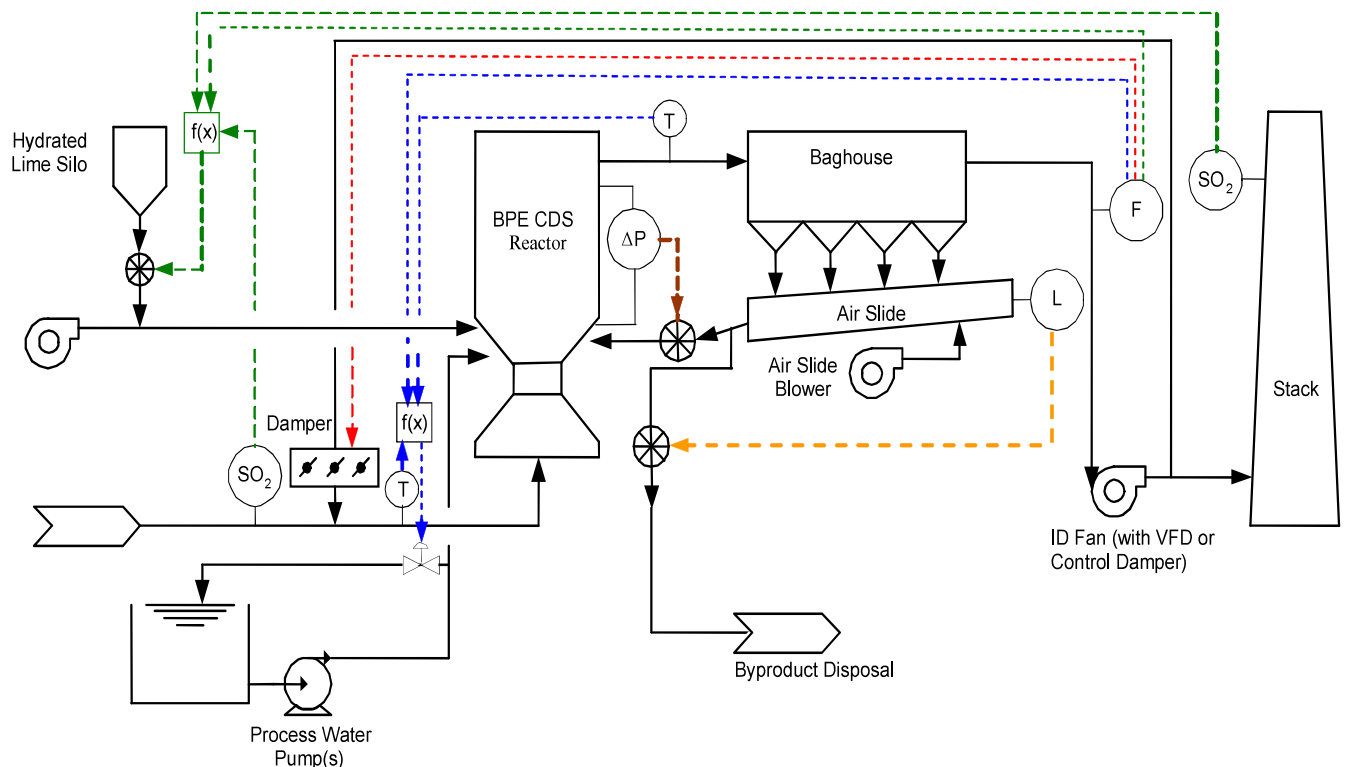


Figure 3-1 CDS Process Overview

The system includes a CDS reactor where hydrated lime and water are injected. The injected water brings the flue gas closer to the saturation temperature where SO₂ absorption is most effective. The CDS byproduct,

which is a mixture of fly ash, unreacted lime, and CaSO_3 , CaSO_4 , CaCO_3 , CaCl_2 and CaF_2 , exits the reactor, and it is removed from the flue gas with a fabric filter. The byproduct removed by the fabric filter is cycled back to the reactor at a high rate through air slides.

The byproduct circulation flow establishes a fluidized bed in the CDS reactor. The fluidized bed provides a high contact time with flue gas to minimize unreacted lime in the system. The fabric filter removes the byproduct to meet the particulate emission requirement as the flue gas exits the stack. The clean flue gas from the CDS is directed to the stack through an Induced Draft fan. The CDS system pressure is negative because of the ID fan. The system includes a duct from the positive discharge of the ID fans to the negative pressure inlet of the CDS. When the boiler operates at low load, a damper in the duct opens to recirculate enough flue gas to maintain a minimum flue gas velocity required for the fluidized bed in the CDS reactor.

At the inlet of the CDS reactor, the flue gas passes through a horizontal duct and takes a 90° vertical turn. Turning vanes may be included in the bend to keep flyash from dropping out. Any solids that may fall out from upsets or shut downs, fall into the reactor bottom hopper and removed.

Once flowing in the vertical direction, the flue gas passes through a venturi. The venturi accelerates the flue gas just as water and fresh hydrated lime are injected. The venturi creates the fluidized bed from byproduct circulated from the fabric filter and injected fresh hydrated lime and water. It assures maximum contact between SO_2 and the acid gases in the flue gas and the hydrated lime and byproduct. Furthermore, the reactor is shaped so that the byproduct flows up through the center and down the sides to create a reflux of byproduct with the flue gas, providing more mixing and contact time.

The water is injected through one or more lances in the reactor. A fine water spray is provided either by “spill-back nozzles” using a high-pressure pump or air atomization. The rate of water injected into the CDS reactor controls the reactor temperature by throttling a needle valve.

In a dry scrubber, high SO_2 removal is achieved when the injected water decreases the inlet flue gas temperature to an optimum operating temperature that keeps the circulating solids dry and minimizes hydrated lime consumption. The temperature is above the adiabatic saturation temperature of the flue gas. The adiabatic saturation temperature depends on the inlet temperature and moisture content of the flue gas. The optimum operating temperature depends on the sulfur and chlorine content of the fuel. The difference between the operating temperature and adiabatic saturation temperature is called the approach temperature. A safe approach temperature is above 30°F. The flue gas temperature decrease is called the spray down temperature. A spray down temperature of at least 65°F is considered necessary for effective SO_2 removal.

The CDS water injection system keeps the operating temperature of the CDS safely above the adiabatic saturation temperature of the flue gas. By operating at a safe approach temperature, the CDS solids, walls and materials stay dry. The CDS is made from mild steel instead of corrosion resistant materials that are necessary when operating wet at saturation temperature.

The CDS can fully scrub the SO_2 and other acid gases out of the flue gas when the inlet temperature is high enough to provide a good spray down to inject water. During system startup, when the inlet temperature is low (230°F to 300°F), it is possible to circulate dry solids in the CDS with little or no water to mitigate SO_3 and other acid gas emissions.

As the SO₂ and acid gases are removed from the flue gas, the byproduct accumulates in the system. The byproduct inventory in the CDS is maintained by intermittently removing the byproduct from the solids recycle stream with the byproduct removal system. The byproduct is then removed or transported to a byproduct disposal system.

There are five major process variables controlled in a CDS process. These controls are primarily feed-forward with feedback trims to minimize response time and swings especially during unit load and coal changes. These process variables include:

- Water injection rate - Calculated using the reactor inlet temperature and flue gas flow measurement to maintain an outlet temperature control set point. The actual outlet temperature trims the water injection rate. Controlling the outlet temperature precisely while maintaining a fine droplet spray allows the user to operate the system at reduced temperatures optimizing the acid gas removal and lime addition. The temperature is set with sufficient safety margin to avoid corrosion from acid gas condensation. Feed forward control provides a tight reactor temperature even with rapid changes in flue gas flow or inlet temperature.
- Lime injection rate – Calculated using inlet reactor SO₂ and flue gas flow and outlet SO₂ control set point. The actual outlet SO₂ concentration trims the lime injection rate. Maintaining outlet SO₂ concentration during normal flue gas flow swings and changes in flue gas quality allows the user to operate the system closer to the required emission rate to minimize lime consumption.
- Byproduct re-circulation rate – Adjusted using reactor inlet and outlet pressure and outlet flue gas flow measurements to maintain a reactor bed pressure drop. There is a bias adjustment between two returns to the reactor to maintain even air slide levels under the fabric filter. Byproduct re-circulation maximizes the contact with flue gas improving lime utilization.
- Byproduct disposal rate – Adjusted to keep a set point air slide level, measured by pressure of the air slide aeration air.
- Flue gas re-circulation rate – Adjusted using the fabric filter outlet flue gas flow measurement.

3.1.2 Hydrated Lime Preparation and Injection

Hydrated lime for a CDS is delivered by truck directly to a hydrated lime silo. Based on CDS chemistry demand, a speed-controlled rotary vane feeder controls the flow of hydrated lime from the hydrated lime silo as it is pneumatically injected by an air blower into the CDS reactor. The hydrated lime control loop controls the SO₂ flue gas concentration at the outlet of the CDS. The loop is a feed forward PID controller, which calculates the hydrated lime demand of the reactor based on the difference between the inlet SO₂ concentration and the outlet SO₂ concentration set point and the flue gas flow rate. The hydrated lime demand is adjusted with a feedback controller based on the difference between the outlet SO₂ concentration and set point.

3.1.3 Water Injection

The injection of water and subsequent cooling of the flue gas set the optimum operating conditions for the reaction of the acid gas pollutants with the basic hydrated lime particles. The temperature of the flue gas is reduced, and the flue gas humidity is increased in the reactor. Additionally, the water rewets the byproduct when it circulates back to the reactor. As shown in Figure 3-2, the water creates new reactive surfaces in the byproduct solid particles.

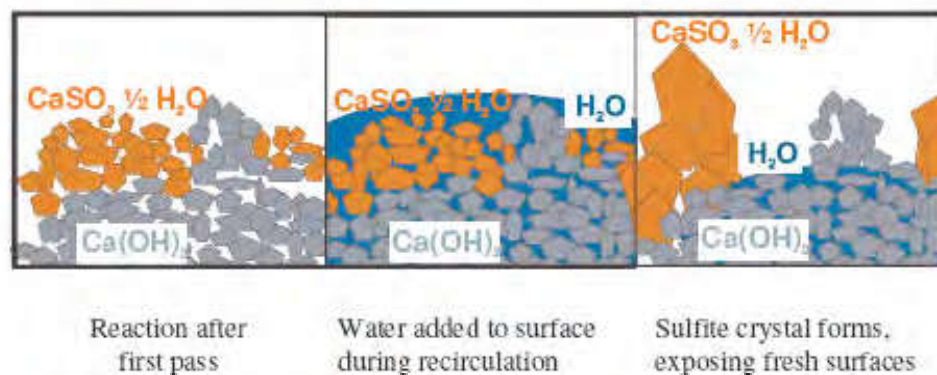


Figure 3-2 Mechanism for the Reactivation of Recirculated Sorbent

Each reactor water lance includes either a high-pressure spill back nozzle or an air atomized nozzle to produce a fine water spray. The lances are positioned in the reactor at a penetration that keeps the spray away from the reactor walls. A layer of air called barrier air is also introduced around the lance to protect the lance. The barrier air is usually ambient air flowing from negative pressure in the CDS reactor through an annular tube.

The water flow control loop controls the reactor outlet flue gas temperature set point by controlling the water supply or return valve. The loop is a feed forward PID controller, which calculates the water demand based on reactor inlet temperature and flue gas flow measurements and an outlet temperature control set point. The water demand is adjusted with a feedback controller based on the difference between the outlet temperature and set point.

If the reactor temperature decreases too close to the adiabatic saturation temperature of the flue gas, then the byproduct circulation and disposal can be difficult to control. Reduced temperatures can also cause corrosion. The water injection rate is maintained to keep the reactor outlet temperature at an approach temperature that provides the lowest hydrated lime consumption without byproduct flow interruptions or corrosion in the reactor.

3.1.4 Particulate Removal – Pulse Jet Fabric Filter

As part of the CDS, the Pulse Jet Fabric Filter (PJFF) removes the circulating byproduct from the flue gas before it exits the stack. The particulate forms a layer on the outside of the filter bags that both aids in filtration and enhances SO₂ and Hg removal. A constant fabric filter pressure drop maintains removal of the circulating byproduct. The pressure drop is maintained by cleaning the bags with compressed air. A pulse of compressed or cleaning air cleans the bags in a sequence until the fabric filter pressure drop returns to set point. The cleaning air pulse knocks the cake of byproduct off the filter bags. The byproduct falls to a hopper below each compartment. The hoppers include startup heaters and vibrators to enhance byproduct flow from the hoppers to the air slides below.

The bags are arranged in compartments. Each fabric filter compartment includes inlet and outlet dampers or poppets. The dampers isolate a compartment to allow maintenance while the CDS operates (on-line maintenance). The fabric filter may include bypass poppets or dampers that are normally closed. During severe upset conditions (for example, a flue gas temperature excursion), the fabric filter is bypassed by opening the bypass dampers.

The fabric filter cleaning air is supplied by a compressor, blower or plant instrument air. If cleaned by compressed air then sufficient drying is required to maintain dry bags. Compressed air is also used for the inlet and outlet dampers and instrumentation. Cleaning proceeds by cycling solenoid valves to pulse each of the bags according to a sequence. The sequence starts when the fabric filter pressure drop is above a set point and ceases when it is below set point. The sequence frequency may change according to flue gas flow to ensure that there is a constant cake layer on the bags.

A multi-point pitot tube device measures the CDS flue gas flow rate. It includes pitot tube static pressure, pitot tube differential pressure, and temperature measurements. It is kept clean by intermittent compressed air. The device is installed in the outlet duct of the fabric filter where the flue gas is clean. There may be several devices depending upon the size of the outlet duct.

3.1.5 Byproduct Circulation

A large flow of byproduct collected by the fabric filter circulates back to the reactor by air slides located below two rows of fabric filter hoppers. Each air slide consists of a sloped wall and closed-top chute that includes an air plenum along the bottom. Air slide aeration blower provides air to the plenum, and the air fluidizes the solids through a thick fabric material permitting the solids to flow by gravity to the reactor.

A dosage roller on each air slide controls the byproduct flow through the air slide. The roller, or flow control gate, is a quarter-turn valve similar to a plug valve. There are two control loops that control the byproduct flow to the reactor. One loop sets a dosage roller position that establishes a fluidized bed pressure drop in the CDS reactor. The fluidized bed pressure drop is measured by the difference between the reactor inlet and outlet static pressures and subtracting the pressure drop due to flue gas flow alone. The second control loop biases the dosing valves to keep the byproduct levels in each air slide the same.

3.1.6 Byproduct Removal

The byproduct generated from the CDS is removed from the air slides by a removal control loop that keeps the air slide levels at a set point. Each air slide includes a byproduct removal train that includes a variable speed rotary feeder to remove the solids and a waste storage silo. The freeboard in the air slides provides capacity for downstream interruptions. The byproduct removal feeder is sized to remove a full flow of byproduct. Byproduct is also removed from the hoppers at the bottom of the CDS reactor in the event of an upset.

3.1.7 Flue Gas Recirculation

To maintain a fluidized bed in the CDS reactors at low loads, a portion of the flue gas stream downstream of the ID fan recirculates to the inlet duct of the CDS reactor through the flue gas recirculation (FGR) duct. A modulating damper at the entrance to the CDS inlet duct modulates the flue gas recirculation rate according to a control loop that keeps the fabric filter outlet flue gas flow above a minimum set point throughout a range of inlet flows. The modulating damper responds immediately and smoothly to flow changes to maintain the CDS throughout a large range of flow.

3.2 Design Features

There are several design features of BPE's CDS that provide superior performance and reliability compared to other types of dry scrubbers. These features include injecting water and hydrated lime separately in the reactor to allow precise approach temperature control avoiding corrosion, simple and precise control of

byproduct circulation to maximize lime utilization, and low venturi velocities and well-designed turning vanes to avoid erosion and minimize pressure drop.

3.2.1 Approach Temperature Control

A precise control of the reactor outlet temperature is maintained by injecting water separately from hydrated lime. This separation has two advantages. First, the approach temperature can be reliably maintained at a value that avoids corrosion, scaling, or solids build up in the reactor. The optimum approach temperature depends on the SO₂ and HCl content of the flue gas. The set point can be controlled based on fuel data or dew point measurements. Maintaining the optimum approach temperature maximizes the SO₂ removed from the flue gas. Second, lime input is not restricted by the spraydown available as is the case with Spray Dryer Absorbers with their rotating atomizers which are prone to pluggage. There are also no limits from mixing or reactions needed to internally produce hydrated lime as in other scrubbers.

3.2.2 Byproduct Circulation and Removal Control

The byproduct collected in the fabric filter system contains a small fraction of un-reacted lime that is utilized when solids are circulated back to the CDS. Air slides are simple devices that can achieve high flow rates of byproduct circulation from the fabric filter hoppers to the reactor while reducing overall parasitic load consumption. Once the byproduct is fluidized, the motive force is simply gravity, compared to blowers or conveyors to move the byproduct from a low elevation to a higher elevation as in other solids recycle systems. The dosing valves modulate the opening in the air slides to precisely control the byproduct circulation rate to establish a fluidized bed in the reactor.

Byproduct that is not recirculated back to the reactor is removed by gravity through vertical variable speed rotary feeders. The air slides include startup heaters to heat the walls before starting circulation and removal. While operating, the reactor temperature control keeps the solids warm and dry to avoid flow interruptions or plugging in the air slides.

3.2.3 Erosion Control

The highest flue gas velocity in the CDS reactor is through a venturi that forms the fluidized bed in the reactor. Erosion depends on the cube of velocity. BPE circulates byproduct ABOVE the venturi to avoid erosion from the high rate of byproduct circulation. The reactor inlet includes turning vanes to straighten the flow and ensure even distribution of flow through the venturi. Any dust flow path is straight through the venturi rather than oblique to it thus minimizing erosion. The reactor outlet and fabric filter inlet are at lower velocity than the venturis, but these ducts carry a large flow of circulated byproduct. Therefore, the ducts may also include turning vanes and plates to ensure straight and even distribution through the inlet plenum and into the compartments of the fabric filter. The turning vanes in the reactor and fabric filter inlets minimize both erosion and pressure drop. Computational Fluid Dynamic models of the flue gas flow in the reactor and fabric filter inlets are completed to design the flow straightening devices.

3.2.4 Corrosion Control

No corrosion control is necessary other than maintaining good operating conditions and properly designing and installing thermal insulation to avoid acid gas condensation in the reactor and fabric filter.

3.2.5 Mercury Control

The CDS system removes a large fraction of mercury without any additional sorbent injection. A Powdered Activated Carbon (PAC) sorbent injection system can be added to the CDS to enhance mercury removal. The CDS removes a large fraction of SO₃ that otherwise would interfere with PAC mercury absorption and the

reactor fluidized bed allows PAC to fully contact with flue gas. Therefore, a PAC system works well together with a CDS, providing a complete mercury removal system.

3.3 Startup, Operation, and Shutdown

The startup, operating, and shutdown procedures described here provide an overview of the detailed procedures for a CDS. Consult BPE CDS operating and maintenance procedures for specific and complete information.

3.3.1 Flue Gas Path

There is no bypass around the CDS System. Therefore, flue gas passes through the CDS whenever the system operates. As long as the fabric filter bypass dampers are closed and the cleaning cycles for the fabric filters are active, boiler particulate is removed to its emission level. The CDS removes SO_2 to its emission level and high percentages of the other acid gases and mercury when byproduct is circulating and hydrated lime and water is injected into the CDS reactor. Most CDS system components are serviced external to the reactor and fabric filter. An individual fabric filter compartment can be isolated for maintenance on each fabric filter while the CDS is in operation.

Generally, when the system operates at less than 60% load, the CDS flue gas recirculation damper opens to recirculate flue gas from the ID fan discharge to the inlet of the CDS reactor. The damper opens in response to a minimum set point measured by the flue gas flow instrumentation at the exit of the fabric filter.

3.3.2 Operating Range

A CDS operates when the inlet flue gas temperature is sufficient for effective spray down in the reactor and the flue gas flow is above a minimum value to support the bed. At low system loads, the minimum flow value can be augmented with recirculated flue gas from the ID fans. The CDS operating temperature is kept at a constant value for a safe approach temperature throughout a system load range. The operating temperature may be adjusted for changes in sulfur and chlorine content in the fly ash but is expected to remain constant within the design specification.

When the inlet flue gas temperature and flow is below minimum, hydrated lime can be injected into the CDS to mitigate SO_3 emissions from the boiler. SO_3 mitigation is an important function of the CDS especially if there is a Selective Catalytic Reduction (SCR) system located upstream that may increase the SO_2 to SO_3 conversion in the flue gas because of the SCR catalyst.

3.3.3 Startup

There are several startup modes for the CDS. Generally, a first startup is after commissioning or after an outage of longer than 30 days. A cold startup is after an outage of 10 to 30 days with empty air slides. A warm start is after an outage shorter than up to 10 days during which it is possible to keep byproduct fluidized and stored in the air slides. A hot start means a restart of one or more of the injection systems after an interruption.

To prepare for a first startup, fill the hydrated lime silo by truck delivery or producing hydrated lime from pebble lime using the pebble lime hydrator facility. If there is a process water tank, it is filled before startup. Eight to twelve hours before startup, start the fabric filter hopper and air slide heaters. Startup heating is needed to keep cold solids from sticking to the fabric filter hopper and air slide walls. Open all compartments

on each fabric filter, and ensure the bypasses are closed. Place the flue gas recirculation dampers in automatic to control the flow to the reactors.

After a short inspection of the CDS to ensure components are ready, the ID fan can be started. Also start the fabric filter cleaning compressor or blower. While running the ID fan, inject hydrated lime into the reactor to coat the fabric filter bags and start filling the air slides.

After the fabric filter bags are coated and the fabric filter and air slide are heated, the upstream process can start operating. Continue to inject hydrated lime to completely fill the air slides. Some of the fabric filter compartments may be closed to keep the compartment temperature above a minimum value but closing compartments for startup is not generally required. However, before circulating byproduct in a reactor, all compartments must be open to handle the startup solids load to the fabric filters.

While firing the upstream SEFA Staged Turbulent Air Reactor (STAR®), hydrated lime can continue to be injected because it effectively mitigates SO₃ from burning high sulfur coal during startup.

After the air slides are full and system increases toward minimum flow, start byproduct circulation with the flue gas recirculation damper open and in automatic and all fabric filter compartments open. Byproduct circulation establishes a fluidized bed in each reactor usually within 5 minutes. As process flow increases above minimum, the flue gas recirculation damper will automatically close.

When the flue gas temperature in the CDS is above a value required for minimum spray down, start injecting water in automatic to reduce the reactor temperature to an optimum approach temperature. As water is injected into each reactor, the resulting flue gas conditions to the fabric filter will reduce the cleaning cycle.

As optimum reactor temperature is established, place the hydrated lime injection in automatic to establish the SO₂ removal set point in each reactor. As long as hydrated lime injection and the optimum temperature are maintained, SO₂ control is maintained throughout startup above minimum flow. As the air slide levels increase due to byproduct generated from SO₂ capture, the byproduct removal system will automatically remove byproduct from the air slides.

3.3.4 Operation

After automatic control of hydrated lime injection, byproduct circulation, water injection, byproduct removal, fabric filter cleaning and flue gas recirculation are established, the CDS is fully operating to control SO₂ and other acid gases from minimum boiler load to full load. A high fabric filter pressure drop will trip byproduct circulation. If byproduct circulation is interrupted, then hydrated lime and water injection automatically stop.

There are a few recommended inspection and maintenance procedures while operating the CDS. For instance, it is recommended to sample hydrated lime, reactor bottom ash, and byproduct to keep an operating history for the CDS. The sample results are generally not used to change operating conditions except if there is a major change in fly ash chlorine content. If there is a major change in fly ash, then a change in reactor operating temperature will optimize hydrated lime consumption. The type of byproduct sampling analyses depends on the final use of the byproduct.

3.3.5 Shutdown

The CDS is generally shut down along with the upstream process. To shut down the CDS, stop injecting hydrated lime and water, but continue to circulate byproduct. After thirty minutes, the circulating byproduct

is dried. Stop byproduct circulation and removal in each reactor. It is generally possible to store byproduct in the air slides for boiler outages up to 10 days. Air slide aeration air should be active whenever solids are in the air slide hoppers, including standby storage. This allows the CDS to be restarted quickly by first reestablishing a fluidized bed and then injecting hydrated lime and water into the reactors.

If the system is down for longer than 10 days, remove the byproduct from the air slides with the byproduct removal system, and shut down the fluidizing air and air slide heaters. Depending upon ambient conditions, draining the process water piping system may be advisable.

3.3.6 SEFA Staged Turbulent Air Reactor (STAR®) Trip

A trip of the upstream STAR system will not immediately trip SO₂ removal in the CDS, however once flue gas temperature or flow decays below minimum alarm points, byproduct circulation, water injection, and hydrated lime injection will trip. An ID fan trip will immediately trip byproduct circulation, and water and hydrated lime injection, thus allowing the suspended bed to carry over into the fabric filter as opposed to falling into the reactor hopper.

3.3.7 Caution

The dry solids such as the hydrated lime and byproduct present an engulfment risk similar to boiler fly ash. Take care when internally inspecting the reactor, silos and bins. Never open ports or inspection hatches below the level of solids, especially in fluidized locations such as the air slide hoppers or air slide conveyors. Fluidized dust will flow freely from any opening. The solids are caustic. Refer to Material Safety Data Sheets and supplier information for precautionary measures. There should be a thin layer of dust on the reactor walls, and the dust layer should not be removed because it protects the walls during startup. However, any large deposits should be removed.

Again, please consult the BPE CDS operating and maintenance procedures for complete information.

3.4 Description of Control and Monitoring Philosophy

The BPEI CDS design consists fundamentally of several general, high level I&C features relative to control and monitoring interface philosophy between the CDS processes and the owner's PLC / distributed control system (DCS):

CDS Instrumentation - Analog instrumentation for interface to the plant monitoring and control system (Owner's PLC) is generally provided per BPEI P&ID drawings, such that all BPEI provided systems are continuously monitored and controlled from the Main Control Room (MCR). Local instrumentation for indication, such as local pressure gages, are provided on several non-critical processes where the owner has supplied the process medium, such as service water and compressed air. The BPEI CDS design generally includes single instrument transmitter interfaces to the plant DCS, unless specific redundant instruments or transmitters are required for equipment protection or personnel safety. Limited instrument redundancy is provided on several systems where critical measurement is deemed a requirement for control purposes, such as redundant temperature and pressure measurements on the CDS reactor inlet and outlet process gas flow. In specific applications, such as hydrated lime bin and the by-product bin, both analog level measurement as well discrete high-level alarm (contact) instruments are provided for additional equipment shutdown and operator alarms.

Fail safe design - Fail safe design for controlled devices, such as motors and controlled valves, are shown on the BPEI P&ID drawings. Fail safe acronyms are represented as Fail Closed (FC), Fail Open (FO), and Fail In Place (FIP).

Package System PLC Interfaces - BPEI's general philosophy for package system interface design (Ex: Pulse Jet Fabric Filter) is such that all control, monitoring, and equipment protection may be implemented locally at the package system PLC level. Critical alarms, process signals, and operator interfaces are typically hard-wired from the local package system PLC to the plant DCS / PLC. Non-critical operator interfaces and data required for displays and alarming in the MCR are typically implemented via Ethernet TCP IP interface.

The primary CDS to plant DCS / PLC interface requirements document is the BPEI provided Input / Output List (I/O List), typically provided during early phases of project execution

3.5 BPE CDS Design

BPE is a leader in taking licensed technology and advancing the state of the art based on:

- Knowledge gained with U.S. installed systems
- Advanced modeling work to simulate full-scale operation
- Incorporation of utilities' requirements for
 - Simple operation
 - High reliability
 - Low emissions
 - Minimal operating and maintenance costs.

For example, with selective catalytic reduction (SCR) technology (Figure 3-3), BPE advanced the art with its proprietary Delta Wing® static mixers, direct ammonia injection, and physical modeling that resulted in industry-leading NO_x removal coupled with low ammonia slip. With wet flue gas desulfurization (WFGD) technology (Figure 3-4), BPE advanced the art with dual-flow spray nozzles, wall rings, and oxidation coupled with agitation that resulted in high SO₂ removal and low limestone stoichiometry.

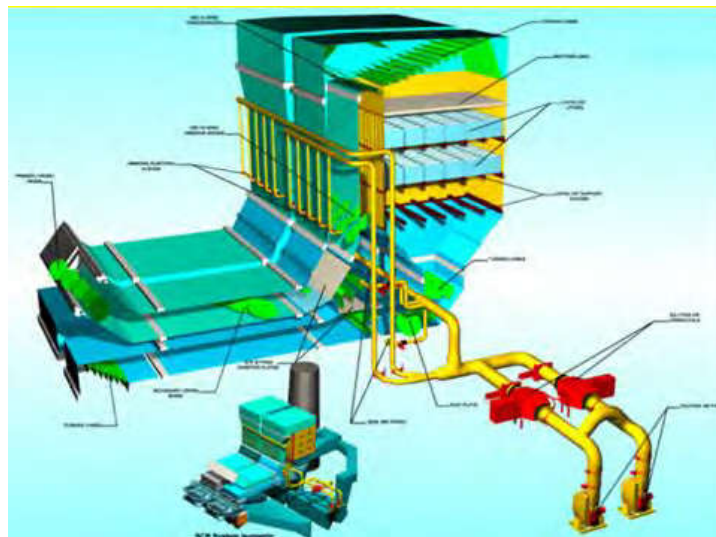
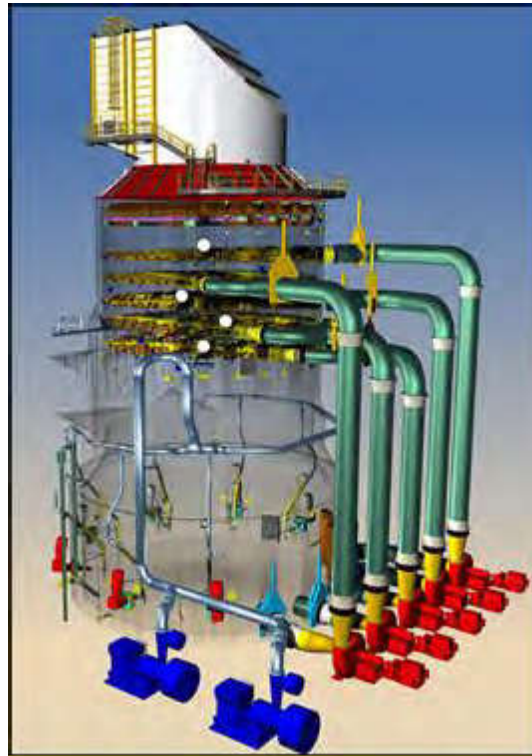


Figure 3-3. BPE SCR System**Figure 3-4. BPE WFGD System**

Similarly, BPE has utilized knowledge gained from the testing and modeling of the CDS projects to maintain:

- Simple operation
- High reliability
- Low emissions
- Low pressure drop
- Low potential for erosion, corrosion, and dropout
- Improved reduced load operation
- Compliance with restricted space requirements
- Minimal operating and maintenance costs

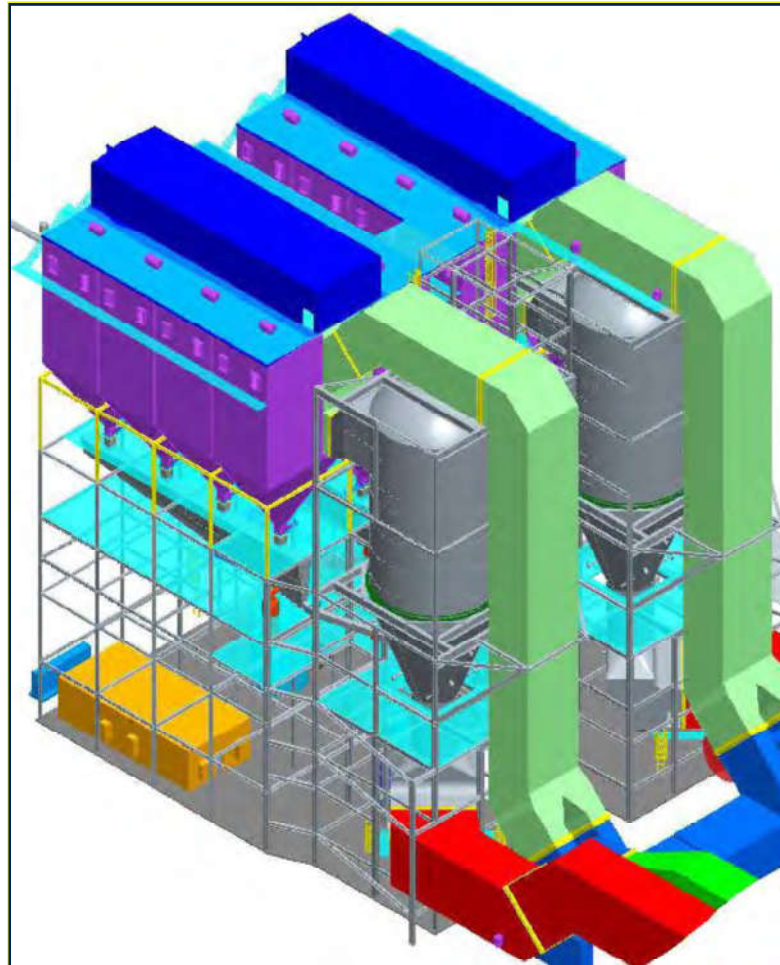


Figure 3-5 BPE DFGD / Fabric Filter System

3.6 Flow Modeling

CDS system flow modeling scope includes computational fluid dynamics (CFD). Designing and optimizing circulating fluidized beds is a challenging task and a CFD model can be a helpful tool.

Simulations show the typical gas flow, pressure, and temperature regime inside the CDS vessels on dual-train systems. Figure 3-9 is an example of the modeling completed on dual-train CDS system at full load conditions. The fast gas jet formed by the venturi nozzle remains attached to the wall throughout the reactor. The knowledge of the solids distribution inside the reactor allows an optimal positioning of the water injection nozzle.

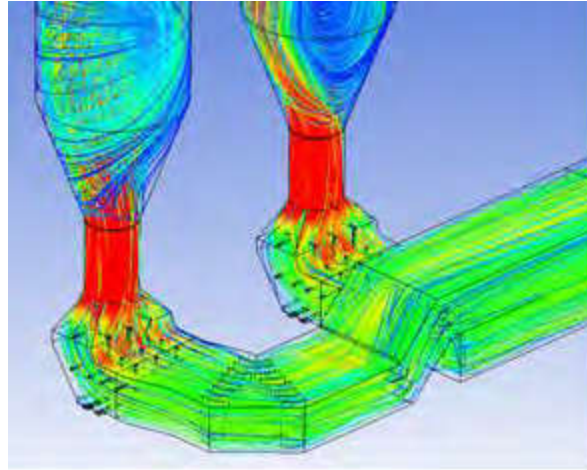


Figure 3-9. Example of Dual Train CDS modeling

Additional modeling looks at flue gas recirculation flow and temperature profile at reduced load conditions. It is important to understand the temperature distribution at reduced load conditions with flue gas recirculation to eliminate areas of low temperature where acid condensation may occur. Figure 3-10 show velocity from a common recirculation duct at minimum load.

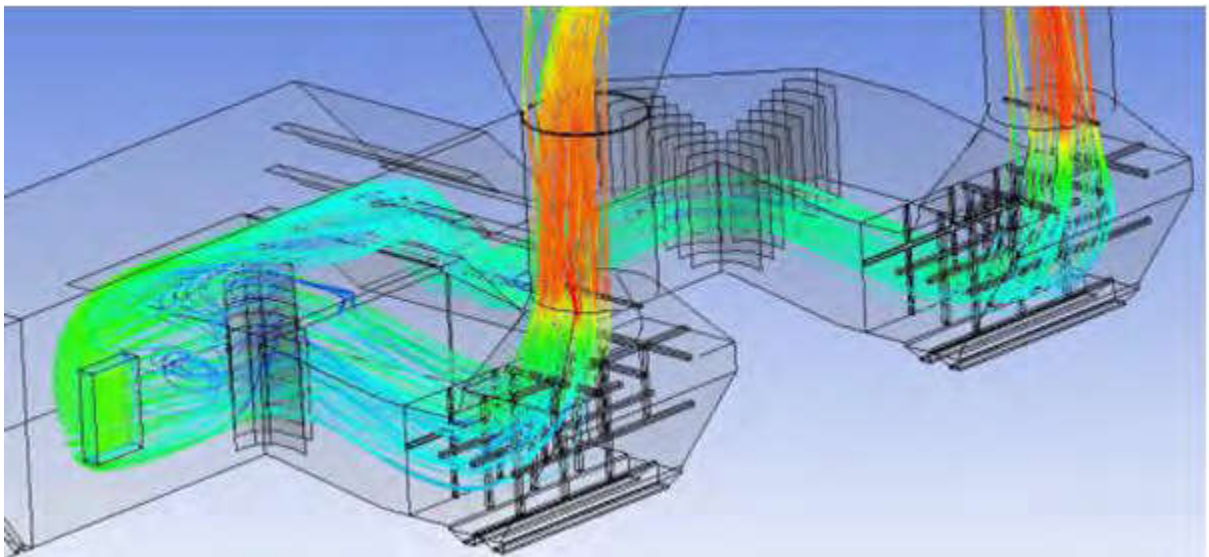


Figure 3-10. Example Velocity from Flue Gas Recirculation Duct

Transition between CDS and Baghouse and Baghouse Compartments

There is also a focus on modeling the transition between the CDS and the baghouse. Figure 3-11 shows the placement of baffle plates to straighten the flow and optimize the distribution across the baghouse compartments. Maintaining even flow distribution across the baghouse compartments maximizes baghouse

performance and optimizes bag life. Modeling of the baghouse compartments is used to optimize the design to maximize particulate dropout prior to the flue gas contacting the filter media, and to minimize hopper re-entrainment.

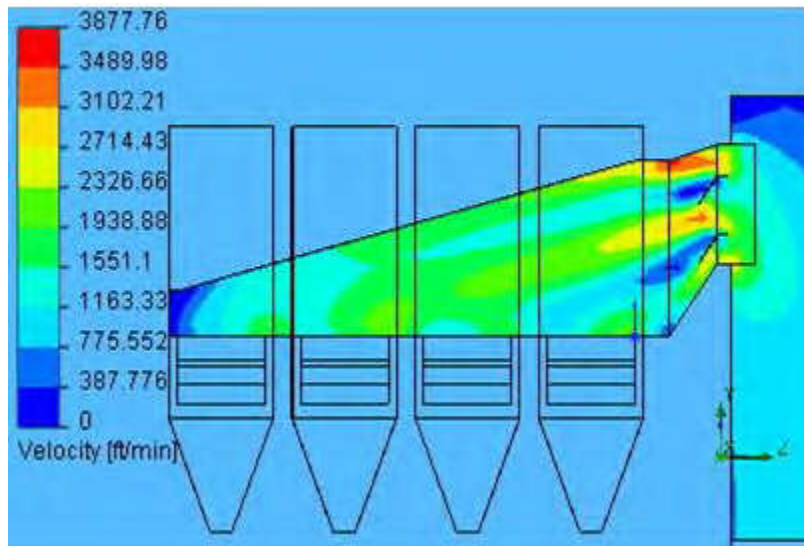


Figure 3-11. Example of Modeling Transition between CDS and Baghouse

3.7 Comparison to Spray Dryer Absorbers (SDA) and other Technologies

In the CDS, instead of lime slurry, dry hydrated lime is injected in the reactor while a fine water spray is injected separately to spray down and control flue gas temperature. The solids are all essentially dry while in an SDA there is potential of wetting walls when spraying a lime slurry especially at reduced flue gas flows. As with a SDA, the CDS is constructed from mild steel. However, ancillary systems are made up of simpler, traditional material handling equipment. In a CDS, the dry solids are conveyed pneumatically and injected with a simple pipe rather than pumping a highly erosive lime slurry and injecting it through an atomizer or dual-fluid nozzles. Additional advantages of a CDS over an SDA are higher SO₂ removal with less lime consumption and less maintenance. Figure 3-12 illustrates superior sulfur removal capability and larger range of the CDS over the SDA. As shown, the CDS is able to remove a higher percentage of SO₂ for higher inlet SO₂ loadings than an SDA. The reason for the CDS superior removal is that there is no limitation to the amount of lime that can be injected unlike an SDA where the lime slurry injection rate is limited by the drying capability of the reactor.

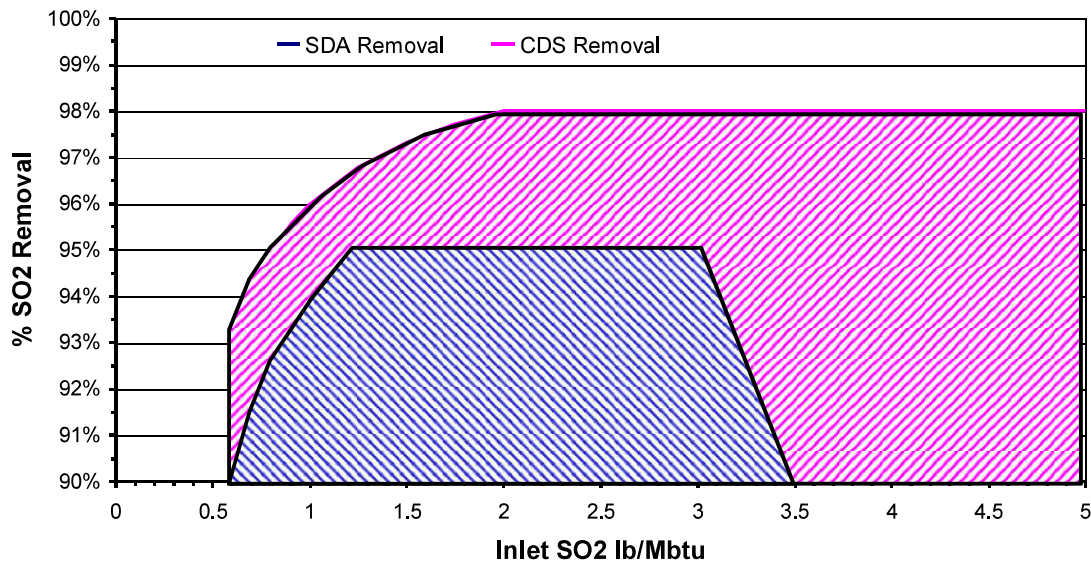


Figure 3-12. CDS SO₂ Removals Compared to SDA

The O&M costs for a CDS is lower than an SDA because

- Simple solids handling equipment.
- Lower auxiliary power consumption (compared to an SDA that utilize high speed rotary atomizer)
- Scrubs up to high sulfur content flue gas.
- No additional emission technology needed during start up or shut down.

Components of an SDA system have to be placed in and out of service during load changes. At low loads when excess air may reduce inlet flue gas temperature, lime spraying in the SDA is restricted. At lower loads, the SDA may need to be bypassed because of low temperature. When bypassed, a separate dry hydrated lime injection system may be needed to maintain SO₂ emissions. The dry hydrated lime injection system requires added lime unloading, storage, and injection systems. During SDA bypass, the injected lime stoichiometry is high to maintain SO₂ emissions because there is no water spray-down.

To maintain velocity in the CDS reactor at low loads, flue gas recirculates from the downstream ID fans to the inlet duct of the CDS through a modulating damper. At high loads, the flue gas recirculation damper is closed. As load reduces, the damper automatically opens and modulates to maintain a required CDS reactor velocity. Therefore, the CDS scrubbing is maintained smoothly throughout a required load range without taking equipment in and out of service. All of the remaining controls function over the entire load range, without any changes to controls or equipment in service.

Additional technology options include utilizing a wet scrubber coupled with a wet venturi evaporator to maintain and zero liquid discharge system. Table 3-1 is a summary of alternative advantages and disadvantages. An economic evaluation comparing capital and O&M costs over a 10-year life cycle is recommended to determine the best option for this project.

Table 3-1 Advantages and Disadvantages of Different FGD Systems EXAMPLE

Parameter	CDS System	SDA System	Scrubber/ Evaporator	Dual Alkali/ Evaporator
Wastewater Purge	0 gpm	0 gpm	0 gpm	0 gpm
System Pressure Drop	12-16 iwc	11-14 iwc	5-6 iwc	5-6 iwc
Materials of Construction	Carbon Steel	Carbon Steel	FRP/Stainless	FRP/Stainless
Caustic Consumption	0	0	High	Low
Lime Consumption	Medium	High (33% > CDS)	0	Low
Byproduct Generation	Medium	High (25% > CDS)	Low	Medium Low
Byproduct	Stable	Stable	Mix w Ash or Lime	Stable
Capital Cost	Medium	Medium Low	Low	Medium Low
Civil	Medium	Medium	Low	Medium Low
O&M	Medium (Pressure Drop)	Medium High (Pressure Drop)	Medium (Reagent)	Low

3.8 Scope of Supply

The scope for one (1) system includes:

3.8.1 CDS System

- One (1) CDS reactor
- One (1) CDS bottom hopper
- One (1) rotary valve
- Auxiliary Valves
- Instrumentation
- Structural Steel, platforms, and access to major components

3.8.2 Hydrated Lime Storage and Handling System

- One (1) Lime storage silo
- Dust collector
- Truck Unloading provisions, with operator station
- Discharge knife gate valves
- Two (2) rotary air lock feeders
- One (1) Hydrated lime silo transfer blower
- Silo level monitor
- Electric heater
- Jib crane
- Termination panel

3.8.3 Byproducts Solids Handling and Recirculation

- Two (2) Airslides
- Two (2) Airslide aeration blowers, one (1) per airslide
- Two (2) Dosing valves
- One (1) Surge bin
- Valves
- Instruments

3.8.4 Water Injection Control Skid

- Two (2) dual fluid water injection lances, one (1) operating, one (1) spare
- Water and air flow control skid
- Valves
- Instruments

3.8.5 Pulse Jet Fabric Filter

- One (1) four-compartment fabric filter with tubesheets, bags, and cages
- Hoppers including heating cable, poke holes, access door and strike plates
- Compartment inlet butterfly, and outlet poppet dampers
- Instrumentation
- Local PLC
- Structural steel including access stairs and landings
- Platforms, ladders and handrails to provide operating and maintenance access
- Automatic pulse-jet cleaning system
- Walk-in plenum design consisting of four (4) compartments

3.8.6 Induced Draft (ID) Fan

- Sleeve Bearings
- Resilient Coupling Included
- G2.5 Tolerance Dynamic Balance
- Bolted access doors in scroll and inlet box
- Variable Inlet Vanes (VIV): for control of fan. Designed for automatic control with
- Pneumatic Actuator
- Pneumatic Actuator for VIV
- Insulation pins for acoustic insulation/cladding (insulation and cladding not included to be supplied by others)
- Loop Powered 4-20 mA Velocity Transmitter with 5m blunt cut cable (1) per fan bearing
- Minco RTD, 100ohm, platinum spring loaded c/w Aluminum connection head
- Motor –To be confirmed (350 HP, 1800 rpm, VFD Start)
- Lube Oil Skid
- One (1) variable frequency drive (VFD)
- Instrumentation

3.8.7 Flue Gas Ductwork

- CDS inlet ductwork nozzle
- CDS to PJFF outlet ductwork
- PJFF to ID Fan ductwork
- Flue gas recirculation ductwork

3.8.8 Structural Steel Framing

Structural steel is as noted on general arrangement drawings included in the appendix of this proposal

- Main Support Steel
- Access and Platforms

3.8.9 Electrical

A Preliminary Motor and Electrical Load List is included in the appendix of this proposal.

3.8.10 Instrument and Controls

Loose instrumentation and/or instrumentation provided with package systems as identified on the Piping and Instrument Diagrams included with this proposal.

3.8.11 Manuals

Operating and maintenance (O&M) manuals. Manuals to include drawings (including P&IDs, general arrangements, load diagrams, exploded views, and logic diagrams), process lists, project specifications, process and functional descriptions, and equipment manufacturer instruction books.

3.8.12 Spare Parts

Spare parts list and a list of any special tools required for operation and maintenance of equipment. Special tools and commissioning and startup spares are included in the scope.

3.8.13 Home Office Services

- Engineering and design
 - Data Sheets for major equipment items
 - Foundation loading, general arrangement and detail drawings for all items indicated in the Scope of Work
 - Operating and maintenance manuals
- Project management and project engineering
- Procurement and expediting of all material items indicated in the Scope of Work
- QA/QC
 - Development of Quality Plan/ITP
 - Inspection of all material items indicated in the Scope of Work

3.8.14 Site Services

- Operator Training – Two (2) x 2-day sessions
- Commissioning – Mechanical checkout, cold commissioning, hot commissioning
- Start-up
- Observe contractor performance verification testing

3.8.15 Terminal Points

- Flue Gas: CDS flue gas Inlet flange, ID Fan outlet flange downstream of FGR duct takeoff
- Instrument Air: Compressed air to hydrated lime silo, water flow control skid, PJFF cleaning air manifold, waste storage bin, and flue gas instrumentation.

- Service Air: Pressure transmitter and water line purges.
- Water: Inlet to water flow control skid.
- Hydrated Lime: Truck unloading flange.
- Electric wiring: at instrument connections, at valve connections, at skid mounted junction boxes.

3.8.16 Exclusions

The following is the general scope of supply excluded from this offering and is to be furnished by others.

- a) Receiving, unloading, storing of shipped equipment and components
- b) Installation services of any kind
- c) Operating personnel for startup and tests
- d) Mechanical equipment alignments
- e) Chemical cleaning and associated duties
- f) Foundation design or civil engineering design
- g) Foundations, anchor bolts, bolt sleeves and equipment bases
- h) Grouting materials and the placing thereof
- i) External insulation and lagging materials
- j) Finish paint, except as noted
- k) Small bore piping 2 1/2" and smaller
- l) Waste solids disposal system
- m) Stack
- n) Stair tower for CDS/baghouse access
- o) Water supply and piping
- p) Instrument air piping and distribution
- q) Fire suppression/protection system
- r) Motor control centers
- s) Control system PLC and HMI, hardware and programming
- t) SO₂ Analyzers
- u) Continuous Emissions Monitoring (CMS) equipment
- v) Electrical control room
- w) Power Supply
- x) Architectural siding, roofing, and doors
- y) Lighting equipment and design
- z) Instrumentation other than specifically identified in this proposal.
- aa) Site Technical Advisor during Construction
- bb) Wiring, and cable
- cc) Wiring and cable raceways and trays
- dd) Grounding system
- ee) DCS Programming

- ff) Acceptance Testing
- gg) Acceptance Testing Equipment
- hh) Asbestos, lead paint, or any hazardous material removal
- ii) Any equipment or services not explicitly stated in this proposal

4.0 Project Execution

BPE has a long history of successful project execution characterized by effective collaboration and integration with Owners, Engineers and EPC contractors. We plan our engineering, fabrication, shipping, erection planning and commissioning activities in conjunction with the other members of the project team, to ensure optimization of the overall plant design and efficiency of erection and startup, all within a safe and well-organized site environment.

We have extensive experience in integrating our project execution activities with those of the EPC contractor. We have worked successfully with most of the major EPC contractors in the US on projects of various sizes and are comfortable in executing projects through direct contracts with the utility, or through assigned contracts to the EPC.

BPE's project execution structure described below is designed to provide an AQC system of the highest quality, delivered on time and erected safely, with all activities coordinated and optimized with the client. We encourage and look forward to further detailed discussion on this topic as we proceed forward in the proposal process.

The Babcock Power Environmental Inc. (BPE) Project Manager will be the focal point of communication with the project team on the installation of Air Quality Control Systems (AQCS) and all associated equipment to be installed. The Project Team will participate in meetings and will establish a Project Plan, which defines in detail the systems to be utilized throughout execution of the project.

The Project Plan will include, as a minimum, the following systems:

- Project Phases
 - Engineering/Design & Subcontracts
 - Procurement
 - Quality Assurance
 - Project Controls
 - Shop Fabrication
 - Site services as noted in this proposal

Ultimately, the integrated construction and commissioning activities will drive the project schedule. BPE engineering and procurement activities will be accomplished in support of the construction plan. Continual refinement of the project schedule will be performed throughout this project.

The Project Manager is the leader of the BPE project team. The core team under the Project Manager's direction will include a Project Engineer, Project Planner/Scheduler, Project Cost Controller and Sub-Contract Manager.

Assigned to the Project Engineer will be lead discipline engineers, as follows:

- Project Design Lead (PDL) – General Arrangements & Detail Graphic Design
- Process Engineer – PFD's, P&ID's, & Chemical Engineering
- Mechanical Systems Engineer – Detail Process Systems Design, & Auxiliary Equipment Engineering
- Structural Design & Stress Analysis Engineer – Structural Steel, Duct & Piping, Stress Analysis & Design
- I&C Engineer – Instrumentation & Controls, Logic and Systems Design

5.0 Quality Assurance / Quality Control

Babcock Power Environmental maintains and implements a robust Quality Management System that includes integrated, yet independent, quality assurance (QA) & Quality Control (QC) functions as part of our standard processes and procedures. These procedures and work processes are implemented from the beginning of a project through its completion and operation. The Quality System Manual specifies requirements used by Babcock Power Environmental to address customer satisfaction, meet customer and applicable regulatory requirements and comply with the ISO 9001:2008 standard. The Quality System Manual addresses the following primary processes:

- Quality Management System and Control of Documents / Records
- Management Responsibility.
- Resource Management
- Product Realization. Including:
 - Design & Development
 - Purchasing Control
 - Operations control
- Measurement, Analysis & Improvement – Including Continual Improvement & Corrective Action
- Participate in pre-award meetings/discussions with suppliers as requested

Project Preparation

- Review project documentation to assure that current quality requirements are incorporated.
- Ensure that additional requirements are specified as needed due to project specific issues.
- Participate in pre-award meetings/discussions with suppliers as required.

Prior to Production

- During pre-production meetings, the following items will be discussed in detail:
 - Project Specific Quality Assurance Requirements
 - Review of applicable BPE QA Engineering Standards and any other QA documents imposed
 - Review of all deliverables – product and documentation.
 - Review of supplier's welding procedures and qualifications if not previously approved.
 - Review of supplier's QA program including project specific Inspection and Test Plan (ITP), QA inspection notifications, and final release documentation
 - BPE inspection involvement and / or the use of 3rd party inspectors as applicable
- The Quality Assurance Plan and ITPs will be reviewed with the client.

Production - Fabrication

- Suppliers are required to meet the requirements specified on drawings, Engineering Standards, and the Purchase Order for the contract.
- BPE QA will coordinate in-process, final and trial fit (when applicable) inspections throughout the fabrication cycle. This will be done thru the use of BPE QA Inspectors and or through the use of a 3rd party inspection firm.

- The following criteria will be used during the inspections:
 - Latest revision of the contract drawings.
 - Applicable Codes ASME, AWS, etc.
 - Client requirements
 - BPE Standards
- Each component, upon completion, shall have the following documentation signed and dated by both the supplier and the BPE inspector or 3rd party representative:
 - Final Release Inspection Report
 - Critical Dimension Sheet
- BPE QA or 3rd party representative will generate an inspection report for each inspection performed. The report shall detail which sections were looked at, overall quality any deficiencies noted, percent complete and any other Quality related items observed.
- Dimensions verified by BPE-QA that exceed the specified drawing tolerances shall be reported directly to the supplier Quality Assurance representative. The supplier has one of three options
 1. Correct the dimensions to be within the specified drawing tolerance.
 2. Review the discrepancies with BPE engineering for acceptability.
 3. Issue a non-conformance report [NCR] to engineering and implement repairs or corrections per engineering instructions.
- All dimensional differences accepted verbally – item (2) above, shall be documented in writing and dated by the BPE Quality Assurance representative or third-party inspector.
- All trial fit operations, if required, shall be verified.
- Inspection at loading shall be conducted.
- Periodic reports (e.g., weekly) and final inspection reports will be generated.
- Review welding procedures and inspect welding. Criteria for acceptance are per the BPE drawings and specifications identified in the Contract.
- Verification of the dimensions will be conducted to assure compliance with the Inspection Procedure and drawing requirements.

Project Documentation

- All project documentation shall be stored electronically. Suppliers are encouraged to provide all quality documentation packages in electronic format.

Support

- In addition to the Quality Assurance/Quality Control Department Quality activities are supported through the entire organization, some examples are noted below:

- Project Engineering, Design Engineering will provide technical interpretations or clarifications, disposition discrepant conditions, and initiate change orders for modified work scope.
- Project Management will impose sufficient schedule control to allow for inspections to be completed.
- Supply Management will keep order current with technical, commercial, and schedule requirements.
- Quality assurance responsibilities will be accomplished, as necessary, by a combination of onsite resident inspector(s) and/or visits by BPE Quality Assurance.

BPE ISO Certificate, and Quality System Manual

The BPE ISO Certificate, and Quality System Manual are included in the appendix of this proposal.

- ISO 9001-2008 Certificate
- QSM-1.001 Rev 13, Quality System Manual

Jahn, Mario

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Thursday, March 24, 2022 10:25 AM
To: Fritz, Mark
Cc: Black, Stephen; Pierson, Robert
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate
Attachments: Stanley UAF Example CDS Proposal.pdf

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Mike, see attached example proposal with pricing for a CDS system. Hopefully this has everything you need for that technology.

We are still reviewing internally to gauge interest in providing a WFGD study proposal. To be frank with our current workload and the very low likelihood of a project moving forward it may not make sense for us to even offer a paid study. I hope to have an answer to you by Monday on whether we will offer a study proposal. Current estimate is \$50k, let me know if this is still something UAF would be willing to pay for.

Thanks,

Brandon Linn

Lead Account Manager

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A Babcock Power Inc. Company

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email | blinn@babcockpower.com

web | <https://www.babcockpower.com>

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 23, 2022 4:28 PM
To: Linn, Brandon <BLinn@babcockpower.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Brandon,

Can you give me a rough idea on the timing of the CDS and WFGD info. Assuming UAF decides to go with the paid WFGD proposal. Thanks.

Mark

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Wednesday, March 23, 2022 10:34 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Mark, sorry for the delay in response. In talking with our engineering team we proposed a CDS system for a similarly sized unit a few years ago. I am going to modify that proposal and send it to you as an indicative price for this option.

Due to the small size of the unit we cannot offer a quick indicative price for a WFGD system, and to develop one would cost more than the \$5k-\$10k we discussed. I would recommend reaching out to an industrial WFGD supplier that has more experience with units of this size.

Thanks,

Brandon Linn
Lead Account Manager



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From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 23, 2022 11:10 AM
To: Linn, Brandon <BLinn@babcockpower.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Brandon,

Can you give me an update regarding UAF BACT Cost Estimate. After the last meeting I believe Babcock Power was going to discuss internally in regards to price and schedule.

Thanks,

Mark

From: Fritz, Mark
Sent: Tuesday, March 8, 2022 10:33 AM
To: Linn, Brandon <BLinn@babcockpower.com>; Rowell, Lance <RowellLance@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

Brandon,

I am the Project Manager for this job and Lance was helping me out with the initial information request. Yes, I am available this week to discuss, please call to coordinate a time.

See below for my answers to your questions in red. I am no expert in WFGD systems, so a discussion of some of my answers may be warranted.

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Tuesday, March 8, 2022 9:05 AM
To: Rowell, Lance <RowellLance@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate
Importance: High

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Lance,

Just following up, as I haven't heard back from you. Would you be available for a call this week to discuss? We are interested, but would like to have a call before we really dig into this.

Thanks,

Brandon Linn
Lead Account Manager



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From: Linn, Brandon
Sent: Wednesday, March 2, 2022 4:45 PM
To: RowellLance@stanleygroup.com
Cc: Black, Stephen <SBlack@babcockpower.com>; FritzMark@stanleygroup.com
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

Lance,

Steve Black forwarded me this email with the attachments to review. A few quick questions from an initial review:

- What is the target stack outlet SO2 for the project, or the target % removal? **Looking for typical removal efficiency for each technology.**
- For the WFGD waste stream for treatment by others, should this be read as the blowdown/purge stream? **If Babcock Power can provide a quotation for all waste treatment system we would be interested.** If dewatering of the absorber bleed is in our scope, would gypsum handling and storage from the discharge of the vacuum or drum filter be by others? **No, include in your scope.**
- For WFGD, any reagent requirements? Limestone, lime, lye/caustic soda (sodium hydroxide)? **The boiler is a CFB that utilizes limestone. I assume limestone as a reagent, unless other reagents have an effect on removal efficiency or capitol cost.**
- Would you consider DSI for SO2 removal, for example Trona? **Yes. But would probably use sodium bicarbonate for its higher removal efficiency and local availability.**

Thanks,

Brandon Linn
Lead Account Manager



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From: Rowell, Lance <RowellLance@stanleygroup.com>
Sent: Wednesday, February 09, 2022 5:00 PM
To: Black, Stephen <SBlack@babcockpower.com>
Cc: Fritz, Mark <FritzMark@stanleygroup.com>
Subject: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Steve,

It was a pleasure talking with you earlier this afternoon.

Stanley Consultants is doing a BACT analysis for the UAF due to the EPA having the area as a non-attainment zone for SOx. As part of this analysis we need to have cost estimates for applicable technologies to reduce the SO2 emissions. Below is a section of the boiler and attached is some applicable data.

Information attached:

Boiler data sheet (includes coal analysis)

Plant layout (CHPP Layout)

UAF Exhaust Gas Data (for exhaust gas entering the baghouse)

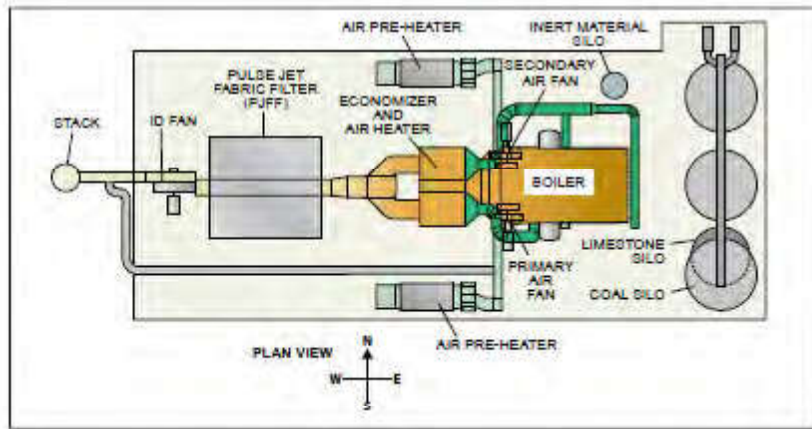
Baghouse data (for existing baghouse)

Unit is a 240,000 lb/hr B&W circulating fluidized bed boiler which was installed in 2017.

We are looking for budget pricing (+/-30%) for material supply, approximate footprint required, utilities/lime used, and if the existing baghouse would need to be replaced.

In our conversation you mentioned that generating this budgetary pricing would probably cost around \$5-\$10k and take approximately 4 weeks. Please review and let me know what it would take to do this budgetary pricing. If there is anything that we are requesting that takes significant effort, please let me know.

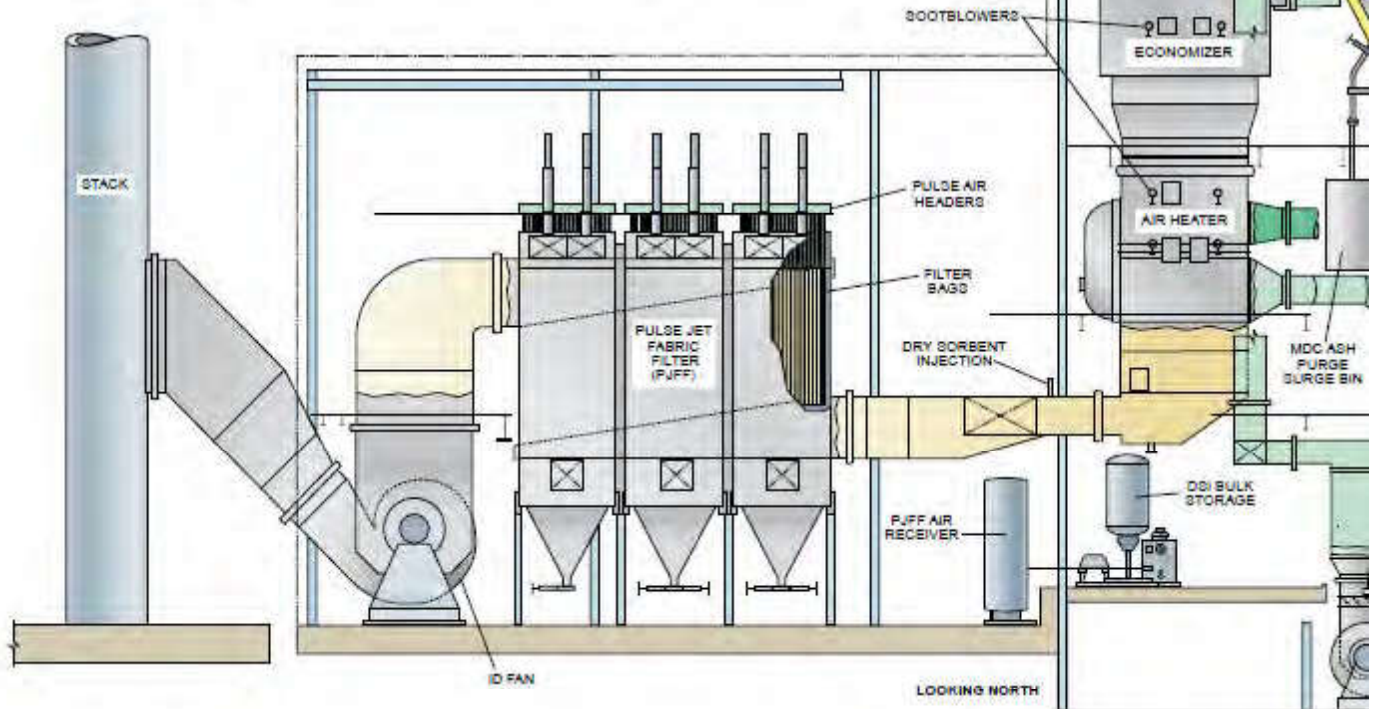
We look forward to hearing from you.



UNIVERSITY OF ALASKA FAIRBANKS COMBINED HEAT and POWER PLANT

Babcock & Wilcox Circulating Fluidized-Bed Boiler

Steam Flow 240,000 lb/hr (30.24 kg/s)
 Steam Pressure 740 psig (5.1 MPa)
 Steam Temperature 750F (399C)



Thanks!



Lance Rowell, PE, PMP, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52761
 T: 563.264.6548 | stanleyconsultants.com

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Public Review Draft

August 19, 2024

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Jahn, Mario

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Monday, August 8, 2022 10:41 AM
To: Solan, John
Cc: Payne, Mark; Jahn, Mario; Ake, Terence
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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John,

Under our standard CDS guideline, we can confirm at least 80% SO2 removal with a CDS for a 0.2 lb/MBtu SO2 input resulting in effluent concentration of 0.04 lb/mmBtu. If this were a firm proposal we would review SO2 removal in more detail for ethe specific fluent gas flow, temperature, etc.

Thanks,

Brandon Linn
Lead Account Manager



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From: Solan, John <SolanJohn@stanleygroup.com>
Sent: Wednesday, August 3, 2022 6:57 PM
To: Linn, Brandon <BLinn@babcockpower.com>
Cc: Payne, Mark <PayneMark@stanleygroup.com>; Jahn, Mario <JahnMario@stanleygroup.com>; Ake, Terence <take@babcockpower.com>
Subject: Re: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Brandon, for what it's worth... the influent concentration is 0.2 LB/MMBTU. With that do we still assume a minimum effluent concentration of 0.04 LB/MMBTU? Thanks!

John Solan, P.E.*, Principal Mechanical Engineer
STANLEY CONSULTANTS
PO Box 192
East Glastonbury, CT. 06025-0192
T: 303.649.7830

* Registered in NC, CO, CT, and AK

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Wednesday, August 3, 2022 7:30:18 PM
To: Solan, John <SolanJohn@stanleygroup.com>
Cc: Payne, Mark <PayneMark@stanleygroup.com>; Jahn, Mario <JahnMario@stanleygroup.com>; Ake, Terence <take@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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John, please let me know if the below answers your question. Thanks,

Our current CDS guideline is 95% maximum removal for fuels less than 0.75 lb/MBtu and 0.04 lb/MBtu minimum SO₂ emission. We believe the U of Alaska fuel is 0.4 lb SO₂/MBtu. The guideline for 0.4 lb SO₂/MBtu fuel would be maximum 90% removal for 0.04 lb SO₂/MBtu emission. Therefore, the CDS part of the graph should be extended to 90% removal for a 0.4 lb SO₂/MBtu. I don't know if SDA can provide similar performance as our given by our current CDS guideline.

Essentially the Y-axis on the graph stops at 90% and the graph is intended to show the difference between CDS and SDA for larger units with more common SO₂ inlet loading. The graph is illustrative/informative, not a contract-level depiction of performance across all possible operating scenarios.

Thanks,

Brandon Linn
Lead Account Manager



BABCOCK POWER SERVICES
A Babcock Power Inc. Company
114 Cornwall | San Antonio, TX 78216

mobile | 774-366-5692

email | blinn@babcockpower.com

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From: Solan, John <SolanJohn@stanleygroup.com>
Sent: Tuesday, August 2, 2022 1:36 PM
To: Linn, Brandon <BLinn@babcockpower.com>
Cc: Payne, Mark <PayneMark@stanleygroup.com>; Jahn, Mario <JahnMario@stanleygroup.com>
Subject: FW: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Hi Brandon!

I am following up on some correspondence that you had with Mark Fritz back in March. I have been reviewing the sample proposal that you send him and I had one question. The SO2 removals graph on page 21 of the document indicates that as the influent sulfur approaches 0.5 lb/mmbtu the capture efficiency of your product goes to zero. After speaking with other vendors, I am sure that this is not the case. For our report to be complete, we would like to know what Babcock thinks the capture efficiency of your CDS system might be in our particular case for our application.

Your continued support is greatly appreciated.

-John



John Solan, P.E.*, Principal Mechanical Engineer
STANLEYCONSULTANTS, P.O. Box 192, East Glastonbury, CT 06025-0192
T: 303.649.7830 | stanleyconsultants.com
* Registered in the States of North Carolina, Colorado, Connecticut, and Alaska

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Tuesday, August 2, 2022 2:29 PM
To: Solan, John <SolanJohn@stanleygroup.com>
Subject: FW: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

From Mark's email box.

From: Linn, Brandon <>
Sent: Thursday, March 24, 2022 10:25 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>; Pierson, Robert <рпиerson@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Mike, see attached example proposal with pricing for a CDS system. Hopefully this has everything you need for that technology.

We are still reviewing internally to gauge interest in providing a WFGD study proposal. To be frank with our current workload and the very low likelihood of a project moving forward it may not make sense for us to even offer a paid study. I hope to have an answer to you by Monday on whether we will offer a study proposal. Current estimate is \$50k, let me know if this is still something UAF would be willing to pay for.

Thanks,

Brandon Linn
Lead Account Manager



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web | <https://www.babcockpower.com>

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 23, 2022 4:28 PM
To: Linn, Brandon <BLinn@babcockpower.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Brandon,

Can you give me a rough idea on the timing of the CDS and WFGD info. Assuming UAF decides to go with the paid WFGD proposal. Thanks.

Mark

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Wednesday, March 23, 2022 10:34 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Mark, sorry for the delay in response. In talking with our engineering team we proposed a CDS system for a similarly sized unit a few years ago. I am going to modify that proposal and send it to you as an indicative price for this option.

Due to the small size of the unit we cannot offer a quick indicative price for a WFGD system, and to develop one would cost more than the \$5k-\$10k we discussed. I would recommend reaching out to an industrial WFGD supplier that has more experience with units of this size.

Thanks,

Brandon Linn
Lead Account Manager



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email | blinn@babcockpower.com

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 23, 2022 11:10 AM
To: Linn, Brandon <BLinn@babcockpower.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Brandon,

Can you give me an update regarding UAF BACT Cost Estimate. After the last meeting I believe Babcock Power was going to discuss internally in regards to price and schedule.

Thanks,

Mark

From: Fritz, Mark
Sent: Tuesday, March 8, 2022 10:33 AM
To: Linn, Brandon <BLinn@babcockpower.com>; Rowell, Lance <RowellLance@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

Brandon,

I am the Project Manager for this job and Lance was helping me out with the initial information request. Yes, I am available this week to discuss, please call to coordinate a time.

See below for my answers to your questions in red. I am no expert in WFGD systems, so a discussion of some of my answers may be warranted.

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

From: Linn, Brandon <BLinn@babcockpower.com>
Sent: Tuesday, March 8, 2022 9:05 AM
To: Rowell, Lance <RowellLance@stanleygroup.com>
Cc: Black, Stephen <SBlack@babcockpower.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate
Importance: High

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Lance,

Just following up, as I haven't heard back from you. Would you be available for a call this week to discuss? We are interested, but would like to have a call before we really dig into this.

Thanks,

Brandon Linn

Lead Account Manager



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From: Linn, Brandon

Sent: Wednesday, March 2, 2022 4:45 PM

To: RowellLance@stanleygroup.com

Cc: Black, Stephen <SBlack@babcockpower.com>; FritzMark@stanleygroup.com

Subject: RE: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

Lance,

Steve Black forwarded me this email with the attachments to review. A few quick questions from an initial review:

- What is the target stack outlet SO2 for the project, or the target % removal? **Looking for typical removal efficiency for each technology.**
- For the WFGD waste stream for treatment by others, should this be read as the blowdown/purge stream? **If Babcock Power can provide a quotation for all waste treatment system we would be interested.** If dewatering of the absorber bleed is in our scope, would gypsum handling and storage from the discharge of the vacuum or drum filter be by others? **No, include in your scope.**
- For WFGD, any reagent requirements? Limestone, lime, lye/caustic soda (sodium hydroxide)? **The boiler is a CFB that utilizes limestone. I assume limestone as a reagent, unless other reagents have an effect on removal efficiency or capitol cost.**
- Would you consider DSI for SO2 removal, for example Trona? **Yes. But would probably use sodium bicarbonate for its higher removal efficiency and local availability.**

Thanks,

Brandon Linn

Lead Account Manager



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email | blinn@babcockpower.com

web | <https://www.babcockpower.com>

From: Rowell, Lance <RowellLance@stanleygroup.com>
Sent: Wednesday, February 09, 2022 5:00 PM
To: Black, Stephen <SBlack@babcockpower.com>
Cc: Fritz, Mark <FritzMark@stanleygroup.com>
Subject: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate

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Steve,

It was a pleasure talking with you earlier this afternoon.

Stanley Consultants is doing a BACT analysis for the UAF due to the EPA having the area as a non-attainment zone for SOx. As part of this analysis we need to have cost estimates for applicable technologies to reduce the SO2 emissions. Below is a section of the boiler and attached is some applicable data.

Information attached:

Boiler data sheet (includes coal analysis)

Plant layout (CHPP Layout)

UAF Exhaust Gas Data (for exhaust gas entering the baghouse)

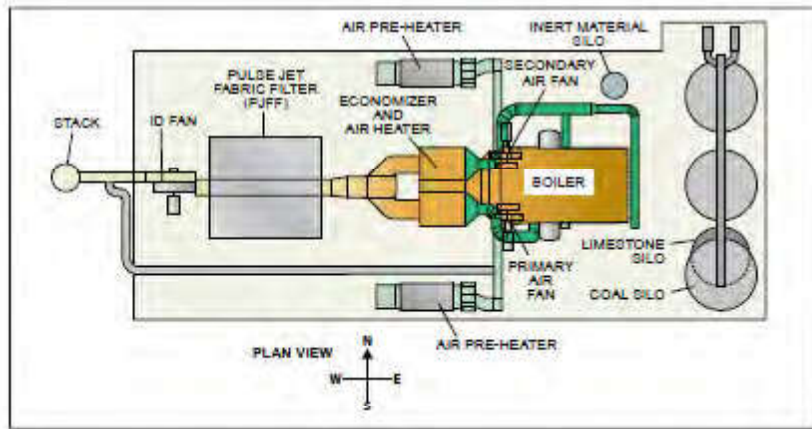
Baghouse data (for existing baghouse)

Unit is a 240,000 lb/hr B&W circulating fluidized bed boiler which was installed in 2017.

We are looking for budget pricing (+/-30%) for material supply, approximate footprint required, utilities/lime used, and if the existing baghouse would need to be replaced.

In our conversation you mentioned that generating this budgetary pricing would probably cost around \$5-\$10k and take approximately 4 weeks. Please review and let me know what it would take to do this budgetary pricing. If there is anything that we are requesting that takes significant effort, please let me know.

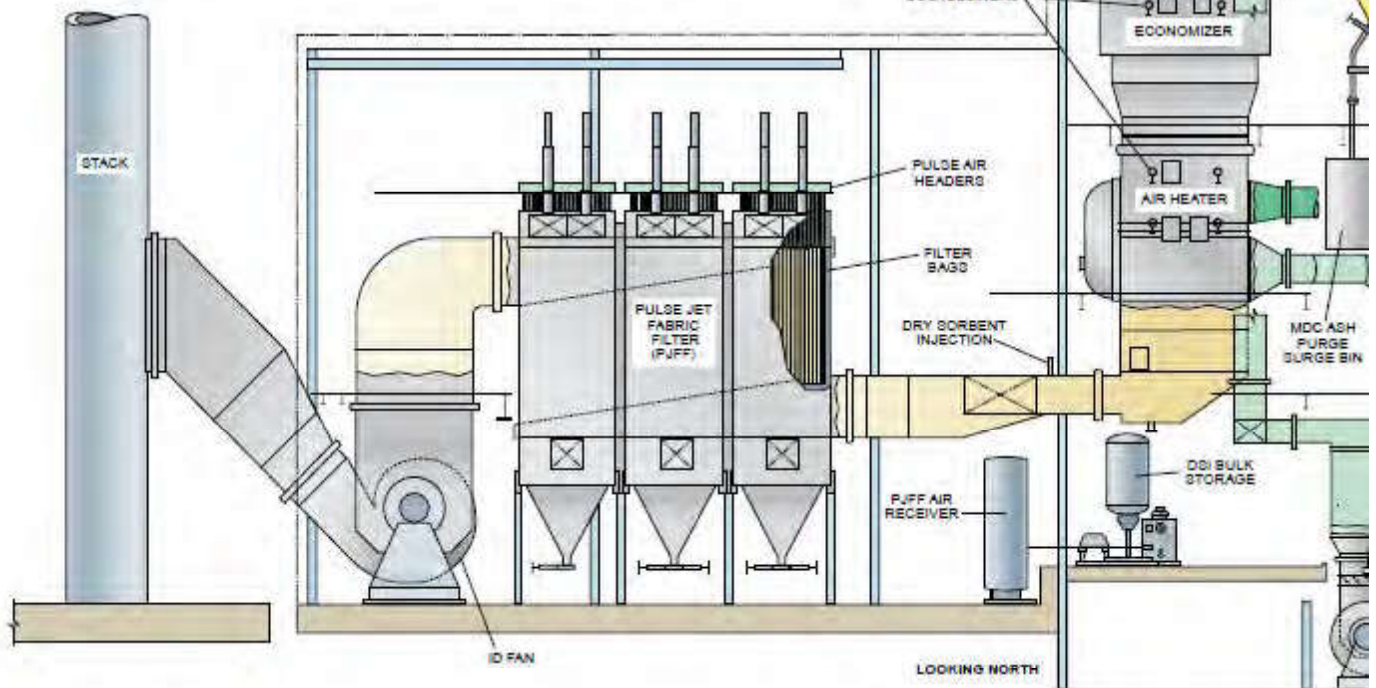
We look forward to hearing from you.



UNIVERSITY OF ALASKA FAIRBANKS COMBINED HEAT and POWER PLANT

Babcock & Wilcox Circulating Fluidized-Bed Boiler

Steam Flow 240,000 lb/hr (30.24 kg/s)
 Steam Pressure 740 psig (5.1 MPa)
 Steam Temperature 750F (399C)



Thanks!



Lance Rowell, PE, PMP, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52761
 T: 563.264.6548 | stanleyconsultants.com

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Public Review Draft

August 19, 2024

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Tri-Mer CDS

Jahn, Mario

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Tuesday, August 23, 2022 6:57 AM
To: Jahn, Mario
Cc: Asa Halliday; Ted Hornus; Deirdre Labert; Vincent DiGiorgio
Subject: RE: P-23.182 Stanley SO2 Removal Project for UAF Fairbanks, AK
Attachments: P-23.182 Stanley SO2 Removal Project University of Alaska Fairbanks AK R2 8-23-2022 SENT.pdf

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Good morning Mario,

Enclosed please find the revised proposal P-23.182 for Stanley's SO2 removal project for UAF in Fairbanks, AK. Based on the recent discussion on converting the CDS model to hydrated lime, I have also updated that section of the proposal. Besides minor editorial changes, the proposal should now be consistent with your requirement of using hydrated lime as sorbent for the SO2.

In case of any further questions or recommendations, please let me know.

Best regards
Martin

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Monday, August 22, 2022 5:56 PM
To: Martin Schroeter <mschroeter@tri-mer.com>
Cc: Asa Halliday <ahalliday@tri-mer.com>; Ted Hornus <thornus@tri-mer.com>; Deirdre Labert <dlabert@tri-mer.com>; Vincent DiGiorgio <vdigiorgio@tri-mer.com>
Subject: RE: P-23.182 Stanley SO2 Removal Project for UAF Fairbanks, AK

Martin,

I wanted to double check with you on the last proposal you provided. The text in the proposal states sodium bicarbonate for the DSI system (see page 16 of 24 in the PDF). But the consumption table at the end of the document states hydrated lime consumption (page 21 of 24 in the PDF). Can you confirm the use of hydrated lime for the DSI system? It would be nice if the document can be updated to avoid any confusion in the future.

Thanks,
Mario

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Tuesday, July 26, 2022 8:29 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Asa Halliday <ahalliday@tri-mer.com>; Ted Hornus <thornus@tri-mer.com>; Deirdre Labert <dlabert@tri-mer.com>; Vincent DiGiorgio <vdigiorgio@tri-mer.com>
Subject: P-23.182 Stanley SO2 Removal Project for UAF Fairbanks, AK

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Good morning Mark,

Enclosed please find the revised proposal P-23.182 Stanley SO2 removal for UAF Fairbanks, AK. We have updated the SorbSaver Pro (DSI) technology sections for hydrated lime injection (Sorbacal SPS or similar quality) and 90% SO2 removal.

We will be pleased to clarify any questions, once you have reviewed the proposal.

In case you have additional questions, please let me know.

Best regards

Martin Schroeter

Sales - Ceramics Technology Group (CTG)

Tri-Mer Corporation

1400 E Monroe Street

Owosso, MI 48867

Mobile Phone: (989)-627-1040

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SO₂ MITIGATION SOLUTIONS

RANGE OF SO₂ MITIGATION SOLUTIONS FOR UAF FAIRBANKS CFB BOILER

REFERENCE NUMBER: P-23.182

REVISION: 2

PREPARED FOR STANLEY CONSULTANTS

MARK FRITZ

225 IOWA AVENUE
MUSCATINE, IA 52657

(563) 607-1430

FRITZMARK@STANLEYGROUP.COM

PROPOSAL ISSUED:

AUGUST 23, 2022

PROPOSAL VALID TO:

SEPTEMBER 6, 2022

TRI-MER CORPORATION

1400 E MONROE STREET
OWOSSO, MI 48867

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(989) 723-7838

PRINCIPAL CONTACT:

MARTIN SCHROETER

(989) 627-1040

MSCHROETER@TRI-MER.COM

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EXECUTIVE SUMMARY

Tri-Mer Corporation (TMC) is delighted to have the opportunity to work with Stanley Consultants (Stanley) to present a range of technical solutions for reducing SO₂ at the University of Alaska (UAF) CHPP plant in Fairbanks, Alaska. Our aim throughout this proposal is to introduce TMC and its technologies to both Stanley and UAF, highlighting our capabilities and experience to ensure we can be considered as a key partner for this project. All related scope and pricing are budgetary at this stage, and we welcome the opportunity to work closer with both Stanley and UAF to better detail these options with the aim of presenting the best available control technology for this project.

Following the initial RFI and subsequent clarifications with Stanley, we have spent considerable time to evaluate the best options, with the recommendations taking into consideration a range of factors including performance requirements, CapEx, OpEx, commodity availability, and risk. Following this review, we present four core solutions for consideration:

1. Circulating Dry Scrubber (CDS) – Adding a scrubber vessel inside the existing building, or in default of available space at the side of the existing building, to the existing baghouse with a forced recirculation of filtrate to the injection point of the sorbent. Turndown rate is maximized by distributing the flow from the boiler into 2 scrubbers.
2. SorbSaver Pro Injection (DSI) – Adding TMC's proprietary DSI injection technology at the inlet of the air preheater that ensures a minimum residence time and mixing. The DSI technology will be capable of handling a wide range of turndown rate.
3. Recirculating Dry Scrubber (RDS) – Adding an integrated scrubber and baghouse system in the designated footprint area, which ties in at the outlet of the boiler and replaces the existing baghouse. Turndown ratio is controlled by clean flue gas recirculation.
4. Caustic Soda Wet Scrubber (CSWS) – Adding a caustic soda wet scrubber in the designated footprint area, which ties in at the outlet of the existing baghouse. Turndown ratio is maximized by distributing the flow from the boiler into three (3) separate scrubber lines but operating only two (2) lines at reduced flow..

At TMC, we believe that selecting the right technology is only one element of the process, and as such, we have the capability to provide a wider range of lifecycle support options.

1. For many clients and projects, we work in partnership early in the process to help identify and solve the immediate need and solution. TMC have a range of pilot, mobile testing and predictive chemistry CFD modeling solutions that can help Stanley evaluate the best technical solution
2. In partnership, we believe that TMC is best served to support Stanley with upfront engineering support to be able to better detail the right solution. With over 60 years' experience and with over 6,500 global installations, TMC is unique in our focus on delivering the right solution. We can do this due to the wide range of technologies we offer, ensuring a more holistic review is achieved, rather than a preference for one technical solution.
3. For all of our projects, we provide our solutions from simple equipment design & supply, all the way through to full turnkey delivery. With in-house fabrication based in Michigan, combined with experience delivering turnkey projects throughout North America, we can work with Stanley to define the right package that suits all parties

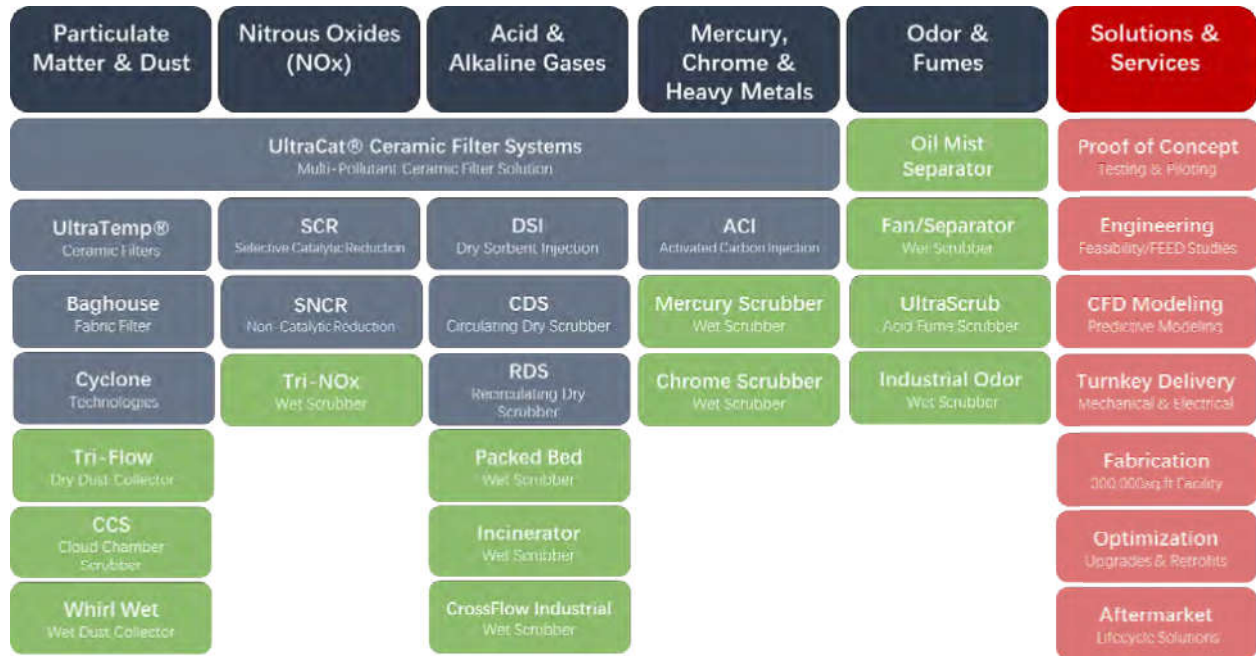
4. While our aim is to offer the right solution, our initial focus is on demonstrating the lowest achievable capital cost solution (LACC), in order to best evaluate what the lowest cost of compliance can be. From this point, we present a wide range of value-adding options, each demonstrating tangible benefits in areas such as lower OpEx, risk mitigation, and reduced maintenance that can be considered in their own merit.
5. The key to our lifecycle service is our continued dedication to support our clients in the long-term. TMC have a wide range of solutions that we can offer. From simple call-out support and spare parts, through to tailored operation & maintenance packages that are individually designed to best serve our clients.

We are confident that TMC has the right technology, can offer the right solution, and importantly is the right partner for both Stanley and UAF, and as such, we look forward to the opportunity to discuss this project with you in the near future.

ABOUT TRI-MER

ABOUT US

For over 60 years, Tri-Mer has developed a strong specialism in the area of air pollution control. The business has over 6,000 global installations for a wide range of technologies and solutions for clients that address all major pollutants. TMC has developed a large number of technologies in-house, and works with proven partners to allow for expanded scope where required.



Based in Owosso, Michigan, TMC is primarily a full-solution-integrator for air pollution control. The company headquarters includes over 200,000 sq. ft. of state-of-the-art steel fabrication and manufacturing facilities. While our wide range of technologies and solutions provide the strong foundation for the business, it is our dedication to exceed your needs through full and flexible lifecycle services, that help to set us apart.

EXPERIENCE

TMC, in combination with our partners, have successfully delivered over 60 sorbent injection systems across North America, together with over 200 systems worldwide. By working together, TMC and our partners are able to provide leading edge SO₂ mitigation technologies with full emission control process understanding. This, together with our capability to deliver full turnkey and aftermarket support, are some of the many ways we aim to better support our clients



AFTERMARKET SUPPORT

The following options present a range of solutions that TMC can provide the customer to support the operation and maintenance of your system. Our aim at this point is to show the range of services that can be provided, and then discuss building a tailored solution that can provide the customer exactly what the customer wants, both for this facility, but also when considering fleet-wide support.

The table below highlights the range of options available to the customer, together with the different tiers of service TMC can deliver depending on your individual requirements. Based on your preferences, TMC will build a tailored aftermarket support package to best suit your needs,

	TIER 1 LEVEL	TIER 2 LEVEL	TIER 3 LEVEL
System Inspections, Reporting, and Instrumentation Calibration	Annual System Inspections & report, combined with spare part inventory reviews. Pressure and temperature transmitter calibration performed by TMC.	Quarterly System Inspections & report, combined with spare part inventory reviews. Pressure and temperature transmitter calibration performed by TMC.	Monthly System Inspections & report, combined with spare part inventory reviews. Weigh scales, pressure and temperature transmitter calibration performed by TMC.
Remote Monitoring Diagnostics & Reporting	Remote Monitoring subscription with quarterly performance reporting	Remote Monitoring subscription with monthly performance reporting, plus proactive optimization analysis	Remote Monitoring subscription with weekly performance reporting, plus proactive optimization analysis
Critical Spare Parts Management	One-off spare part requests after Year 1, Customer stores all spare parts at your facility	Management of spare parts at customer's facility, with auto ordering of parts to maintain full set at all times	Management of spare parts at TMC facility, with auto ordering of parts to maintain full set at all times
Routine Maintenance & Consumable Management	All pre-defined routine maintenance, with consumables purchased by customer	All pre-defined routine maintenance, with consumables purchased by TMC	All routine and unscheduled maintenance, with TMC purchasing specified consumables
Programming & Automation	Provide suggestions to customer for programming and automation upgrades	Base support contract, including support during business hours	Upgraded support contract, including support 24/7
System Operation	Operator Oversight (in conjunction with preferred inspection schedule)	Full-time operation, 1 shift	Full-Time operation, with 2 nd /3 rd shift call-out support

DESIGN & PERFORMANCE CRITERIA

PROCESS CRITERIA

UAF combined heat and power plant CHPP consists of one high efficiency CFB boiler. The boiler is of a circulating bed type manufactured by B&W and has heat input of 295.6 MBtu/hr at a production capacity of 240 Mlb/hr of steam @ MCR. The boiler is fired with coal of Alaskan convenience with a higher heating value of 7,560 Btu/lb. Since the coal with 0.20 wt.% contains a considerable amount of sulfur the CHPP is required to reduce SO₂ emission, Presently, the boiler is equipped with furnace sorbent injection (FSI) of limestone and a baghouse for PM control. The CHPP typically operates between 33 – 100% MCR. The emission control system has to be design handle the full range of turndown.

EXHAUST GAS DATA AT THE FLUE TIE-IN DOWNSTREAM OF THE ECONOMIZER

The design is based on following data informed in the Request for Budgetary Quote received on 3/25/2021 as well as in an email dated of 4/1/2021 sent by Mr. Griffin Karr. You are kindly requested to review and confirm below shown design basis. In case you see any wrong information, please let us immediately know.

Condition		100% MCR	70% MCR	40% MCR	33% MCR
Fuel Input	MMBtu/hr	295.6	206	118.8	118.0
Elevation	ft	446	446	446	446
Flow Rate	acfm	89,832	61,165	50,217	65,748
Temperature	F	289	265	288	354
Pressure	inH ₂ O	-2.0	-2.0	-2.0	-2.0
Flue Gas Composition					
H ₂ O	%	8.5	8.5	8.5	8.5
N ₂	%				
O ₂	%	3.7	3.7	3.7	3.7
Ar	%	0.0	0.0	0.0	0.0
CO ₂	%	16.1	16.1	16.1	16.1
Inlet Conditions					
NO _x	lb/MMBtu	0.0	0.0	0.0	0.0
SO ₂	lb/MMBtu	0.2	0.2	0.2	0.2
HCl	lb/MMBtu	0.0	0.0	0.0	0.0
PM	lb/MMBtu	9.0	9.0	9.0	9.0

PERFORMANCE CRITERIA

The presented technical solutions are expected to meet following performance

SYSTEM	CDS	DSI	RDS	CSWS	MEASUREMENT METHOD at stack based on a 30-day rolling average
SO ₂ , %	90 %	90 %	89%	> 99%	US EPA Method 6C
PM, lb/MMBtu	0.012	0.012	0.012	0.012	US EPA Method 5
Pressure drop, in WC	5	0	10	7	@ 100% MCR

PROJECT APPROACH

Following the initial RFI and subsequent clarifications with Stanley, we understand that Stanley and UAF are investigating different technologies for control of SO₂ and PM emission with focus on main factors that drive a site-specific solution, consisting of, but not limited to, performance requirements and availability of the boilers, total cost of ownership (TOC) a.o.. Following this review, we present three core solutions for consideration:

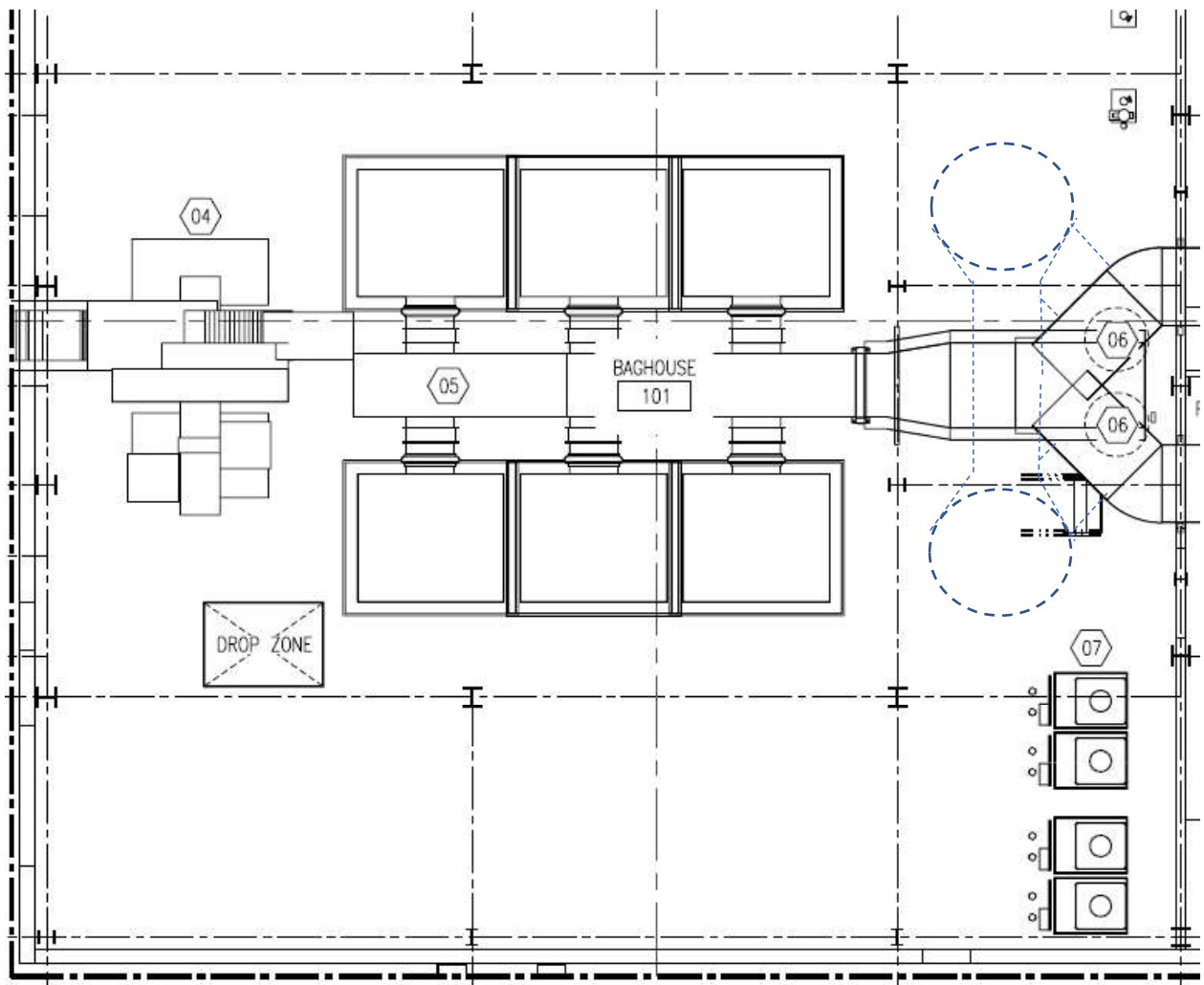
CIRCULATING DRY SCRUBBER (CDS)

The circulating dry scrubber solution will be installed as add-on equipment upstream of the existing PJFF. For optimum chemical reaction, hydrated lime-based sorbent (Sorbacal SPS or similar quality) is injected upstream of the economizer. Due to its high degree of integration with and short distance to existing equipment, the circulating dry scrubber represents the low capital cost (LCC) equipment solution for dry SO₂ emission control technologies.

Operational flexibility is achieved by splitting the flue gas coming from the economizer into 2 separate lines, each equipped with a dry scrubber. The exhaust of the dry scrubbers is recombined and returned to the inlet of the existing PJFF. The additional pressure drop of the added ductwork and dry scrubber equipment is expected to fall into the extra capacity of the existing ID-fans.

The solid waste stream extracted from the hopper section of the existing PJFF will be pneumatically returned to the injection point in the bottom of the dry scrubber. A purge stream corresponding to the incoming flow of fly ash and fresh sorbent will be extracted from the hopper section and returned to the existing ash handling system of the CHPP.

It is suggested to investigate placing the scrubber vessels inside the existing baghouse building.

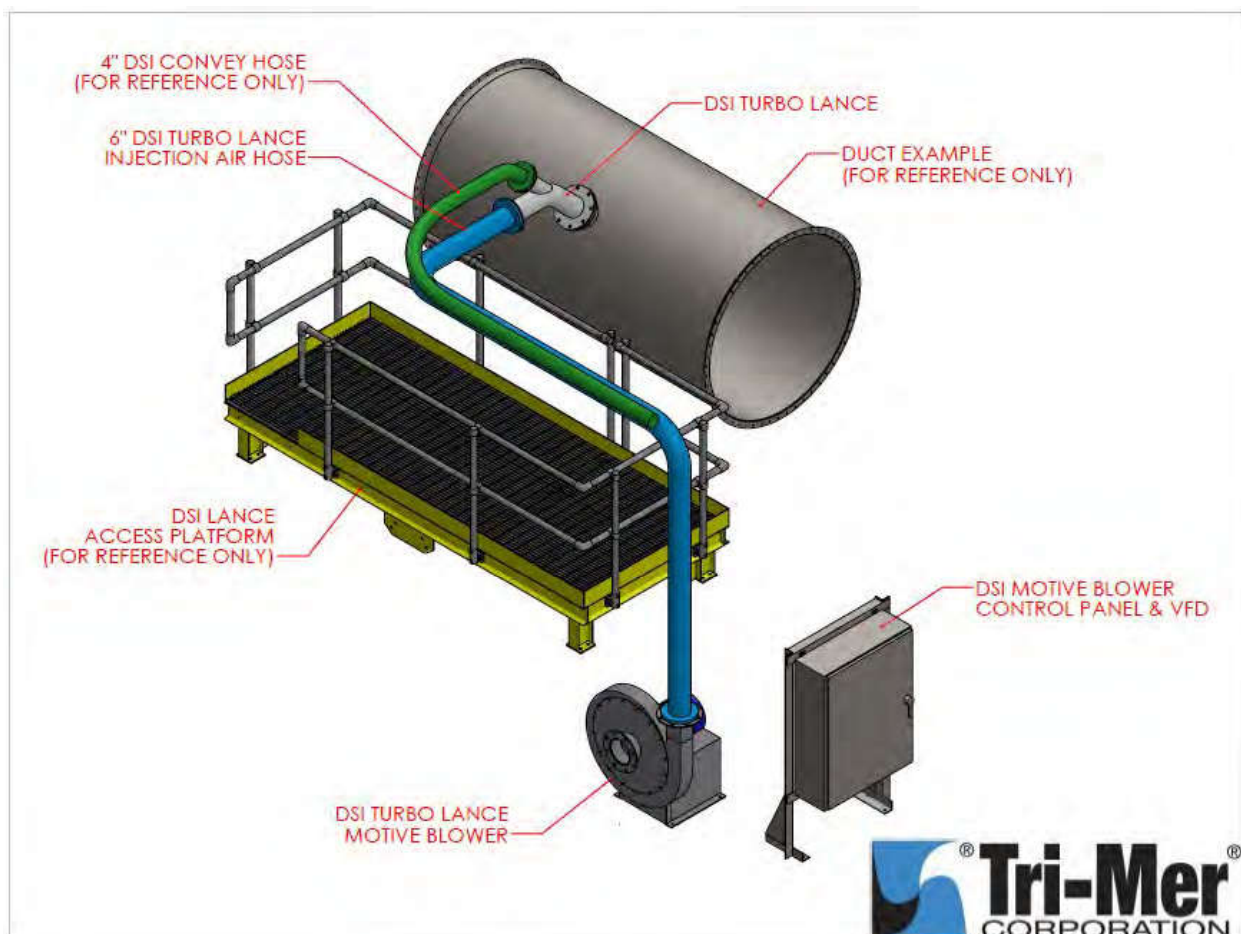


SORBSAVER PRO INJECTION (DSI)

The SorbSaver Pro injection solution consists of an air blower assisted injector, which is mounted on the outside of the duct. Since none of its parts is inserted into the gas flow, it is protected from deteriorating impact of flue gas constituents and allows for easy maintenance. Like in a bi-fluid nozzle the assisting blower air is atomizing the sorbent, while leaving the nozzle. The additional momentum contributes to distribute the sorbent over the complete cross section of the duct in a massive plume. This instant dispersion of the sorbent forms the basis of an improved inflight reaction. In comparison to conventional lance injection technology, improvement of inflight SO₂ removal efficiency of 60-80% have been monitored and combined with baghouse a still considerable 20-30%.

The SorbSaver Pro allows for a wide turndown rate in excess of 1:10.

Since SorbSaver Pro does not add any further equipment in the way of the flue gas flow, no additional pressure drop is expected. SorbSaver Pro is capable of being combined with any separation technology, like cyclone, ESP, baghouse or hot gas filter, whether pre-existing or tailor designed.

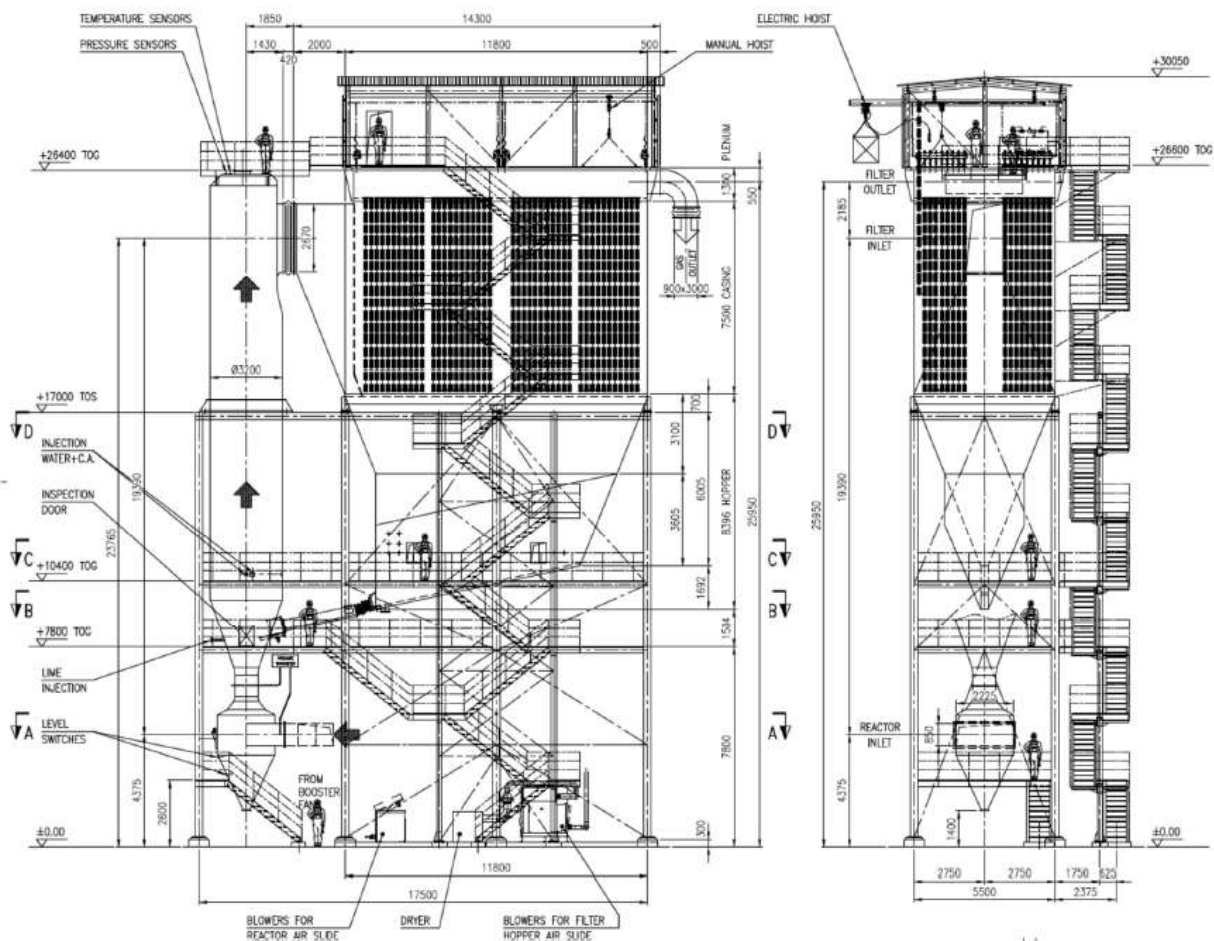


RECIRCULATING DRY SCRUBBER (RDS)

The recirculating dry scrubber solution is the most self-integrated technology and will replace all existing equipment from inlet of existing PJFFs to ID-fans and stack. While the recirculating dry scrubber is the most capital-intensive solution, it allows the use of lime-based sorbent at low fresh sorbent consumption. Although both the circulating as well as the recirculating scrubber technologies are based on the same principle of again and again exposing the sorbent material to the exhaust gas, the self-integration of the recirculating dry scrubber technology allows for a higher dust load. Increased recirculation rate of the sorbent material minimizes the consumption and subsequently allows for usage of less reactive sorbent material.

Operational flexibility is achieved by clean flue gas recycle to the inlet of the dry scrubber. New ID-fans will provide the energy to overcome the pressure drop of the recirculating dry scrubber and exhaust the treated flue gas to a new stack for each boiler.

Below drawing demonstrates the arrangement of a recirculation dry scrubber system.

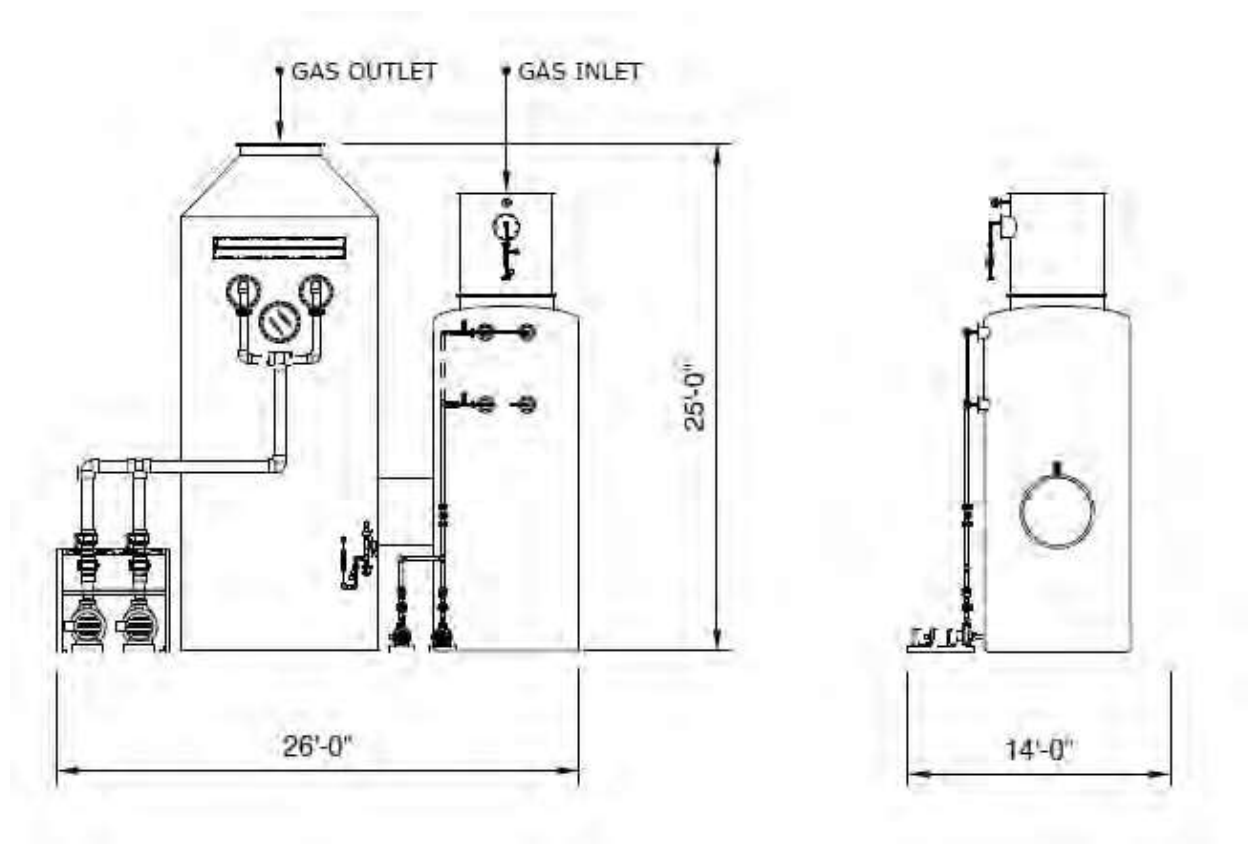


CAUSTIC SODA WET SCRUBBER (CSWS)

The caustic soda wet scrubber solution will be installed as add-on equipment downstream of the existing PJFF. Due to its high degree of integration into existing plant equipment, while utilizing the required existing PJFFs and ID-fans, as well as high performance efficiency for SO₂ control at the specified temperature level, caustic soda wet scrubber represents a low capital cost (LCC) equipment solution.

Flue gas from the boiler will be routed from tie-in point downstream of the PJFF. Operational flexibility is achieved by splitting the flue gas coming from the existing ID-fans to the designated footprint area, bridging the existing road between the baghouse building and the designated footprint area. The flue gas from each individual boiler will be split into three (3) separate lines consisting of a quench equipped to condition the flue gas temperature to optimal operation temperature for the downstream packed bed caustic soda scrubber unit. Additional booster ID-fans for each line provide the energy to overcome the pressure drop of the wet scrubber system and exhaust the treated flue gas to stack.

Below flow schematic demonstrates the arrangement of equipment for one individual line of the wet scrubber solution package.



SCOPE OF WORK

CIRCULATING DRY SCRUBBER (CDS)

In order to reduce the SO₂ to the required emission at stack we designed a circulating dry scrubber (CDS) system, which utilizes the existing baghouse (PJFF), flue gas fan and stack. The treatment takes mainly place in the reactor upstream of the existing baghouse.

The flue gases coming from the boiler will enter the reactor centrally from the bottom part of two (2) reactors treating half flow and it will move in turbulent flow with the fresh hydrated lime (Sorbacal SPS or similar quality) and back-flowing lime products to the top section of the reactor. The flue gases will exit from the top of the absorber as a dust/gas mixture and then will enter the existing bag filter.

Reagent injection rate will be controlled by a feedback signal for pollutants contents coming from CEMS (by Others).

The dust collected in the hopper part of the baghouse will be pneumatically transported to a buffer silo. A large portion of the material collected in the buffer silo will feed the solids recycling system by means of a control valve and a pneumatic transport system.

The by-product will be discharged from the buffer silo by pneumatic transportation to the existing dust handling system.

The split of the total flue gas flow into two separate reactors allows for operation of the reaction system over the large span of turn-down ratio required. The exhaust of both reactors will be recombined upstream of the baghouse inlet.

BASIC SCOPE

SORBENT SUPPLY

Hydrated lime supply consists of one (1) 3,700 cft silo with one (1) volumetric feeder. The hydrated lime will be pneumatically transported to the injection location upstream of the reactors.

REACTORS

The reactors will consist of two (2) parallel reactor vessels incl. support structure. Each reactor can be isolated by one (1) inlet and one (1) outlet damper. The existing duct will be equipped between tie-in point and return breach with one (1) pneumatic double blade damper with sealing air for bypass service.

DUST COLLECTION AND RECIRCULATION SYSTEM

The dust collection system will consist of one (1) screw transport system from extraction point of the hoppers of the baghouse to one (1) 1,100 cft buffer silo. From the buffer silo, the majority of the dust is recirculated by screws to the injection point of the back-flowing lime products into the reactors. A purge flow of dust is extracted to one (1) dense phase pneumatically transport line to connect the buffer silo with the existing dust handling system.

INTERCONNECTING DUCTWORK

Ductwork from economizer outlet to inlet of the CDS reactors and outlet of the CDS reactors to inlet of the existing baghouse, consisting of in total 250 ft of 58" diameter round duct fabricated of A36, including standard duct supports and seven (7) expansion joints.

SORBSAVER PRO INJECTION (DSI)

In order to reduce the SO₂ to the required emission at stack we designed a proprietary SorbSaver Pro injection system, which will inject the hydrated lime (Sorbacal SPS or similar quality) preferentially upstream of the economizer, utilizing the existing baghouse (PJFF), flue gas fan and stack. The treatment takes mainly place in the duct and in the filter cake of the baghouse.

Reagent injection rate will be controlled by a feedback signal for pollutants contents coming from CEMS (by Others).

The dust collected in the hopper part of the baghouse will be treated together with fly ash in the existing ash collection system.

The SorbSaver Pro injection has the capability to handle the full range of expected turndown rate.

BASIC SCOPE

SORBENT SUPPLY

Hydrated lime (Sorbacal SPS or similar quality) supply consists of two (2) 3,000 cft silo, including bin activator and fill rotary valve, with one (1) gravimetric feeder upstream of one (1) 250 ft long rubber hose, propelled by one (1) fan, each. The sorbent of each line will be equally split to two (2) SorbSaver Pro injectors per air pre-heater (APH) inlet duct.

SORBSAVER PRO INJECTOR

The SorbSaver Pro injectors will be mounter on the outside of the inlet duct of the APH. The injector will be equipped with a blower fan supplying the atomizing air for fast distribution of the sorbent in the flue gas.

RECIRCULATING DRY SCRUBBER (RDS)

To reduce the pollutants' content to the presented levels, we are offering a properly designed dry flue gas treatment system, with injection of hydrated lime as reagent. The treatment will be performed upstream the bag filter through a Reaction Tower (scrubber/absorber) and it will also take place in the bag filter thanks to its volume, and thanks to the cake effect.

The flue gases coming from the boiler will enter the reactor centrally from the bottom part of the reactor and it will move in turbulent flow with the fresh hydrated lime and back-flowing lime products to the top section of the reactor. Inside the reactor, after lime injection and dust recirculation, water will be injected to control temperature and improve abatement performance. The flue gases will exit from the top of the absorber as a dust/gas mixture and then will enter the bag filter.

Reagent injection rate will be controlled by a feedback signal for pollutants contents coming from CEMS (by Others).

A large portion of the material collected in the hoppers (which act as storage bins) will feed the solids recycling system by means of a control valve and a fluidized slides system.

The by-product will be discharged out through the filter hoppers by means of control valves into the new pneumatic dust transport system.

A flue gas recirculation will assure the correct minimum gas flow to the reactor in case the flow from the process is below approx. 75% of the nominal. A modulating damper will regulate the flow recirculation depending on the process variations.

BASIC SCOPE

SORBENT SUPPLY

Hydrated lime supply consists of one (1) 3,200 cft silo with one (1) loss in weight feeder. The hydrated lime will be pneumatically transported with two (2) parallel working blowers to the injection location in the bottom of the reaction vessel.

REACTOR

The reactor system is consisting of one (1) reactor vessel incl. support structure. Water will be injected for flue gas conditioning and agglomeration. The water injection system consists of two (2) spillback high pressure pumps, one (1) in service and one (1) in stand-by, feeding to spray lances downstream of the solids.

BAGHOUSE FILTER

The baghouse filter is consisting of two (2) parallel compartments, each of them capable to be fully isolated. The baghouse is equipped with a back pulse jet system allowing online filter cleaning, incl. pressurized air receiver tanks, solenoid valves and plow pipes (Compressed air supply Class 1/2/1, ISO 8573-1:2010, by customer). The baghouse contains 840 PPS Raiton bags or similar fabric quality. The dust will be collected in the hopper section, which is also the buffer for the recirculation material.

DUST COLLECTION AND RECIRCULATION SYSTEM

The dust recirculation system is designed to allow for a max flow of 90 US short tons/hr, based on the performance requirements. The dust recirculation system consists of one (1) hopper air slide transporting the dust directly from the hopper section of the baghouse to the re-injection point of the reacted hydrated lime. One (1) rotary valve at hopper outlet will dose the recirculation feed rate. One (1) cut-off valve at the end of the air slide controls the amount of extracted dust, which will be pneumatically transported to the dust handling system.

The extracted dust will be pneumatically transported to two (2) dust storage silos of a capacity of 5,300 cft, each.

ID FAN

One (1) 200 hp ID fan incl. motor and VFD

INTERCONNECTING DUCTWORK

Ductwork upstream of RDS inlet, consisting of 200 ft of 58" diameter round duct fabricated of A36, including standard duct supports and seven (7) expansion joints.

All interconnecting ductwork from outlet of the baghouse to stack, including the stack. Ductwork upstream of quench inlet is by others.

CAUSTIC SODA WET SCRUBBER (CSWS)

The caustic soda wet scrubber solution will be installed as add-on equipment downstream of the existing PJFF. Due to its high degree of integration into existing plant equipment, while utilizing the required existing PJFFs and ID fans, as well as high performance efficiency for SO₂ control at the specified temperature level. caustic soda wet scrubber represents a low capital cost equipment solution. Turndown will be realized by operating two (2) of the three (3) quench/packed bed scrubber lines.



BASIC SCOPE PER BOILER

QUENCH COLUMNS

Three (3) quench columns in vertical configuration (countercurrent) operating in parallel to facilitate evaporative cooling of gas stream prior to scrubber inlet. Quench columns to be constructed of 316 stainless steel. Liquid delivery to be supplied via downstream scrubber recirculation pumps. Fresh water supply should be supplied to spray header as an alternate to the re

VERTICAL FLOW (V/F) PACKED BED SCRUBBER

Three (3) wet packed bed scrubbers in vertical configuration (countercurrent) operating in parallel. Scrubbers shall be constructed of white polypropylene. Random dump packing to be Tri-Packs® type in polypropylene material of construction.

Mist eliminator to be mesh pad type in polypropylene material of construction. Integral recirculation system to consist of 100% redundant horizontal pumps, schedule 80 CPVC plumbing and internal sump.

EXHAUST BLOWER

(3) pressure blowers designed for operating in parallel. Exhaust blower housing and impeller to be constructed of FRP, base and pedestal to be constructed of carbon steel.

EXHAUST STACK

Exhaust stack to be breach-fitted type in UV-inhibited white polypropylene construction, 16-0" overall height. Not a freestanding assembly, guy-wire anchor points, support to be determined in design phase

CHEMICAL FEED PUMP ASSEMBLY

Three (3) polypropylene enclosures with clear polycarbonate doors to house 100% redundant chemical feed pump assemblies. Pumps to be electric metering or air-actuated type for supply of NaOH to scrubber system.

INTERCONNECTING DUCTWORK

Ductwork upstream of quench inlet consisting of 250 ft of 54" diameter round duct fabricated of A36, including standard duct supports and seven (7) expansion joints.

Interconnecting ductwork between outlets of three (3) scrubbers and three (3) exhaust blower inlets is included,

contingent on exhaust blower being located on grade immediately proximal to scrubber and quench columns. Ductwork to be constructed of white polypropylene.

Ductwork between three (3) exhaust blower outlets and (1) exhaust stack inlet to be constructed of white polypropylene, contingent on the stack being within 250 feet of the exhaust blowers.

PRE-ASSEMBLY AT TRI-MER CORPORATION

To include assembly and alignment of exhaust duct from scrubber outlet to exhaust fan inlet and setting of exhaust stack on exhaust fan. Match marking duct, exhaust stack or breech fitted exhaust stack, and pre drilling flanges as required.

SYSTEM CONSUMPTION ESTIMATES

The proposed systems are expected to have following consumption figures:

	CDS	DSI	RDS	CSWS
Power	120 kW ¹	48 kW	244 kW	310 kW
Water	-	-	16 gpm	44 gpm
Compressed air ²	62 scfm	-	292 scfm	-
Hydrated lime	280 lb/hr ³	563 lb/hr ³	144 lb/hr	-
Ash	2,895 lb/hr	3,195 lb/hr	2,875 lb/hr	-
50% NaOH	-	-	-	117 gph

¹ Estimated power consumption is based on booster fans to overcome the additional pressure drop

² Compressed air us of pre-existing PJFF is not included

³ Consumption figures are based on Sorbacal SPS or similar quality

CLARIFICATIONS & EXCLUSIONS

The basis for all pricing, design, engineering and performance requirements contained in this proposal are based solely on the information received from Stanley. As with any proposal of this complexity there are exclusions that require clarification and for this project those are listed below.

	CDS	DSI	RDS	CSWS
Any permits	X	X	X	X
Anchor bolts	X	X	X	X
Utilities – Power, water, sorbent, and drain	X	X	X	X
Gas analyzers or CEMS	X	X	X	X
Lightning	X	X	X	X
Spare parts	X	X	X	X
Control room	X	X	X	X
Unit DCS, MCC and control panels	X	X	X	
Compressor station and building	X	X	X	X
Compressed air piping	X	-	X	-
Electrical field material, junction boxes, cables, wiring	X	X	X	X
Dismantling of existing manifold or equipment	X	X	X	X
Thermal insulation supply and field insulation works	X	X	X	X
Civil engineering	X	X	X	X
Foundations, civil and building works	X	X	X	X
Interconnecting piping caused by fresh sorbent silo placing outside of designated installation area	X	X	X	X
Interconnecting piping to customer's solid waste handling system	X	X	X	X
Mechanical & Electrical installation	X	X	X	X
Start-up and field services				X
Duties, taxes, tariffs or insurance	X	X	X	X
Supports or catwalk assemblies		X		X
Supply and/or bulk storage of chemicals	-	-	-	X
CE documentation of certification	-	-	-	X
Heat tracing and thermal insulation of scrubber liquid recirculation system	-	-	-	X
Freight to jobsite	X	X	X	X
Seismic calculations, wind loading, foundational loading, and center of gravity calls	X	X	X	X
All materials and services not specifically listed in this proposal are to be supplied by Stanley.	X	X	X	X
Function tests will be performed with commissioning after equipment is installed to ascertain that the system is fully functional according to specifications. Emission tests shall be ordered and paid for by the client to an independent company a maximum of 30 days after installation to confirm the performance of the system.	X	X	X	X
Operator shall maintain strict adherence to the Operation and Maintenance manual and any sub-component maintenance manuals and schedules	X	X	X	X
Drawings are provided in standard 2-D format. 3-D modeling is available upon requests. Additional time and fees may apply. Pricing includes a maximum of two (2) revision rounds per submittal.	X	X	X	X

Additional revisions may be completed at an additional cost of \$125 per hour.				
Integration to additional site equipment is not included	X	X	X	X
Any interconnecting ductwork, expansion joints, dampers, and supports not specified above	X	X	X	X
Access platforms or catwalks		X		X
Motor Control Center (MCC) and all required VFDs shall be provided by Stanley				X
Integration of Tri-Mer supplied controls with site controls	X	X	X	X
All piping, installation, supports, anchors and hardware	X	X	X	X
Any required eyewash stations	-	-	-	X
Utilities, power, Switchgear or power distribution panels	X		X	X
Short Circuit and Arc-Flash Analysis	X	X	X	X
All CEMS equipment, installation, utilities and calibration gases	X	X	X	X
Professional engineer seals or stamps are excluded	X	X	X	X
Installation and field wiring to the main panel, J-boxes, motors, and instruments	X	X	X	X
Installation supervision and startup services				X
Site safety supervision	X	X	X	X
Air permit is required to confirm engineering design and pricing	X	X	X	X
All construction permits and associated fees	X	X	X	X
All air permits and associated fees, and any third-party source testing	X	X	X	X
All applicable duties, taxes, tariffs, or insurance	X	X	X	X
Bromine treated lumber for overseas crating	X	X	X	X
To avoid unnecessary contingency due to the uncertainty of future trucking costs, freight will be billed at cost plus 10% administrative/handling fee.	X	X	X	X

COMMERCIAL

PRICING

The following pricing is based on our current understanding of this project. All pricing is budgetary unless otherwise stated, and pricing is valid for 14 days from issuance of the proposal. All pricing is exclusive of shipping (cost plus 10% administrative fee), and taxes.

CIRCULATING DRY SCRUBBER (CDS)

- **Base Engineering & Equipment** _____ **\$3,028,950**

SORBSAVER PRO INJECTION (DSI)

- **Base Engineering & Equipment** _____ **\$782,780**

RE-CIRCULATING DRY SCRUBBER (RDS)

- **Base Engineering & Equipment** _____ **\$8,146,590**

CAUSTIC SODA WET SCRUBBER (CSWS)

- **Base Engineering & Equipment** _____ **\$1,689,320**

TERMS & CONDITIONS

TMC will be happy to further discuss commercial items such as payment terms, schedule implications, together with overall terms & conditions as the project moves to a firm status.

Jahn, Mario

From: Fritz, Mark
Sent: Friday, March 18, 2022 6:19 PM
To: mschroeter@tri-mer.com
Cc: Solan, John
Subject: University of Alaska Fairbanks BACT Analysis - Budgetary Cost Estimate
Attachments: Boiler Data.pdf; UAF AQCS Options And.docx; UAF Exhaust Gas Data.docx; Baghouse Info.pdf; CHPP Layout.pdf

Martin,

Stanley Consultants is doing a BACT analysis for the UAF. As part of this analysis, we need to have cost estimates for applicable technologies to reduce the SO₂ emissions. Attached is some applicable data.

Information attached:

Boiler data sheet (includes coal analysis)

Plant layout (CHPP Layout)

UAF Exhaust Gas Data (for exhaust gas entering the baghouse)

Baghouse data (for existing baghouse)

Unit is a 240,000 lb/hr B&W circulating fluidized bed boiler which was installed in 2017.

After reviewing the attached information, could you please call me to discuss. We look forward to hearing from you.

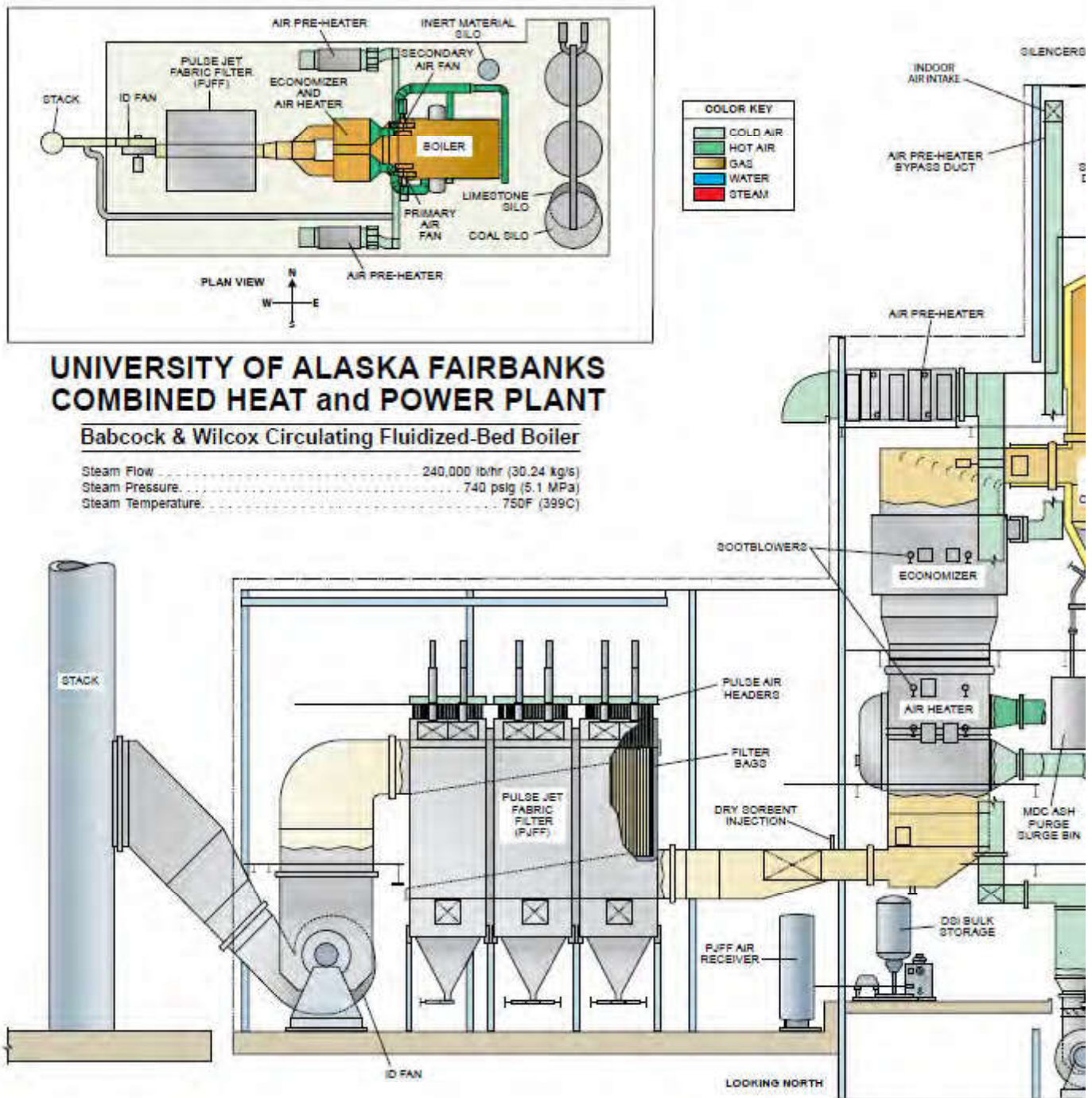
Mark



Mark Fritz, Principal Mechanical Engineer

STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657

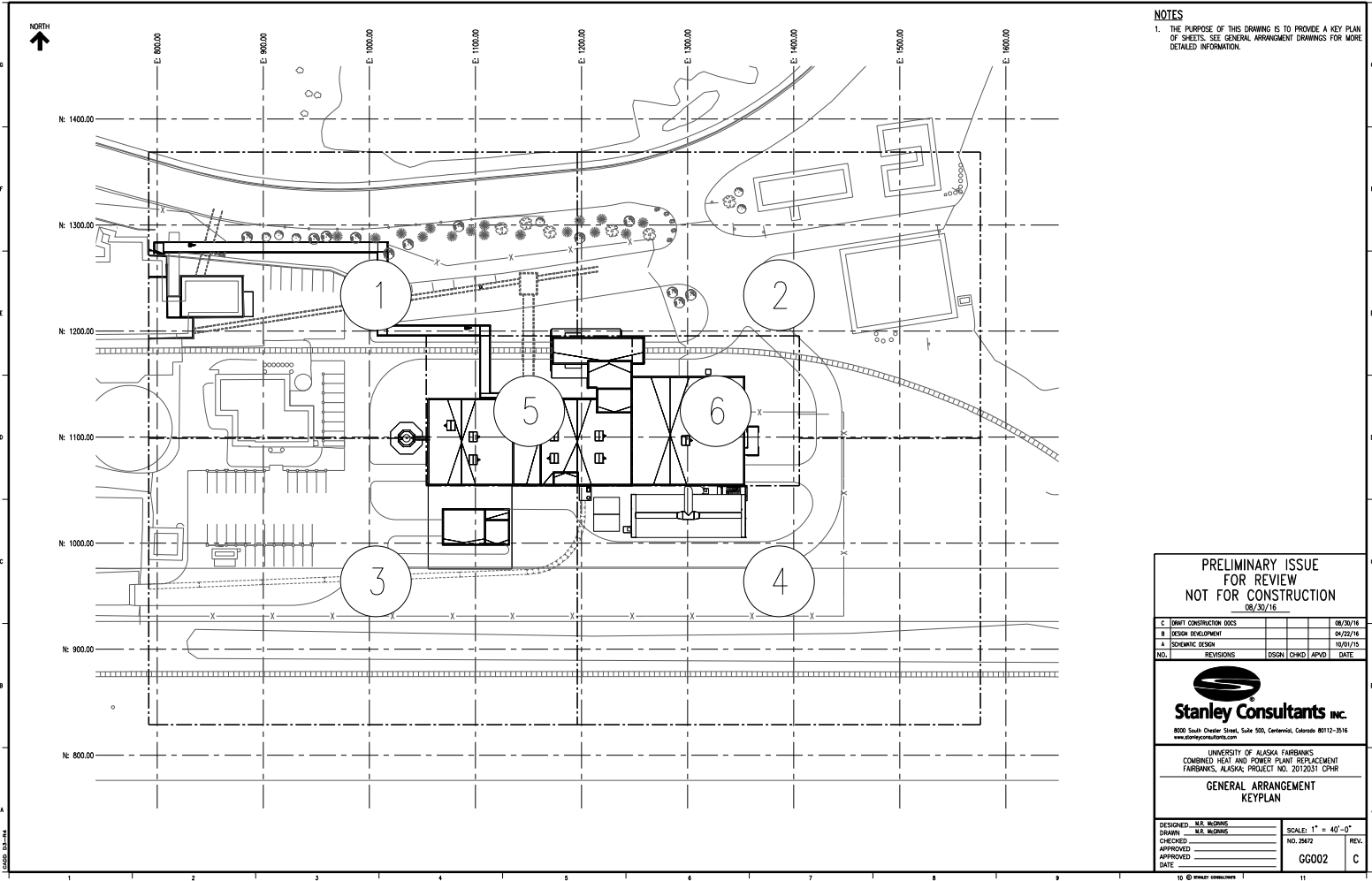
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com



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Exhaust Gas Data at Tie-In

H2O	%	8.5
O2	%	3.7
N2	%	71.7
CO2	%	16.1
Inlet SO2	lb/MMBTU	.2
Inlet HCl	lb/MMBTU	0
Inlet PM	lb/MMBTU	9.0



NOTES
 1. THE PURPOSE OF THIS DRAWING IS TO PROVIDE A KEY PLAN OF SHEETS. SEE GENERAL ARRANGEMENT DRAWINGS FOR MORE DETAILED INFORMATION.

**PRELIMINARY ISSUE
 FOR REVIEW
 NOT FOR CONSTRUCTION**
 08/30/16

C	INITIAL CONSTRUCTION ISSUES	08/30/16
B	DESIGN DEVELOPMENT	04/22/16
A	SCHEMATIC DESIGN	10/01/15

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

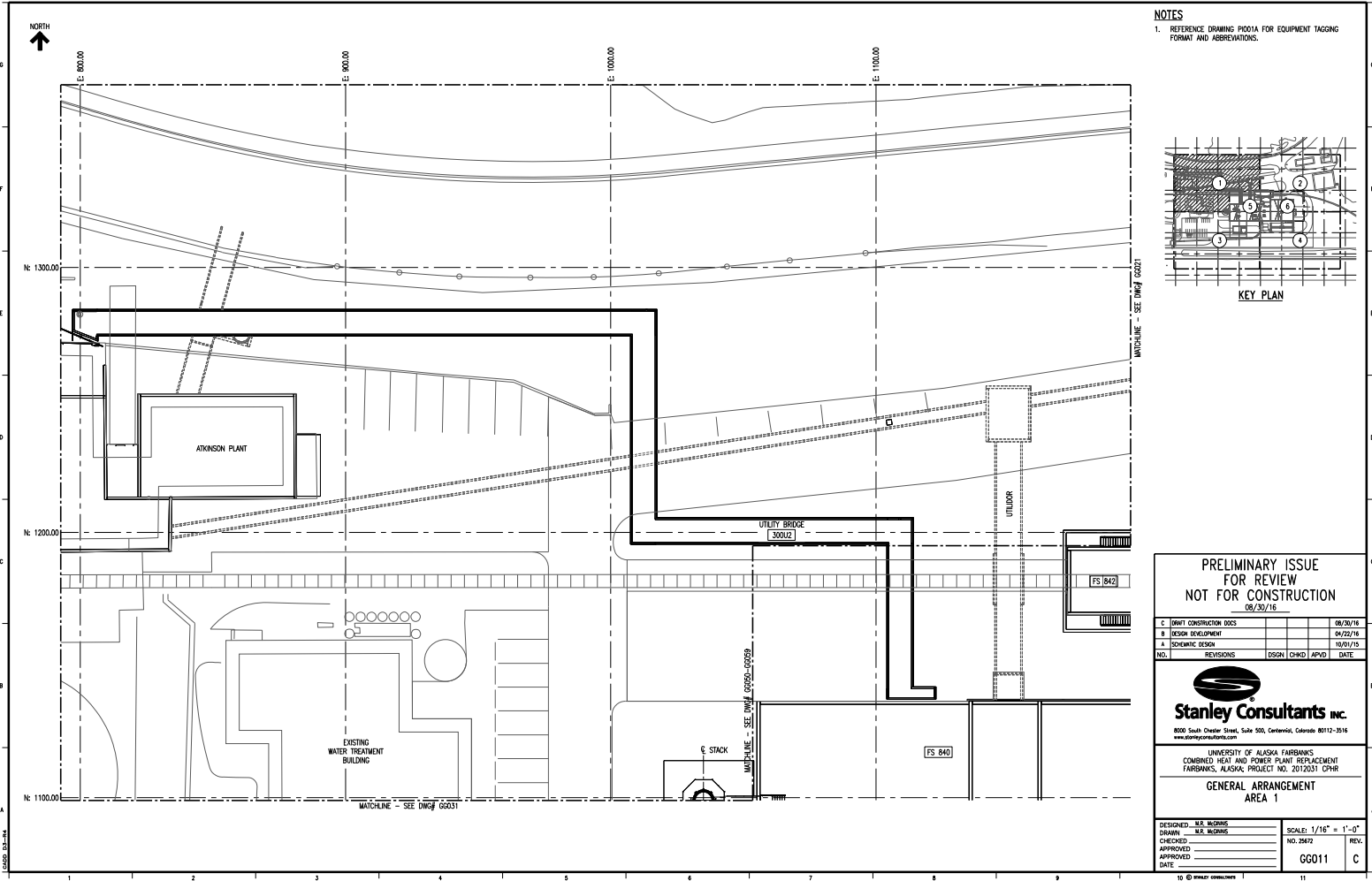
Stanley Consultants INC.
 800 South Chester Street, Suite 500, Centennial, Colorado 80112-3516
 www.stanleyconsultants.com

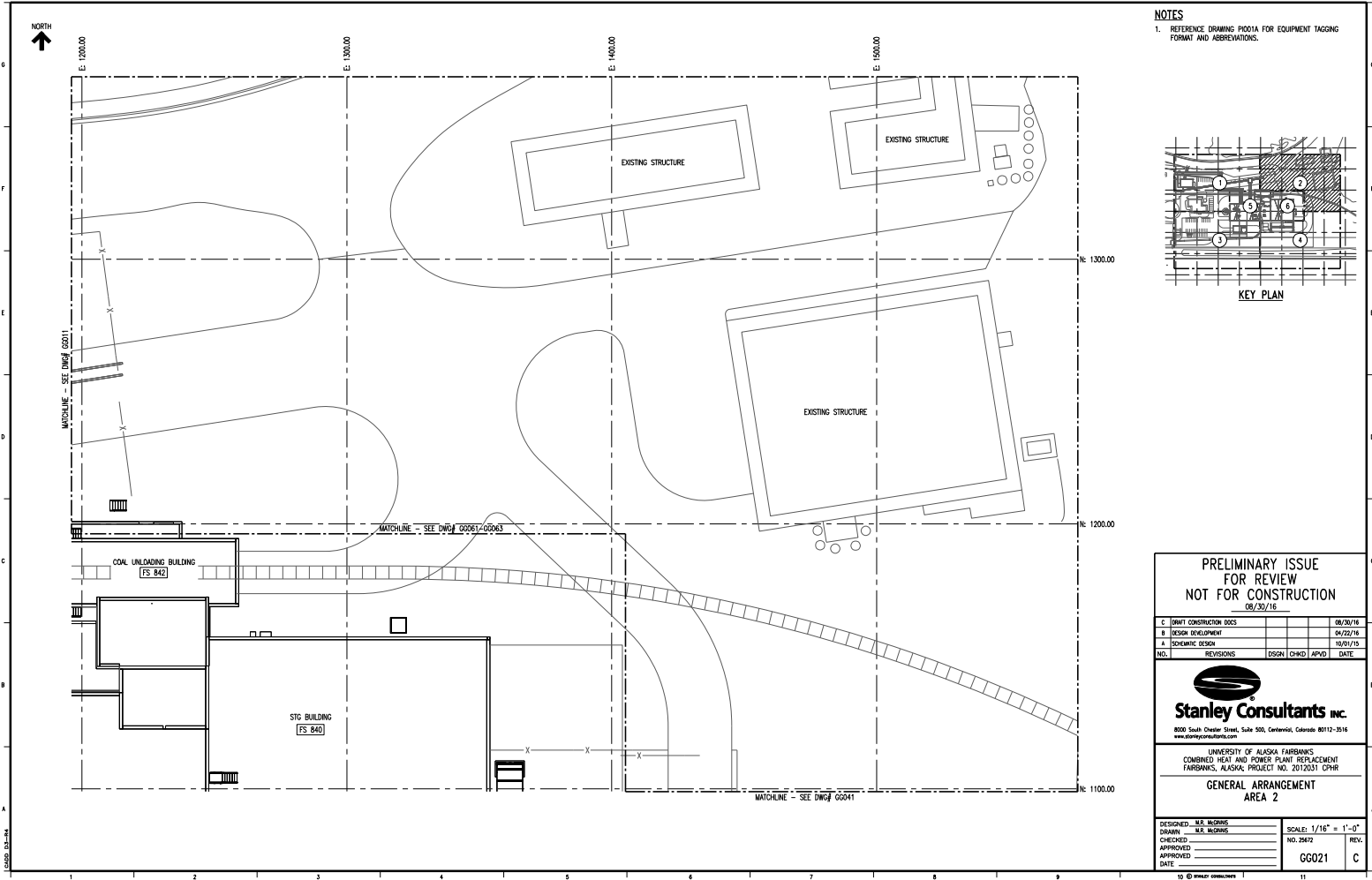
UNIVERSITY OF ALASKA FAIRBANKS
 COMBINED HEAT AND POWER PLANT REPLACEMENT
 FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPFR

**GENERAL ARRANGEMENT
 KEYPLAN**

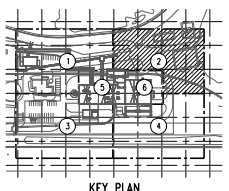
DESIGNED: <u>MR. MCKINNS</u>	SCALE: 1" = 40'-0"	REV.
DRAWN: <u>MR. MCKINNS</u>	NO. 25672	C
CHECKED: _____	GG002	
APPROVED: _____		
DATE: _____		

10 © STANLEY CONSULTANTS 11





NOTES
 1. REFERENCE DRAWING P001A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.



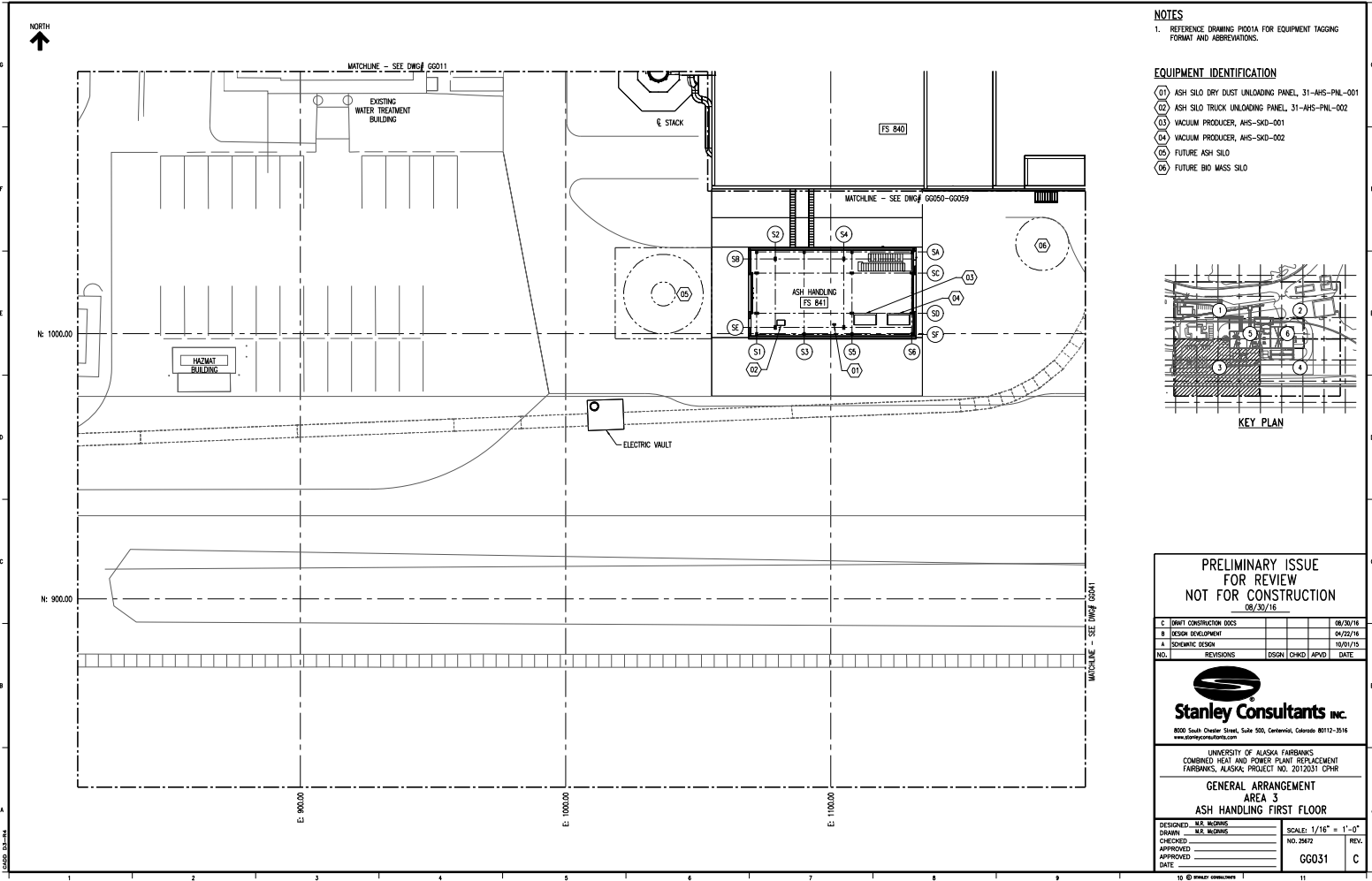
**PRELIMINARY ISSUE
 FOR REVIEW
 NOT FOR CONSTRUCTION**
 08/30/16

C	INITIAL CONSTRUCTION ISSUES	08/30/16			
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A	SCHEMATIC DESIGN	10/01/15			
NO.	REVISIONS	DSGN	CHKD	APVD	DATE

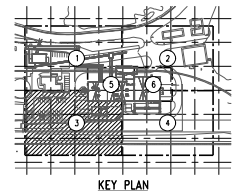
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 www.stanleyconsultants.com

UNIVERSITY OF ALASKA FAIRBANKS
 COMBINED HEAT AND POWER PLANT REPLACEMENT
 FAIRBANKS, ALASKA PROJECT NO. 2012031 CPHR
**GENERAL ARRANGEMENT
 AREA 2**

DESIGNED BY: _____	SCALE: 1/16" = 1'-0"	REV. _____
DRAWN BY: _____	NO. 25672	_____
CHECKED BY: _____	GG021	C
APPROVED BY: _____		
DATE: _____		



- NOTES**
1. REFERENCE DRAWING PFD01A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.
- EQUIPMENT IDENTIFICATION**
- (D1) ASH SLO DRY DUST UNLOADING PANEL, 31-AHS-PNL-001
 - (D2) ASH SLO TRUCK UNLOADING PANEL, 31-AHS-PNL-002
 - (D3) VACUUM PRODUCER, AHS-SKD-001
 - (D4) VACUUM PRODUCER, AHS-SKD-002
 - (D5) FUTURE ASH SLO
 - (D6) FUTURE BIO MASS SLO



**PRELIMINARY ISSUE
FOR REVIEW
NOT FOR CONSTRUCTION**
08/30/16

C	INITIAL CONSTRUCTION ISSUES	08/30/16
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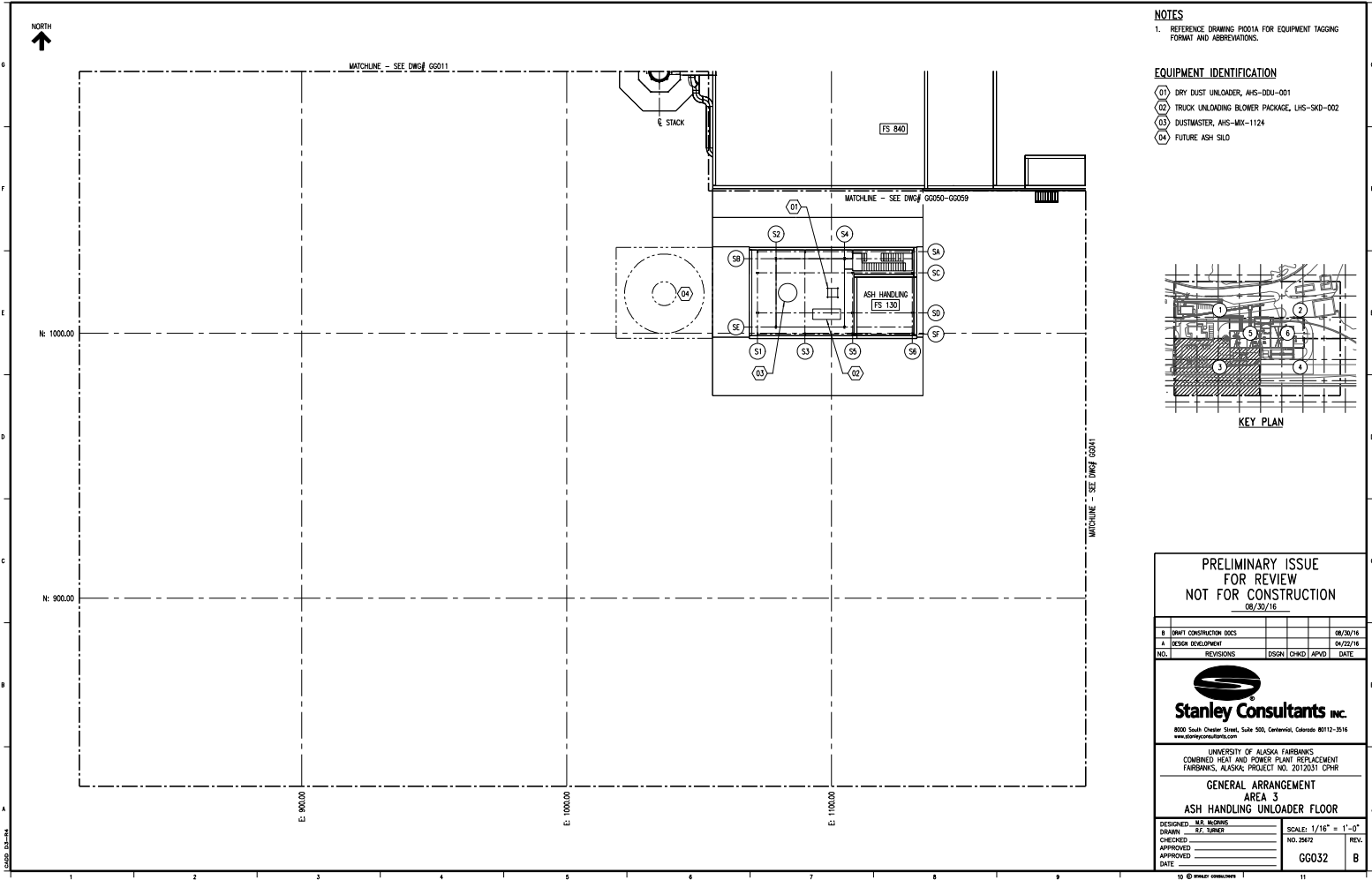
Stanley Consultants INC.
800 South Chester Street, Suite 500, Centennial, Colorado 80112-3516
www.stanleyconsultants.com

UNIVERSITY OF ALASKA FAIRBANKS
COMBINED HEAT AND POWER PLANT REPLACEMENT
FAIRBANKS, ALASKA PROJECT NO. 2012031 CPHR

**GENERAL ARRANGEMENT
AREA 3
ASH HANDLING FIRST FLOOR**

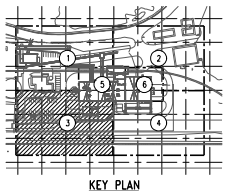
DESIGNED BY: MCKINNS	SCALE: 1/16" = 1'-0"	REV.
DRAWN BY: MCKINNS	NO. 25672	C
CHECKED BY: _____	GG031	
APPROVED BY: _____		
DATE: _____		

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NOTES
 1. REFERENCE DRAWING PFD01A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.

- EQUIPMENT IDENTIFICATION**
- (D1) DRY DUST UNLOADER, AHS-DDU-001
 - (O2) TRUCK UNLOADING BLOWER PACKAGE, LIS-SKD-002
 - (O3) DUSTMASTER, AHS-MX-1124
 - (O4) FUTURE ASH SILO



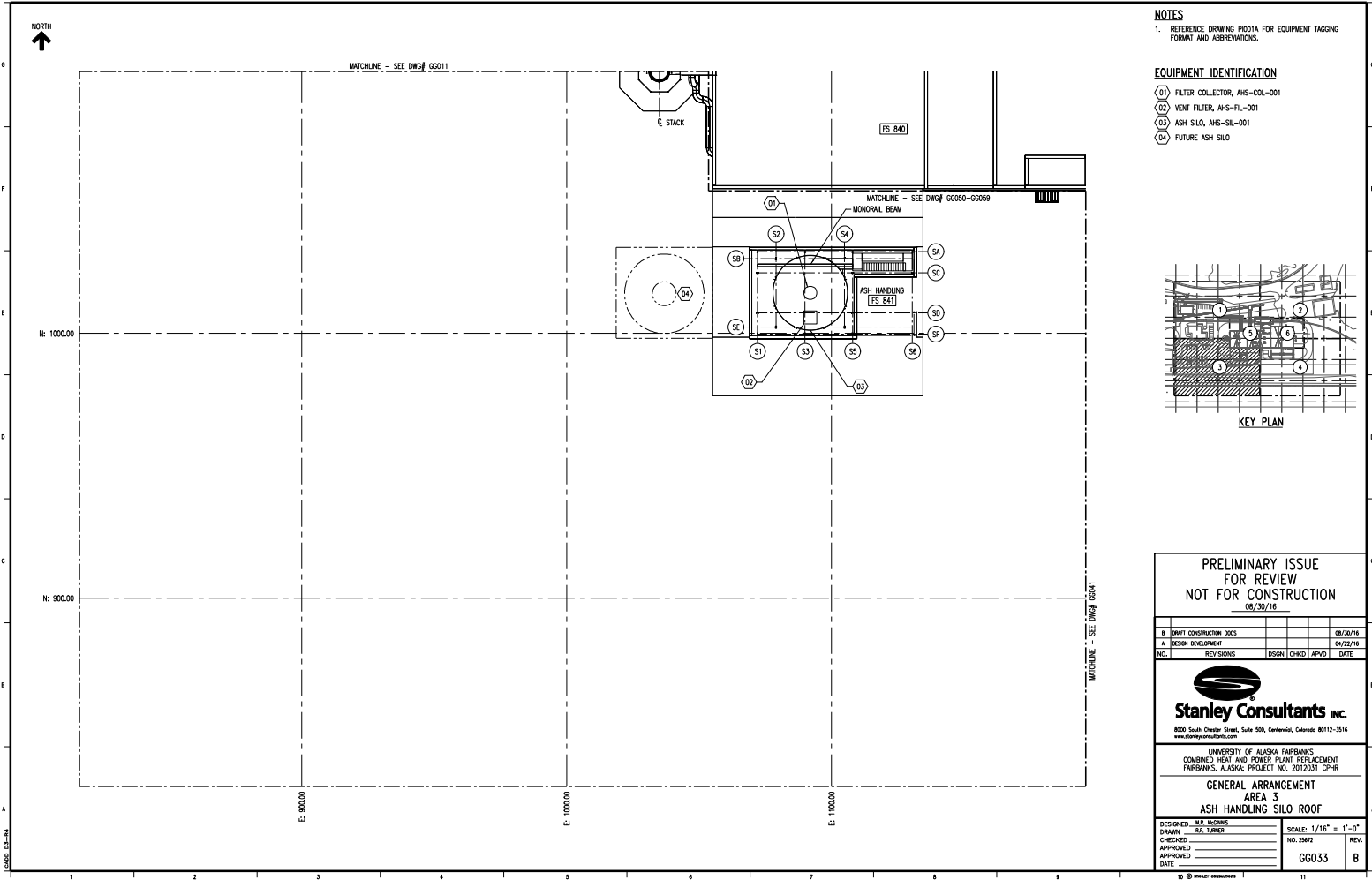
**PRELIMINARY ISSUE
 FOR REVIEW
 NOT FOR CONSTRUCTION**
 08/30/16

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A	DESIGN DEVELOPMENT			04/22/16	
NO.	REVISIONS	DSGN	CHKD	APVD	DATE



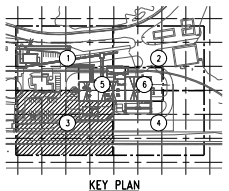
UNIVERSITY OF ALASKA FAIRBANKS
 COMBINED HEAT AND POWER PLANT REPLACEMENT
 FAIRBANKS, ALASKA PROJECT NO. 2012031 CPHR
**GENERAL ARRANGEMENT
 AREA 3
 ASH HANDLING UNLOADER FLOOR**

DESIGNED BY	NO. 25472	SCALE: 1/16" = 1'-0"	REV.
DRAWN BY	GG032		8
CHECKED BY			
APPROVED BY			
DATE			



NOTES
 1. REFERENCE DRAWING PFD01A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.

- EQUIPMENT IDENTIFICATION**
- D1 FILTER COLLECTOR, AHS-COL-001
 - D2 VENT FILTER, AHS-FIL-001
 - D3 ASH SILO, AHS-SL-001
 - D4 FUTURE ASH SILO



**PRELIMINARY ISSUE
 FOR REVIEW
 NOT FOR CONSTRUCTION**
 08/30/16

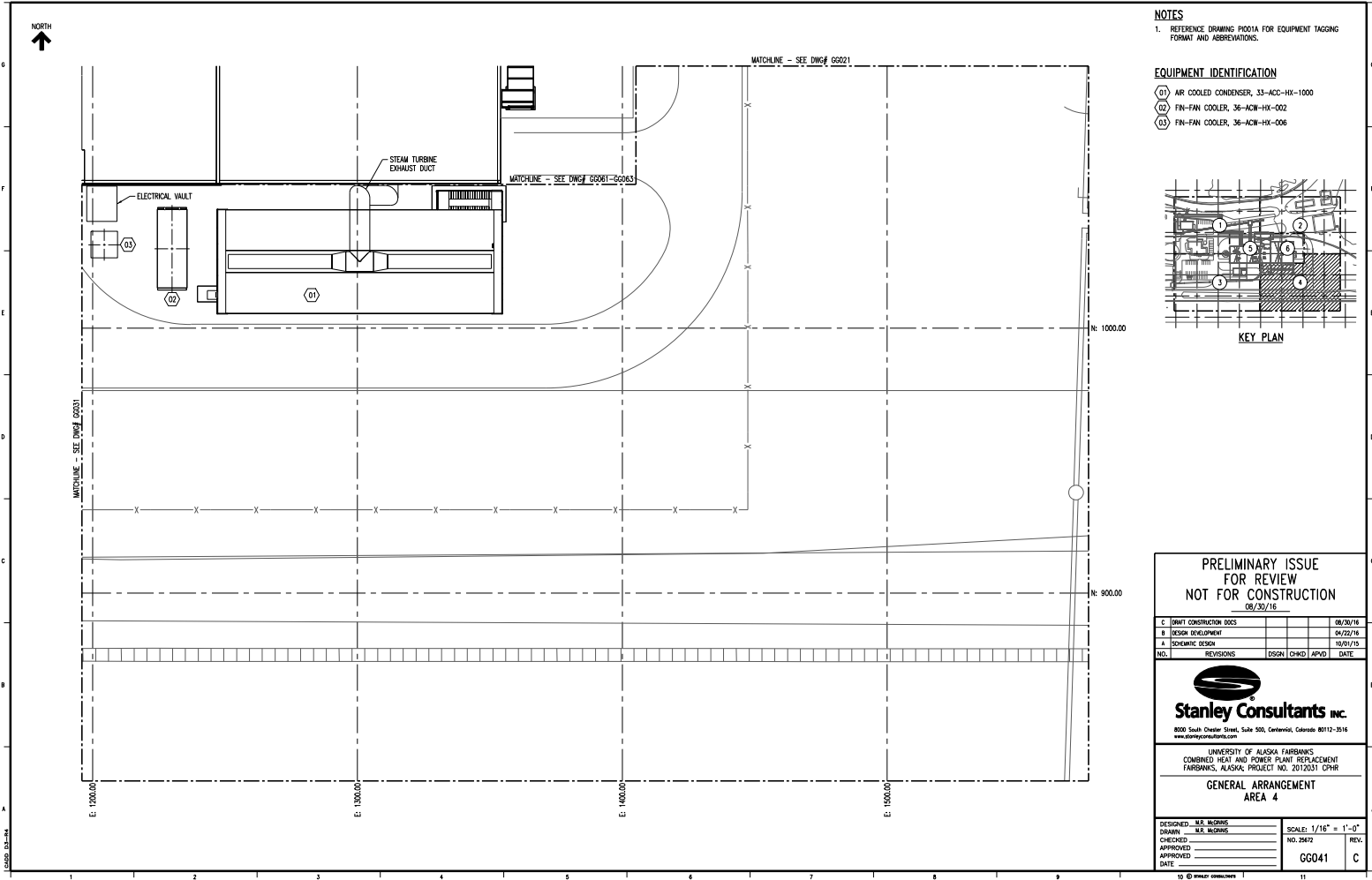
B	DRAFT CONSTRUCTION INDEX			08/30/16	
A	DESIGN DEVELOPMENT			04/22/16	
NO.	REVISIONS	DSGN	CHKD	APVD	DATE

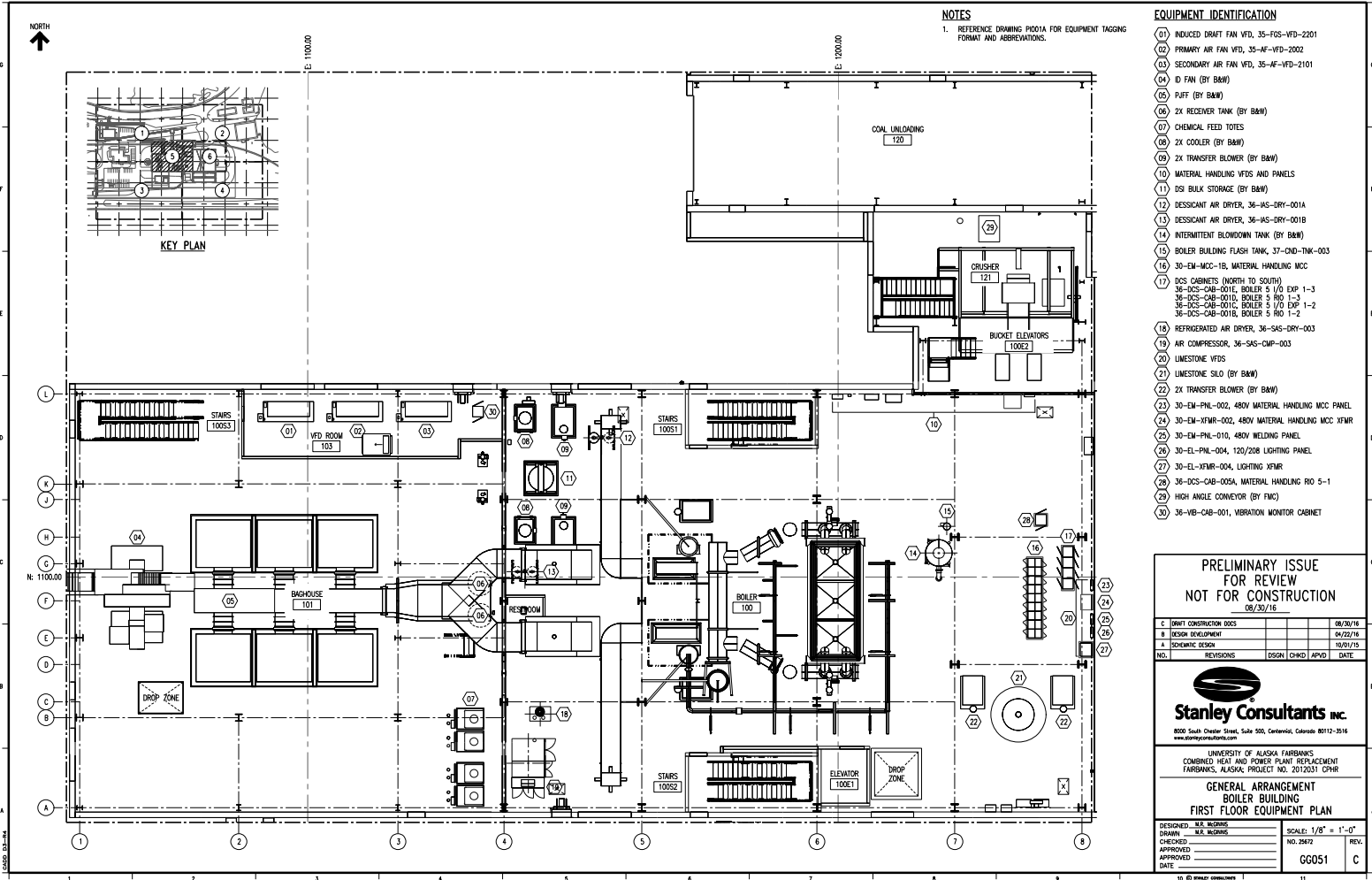
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 COMBINED HEAT AND POWER PLANT REPLACEMENT
 FAIRBANKS, ALASKA PROJECT NO. 2012031 CPHR

**GENERAL ARRANGEMENT
 AREA 3
 ASH HANDLING SILO ROOF**

DESIGNED BY: MGR	SCALE: 1/16" = 1'-0"	REV.
DRAWN BY: JTB	NO. 25672	8
CHECKED BY:		
APPROVED BY:	GG033	
DATE:		





NOTES
1. REFERENCE DRAWING PG01A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.

- EQUIPMENT IDENTIFICATION**
- 01 INDUCED DRAFT FAN VFD, 35-FOS-VFD-2201
 - 02 PRIMARY AIR FAN VFD, 35-AF-VFD-2002
 - 03 SECONDARY AIR FAN VFD, 35-AF-VFD-2101
 - 04 D FAN (BY B&W)
 - 05 PUFF (BY B&W)
 - 06 2X RECEIVER TANK (BY B&W)
 - 07 CHEMICAL FEED TOTES
 - 08 2X COOLER (BY B&W)
 - 09 2X TRANSFER BLOWER (BY B&W)
 - 10 MATERIAL HANDLING VFDs AND PANELS
 - 11 DSI BULK STORAGE (BY B&W)
 - 12 DESSICANT AIR DRYER, 36-AS-DRY-001A
 - 13 DESSICANT AIR DRYER, 36-AS-DRY-001B
 - 14 INTERMITTENT BLOWDOWN TANK (BY B&W)
 - 15 BOILER BUILDING FLASH TANK, 37-OND-TNK-003
 - 16 30-EM-MCC-1B, MATERIAL HANDLING MCC
 - 17 DCS CABINETS (NORTH TO SOUTH)
36-DCS-CAB-001E, BOILER 5 I/O EXP 1-3
36-DCS-CAB-001D, BOILER 5 RIO 1-3
36-DCS-CAB-001C, BOILER 5 I/O EXP 1-2
36-DCS-CAB-001B, BOILER 5 RIO 1-2
 - 18 REFRIGERATED AIR DRYER, 36-SAS-DRY-003
 - 19 AIR COMPRESSOR, 36-SAS-CMP-003
 - 20 LIMESTONE VFDs
 - 21 LIMESTONE SILO (BY B&W)
 - 22 2X TRANSFER BLOWER (BY B&W)
 - 23 30-EM-PNL-002, 480V MATERIAL HANDLING MCC PANEL
 - 24 30-EM-YTHR-002, 480V MATERIAL HANDLING MCC YTHR
 - 25 30-EM-PNL-010, 480V WELDING PANEL
 - 26 30-EL-PNL-004, 120/208 LIGHTING PANEL
 - 27 30-EL-YTHR-004, LIGHTING YTHR
 - 28 36-DCS-CAB-005A, MATERIAL HANDLING RIO 5-1
 - 29 HIGH ANGLE CONVEYOR (BY FMC)
 - 30 36-VB-CAB-001, VIBRATION MONITOR CABINET

**PRELIMINARY ISSUE
FOR REVIEW
NOT FOR CONSTRUCTION**
08/30/16

C	SMART CONSTRUCTION ISSUES	08/30/16
B	DESIGN DEVELOPMENT	04/22/16
A	SCHEMATIC DESIGN	10/01/15
NO.	REVISIONS	DESIGN CHECK APPROVE DATE

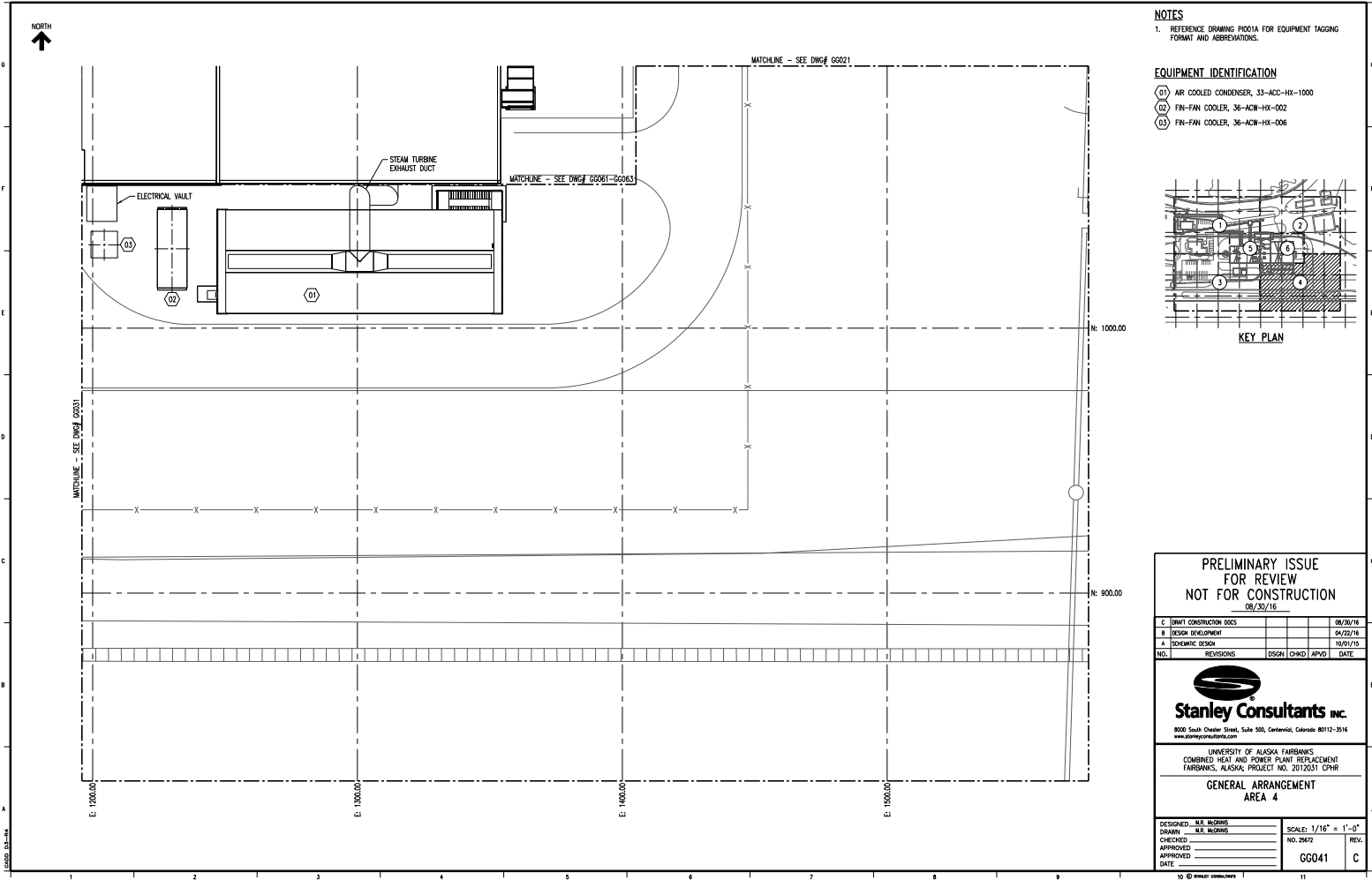
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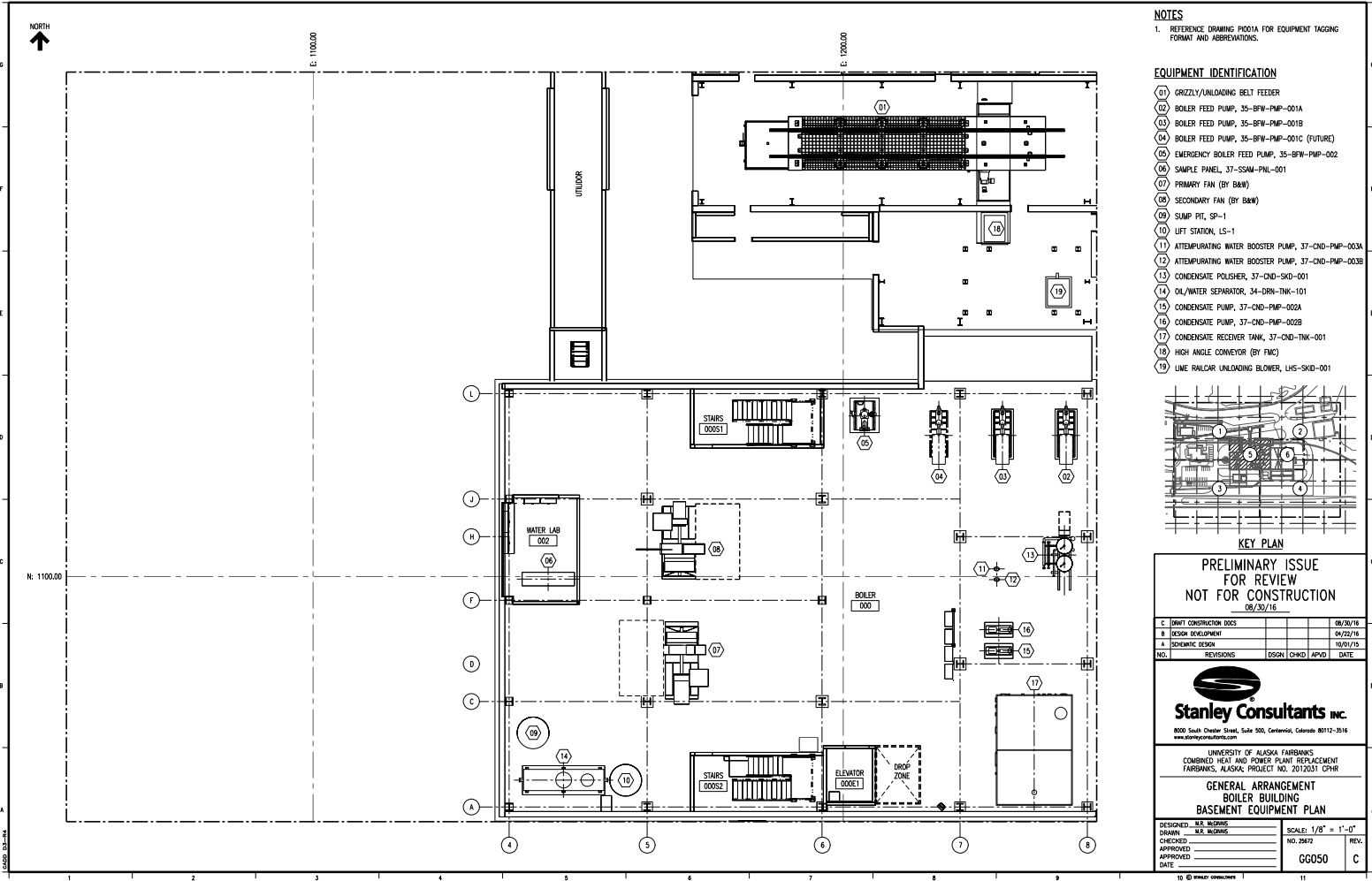
UNIVERSITY OF ALASKA FAIRBANKS
COMBINED HEAT AND POWER PLANT REPLACEMENT
FAIRBANKS, ALASKA PROJECT NO. 2012031 CPHR

**GENERAL ARRANGEMENT
BOILER BUILDING
FIRST FLOOR EQUIPMENT PLAN**

DESIGNED: <u>ME, INCORP</u>	SCALE: 1/8" = 1'-0"	REV.
DRAWN: <u>ME, INCORP</u>	NO. 26472	C
CHECKED: _____		
APPROVED: _____		
DATE: _____	GG051	

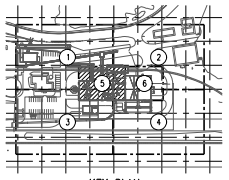
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NOTES
 1. REFERENCE DRAWING P001A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.

- EQUIPMENT IDENTIFICATION**
- 01 GRIZZLY/UNLOADING BELT FEEDER
 - 02 BOILER FEED PUMP, 35-BFW-PMP-001A
 - 03 BOILER FEED PUMP, 35-BFW-PMP-001B
 - 04 BOILER FEED PUMP, 35-BFW-PMP-001C (FUTURE)
 - 05 EMERGENCY BOILER FEED PUMP, 35-BFW-PMP-002
 - 06 SAMPLE PANEL, 37-SSAM-PNL-001
 - 07 PRIMARY FAN (BY B&W)
 - 08 SECONDARY FAN (BY B&W)
 - 09 SUMP PIT, SP-1
 - 10 LIFT STATION, LS-1
 - 11 ATTEMPURATING WATER BOOSTER PUMP, 37-CND-PMP-003A
 - 12 ATTEMPURATING WATER BOOSTER PUMP, 37-CND-PMP-003B
 - 13 CONDENSATE POLISHER, 37-CND-SKD-001
 - 14 OIL/WATER SEPARATOR, 34-DRW-TNK-101
 - 15 CONDENSATE PUMP, 37-CND-PMP-002A
 - 16 CONDENSATE PUMP, 37-CND-PMP-002B
 - 17 CONDENSATE RECEIVER TANK, 37-CND-TNK-001
 - 18 HIGH ANGLE CONVEYOR (BY FMC)
 - 19 LINE ROLLER UNLOADING BLOWER, LHS-SKD-001



KEY PLAN

PRELIMINARY ISSUE FOR REVIEW NOT FOR CONSTRUCTION
 08/30/16

C	LIMIT CONSTRUCTION ISSUES	08/30/16
B	DESIGN DEVELOPMENT	04/22/16
A	SCHEMATIC DESIGN	10/01/15

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

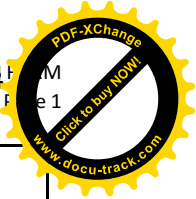
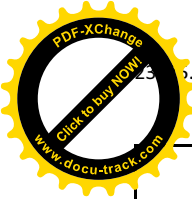
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 COMBINED HEAT AND POWER PLANT REPLACEMENT
 FAIRBANKS, ALASKA PROJECT NO. 2012031 CPHR

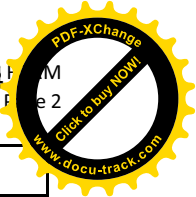
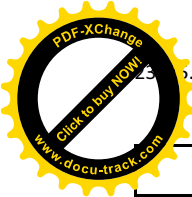
**GENERAL ARRANGEMENT
 BOILER BUILDING
 BASEMENT EQUIPMENT PLAN**

DESIGNED: M.D. MCKENZIE	SCALE: 1/8" = 1'-0"	REV.
DRAWN: M.D. MCKENZIE	NO. 25472	C
CHECKED: _____		
APPROVED: _____		
DATE: _____	GG050	

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BAGHOUSE DATA SHEET		Equipment Name: Baghouse	
		Tag No.:	
DESCRIPTION	Units	SPEC DATA	VENDOR DATA
GUARANTEED PREDICTED PERFORMANCE DATA			
Particulate emissions, stack outlet:			
Particulate Matter (filterable), all baghouse modules on line	lb/MMBtu input	Reference Emissions Guarantees	
Particulate Matter (filterable), one baghouse module off line	lb/MMBtu input	0.030	
Particulate emissions, stack outlet:			
Particulate Matter (filterable), all baghouse modules on line	gr/scf	Reference Emissions Guarantees	
Particulate Matter (filterable), one baghouse module off line	gr/scf	0.05	
PM10 emissions, stack outlet:			
PM10 (filterable and condensable), all baghouse modules on line	lb/MMBtu input	Reference Emissions Guarantees	
PM10 (filterable and condensable), one baghouse module off line	lb/MMBtu input	0.012	
PM2.5 emissions, stack outlet:			
PM2.5 (filterable and condensable), all baghouse modules on line	lb/MMBtu input	Reference Emissions Guarantees	
PM2.5 (filterable and condensable), one baghouse module off line	lb/MMBtu input	0.012	
Opacity of flue gas leaving stack, percent, 6-minute average			
Bag Leak Detection System	mg/acm	10 or less	
System friction losses:			
Baghouse including manifolds, all modules on line	In. H ₂ O		<5 (est)
Baghouse including manifolds, one module off line	In. H ₂ O		≤6 (est)
Ductwork, inlet ⁽¹⁾	In. H ₂ O		0.3 (est)
Ductwork, outlet ⁽¹⁾	In. H ₂ O		0.3 (est)
Baghouse bypass duct	In. H ₂ O		3 (est)
Power requirements:			
Hopper heaters	kW		5 (est)
Hopper vibrators	kW		Not Included/Recommended
Other	kW		None
Other	kW		None
Compressed air requirements:			
Bag pulse cleaning air:			
Consumption	scfm		50 (est)
Normal pressure	psig		100
Minimum pressure	psig		80
Instrument air consumption:			
Maximum instantaneous	scfm		40 (est)
Average	scfm		>10 (est)
Other			
Bypass damper leakage	%		0% (with seal gas)
PHYSICAL DATA AND SPECIFICATIONS			
Installed Weight:			
Supporting steel including enclosure	lb		Included In Boiler Tab
Baghouse	lb		163,000 lbs per PJFF
Breeching and ducts	lb		Included In Boiler Tab
Baghouse equipment data:			
Seller			
Number of modules			
Air-to-cloth ratio with even distribution. (do not include area of cloth over cages, Venturis, bottom caps, or seams):			



All modules in service under maximum operating conditions, gross			3.9
One module out for cleaning under maximum operating conditions, net			2.6
Filter bags:			
Fabric material/bag Seller			PPS with ePTFE membrane
Weight	oz/sq yd		16
Coating	% by weight		ePTFE membrane
Permeability (clean)	cfm/sq ft @ 1/2" wg		7 - 12 (est.)
Total bag weight without hardware	lb		4.5 (est.)
Cage construction:			
Wire size, and material			9 ga, Carbon Steel
Horizontal wire spacing			8"
Maximum opening size			5.9" Dia
Venturi material			N/A
Number of bags	per module		752
Bag size (diameter x length)	in.		6" x 19'8"
Bag spacing, center to center	in		8
Effective filter area per bag, used in computing air-to-cloth ratio	sq. ft.		29.52
Total filter area per module	sq. ft.		7438
Bag temperature rating:			
Continuous	F		330
Maximum short duration	F		350
Guaranteed bag life	Hrs		See Vendor's guarantee Section from proposal
Method of bag replacement (description - use separate sheet if necessary)			Remove blowpipe, pull out cage, drop bag into hopper,
Cleaning cycle time, minutes (isolation, pulse, settling, on-line):	Min		On-line cleaning, casing cleaned every 30 minutes
Adjustable cleaning cycle range per compartment	Min		Cleaning based on DP not time
Expected cleaning period per compartment, minutes	Min		3 min (est.)
Physical data:			
Baghouse overall dimensions (not including breeching, ducts):			
Length, parallel to gas flow	ft-in		See GA Drawing
Width, transverse to gas flow	ft-in		See GA Drawing
Height, above dust hopper flange connection	ft-in		See GA Drawing
Dimensions of each module:			
Height (overall)	ft-in		See GA Drawing
Width	ft-in		See GA Drawing
Length	ft-in		See GA Drawing
Side casing material and thickness	in.		A36 Carbon Steel, 3/16"
Hopper material and thickness	in		A36 Carbon Steel, 1/4"
Plenum casing material and thickness	in		A36 Carbon Steel, 3/16"

FUEL CHARACTERISTICS			LOAD CONDITION					
FUEL ANALYSIS		DESIGN	STEAM LEAVING SH, MLB/HR	MCR	70%	40%	33%	
A AREA	MINE	USIBELLI	TYPE OF FUEL	Coal	Coal	Coal	Coal	
	STATE/PROVINCE	HEALY, AK	EXCESS AIR LEAVING ECONOMIZER, %	15	15	66	102	
	COUNTRY	USA	NO. OF BURNERS IN OPERATION	0	0	0	0	
PROXIMATE ANALYSIS	% BY	WT	OUTPUT PER PTC 4-2013, MKB/HR	253.4	177.4	100.1	95.3	
	TOTAL MOIST.	28.50	FUEL INPUT, MKB/HR	295.6	206.0	118.8	118.0	
	VOL. MATTER	36.00	QUANTITY - MLB/HR	FUEL FLOW	39.1	27.3	15.7	15.6
	FIXED CARBON	26.50		FLUE GAS ENTERING AIR HEATER	284.7	199.0	157.8	187.0
	ASH	9.00		FLUG GAS ENTERING STACK (ACFM)	89,832	61,165	50,217	65,748
	TOTAL	100.00		TOTAL AIR TO BURNING EQUIPMENT	246.7	172.0	141.2	170.5
% BY	WT	SECONDARY AIR LEAVING AH		117.1	64.9	17.8	21.8	
ASH	9.00	PRIMARY AIR LEAVING AH		117.1	97.3	115.3	140.3	
ULTIMATE ANALYSIS	H2O	28.50	AIR HTR LEAKAGE (TOTAL AIR TO GAS)	1.0	1.4	2.5	2.5	
	C	43.75	SUPERHEAT SPRAY FLOW	7.88	7.48	0.00	0.74	
			BLOWDOWN	1.20	0.84	0.48	12.00	
			PRESSURE PSIG	FEEDWATER	740.00	692.00	660.00	656.00
				SPRAY WATER	720.00	702.00	0.00	0.00
				DRUM	693	658	636	633
				STEAM AT SH OUTLET	625	625	625	625
	S	0.20	TEMPERATURE - F	STEAM LEAVING SUPERHEATER	750	750	728	760
	O2	14.93		WATER ENTERING ECONOMIZER	350	350	350	260
	MERCURY, dry	< 0.07 mg/g		FLUE GAS LEAVING AH (EXCL. LKG)	285	260	285	350
				ENTERING STACK	289	265	288	354
	FLOURINE, dry	< 81 mg/g		AIR ENTERING PRI. AIR FAN (1)	77	88	111	123
CHLORINE, dry	< 18 mg/g	ENTERING SEC. AIR FAN (1)		77	77	77	77	
TOTAL	100.00		LEAVING AIR HEATER (SEC)	335	335	275	337	
HHV, BTU/LB	7,560		LEAVING AIR HEATER (PRI)	335	309	380	508	
SORBENT CHARACTERISTICS			FUEL TO BURNING EQUIPMENT	40	40	40	40	
LIMESTONE ANALYSIS		DESIGN	DRY GAS	4.38	3.86	6.02	9.80	
ANALYSIS	% BY	WT	H2 & H2O IN FUEL	8.53	8.45	8.51	8.75	
	CaCO3	95.00	MOISTURE IN AIR	0.07	0.06	0.10	0.16	
	MgCO3	0.90	MOISTURE IN SORBENT	0.00	0.00	0.00	0.00	
	SiO2	3.30	UNBURNED COMBUSTIBLE IN RESIDUE	0.50	0.50	0.50	0.50	
	H2O	0.80	RADIATION	0.36	0.51	0.91	0.96	
	TOTAL	100.00	SENSIBLE HEAT IN REFUSE	0.07	0.10	0.09	0.13	
NOTES	(1) PTC 4 BOUNDARY IS AT FAN INLETS W/SPECIFIED ENTERING AIR TEMP OF 77°F & SPECIFIED 40°F AMBIENT (FUEL) TEMP (2) PREDICTED PERFORMANCE BASED ON CONDITIONS & EQUIPMENT SHOWN ON THIS SUMMARY SHEET & ON GENERAL ARRGT DRAWINGS B0312851 & B0312852 (3) BAROMETRIC PRESSURE = 29.40 IN HG 0.009 LB H2O PER LB COMBUSTION AIR (4) SPRAY WATER PRESSURE AT EXPECTED OPERATING CONDITIONS, FURTHER UPSET PERFORMANCE TO BE PROVIDED LATER		MANUFACTURER'S MARGIN	0.40	0.40	0.40	0.40	
			SORBENT CALCINATION/DEHYDRATION	0.23	0.23	0.23	0.23	
			OTHER LOSSES (UNMEASURED)	0.10	0.10	0.10	0.10	
			TOTAL LOSSES	14.64	14.21	16.87	21.03	
			HEAT CREDITS, %	ENTERING DRY AIR	0.00	0.12	0.81	1.36
			MOISTURE IN AIR	0.00	0.00	0.01	0.02	
			SENSIBLE HEAT IN FUEL	-0.16	-0.16	-0.16	-0.16	
			SULFATION	0.11	0.11	0.11	0.11	
			MOISTURE IN LIMESTONE	0.00	0.00	0.00	0.00	
			AUXILIARY EQUIPMENT POWER	0.42	0.23	0.42	0.42	
TOTAL CREDITS	0.37	0.30	1.19	1.76				
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Scope of Work

Project: University of Alaska Fairbanks (UAF) - CHPP Plant AQCS Options for SO₂ Control Cost Estimate

PROJECT UNDERSTANDING

Stanley is performing a study level cost estimate to retrofit desulfurization options for the UAF campus utility plant.

» Circulating Dry Scrubber (CDS)

Stanley is requesting the following information to support our cost estimating effort. The option should be sized to assuming the boiler is operating at MCR with the SO₂ concentration in the flue gas out of the boiler at the permitted level SO₂, 0.2 lb/MMBTU.

The following information is requested.

INFORMATION REQUESTED

1. SO₂ removal efficiency.
2. Budget pricing, FOB UAF, assuming new technologies will be housed inside a new heated enclosure. The pricing will be for material only, installation will be estimated by others. The costs associated with enclosure and civil work will be estimated by others.
 - a. Mechanical work inside the new enclosure. Assume reagent storage silos are include inside the enclosure and sized for 30 day of storage. All required tie-ins are assumed to at enclosure boundary.
 - b. Prepare a small write-up regarding the scope of the items included in the estimated.
3. Electrical load and voltage for each major load.
4. Approximation of the size of enclosure, including a length, width, and height.
5. Opinion if existing backhouse can be used unmodified with each technology. If technology requires new baghouse, provide a budgetary price for new baghouse.
6. If technology produces a liquid or solid waste, quantify the amount.
7. Reagent required type and consumption rates.
8. Utility usage water, air, etc.
9. Increase in fly ash (byproduct) from the technology, if any.
10. Increase in flue gas pressure drop.
11. CDS Qualifications:
 - a. List of specific experience with CDS.
 - b. Where are the CDS installations in the US?
 - c. For installation, is it still operating?
 - d. For each installation, what is the fuel type, size, and type of combustion unit from which emissions are controlled?

SCHEDULE

Stanley requests the information in three weeks, if possible. Partial release of information, such as building sizes, removal efficiency, etc., will allow use to start our estimating work.

INFORMATION INCLUDED

The following information is included to support the information requested. If additional information is required please request.

1. Performance Data for the boiler
2. Typical Exhaust gas composition

3. Baghouse Information

Jahn, Mario

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Friday, June 24, 2022 3:27 PM
To: Jahn, Mario; Solan, John; Payne, Mark
Cc: Joe Riley; Ted Hornus; David Bennett
Subject: RE: P-23.182 Stanley UAF SO2 Control Project | List of Non - Tri-Mer References for CDS Technology
Attachments: CDS References R.2 6-24-2022.pdf

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Hello Mario,

Enclosed please find the updated reference list for the CDS applications. I will then follow up with an updated proposal for the DSI solution with increased SO2 removal efficiency >90% during the week of July 4th.

In case of any questions, please let me know.

Best regards
Martin

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Friday, June 24, 2022 4:39 PM
To: Martin Schroeter <mschroeter@tri-mer.com>; Solan, John <SolanJohn@stanleygroup.com>; Payne, Mark <PayneMark@stanleygroup.com>
Cc: Joe Riley <jriley@stmecosystems.com>; Ted Hornus <thornus@tri-mer.com>; David Bennett <dbennett@tri-mer.com>
Subject: RE: P-23.182 Stanley UAF SO2 Control Project | List of Non - Tri-Mer References for CDS Technology

Good Afternoon Martin,

I wanted to check-in and see how things were going on your end with regards to the additional references that we asked for below, as well as an updated DSI quote. We are rapidly coming to the end of our evaluation and are still awaiting these key items. Let me know if you have run into any issues or need additional questions answered from us.

Best Regards,
Mario

From: Jahn, Mario
Sent: Wednesday, June 15, 2022 8:50 AM
To: Martin Schroeter <mschroeter@tri-mer.com>; Solan, John <SolanJohn@stanleygroup.com>; Payne, Mark <PayneMark@stanleygroup.com>
Cc: Joe Riley <jriley@stmecosystems.com>; Ted Hornus <thornus@tri-mer.com>; David Bennett <dbennett@tri-mer.com>
Subject: RE: P-23.182 Stanley UAF SO2 Control Project | List of Non - Tri-Mer References for CDS Technology

Martin,

Thank you very much for providing the additional references. I noticed that you have additional columns that weren't part of your last reference list. Is there a way you can add the additional columns to your previous reference list? I know that there might be confidentiality issues with this, but if you can also list the name of the plant that would help as well.

Industry	Location	Flow, acfm	Process	Year
WTE	Oklahoma, USA	< 100,000	Incineration	2010
Cement	Italy	400,000 – 800,000	Cement kiln	2009
Power	China	> 800,000	Coal fired boiler	2007
Hazardous waste	Pennsylvania, USA	100,000 – 400,000	Incineration	2005
Power	Alabama, USA	< 100,000	Coal fired boiler	2004
Power	France	100,000 – 400,000	Biomass fired boiler	2003
Minerals	New Jersey, USA	< 100,000	Dryer	2003

Kind regards,
Mario

From: Martin Schroeter <mschroeter@tri-mer.com>

Sent: Wednesday, June 15, 2022 8:16 AM

To: Jahn, Mario <JahnMario@stanleygroup.com>; Solan, John <SolanJohn@stanleygroup.com>

Cc: Joe Riley <jriley@stmecosystems.com>; Ted Hornus <thornus@tri-mer.com>; David Bennett <dbennett@tri-mer.com>

Subject: P-23.182 Stanley UAF SO2 Control Project | List of Non - Tri-Mer References for CDS Technology

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mario and John,

Enclosed please find a list of CDS installations during the period of late 1990-ties to early 2000-s performed by FLS Airtech.

Best regards

Martin Schroeter

Sales - Ceramics Technology Group (CTG)

Tri-Mer Corporation

1400 E Monroe Street

Owosso, MI 48867

Mobile Phone: (989)-627-1040

Office Phone: (989)-723-7838

Email: mschroeter@tri-mer.com



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SO₂ MITIGATION SOLUTIONS

List of Non – Tri-Mer References for CDS Technology of Relevant Size During
Late 1990-ties to early 2000-s

REFERENCE NUMBER: P-23.182

PREPARED FOR STANLEY CONSULTANTS

As Part of Proposal No. P-23.182

Mario Jahn

8000 S Chester St, Suite 500
CENTENNIAL, CO 80112

(303) 725-1361

JAHNMARIO@STANLEYGROUP.COM

PROPOSAL ISSUED:

JUNE 24, 2022

PROPOSAL VALID TO:

-

TRI-MER CORPORATION

1400 E MONROE STREET
OWOSSO, MI 48867

WWW.TRI-MER.COM

(989) 723-7838

PRINCIPAL CONTACT:

MARTIN SCHROETER

(989) 627-1040

MSCHROETER@TRI-MER.COM

UPDATED REFERENCES FOR CDS TECHNOLOGY > 100,000 SCFM

Industry	Location	Flow, scfm	Process	Supplier	Technology	Year	Remark
WTE	Oklahoma, USA	100,000	Incineration	Boldeco	CDS	2010	Closed
Cement	Italy	400,000 – 800,000	Cement kiln	Boldrocchi	CDS	2009	operating
Power	China	> 800,000	Coal fired boiler	Boldeco	CDS	2007	Closed
Hazardous waste	Pennsylvania, USA	100,000 – 400,000	Incineration	Boldeco	CDS	2005	Status unknown
Power	Alabama, USA	< 100,000	Coal fired boiler	Boldeco	CDS	2004	Converted to Gas
Power	France	100,000 – 400,000	Biomass fired boiler	Boldrocchi	CDS	2003	operating
Minerals	New Jersey, USA	< 100,000	Dryer	Boldeco	CDS	2003	Status unknown
Mining	Kiruna, Sweden	227,700	135 MWe boiler	FLS Airtech	CDS / ESP	1994	Status unknown
Power	Hamilton, USA	146,000	80 MWe coal fired boiler	FLS Airtech	CDS	1995	Converted to gas
Power	Nichom Phatthana, Thailand	2 x 108,000	Coal fired boiler	FLS Airtech	CDS	1998	Status unknown
Power	Xiaolong Tan, China	310,000	125 MWe coal fired boiler	FLS Airtech	CDS	2000	Status unknown
Biomass	Elean, UK	100,000	38 MWe Straw fired boiler	FLS Airtech	CDS / FF	2000	Operational

Mining	Kiruna, Sweden	150,000	Boiler	FLS Airtech	CDS / ESP	2004	Status unknown
Power	Shuaiba, Kuwait	221,900	Coal fired boiler	FLS Airtech	CDS / FF	2005	Status unknown

MEETING NOTES

Date: June 9, 2022

Place: Web/Conference Call

Project/Purpose: University of Alaska Fairbanks
SO2 Best Available Control Technology Study

Attendees: Mark Payne (SCI)
Mario Jahn (SCI)
John Solan (SCI)
Martin Schroeter (Tri-Mer)
Ted Hornus (Tri-Mer)
Joe Riley (STM Ecosystems)

Notes By: John Solan

The following meeting notes set forth our understanding of the discussions and decisions made at this meeting. If no objections, questions, additions, or comments are received within 5 working days from issuance of the meeting notes, we will assume that our understandings are correct. We are proceeding based on the contents of these meeting notes.

Topics:**BACT Study Process:**

- SCI briefly reviewed the BACT Study process including the underlying reasoning and the protocol for conducting the study.
- SCI emphasized to Tri-Mer that any opinions that they had regarding the technology that might be “best” or “least expensive” or “most cost effective” were irrelevant. The BACT process was developed to provide a structured framework to determine which technologies were technically feasible and then to select the best available control technology from the technically feasible options.
- SCI further emphasized that, based on the BACT study protocol. The selected solution will be the technology that achieves the greatest reduction in SO2 emissions while still being cost effective.

References:

- Stanley requested additional references to provide additional, older references that indicate that the technology is fully mature and suitable for a 30-year design life.
 - Tri-Mer stated that they would try to find references of older plants, however they may be from projects that pre-date Tri-Mer.
 - They talked about an EPRI study conducted at an Alabama Power plant. This was an R&D study to test out a multi-pollutant system for proof of concept. This was only a 4 MW, 16,000 CFM side-stream test.
 - Additional information on provided references shall include whether the technology was full scale or slipstream.
 - CDS experience is lacking in coal power plants. They have some on non-coal glass plants. Tri-Mer made the comment they really do not have any references for coal power plants
 - SCI also requested additional information regarding previously provided reference so that performance and operating status can be verified.

Dry Sorbent Injection

- Tri-Mer stated that they were confident that they could achieve greater than 90% efficiency (SO2 capture)

with their SorbSaver Pro Dry Sorbent Injection System. To accomplish this efficiency, however, they would need to install the injection point upstream of the existing tubular air heaters.

- Tri-Mer requested that SCI provide flue gas temperature data immediately downstream of the economizers and also boiler drawings. This information will allow them to confirm their predicted performance numbers.
 - SCI stated that they would request the temperature data from the plant and would provide the data along with the drawings when it was available.

Tri-Mer Circulating Dry Scrubber

- Tri-Mer stated that their Circulating Dry Scrubber (CDS) system differed from traditional CDS systems in that their system recirculates a portion of the ash collected by the baghouse back to the CDS reactor(s) via pneumatic transport. This approach eliminates the need for an elevated baghouse, as is seen with traditional CDS systems. This would allow the UAF plant to keep their existing baghouse.
- The only verifiabl

Tri-Mer Recirculating Dry Scrubber

- Tri-Mer stated that their Recirculating Dry Scrubber (RDS) system is very similar to that of a traditional CDS system. This system would require that the existing plant baghouse be replaced with an elevated baghouse to facilitate the return of ash and sorbents from the baghouse to the reactors via an air slide.

Tri-Mer Caustic Soda Wet Scrubber

- Tri-Mer stated that their Caustic Soda Wet Scrubber system was an offering that the provided for other industrial flue gas applications, but one that does not often get employed on power projects.
- They stated that it differs from traditional Wet Flue Gas Desulfurization systems in that it uses a caustic soda liquid instead of the traditional reagent slurry.
- Tri-Mer further stated that, while the system works well on several industrial processes, it can be very sensitive to changes in the process. Therefore, while technically available for installation, it may not be the correct solution for this project due to the variable nature of plant operations.

Distribution:

file
Boreal



Appendix E

Dry Sorbent Injection Vendor Data

Andritz DSI Email.....	Page E-1
B&W DSI Email	Page E-13
BACT, Inc DSI Email	Page E-20
Tri-Mer DSI Email	Page E-45

Andritz DSI Email

Jahn, Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Friday, May 20, 2022 4:26 PM
To: Jahn, Mario; Prieler Harald
Cc: Verreault Ron; Solan, John
Subject: Re: Cost Estimating Support for Desulfurization Technologies

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Mario

We were not planning on bidding the other two technologies as to us for a CFB boiler application we think a CDS is a slam dunk choice, mostly because the CDS will not need any fresh lime addition as it can use residual active calcium coming from the boiler. Please see my email to Mark below from March 21 for more details. Let us know if that doesn't answer your questions. Thanks.

Paul Petty
Andritz Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Friday, May 20, 2022 5:25:28 PM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul/Harald,

I'm looking thru the RFQ documentation that Mark Fritz sent to you in February and noticed that we had also asked for pricing of a WFGD and SDA. Is this pricing coming at a future time or was pricing not provided for these technologies for another reason?

Thanks,



Mario Jahn, Mechanical Engineer
STANLEYCONSULTANTS, 8000 South Chester Street Suite 500, Centennial, CO 80112
T: 303.649.7895 | M: 303.725.1361 | stanleyconsultants.com

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Friday, May 20, 2022 10:41 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>

Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>

Subject: RE: Cost Estimating Support for Desulfurization Technologies

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mario,

Understood, thank you for the update, that helps frame this as “near term” or “not near term”. Thanks again

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>

Sent: Friday, May 20, 2022 11:32 AM

To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>

Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>

Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul,

Thanks for the info.

Viability: We are still performing the BACT analysis. Final viability will be determined by the EPA based on the findings of the BACT analysis.

Timing: My best guess at this moment in time is that we would have direction from the EPA around Q1, 2023.

Hope that helps.

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>

Sent: Friday, May 20, 2022 9:03 AM

To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>

Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>

Subject: RE: Cost Estimating Support for Desulfurization Technologies

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mario,

Please see attached for a preliminary I/O list. Our "typical" list has been checked vs. the scope for project and preliminary corrections made to match but there are a few items that would need to be confirmed such as what SO₂, PM, CEMS etc. type signals are available for use. This does not include any scope by others like any pneumatic conveying system to disposal of the byproduct or the instrument air compressors.

Is there any update you can provide us on the project in terms of viability and timing? Thanks.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Friday, May 20, 2022 8:57 AM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Paul,

Sounds good. We appreciate the support on this.

Regards,
Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Thursday, May 19, 2022 5:48 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mario,

Email received, we'll get back with you shortly with the I/O count. No, we had not heard that Mark retired from Stanley. We look forward to working with you on the project going forward. Thanks.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, May 18, 2022 7:34 PM
To: Petty Paul <Paul.Petty@andritz.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Good Afternoon Paul and Harald,

I'm not sure if you are aware, but Mark Fritz retired from Stanley last week. I'll be your contact moving forward for this project. I've been coming up to speed with the information that was provided by Andritz. I do apologize if my question was previously asked and answered, but I was wondering if you had a preliminary count of I/O for a project this size.

Thanks in advance for your help.

Regards,



Mario Jahn, Mechanical Engineer

STANLEYCONSULTANTS, 8000 South Chester Street Suite 500, Centennial, CO 80112
T: 303.649.7895 | M: 303.725.1361 | stanleyconsultants.com

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Tuesday, April 26, 2022 6:47 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>
Cc: Verreault Ron <Ron.Verreault@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Hello Mark,

I thought I would check in to see if you could provide any update and "next steps" for the below project. Thanks again,

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Petty Paul

Sent: Monday, March 21, 2022 2:03 PM

To: Fritz, Mark <FritzMark@stanleygroup.com>; Prieler Harald <Harald.Prieler@andritz.com>

Cc: Verreault Ron <Ron.Verreault@andritz.com>

Subject: RE: Cost Estimating Support for Desulfurization Technologies

Mark,

Please find attached our budgetary proposal for a TurboCDS scrubber and baghouse for your U of A Fairbanks project. A few notes about this proposal

1. As this is a CFB Boiler project, we are not offering the SDA or limestone WFGD options at this time. This is due to the following factors:
 - a. Regarding WFGD, experience is clear that WFGD would not make economic sense for a project this small, with such a low inlet SO₂ value. A WFGD would be higher in capital cost than a DFGD and will require a liquid waste stream to be disposed of. Typically, therefore, the project needs to be large enough that a high amount of SO₂ is being removed from the flue gas so that the much lower reagent costs of limestone type WFGD systems can over time result in a lower NPV for the project. For this project our quoted DFGD system actually requires no sorbent (see below) and so a WFGD will have no advantage, other than reuse of the baghouse. The existing baghouse could be reused but note that to offer any PM emissions guarantees new bags and cages would need to be installed and this offsets a significant portion of that benefit. We are confident that even with the existing baghouse this is a higher capital / NPV cost
 - b. Regarding SDA the capital cost is usually similar to a CDS but in this case the SDA will require a slaking system where the CDS will have no lime injection system of any kind (see below) so the capital cost will be higher for the SDA. As with the WFGD the existing baghouse can likely be reused but this benefit is offset by the need for new bags and in the case of an SDA modified inlet duct as well. Also, we are not clear what outlet SO₂ emissions rate is required but guarantees below about 0.06 #/MMBTU for SO₂ are difficult for an SDA. A CDS can achieve much lower values, equal to WFGD performance but at lower cost. In short, the CDS will have superior SO₂ performance and the capital cost of the SDA, with a reused baghouse, is likely similar to the CDS with a new baghouse. The NPV will favor the CDS due to the lack of lime consumption costs for the CDS and lower operating/maintenance costs due to the lack of a slaking system.
2. As mentioned above, the TurboCDS is an excellent fit for use with a limestone fired CFB Boiler. This is because a portion of the limestone injected into the boiler is calcined to CaO but does not react with acid gases in the boiler before exiting the economizer. A portion of this CaO is still chemically active and once it enters the TurboCDS it is hydrated into Ca(OH)₂ where it again becomes chemically active and is effective at reducing SO₂. Andritz has a number of CFB/CDS installations in the US, including Luminant Sandow, CLECO Rodemacher, Dominion Virginia City and Georgia Pacific Port Hudson. Some discussion would need to take place to confirm the Ca/S of the boiler but experience indicates that for a design boiler SO₂ outlet value of 0.2 #/MMBTU it is highly likely that enough active CaO will exit the boiler to allow Andritz to guarantee zero fresh lime addition in the scrubber for 90% removal to 0.02 #/MMBTU. This also eliminates the need for a lime silo and feed system.
3. Note that Andritz assumes 0.01 #/MMBTU PM guarantees and 0.02 #/MMBTU SO₂ guarantees are acceptable as none were specified. Please advise if different values are desired.
4. We assume you require the emissions to be met with one baghouse compartment out of service, as is typical. If this is not the case we can make the baghouse significantly smaller or consider use of alternate technologies.

Thank you for your interest in Andritz. Hopefully this is responsive to your request. Please let us know if you have any questions. Thanks again.

Best regards,

Paul Petty
Andritz, Inc.
+1 667 351 8872

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 9, 2022 3:05 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Harald,

No problem. It had been a while since we talked and I wanted to touch base to see if there had been any changes in the end of March date.

Thanks,

Mark

From: Prieler Harald <Harald.Prieler@andritz.com>
Sent: Wednesday, March 9, 2022 12:44 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Hello Mark

as mentioned in my previous email, we are busy with some other proposal and project work at the moment, but we believe being able to provide you some information on the project by end of March.
Hoping this Works for you.

Thanks and

Best regards,

Harald Prieler
Regional Manager Americas
Air Pollution Control

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, March 9, 2022 3:19 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Harald,

When is a good time to discuss this proposal? Project was temporary delayed but is back on track.

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

From: Prieler Harald <Harald.Prieler@andritz.com>
Sent: Tuesday, February 8, 2022 12:23 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Petty Paul <Paul.Petty@andritz.com>
Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Thanks Mark.

As a matter of fact, we are working on several firm proposals at the moment, therefore it will be difficult to provide you something before end of March.

We are trying our best to do it earlier, but I do not want to provoke wrong expectations.

Hoping, this is ok for you.

Best regards,

Harald Prieler
Regional Manager Americas
Air Pollution Control

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Tuesday, February 8, 2022 1:05 PM

To: Prieler Harald <Harald.Prieler@andritz.com>

Cc: Petty Paul <Paul.Petty@andritz.com>

Subject: RE: Cost Estimating Support for Desulfurization Technologies

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Harold,

Yes existing baghouse is downstream of the boiler. Have attached a few layout drawings. Do you have a idea of when we might see some of the requested information? If you need any further information, please ask.

Regards,

Mark



Mark Fritz, Principal Mechanical Engineer

STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657

T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

From: Prieler Harald <Harald.Prieler@andritz.com>

Sent: Thursday, February 3, 2022 4:41 AM

To: Fritz, Mark <FritzMark@stanleygroup.com>

Cc: Petty Paul <Paul.Petty@andritz.com>

Subject: FW: Cost Estimating Support for Desulfurization Technologies

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Mark

confirming that we have received your inquiry.

We'll assess it and let you know, how we can Support you on this project.

Following quick clarifications:

- the attached baghouse data sheet is for an existing BHF downstream the boiler – please confirm.
- A layout of the CHPP would be very helpful to assess the different alternatives.

Thanks and br

Harald

Best regards,

Harald Prieler

Regional Manager Americas

Air Pollution Control

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, February 2, 2022 6:15 PM
To: Prieler Harald <Harald.Prieler@andritz.com>
Subject: Cost Estimating Support for Desulfurization Technologies

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

Harold,

See attached for the Scope and additional information we discussed on the phone. I have tried to minimize the requested information and provide just what we need to finish the cost estimate. Please do not hesitate to call to discuss further, or if there is additional information you require.

Regard,

Mark



Mark Fritz, Principal Mechanical Engineer
STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657
T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

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Public Review Draft

August 19, 2024

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Thank you

B&W DSI Email

Jahn, Mario

From: Pon, Ronald T <rtpon@babcock.com>
Sent: Wednesday, February 9, 2022 11:50 PM
To: Fritz, Mark
Cc: Solan, John; Frances Isgrigg; Walukiewicz, Henry D; Mitchell, Joseph M; Perkins, Sharon D
Subject: RE: AQCS Cost Estimate for UAF

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mark,

Sorry for the delay in getting back to you as I've been on the road this week.

The pricing for the engineering review is based on simultaneous evaluation each of the four technologies at 40 hours for each evaluation along with an additional 15 hours for project management and report writing. The Hourly Rate for the engineering to support this effort averages to \$200 per hour.

Best regards,
Ron



Ronald Pon
Account Manager
Email: rtpon@babcock.com
Desk: 707.265.1055
Mobile: 925.451.4272
FAX: 707.265.1000
710 Airpark Road
Napa, CA 94558
www.babcock.com • NYSE BW
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TARGET ZERO - To finish each and every day injury- and incident-free

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Thursday, February 3, 2022 7:24 AM
To: Pon, Ronald T <rtpon@babcock.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>; Frances Isgrigg <fisgrigg@alaska.edu>
Subject: EXTERNAL: RE: AQCS Cost Estimate for UAF

Ron,

Can you provide a breakdown of your costs and make the attached SOW part of the proposal?

Mark

From: Pon, Ronald T <rtpon@babcock.com>
Sent: Tuesday, February 1, 2022 10:25 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>; Hensel, Ryan D <rdhensel@babcock.com>; Mitchell, Joseph M <JMMitchell@babcock.com>; Perkins, Sharon D <sdperkins@babcock.com>
Subject: RE: AQCS Cost Estimate for UAF

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mark,

The Babcock & Wilcox Company (B&W) is pleased to offer Proposal P-082524 to perform an engineering review of the available SO₂ control technologies (Wet Flue Gas Desulfurization (WFGD), Circulating Dry Scrubber (CDS), Spray Dry Absorbers (SDA), and Dry Sorbent Injection (DSI)) for the University of Alaska Fairbanks (UAF). The study will consist of finding a similarly sized application in B&W's experience for each technology to provide high level values for expected pricing and performance.

Due to the criticality of this request and quick turnaround, B&W respectfully requests that a PO be issued as quickly as possible if this is something that Stanley and UAF would like to proceed.

Please feel free to contact me with any questions or comments.

Best regards,
Ron



Ronald Pon
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From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, January 26, 2022 12:01 PM
To: Pon, Ronald T <rtpon@babcock.com>
Cc: Hensel, Ryan D <rdhensel@babcock.com>; Mitchell, Joseph M <JMMitchell@babcock.com>
Subject: EXTERNAL: RE: AQCS Cost Estimate for UAF

Ron,

Yes, the proposed time will work for me.

Mark

From: Pon, Ronald T <rtpon@babcock.com>
Sent: Wednesday, January 26, 2022 1:50 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Hensel, Ryan D <rdhensel@babcock.com>; Mitchell, Joseph M <JMMitchell@babcock.com>
Subject: Re: AQCS Cost Estimate for UAF

***** EXTERNAL EMAIL - Use caution and verify authenticity before trusting any contents. *****

Mark

Sorry for the delay in getting back to you

Would you be available to do a call Friday at 7 am, PDT / 8 am, MDT / 9 am, CDT / 10 am, EDT

Ron

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From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Thursday, January 13, 2022 7:34:17 AM
To: Pon, Ronald T <rtpon@babcock.com>
Subject: EXTERNAL: RE: AQCS Cost Estimate for UAF

Ron,

I have simplified our requested information. Please call to discuss or let me know when you are available to discuss.

Mark

From: Fritz, Mark
Sent: Wednesday, January 5, 2022 9:38 AM
To: Pon, Ronald T (rtpon@babcock.com) <rtpon@babcock.com>
Subject: AQCS Cost Estimate for UAF

Ron,

See attached for the preliminary scope of work to support our cost estimating work for UAF CHPP. Please call to discuss.

I have left the schedule blank for now. We can discuss after you get a chance to review the scope of work.

My current schedule for this week

Today – Open except 1:00 – 2:00 PM CST

Thursday - open

Friday - PM is open.

Mark



Mark Fritz, Principal Mechanical Engineer

STANLEYCONSULTANTS, 225 Iowa Avenue, Muscatine, Iowa 52657

T: 563.264.6473 | M: 563-607-1430 | stanleyconsultants.com

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