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ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Air Permits Program

BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION ADDENDUM
for
University of Alaska Fairbanks
Fairbanks Campus Power Plant

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Reviewed by: Moses Coss
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Abbreviations/Acronyms

AAC ....Alaska Administrative Code
AAAQS ....Alaska Ambient Air Quality Standards
Department ....Alaska Department of Environmental Conservation
BACT ....Best Available Control Technology
CFB……………………Circulating Fluidized Bed
CFR. ....Code of Federal Regulations
Cyclones………………Mechanical Separators
DFP……………………Diesel Particulate Filter
DLN..............................Dry Low NOx
DOC…………………...Diesel Oxidation Catalyst
EPA ....Environmental Protection Agency
ESP……………………Electrostatic Precipitator
EU.................................Emission Unit
FITR…………………...Fuel Injection Timing Retard
GCPs…………………..Good Combustion Practices
HAP ....Hazardous Air Pollutant
ITR……………………Ignition Timing Retard
LEA……………………Low Excess Air
LNB……………………Low NOx Burners
MR&Rs ....Monitoring, Recording, and Reporting
NESHAPS ....National Emission Standards for Hazardous Air Pollutants
NSCR…………………Non-Selective Catalytic Reduction
NSPS ....New Source Performance Standards
ORL ....Owner Requested Limit
PSD................................Prevention of Significant Deterioration
PTE................................Potential to Emit
RICE, ICE ....Reciprocating Internal Combustion Engine, Internal Combustion Engine
SCR ....Selective Catalytic Reduction
SIP ....Alaska State Implementation Plan
SNCR…………………Selective Non-Catalytic Reduction
ULSD ....Ultra Low Sulfur Diesel

Units and Measures

gal/hr..............................gallons per hour
g/kWh ....grams per kilowatt hour
g/hp-hr ....grams per horsepower hour
hr/day.............................hours per day
hr/yr ....hours per year
hp ....horsepower
lb/hr ....pounds per hour
lb/MMBtu ....pounds per million British thermal units
lb/1000 gal ....pounds per 1,000 gallons
kW ....kilowatts
MMBtu/hr......................million British thermal units per hour
MMscf/hr.......................million standard cubic feet per hour
ppmv..............................parts per million by volume
tpy.................................tons per year

Pollutants

CO ....Carbon Monoxide
HAP ....Hazardous Air Pollutant
NOx ....Oxides of Nitrogen
SO_2 ....Sulfur Dioxide
$PM_{2.5}$ ....Particulate Matter with an aerodynamic diameter not exceeding 2.5 microns
PM_{10} ....Particulate Matter with an aerodynamic diameter not exceeding 10 microns

1. INTRODUCTION

The University of Alaska Fairbanks (UAF) Campus facility has two oil-fired boilers (converted to dual fuel-fired by Minor Permit No. AQ0316MSS02), installed in 1970 and 1987. The power plant also has a 13,266 hp backup diesel generator installed in 1998. The UAF Campus also includes 13 diesel-fired boilers installed between 1985 and 2005, three emergency diesel engines installed between 1998 and 2019, one classroom engine installed in 1987, and one permitted diesel engine installed in 2013. Additional permitted EUs installed in 2016 at the UAF Campus include limestone, sand, and ash handling systems, a circulating fluidized bed **with limestone injection (FBLI)** dual fuel-fired boiler, and a coal handling system.

In a letter dated April 24, 2015, the Alaska Department of Environmental Conservation (Department) requested the stationary sources expected to be major stationary sources in the particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers ($PM_{2.5}$) serious nonattainment area perform a voluntary Best Available Control Technology (BACT) review in support of the state agency's required SIP submittal once the nonattainment area is re-classified as a Serious $PM_{2.5}$ nonattainment area. The designation of the area as "Serious" with regard to nonattainment of the 2006 24-hour $PM_{2.5}$ ambient air quality standards was published in Federal Register Vol. 82, No. 89, May 10, 2017, pages 21703-21706, with an effective date of June 9, 2017.[1]

The initial BACT Determination for UAF was included in Part 3 of Appendix III.D.7.07 Control Strategies Chapter, in the State Air Quality Control Plan adopted on November 19, 2019, with amendments adopted on November 18, 2020, as part of a complete SIP package.[2] The *EPA's Air Plan Partial Approval and Partial Disapproval; AK, Fairbanks North Star Borough; 2006 24-hour $PM_{2.5}$ Serious Area and 189(d) Plan*[3] published in the Federal Register on December 5, 2023 (*88 Fed. Reg. 84657*) disapproved of Alaska's initial BACT determinations for $PM_{2.5}$ and SO_2 controls. This BACT addendum addresses the significant EUs listed in Title V Operating Permit AQ0316TVP03 and Minor Permit AQ0316MSS08. The BACT addendum also accounts for EPA's comments listed in Memorandum dated August 24, 2022 from Zach Hedgpeth, R10/LSASD/ECB and Larry Sorrels OAQPS/HEID/AEG to Matthew Jentgen, ARD.[4] This BACT Addendum provides the Department's review of the BACT analysis for $PM_{2.5}$, and the BACT analysis for sulfur dioxide (SO_2) emissions, which is a precursor pollutant that can form $PM_{2.5}$ in the atmosphere post combustion. Note that the section for oxides of nitrogen (NOx), which is also a precursor pollutant that can form $PM_{2.5}$ in the atmosphere post combustion, has been removed from this addendum because the EPA has approved[3] of the Department's

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[1] Federal Register, Vol. 82, No. 89, Wednesday May 10, 2017 (https://dec.alaska.gov/air/anpms/comm/docs/2017-09391-CFR.pdf).

[2] Background and detailed information regarding Fairbanks $PM_{2.5}$ State Implementation Plan (SIP) can be found at http://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/.

[3] The EPA's Air Plan Partial Approval and Partial Disapproval; AK, Fairbanks North Star Borough; 2006 24-hour $PM_{2.5}$ Serious Area and 189(d) Plan can be found at https://www.regulations.gov/document/EPA-R10-OAR-2022-0115-0426.

[4] Document 000008 EPA Technical Support Document – UAF BACT TSD v20220824: https://www.regulations.gov/document/EPA-R10-OAR-2022-0115-0215.

comprehensive NOx precursor demonstration under 40 C.F.R. 51.1006(a)(1) and 51.1010(a)(2)(ii).

The following sections review UAF's BACT analysis for technical accuracy and adherence to accepted engineering cost estimation practices.

2. BACT EVALUATION

A BACT analysis is an evaluation of all available control options for equipment emitting the triggered pollutants and a process for selecting the best option based on feasibility, economics, energy, and other impacts. 40 CFR 52.21(b)(12) defines BACT as a site-specific determination on a case-by-case basis. The Department's goal is to identify BACT for the permanent emission units (EUs) at the UAF Campus Facility that emit $PM_{2.5}$ and SO_2, establish emission limits which represent BACT, and assess the level of monitoring, recordkeeping, and reporting (MR&Rs) necessary to ensure UAF applies BACT for the EUs. The Department based the BACT review on the five-step top-down approach set forth in Federal Register Volume 61, Number 142, July 23, 1996 (Environmental Protection Agency). Table A presents the EUs subject to BACT review.

Table A: Emission Units Subject to BACT Review

EU ID[1]	Description of EU	Rating / Size		Fuel Type	Installation or Construction Date
3	Dual-Fired Boiler	180.9	MMBtu/hr	Dual Fuel	1970
4	Dual-Fired Boiler	180.9	MMBtu/hr	Dual Fuel	1987
8	Peaking/Backup Diesel Generator	13,266	hp	Diesel	1999
9A	Medical/Pathological Waste Incinerator	83	lb/hr	Medical / Infectious Waste	2006
17	**Diesel Boiler**	**4.93**	**MMBtu/hr**	**Diesel**	**2003**
18	**Diesel Boiler**	**4.93**	**MMBtu/hr**	**Diesel**	**2003**
19	Diesel Boiler	6.13	MMBtu/hr	Diesel	2004
20	Diesel Boiler	6.13	MMBtu/hr	Diesel	2004
21	Diesel Boiler	6.13	MMBtu/hr	Diesel	2004
22	**Diesel Boiler**	**8.5**	**MMBtu/hr**	**Diesel**	**2005**
24	Diesel Generator Engine	51	kW	Diesel	2001
26	Diesel Generator Engine	45	kW	Diesel	1987
27	Diesel Generator Engine	500	hp	Diesel	2013
29	Diesel Generator Engine	314	hp	Diesel	2013
34	**Diesel Generator Engine**	**324**	**hp**	**Diesel**	**2015**
35	**Diesel Generator Engine**	**1,220**	**hp**	**Diesel**	**2019**
105	Limestone Handling System	1,200	acfm	N/A	2019
107	Sand Handling System	1,600	acfm	N/A	2019
109	Ash Handling System	1,000	acfm	N/A	2019
110	Ash Handling System Vacuum	2,000	acfm	N/A	2019
111	Ash Loadout to Truck	N/A		N/A	2019
113	Dual Fuel-Fired Circulating Fluidized Bed (CFB) Boiler	295.6	MMBtu/hr	Coal/Woody Biomass	2019
114	Dry Sorbent Handling Vent Filter Exhaust	5	acfm	N/A	2019
128	Coal Silo No. 1 with Bin Vent	1,650	acfm	N/A	2019
129	Coal Silo No. 2 with Bin Vent	1,650	acfm	N/A	2019
130	Coal Silo No. 3 with Bin Vent	1,650	acfm	N/A	2019

Table Notes:
[1] **Since the previous BACT analysis for UAF was adopted on November 19, 2019, amendments adopted November 19, 2020, EUs 23 and 28 have been permanently removed from the stationary source and EUs 34 and 35 have been added.**

Five-Step BACT Determinations
The following sections explain the steps used to determine BACT for $PM_{2.5}$ and SO_2 for the applicable equipment.

Step 1 Identify All Potentially Available Control Technologies
The Department identifies all available control technologies for the EUs and the pollutant under consideration. This includes technologies used throughout the world or emission reductions through the application of available control techniques, changes in process design, and/or operational limitations. To assist in identifying available controls, the Department reviews available technologies listed on the Reasonably Available Control Technology (RACT), BACT, and Lowest Achievable Emission Rate (LAER) Clearinghouse (RBLC). The RBLC is an EPA database where permitting agencies nationwide post imposed BACT for PSD sources. In addition to the RBLC search, the Department used several search engines to look for emerging and tried technologies used to control $PM_{2.5}$ and SO_2 emissions from equipment similar to those listed in Table A.

Step 2 Eliminate Technically Infeasible Control Technologies:
The Department evaluates the technical feasibility of each control technology based on source specific factors in relation to each EU subject to BACT. Based on sound documentation and demonstration, the Department eliminates control technologies deemed technically infeasible due to physical, chemical, and engineering difficulties.

Step 3 Rank the Remaining Control Technologies by Control Effectiveness
The Department ranks the remaining control technologies in order of control effectiveness with the most effective at the top.

Step 4 Evaluate the Most Effective Controls and Document the Results as Necessary
The Department reviews the detailed information in the BACT analysis about the control efficiency, emission rate, emission reduction, cost, environmental, and energy impacts for each option to decide the final level of control. The analysis must present an objective evaluation of both the beneficial and adverse energy, environmental, and economic impacts. A proposal to use the most effective option does not need to provide the detailed information for the less effective options. If cost is not an issue, a cost analysis is not required. Cost effectiveness for a control option is defined as the total net annualized cost of control divided by the tons of pollutant removed per year. Annualized cost includes annualized equipment purchase, erection, electrical, piping, insulation, painting, site preparation, buildings, supervision, transportation, operation, maintenance, replacement parts, overhead, raw materials, utilities, engineering, start-up costs, financing costs, and other contingencies related to the control option. Sections 4 and 5 present the Department's BACT Determinations for $PM_{2.5}$ and SO_2.

Step 5 Select BACT

The Department selects the most effective control option not eliminated in Step 4 as BACT for the pollutant and EU under review and lists the final BACT requirements determined for each EU in this step. A project may achieve emission reductions through the application of available technologies, changes in process design, and/or operational limitations. The Department reviewed UAF's BACT analysis and made BACT determinations for $PM_{2.5}$ and SO_2 for the UAF Campus Power Plant. These BACT determinations are based on the information submitted by UAF in their analysis, information from vendors, suppliers, sub-contractors, RBLC, and an exhaustive internet search.

3. BACT DETERMINATION FOR NO_X

As discussed in the Section 1 Introduction, this BACT addendum has removed the previous NOx BACT determinations included in the State Air Quality Control Plan adopted on November 19, 2019, with amendments adopted on November 18, 2020,[2] because the optional comprehensive precursor demonstration (as allowed under 40 C.F.R. 51.1006(1) and 51.1010(a)(2)(ii)) for the precursor gas NOx for point sources illustrates that NOx controls are not needed. The Department submitted with the Serious SIP a final comprehensive precursor demonstration as justification not to require post emission controls for NOx. Please see the precursor demonstration for NOx in the Serious SIP Modeling Chapter III.D.7.8.[2] The $PM_{2.5}$ NAAQS Final SIP Requirements Rule states if the state determines through a precursor demonstration that controls for a precursor gas are not needed for attaining the standard, then the controls identified as BACT/BACM or Most Stringent Measure for the precursor gas are not required to be implemented.[5] The Department's NOx precursor demonstration was approved in *EPA's Air Plan Partial Approval and Partial Disapproval; AK, Fairbanks North Star Borough; 2006 24-hour $PM_{2.5}$ Serious Area and 189(d) Plan*[3] published in the Federal Register on December 5, 2023 (*88 Fed. Reg. 84657*).

4. BACT DETERMINATION FOR $PM_{2.5}$

The Department based its $PM_{2.5}$ assessment on BACT determinations found in the RBLC, internet research, and BACT analyses submitted to the Department by GVEA for the North Pole Power Plant and Zehnder Facility, Aurora for the Chena Power Plant, US Army for Fort Wainwright, and UAF for the Combined Heat and Power Plant.

4.1 $PM_{2.5}$ BACT for the Large Dual Fuel-Fired Boiler (EU 113)

Possible $PM_{2.5}$ emission control technologies for large dual fuel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 11.110, Coal Combustion in Industrial Size Boilers and Furnaces. The search results are listed in Table 4-1.

Table 4-1. RBLC Summary of $PM_{2.5}$ Control for Industrial Coal-Fired Boilers

[5] https://www.gpo.gov/fdsys/pkg/FR-2016-08-24/pdf/2016-18768.pdf

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
Pulse Jet Fabric Filters	4	0.012 – 0.024
Electrostatic Precipitators	2	0.02 – 0.03

RBLC Review
A review of similar units in the RBLC indicates that fabric filters and electrostatic precipitators are the principle particulate matter control technologies installed on large dual fuel-fired boilers. The lowest $PM_{2.5}$ emission rate listed in RBLC is 0.012 lb/MMBtu.

Step 1 - Identification of $PM_{2.5}$ Control Technologies for the Large Dual Fuel-Fired Boiler
From research, the Department identified the following technologies as available for control of $PM_{2.5}$ emissions from the large dual fuel-fired boiler:

(a) Fabric Filters
Fabric filters or baghouses are comprised of an array of filter bags contained in housing. Air passes through the filter media from the "dirty" to the "clean" side of the bag. These devices undergo periodic bag cleaning based on the build-up of filtered material on the bag as measured by pressure drop across the device. The cleaning cycle is set to allow operation within a range of design pressure drop. Fabric filters are characterized by the type of cleaning cycle: mechanical-shaker,[6] pulse-jet,[7] and reverse-air.[8] Fabric filter systems have control efficiencies of 95% to 99.9%, and are generally specified to meet a discharge concentration of filterable particulate (e.g., 0.01 grains per dry standard cubic feet). The Department considers fabric filters a technically feasible control technology for the large dual fuel-fired boiler.

(b) Wet and Dry Electrostatic Precipitators (ESP)
ESPs remove particles from a gas stream by electrically charging particles with a discharge electrode in the gas path and then collecting the charged particles on grounded plates. The inlet air is quenched with water on a wet ESP to saturate the gas stream and ensure a wetted surface on the collection plate. This wetted surface along with a periodic deluge of water is what cleans the collection plate surface. Wet ESPs typically control streams with inlet grain loading values of 0.5 – 5 gr/ft^3 and have control efficiencies between 90% and 99.9%.[9] Wet ESPs have the advantage of controlling some amount of condensable particulate matter. The collection plates in a dry ESP are periodically cleaned by a rapper or hammer that sends a shock wave that knocks the collected particulate off the plate. Dry ESPs typically control streams with inlet grain loading values of 0.5 – 5 gr/ft^3 and have control efficiencies between 99% and 99.9%.[10] The Department considers ESP a technically feasible control technology for the large dual fuel-fired boiler.

[6] https://www3.epa.gov/ttn/catc/dir1/ff-shaker.pdf
[7] https://www3.epa.gov/ttn/catc/dir1/ff-pulse.pdf
[8] https://www3.epa.gov/ttn/catc/dir1/ff-revar.pdf
[9] https://www3.epa.gov/ttn/catc/dir1/fwespwpi.pdf
https://www3.epa.gov/ttn/catc/dir1/fwespwpl.pdf
[10] https://www3.epa.gov/ttn/catc/dir1/fdespwpi.pdf
https://www3.epa.gov/ttn/catc/dir1/fdespwpl.pdf

(c) Wet Scrubbers
Wet scrubbers use a scrubbing solution to remove $PM/PM_{10}/PM_{2.5}$ from exhaust gas streams. The mechanism for particulate collection is impaction and interception by water droplets. Wet scrubbers are configured as counter-flow, cross-flow, or concurrent flow, but typically employ counter-flow where the scrubbing fluid is in the opposite direction as the gas flow. Wet scrubbers have control efficiencies of 50% - 99%.[11] One advantage of wet scrubbers is that they can be effective on condensable particulate matter. A disadvantage of wet scrubbers is that they consume water and produce water and sludge. For fine particulate control, a venturi scrubber can be used, but typical loadings for such a scrubber are 0.1-50 grains/scf. The Department considers the use of wet scrubbers to be a technically feasible control technology for the large dual fuel-fired boiler.

(d) Cyclone
Cyclones are used in industrial applications to remove particulate matter form exhaust flows and other industrial stream flows. Dirty air enters a cyclone tangentially and the centrifugal force moves the particulate matter against the cone wall. The air flows in a helical pattern from the top down to the narrow bottom before exiting the cyclone straight up the center and out the top. Large and dense particles in the stream flow are forced by inertia into the walls of the cyclone where the material then falls to the bottom of the cyclone and into a collection unit. Cleaned air then exits the cyclone either for further treatment or release to the atmosphere. The narrowness of the cyclone wall and the speed of the air flow determine the size of particulate matter that is removed from the stream flow. Cyclones are most efficient at removing large particulate matter (PM_{10} or greater). Conventional cyclones are expected to achieve 0 to 40 percent $PM_{2.5}$ removal. High efficiency single cyclones are expected to achieve 20 to 70 percent $PM_{2.5}$ removal. The Department considers cyclones a technically feasible control technology for the large dual fuel-fired boiler.

(e) Settling Chamber
Settling chambers appear only in the biomass fired boiler RBLC inventory for particulate control, not in the coal fired boiler RBLC inventory. This type of technology is a part of the group of air pollution control collectively referred to as "pre-cleaners" because the units are often used to reduce the inlet loading of particulate matter to downstream collection devices by removing the larger, abrasive particles. The collection efficiency of settling chambers is typically less than 10 percent for PM_{10}. The EPA fact sheet does not include a settling chamber collection efficiency for $PM_{2.5}$. The Department does not consider settling chambers a technically feasible control technology for the large dual fuel-fired boiler.

(f) Good Combustion Practices (GCPs)
GCPs typically include the following elements:

1. **Sufficient residence time to complete combustion;**

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[11] https://www3.epa.gov/ttn/catc/dir1/fcondnse.pdf
https://www3.epa.gov/ttn/catc/dir1/fiberbed.pdf
https://www3.epa.gov/ttn/catc/dir1/fventuri.pdf

2. **Providing and maintaining proper air/fuel ratio;**
3. **High temperatures and low oxygen levels in the primary combustion zone;**
4. **High enough overall excess oxygen levels to complete combustion and maximize thermal efficiency.**

Combustion efficiency is dependent on the gas residence time, the combustion temperature, and the amount of mixing in the combustion zone. GCPs are accomplished primarily through combustion chamber design as it relates to residence time, combustion temperature, air-to-fuel mixing, and excess oxygen levels. Proper management of the combustion process will result in a reduction of $PM_{2.5}$ emissions. The Department considers GCPs a technically feasible control technology for the large dual fuel-fired boiler.

Step 2 - Elimination of Technically Infeasible $PM_{2.5}$ Control Technologies for the Large Dual Fuel-Fired Boiler

As explained in Step 1 of Section 4.1, the Department does not consider a settling chamber a technically feasible control technology to control $PM_{2.5}$ emissions from the large dual fuel-fired boiler.

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Large Dual Fired Boiler

The following control technologies have been identified and ranked by efficiency for the control of $PM_{2.5}$ from the dual fuel-fired boiler:

(a)	Fabric Filters	(99.9% Control)
(b)	Electrostatic Precipitator	(99.6% Control)
(c)	Scrubber	(50% - 99% Control)
(d)	Cyclone	(20% - 70%)
(f)	Good Combustion Practices	(Less than 40%)

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for $PM_{2.5}$ emissions from the large dual fuel-fired boiler:

(a) $PM_{2.5}$ emissions shall be controlled by installing, operating, and maintaining a fabric filter; and

(b) $PM_{2.5}$ emissions shall not exceed 0.012 lb/MMBtu.

Step 5 - Selection of $PM_{2.5}$ BACT for the Large Dual Fuel-Fired Boiler

The Department's finding is that BACT for $PM_{2.5}$ emissions from the large dual fuel-fired boiler is as follows:

(a) $PM_{2.5}$ emissions from EU 113 shall be controlled by operating and maintaining fabric filters at all times of operation;

(b) **$PM_{2.5}$ emissions from EU 113 shall be controlled by maintaining good combustion practices at all times the units are in operation;**

(c) $PM_{2.5}$ emissions from EU 113 shall not exceed 0.012 lb/MMBtu[12] **averaged over a three-hour period;**

(d) Initial compliance with the proposed $PM_{2.5}$ emission limit will be demonstrated by conducting a performance **test for $PM_{2.5}$, including condensable PM; and**

(e) **Maintain compliance with State opacity standards listed under 50.055(a)(1).**

Table 4-2 lists the $PM_{2.5}$ BACT determination for this facility along with those for other industrial coal-fired boilers in the Serious $PM_{2.5}$ nonattainment area.

Table 4-2. Comparison of $PM_{2.5}$ BACT for Coal-Fired Boilers at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
UAF	One Dual Fuel-Fired Boiler	295.6 MMBtu/hr	0.012 lb/MMBtu[12]	Fabric Filters; **Good Combustion Practices**
Fort Wainwright	Six Coal-Fired Boilers	1,380 MMBtu/hr	0.045 lb/MMBtu[13]	Full Steam Baghouse; **Good Combustion Practices**
Chena	**4 Coal-Fired Boilers**	**497 MMBtu/hr (combined)**	**0.045 lb/MMBtu**[13]	**Full Stream Baghouse**; **Good Combustion Practices**

4.2 $PM_{2.5}$ BACT for the Mid-Sized Diesel-Fired Boilers (EUs 3 and 4)

Possible $PM_{2.5}$ emission control technologies for mid-sized diesel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 12.220, Industrial Size Distillate Fuel Oil Boilers (>100 MMBtu/hr and ≤ 250 MMBtu/hr). The search results for mid-sized diesel-fired boilers are summarized in 4-3.

Table 4-3. RBLC Summary of $PM_{2.5}$ Control for Mid-Sized Boilers Firing Diesel

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
No Control Specified	7	0.0066 – 0.02
Good Combustion Practices	3	0.007 – 0.015

Possible $PM_{2.5}$ emission control technologies for mid-sized diesel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 12.310, Industrial Size Gaseous Fuel Boilers (>100 MMBtu/hr and ≤ 250 MMBtu/hr). The search results for mid-sized diesel-fired boilers are summarized in Table 4-4.

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[12] **Boiler manufacturer Babcock & Wilcox's $PM_{2.5}$ emission guarantee, used to calculate potential to emit in Air Quality Permit AQ0316MSS06.**

[13] **The 0.045 lb/MMBtu emission rate is calculated using EPA AP-42 Tables 1.1-50.04 lb/MMBtu for spreader stoker boilers with a baghouse) and 1.1-6 (0.01A lb/ton for $PM_{2.5}$ sized particles for a boiler with a baghouse converted to lb/MMBtu using the typical gross as received heat value of 7,560 Btu/lb and an ash content (A) of 7 percent). Heat and ash content of the Usibelli coal is identified in the coal data sheet at: http://usibelli.com/coal/data-sheet.**

Table 4-4. RBLC Summary of $PM_{2.5}$ Control for Mid-Sized Boilers Firing Natural Gas

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
Limited Operation	2	0.0074 – 0.3
Good Combustion Practices	42	0.0019 – 0.008
No Control Specified	19	0.0074 – 0.01

RBLC Review
A review of similar units in the RBLC indicates limited operation and good combustion practices are the principle $PM_{2.5}$ control technologies installed on mid-sized boilers. The lowest $PM_{2.5}$ emission rate listed in the RBLC is 0.0019 lb/MMBtu.

Step 1 - Identification of $PM_{2.5}$ Control Technology for the Mid-Sized Diesel-Fired Boilers
From research, the Department identified the following technologies as available for $PM_{2.5}$ control of mid-sized diesel-fired boilers:

(a) Fabric Filters
The theory behind fabric filters was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers fabric filters a technically feasible control technology for the mid-sized diesel-fired boilers.

(b) Electrostatic Precipitators
The theory behind ESPs was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers ESPs a technically feasible control technology for the mid-sized diesel-fired boilers.

(c) Scrubber
The theory behind scrubbers was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers scrubbers a technically feasible control technology for the mid-sized diesel-fired boilers.

(d) Cyclone
The theory behind cyclones was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers cyclones a technically feasible control technology for the mid-sized diesel-fired boilers.

(e) Natural Gas
The theory behind the use of natural gas for the mid-sized diesel-fired boilers was discussed in detail in the NOx BACT for the mid-sized diesel-fired boilers. The Department does not consider switching to natural gas a technically feasible control technology for the mid-sized diesel-fired boilers.

(f) Limited Operation
EU 4 currently operates under a combined annual NOx emission limit with EU 8. Limiting the operation of emissions units reduces the potential to emit of those units. The Department considers limited operation a technically feasible control technology for the mid-sized diesel-fired boilers.

(g) Good Combustion Practices
The theory of GCPs was discussed in detail in the $PM_{2.5}$ BACT section for the large dual fuel-fired boiler and will not be repeated here. Proper management of the combustion process will result in a reduction of $PM_{2.5}$ emissions. The Department considers GCPs a technically feasible control technology for the mid-sized diesel-fired boilers.

Step 2 - Eliminate Technically Infeasible $PM_{2.5}$ Control Technologies for the Mid-Sized Diesel-Fired Boilers
As explained in Step 1 of Section 4.2, the Department does not consider natural gas as a technically feasible technology to control particulate matter emissions from the mid-sized diesel-fired boilers.

Additionally, due to the residue from the diesel combustion in the exhaust gas, fabric filters, scrubbers, ESPs, and cyclones are not technically feasible control technologies.

EU 3 is used as a backup to the existing large boilers if one of them fails, and will be used as the backup to EU 113 if it fails. As the backup EU, it is not technically feasible to use an operational limit to control $PM_{2.5}$ emissions.

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Mid-Sized Diesel-Fired Boilers
UAF has selected the only remaining control technologies, therefore, ranking is not required.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for the mid-sized diesel-fired boilers:

(a) $PM_{2.5}$ emissions from EU 3 and 4 shall not exceed 0.016 lb/MMBtu while firing diesel fuel;

(b) $PM_{2.5}$ emissions from EU 4 shall not exceed 7.6 lb/MMscf while firing natural gas; and

(c) $PM_{2.5}$ emissions from EU 4 will be limited by complying with the combined annual NOx emission limit of 40 tons per 12 month rolling period for EUs 4 and 8.

Step 5 - Selection of $PM_{2.5}$ BACT for the Mid-Sized Diesel-Fired Boilers
The Department's finding is that BACT for $PM_{2.5}$ emissions from EUs 3 and 4 is as follows:

(a) $PM_{2.5}$ emissions from EUs 3 and 4 shall not exceed 0.012 lb/MMBtu[14] averaged over a 3-hour period while firing diesel fuel;

(b) $PM_{2.5}$ emissions from EU 4 shall not exceed 0.0075 lb/MMBtu[15] averaged over a 3-hour period while firing natural gas;

(c) $PM_{2.5}$ emissions from EU 4 shall be controlled by limiting combined NOx emissions of EU 4 and 8 to no more than 40 tons per 12-month rolling period;

[14] Emission factor from AP-42 Table's 1.3-2 (total condensable particulate matter from No. 2 oil, 1.3 lb/1,000 gal) and 1.3-6 ($PM_{2.5}$ size-specific factor from distillate oil, 0.25 lb/1,000 gal) converted to lb/MMBtu.
[15] Emission factor from AP-42 Table 1.4-2 for total particulate matter and converted to lb/MMBtu.

(d) **Initial compliance with the proposed $PM_{2.5}$ emission limits will be demonstrated by conducting a performance test; and**

(e) Maintain good combustion practices at all times by following the manufacturer's operation **and maintenance** procedures.

Table 4-5 lists the BACT determination for the facility along with those for other mid-sized boilers in the Serious $PM_{2.5}$ nonattainment area.

Table 4-5. Comparison of $PM_{2.5}$ BACT Limits for the Mid-Sized Diesel-Fired Boilers

Facility	EU ID	Process Description	Capacity	Fuel	Limitation	Control Method
UAF	3	Dual Fuel-Fired Boilers	100 – 250 MMBtu/hr	Diesel	0.012 lb/MMBtu[14]	Good Combustion Practices
	4			Diesel	0.012 lb/MMBtu[14]	Limited Operation Good Combustion Practices
				Natural Gas	0.0075 lb/MMBtu[15]	

4.3 $PM_{2.5}$ BACT for the Small Diesel-Fired Boilers (EUs 17 through 22)

Possible $PM_{2.5}$ emission control technologies for small diesel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 13.220, Commercial/Institutional Size Boilers (<100 MMBtu/hr). The search results for diesel-fired boilers are summarized in Table 4-6.

Table 4-6. RBLC Summary of $PM_{2.5}$ Control for Small Diesel-Fired Boilers

Control Technology	Number of Determinations	Emission Limits
Good Combustion Practices	3	0.25 lb/gal
		0.1 tpy
		2.17 lb/hr

RBLC Review

A review of similar units in the RBLC indicates good combustion practices are the principle $PM_{2.5}$ control technologies installed on diesel-fired boilers. The lowest $PM_{2.5}$ emission rate listed in the RBLC is 0.1 tons per year (tpy).

Step 1 - Identification of $PM_{2.5}$ Control Technology for the Small Diesel-Fired Boilers

From research, the Department identified the following technologies as available for control of $PM_{2.5}$ emissions from the small diesel-fired boilers:

(a) Scrubbers
The theory behind scrubbers was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers scrubbers as a technically feasible control technology for the small diesel-fired boilers.

(b) Limited Operation

The theory behind limited operation was discussed in detail in the $PM_{2.5}$ BACT section for the mid-sized diesel-fired boilers and will not be repeated here. The Department considers limited operation a technically feasible control technology for the small diesel-fired boilers.

(c) Good Combustion Practices
The theory of GCPs was discussed in detail in the **<u>$PM_{2.5}$ BACT section for the large dual fuel-fired boiler</u>** and will not be repeated here. Proper management of the combustion process will result in a reduction of $PM_{2.5}$ emissions. The Department considers GCPs a technically feasible control technology for the small diesel-fired boilers.

Step 2 - Eliminate Technically Infeasible $PM_{2.5}$ Control Technologies for the Diesel-Fired Boilers
All identified control devices are technically feasible for the small diesel-fired boilers.

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Small Diesel-Fired Boilers
The following control technologies have been identified and ranked by efficiency for the control of $PM_{2.5}$ emissions from the small diesel-fired boilers:

(a) Scrubber (70% - 90% Control)
(c) Good Combustion Practices (Less than 40% Control)
(b) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF provided an economic analysis of the installation of a scrubber. A summary of the analysis is shown below:

Table 4-7. UAF Economic Analysis for Technically Feasible $PM_{2.5}$ Controls

Control Alternative	Captured Emissions (tpy)	Emission Reduction (tpy)	Capital Cost ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
Scrubber	0.01	0.93	$300,000	$42,713	$47,939
Capital Recovery Factor = 0.1424 (7% for a 10 year life cycle)					

UAF contends that the economic analysis indicates the level of $PM_{2.5}$ reduction does not justify the use of a scrubber to be used in conjunction with limited operation on the small diesel-fired boilers based on the excessive cost per ton of $PM_{2.5}$ removed per year.

UAF proposes the following as BACT for $PM_{2.5}$ emissions for the small diesel-fired boilers:

(a) **<u>$PM_{2.5}$ emissions from the operation of the small diesel-fired boilers EUs 19 through 22 will be controlled by limiting the combined operation to no more than 18,739</u>** hours per 12-month rolling period; and

(b) $PM_{2.5}$ emissions from the small diesel-fired boilers shall not exceed 7.06 g/MMBtu.

Department Evaluation of BACT for $PM_{2.5}$ Emissions from the Small Diesel-Fired Boilers.

The Department reviewed UAF's proposal and finds that the 6 small diesel-fired boilers have a combined potential to emit (PTE) of less than 2 tpy for $PM_{2.5}$ based on unrestricted operation of EUs 17 and 18 and a limit of 18,739 combined hours of operation per 12 month rolling period for EUs 19 through 22. The Department does not agree with all of the assumptions made by UAF in its cost analysis. However, the Department believes that at less than 2 tpy of $PM_{2.5}$ emissions spread across six boilers, the cost effectiveness in terms of dollars per ton for add-on pollution control for these units is economically infeasible.

Step 5 - Selection of $PM_{2.5}$ BACT for the Small Diesel-Fired Boilers
The Department's finding is that BACT for $PM_{2.5}$ emissions from the diesel-fired boilers is as follows:

(a) **$PM_{2.5}$ emissions from the operation of the small diesel-fired boilers EUs 19 through 22 will be controlled by limiting the combined operation to no more than 18,739 hours per 12-month rolling period;** [16]

(b) **$PM_{2.5}$ emissions from EUs 17 through 22 shall not exceed 0.016 lb/MMBtu;**[17]

(c) **Demonstrate compliance with the numerical BACT emission limit by complying with 40 C.F.R 63 Subpart JJJJJJ; and**

(d) **Maintain good combustion practices at all times by following the manufacturer's operation and maintenance procedures.**

Table 4-8 lists the $PM_{2.5}$ BACT determination for this facility along with those for other small diesel-fired boilers rated at less than 100 MMBtu/hr in the Serious $PM_{2.5}$ nonattainment area.

Table 4-8. $PM_{2.5}$ BACT Limits for the Small Diesel-Fired Boilers

Facility	Process Description	Capacity	Limitation	Control Method
UAF	6 Diesel-Fired Boilers	< 100 MMBtu/hr	0.016 lb/MMBtu[14]	Limited Operation Good Combustion Practices
Fort Wainwright	4 Diesel-Fired Boilers	< 100 MMBtu/hr	0.016 lb/MMBtu[14]	Good Combustion Practices
Zehnder Facility	2 Diesel-Fired Boilers	< 100 MMBtu/hr	0.016 lb/MMBtu[14]	Good Combustion Practices

4.4 $PM_{2.5}$ BACT for the Large Diesel-Fired Engines (EUs 8 and 35)

Possible $PM_{2.5}$ emission control technologies for large diesel-fired engines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process codes

[16] **Limit established in Minor Permit AQ0316MSS07 to avoid minor permitting under 18 AAC 50.502(c)(3)(A)(iii).**

[17] **Emission factor corrected from 2019 SIP: AP-42 Table's 1.3-2 (total condensable particulate matter from No. 2 oil, 1.3 lb/1,000 gal) and 1.3-7 ($PM_{2.5}$ size-specific factor from distillate oil, 0.83 lb/1,000 gal) converted to lb/MMBtu. Note that the E.F. has been corrected from the previous SIP because the small boilers are considered "commercial" under Table 1.3-7 and not "industrial" under Table 1.3-6.**

17.110-17.190, Large Internal Combustion Engines (>500 hp). The search results for large diesel-fired engines are summarized in Table 4-9.

Table 4-9. RBLC Summary of $PM_{2.5}$ Control for the Large Diesel-Fired Engines

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Federal Emission Standards	12	0.03 – 0.02
Good Combustion Practices	28	0.03 – 0.24
Limited Operation	11	0.04 – 0.17
Low Sulfur Fuel	14	0.15 – 0.17
No Control Specified	14	0.02 – 0.15

RBLC Review
A review of similar units in the RBLC indicates that good combustion practices, compliance with the federal emission standards, low ash/sulfur diesel, and limited operation are the principle $PM_{2.5}$ control technologies installed on large diesel-fired engines. The lowest $PM_{2.5}$ emission rate in the RBLC is 0.02 g/hp-hr.

Step 1 - Identification of $PM_{2.5}$ Control Technology for the Large Diesel-Fired Engines
From research, the Department identified the following technologies as available for control of $PM_{2.5}$ emissions diesel-fired engines rated at 500 hp or greater:

(a) Diesel Particulate Filter (DPF)
DPF is a control technology that are designed to physically filter particulate matter from the exhaust stream. Several designs exist which require cleaning and replacement of the filter media after soot has become caked onto the filter media. Regenerative filter designs are also available that burn the soot on a regular basis to regenerate the filter media. The Department considers DPF a technically feasible control technology for the large diesel-fired engines.

(b) Positive Crankcase Ventilation
Positive crankcase ventilation is the process of re-introducing the combustion air into the cylinder chamber for a second chance at combustion after the air has seeped into and collected in the crankcase during the downward stroke of the piston cycle. This process allows any unburned fuel to be subject to a second combustion opportunity. Any combustion products act as a heat sink during the second pass through the piston, which will lower the temperature of combustion and reduce the thermal NOx formation. Positive crankcase ventilation is included in the design of EU 8. The Department considers positive crankcase ventilation a technically feasible control technology for the large diesel-fired engines.

(c) Low Ash Diesel
Residual fuels and crude oil are known to contain ash forming components, while refined fuels are low ash. Fuels containing ash can cause excessive wear to equipment and foul engine components. EU 8 is fired exclusively on distillate fuel which is a form of refined fuel. The potential $PM_{2.5}$ emissions are based on emission factors for distillate fuel. EU 8 is capable of firing either diesel or heavy fuel oil (non-low ash fuel) according to

manufacturer specifications. The Department considers low ash diesel as a technically feasible control technology for the large diesel-fired engines.

(d) Federal Emission Standards
RBLC determinations for federal emission standards require the engines meet the requirements of 40 C.F.R. 60 NSPS Subpart IIII, 40 C.F.R 63 Subpart ZZZZ, non-road engines (NREs), or EPA tier certifications. NSPS Subpart IIII applies to stationary compression ignition internal combustion engines that are manufactured or reconstructed after July 11, 2005. EU 8 was manufactured prior to July 11, 2005 and has not been reconstructed since. Therefore, EU 8 is not subject to NSPS Subpart IIII. EU 8 is considered an institutional emergency engine and is therefore exempt from NESHAP Subpart ZZZZ. For these reasons federal emission standards will not be carried forward as a control technology. However, EU 35 is newly installed in 2019 and is subject to the requirements of 40 C.F.R. 60 Subpart IIII, which is considered the baseline emission rate for the EU.

(e) Limited Operation
EU 8 currently operates under a combined annual NOx emission limit with EU 4. Limiting the operation of emissions units reduces the potential to emit of those units. Additionally, EU 35 is currently restricted by the NSPS Subpart IIII requirements for emergency engines. Therefore, the Department considers limited operation a technically feasible control technology for the large diesel-fired engines.

(f) Good Combustion Practices
The theory of GCPs was discussed in detail in the **$PM_{2.5}$ BACT section for the large dual fuel-fired boile**r and will not be repeated here. Proper management of the combustion process will result in a reduction of $PM_{2.5}$ emissions. The Department considers GCPs a technically feasible control technology for the large diesel-fired engines.

Step 2 - Eliminate Technically Infeasible $PM_{2.5}$ Control Technologies for the Large Engines
As explained in Step 1 of Section 4.4, the Department does not consider meeting the federal emission standards as a technically feasible technology to control $PM_{2.5}$ emissions from EU 8. Additionally, EU 8 is equipped with SCR for controlling NOx emissions, which creates a backpressure. This backpressure does not allow for the operation of a DPF. Therefore, a DPF is not a technically feasible $PM_{2.5}$ control option for the **EU but does remain an option for EU 35.**

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Large Diesel-Fired Engines
The following control technologies have been identified and ranked by efficiency for the control of $PM_{2.5}$ emissions from the large diesel-fired engines:

(a)	**Diesel Particulate Filter**	**(85 – 90% Control)**
(f)	Good Combustion Practices	(Less than 40% Control)
(b)	Positive Crankcase Ventilation	(~10% Control)
(c)	Low Ash/Sulfur Diesel	(~20% Control)
(f)	Limited Operation	(0% Control)
(d)	**Federal Emission Standards**	**(0% Control)**

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for $PM_{2.5}$ emissions from the large diesel-fired engines:

(a) $PM_{2.5}$ emissions from **EU 8** shall be controlled by operating with positive crankcase ventilation;

(b) $PM_{2.5}$ emissions shall not exceed 0.32 g/hp-hr;

(c) EU 8 shall combust only low ash diesel; and

(d) $PM_{2.5}$ emissions from EU 8 will be limited by complying with the combined annual NOx emission limit of 40 tons per 12 month rolling period for EUs 4 and 8.

Department Evaluation of BACT for $PM_{2.5}$ Emissions from the Large Diesel-Fired Engines

Considering EU 8 cannot operate with a DPF due to the unacceptable increase in backpressure that the DPF would cause, UAF has proposed the top level of $PM_{2.5}$ controls for the engine. However, for EU 35 a DPF is a technically feasible control option. With that said, EU 35 has potential $PM_{2.5}$ emissions of 0.03 tpy, which is an order of magnitude lower than the two other diesel engines EUs 26 and 27 that the Department found DPFs to be economically infeasible in Table's 4-13 and 4-14. Therefore, the Department did not perform a cost analysis for DPF on EU 35 as it would have an even higher cost/ton value. The Department notes that EU 35 is limited to 100 hours per calendar year of non-emergency operation and required to combust ULSD under the existing federal NSPS Subpart IIII requirements.

Step 5 - Selection of $PM_{2.5}$ BACT for the Large Diesel-Fired Engines

The Department's finding is that the BACT for $PM_{2.5}$ emissions from the large diesel-fired engines is as follows:

(a) $PM_{2.5}$ emissions from EUs 8 and 35 shall be controlled by operating positive crankcase ventilation, maintaining good combustion practices **by following the manufacturer's operation and maintenance procedures, and combusting ULSD at all times the EUs are in operation;**

(b) Limit non-emergency operation of EUs 8 **and 35** to no more than 100 hours per year;

(c) Combined NOx emissions from EUs 4 and 8 shall not exceed 40 tons per rolling 12-month period;

(d) $PM_{2.5}$ emissions from EU 8 shall not exceed 0.32 g/hp-hr[18] over a 3-hour period;

(e) *$PM_{2.5}$ e*missions from EU 35 shall not exceed 0.05 g/hp-hr over a 3-hour period; and

(f) Demonstrate compliance with the numerical BACT emission limit for EU 35 by complying with 40 C.F.R. Subpart IIII.

[18] Emission factor from AP-42 Table 3.4-1 (0.0007 lb/hp-hr) converted to g/hp-hr

Table 4-10 lists the BACT determination for this facility along with those for other diesel-fired engines rated at more than 500 hp located in the Serious $PM_{2.5}$ nonattainment area.

Table 4-10. Comparison of $PM_{2.5}$ BACT for the Large Diesel-Fired Engine at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
UAF	Large Diesel-Fired Engines	> 500 hp	**0.05 –** 0.32 g/hp-hr	Positive Crankcase Ventilation Limited Operation **Ultra-Low Sulfur Deisel**
Fort Wainwright	Large Diesel-Fired Engines	> 500 hp	0.15 – 0.32 g/hp-hr	Limited Operation Ultra-Low Sulfur Diesel Federal Emission Standards
GVEA North Pole	Large Diesel-Fired Engines	> 500 hp	0.32 g/hp-hr	Limited Operation Good Combustion Practices
GVEA Zehnder	Large Diesel-Fired Engines	> 500 hp	0.32 g/hp-hr	Limited Operation Good Combustion Practices

4.5 $PM_{2.5}$ BACT for the Small Diesel-Fired Engines (EUs 24, 26, 27, 29, and 34)

Possible $PM_{2.5}$ emission control technologies for small engines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 17.210, Small Internal Combustion Engines (<500 hp). The search results for small diesel-fired engines are summarized in Table 4-11.

Table 4-11. RBLC Summary for $PM_{2.5}$ Control for the Small Diesel-Fired Engine

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Federal Emission Standards	3	0.15
Good Combustion Practices	19	0.15 – 0.4
Limited Operation	7	0.15 – 0.17
Low Sulfur Fuel	7	0.15 – 0.3
No Control Specified	14	0.02 – 0.09

RBLC Review
A review of similar units in the RBLC indicates low ash/sulfur diesel, compliance with federal emission standards, limited operation, and good combustion practices are the principle $PM_{2.5}$ control technologies installed on small diesel-fired engines. The lowest $PM_{2.5}$ emission rate listed in the RBLC is 0.02 g/hp-hr.

Step 1 - Identification of $PM_{2.5}$ Control Technology for the Small Diesel-Fired Engines
From research, the Department identified the following technologies as available for control of $PM_{2.5}$ emissions from the diesel-fired engines rated at 500 hp or less:

(a) Diesel Particulate Filter
The theory behind DPF was discussed in detail in the $PM_{2.5}$ BACT for the large diesel-fired engine and will not be repeated here. The Department considers DPF a technically feasible control technology for the small diesel-fired engines.

(b) Low Ash Diesel
Residual fuels and crude oil are known to contain ash forming components, while refined fuels are low ash. Fuels containing ash can cause excessive wear to equipment and foul engine components. The Department considers low ash diesel a technically feasible control technology for the small diesel-fired engines.

(c) Federal Emission Standards
The theory behind federal emission standards for the small diesel-fired engine was discussed in detail in the $PM_{2.5}$ BACT section for the large diesel-fired engines and will not be repeated here. The Department considers federal emission standards a technically feasible control technology for the small diesel-fired engines.

(d) Limited Operation
The theory behind limited operation for the small diesel-fired engine was discussed in detail in the $PM_{2.5}$ BACT section for the large diesel-fired engine and will not be repeated here. The Department considers limited operation a technically feasible control technology for the small diesel-fired engines.

(e) Good Combustion Practices
The theory of GCPs was discussed in detail in the **$PM_{2.5}$ BACT section for the large dual fuel-fired boiler** and will not be repeated here. Proper management of the combustion process will result in a reduction of $PM_{2.5}$ emissions. The Department considers GCPs a technically feasible control technology for the small diesel-fired engines.

Step 2 - Eliminate Technically Infeasible $PM_{2.5}$ Control Technologies for the Small Engines
All identified control technologies are technically feasible for the small diesel-fired engines.

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Small Diesel-Fired Engines
The following control technologies have been identified and ranked by efficiency for the control of $PM_{2.5}$ emissions from the small diesel-fired engines:

(a) Diesel Particulate Filter (**85**% - 90% Control)
(b) Low Ash/ Sulfur Diesel (25% Control)
(e) Good Combustion Practices (Less than 40% Control)
(c) Federal Emission Standards (0% Control)
(d) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF provided an updated economic analysis on August 16, 2023, for the installation of a DPF on EU 27. The updated cost analysis included a new annual interest rate of 8.5% and a 20-year equipment life, as well as a new capital investment value of $78,210. The updated

capital investment value for a DPF was provided by NC Power Systems on April 14, 2023, and replaces the old quote from a preliminary vendor that was obtained in 2015. UAF did not include direct annual costs, including operating labor, maintenance labor, and maintenance materials. Therefore, they note that their cost estimate is considered conservatively low. A summary of the analysis is shown below:

Table 4-12. UAF Economic Analysis for Technically Feasible $PM_{2.5}$ Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
DPF	0.36	0.31	$78,210	$8,115	$26,539
Capital Recovery Factor = 0.1038 (8.25% interest rate for a 20-year equipment life)					

UAF contends that the economic analysis indicates the level of $PM_{2.5}$ reduction does not justify the use of DPF for EU 27 based on the excessive cost per ton of $PM_{2.5}$ removed per year.

UAF proposes the following as BACT for $PM_{2.5}$ emissions from the small diesel-fired engine EU 27:

(a) $PM_{2.5}$ emissions from EU 27 will be controlled by limiting the operation to no more than 4,380 hours per 12-month rolling period;

(b) Comply with the federal emission standards of NSPS Subpart IIII, Tier 3; and

(c) $PM_{2.5}$ emissions from EU 27 will not exceed 0.15 g/hp-hr.

Department Evaluation of BACT for $PM_{2.5}$ Emissions from the Small Diesel-Fired Engines

The Department revised the updated cost analysis provided by UAF for the installation of a DPF on EU 27. In addition, the Department added a new cost analysis for the installation of DPF on EU 26, which has the highest baseline emissions of the various small diesel-fired engines at UAF. The Department used the updated NC Power Systems capital investment quote of $78,210 for both engines, updated the annual interest rate to the current bank prime interest rate of 8.5%, updated the potential emissions to those found in the TAR of Minor Permit AQ0316MSS08 and assumed a maximum control efficiency of 90%, and left the 20-year equipment life unchanged for EU 27 and assumed a 15-year equipment life for EU 26. The Department notes that emissions for EU 26 and EU 27 are calculated at 8,760 and 4,380 hours per year respectively. Therefore, the estimated equipment life of 15 and 20 years is a conservative estimate considering EPA's estimate of the typical lifespan of a DPF is 10,000 hours or more.[19] The Department also left out annual costs related to labor and maintenance of the DPF, which continues the trend of ensuring a conservatively low-cost estimate. A summary of the analyses are shown below:

[19] EPA's May 2010 technical bulletin on diesel particulate filters, EPA-420-F-10-029: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjI95b27vOAAxWyMn0KHb4kCn0QFnoECBsQAQ&url=https%3A%2F%2Fwww.epa.gov%2Fsites%2Fdefault%2Ffiles%2F2016-03%2Fdocuments%2F420f10029.pdf&usg=AOvVaw0i3wXeZ0Jd1oAbcVnvTnPQ&opi=89978449.

Table 4-13. Department's Economic Analysis for Technically Feasible $PM_{2.5}$ Controls on EU 26

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Capital Cost ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
DPF	**0.61**	**0.55**	**$78,210**	**$9,418**	**$17,099**
Capital Recovery Factor = 0.1204 (8.5% interest rate for a 15-year equipment life)					

Table 4-14. Department Economic Analysis for Technically Feasible $PM_{2.5}$ Controls on EU 27

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Capital Cost ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
DPF	**0.45**	**0.41**	**$78,210**	**$8,265**	**$20,271**
Capital Recovery Factor = 0.1057 (8.5% interest rate for a 20-year equipment life)					

The Department's economic analyses indicate that the level of $PM_{2.5}$ reduction does not justify the use of a DPF **for the control of $PM_{2.5}$ emissions from the small diesel-fired engines EUs 24, 26, 27, 29, and 34.**

Step 5 - Selection of $PM_{2.5}$ BACT for the Small Diesel-Fired Engines
The Department's finding is that BACT for $PM_{2.5}$ emissions from the small diesel-fired engines is as follows:

(a) Limit operation of EU 27 to no more than 4,380 hours per 12-month rolling period;

(b) Limit non-emergency operation of EUs 24, 29, **and 34** to no more than 100 hours per year each;

(c) Maintain good combustion practices by following the manufacturer's operational and maintenance procedures at all times of operation;

(d) EUs 27 **and 34** shall comply with the federal emission standards of NSPS Subpart IIII, Tier 3; and

(e) Demonstrate compliance with the numerical BACT emission limits listed in Table 4-15 by maintaining records of maintenance procedures conducted in accordance with 40 C.F.R. Subparts 60 and 63, and the EU operating manuals:

Table 4-15. Determination of $PM_{2.5}$ BACT Limits for the Small Diesel-Fired Engines

EU	Year	Description	Size	Status	BACT Limit	Proposed BACT
26	1987	Mitsubishi-Bosh	64 hp	AP-42 Table 3.3-1	1.0 g/hp-hr	**Good Combustion Practices**
27	TBD	Caterpillar C-15	500 Hp	Certified Engine	0.15 g/hp-hr	Limit Operation to 4,380 hours per year and Good Combustion Practices
24	2001	Cummins	**72 hp**	AP-42 Table 3.3-1	1.0 g/hp-hr	Limit Operation for non-

EU	Year	Description	Size	Status	BACT Limit	Proposed BACT
29	2013	Cummins	314 hp	Certified Engine	0.015 g/hp-hr	emergency use (100 hours each per year) and Good Combustion Practices
34	2015	Cummins	324 hp	Certified Engine	0.15 g/hp-hr	

Table 4-16 lists the BACT determination for this facility along with those for other diesel-fired engines rated at less than 500 hp located in the Serious $PM_{2.5}$ nonattainment area.

Table 4-16. Comparison of $PM_{2.5}$ BACT for the Small Engines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
UAF	Small Diesel-Fired Engines	< 500 hp	0.015 – 1.0 g/hp-hr	Good Combustion Practices Limited Operation
Fort Wainwright	Small Diesel-Fired Engines	< 500 hp	0.015 – 1.0 g/hp-hr	Good Combustion Practices Limited Operation

4.6 $PM_{2.5}$ BACT for the Pathogenic Waste Incinerator (EU 9A)

Possible $PM_{2.5}$ emission control technologies for waste incinerators were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 21.300 for Hospital, Medical and Infectious Waste Incinerators. The search results for pathogenic waste incinerators are summarized in Table 4-17.

Table 4-17. RBLC Summary of $PM_{2.5}$ Control for Pathogenic Waste Incinerator

Control Technology	Number of Determinations	Emission Limits (lb/hr)
Multiple Chamber Design	1	0.0400

RBLC Review
A review of similar units in the RBLC indicates multiple chamber design is the principle $PM_{2.5}$ control technology installed on pathogenic waste incinerators. The lowest emission rate listed in the RBLC is 0.0400 lb/hr

Step 1 - Identification of $PM_{2.5}$ Control Technology for the Pathogenic Waste Incinerator
From research, the Department identified the following technologies as available for control of $PM_{2.5}$ emissions from pathogenic waste incinerators:

(a) Fabric Filters
The theory behind fabric filters was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers fabric filters a technically feasible control technology for the pathogenic waste incinerator.

(b) ESPs
The theory behind ESPs was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers ESPs a technically feasible control technology for the pathogenic waste incinerator.

(c) Multiple Chambers

A multiple chamber incinerator introduces the waste material and a portion of the combustion air in the primary chamber. The waste material is combusted in the primary chamber. The secondary chamber introduces the remaining air to complete the combustion of all incomplete combustion products. Many of the volatile organic compounds from waste material are completely combusted in the secondary chamber. Solid waste incinerators can reduce PM_{10} emissions up to 70 percent using multiple chambers. The expectation is that less than 70 percent control of $PM_{2.5}$ would be removed. The Department considers multiple chambers a technically feasible control technology for the pathogenic waste incinerator.

(d) Limited Operation
The theory behind the limited operation for EU 9A was discussed in detail in the $PM_{2.5}$ BACT section for the pathogenic waste incinerator and will not be repeated here. The Department considers limited operation a technically feasible control technology for the pathogenic waste incinerator.

(e) Good Combustion Practices
The theory of GCPs was discussed in detail in the **$PM_{2.5}$ BACT section for the large dual fuel-fired boilers** and will not be repeated here. Proper management of the combustion process will result in a reduction of $PM_{2.5}$ emissions. The Department considers GCPs a technically feasible control technology for the pathogenic waste incinerator.

Step 2 - Eliminate Technically Infeasible $PM_{2.5}$ Controls for Pathogenic Waste Incinerator
The applicant provided information from the manufacturer of the pathogenic waste incinerator that an ESP is a technically infeasible $PM_{2.5}$ control for the pathogenic waste incinerator due to the high moisture content of the exhaust.

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Pathogenic Waste Incinerator
The following control technologies have been identified and ranked by efficiency for the control of $PM_{2.5}$ emissions from the pathogenic waste incinerator:

(a)	Fabric Filter	(99.9% Control)
(e)	Good Combustion Practices	(Less than 40% Control)
(c)	Multiple Chambers	(0% Control)
(d)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF provided an economic analysis for the installation of a fabric filter. A summary of the analysis is shown below:

Table 4-18. UAF Economic Analysis for Technically Feasible $PM_{2.5}$ Controls

Control Alternative	Captured Emissions (tpy)	Emission Reduction (tpy)	Capital Cost ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
Fabric Filter	0.01	0.24	$1,300,000	$217,011	$761,441
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

UAF contends that the economic analysis indicates the level of $PM_{2.5}$ reduction does not justify the use of a fabric filter in conjunction with the multiple chamber design and limited operation based on the excessive cost per ton of $PM_{2.5}$ removed per year.

UAF proposes the following as BACT for $PM_{2.5}$ emissions from the pathogenic waste incinerator:

(a) $PM_{2.5}$ emissions from the operation of EU 9A will be controlled with a multiple chamber design and by limiting operation to no more than 109 tons of waste combusted per 12-month rolling period;

(b) $PM_{2.5}$ emissions from EU 9A shall not exceed 4.67 lb/ton; and

(c) Compliance with the operating hours limit will be demonstrated by monitoring and recording the weight of waste combusted on a monthly basis.

Step 5 - Selection of $PM_{2.5}$ BACT for the Pathogenic Waste Incinerator

The Department's finding is that BACT for $PM_{2.5}$ emissions from the pathogenic waste incinerator is as follows:

(a) $PM_{2.5}$ emissions from EU 9A shall be equipped with a multiple chamber design;

(b) Total PM emissions from EU 9A shall not exceed 4.67 lb/ton;[20]

(c) Limit the operation of EU 9A to 109 tons of waste combusted per 12-month rolling period;

(d) Maintain good combustion practices at all times by following the manufacturer's operation and maintenance procedures; and

(e) Compliance with the proposed operational limit will be demonstrated by recording pounds of waste combusted for the pathogenic waste incinerator.

Table 4-19 lists the BACT determination for this facility along with those for other waste incinerators located in the Serious $PM_{2.5}$ nonattainment area.

Table 4-19. Comparison of $PM_{2.5}$ BACT for Pathogenic Waste Incinerators at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
UAF	One Pathogenic Waste Incinerator	83 lb/hr	4.67 lb/ton **109 tons of waste per 12-month period**	Multiple Chambers Good Combustion Practices Limited Operation

[20] **AP-42 Table 2.3-2. Emission factors for total particulate matter, lead, and TOC for controlled air medical waste incinerators for uncontrolled devices**

4.7 $PM_{2.5}$ BACT for the Material Handling Units (EUs 105, 107, 109 through 111, 114, and 128 through 130)

Possible $PM_{2.5}$ emission control technologies for material handling were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process codes 99.100 - 190, Fugitive Dust Sources. The search results for material handling units are summarized in Table 4-20.

Table 4-20. $PM_{2.5}$ Control for Material Handling Units

Control Technology	Number of Determinations	Emission Limits
Fabric Filter / Baghouse	10	0.005 gr/dscf
Electrostatic Precipitator	3	0.032 lb/MMBtu
Wet Suppressants / Watering	3	29.9 tpy
Enclosures / Minimizing Drop Height	4	0.93 lb/hr

RBLC Review
A review of similar units in the RBLC indicates good operational practices, enclosures, fabric filters, and minimizing drop heights are the principle $PM_{2.5}$ control technologies for material handling operations.

Step 1 - Identification of $PM_{2.5}$ Control Technology for the Material Handling Units
From research, the Department identified the following technologies as available for $PM_{2.5}$ control of the material handling units:

(a) Fabric Filters
The theory behind fabric filters was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers fabric filters a technically feasible control technology for EUs 105, 107, 109, 110, 114, and 128 through 130. The ash unloading to disposal trucks (EU 111) occurs in a building with large doors. During ash unloading the doors remain closed to prevent the release of fugitive emissions. Therefore, the Department does not consider a fabric filter a technically feasible control technology for EU 111.

(b) Scrubbers
The theory behind scrubbers was discussed in detail in the $PM_{2.5}$ BACT for the large dual fuel-fired boiler and will not be repeated here. The Department considers scrubbers a feasible control technology for the material handling units, except for EU 111. EU 111 does not have collected emissions and therefore a scrubber is not considered a technically feasible control technology.

(c) Suppressants
The use of dust suppression to control particulate matter can be effective for stockpiles and transfer points exposed to the open air. Applying water or a chemical suppressant can bind the materials together into larger particles which reduces the ability to become entrained in the air either from wind or material handling activities. The Department considers the use of suppressants a technically feasible control technology for all of the material handling units.

(d) Enclosures
An enclosure prevents the release of fugitive emissions into the ambient air by confining all fugitive emissions within a structure and preventing additional fugitive emissions from being generated from winds eroding stockpiles and lifting particulate matter from conveyors. Often enclosures are paired with fabric filters. The RBLC does not identify a control efficiency for an enclosure that is not associated with another control option. The Department considers enclosures a technically feasible control technology for the material handling units.

(e) Wind Screens
A wind screen is similar to a solid fence which is used to lower wind velocities near stockpiles and material handling sites. As wind speeds increase, so do the fugitive emissions from the stockpiles, conveyors, and transfer points. The use of wind screens is appropriate for materials not already located in enclosures. Due to all of the material handling units being operated in enclosures the Department does not consider wind screens a technically feasible control option for the material handling units.

(f) Vents/Closed System Vents/Negative Pressure Vents
Vents can control fugitive emissions by collecting fugitive emissions from enclosed loading, unloading, and transfer points and then venting emissions to the atmosphere or back into other equipment such as a storage silo. Other vent control designs include enclosing emission units and operating under a negative pressure. The Department considers vents to be a technically feasible control technology for the material handling units, except for EU 111. EU 111 does not have collected emissions and the vent system would be ineffective when trucks enter and depart the loading area.

Step 2 - Eliminate Technically Infeasible $PM_{2.5}$ Controls for the Material Handling Units
As explained in Step 1 of Section 4.7, the Department does not consider fabric filters, scrubbers, and vents as technically feasible $PM_{2.5}$ control technologies for EU 111. The Department does not consider wind screens as technically feasible $PM_{2.5}$ control technologies for the material handling units.

Step 3 - Rank the Remaining $PM_{2.5}$ Control Technologies for the Material Handling Units
The following control technologies have been identified and ranked for control of particulates from the material handling equipment:

(a)	Fabric Filters	(50 - 99% Control)
(d)	Enclosures	(50 - 99% Control)
(b)	Scrubber	(50% - 99% Control)
(e)	Cyclone	(20% - 70% Control)
(c)	Suppressants	(less than 90% Control)
(f)	Vents	(less than 90% Control)

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for $PM_{2.5}$ emissions from the material handling units:

(a) $PM_{2.5}$ emissions from EUs 105, 107, 109 through 111, 114, and 128 through 130 will be controlled by enclosing each EU.

(b) $PM_{2.5}$ emissions from the operation of the material handling units, except EU 111, will be controlled by installing, operating, and maintaining fabric filters and vents.

(c) $PM_{2.5}$ emissions from EUs 105, 107, 109, 110, and 128 through 130 shall not exceed 0.003 gr/dscf.

(d) $PM_{2.5}$ emissions from EU 111 shall not exceed $5.5x10^{-5}$ lb/ton.

(e) $PM_{2.5}$ emissions from EU 114 shall not exceed 0.05 gr/dscf.

Step 5 - Selection of $PM_{2.5}$ BACT for the Material Handling Units

The Department's finding is that BACT for $PM_{2.5}$ emissions from the material handling equipment is as follows:

(a) $PM_{2.5}$ emissions from EUs 105, 107, 109 through 111, 114, and 128 through 130 will be controlled by enclosing each EU;

(b) $PM_{2.5}$ emissions from the operation of the material handling units, except EU 111, will be controlled by installing, operating, and maintaining fabric filters and vents; and

(c) **Compliance with the $PM_{2.5}$ emission rates for the material handling units shall be demonstrated by following the fugitive dust control plan and the manufacturer's operating and maintenance procedures at all times of operation**; and

(d) Comply with the numerical emission limits listed in Table 4-20:

Table 4-20. $PM_{2.5}$ BACT Control Technologies for the Material Handling Units

EU ID	Process Description	Capacity	Limitation	Control Method
105, 107, 109, 110, & 128 - 130	7 Material Handling Units	Varies	0.003 gr/dcf	Fabric Filter & Enclosure & Vent
111	Ash Loadout to Truck	N/A	5.50E-05 lb/ton	Enclosure
114	Dry Sorbent Handing Vent Filter Exhaust	5 acfm	0.050 gr/dcf	Fabric Filter & Enclosure & Vent

5. BACT DETERMINATION FOR SO_2

The Department based its SO_2 assessment on BACT determinations found in the RBLC, internet research, and BACT analyses submitted to the Department by GVEA for the North Pole Power Plant and Zehnder Facility, Aurora for the Chena Power Plant, US Army for Fort Wainwright, and UAF for the Combined Heat and Power Plant.

5.1 SO_2 BACT for the Large Dual Fuel-Fired Boiler (EU 113)

Possible SO_2 emission control technologies for the large dual fuel-fired boiler were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 11.110, Coal Combustion in Industrial Size Boilers and Furnaces. The search results are summarized in Table 5-1.

Table 5-1: RBLC Summary of SO_2 Control for Industrial Coal-Fired Boilers

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
Flue Gas Desulfurization / Scrubber / Spray Dryer	10	0.06 – 0.12
Limestone Injection	10	0.055 – 0.114
Low Sulfur Coal	4	0.06 – 1.2

RBLC Review

A review of similar units in the RBLC indicates flue gas desulfurization and low sulfur coal are the principle SO_2 control technologies installed on large dual fuel-fired boilers. The lowest SO_2 emission rate in the RBLC is 0.055 lb/MMBtu.

Step 1 - Identification of SO_2 Control Technology for the Large Dual Fuel-Fired Boiler

From research, the Department identified the following technologies as available for control of SO_2 emissions from the large dual fuel-fired boiler:

(a) Flue Gas Desulfurization (FGD)

FGD is a set of technologies used to remove SO_2, acid gases such as hydrogen chloride (HCL), and hazardous air pollutants (e.g., mercury (Hg)), from exhaust flue gases. FGD is a common add-on control technology that uses chemical processes to remove of SO_2 at coal-fired power plants. FGD control systems includes wet flue gas desulfurization (WFGD, AKA wet scrubbers), spray dry adsorption (SDA), circulating dry scrubber (CDS), and dry sorbent injection (DSI). These four control technologies are discussed below in detail using information submitted from UAF's BACT analysis and Section 5 – SO_2 and Acid Gas Controls of the EPA Air Pollution Control Cost Manual (EPA CCM).[21]

1. WFGD (Wet Scrubbers)

A Wet FGD system controls SO_2 emissions using solutions containing alkali reagents. Wet FGD systems may use limestone, lime, sodium-based alkaline, or dual alkali-based sorbents. Wet FGD systems can also be categorized as "once-through" or "regenerable" depending on how the waste solids generated are handled. In a once-through system the spent sorbent is disposed as waste. Regenerable systems recycle the sorbent back into the system and recover the salts for sale as byproduct (e.g., gypsum). Regenerable systems have higher capital costs than once-through systems due to the additional equipment required to separate and dry the recovered salts. However, regenerable systems may be the best option for plants where disposal options are limited or nearby markets for byproducts are available.

Most WFGD systems use a limestone slurry sorbent which reacts with the SO_2 and falls to the bottom of the absorber tower where it is collected. Wet FGD systems generally have the highest control efficiencies. New wet FGD systems can achieve

[21] EPA Air Pollution Control Cost Manual and associated and associated cost spreadsheets are available at the following website: https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution.

SO_2 removal of 99% and HCl removal of over 95%. Packed tower wet FGD systems may achieve efficiencies as high as 99.9% for some pollutant-solvent systems.

WFGD systems are typically located downstream of any particle collection system (baghouse, electrostatic precipitator) and the induced draft fan. WFGD systems are typically located immediately before the flue gas stack. This location allows for fly ash to be removed prior to the absorber thus reducing the amount of solids collected by the falling slurry. This configuration also allows for a "dry" induced draft fan, saving significant capital and maintenance costs given the conditions of the flue gas stream leaving the absorber.

A wet flue gas desulfurization system has a significant amount of auxiliary equipment in addition to the absorber and slurry recirculation system. This equipment varies greatly between plants depending on the specific needs of the plant and the availability of different forms of the reagents being used. In general, the auxiliary equipment necessary to store, prepare, and handle the reagent includes dry reagent storage silos, weigh feeders, mills, classifiers, and blowers. Spent reagent is typically collected as a slurry from the reservoir and dewatered using vacuum table filters, or similar equipment. The waste solids are either then transported to a landfill or sold for secondary uses (such as in the manufacture of wallboard). The water recovered from the spent reagent is reused in the process to the extent possible. However, a portion of the water must be purged and replaced with fresh water in order to limit the concentrations of chlorides. UAF's analysis assumes that the purged water can be disposed of in the local sewer system, which may not be the case. In the event that the water cannot be disposed of, a zero liquid discharge (ZLD) system will be required. These systems consist of the equipment necessary to concentrate dissolved solids in wastewater streams and then evaporate any remaining water, leaving only solids for disposal.

UAF contacted several vendors to request equipment quotes for a WFGD system on EU 113. UAF was not able to obtain any vendor quotes for appropriate WFGD system equipment. UAF stated that vendors were unwilling to provide estimates and did not understand the rationale for potentially installing WFGD on a CFB boiler with limestone injection that already controls SO_2 emissions. Vendors indicated that a WFGD would not be practical or cost-effective. UAF and its consultants also believe that vendors were unwilling or unable to provide a study-level cost estimate for WFGD equipment because the vendors did not have an existing design for a system sized appropriately for EU 113 which is small when compared to typical coal-fired boilers at utility power plants. UAF stated that developing a study-level cost estimate would have required the investment of significant resources, which the vendors appeared to be unwilling to do. UAF noted, the WFGD cost estimating tool that EPA provides as part of the EPA CCM[22]is intended for boilers that are at least three times the size of EU 113. The lack of

[22] EPA Control Manual: https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution#cost%20manual

vendor input raises doubts as to whether UAF would realistically be able to procure a WFGD system for EU 113 if ultimately required to do so. Given this lack of vendor response, UAF is hesitant to consider WFGD as an available SO_2 emission control technology at this time. However, for the sake of completeness, UAF provided a cost analysis for WFGD using the EPA CCM "Wet and Dry Scrubbers and Acid Gas Control Cost Calculation Spreadsheet."[22] The Department considers WFGD to be a technologically feasible control technology for EU 113.

2. Spray Dry Absorbers (SDA, AKA Dry Lime FGD)

Spray Dry Absorbers are gas absorbers in which a small amount of water is mixed with the sorbent. Lime (CaO) is usually the sorbent used in the spray drying process, but hydrated lime ($Ca(OH)_2$) is also used and can provide greater SO_2 removal. Slurry consisting of lime and recycled solids is atomized/sprayed into the absorber. The SO_2 in the flue gas is absorbed into the slurry and reacts with the lime and fly ash alkali to form calcium salts. The scrubbed gas then passes through a particulate control downstream of the spray drier where additional reactions and SO_2 removal may occur, especially in the filter cake of a fabric filter (baghouse). Spray dryers can achieve SO_2 removal efficiencies up to 95%, depending on the type of coal burned.

UAF was unable to obtain any vendor quotes for an SDA system for EU 113. UAF stated that vendors indicated that a CDS system would likely have similar costs to an SDA system but provide more effective SO_2 removal. UAF therefore concluded that control system equipment vendors do not appear to provide new SDA systems at this time. The lack of positive vendor input raises doubts as to whether UAF would realistically be able to procure an SDA system for EU 113 if ultimately required to do so. Based on this vendor information, UAF is hesitant to consider SDA as an available SO_2 emission control technology at this time. Considering that UAF did not submit vendor quote for SDA controls because CDS control technology offers a higher SO_2 removal efficiency at a lower price point, the Department agrees with UAF's assessment that SDA is now technologically obsolete for EU 113 and therefore technologically infeasible.

3. Circulating Dry Scrubbers (CDS)

Similar to other dry flue gas desulfurization systems, the CDS system is located after the air preheater, and byproducts from the system are collected in an integrated fabric filter. Unlike the SDA systems, a CDS system is considered a circulating fluidized bed of hydrated lime reagent to remove SO_2 rather than an atomized lime slurry; however, similar chemical reaction kinetics are used in the SO_2 removal process. In a CDS system, flue gas is treated in type of Dry Lime FGD system in which the waste gas stream passes through an absorber vessel where the flue gas stream flows through a fluidized bed of hydrated lime and recycled byproduct. Water is injected into the absorber through a venturi located at the base of the absorber for temperature control. Flue gas velocity through the vessel is maintained to keep the fluidized bed of particles suspended in the absorber. Water sprayed into the absorber cools the flue gas from approximately 300° F at the inlet

to the scrubber to approximately 160° F at the outlet of the fabric filter. The hydrated lime absorbs SO_2 from the gas and forms calcium sulfite and calcium sulfate solids. The desulfurized flue gas passing out of the absorber contains solid sorbent mixed with the particulate matter, including reaction products, unreacted hydrated lime, calcium carbonate, and fly ash. The solid sorbent and particulate matter are collected by the fabric filter. CDS can achieve over 98% reduction in SO_2 and other acid gases.

UAF obtained cost estimates for the installation of a CDS control system from Andritz, Babcock Power Environmental Inc. (BPE), and Tri-Mer Corporation (Tri-Mer). Of the three proposals, the Andritz proposal was the most complete. The Tri-Mer proposal was a similar price to Andritz and also provided significant amounts of information. The BPE proposal appeared to be the low bid, but the price was provided in 2017 dollars. The final annual 2021 CEPCI value of 708.0 was used to escalate the BPE price to current day dollars, resulting in the BPE offering being significantly more expensive than the other two quotes. Given the similar pricing between Andritz and Tri-Mer, UAF chose the Andritz system as the quotation to be used in the cost-effectiveness evaluation because the Andritz system did not require consuming any sorbent and so would represent the lowest overall cost. Quoted SO_2 removal efficiencies were similar across the three proposals. All three OEMs provided removal efficiencies that were slightly lower than the typical values in the EPA CCM[22], largely because of the very low influent concentration of SO_2. As influent concentrations declines, sorbent particles have more difficulty interacting with the SO_2 molecules and the overall capture efficiency declines. Therefore SO_2 removal efficiency was calculated at 90% for the CDS. The Department considers CDS to be a technologically feasible control technology for EU 113.

4. Dry Sorbent Injection (DSI)

Unlike the three other FGD systems, dry sorbent injection (DSI) is not a stand-alone, add-on air pollution control system but a modification to the combustion unit or ductwork. DSI systems inject a powdered alkaline reagent directly into the flue gas duct ahead of the particle collection device. Where hydrated lime is used as the reagent, the addition of water may be necessary to complete the chemical reaction. These reagents react with the sulfur (and other acid gases) in-flight and on the surfaces of the particle collection device. The products of reaction, unreacted reagent, and fly ash are collected at the bottom of the particle collection device and disposed of through the plants fly ash collection system. Reagents typically utilized in DSI systems include hydrated lime, Trona, and sodium bicarbonate. According to the EPA CCM[22] DSI can achieve SO_2 control efficiencies ranging from 50 to 70% and has been used in power plants, biomass boilers, and industrial applications (e.g., metallurgical industries). However, Solvay, a supplier of sodium bicarbonate and trona based sorbent material for DSI systems, commented on the Fairbanks $PM_{2.5}$ Serious Nonattainment SIP indicating that they have received vendor quotes stating that a 95% reduction in SO_2 emissions can be achieved on coal fired boilers in Alaska**. UAF's updated vendor quotes include a 90% control efficiency for DSI via Tri-Mer, and 85% control efficiency via BACT, Inc.** The Department considers DSI to be a technologically feasible control technology for EU 113.

(b) Fluidized Bed Limestone Injection (FBLI)
FBLI is considered separate from the other FGD control technologies because the limestone is injected into the boiler as part of the combustion process, as opposed to being injected into the flue gas after the combustion process has been completed. Section 5 (SO_2 and Acid Gas Controls) of the EPA CCM[22] includes a section on FBLI that specifically references EU 113 at the University of Alaska Fairbanks. FBLI is also considered an integral part of the design of EU 113**. However, because the fluidized coal bed can be created with alternative fluidizing materials such as sand without the same SO_2 emission reduction benefits as limestone, FBLI is considered** an add-on control. The FBLI process involves crushed coal and a fluidizing materials such as ground limestone, along with recirculated ash, which are suspended in the boiler by an upward stream of hot air. The coal is combusted in this fluidized mixture. The limestone reacts with SO_2 to form solids (effectively gypsum) that can be captured by the baghouse. FBLI is an available control technology and is already in use on EU 113. The circulating fluidized bed (CFB) technology of EU 113, including FBLI, is considered the base case for this BACT analysis. The initial baseline emissions rate used in the Permittee's analysis is the existing EU 113 SO_2 PTE of 258.9 tpy, the rolling 12-month emission limit in Conditions 36.1 and 61.2 of Permit AQ0316TVP03. The limit is based on the New Source Performance Standards (NSPS) SO_2 emission standard of 0.20 pounds per million British thermal unit (lb/MMBtu) in 40 CFR 60.42b(k)(1). **However, as demonstrated by the semi-annual continuous emissions monitoring system (CEMS) information submitted by the Permittee with their semi-annual reports, the actual SO_2 emission rates have been considerably lower.** The Department considers FBLI to be a technologically feasible control technology for EU 113.

(c) Low Sulfur Coal
UAF purchases coal from the Usibelli Coal Mine located in Healy, Alaska. This coal mine is located 115 miles south of Fairbanks. The coal mined at Usibelli is sub-bituminous coal and has a relatively low sulfur content with guarantees of less than 0.4 percent by weight. Usibelli Coal Data Sheets indicate a range of 0.08 to 0.28 percent Gross As Received (GAR) percent Sulfur (%S). According to the U.S. Geological Survey, coal with less than one percent sulfur is classified as low sulfur coal. The Department considers the use of low sulfur coal a technically feasible control technology for the large dual fuel-fired boiler. **Because the Permittee already combusts low sulfur coal, this control option represents the baseline emissions rate, or a 0% emissions control.**

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the **$PM_{2.5}$ BACT section for the large dual fuel-fired boiler** and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2 emissions. The Department considers GCPs a technically feasible control technology for the large dual fuel-fired boiler.

Step 2 - Eliminate Technically Infeasible SO_2 Controls for the Large Dual Fuel-Fired Boiler
As discussed in Step 1, the Department considers SDA to be technologically unfeasible for controlling SO_2 emissions from the large dual fuel-fired boiler at UAF.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Large Dual Fuel-Fired Boiler
The following control technologies have been identified and ranked by efficiency for control of SO_2 emissions from the large dual fuel-fired boiler:

(a-1)	Wet Scrubber	(99% Control)
(a-3)	Circulating Dry Scrubbers	(90% - 98% Control)
(a-4)	Dry Sorbent Injection	(50% - 95% Control)
(b)	**Fluidized Bed Limestone Injection**	**(50% - 70% Control)**
(d)	Good Combustion Practices	(Less than 40% Control)
(c)	Low Sulfur Coal	(**0% Control, Baseline**)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF provided updated economic analyses on July 6, 2023, for the installation of WFGD, CDS, and DSI control technologies. With the updated analyses, UAF obtained new quotes from vendors for the installation of DSI and CDS and was unable to obtain any vendor quotes for WFGD and SDA as the vendors said that these control technologies would not be cost effective compared to DSI and CDS for EU 113. For the sake of completeness, **UAF provided a cost analysis for WFGD using the EPA CCM "Wet and Dry Scrubbers and Acid Gas Control Cost Calculation Spreadsheet."[22] UAF's analyses used control efficiencies of 95% for WFGD, 90 for CDS, 90% for DSI via the Tri-Mer quote, and 85% for DSI via the BACT, Inc. quote. Additionally, UAF also performed an incremental cost analysis for the different SO_2 control technologies. For a particular control technology, the incremental cost analysis compares the difference in total annual cost between that technology and the next lowest-ranked technology and divides that value by the difference in emissions reductions between the two technologies. For this analysis, UAF assumed the baseline emission rates to be the current permit limit of 0.20 lb/MMBtu, with the operation of the coal-fired boiler using FBLI. Summaries of these two analyses are shown below in Table 5-2 for the regular "average cost effectiveness" and Table 5-3 for the incremental cost-effectiveness. Both analyses include the name of the vendor who provided the quote for the CDS and DSI control systems.**

Table 5-2. UAF Economic Analysis for Technically Feasible SO_2 Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
WFGD	258.9	246.0	$52,968,345	$7,589,888	$30,859
CDS (Andritz)	258.9	233.0	$32,505,815	$5,757,437	$24,709

DSI (Tri-Mer)	**258.9**	**233.0**	**$5,794,396**	**$5,193,086**	**$22,287**
DSI (BACT, Inc)	**258.9**	**220.1**	**$11,565,826**	**$3,121,966**	**$14,187**
Capital Recovery Factor = 0.0847 (7.5% interest rate for a 30-year equipment life)					

Table 5-3. UAF Incremental Economic Analysis for Technically Feasible SO_2 Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Incremental Cost Effectiveness ($/ton)
WFGD	**258.9**	**246.0**	$52,968,345	$7,589,888	$141,557
CDS (Andritz)	**258.9**	**233.0**	$32,505,815	$5,757,437	$203,590
DSI (Tri-Mer)	**258.9**	**233.0**	$5,794,396	$5,193,086	$159,994
DSI (BACT, Inc)	**258.9**	**220.1**	$11,565,826	$3,121,966	$14,187
FBLI – Base	**258.9**	**0.0**	**0.0**	**0.0**	**-**
Capital Recovery Factor = 0.0847 (7.5% interest rate for a 30-year equipment life)					

UAF contends that the economic analysis indicates the level of SO_2 reduction does not justify the use of WFGD, CDS, or DSI for the dual fuel-fired boiler based on the excessive cost per ton of SO_2 removed per year. **However, UAF has proposed a new enforceable limit for EU 113 which has been achieved in practice at the facility using FBLI.**

UAF proposes the following as BACT for SO_2 emissions from the dual fuel-fired boiler:

(a) SO_2 emissions from the operation of EU 113 will be controlled by the operation of FBLI at all times the unit is in operation;

(b) SO_2 emissions from EU 113 will be controlled by burning low sulfur coal at all times the dual fuel-fired boiler is combusting coal; and

(c) SO_2 emissions from EU 113 will not exceed **0.125** lb/MMBtu.

Department Evaluation of BACT for SO_2 Emissions from the Dual Fuel-Fired Boiler
The Department revised the cost analyses provided for the installation of wet scrubbers, circulating dry scrubbers, and both dry sorbent injection analyses. For all the analyses, the Department left the 30-year control equipment life unchanged, updated the annual interest rate to 8.5% (current bank prime interest rate), and updated the baseline emissions rate to 0.10 lb/MMBtu. This emissions rate was selected by the Department after evaluating the semi-annual CEMS data for SO_2 emissions from EU 113 for 2022 and 2023. During that time-period, the highest 30-day average rolling emissions occurred during the period of July 1 to December 31 of 2022, with a value of 0.06 lb/MMBtu. The Department chose the SO_2 emissions rates of 0.1 lb/MMBtu after performing a statistical analysis using the highest 30-day average rolling emissions that occurred during each of the semi-annual periods from 2022 through 2023 and using a 99% confidence interval, which resulted in a value of 0.092

lb/MMBtu. The Department rounded up from the 99% confidence interval to a 0.10 lb/MMBtu, which is half of the 0.2 lb/MMBtu existing NSPS Subpart Db limit for EU 113, and matches the limit found on GVEA's Healy EU 2, which is equipped with both DSI and SDA, and is the most stringent SO_2 limit found on a coal-fired boiler in the state of Alaska. The Department notes that UAF proposed a revised SO_2 limit for EU 113 of 0.125 lb/MMBtu in a December 22, 2023, submittal. In UAF's submittal, they noted that EU 113 has had daily average SO_2 emissions as high as 0.564 lb/MMBtu and that the sulfur content of the coal delivered from the Usibelli Coal Mine can vary from 0.08 – 0.28 percent by weight and has averaged 0.129 percent by weight since January 2020. The Department took this into consideration when selecting 0.10 lb/MMBtu as the SO_2 emissions rate. The Department notes that although the daily average emissions rate has been higher than 0.10 lb/MMBtu, that there has been two years' worth of CEMS data that shows an ample margin of compliance with the selected emissions rate on a 30-day rolling basis, which is the averaging period selected for the CEMS equipped EU 113.

Although the Department changed the baseline emissions rate for EU 113, the final controlled emissions rates were left unchanged from the emissions guarantees provided by UAF's vendors, which resulted in a lower assumed control efficiency. No other changes were made to the CDS analysis. For the WFGD analysis, the Department updated the Chemical Engineering Plant Cost Index (CEPCI) to the latest value of 816.0[23] for 2022 prices. Additionally, for the WFGD analysis, in order to demonstrate a conservative approach, the Department used the default values from the EPA CCM for limestone cost, water cost, electricity cost, waste disposal cost, and labor rate. For the two DSI cost analyses, the Department removed the 25% increase in assumed cost for the DSI installation which is accounted for elsewhere in the analysis. Also for the two DSI cost analyses, in order to demonstrate a conservative approach, the Department used the assumed cost percentages from the EPA CCM for the instrumentation, freight, foundations and support, handling and erection, electrical, piping, insulation, painting, engineering, construction and field expenses, contractor fees, start-up, performance tests, contingency, operating and maintenance labor hours, overhead, property tax, and administrative changes and insurance. A summary of the analysis is shown below in Table 5-4.

Table 5-4. Department Economic Analysis for Technically Feasible SO_2 Controls

Control Alternative	Potential to Emit (PTE)	Emission Reduction (tpy)	Total Capital Cost ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
WFGD	129.5	116.5	$60,051,550	7,939,734	68,137
CDS (Andritz)	129.5	103.6.	$32,505,815	6,029,814	58,215
DSI (Tri-Mer)	129.5	103.6.	$3,668,667	4,223,707	40,778
DSI (BACT, Inc)	129.5	90.6	$14,411,039	3,203,706	$35,349

[23] The CEPCI for 2022 is located at the following website: https://toweringskills.com/financial-analysis/cost-indices/.

Capital Recovery Factor = 0.0931 (8.5% interest rate for a 30-year equipment life)

The Department's economic analysis indicates the level of SO_2 reduction does not justify the use of any additional SO_2 controls as BACT for the dual fuel-fired boiler located in the Serious $PM_{2.5}$ nonattainment area. However, because the Department assumed a different baseline emissions rate for the cost analyses with the operation of FBLI, that is now selected as BACT.

Step 5 - Selection of SO_2 BACT for the Large Dual Fuel-Fired Boiler
The Department's finding is that BACT for SO_2 emissions from the dual fuel-fired boiler is as follows:

(a) SO_2 emissions from EU 113 shall be controlled by operating and maintaining FBLI at all times the unit is in operation;

(b) EU 113 shall not exceed a SO_2 emission rate of 0.10 lb/MMBtu[24] determined on a 30-day rolling average;

(c) Maintain good combustion practices at all times of operation by following the manufacturer's operating and maintenance procedures; and

(d) Compliance with the proposed SO_2 emission rate for the dual fuel-fired boiler will be demonstrated through **CEMS monitoring and reporting**.

Table 5-5 lists the SO_2 BACT determination for this facility along with those for other coal-fired boilers in the Serious $PM_{2.5}$ nonattainment area.

Table 5-5. Comparison of SO_2 BACT for Coal-Fired Boilers at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method[25]
UAF	Dual Fuel-Fired Boiler	295.6 MMBtu/hr	**0.10 lb/MMBtu[24]**	**Fluidized Bed Limestone Injection** Limestone Injection
Fort Wainwright	6 Coal-Fired Boilers	1,380 MMBtu/hr (combined)	**0.04 lb/MMBtu[26]**	Dry Sorbent Injection Operational Limit
Chena	4 Coal-Fired Boilers	497 MMBtu/hr (combined)	**0.301 lb/MMBtu[27]**	**Good Combustion Practices**

[24] **See the discussion above on how the Department selected an SO_2 emissions rate in Step 4 -Department Evaluation of BACT for SO_2 Emissions from the Dual Fuel-Fired Boiler.**
[25] **Note that the Department removed the reference to low sulfur coal, which was never selected as part of the top down BACT determination process and is already the only type of coal available to sources in Alaska.**
[26] **Fort Wainwright and Chena Power Plants SO_2 emission rates are vendor provided emission guarantees.**
[27] **BACT limit is the average emissions rate from two recent SO_2 source test accepted by the Department, which occurred on November 19, 2011 and July 12, 2019.**

5.2 SO_2 BACT for the Mid-Sized Diesel-Fired Boilers (EUs 3 and 4)

Possible SO_2 emission control technologies for mid-sized diesel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 12.220, Industrial Size Distillate Fuel Oil Boilers (>100 MMBtu/hr and ≤ 250 MMBtu/hr). The search results for mid-sized diesel-fired boilers are summarized in Table 5-6.

Table 5-6. RBLC Summary of SO_2 Control for Mid-Sized Boilers Firing Diesel

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
No Control Specified	2	0.0006

Possible SO_2 emission control technologies for mid-sized diesel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 12.310, Industrial Size Gaseous Fuel Boilers (>100 MMBtu/hr and ≤ 250 MMBtu/hr). The search results for mid-sized diesel-fired boilers are summarized in Table 5-7.

Table 5-7. RBLC Summary of SO_2 Control for Mid-Sized Boilers Firing Natural Gas

Control Technology	Number of Determinations	Emission Limits
Low Sulfur Fuel	2	0.89 - 11.24 (tpy)
Good Combustion Practices	5	0.03 – 0.18 (lb/hr)
No Control Specified	4	0.01 – 0.09 (lb/hr)

RBLC Review
A review of similar units in the RBLC indicates low sulfur fuel and good combustion practices are the principle SO_2 control technologies installed on mid-sized boilers. The lowest SO_2 emission rate listed in the RBLC is 0.0006 lb/MMBtu.

Step 1 - Identification of SO_2 Control Technology for the Mid-Sized Diesel-Fired Boilers
From research, the Department identified the following technologies as available for SO_2 control for the mid-sized diesel-fired boilers:

(a) Ultra Low Sulfur Diesel
ULSD has a fuel sulfur content of 0.0015 percent sulfur by weight or less. Using ULSD would reduce SO_2 emissions because the mid-sized diesel-fired boilers are combusting standard diesel that has a sulfur content of up to 0.5 percent sulfur by weight. Switching to ULSD could reach a great than 99 percent decrease in SO_2 emissions from the mid-sized diesel-fired boilers. The Department considers ULSD a technically feasible control technology for the mid-sized diesel-fired boilers.

(b) Natural Gas
The theory of operating the mid-sized diesel-fired boilers on natural gas was discussed in detail in the NOx BACT for the mid-sized diesel-fired boilers and will not be repeated here. The Department does not consider operating the mid-sized diesel-fired boilers on natural gas as a technically feasible control technology.

(c) Limited Operation
The theory of limited operation for the mid-sized diesel-fired boilers was discussed in detail in the $PM_{2.5}$ BACT section for the mid-sized diesel-fired boilers and will not be repeated here. The Department considers limited operation a technically feasible control technology for the mid-sized diesel-fired boilers.

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the $PM_{2.5}$ BACT section for the large dual fuel-fired boiler and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2 emissions. The Department considers GCPs a technically feasible control technology for the mid-sized diesel-fired boilers.

Step 2 - Eliminate Technically Infeasible SO_2 Control Technologies for the Mid-Sized Diesel-Fired Boilers
Limited operation for EU 3 is a technically infeasible control technology as it is a backup unit.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Mid-Sized Diesel-Fired Boilers
The following control technologies have been identified and ranked by efficiency for the control of SO_2 emissions from themed-sized diesel-fired boilers.

(a)	Ultra Low Sulfur Diesel	(99% Control)
(d)	Good Combustion Practices	(Less than 40% Control)
(c)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for SO_2 emissions from the mid-sized diesel-fired boilers:

(a) SO_2 emissions from EUs 3 and 4 shall combust ULSD while firing diesel fuel;

(b) SO_2 emissions from EU 4 shall not exceed 0.60 lb/MMscf while firing natural gas; and

(c) SO_2 emissions from EU 4 will be limited by complying with the combined annual NOx emission limit of 40 tons per 12 month rolling period for EUs 4 and 8.

Step 5 - Selection of SO_2 BACT for the Mid-Sized Diesel-Fired Boilers
The Department's finding is that BACT for SO_2 emissions from the mid-sized diesel-fired boilers is as follows:

(a) SO_2 emissions from EUs 3 and 4 shall be controlled by only combusting ULSD when firing diesel fuel;

(b) SO_2 emissions from EU 4 will be limited by complying with the combined annual SO_2 emission limit of 40 tons per 12 month rolling period for EUs 4 and 8;

(c) SO_2 emissions from EU 4 while firing natural gas shall not exceed 0.60 lb/MMscf;

(d) Maintain good combustion practices by following the manufacturer's maintenance procedures at all times of operation; and

(e) Compliance with the proposed SO_2 emission limit will be demonstrated through fuel shipment receipts and/or fuel testing for sulfur content.

Table 5-8 lists the BACT determination for this facility along with those for other mid-sized diesel-fired boilers located in the Serious $PM_{2.5}$ nonattainment area.

Table 5-8. Comparison of SO_2 BACT for the Mid-Sized Diesel-Fired Boilers at Nearby Power Plants

Facility	EU ID	Process Description	Capacity	Fuel	Limitation	Control Method
UAF	3	Dual Fuel-Fired Boilers	100 – 250 MMBtu/hr	Diesel	15 ppmw S in fuel	Ultra Low Sulfur Diesel
	4			Diesel	15 ppmw S in fuel	Limited Operation Ultra Low Sulfur Diesel
				Natural Gas	0.60 lb/MMscf	

5.3 SO_2 BACT for the Small Diesel-Fired Boilers (EUs 17 through 22)

Possible SO_2 emission control technologies for small diesel-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 13.220, Commercial/Institutional Size Boilers (<100 MMBtu/hr). The search results for small diesel-fired boilers are summarized in Table 5-9.

Table 5-9. RBLC Summary of SO_2 Control for Small Diesel-Fired Boilers

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
Low Sulfur Content	5	0.0036 – 0.0094
Good Combustion Practices	4	0.0005
No Control Specified	5	0.0005

RBLC Review

A review of similar units in the RBLC indicates that good combustion practices and combustion of low sulfur fuel are the principle SO_2 control technologies installed on small diesel-fired boilers. The lowest SO_2 emission rate listed in the RBLC is 0.0005 lb/MMBtu

Step 1 - Identification of SO_2 Control Technology for the Small Diesel-Fired Boilers

From research, the Department identified the following technologies as available for SO_2 control for the small diesel-fired boilers:

(a) ULSD
The theory of ULSD was discussed in detail in the SO_2 BACT for the mid-sized diesel-fired boilers and will not be repeated here. The Department considers ULSD a technically feasible control technology for the small diesel-fired boilers.

(b) Limited Operation
The theory behind limited operation was discussed in detail in the $PM_{2.5}$ BACT section for the small diesel-fired boilers and will not be repeated here. The Department considers

limited operation as a technically feasible control technology for the small diesel-fired boilers.

(c) Good Combustion Practices
The theory of GCPs was discussed in detail in the $PM_{2.5}$ BACT section for the large dual fuel-fired boiler and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2. The Department considers GCPs a technically feasible control technology for the small diesel-fired boilers.

Step 2 - Eliminate Technically Infeasible SO_2 Control Technologies for the Small Diesel-Fired Boilers
All identified control technologies are technically feasible for the diesel-fired boilers.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Small Diesel-Fired Boilers
The following control technologies have been identified and ranked by efficiency for the control of SO_2 emissions from the small diesel-fired boilers:

(a)	Ultra Low Sulfur Diesel	(99% Control)
(c)	Good Combustion Practices	(Less than 40% Control)
(b)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for SO_2 emissions from the small diesel-fired boilers:

(a) SO_2 emissions from the operation of the small diesel-fired boilers **EUs 19 through 22** will be controlled by limiting the combined operation to no more than **18,739** hours per 12-month rolling period;

(b) SO_2 emissions from the operation of the small diesel-fired boilers shall be controlled by using ULSD (0.0015 sulfur by weight) at all times of operation; and

(c) Compliance with the proposed SO_2 emission limit will be demonstrated through fuel shipment receipts and/or fuel testing for sulfur content.

Step 5 - Selection of SO_2 BACT for the Small Diesel-Fired Boilers
The Department's finding is that BACT for SO_2 emissions from the diesel-fired boilers is as follows:

(a) SO_2 emissions from EUs **19 through 22 will be controlled by limiting the combined operation to no more than 18,739** hours per 12-month rolling period;

(b) SO_2 emissions from the diesel-fired boilers **EUs 17 through 22**[28] shall be controlled by combusting only ULSD; and

(c) Compliance will be demonstrated with fuel shipment receipts and/or fuel tests for sulfur content.

Table 5-10 lists the SO_2 BACT determination for this facility along with those for other small diesel-fired boilers rated at less than 100 MMBtu/hr in the Serious $PM_{2.5}$ nonattainment area.

Table 5-10. Comparison of SO_2 BACT for the Small Diesel-Fired Boilers at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
Fort Wainwright	4 Diesel-Fired Boilers (*)	< 100 MMBtu/hr	15 ppmw S in fuel	Limited Operation Good Combustion Practices Ultra-Low Sulfur Diesel
UAF	6 Diesel-Fired Boilers	< 100 MMBtu/hr	15 ppmw S in fuel	Limited Operation Ultra-Low Sulfur Diesel
GVEA Zehnder	2 Diesel-Fired Boilers	< 100 MMBtu/hr	15 ppmw S in fuel	Good Combustion Practices Ultra-Low Sulfur Diesel

(*) The number of diesel fired boilers was updated in this BACT Amendment by removing those boilers that are considered insignificant emission units

5.4 SO_2 BACT for the Large Diesel-Fired Engines (EUs 8 and 35)

Possible SO_2 emission control technologies for large engines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process codes 17.100 - 17.190, Large Internal Combustion Engines (>500 hp). The search results for large diesel-fired engines are summarized in Table 5-11.

Table 5-11. RBLC Summary Results for SO_2 Control for Large Diesel-Fired Engines

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Low Sulfur Diesel	27	0.005 – 0.02
Federal Emission Standards	6	0.001 – 0.005
Limited Operation	6	0.005 – 0.006
Good Combustion Practices	3	None Specified
No Control Specified	11	0.005 – 0.008

RBLC Review

A review of similar units in the RBLC indicates combustion of low sulfur fuel, limited operation, and good combustion practices are the principle SO_2 control technologies installed on large diesel-fired engines. The lowest emission rate listed in the RBLC is 0.001 g/hp-hr.

[28] **EUs 17, 18, and 22 required by Condition 5 of AQ0316MSS07 and 40 of AQ0316TVP03, EUs 19 through 21 required by Condition 9 of AQ0316MSS04 and 30 of AQ0316TVP03.**

Step 1 - Identification of SO_2 Control Technology for the Large Diesel-Fired Engines
From research, the Department identified the following technologies as available for the control of SO_2 emissions from the large diesel-fired engine:

(a) Ultra Low Sulfur Diesel
The theory of ULSD was discussed in detail in the SO_2 BACT for the mid-sized diesel-fired boilers and will not be repeated here. The Department considers ULSD a technically feasible control technology for the large diesel-fired engine.

(b) Federal Standards
The theory of federal emission standards was discussed in detail in the **PM2.5 BACT section for the large diesel-fired engines** and will not be repeated here. The Department does not consider federal emission standards a technically feasible control technology for the large diesel-fired engine **EU 8.**

(c) Limited Operation
EU 8 currently operates under a combined annual NOx emission limit with EU 4. Limiting the operation of emissions units reduces the potential to emit of those units. Additionally, EU 35 is currently restricted by the NSPS Subpart IIII requirements for emergency engines. Therefore, the Department considers limited operation a technically feasible control technology for the large diesel-fired engines.

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the **PM2.5 BACT section for the large dual fuel-fired boiler** and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2 emissions. The Department considers GCPs a technically feasible control technology for the large diesel-fired engine.

Step 2 - Eliminate Technically Infeasible SO_2 Control Technologies for the Large Diesel-Fired Engines
As explained in Step 1 of Section 5.4, the Department does not consider federal emission standards as a technically feasible control technology to control SO_2 emissions from the large diesel-fired engine EU 8.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Large Diesel-Fired Engines

(a)	Ultra Low Sulfur Diesel	(99% Control)
(d)	Good Combustion Practices	(Less than 40% Control)
(c)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for SO_2 emissions from the large diesel-fired engines:

(a) SO_2 emissions from EU 8 shall be controlled by combusting ULSD (0.0015 weight percent sulfur); and

(b) SO_2 emissions from EU 8 will be limited by complying with the combined annual NOx emission limit of 40 tons per 12 month rolling period for EUs 4 and 8.

Step 5 - Selection of SO_2 BACT for the Large Diesel Fired-Engines

The Department's finding is that BACT for SO_2 emissions from the large diesel-fired engines is as follows:

(a) SO_2 emissions from EUs 8 **and 35** shall be controlled by combusting only ULSD (0.0015 weight percent sulfur);

(b) Limit the combined operation of EU 4 and 8 to no more than 40 tons of SO_2 per 12-month rolling average;

(c) Limit non-emergency operation of EUs 8 **and 35** to no more than 100 hours per year;

(d) Maintain good combustion practices by following the manufacturer's maintenance procedures at all times of operation; and

(e) Compliance will be demonstrated with fuel shipment receipts and/or fuel tests for sulfur content.

Table 5-12 lists the BACT determination for this facility along with those for other diesel-fired engines rated at more than 500 hp located in the Serious $PM_{2.5}$ nonattainment area.

Table 5-12. Comparison of SO_2 BACT for Large Diesel-Fired Engines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
Fort Wainwright	8 Large Diesel-Fired Engines	> 500 hp	15 ppmw S in fuel	Limited Operation Good Combustion Practices Ultra-Low Sulfur Diesel
UAF	2 Large Diesel-Fired Engines	**> 500 hp**	15 ppmw S in fuel	Limited Operation Good Combustion Practices Ultra-Low Sulfur Diesel
GVEA North Pole	Large Diesel-Fired Engine	600 hp	500 ppmw S in fuel15	Good Combustion Practices Ultra-Low Sulfur Diesel
GVEA Zehnder	2 Large Diesel-Fired Engines	11,000 hp	ppmw S in fuel	Good Combustion Practices Ultra-Low Sulfur Diesel

5.5 SO_2 BACT for the Small Diesel-Fired Engines (EUs 24, 26, 27, 29, and 34)

Possible SO_2 emission control technologies for small engines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 17.210, Small Internal Combustion Engines (<500 hp). The search results for small diesel-fired engines are summarized in Table 5-13.

Table 5-13. RBLC Summary of SO_2 Controls for Small Diesel-Fired Engines

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Low Sulfur Diesel	6	0.005 – 0.02
No Control Specified	3	0.005

RBLC Review
A review of similar units in the RBLC indicates combustion of low sulfur fuel is the principle SO_2 control technology for small diesel-fired engines. The lowest SO_2 emission rate listed in the RBLC is 0.005 g/hp-hr.

Step 1 - Identification of SO_2 Control Technology for the Small Diesel-Fired Engines
From research, the Department identified the following technologies as available for control of SO_2 emissions from diesel-fired engines rated at less than 500 hp:

(a) Ultra Low Sulfur Diesel
The theory of ULSD was discussed in detail in the SO_2 BACT for the mid-sized diesel-fired boilers and will not be repeated here. The Department considers ULSD a technically feasible control technology for the small diesel-fired engines.

(b) Limited Operation
The theory of limited operation for EU 27 was discussed in detail in the $PM_{2.5}$ BACT section for the large diesel-fired engine and will not be repeated here. The Department considers limited operation a technically feasible control technology for the small diesel-fired engines.

(c) Good Combustion Practices
The theory of GCPs was discussed in detail in **the $PM_{2.5}$ BACT section for the large dual fuel-fired boiler** and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2 emissions. The department considers GCPs a technically feasible control technology for the small diesel-fired engines.

Step 2 - Eliminate Technically Infeasible SO_2 Control Technologies for the Small Engines
All identified control technologies are technically feasible for the small diesel-fired engines.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Small Diesel-Fired Engines
The following control technologies have been identified and ranked by efficiency for the control of SO_2 emissions from the small diesel-fired engines.

(a) Ultra Low Sulfur Diesel (99% Control)
(c) Good Combustion Practices (Less than 40% Control)
(c) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for SO_2 emissions from the small diesel-fired engine EU 27:

(a) SO_2 emissions from the operation of the small diesel-fired engine shall be controlled by using ULSD at all times of operation (0.0015 weight percent sulfur); and
(b) SO_2 emissions from the operation of the small diesel-fired engine will be controlled by limiting operation to no more than 4,380 hours per 12-month rolling period.

Department Evaluation of BACT for SO_2 Emissions from Small Diesel-Fired Engines

The Department reviewed UAF's proposal and found that in addition to combusting only ULSD, and limiting operation of the small diesel-fired engine, good combustion practices is BACT for SO_2.

Step 5 - Selection of SO_2 BACT for the Small Diesel-Fired Engines

The Department's finding is that BACT for SO_2 emissions from the small diesel-fired engines is as follows:

(a) SO_2 emissions from small diesel-fired engines shall be controlled by combusting only ULSD at all times of operation;
(b) SO_2 emissions from the operation of EU 27 will be controlled by limiting operation to no more than 4,380 hours per 12-month rolling period;
(c) Limit non-emergency operation of EUs 24, 29**, and 34** to no more than 100 hours per year each;
(d) Maintain good combustion practices by following the manufacturer's operational procedures at all times of operation;
(e) Compliance will be demonstrated with fuel shipment receipts and/or fuel tests for sulfur content; and
(f) Compliance with the operating hours limit will be demonstrated by monitoring and recording the number of hours operated on a monthly basis.

Table 5-14 lists the BACT determination for this facility along with those for other diesel-fired engines rated at less than 500 hp located in the Serious $PM_{2.5}$ nonattainment area.

Table 5-14. Comparison of SO_2 BACT for Small Diesel-Fired Engines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
Fort Wainwright	Small Diesel-Fired Engines	< 500 hp	15 ppmw S in fuel	Limited Operation Ultra-Low Sulfur Diesel Good Combustion Practices
UAF	Small Diesel-Fired Engines	< 500 hp	15 ppmw S in fuel	Limited Operation[29] Ultra-Low Sulfur Diesel Good Combustion Practices

[29] EU 26 does not have limits on operating hours. See Step 5 above for specifics.

5.6 SO_2 BACT for the Pathogenic Waste Incinerator (EU 9A)

Possible SO_2 emission control technologies for pathogenic waste incinerators were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 21.300 for Hospital, Medical, and Infectious Waste Incinerators. The search results for pathogenic waste incinerators are summarized in Table 5-15.

Table 5-15. RBLC Summary of SO_2 Control for the Pathogenic Waste Incinerator

Control Technology	Number of Determinations	Emission Limits (lb/hr)
Natural Gas	1	0.0500

RBLC Review
A review of similar units in the RBLC indicates use of natural gas as fuel is the principle SO_2 control technology installed on pathogenic waste incinerators. The lowest emission rate listed in the RBLC is 0.0500 lb/hr.

Step 1 - Identification of SO_2 Control Technology for the Pathogenic Waste Incinerator
From research, the Department identified the following technologies as available for control of SO_2 emissions from pathogenic waste incinerators:

(a) Natural Gas
Natural gas combustion has a lower SO_2 emission rate than standard diesel combustion and can be a preferred fuel for this reason. The availability of natural gas in Fairbanks can be limited. The Department considers natural gas as a technically feasible control option for the pathogenic waste incinerator.

(b) Ultra Low Sulfur Diesel
The theory of ULSD was discussed in detail in the SO_2 BACT for the mid-sized diesel-fired boilers and will not be repeated here. The Department considers ULSD a technically feasible control technology for the pathogenic waste incinerator.

(c) Limited Operation
The theory behind the limited operation for EU 9A was discussed in detail in the **$PM_{2.5}$ BACT section for the large dual fuel-fired boilers** and will not be repeated here. The Department considers limited operation a technically feasible control technology for the pathogenic waste incinerator.

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the **$PM_{2.5}$ BACT section for the large dual fuel-fired boiler** and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2 emissions. The Department considers GCPs a technically feasible control technology for the pathogenic waste incinerator.

Step 2 - Eliminate Technically Infeasible SO_2 Control Technologies for the Pathogenic Waste Incinerator
Natural gas is eliminated as a technically infeasible SO_2 control technology for the pathogenic waste incinerator due to the limited availability.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Pathogenic Waste Incinerator
The following control technologies have been identified and ranked by efficiency for the control of SO_2 emissions from the pathogenic waste incinerator:

(b) Ultra Low Sulfur Diesel (99% Control)
(c) Good Combustion Practices (Less than 40% Control)
(c) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

UAF BACT Proposal

UAF proposes the following as BACT for SO_2 emissions from the pathogenic waste incinerator:

(a) SO_2 emissions from the operation of EU 9A will be controlled by limiting operation to no more than 109 tons of waste combusted per 12-month rolling period;

(b) SO_2 emissions from the operation of EU 9A shall be controlled by combusting ULSD at all times of operation; and

(c) Compliance will be demonstrated with fuel shipment receipts and/or fuel tests for sulfur content.

Department Evaluation of BACT for SO_2 Emissions from the Pathogenic Waste Incinerator

The Department reviewed UAF's proposal and found that in addition to combusting only ULSD, and limiting operation, good combustion practices is BACT for control of SO_2 emissions from the pathogenic waste incinerator.

Step 5 - Selection of SO_2 BACT for the Pathogenic Waste Incinerator
The Department's finding is that BACT for SO_2 emissions from the pathogenic waste incinerator is as follows:

(a) SO_2 emissions from the operation of EU 9A will be controlled by limiting operation to no more than 109 tons of waste combusted per 12-month rolling period;

(b) SO_2 emissions from the operation of EU 9A shall be controlled by combusting ULSD at all times of operation;

(c) Maintain good combustion practices by following the manufacturer's operational procedures at all times of operation; and

(d) Compliance shall be demonstrated by obtaining fuel shipment receipts and/or fuel tests for sulfur content.

6. BACT DETERMINATION SUMMARY

Table 6-1. NOx BACT Limits

EU ID	Description	Capacity	Proposed BACT Limit	Proposed BACT Control
All	**N/A**	**N/A**	**EPA approved a comprehensive precursor demonstration for NOx See details in the Section 1 Introduction**	

Table 6-2. $PM_{2.5}$ BACT Limits

EU ID	Description	Capacity	Proposed BACT Limit	Proposed BACT Control
3	Mid-Sized Diesel-Fired Boiler	180.9 MMBtu/hr	0.012 lb/MMBtu	Good Combustion Practices
4	Mid-Sized Diesel-Fired Boiler	180.9 MMBtu/hr	Diesel: 0.012 lb/MMBtu NG: 0.0075 lb/MMBtu	Limited Operation (EUs 4 and 8 combined 40 tons per rolling 12 month period); Good Combustion Practices
8	Large Diesel-Fired Engine	13,226 hp	0.32 g/hp-hr	Positive Crankcase Ventilation; Limited Operation (EUs 4 and 8 combined 40 tons per rolling 12 month period) and **EU 8 to no more than 100 hours of non-emergency operation per year; and ULSD**
9A	Pathogenic Waste Incinerator	83 lb/hr	4.67 lb/ton	Multiple Chambers; Limited Operation (109 tons per rolling 12 month period); Good Combustion Practices
17	**Small Diesel-Fired Boiler**	**4.93 MMBtu/hr**	**0.012 lb/MMBtu**	**Good Combustion Practices**
18	**Small Diesel-Fired Boiler**	**4.93 MMBtu/hr**	**0.016 lb/MMBtu**	
19	Small Diesel-Fired Boiler	6.13	**0.016** lb/MMBtu	Limited Operation (19,650 hours per rolling 12 month period combined) Good Combustion Practices
20	Small Diesel-Fired Boiler	6.13	**0.016** lb/MMBtu	
21	Small Diesel-Fired Boiler	6.13 MMBtu/hr	**0.016** lb/MMBtu	
26	Small `Diesel-Fired Engine	45 kW	1.0 g/hp-hr	**Good Combustion Practices**
27	Caterpillar C-15	500 hp	0.15 g/hp-hr	Good Combustion Practices Limited Operation (4,380 hours per year)
24	Cummins	51 kW	1.0 g/hp-hr	Limit Operation for non-emergency use (100 hours each per year) Good Combustion Practices
29	**Cummins**	**314 hp**	**0.015 g/hp-hr**	
34	**Cummins**	**324 hp**	**0.15 g/hp-hr**	
35	**Cummins**	**1,220 hp**	**0.015 g/hp-hr**	**Limit Operation for non-emergency use (100 hours each per year), Positive Crankcase Ventilation, ULSD, and Good Combustion Practices**
105	Material Handling Unit	1,600 acfm	0.003 gr/dscf	Fabric Filters Enclosures
107	Material Handling Unit	1,600 acfm	0.003 gr/dscf	
109	Material Handling Unit	1,600 acfm	0.003 gr/dscf	

110	Material Handling Unit	2,000 acfm	0.003 gr/dscf	Vents
111	Material Handling Unit	N/A	$5.5x10^{-5}$ lb/ton	Enclosure
113	Large Dual Fuel-Fired Boiler	295.6 MMBtu/hr	0.012 lb/MMBtu	Fabric Filters **Good Combustion Practices**
114	Material Handling Unit	5 acfm	0.05 gr/dscf	Fabric Filters Enclosures Vents
128	Material Handling Unit	1,650 acfm	0.003 gr/dscf	
129	Material Handling Unit	1,650 acfm	0.003 gr/dscf	
130	Material Handling Unit	1,650 acfm	0.003 gr/dscf	

Table 6-3. SO_2 BACT Limits

EU ID	Description	Capacity	Proposed BACT Limit	Proposed BACT Control
3	Mid-Sized Diesel-Fired Boiler	180.9 MMBtu/hr	15 ppmv S in Fuel	Ultra-Low Sulfur Diesel
4	Mid-Sized Diesel-Fired Boiler	180.9 MMBtu/hr	Diesel: 15 ppmv S in Fuel NG: 0.60 lb/MMscf	Ultra-Low Sulfur Diesel Limited Operation (EUs 4 and 8 combined 40 tons per rolling 12 month period)
8	Large Diesel-Fired Engine	13,226 hp	15 ppmv S in Fuel	Limited Operation (EUs 4 and 8 combined 40 tons per rolling 12 month period) **and EU 8 to no more than 100 hours of non-emergency operation per year** Good Combustion Practices **and ULSD**
9A	Pathogenic Waste Incinerator	83 lb/hr	15 ppmv S in Fuel	Ultra-Low Sulfur Diesel Limited Operation (109 tons per rolling 12 month period)
17	**Small Diesel-Fired Boiler**	**4.93 MMBtu/hr**	**15 ppmv S in Fuel**	**Ultra-Low Sulfur Diesel**
18	**Small Diesel-Fired Boiler**	**4.93 MMBtu/hr**	**15 ppmv S in**	
19	Small Diesel-Fired Boiler	6.13 MMBtu/hr	15 ppmv S in Fuel	Limited Operation (19,650 hours per rolling 12 month period combined) Ultra-Low Sulfur Diesel
20	Small Diesel-Fired Boiler	6.13 MMBtu/hr	15 ppmv S in Fuel	
21	Small Diesel-Fired Boiler	6.13 MMBtu/hr	15 ppmv S in Fuel	
26	Small `Diesel-Fired Engine	45 kW	15 ppmv S in Fuel	**Good Combustion Practices and ULSD**
27	Caterpillar C-15	500 hp	15 ppmv S in Fuel	Good Combustion Practices a**nd ULSD** Limited Operation (4,380 hours per year)
24	Cummins	51 kW	15 ppmv S in Fuel	**Limit Operation for non-emergency use (100 hours each per year),**
29	Cummins	314 hp	15 ppmv S in Fuel	

EU ID	Description	Capacity	Proposed BACT Limit	Proposed BACT Control
34	**Cummins**	**324 hp**	**15 ppmv S in**	**Good Combustion Practices and ULSD**
35	**Cummins**	**1,220 hp**	**15 ppmv S in**	
113	Large Dual Fuel-Fired Boiler	295.6 MMBtu/hr	0.10 lb/MMBtu	**Fluidized Bed Limestone Injection**[25]

Stationary Source: Campus Power Plant

Emission Units: EU ID 113 (295.6 MMBtu/hr – Large Dual Fuel-Fired Boilers)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping, and Reporting Requirements** [1]
0.012 lb/MMBtu (3-hr avg);	• Conduct a one-time performance test using EPA Method 201A and 202 to demonstrate compliance and submit results to the Department. • Report source test results as required by Operating Permit.
Control emissions with fabric filters at all times of operation.	• Certify in Facility Operating Report that fabric filters are operated at all times the boiler is in operation. • Operate, inspect, and maintain the fabric filters according to the manufacturer's instructions and recommendations. • Include a summary of inspection and maintenance conducted in each semi-annual operating report.
Good Combustion Practices	• Keep records of maintenance conducted on the emission unit to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's recommended maintenance procedures.
Maintain compliance with State opacity standards listed under 50.055(a)(1).	• Monitor, record, and report visible emissions using a Continuous Opacity Monitoring System (COMS) installed and maintained as directed in the corresponding Operating Permit.

Emission Units: EU ID 3 (180.9 MMBtu/hr – Mid-Sized Diesel-Fired Boiler) and EU ID 4 (180.9 MMBtu/hr – Mid-Sized Dual Fuel-Fired Boiler)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping, and Reporting Requirements** [1]
0.012 lb/MMBtu (3-hr avg) for EU ID 3 and EU ID 4 (while firing diesel fuel);	• Conduct a one-time performance test using EPA Method 201A and 202 to demonstrate compliance and submit results to the Department. • Report source test results as required by Operating Permit.
0.0075 lb/MMBtu (3-hr avg) for EU ID 4 (while firing natural gas);	• Conduct a one-time performance test using EPA Method 201A and 202 to demonstrate compliance and submit results to the Department. • Report source test results as required by Operating Permit.
Control emissions from EU 4 by limiting NO_x emissions from EUs 4 and 8 to no more than 40 tons per 12-month rolling period.	• Demonstrate compliance with this BACT measure by complying with Condition 3 of Minor Permit No. AQ0316MSS05.
Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure.

[1] While the substantive requirements are described here, for any permit containing the requirement, the actual language may differ in non-substantive ways and include additional details.

	• Keep a copy of the manufacturer's and the operator's recommended maintenance procedures. • Comply with the boiler tune-up and MR&R requirements in NESHAP Subpart JJJJJJ. • At least once during each quarter that the emission unit operates, measure CO and O_2 in the exhaust stream using a portable handheld combustion analyzer. Record the results, the load of the EU, the date and time of measurement, and report these values in the following semi-annual operating report required by the Operating Permit.

Emission Units: EU IDs 17 through 22 (<500 MMBtu/hr – Small Diesel-Fired Boilers)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping, and Reporting Requirements[1]**
0.016 lb/MMBtu (3-hr avg); Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's recommended maintenance procedures. • Comply with the boiler tune-up and MR&R requirements in NESHAP Subpart JJJJJJ.
Limited combined operation of EUs 19 through 22 to no more than 18,739 hours per 12-month rolling period.	• Demonstrate compliance with this BACT measure by complying with Condition 7 of Minor Permit No. AQ0316MSS07.

Emission Units: EU IDs 8 and 35 (>500 hp – Large Diesel-Fired Engines)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements [1]**
0.32 g/hp-hr (3-hr avg) for EU 8; Good Combustion Practices	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's maintenance procedures.
0.05 g/hp-hr (3-hr avg) for EU 35; Good Combustion Practices	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's maintenance procedures. • Comply with the applicable requirements of 40 C.F.R. 60, Subpart IIII.
Limit non-emergency operation of EUs 8 and 35 to 100 hours per year, each.	• For EU 8, demonstrate compliance by complying with the NESHAP Subpart ZZZZ emergency engine requirements listed in 40 C.F.R. 63.6640(f). • For EU 35, demonstrate compliance by complying with the NSPS Subpart IIII emergency engine requirements listed in 40 C.F.R. 60.4211(f).

Limit NO_x emissions from EUs 4 and 8 to no more than 40 tons per 12-month rolling period.	• To demonstrate compliance with this BACT measure, comply with Condition 3 of Minor Permit No. AQ0316MSS05.
Operate positive crankcase ventilation.	• Submit initial certification in a Facility Operating Report that positive crankcase ventilation systems have been installed, or are an inherent design, on EUs 8 and 35. • Operate, maintain, and inspect according to the manufacturer's instructions and recommendations.
Ultra-low sulfur diesel (ULSD)	• For each shipment of fuel, test the sulfur content or keep receipts that specify fuel grade, date and time, and quantity of fuel received. Keep records of the results of sulfur content tests and receipts for fuel shipments. • Include in each semi-annual operating report, a summary of fuel test results and shipping receipts from the reporting period.

Emission Units: EU IDs 24, 26, 27, 29, and 34 (<500 MMBtu/hr – Small Diesel-Fired Engines)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping, and Reporting Requirements[1]**
0.015 g/hp-hr for EU 29; 0.15 g/hp-hr for EUs 27 and 34; Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's maintenance procedures. • Comply with the applicable requirements of 40 C.F.R. 60, Subpart IIII.
1.0 g/hp-hr for EUs 24 and 26; Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's maintenance procedures. • Comply with the applicable requirements of 40 C.F.R. 63, Subpart ZZZZ.
EUs 27 and 34 shall comply with the federal Tier 3 emission standards of NSPS Subpart IIII.	• Submit initial certification in a Facility Operating Report certifying that EUs 27 and 34 are rated to at least meet the Tier 3 emission standards of NSPS Subpart IIII.
Limit operation for EU 27 to no more than 4,380 hours per 12-month rolling period.	• For EU 27, demonstrate compliance with this BACT measure by complying with Condition 4 of Minor Permit No. AQ0316MSS03.
Limit non-emergency operation of EUs 24, 29, and 34 to no more than 100 hours per year, each.	• For EU 24, demonstrate compliance with this BACT measure by complying with NESHAP Subpart ZZZZ emergency engine requirements listed in 40 C.F.R. 63.6640(f).

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping, and Reporting Requirements**[1]
	• For EUs 29 and 34, demonstrate compliance with this BACT measure by complying with the NSPS Subpart IIII emergency engine requirements listed in 40 C.F.R. 60.4211(f).

Emission Units: EU ID 9A (Pathogenic Waste Incinerator)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Multiple chamber design.	• Submit initial certification in a Facility Operating Report that the incinerator (EU ID 9A) meets a multiple chamber design.
Limit the operation of EU 9A to combust no more than 109 tons of waste per 12-month rolling period.	• Demonstrate compliance with this BACT measure by complying with Condition 12 of Minor Permit AQ0316MSS08.
4.67 lb/ton; Good Combustion Practices.	• Keep records of maintenance conducted on emissions unit to comply with this BACT measure. • Keep a copy of the manufacturer's maintenance and operational procedures. • Certify that the manufacturer's maintenance and operational procedures are being followed in each semi-annual report.

Emission Units: EU IDs 105, 107, 109 through 111, 114, and 128 through 130 (Material Handling Units)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Control emissions from the material handling units by operating each EU in an enclosure.	• Submit initial compliance certifying that each material handling unit is enclosed. • Keep records identifying each time period that each of the EUs are operated outside an enclosure. • Monitor that overhead door(s) at ash loading building are closed while loading the trucks. Monitor that ash truck bodies are free of ash before they leave the building, and that their loads are tarped before they leave the building area. Monitor the implementation of a comprehensive fugitive dust control program that includes provisions to minimize fugitive dust from coal ash handling operations. • Report as a permit deviation whenever any of the EUs are operated outside of an enclosure.
Control emissions from material handling units, except EU 111, with fabric filters at all times of operation.	• Certify in Facility Operating Report that fabric filters are operated at all times the material handling units, except EU 111, are in operation. • Operate, inspect, and maintain the fabric filters according to the manufacturer's instructions and recommendations. • Report in each Facility Operating Report a summary of inspections and maintenance conducted.

Emission limit of 0.003 gr/dscf for EUs 105, 107, 109, 110, and 128-130; 0.050 gr/dcf for EU 114;	• Follow stationary source's fugitive dust control plan and the manufacturer's operating and maintenance procedures at all times of operation.
5.50E-05 lb/ton for EU 111;	• Demonstrate compliance with this BACT measure by complying with Condition 14 of Minor Permit No. AQ0316MSS08.

Stationary Source: UAF – Campus Power Plant

Emission Units: EU ID 113 (295.6 MMBtu/hr – Large Dual Fuel-Fired Boiler)

Pollutant of Concern: SO_2	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
0.10 lb/MMBtu (30-day rolling average);	• Compliance with the proposed SO_2 emission rate for the dual fuel-fired boiler will be demonstrated through CEMS monitoring and reporting. • Install, calibrate, maintain, and operate CEMS for measuring SO_2 concentrations and either O_2 or CO_2 concentrations according to the requirements of NSPS Subpart Db for CEMS that may be used to meet the SO_2 emission monitoring requirements of 40 C.F.R. 60.47b. • Record the CEMS data and include the recorded data in each semi-annual operating report.
Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's recommended maintenance procedures. • Comply with the boiler tune-up and MR&R requirements in NESHAP Subpart JJJJJJ.
Control emissions with fluidized bed with limestone injection (FBLI) at all times of operation.	• Certify in Facility Operating Report that the FBLI system is operated at all times the boiler is in operation. • Operate, maintain, and inspect according to the manufacturer's instructions and recommendations. • Include a summary of inspections and maintenance conducted in each semi-annual operating report.

Emission Units: EU ID 3 (180.9 MMBtu/hr – Mid-Sized Diesel-Fired Boiler) and EU ID 4 (180.9 MMBtu/hr – Mid-Sized Dual Fuel-Fired Boiler)

Pollutant of Concern: SO_2	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Combust only Ultra Low Sulfur Diesel (ULSD) at no more than 0.0015 percent sulfur by weight.	• For each shipment of fuel, test the sulfur content or keep receipts that specify fuel grade, date and time, and quantity of fuel received. Keep records of the results of sulfur content tests and receipts for fuel shipments. • Include in each semi-annual operating report, a summary of fuel test results and shipping receipts from the reporting period.
0.60 lb/MMscf for EU ID 4 (while firing natural gas);	• Demonstrate compliance with this BACT measure by complying with Condition 10 of Minor Permit No. AQ0316MSS08.
Limit the combined SO_2 emissions from EUs 4	• Demonstrate compliance with this BACT measure by complying with Condition 2 of Minor Permit No. AQ0316MSS05.

[1] While the substantive requirements are described here, for any permit containing the requirement, the actual language may differ in non-substantive ways and include additional details.

and 8 to no more than 40 tons per 12-month rolling period.	
Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's recommended maintenance procedures. • Comply with the boiler tune-up and MR&R requirements in NESHAP Subpart JJJJJJ.

Emission Units: EU IDs 17 through 22 (<500 MMBtu/hr – Small Diesel-Fired Boilers)

Pollutant of Concern: $PM_{2.5}$	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Combust Only Ultra Low Sulfur Diesel (ULSD) at no more than 0.0015 percent sulfur by weight.	• For each shipment of fuel, test the sulfur content or keep receipts that specify fuel grade, date and time, and quantity of fuel received. Keep records of the results of sulfur content tests and receipts for fuel shipments. • Include in each semi-annual operating report, a summary of fuel test results and shipping receipts from the reporting period.
For EUs 19 through 22, limit the combined operation to no more than 18,739 hours per 12-month rolling period.	• Demonstrate compliance with this BACT measure by complying with Condition 7 of Minor Permit No. AQ0316MSS07.

Emission Units: EU IDs 8 and 35 (>500 hp – Large Diesel-Fired Engines)

Pollutant of Concern: SO_2	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Combust Only Ultra Low Sulfur fuel at no more than 0.0015 percent sulfur by weight.	• For each shipment of fuel, test the sulfur content or keep receipts that specify fuel grade, date and time, and quantity of fuel received. Keep records of the results of sulfur content tests and receipts for fuel shipments. • Include in each semi-annual operating report, a summary of fuel test results and shipping receipts from the reporting period.
Limited NO_x emissions from EUs 4 and 8 to no more than 40 tons per 12-month rolling period.	• Demonstrate compliance by complying with Condition 3 of Minor Permit No. AQ0316MSS05.
Limited non-emergency operation of EUs 8 and 35 to no more than 100 hours per year, each.	• For EU 8, demonstrate compliance by complying with the NESHAP Subpart ZZZZ emergency engine requirements listed in 40 C.F.R. 63.6640(f). • For EU 35, demonstrate compliance by complying with the NSPS Subpart IIII requirements listed in 40 C.F.R. 60.4211(f).

Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's recommended maintenance procedures. • For EU 35, comply with the applicable requirements of 40 C.F.R. 60, Subpart IIII.

Emission Units: EU IDs 24, 26, 27, 29, and 34 (<500 MMBtu/hr – Small Diesel-Fired Boilers)

Pollutant of Concern: SO_2	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Combust Only Ultra Low Sulfur fuel at no more than 0.0015 percent sulfur by weight.	• For each shipment of fuel, test the sulfur content or keep receipts that specify fuel grade, date and time, and quantity of fuel received. Keep records of the results of sulfur content tests and receipts for fuel shipments. • Include in each semi-annual operating report, a summary of fuel test results and shipping receipts from the reporting period.
Limited operation for EU 27 to no more than 4,380 hours per 12-month rolling period.	• Demonstrate compliance with this BACT measure by complying with Condition 4 of Minor Permit No. AQ0316MSS03.
Limited non-emergency operation for EUs 24, 29, and 34 to no more than 100 hours per year, each.	• For EU 24, demonstrate compliance by complying with the NESHAP Subpart ZZZZ emergency engine requirements listed in 40 C.F.R. 63.6640(f). • For EUs 29 and 34, demonstrate compliance by complying with the NSPS Subpart IIII requirements listed in 40 C.F.R. 60.4211(f).
Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's and the operator's recommended maintenance procedures. • For EUs 27, 29, and 34, comply with the applicable requirements of 40 C.F.R. 60, Subpart IIII. • For EU 26, comply with the applicable requirements of 40 C.F.R. 63, Subpart ZZZZ.

Emission Units: EU ID 9A (Pathogenic Waste Incinerator)

Pollutant of Concern: SO_2	
BACT Measure	**Monitoring, Recordkeeping and Reporting Requirements** [1]
Combust Only Ultra Low Sulfur fuel at no more than 0.0015 percent sulfur by weight.	• For each shipment of fuel, test the sulfur content or keep receipts that specify fuel grade, date and time, and quantity of fuel received. Keep records of the results of sulfur content tests and receipts for fuel shipments. • Include in each semi-annual operating report, a summary of fuel test results and shipping receipts from the reporting period.

Limit operation of EU 9A to no more than 109 tons of waste combusted per 12-month rolling period.	• Demonstrate compliance with this BACT measure by complying with Condition 12 of Minor Permit No. AQ0316MSS08.
Good Combustion Practices.	• Keep records of maintenance conducted on emissions units to comply with this BACT measure. • Keep a copy of the manufacturer's maintenance and operational procedures. • Certify that the manufacturer's maintenance and operational procedures are being followed in each semi-annual report.

Air Pollution Control Cost Estimation Spreadsheet For Wet and Dry Scrubbers for Acid Gas Control

U.S. Environmental Protection Agency
Air Economics Group
Health and Environmental Impacts Division
Office of Air Quality Planning and Standards
(May 2021)

This spreadsheet allows users to estimate the capital and annualized costs for installing and operating scrubbers for reducing sulfur dioxide and acidic gas emissions from fossil fuel-fired combustion units and other industrial sources of acid gases.

The calculation methodologies used in this spreadsheet are those presented in the U.S. EPA's Air Pollution Control Cost Manual. This spreadsheet is intended to be used in combination with the acid gas absorber chapter and cost estimation methodology in the Control Cost Manual. For a detailed description of acid gas absorbers and the cost methodologies, see Section 5, Chapter 1 (Wet and Dry Scrubbers for Acid Gas Control) of the Air Pollution Control Cost Manual (as updated in 2021). A copy of the Control Cost Manual is available on the U.S. EPA's "Technology Transfer Network" website at: https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution.

This spreadsheet can be used to estimate capital and annualized costs for three types of acid gas scrubbers:

(1) Wet flue gas desulfurization (WFGD) systems used to control SO_2 emissions from coal-fired utility boilers over 100 MW.
(2) Spray dryer absorber (SDA) used to control SO_2 emissions from coal-fired utility boilers of equal to or greater than 50 MW.
(3) Wet packed-bed scrubbers used to control acid gases from industrial emission sources of any size.

<u>WFGD and SDA Control Systems</u>
The methodologies for WFGD and SDA systems are based on those from the U.S. EPA Clean Air Markets Division (CAMD)'s Integrated Planning Model (IPM version 6). The size and costs of a WFGD and SDA are based primarily on the size of the combustion unit and the sulfur content of the coal burned. The WFGD methodology include cost algorithms for capital and operating cost for wastewater treatment consisting of chemical pretreatment, low hydraulic residence time biological reduction and ultrafiltration to treat wastewater generated by the WFGD system. The IPM equations estimate the purchased equipment cost and the direct and indirect installation costs based on cost data for multiple lump-sum contracts. Turnkey contracts where the price is fixed at the time the contract is signed and the contractor undertakes responsibility for the completion of the project, are generally 10 to 15% higher than the multiple lump-sum contracts. For additional information regarding the IPM, see the EPA Clean Air Markets webpage at http://www.epa.gov/airmarkets/power-sector-modeling.

Users should complete the Wet & Dry FGD Data Inputs tab to estimate costs for WFGD and SDA systems.

<u>Packed-Bed Scrubbers</u>
The cost methodology for wet packed-bed scrubbers can be used for estimating costs for any size of packed tower absorber used to control flue gas containing any acidic pollutants (e.g., HCl and HF). The capital and operating costs are based on the waste gas composition and properties of the pollutant and sorbent. The waste gas is assumed to comprise a two-component waste gas mixture (pollutant/air), where the pollutant consists of a single compound present in dilute quantities. The waste gas is assumed to behave as an ideal gas and the solvent is assumed to behave as an ideal solution. Heat effects associated with absorption are considered to be minimal due to the low pollutant concentration. The procedures also assume that, in chemical absorption, the process is not reaction rate limited, i.e., the reaction of the pollutant with the solvent is considered fast compared to the rate of absorption of the pollutant into the solvent.

Users should complete the PB Scrubber Data Inputs tab to estimate costs for packed-bed scrubbers.

The calculations provide study-level estimates (±30%) of capital and annual costs. Default values included in the spreadsheet are taken from the Control Cost Manual and other sources, such as the U.S. Energy Information Administration (EIA), and are included only as an example of how to complete the data inputs sheets. The actual costs may vary from those calculated here due to site-specific conditions. Selection of the most cost-effective control option should be based on a detailed engineering study and cost quotations from control system suppliers.

Instructions

<u>Step 1</u>: Please select the ***FGD Data Inputs*** ***<u>or</u>*** ***PB Scrubber Data Inputs*** tab. Click he ***Reset Form*** button at the top of the sheet to reset all parameters to default values.

<u>Step 2</u>: Complete the cells highlighted in yellow. The highlighted cells are pre-populated with example or default values. Users should replace the pre-populated values with current values for each parameter that are specific to the facility. All data entry fields in the ***PB Scrubber Data Inputs*** tab should be completed. While most fields in the ***FGD Data Inputs*** tab apply to both WFGD and SDA systems, a few data entry fields are specific to the type of control system and may be left blank if the user does not wish to estimate costs for both systems. References documenting the source of each value should be documented in the ***Data Sources for Default Values Used in Calculations*** located on the ***FGD Data Inputs*** and ***PB Scrubber Data Inputs*** tabs.

<u>Step 3</u>: Once all of the data fields are complete, select the ***SDA Design Parameters, WFGD Design Parameters,*** or ***PB Scrubber Design Parameters*** tab (as applicable) to see the calculated design parameters. Select the ***SDA Cost Estimate, WFGD Cost Estimate,*** or ***PB Scrubber Cost Estimate*** tabs to view the calculated cost data for the installation and operation of the scrubber.

Data Inputs for Spray Dryer Absorber and Wet FGD

Enter the following data for your combustion unit:

Retrofit

Is the FGD for a new boiler or retrofit of an existing boiler?

Please enter a retrofit factor. Enter 1 for projects of average difficulty. Enter values >1 for more difficult retrofits and enter <1 for less difficult retrofits. 1

Directions: Enter data in highlighted data fields.

What is the gross MW rating at full load capacity (A)? 29.50 MW

Provide the following information for the coal burned:

Select type of coal burned: Sub-Bituminous

Enter the sulfur content (%S) percent by weight

OR

SO_2 Emissions (SO_{2in}) 0.10 lb/MMBtu

Oulet SO_2 Emissions (SO_{2out}) 0.01 lb/MMBtu

What is the higher heating value of the fuel (HHV)? Btu/lb

*HHV is the weighted average value calculated using the values entered in the coal blend composition table.

*Note: You do not need to enter a value for the HHV since you entered SO2 emissions in lb/MMBtu above

What is the estimated actual annual MWh output? 258,463 MWh

Waste from a WFDG system disposed in an onsite or offsite landfill? Offsite Landfill

Gross heat input rate (GHR) 10.02 MMBtu/MWh

Enter the following design parameters for the proposed FGD System:

Number of hours the scrubber operates (t_{ABS}) 8760 Hours

Plant Elevation 446 Feet above sea level

Number of hours the boiler operates (t_{plant})	8760	Hours

Number of Full Time Operators (FT):

SDA System		
WFGD system	6	

Estimated equipment life:

SDA System		Years
Wet FGD System	30	Years
Estimated equipment life for mercury monitor for wastewater treatment system for Wet FGD Systems	6	Years

Enter the cost data for the proposed FGD System:

Desired dollar-year for Capital Costs	2022			
CEPCI for 2022	816	Enter the CEPCI value for 2022	541.7	2016 CEPCI*
Annual Interest Rate (i)	8.5	Percent		

Sorbent Cost:

Lime (for SDA)		$/ton of Lime
Limestone (for Wet FGD)	30.00	$/ton of Limestone
Water ($Cost_{water}$)	0.0042	$/gallon
Electricity ($Cost_{elect}$)	0.0361	$/kWh*
Waste Disposal cost ($Cost_{waste}$)	30.00	$/ton
Labor Rate	60.00	$/hour
Purchase Equipment Cost for Mercury Monitor for wastewater treatment System (MMCost)	-	$/monitor

*Note: CEPCI = Chemical Engineering Plant Cost Index. The use of CEPCI in this spreadsheet is not an endorsement of the index, but is there merely to allow for availability of a well-known cost index to spreadsheet users. Use of other well-known cost indexes (e.g., M&S) is acceptable.

Data Sources for Default Values Used in Calculations:

Data Element	Default Value	Sources for Default Value	If you used your own site-specific values, please enter the value used and the reference source . . .	Recommended data sources for site-specific information
Lime ($/ton)	125	U.S. Environmental Protection Agency (EPA). Documentation for EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model. Office of Air and Radiation. January 2017. Available at: https://www.epa.gov/airmarkets/documentation-epas-power-sector-modeling-platform-v6.	Not applicable	N/A
Limestone ($/ton)	30	U.S. Environmental Protection Agency (EPA). Documentation for EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model. Office of Air and Radiation. January 2017. Available at: https://www.epa.gov/airmarkets/documentation-epas-power-sector-modeling-platform-v6.	$288/ton was used. This information was provided by UAF personnel for the limestone currently delivered to site and being burned in the boiler. Additional refinement needs to be accounted for as the current limestone particle sizes are too big for the a WFGD slurry feed stream. It is assumed that any particle refinement is being accounted for in the Reagent Preparation Equipment Costs that are calculated in the "WFGD Cost Estimate" tab. It is not fully understood what equipment is included in the EPA provided costs. If additional milling is not part of the Reagent Preparation Equipment Costs, then additional pricing of a mill should be included. For this scenario, additional pricing for a mill was not included.	Check with reagent vendors for current prices.

Water Cost ($/gallon)	0.00420	Average water rates for industrial facilities (compiled by Black & Veatch. See '50 Largest Cities Water/Wastewater Rate Survey - 2018-2019.'Available at www.bv.com/sites/default/files/2019-10/50_Largest_Cities_Rate_Survey_2018_2019_Report.pdf.	$0.0122/gallon of water pricing was provided by UAF Facility Services Utility Rates for 2022	Plant's utility bill or Black & Veatch's "50 Largest Cities Water/Wastewater Rate Survey." Available at http://www.saws.org/who_we_are/community/RAC/docs/2014/50-largest-cities-brochure-water-wastewater-rate-survey.pdf. .
Electricity Cost ($/kWh)	0.0361	U.S. Energy Information Administration. Electric Power Annual 2016, Table 8.4, Published December 2017. Available at: https://www.eia.gov/electricity/annual/pdf/epa.pdf	$0.2050/kWh electricity pricing was provided by UAF Facility Services Utility Rates for 2022	Plant's utility bill or use U.S. Energy Information Administration (EIA) data for most recent year. Available at http://www.eia.gov/electricity/data.cfm#sales.
Waste Disposal Cost ($/ton)	30	U.S. Environmental Protection Agency (EPA). Documentation for EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model. Office of Air and Radiation. January 2017. Available at: https://www.epa.gov/airmarkets/documentation-epas-power-sector-modeling-platform-v6.	$257/ton. Ash hauling rates provided by UAF personnel ranged from $220-$293/ton. The variance is mostly attributed to the moisture content in the ash as well as the water added prior to load out to mitigate dust during transportation. $257 was used as it was an average of the low and high value. Email dated 7/8/22 from Frances Isgrigg (UAF) to Mark Payne (SCI) and Courtney Kimball (Boreal). It should be noted that the ash disposal does not include any additional costs for regulated or hazardous waste pollutants that may be captured during the WFGD process. The ash hauling rates being used in the spreadsheet may or may not increase due to additional pollutants in the ash. We believe that using the current average ash hauling rate will provide a conservatively low effective cost for SO2 removal per year.	Check with reagent vendors for current prices.
Higher Heating Value (HHV) (Btu/lb)	8,826	Average HHV based 2016 coal data compiled by the Office of Oil, Gas, and Coal Supply Statistics, U.S. Energy Information Administration (EIA) from data reported on EIA Form EIA-923, Power Plant Operations Report. Available at http://www.eia.gov/electricity/data/eia923/.	N/A. Value was not needed as SO2 content was specified as lb/MMBtu.	Fuel supplier or use U.S. Energy Information Administration (EIA) data for most recent year. Available at http://www.eia.gov/electricity/data/eia923/.
Average Sulfur Content (%)	0.41	Average sulfur content based on U.S. coal data for 2016 compiled by the U.S. Energy Information Administration (EIA) from data reported on EIA Form EIA-923, Power Plant Operations Report. Available at http://www.eia.gov/electricity/data/eia923/.	Sulfur content is not being used because inlet SO2 emissions are provided instead. The inlet SO2 emission rate is 0.20 lb/MMBtu per Condition 13.1 of Permit AQ0316MSS06 Revision 2. That emission rate is the basis of the SO2 PTE for EU 113 (258.9 tpy per Condition 13 of Permit AQ0316MSS06 Revision	Fuel supplier or use U.S. Energy Information Administration (EIA) data for most recent year. Available at http://www.eia.gov/electricity/data/eia923/.
Interest Rate	3.25	Default bank prime rate March 2, 2021 (available as the rates listed under 'bank prime loan' at https://www.federalreserve.gov/releases/h15/).	7.50%. Updated prime rate as of December 27, 2022.	Use current bank prime rate available at https://www.federalreserve.gov/releases/h15/.
Hourly Labor Rate ($/hour)	60	U.S. Environmental Protection Agency (EPA). Documentation for EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model. Office of Air and Radiation. January 2017. Available at: https://www.epa.gov/airmarkets/documentation-epas-power-sector-modeling-platform-v6.	$49/hour. Value provided by Frances Isgrigg (UAF). This is a burdened rate of an individual who would be working on this equipment at the plant.	Plant data.

	Data Element	Default Value	Sources for Default Value	If you used your own site-specific values, please enter the value used and the reference source . . .	Recommended data sources for site-specific information
Cell C10	Gross MW rating at full load capacity	N/A	The facility at UAF was designed and constructed as a Combined Heat Power facility which serves the University in two ways; providing distribution steam for campus heating and other processes, and electricity for electrical demand on the campus. The Boiler and Steam Turbine at UAF were design as a bottoming cycle facility which means that the boiler is ramped as needed to meet the amount of steam heating that is required on campus. The left over steam is sent to the steam turbine to convert the remaining energy to electricity. This differs to a traditional power plant that uses all of it's generated steam to generate electricity with little to no distribution of steam for processes or users. In order to utilize the EPA spreadsheet, a theoretical MW value needed to be calculated for the CHP facility. To calculate an electrical generation power plant equivalency, we used the BTU input of the Boiler (total coal flow into the boiler), then using the Boiler efficiency which equates the amount of BTU's that the boiler captures in the steam cycle. These BTU's were then divided by the Steam Turbine efficiency, also know has Heat Rate (BTU/kW) which yields a theoretical MW value based on how the steam turbine can convert BTU's to kW. The resultant was used as a electrical "equivalent" in the spreadsheet. It should be noted that the facility has no way of generating the calculated theoretical MW value as the existing Steam Turbine cannot operate beyond it's 17MW nameplate.	Value used: 29.5 MW "CHPP MW Equivalent" = Boiler BTU Input x Boiler Efficiency / Steam Turbine Heat Rate. Boiler input: 295,600,000 lb/hr (Provided by B&W) Boiler efficiency: 85.73% (Provided by B&W) Steam Turbine efficiency: 8,589 Btu/kWh (Provided by Shin Nippon)	
C17	Oulet SO2 Emissions (SO2out) (lb/mmbtu)	N/A	SO2 output emissions	0.01 lb/mmbtu was entered to show the WFGD efficiency at 95%	

Cell C34	Annual MWH output	N/A	This calculates the total MWh produced by the boiler. This was calculated using electrical capacity equivalent MW (rating) and multiplying by 8,760 hours per year for an annual MWh output	258,463 MWh Annual MWh output = Capacity x hours of operation/year Annual MWh output = 29.50MW x 8,760 hours/year	
Cell C38	Gross heat input rate	N/A	This calculates the total amount of heat input into the boiler by the coal per MW electrical capacity. Values of the equation include: Permitted Maximum Heat Input into the Boiler (MMBtu/hr) / MW capacity	10.02 MMBTU/MWh Gross Heat Input Rate (GHIR) = Max Heat Input / MW capacity GHIR = 295.6 MMBtu/hr / 29.5 MW GHIR = 10.02 MMBTU/MWh	
Cell C44	Number of hours of Scrubber Operation	N/A	Value set at total hours that Scrubber can operate per year, but no more than Boiler operation.	8,760 hours in one year.	
Cell C45	Number of hours of Boiler Operation	N/A	Value set at total hours that Boiler can operate per year.	8,760 hours in one year.	
Cell C47	SDA System Full Time Operators	8	EPA recommended default value of 8 operators for SDA system.	Not applicable	
Cell C48	WFDG System Full Time Operators	12	EPA recommended default value of 12 operators for WFGD system (<500MW plant size)	Value used: 6 The EPA default value is 12 for a plant that is between 100 MW and 500 MW. The theoretical electrical capacity of the UAF CHPP is 29.5 MW. Based on the size of the equipment and the EPA recommendation, the value was set at 6 operators. The plant operates and staff's the plants operation for Monday thru Sunday, 24 hours per day. The plant has a total of 4 shifts available during the week (2 weekly sections, with each weekly section staffed during the day and separately at night). WFGD's are material handling intensive and require support during material offloading, material transfer, material batching and during operational hours. 6 Full time operators averages to 1.25 fulltime equivalents during each shift. It should be noted that the sensitivity of operators on a WFGD cost effectiveness result is some what small. The difference in effectiveness between the currently used 6 operators and using no new additional operators is roughly \$2,500/ton of SO2 removed (\$28,500 to \$26,000).	
Cell C57	CEPCI for 2022	N/A	Provide latest Chemical Engineering Plant Cost Index (CEPCI)	Value used: 708 Value was taken from Chemical Engineering magazine, August 2022 Issue. Value was provided as a final 2021 index number.	

Wet FGD Design Parameters

The following design parameters for the wet FGD system were calculated based on the values entered on the *FGD Data Inputs* tab. These values were used to prepare the costs shown on the *Wet FGD*

Parameter	Equation	Calculated Value	Units	
Maximum Annual Heat Input Rate (Q_B) =	A x GHR =	296	MMBtu/hour	
Maximum Annual MWh Output (B_{MW}) =	A x 8760 =	258,463	MWh	
Estimated Actual Annual MWh Output (B_{output}) =	Value entered by user	258,463	MWh	
Heat Rate Factor (HRF) =	Gross Plant Heat Rate/10 =	1.00		
Total System Capacity Factor (CF_{total}) =	$(B_{output}/B_{mw})*(t_{ABS}/t_{plant})$ =	1.000	fraction	
Total effective operating time for the scrubber (t_{op}) =	CF_{total} x 8760 =	8,760	hours	
SO_2 Removal Efficiency (EF) =	$(SO_{2in} - SO_{2out})/SO_{2in}$ =	90	percent	
SO_2 removed per hour =	SO_{2in} x EF x Q_B =	27	lb/hour	
Total SO_2 removed per year =	$(SO_{2in}$ x EF x Q_B x $t_{op})/2000$ =	116.53	tons/year	
Coal Factor ($Coal_F$) =	1 for bituminous; 1.05 for sub-bituminous; 1.07 for lignite (weighted average is used for coal blends)	1.05		
Inlet SO_2 Emissions (SO_{2in}) =	Value entered by user	0.10	lb/MMBtu	
Elevation Factor (ELEVF) =	14.7 psia/P =			Not applicable; elevation factor does not apply to plants located at elevations
Atmospheric pressure at 446 feet above sea level (P) =	$2116 \times [(59-(0.00356xh)+459.7)/518.6]^{5.256} \times (1/144)$* =	14.5	psia	
Retrofit Factor (RF) =	Retrofit to existing boiler	1.00		

* Equation is from the National Aeronautics and Space Administration (NASA), Earth Atmosphere Model. Available at https://spaceflightsystems.grc.nasa.gov/education/rocket/atmos.html.

Capital Recovery Factor:

Parameter	Equation	Calculated Value	
Capital Recovery Factor (CRF) =	$i (1+ i)^n/(1+ i)^n - 1$ = Where n = Equipment Life and i= Interest Rate	0.0931	Wet FGD System
		0.2196	Mercury Monitor for Wastewater Treatment System

Parameter	Equation	Calculated Value	Units
Electricity Usage:			
Electricity Consumption (P) =	$0.0112e^{0.155xS}$ x CoalF x HRF x A x 1,000 =	353	kW

Water Usage: Water consumption (q_{water}) =	[(1.674 x S + 74.68) x A x CoalF x HRF]/1,000	2.3	kgallons/hour
Limestone Usage: Limestone consumption rate ($Q_{Limestone}$) =	[17.52 x A x S x HRF]/2,000] x (EF/0.98) =	0.02	tons/hour
Waste Generation: Waste generation rate (q_{waste}) =	[1.811 x $Q_{Limestone}$ x (EF/0.98) =	0.0	tons/hour
Wastewater Flow Rate: Wastewater flow rate (F) =	A x (0.4 gallons/min/MW) =	12	gallons/minute

Wet FGD Cost Estimate

Total Capital Investment (TCI)

$$TCI = 1.3 \times (ABS_{cost} + RPE_{cost} + WHE_{Cost} + BOP_{cost}) + WWT_{Cost}$$

Capital costs for the absorber (ABS_{cost}) =	$9,637,571	
Reagent Preparation Equipment Costs (RPE_{cost}) =	$1,721,750	
Waste Handling Equipment (WHE_{Cost}) =	$639,803	
Balance of Plant Costs (BOP_{cost}) =	$18,559,202	
Wastewater Treatment Facility Costs (WWT_{cost}) =	$15,635,173	
Total Capital Investment (TCI) =	$60,051,550	in 2022 dollars with disposal at offsite landfill

Wet FGD Capital Costs (ABS_{cost})

$$ABS_{cost} = 584{,}000 \times (A)^{0.716} \times (CoalF \times HRF)^{0.6} \times (S/2)^{0.02} \times ELEVF \times RF$$

Wet FGD Capital Costs (ABS_{cost}) =	$9,637,571	in 2022 dollars

Reagent Preparation Costs (RPE_{cost})

$$RPE_{cost} = 202{,}000 \times A^{0.716} \times (S \times HRF)^{0.3} \times RF$$

Reagent Preparation (RPE_{cost}) =	$1,721,750	in 2022 dollars

Waste Handling Equipment (WHE_{Cost})

$$WHE_{cost} = 106{,}000 \times A^{0.716} \times (S \times HRF)^{0.45} \times RF$$

Waste Recycling/Handling (WHE_{cost}) =	$639,803	in 2022 dollars

Balance of Plant Costs (BOP_{cost})

$$BOP_{cost} = 1{,}070{,}000 \times (A)^{0.716} \times (CoalF \times HRF)^{0.4} \times ELEVF \times RF$$

Balance of Plant Costs (BOP_{cost}) =	$18,559,202	in 2022 dollars

Wastewater Treatment Facility Costs (WWT_{cost})	
Wastewater Treatment Facility Costs with Onsite Landfill	
	WWT_{cost} = (41.36 F + 11,157,588) x RF x 0.898
Wastewater Treatement Facility Costs with Offsite Landfill	
	WWT_{cost} = (41.16 F + 11,557,843) x RF x 0.898
Wastewater Treatment Facility Costs (WWT_{cost}) =	$15,635,173 in 2022 dollars with disposal at offsite landfill

Total Annual Cost (TAC)

TAC = Direct Annual Costs + Indirect Annual Costs

Direct Annual Costs (DAC) =	$2,315,662	
Indirect Annual Costs (IDAC) =	$5,624,073	
Total annual costs (TAC) = DAC + IDAC	$7,939,734	in 2022 dollars

Direct Annual Costs (DAC)

DAC = Annual Maintenance Cost + Annual Operator Cost + Annual Reagent Cost + Annual Make-up Water Cost + Annual Waste Disposal Cost + Annual Auxiliary Power Cost + Annual Wastewater Treatment

Annual Maintenance Cost =	0.015 x TCI =	$900,773	
Annual Operator Cost =	FT × 2,080 × Hourly Labor Rate	$748,800	
Annual Reagent Cost =	$Q_{limestone}$ x $Cost_{Limestone}$ x t_{op} =	$6,250	
Annual Electricity Cost =	P x $Cost_{elect}$ x t_{op} =	$111,649	
Annual Make-up Water Cost =	q_{water} x $Cost_{water}$ x t_{op} =	$85,472	
Annual Waste Disposal Cost =	q_{waste} x $Cost_{fuel}$ x t_{op} =	$10,394	
Annual Wastewater Treatment Cost =	(6.3225F + 472,080) x 0.958 x CFtotal x ESC =	$452,324	(with disposal at offsite landfill)
Replacement Cost for Mercury Monitor =	CF_{mm} x MM_{Cost} =	$0	(replaced once every 6 years.)
Direct Annual Cost =		$2,315,662	in 2022 dollars

Indirect Annual Cost (IDAC)

IDAC = Administrative Charges + Capital Recovery Costs

Administrative Charges (AC) =	0.03 x (Annual Operator Cost + 0.4(Annual Maintenance Cost)) =	$33,273	
Capital Recovery Costs (CR)=	CRF x TCI =	$5,590,799	
Indirect Annual Cost (IDAC) =	AC + CR =	$5,624,073	in 2022 dollars

Cost Effectiveness = Total Annual Cost/ SO_2 Removed/year

Total Annual Cost (TAC) =	$7,939,734	per year in 2022 dollars
SO_2 Removed =	116.5	tons/year
Cost Effectiveness =	$68,137	per ton of SO_2 removed in 2022 dollars

Typical Costs for Random Packing Materials (1991$)

Nominal Diameter (inches)	Construction Material	Packing Type	Packing cost ($/ft^3)	
			<100 ft^3	>100 ft^3
1	304 stainless steel	Pall rings, Raschig rings, Ballast rings	70-109	65-99
1	Ceramic	Raschig rings, Berl saddles	33-44	26-36
1	Polypropylene	Tri-Pak®, Pall rings, Ballast rings, Flexisaddles	14-37	Dec-34
2	Ceramic	Berl saddles, Raschig rings	13-32	30-Oct
2	Polypropylene	Tri-Pac®, Lanpac®, Flexiring, Flexisaddle Tellerette®	20-Mar	19-May
3.5	304 stainless steel	Ballast rings	30	27
3.5	Polypropylene	Tri-pack®, Lanpac®, Ballast rings	14-Jun	12-Jun

Physical Properties of Common Pollutants

Pollutant	Molecular Weight	Diffusivity in Air at 25°C (cm^2/sec)	Diffusivity in Water at 20°C (cm^2/sec x 10^5)
Ammonia	17	0.236	1.76
Methanol	32	0.159	1.28
Ethyl Alcohol	46	0.119	1
Propyl Alcohol	60	0.1	0.87
Butyl Alcohol	74	0.09	0.77
Acetic Acid	60	0.133	0.88
Hydrogen Chloride	36	0.187	2.64
Hydrogen Bromide	36	0.129	1.93
Hydrogen Fluoride	20	0.753	3.33

Typical Packing Factors for Various Packing Materials for Wet Packed Tower Absorbers

Packing Type	Construction Level	Nominal Diameter (inches)	Fp	a
Raschig rings	Ceramic	0.5	640	111
		0.625	380	100
		0.75	255	80
		1.0	160	58
		1.5	95	38
		2.0	65	28
		3.0	37	
Raschig rings	Metal	0.5	410	118
		0.625	290	
		0.75	230	72
		1.0	137	57
		1.5	83	41
		2.0	57	31
		3.0	32	21
Pall rings	Metal	0.625	70	131
		1.0	48	66
		1.5	28	48
		2.0	20	36
		3.5	16	
Pall rings	Polypropylene	0.625	97	110
		1.0	52	63
		1.5	32	39
		2.0	25	31
Berl saddles	Ceramic	0.5	240	142
		0.75	170	82
		1.0	110	76
		1.5	65	44
		2.0	45	32
Intalox saddles	Ceramic	0.5	200	190
		0.75	145	102
		1.0	98	78
		1.5	52	60
		2.0	40	36
		3.0	22	
Tri-Packs®	Plastic	2.0	16	48
		3.5	12	38

Packing Constants Used to Estimate H_G For Wet Packed Tower Absorbers

Packing Type	Size (inches)	Packing Constants			Applicable Range[a]	
		α	B	γ	G_{sfr}	L_{sfr}
Raschig Rings	0.625	2.32	0.45	0.47	200-500	500-1,500
	1.0	7	0.39	0.58	200-800	400-500
	1.0	6.41	0.32	0.51	200-600	500-4,500
	1.5	1.73	0.38	0.66	200-700	500-1,500
	1.5	2.58	0.38	0.4	200-700	1,500-4,500
	2.0	3.82	0.41	0.45	200-800	500-4,500
Berl Saddles	0.5	32.4	0.3	0.74	200-700	500-1,500
	0.5	0.81	0.3	0.24	200-700	1,500-4,500
	1.0	1.97	0.36	0.4	200-800	400-4,500
	1.5	5.05	0.32	0.45	200-1,000	400-4,500
Partition Rings	3.0	640	0.58	1.06	150-900	3,000-10,000
LanPac®	2.3	7.6	0.33	-0.48	400-3,000	500-8,000
Tri-Packs®	2.0	1.4	0.33	0.4	100-900	500-10,000
	3.5	1.7	0.33	0.45	100-2,000	500-10,000

[a] Units of lb/hr-ft^2

Packing Constants Used to Estimate H_L For Wet Packed Tower Absorbers

Packing Type	Size (inches)	Packing Constants		Applicable Range[a]
		φ	*b*	L^a_{sfr}
Raschig Rings	0.375	0.00182	0.46	400-15,000
	1.0	0.00357	0.35	400-15,000
	1.5	0.01	0.22	400-15,000
	2.5	0.0111	0.22	400-15,000
	2.0	0.0125	0.22	400-15,000
Berl Saddles	0.5	0.00666	0.28	400-15,000
	1.0	0.00588	0.28	400-15,000
	1.5	0.00625	0.28	400-15,000
Partition Rings	3.0	0.0625	0.09	3,000-14,000
LanPac®	2.3	0.0039	0.33	500-8,000
	3.5	0.0042	0.33	500-8,000
Tri-Packs®	2.0	0.0031	0.33	500-10,000
	3.5	0.004	0.33	500-10,000

[a] Units of lb/hr-ft^2

Packing Constants Used to Estimate Pressure Drop For Wet Packed Tower Absorbers

Packing Type	Construction Material	Nominal Diameter (inches)	c	j
Raschig rings	ceramic	0.5	3.1	0.41
		0.75	1.34	0.26
		1	0.97	0.25

		1.25	0.57	0.23
		1.5	0.39	0.23
		2	0.24	0.17
Raschig rings	metal	0.625	1.2	0.28
		1	0.42	0.21
		1.5	0.29	0.2
		2	0.23	0.135
Pall rings	metal	0.625	0.43	0.17
		1	0.15	0.16
		1.5	0.08	0.15
		2	0.06	0.12
Berl saddles	ceramic	0.5	1.2	0.21
		0.75	0.62	0.17
		1	0.39	0.17
		1.5	0.21	0.13
Intalox saddles	ceramic	0.5	0.82	0.2
		0.75	0.28	0.16
		1	0.31	0.16
		1.5	0.14	0.14

[a] Units of lb/hr-ft^2

Shaded cells indicate user inputs.

Total Capital Investment - CDS (Circulating Dry Scrubber)

Project: UAF - BACT Analysis
Vendor: Andritz

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Capital Costs

DIRECT COSTS		QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST		
(1)	**Purchased equipment and material costs**							
(a)	**Basic equipment**							
	CDS System	1	EA	$ 16,950,000.00				
	ID Fan	1	EA	$ 567,879.00				
	Fire System	1	EA	$ 134,000.00				
	HVAC	1	EA	$ 445,000.00				
	Demo of existing Water Treatment Building	1	EA	$ 500,000.00				
	Total CDS System						TOTAL =	$ 18,596,879
(b)	**Instrumentation**							
	Total Instrumentation	1	EA	$ 760,000.00				
							TOTAL =	$ 760,000
(c)	**Freight**							
	ID Fan System Freight	1	LOT	112,000.00				
							TOTAL =	$ 112,000
(d)	**Extended Outage Costs**							
	Additional days beyond a typical 3 week outage	21	days	$ 48,028.00				
							TOTAL =	$ 1,008,588
(e)	**Vendor representatives fees**							
	Onsite Vendor Representatives fees (enter no. of days and daily rate)	7	Days	2000				$ 14,000
							TOTAL =	$ 14,000
Purchased Equipment and Material Cost (PEMC)							PEMC =	$ 20,491,467
(2)	**Direct Installation Costs**							
(a)	**Concrete (CDS Building, Duct Supports)**	1	LOT	$ 800,000.00				$ 800,000
(b)	**Site Vibro Compaction (CDS Building, Supports)**	1	LOT	$ 423,000.00				$ 423,000
(c)	**Structural Steel (CDS Building, Supports, Duct)**	1	LOT	$ 3,064,000.00				$ 3,064,000
(d)	**Electrical**	1	LOT	$ 883,000.00				$ 883,000
(e)	**Insulation**	1	LOT	$ 66,000.00				$ 66,000
(f)	**Abovegrade piping**	1	LOT	$ 442,000.00				$ 442,000
(g)	**Golden Heart Utility Relocation**	1	LOT	$ 856,212.16				$ 856,212
Direct Installation Costs (DIC) - Estimate for new building, foundation, piping, electrical, etc.							DIC =	$ 6,534,212
Total Direct Costs (TDC)							TDC = (PEMC) + (DIC) =	$ 27,025,679
INDIRECT COSTS								
(3)	Engineering, Procurement & Construction Support Services	10%	% TDC			$ 2,702,568		
(4)	Performance tests	1	EA	$ 75,000		$ 75,000		
Total Indirect Costs (TIC)							TIC =	$ 2,777,568
MANAGEMENT AND CONTINGENCY COSTS								
(5)	Contingency	10%	% TDC			$ 2,702,568		
Total Management and Contingency Costs (TM&CC)							TM & CC =	$ 2,702,568
TOTAL CAPITAL INVESTMENT (TCI)							TCI = (TDC)+(TIC)+(TM&CC) =	$ 32,505,815

Line Number/Description	Title	Comment
Line Number 1a	Total CDS System	CDS price provided by OEM Vendor. Cost includes equipment supply and installation costs. Andritz provided a rough installation factor based on material supply. Assumed installation costs were the same as equipment supply.
Line Number 1a	ID Fan	Pricing provided by Clarage for new ID Fan. Fan shipping is provided in line number 1c.
Line Number 1a	Fire System	Fire System costs for the new CDS Building. Costs were derived from the original UAF estimate and scaled based on a cost/square foot and escalated using CEPCI.
Line Number 1a	HVAC	HVAC costs for the new CDS Building. Costs were derived from the original UAF estimate and scaled based on a cost/square foot and escalated using CEPCI.
Line Number 1a	Water Treatment Building Demolition	Water Treatment Building Demolition costs to demolish the existing water treatment building. The new CDS building will be built in it's place. Estimated costs were derived on a level of effort basis
Line Number 1b	Total Instrumentation	Total costs for new cabinets and integrating CDS I/O into existing UAF DCS.
Line Number 1c	ID Fan Shipping Costs	Costs to ship ID fan to site.
Line Number 1d	Extended Outage Costs	UAF typically schedules for a 3 week outage on Boiler #5. A CDS outage will take 6 weeks and University will incur 3 additional weeks of outage costs that include purchasing electric power and running additional boilers for steam generation. Costs per day were provided by UAF personnel. The daily outage cost calculations are presented in the last section of Appendix G beginning on page G-73.
Line Number 1e	Vendor Representative Costs	Costs incurred for OEM to send a Field Technician to the field to confirm installation and provide technical guidance if needed. Cost per day includes hourly burdened rate for employee daily allowances and travel expenses. Based on general engineering and project experience.
Line Number 2a thru 2g	Direct Install Costs	Costs broken down into individual disciplines for balance of plant equipment, materials and labor for the CDS System. Cost estimate basis for each discipline are provided as attachments.
Line Number 3	Engineering Services	Costs for Preliminary Engineering costs to assist the University in soliciting bidders with specifications, preliminary drawings and procurement support for the AQCS system. Additional services include home office support for shop drawing review and occasional site support during construction for potential issues. Engineering is a percentage of the Total Direct Costs of the Project.
Line Number 4	Performance Test	Costs for a 3rd party performance testing company to validate emissions and performance guarantees by CDS vendor during operation
Line Number 5	Construction Contingency	Construction Contingency is an allottment for additonal or unexpected costs during the project. RS Means defines contingency allowances and ranges between 3-20% depending on what design stage the project is in. A 10% contingency is a project that is in Design Development, wheras a Conceptual Design phase allows for a 20% contingency. A 10% contingency for this cost estimate is considered low as the project is still in a Development phase.

Shaded cells indicate user inputs.

Total Capital Investment - CDS (Circulating Dry Scrubber)

Project: UAF - BACT Analysis
Vendor: Andritz

ADEC Reviewer: Moses Coss

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Capital Costs

Factor or Quote

DIRECT COSTS			QTY	UNIT	UNIT COST	% of PEMC	TOTAL LABOR COST		
(1)	**Purchased equipment and material costs**								
	(a)	**Basic equipment**							
		CDS System	1	EA	$ 16,950,000.00	82.72%			
		ID Fan	1	EA	$ 567,879.00	2.77%			
		Fire System	1	EA	$ 134,000.00	0.65%			
		HVAC	1	EA	$ 445,000.00	2.17%			
		Demo of existing Water Treatment Building	1	EA	$ 500,000.00	2.44%			
		Total CDS System						TOTAL =	$ 18,596,879
	(b)	**Instrumentation**							
		Total Instrumentation	1	EA	$ 760,000.00	3.71%			
								TOTAL =	$ 760,000
	(c)	**Freight**							
		ID Fan System Freight	1	LOT	112,000.00	0.55%			
								TOTAL =	$ 112,000
	(d)	**Extended Outage Costs**							
		Additional days beyond a typical 3 week outage	21	days	$ 48,028.00	0.23%			
								TOTAL =	$ 1,008,588
	(e)	**Vendor representatives fees**							
		Onsite Vendor Representatives fees (enter no. of days and daily rate)	7	Days	2000	0.01%			$ 14,000
								TOTAL =	$ 14,000
Purchased Equipment and Material Cost (PEMC)								PEMC =	$ 20,491,467
(2)	**Direct Installation Costs**								
	(a)	**Concrete (CDS Building, Duct Supports)**	1	LOT	$ 800,000.00	12.24%			$ 800,000
	(b)	**Site Vibro Compaction (CDS Building, Supports)**	1	LOT	$ 423,000.00	6.47%			$ 423,000
	(c)	**Structural Steel (CDS Building, Supports, Duct)**	1	LOT	$ 3,064,000.00	46.89%			$ 3,064,000
	(d)	**Electrical**	1	LOT	$ 883,000.00	13.51%			$ 883,000
	(e)	**Insulation**	1	LOT	$ 66,000.00	1.01%			$ 66,000
	(f)	**Abovegrade piping**	1	LOT	$ 442,000.00	6.76%			$ 442,000
	(g)	**Golden Heart Utility Relocation**	1	LOT	$ 856,212.16	13.10%			$ 856,212
Direct Installation Costs (DIC) - Estimate for new building, foundation, piping, electrical, etc.						20%	of TCI	DIC =	$ 6,534,212
						32%	of PEMC		
Total Direct Costs (TDC)								TDC = (PEMC) + (DIC) =	$ 27,025,679
INDIRECT COSTS									
(3)	Engineering, Procurement & Construction Support Services		10%	% TDC			$ 2,702,568		
(4)	Performance tests		1	EA	$ 75,000	0.37%	$ 75,000		
Total Indirect Costs (TIC)						$ 204,914.67		TIC =	$ 2,777,568
MANAGEMENT AND CONTINGENCY COSTS									
(5)	Contingency		10%	% TDC			$ 2,702,568		
Total Management and Contingency Costs (TM&CC)								TM & CC =	$ 2,702,568
TOTAL CAPITAL INVESTMENT (TCI)								TCI = (TDC)+(TIC)+(TM&CC) =	$ 32,505,815

19.72251131

Line Number/Description	Title	ADEC Comments
Line Number 1a	Total CDS System	Cost determined to be reasonable. See comment for TCI below
Line Number 1a	ID Fan	Cost determined to be reasonable. Quote from Clarage. UAF does not propose the replacement of the existing baghouse, but the ID Fan system upgrade.
Line Number 1a	Fire System	Cost determined to be reasonable. UAF provided the basis of the cost estimate based on the estimated square footage for a new CDS system building and the individual elements needed for additional fire safety needed as a result of implementing a CDS system.
Line Number 1a	HVAC	Cost determined to be reasonable. UAF provided the basis of the cost estimate based on the additional heating that will be required for the new building with a square footage of 3,538 SQ FT and estimated $126,069 in 2017 dollars at $35.63/sqft. This value was adjusted to 2021 dollars using the CEPCI index ($44..45/sqft) and a new square footage of 10,000 based on a recommendation by the vendor yielding a total of $445,000. As a point of comparison, in the lower 48 states, capicatl costs for HVAC retrofits for commercial buildings cost $25 to $60 per square foot, so UAF's calculated cost does not seem out of line. EPA's pollution control manual does not have specific guidance on costs associated with hydronic heating.
Line Number 1a	Water Treatment Building Demolition	Cost determined to be reasonable. UAF provided labor and equipment costs based on CSI costs schedule
Line Number 1b	Total Instrumentation	Cost determined to be reasonable. UAF provided estimate based on a project Stanley Consultans, Inc. designed in 2016 in Iowa, with personal and plant costs adjusted to 2021 and to reflect the project to be located in Fairbanks, AK. No equivalent guidance on backup control costs were found in EPA's pollution control manual except that it susggests that typical Instrumentation costs are around 10% of total equipment costs vs th 3.7% estimated by UAF.
Line Number 1c	ID Fan Shipping Costs	Cost determined to be reasonable. Table 2.4 of EPA's pollution control manual lists a typical value of 0.05% of the total equipment cost as guidance for freight costs. UAF freight cost represent approximately 0.55% of the cost of the ID fan, which is equivalent to EPA's cost guidance.
Line Number 1d	Extended Outage Costs	Cost determined to be reasonable. No equivalent guidance on extended outage costs were found in EPA's pollution control manual.
Line Number 1e	Vendor Representative Costs	Cost determined to be reasonable. No equivalent guidance on vendor representative costs were found in EPA's pollution control manual.
Line Number 2a thru 2g	Direct Install Costs	Cost determined to be reasonable. UAF calculate the Direct Installation Costs as approximately 20% of the TCI. In section 2.6.1.2, the EPA's pollution control manual provides installation costs for Venturi Scrubbers, listing them as 0.56 of PEC. UAF determined that the installation costs would be be around 0.32 of PECM. An article published by William Vatavuk from the US EPA and Robert Neveril from Gard, Inc published in the Chemical Engineering Journal in November 1980, provides a multiplier for for direct installation costs for gas absorbers of 0.85 of the base price. UAF's estimate is below this value and within 30% of EPA's 1980 article.
Line Number 3	Engineering Services	Cost determined to be reasonable. In section 2.6.1.2, the EPA's pollution control manual provides installation costs for Venturi Scrubbers, listing them as 0.1 of PEC. UAF used the same factor for this line item.
Line Number 4	Performance Test	Cost determined to be reasonable. In table 1.2, the EPA's pollution control manual provides performance tests costs as 0.01 of PEC ($200K). That is, UAF's estimate ($75K) is well under EPA's manual.
Line Number 5	Construction Contingency	Cost determined to be reasonable. EPA's manual provides for contingency factors for SNCR applications higher than UAF's estimates.
TCI	TOTAL CAPITAL INVESTMENT (TCI)	Cost determined to be resonable. Absent specific TCI information on CDS retrofits for single stack coal power plants, total cost of CDS system may be reasonable. According to a Power Engineering article from 2011 a CDS installed system for a 600 MW plant is about $250MM. A linear relationship (without taking into account economies of scale) would be equivalent to about $15.6MM (in today's dollars) for a 28MW (approx UAF boiler) power plant. While this cost is about half of UAF's TCI estimation, both a larger and smaller plant will likely need the same number and type of components, where a larger plant will simply need components with higher rated capacity (e.g. a larger absorber, larger bi-product silo, etc). Therefore the cost - size relationship may not be linear but follow an S-shaped curve between the smaller and larger capacities considered. In their estimate, UAF does not propose the replacement of the existing baghouse. No equivalent guidance on overall costs for TCI were found in EPA Pollution control cost manual.

Shaded cells indicate user inputs

Total Annualized Costs - CDS (Circulating Dry Scrubber)

Project: UAF - BACT Analysis
Vendor: Andritz

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Annualized Costs						
DIRECT ANNUAL COSTS	**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**	**TOTAL**
(1) Operating Labor	8,864	MH	49.09	Excluded	$ 435,134	$ 435,134
(2) Supervisory Labor		MH		Excluded	Excluded	Excluded
(3) Maintenance Labor	520	MH	49.09	Excluded	$ 25,527	$ 25,527
(4) Maintenance Materials	1	LOT	25,527	$ 25,527	Excluded	$ 25,527
(5) Utilities						
(a) Reagent:		TON	-	N/A	N/A	N/A
(b) Electricity:	5,452,399	kWh	0.205	$ 1,117,742	Excluded	$ 1,117,742
(c) Water:	8,935	(K) Gallons	11.30	$ 100,968	Excluded	$ 100,968
Total Direct Annual Costs (TDAC)					TDAC =	$ 1,704,897
INDIRECT ANNUAL COSTS						
(6) Overhead	1%	%			$ 325,058	$ 325,058
(7a) Administrative Charges, Insurance	3%	% total capital			$ 975,174	$ 975,174
(7b) Capital Recovery Factor [see inputs below]	0.0847					
(8) Capital Recovery					CRF * TCI =	$ 2,752,308
Total Indirect Annual Costs (TIAC)					TIAC =	$ 4,052,540
TOTAL ANNUALIZED COSTS (TAC)					TAC = (TDAC) + (TIAC) =	$ 5,757,437
Cost effectiveness ($/ton)					TAC/Emission Reduction =	**$ 55,585.39**

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manual)	7.50	%
Project Life (EPA OAQPS Control Cost Manual)	30	years

Uncontrolled emissions (tpy) = 129.47
controlled emissions (tpy) = 25.89
Reduction (tpy) = 103.58

Line Number/Description	Title	Stationary Source Comment
Line Number 1 and 3	Operating/Maintenance Labor	Provided by UAF. Rate is burdoned rate for level of personnel operating and performing maintenance on this type of equipment. Additional FT operations person is assumed per shift. Four total shifts per week. Quarter FT maintenance persons is assumed for the new CDS system.
Line Number 4	Maintenance Material	Allotment for maintenance materials. Item is equal to the maintenance labor allotment in line 3.
Line Number 5a	Reagent	CDS vendor will not require injection of reagent for SO_2 reduction.
Line Number 5b	Electricity	Pricing provided by UAF for published utility rates on campus. Electical consumption rate provided by CDS vendor. Additional consumption by larger ID Fan was also included.
Line Number 5c	Water	Pricing provided by UAF for published utility rates on campus. Water consumption rate provided by CDS vendor.
Line Number 6	Overhead	Calculated as percent of Total Capital Investment
Line Number 7a	Admin Charges, etc	Calculated as percent of Total Capital Investment
Line Number 7b	Capital Recovery Factor	EPA calculated factor using Interest Rate and Project Life Span
Line Number 8	Capital Recovery	Capital Recovery Factor times Total Capital Investment.
Annual Interest Rate (EPA OAQPS Control Cost Manual)	Annual Interest Rate	Latest federal prime rate. https://www.federalreserve.gov/releases/h15/
Project Life (EPA OAQPS Control Cost Manual)	Project Life	Project Life expectancy in years.

Total Annualized Costs - CDS (Circulating Dry Scrubber)

Project: UAF - BACT Analysis
Vendor: Andritz

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Annualized Costs							
DIRECT ANNUAL COSTS	**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**	**TOTAL**	
(1) Operating Labor	8,864	MH	49.09	Excluded	$ 435,134	$ 435,134	
(2) Supervisory Labor		MH		Excluded	Excluded	Excluded	
(3) Maintenance Labor	520	MH	49.09	Excluded	$ 25,527	$ 25,527	
(4) Maintenance Materia	1	LOT	25,527	$ 25,527	Excluded	$ 25,527	0.4% of TAC
(5) Utilities							
(a) Reagent:		TON	-	N/A	N/A	N/A	
(b) Electricity:	5,452,399	kWh	0.205	$ 1,117,742	Excluded	$ 1,117,742	
(c) Water:	8,935	(K) Gallons	11.30	$ 100,968	Excluded	$ 100,968	
Total Direct Annual Costs (TDAC)					TDAC =	$ 1,704,897	
INDIRECT ANNUAL COSTS							
(6) Overhead	1%	%			$ 325,058	$ 325,058	
(7a) Administrative Charge	3%	total capital			$ 975,174	$ 975,174	
(7b) Capital Recovery Fact	0.0931						
(8) Capital Recovery					CRF * TCI =	$ 3,024,685	
Total Indirect Annual Costs (TIAC)					TIAC =	$ 4,324,917	
TOTAL ANNUALIZED COSTS (TAC)					TAC = (TDAC) + (TIAC) =	$ 6,029,814	
Cost effectiveness ($/ton)					TAC/Emission Reduction =	**$ 58,215**	

Data Inputs for Capital Recovery Factor:		
Annual Int	8.50	%
Project Lif	30	years

Uncontrolled emissions (tpy) = 129.47
controlled emissions (tpy) = 25.89
Reduction (tpy) = 103.58

Line Number/Description	Title	Stationary Source Comment	ADEC Comment
Line Number 1 and 3	Operating/Maintenance Labor	Provided by UAF. Rate is burdoned rate for level of personnel operating and performing maintenance on this type of equipment. Additional FT operations person is assumed per shift. Four total shifts per week. Quarter FT maintenance persons is assumed for the new CDS system.	Cost determined to be reasonable. No similar operating / maintenance labor costs are listed in EPA's pollution control manual.
Line Number 4	Maintenance Material	Allotment for maintenance materials. Item is equal to the maintenance labor allotment in line 3.	Cost determined to be reasonable. This costs represents < 0.5% of the TAC and seems to insignificant to warrant additional scrutiny.
Line Number 5a	Reagent	CDS vendor will not require injection of reagent for SO_2 reduction.	N/A
Line Number 5b	Electricity	Pricing provided by UAF for published utility rates on campus. Electical consumption rate provided by CDS vendor. Additional consumption by larger ID Fan was also included.	Cost determined to be reasonable. Power consumption cost was also calculated.
Line Number 5c	Water	Pricing provided by UAF for published utility rates on campus. Water consumption rate provided by CDS vendor.	Cost determined to be reasonable.
Line Number 6	Overhead	Calculated as percent of Total Capital Investment	Cost determined to be reasonable. In table 1.7, EPA Pollution control manual lists overhead as 60% of total labor and maintenance materials. UAF's estimate is below this estimate.
Line Number 7a	Admin Charges, etc	Calculated as percent of Total Capital Investment	Cost determined to be reasonable.
Line Number 7b	Capital Recovery Factor	EPA calculated factor using Interest Rate and Project Life Span	The formula used corresponds to the Eq 4.3 in EPA's pollution control manual
Line Number 8	Capital Recovery	Capital Recovery Factor times Total Capital Investment.	Cost determined to be reasonable.
erest Rate (EPA OAQPS Control Co	Annual Interest Rate	Latest federal prime rate. https://www.federalreserve.gov/releases/h15/	Cost determined to be reasonable.
t Life (EPA OAQPS Control Cost M	Project Life	Project Life expectancy in years.	Cost determined to be reasonable.

Shaded cells indicate user inputs.

Total Capital Investment - DSI (Dry Sorbent Injection)

Project: UAF - BACT Analysis
Vendor: BACT Process Systems, Inc.

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Capital Costs

DIRECT COSTS			QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST		
(1)	Purchased equipment and material costs								
	(a)	Basic equipment							
		DSI System	1	EA	5,875,000				
		ID Fan	1	EA	431,588				
		Total DSI System						TOTAL =	$ 6,306,588
	(b)	Instrumentation							
		Total Instrumentation	1	EA	142,000				
								TOTAL =	$ 142,000
	(c)	Freight							
		ID Fan Freight	1	EA	$ 85,120				
								TOTAL =	$ 85,120
	(d)	Extended Outage Costs							
		Additional days beyond a typical 3 week outage	35	Days	$ 48,028.00				
								TOTAL =	$ 1,680,980
	(e)	Vendor representatives Costs							
		Onsite Vendor Representatives Costs (enter no. of days and daily rate)	5	Days	2000				
								TOTAL =	$ 10,000
Purchased Equipment and Material Cost (PEMC)			All above costs included in vendor scope.					PEMC =	$ 8,224,688
(2)	Direct Installation Costs								
	(a)	Concrete	1	LOT	$ 98,000				$ 98,000
	(b)	Site Vibro Compaction (DSI Unloading Building/Storage Silo)	1	LOT	$ 31,000				$ 31,000
	(c)	Structural steel	1	LOT	$ 84,000				$ 84,000
	(d)	Electrical	1	LOT	$ 771,000				$ 771,000
	(e)	Abovegrade piping	1	LOT	$ 367,000				$ 367,000
Direct Installation Costs (DIC) - Guess at new building, foundation, piping, electrical, etc.								DIC =	$ 1,351,000
Total Direct Costs (TDC)								TDC = (PEMC) + (DIC) =	$ 9,575,688
INDIRECT COSTS									
(3)	Engineering, Procurement & Construction Support Services		10%	% TDC			$ 957,569		
(4)	Performance tests		1	EA	$ 75,000		$ 75,000		
Total Indirect Costs (TIC)								TIC =	$ 1,032,569
MANAGEMENT AND CONTINGENCY COSTS									
(5)	Contingency		10%	% TDC			$ 957,569		
Total Management and Contingency Costs (TM&CC)								TM & CC =	$ 957,569
TOTAL CAPITAL INVESTMENT (TCI)								TCI = (TDC)+(TIC)+(TM&CC) =	**$ 11,565,826**

Total Capital Investment - DSI (Dry Sorbent Injection)

Project: UAF - BACT Analysis
Vendor: BACT Process Systems, Inc.

Date: XX/XX/2023
Edited By: D. Jones
QA By: M. Coss
Rev:

Capital Costs

DIRECT COSTS			QTY	UNIT	UNIT COST	. MATERIAI	)TAL LABOR COST		
(1)	Purchased equipment and material costs								
	(a)	Basic equipment							
		DSI System	1	EA	4,700,000				
		ID Fan	1	EA	431,588				
		Total DSI System		A	Equipment Cost (EPA CCM)			TOTAL =	$ 5,131,588
	(b)	Instrumentation							
		Total Instrumentatior	1	EA	10%	CCM Table 1.8			
								TOTAL =	$ 513,159
	(c)	Freight							
		ID Fan Freight	1	EA	5%	CCM Table 1.8			
								TOTAL =	$ 256,579
	(d)	Extended Outage Costs							
		Additional days beyo	0	Days	$ -				
								TOTAL =	$ -
	(e)	Vendor representatives Costs							
		Onsite Vendor Representatives C		Days					
								TOTAL =	$ -
Purchased Equipment and Material Cost (PEMC)			All above costs included in vendor scope.					PEMC =	$ 5,901,326
(2)	Direct Installation Costs								
	(a)	Foundations & Sup	1	LOT	12%	CCM Table 1.8			$ 708,159
	(b)	Handling & Erectio	1	LOT	40%	CCM Table 1.8			$ 2,360,530
	(c)	Electrical	1	LOT	1%	CCM Table 1.8			$ 59,013
	(d)	Piping	1	LOT	30%	CCM Table 1.8			$ 1,770,398
	(e)	Insulation	1		1%	CCM Table 1.8			$ 59,013
	(f)	Painting	1	LOT	1%	CCM Table 1.8			$ 59,013
Direct Installation Costs (DIC) - Guess at new building, foundation, piping, electrical, e				85%				DIC =	$ 5,016,127
Total Direct Costs (TDC)								TDC = (PEMC) + (DIC) =	$ 10,917,454
INDIRECT COSTS									
(3)	Engineering		10%	CCM Table 1.8					$ 1,091,745
	Construction and Field Exp.		10%	CCM Table 1.8					$ 1,091,745
	Contractor Fees		10%	CCM Table 1.8					$ 1,091,745
	Start-Up		1%	CCM Table 1.8					$ 109,175
(4)	Performance tests		1%	CCM Table 1.8					$ 109,175
Total Indirect Costs (TIC)			32%					TIC =	$ 3,493,585
MANAGEMENT AND CONTINGENCY COSTS									
(5)	Contingency		10%	% TDC					$ 1,441,103.87
Total Management and Contingency Costs (TM&CC)								TM & CC =	$ -
TOTAL CAPITAL INVESTMENT (TCI)								TCI = (TDC)+(TIC)+(TM&CC) =	**$ 14,411,039**

Line Number/Description	Title	UAF Comments	Department Comments
Line Number 1a	Total DSI System	DSI price provided by OEM Vendor. Cost includes equipment supply and installation costs. Installation costs of vendor supplied equipment was assumed to be 25% of equipment cost.	The Department removed the 25% increase in cost for equipment installation which is accounted for elsewhere.
Line Number 1a	ID Fan	Pricing provided by Clarage for new ID Fan for CDS system. Fan pricing was scaled from 1250 HP to 950 HP. Fan shipping is provided in line number 1c.	Left unchanged from UAF's price quote and calculations
Line Number 1b	Total Instrumentation	Total costs for new communication links and I/O integration into existing DCS room.	Used EPA's Pollution Cost Control Manual Table 1.8 assumption of 10% of the cost of the equipment price.
Line Number 1c	ID Fan Shipping Costs	Costs to ship ID fan to site. CDS pricing was used and scaled from 1250 HP to 950 HP.	Used EPA's Pollution Cost Control Manual Table 1.8 assumption of 5% of the cost of the equipment price.
Line Number 1d	Extended Outage Costs	UAF typically schedules for a 3 week outage on Boiler #5. A DSI outage will take 8 weeks and the University will incur 5 additional weeks of outage costs that inlcude purchasing electric power and running additional boilers for steam generation. Costs per day were provided by UAF personnel. The daily outage cost calculations are presented in the last section of	The Department removed these costs for the cost calculation in order to make a conservative estimate.
Line Number 1e	Vendor Representative Costs	Costs incurred for OEM to send a Field Technician to the field to confirm installation and provide technical guidance if needed. Cost per day includes hourly burdened rate for employee daily allowances and travel expenses.	The Department removed these costs and included a cost for startup below under (3).
Line Number 2a thru 2e	Direct Install Costs	Costs broken down into individual disciplines for balance of plant equipment, materials and labor for the DSI System. Cost estimate basis for each discipline are provided as attachments.	Used the direct installation cost percentages from EPA's Pollution Cost Control Manual Table 1.8.
Line Number 3	Engineering Services	Costs for Preliminary Engineering costs to assist the University in soliciting bidders with specifications, preliminary drawings and procurement support for the AQCS system. Additional services include home office support for shop drawing review and occasional site support during construction for potential issues. Engineering is a percentage of the Total Direct Costs of the Project.	
Line Number 4	Performance Test	Costs for a 3rd party performance testing company to validate emissions and performance guarantees by DSI vendor during operation	Used the direct installation cost percentages from EPA's Pollution Cost Control Manual Table 1.8.
Line Number 5	Construction Contingency	Construction Contingency is an allottment for additonal or unexpected costs during the project. RS Means defines contingency allowances and ranges between 3-20% depending on what design stage the project is in. A 10% contingency is a project that is in Design Development, wheras a Conceptual Design phase allows for a 20% contingency. A 10% contingency for this cost estimate is considered low as the project is still in a Development phase.	Used the 10% contingency factor from EPA's Pollution Cost Control Manual Table 1.8, Footnote c.

Shaded cells indicate user inputs

Total Annualized Costs - DSI (Dry Sorbent Injection)

Project: UAF - BACT Analysis
Vendor: BACT Process Systems, Inc.
Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Annualized Costs

DIRECT ANNUAL COSTS		QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST	TOTAL
(1)	Operating Labor	8,864	MH	49.09	Excluded	$ 435,134	$ 435,134
(2)	Supervisory Labor		MH		Excluded	Excluded	Excluded
(3)	Maintenance Labor	520	MH	49.09	Excluded	$ 25,527	$ 25,527
(4)	Maintenance Materials	1	LOT	25,527	$ 25,527	Excluded	$ 25,527
(5)	Utilities						
(a)	Hydrated Lime:	394	TON	1,377	$ 542,813	Excluded	$ 542,813
(b)	Electricity:	2,683,276	kWh	0.205	$ 550,071	Excluded	$ 550,071
(c)	Water:	8,935	(k)Gallons	11.30	$ 100,968	Excluded	$ 100,968
Total Direct Annual Costs (TDAC)						TDAC =	$ 1,680,040
INDIRECT ANNUAL COSTS							
(6)	Overhead	1%	%			$ 115,658	$ 115,658
(7a)	Administrative Charges, Insurance	3%	% total capital			$ 346,975	$ 346,975
(7b)	Capital Recovery Factor [see inputs below]	0.0847					
(8)	Capital Recovery					CRF * TCI =	$ 979,293
Total Indirect Annual Costs (TIAC)						TIAC =	$ 1,441,926
TOTAL ANNUALIZED COSTS (TAC)						TAC = (TDAC) + (TIAC) =	$ 3,121,966

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manual)	7.50	%
Project Life (EPA OAQPS Control Cost Manual)	30	years

Uncontrolled emissions (tpy) =	129.47
controlled emissions (tpy) =	38.84
Reduction (tpy) =	90.63

Total Annualized Costs - DSI (Dry Sorbent Injection)

Project: UAF - BACT Analysis
Vendor: BACT Process Systems, Inc.
Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Annualized Costs

DIRECT ANNUAL COSTS		QTY	UNIT	UNIT COST	TAL MATERIALS (	TAL LABOR COST	TOTAL
(1)	Operating Labor	548	MH	49.09			$ 26,877
(2)	Supervisory Labor	15%	% of Operating Labor				$ 4,032
(3)	Maintenance Labor	548	MH	49.09			$ 26,877
(4)	Maintenance Materials		LOT	-			$ -
(5)	Utilities						
(a)	Hydrated L	394	TON	1,377	$ 542,813	Excluded	$ 542,813
(b)	Electricity:	2,683,276	kWh	0.205	$ 550,071	Excluded	$ 550,071
(c)	Water:	8,935	(k)Gallons	11.30	$ 100,968	Excluded	$ 100,968
Total Direct Annual Costs (TDAC)						TDAC =	$ 1,251,638
INDIRECT ANNUAL COSTS							
(6)	Overhead	60%	of total labor and material costs CCM Table 1.9				$ 34,671
(7)	Property Tax	1%	of Total Capital Investment - CCM Table 1.9				$ 144,110
(7a)	Administrative Charge	3%	of Total Capital Investment - CCM Table 1.9				$ 432,331
(7b)	Capital Recovery Facto	0.0931					
(8)	Capital Recovery					CRF * TCI =	$ 1,340,955
Total Indirect Annual Costs (TIAC)						TIAC =	$ 1,952,068
TOTAL ANNUALIZED COSTS (TAC)						TAC = (TDAC) + (TIAC) =	$ 3,203,706
Cost Per Ton ($/ton)					TAC/Tons of SO2 Removed		$ 35,349

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS	8.50	%
Project Life (EPA OAQPS Control C	30	years

Uncontrolled emissions (tp	129.47
controlled emissions (tpy)	38.84
Reduction (tpy) =	90.63

Line Number/Description	Title	UAF Comments	Department Comments
Line Number 1 through 3	Operating/Maintenance Labor	Provided by UAF. Rate is burdoned rate for level of personnel operating and performing maintenance on this type of equipment. Additional FT operations person is assumed per shift. Four total shifts per week. Quarter FT maintenance persons is assumed for the new DSI system.	Assumed 0.5 hours per shift for operating and maintenance labor, and 15% of operator labor for supervisor labor per Table 1.9 of EPA CCM
Line Number 4	Maintenance Material	Allotment for maintenance materials. Item is equal to the maintenance labor allotment in line 3.	Did not include an allotment for maintenance materials
Line Number 5a	Hydrated Lime	Hydrated Lime consumption rates provided by DSI vendor. Hydrated Lime costs provided by L'hoist.	Left unchanged from UAF's calculations
Line Number 5b	Electricity	Pricing provided by UAF for published utility rates on campus. Electical consumption rate provided by DSI vendor. Additional consumption by larger ID Fan was also included.	Left unchanged from UAF's calculations
Line Number 5c	Water	Pricing provided by UAF for published utility rates on campus. Water consumption rate provided by DSI vendor.	Left unchanged from UAF's calculations
Line Number 6	Overhead	Calculated as percent of Total Capital Investment	Calculated as 60% of total labor and material costs per Table 1.9 of EPA's CCM
Line Number 7a	Admin Charges, etc	Calculated as percent of Total Capital Investment	Calculated as 3% of total total capital investment (admin charges + insurance) and 1% (property tax) per Table 1.9 of EPA's CCM
Line Number 7b	Capital Recovery Factor	EPA calculated factor using Interest Rate and Project Life Span	Updated to current bank prime interest rate of 8.5%
Line Number 8	Capital Recovery	Capital Recovery Factor times Total Capital Investment.	
Annual Interest Rate (EPA OAQPS Control Cost Manual)	Annual Interest Rate	Latest federal prime rate. https://www.federalreserve.gov/releases/h15/	
Project Life (EPA OAQPS Control Cost Manual)	Project Life	Project Life expectancy in years.	Left life expectancy unchaged at 30 years

Shaded cells indicate user inputs.

Total Capital Investment - DSI (Dry Sorbent Injection)

Project: UAF - BACT Analysis
Vendor: Tri-Mer

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Capital Costs

DIRECT COSTS		QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST		
(1)	**Purchased equipment and material costs**							
(a)	**Basic equipment**							
	DSI System	1	EA	978,475				
	ID Fan	1	EA	431,588				
	Total DSI System						TOTAL =	$ 1,410,063
(b)	**Instrumentation**							
	Total Instrumentation	1	EA	142,000				
							TOTAL =	$ 142,000
(c)	**Freight**							
	ID Fan Freight	1	EA	$ 85,120				
							TOTAL =	$ 85,120
(d)	**Extended Outage Costs**							
	Additional days beyond a typical 3 week outage	35	MH	$ 48,028.00				
							TOTAL =	$ 1,680,980
(e)	**Vendor representatives fees**							
	Onsite Vendor Representatives fees (enter no. of days and daily rate)	5	Days	2000		$ 10,000		
							TOTAL =	$ 10,000
Purchased Equipment and Material Cost (PEMC)		All above costs included in vendor scope.					PEMC =	$ 3,328,163
(2)	**Direct Installation Costs**							
(a)	**Concrete**	1	LOT	$ 196,000	$ 196,000			$ 196,000
(b)	**Site Vibro Compaction (DSI Unloading Building/Storage Silo)**	1	LOT	$ 62,000	$ 62,000			$ 62,000
(c)	**Structural steel**	1	LOT	$ 42,000	$ 42,000			$ 42,000
(d)	**Electrical**	1	LOT	$ 771,000	$ 771,000			$ 771,000
(e)	**Abovegrade piping**	1	LOT	$ 367,000	$ 367,000			$ 367,000
Direct Installation Costs (DIC) - Guess at new building, foundation, piping, electrical, etc.							DIC =	$ 1,438,000
Total Direct Costs (TDC)							TDC = (PEMC) + (DIC) =	$ 4,766,163
INDIRECT COSTS								
(3)	Engineering, Procurement & Construction Support Services	10%	% TDC			$ 476,616		
(4)	Performance tests	1	EA	$ 75,000		$ 75,000		
Total Indirect Costs (TIC)							TIC =	$ 551,616
MANAGEMENT AND CONTINGENCY COSTS								
(5)	Contingency	10%	% TDC			$ 476,616		
Total Management and Contingency Costs (TM&CC)							TM & CC =	$ 476,616
TOTAL CAPITAL INVESTMENT (TCI)							TCI = (TDC)+(TIC)+(TM&CC) =	$ 5,794,396

Total Capital Investment - DSI (Dry Sorbent Injection)

Project: UAF - BACT Analysis
Vendor: Tri-Mer

Date: 12/28/2022
Prepared By: M. Jahn
Updated By: C. Kimball
Rev: B

Capital Costs

DIRECT COSTS		QTY	UNIT	UNIT COST	L MATERIALS	TAL LABOR COST		
(1)	**Purchased equipment and material costs**							
(a)	**Basic equipment**							
	DSI System	1	EA	782,780				
	ID Fan	1	EA	431,588				
	Total DSI System						TOTAL =	$ 1,214,368
(b)	**Instrumentation**							
	Total Instrumentation	1	EA	10%	CCM Table 1.8			
							TOTAL =	$ 121,437
(c)	**Freight**							
	ID Fan Freight	1	EA	5%	CCM Table 1.8			
							TOTAL =	$ 60,718
(d)	**Extended Outage Costs**							
	Additional days beyond a typical 3 week outage		MH					
							TOTAL =	$ -
(e)	**Vendor representatives fees**							
	Onsite Vendor Representatives fees (enter no. of		Days		$ -			
							TOTAL =	$ -
Purchased Equipment and Material Cost (PEMC)		All above costs included in vendor scope.					PEMC =	$ 1,396,523
(2)	**Direct Installation Costs**							
(a)	**Foundations & Support**	1	LOT	12%	CCM Table 1.8			$ 167,583
(b)	**Handling & Erection**	1	LOT	40%	CCM Table 1.8			$ 558,609
(c)	**Electrical**	1	LOT	1%	CCM Table 1.8			$ 13,965
(d)	**Piping**	1	LOT	30%	CCM Table 1.8			$ 418,957
(e)	**Insulation**	1		1%	CCM Table 1.8			$ 13,965
(f)	**Painting**	1	LOT	1%	CCM Table 1.8			$ 13,965
Direct Installation Costs (DIC) - Guess at new building, foundation, piping, electrical,				**85%**			DIC =	$ 1,187,045
Total Direct Costs (TDC)							TDC = (PEMC) + (DIC) =	$ 2,583,568
INDIRECT COSTS								
(3)	Engineering	10%	CCM Table 1.8					$ 258,357
	Construction and Field Exp.	10%	CCM Table 1.8					$ 258,357
	Contractor Fees	10%	CCM Table 1.8					$ 258,357
	Start-Up	1%	CCM Table 1.8					$ 25,836
(4)	Performance tests	1%	CCM Table 1.8					$ 25,836
Total Indirect Costs (TIC)		**32%**					TIC =	$ 826,742
MANAGEMENT AND CONTINGENCY COSTS								
(5)	Contingency	10%	% TDC			$ 258,357		
Total Management and Contingency Costs (TM&CC)							TM & CC =	$ 258,357
TOTAL CAPITAL INVESTMENT (TCI)							TCI = (TDC)+(TIC)+(TM&CC) =	$ 3,668,667

Line Number/Description	Title	UAF Comment	Department Comments
Line Number 1a	Total DSI System	DSI price provided by OEM Vendor. Cost includes equipment supply and installation costs. Installation costs of vendor supplied equipment was assumed to be 25% of equipment cost.	The Department removed the 25% increase in cost for equipment installation which is accounted for elsewhere.
Line Number 1a	ID Fan	Pricing provided by Clarage for new ID Fan for CDS system. Fan pricing was scaled from 1250 HP to 950 HP. Fan shipping is provided in line number 1c.	Left unchanged from UAF's price quote and calculations
Line Number 1b	Total Instrumentation	Total costs for new communication links and I/O integration into existing DCS room.	Used EPA's Pollution Cost Control Manual Table 1.8 assumption of 10% of the cost of the equipment price.
Line Number 1c	ID Fan Shipping Costs	Costs to ship ID fan to site. CDS pricing was used and scaled from 1250 HP to 950 HP.	Used EPA's Pollution Cost Control Manual Table 1.8 assumption of 5% of the cost of the equipment price.
Line Number 1d	Extended Outage Costs	UAF typically schedules for a 3 week outage on Boiler #5. A DSI outage will take 8 weeks and the University will incur 5 additional weeks of outage costs that inlcude purchasing electric power and running additional boilers for steam generation. Costs per day were provided by UAF personnel. The daily outage cost calculations are presented in the last	The Department removed these costs for the cost calculation in order to make a conservative estimate.
Line Number 1e	Vendor Representative Costs	Costs incurred for OEM to send a Field Technician to the field to confirm installation and provide technical guidance if needed. Cost per day includes hourly burdened rate for employee daily allowances and travel expenses.	The Department removed these costs and included a cost for startup below under (3).
Line Number 2a thru 2e	Direct Install Costs	Costs broken down into individual disciplines for balance of plant equipment, materials and labor for the DSI System. Cost estimate basis for each discipline are provided as attachments.	Used the direct installation cost percentages from EPA's Pollution Cost Control Manual Table 1.8.
Line Number 3	Engineering Services	Costs for Preliminary Engineering costs to assist the University in soliciting bidders with specifications, preliminary drawings and procurement support for the AQCS system. Additional services include home office support for shop drawing review and occasional site support during construction for potential issues. Engineering is a percentage of the Total Direct Costs of the Project.	
Line Number 4	Performance Test	Costs for a 3rd party performance testing company to validate emissions and performance guarantees by DSI vendor during operation	Used the indirect installation cost percentages from EPA's Pollution Cost Control Manual Table 1.8.
Line Number 5	Construction Contingency	Construction Contingency is an allottment for additonal or unexpected costs during the project. RS Means defines contingency allowances and ranges between 3-20% depending on what design stage the project is in. A 10% contingency is a project that is in Design Development, wheras a Conceptual Design phase allows for a 20% contingency. A 10% contingency for this cost estimate is considered low as the project is still in a Development phase.	Used the 10% contingency factor from EPA's Pollution Cost Control Manual Table 1.8, Footnote c.

Shaded cells indicate user inputs

Total Annualized Costs - DSI (Dry Sorbent Injection)

Project:	UAF - BACT Analysis						Date:	12/28/2022
Vendor:	Tri-Mer						Prepared By:	M. Jahn
							Checked By:	C. Kimball
							Rev:	B
Annualized Costs								
DIRECT ANNUAL COSTS		**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**		**TOTAL**
(1)	Operating Labor	8,864	MH	49.09	Excluded	$ 435,134		$ 435,134
(2)	Supervisory Labor		MH		Excluded	Excluded		Excluded
(3)	Maintenance Labor	520	MH	49.09	Excluded	$ 25,527		$ 25,527
(4)	Maintenance Materials	1	LOT	25,527	$ 25,527	Excluded		$ 25,527
(5)	Utilities							
(a)	Hydrated Lime:	2,466	TON	1,377	$ 3,395,599	Excluded		$ 3,395,599
(b)	Electricity:	2,380,180	kWh	0.205	$ 487,937	Excluded		$ 487,937
(c)	Water:	8,935	(k)Gallons	11.30	$ 100,968	Excluded		$ 100,968
Total Direct Annual Costs (TDAC)							TDAC =	$ 4,470,691
INDIRECT ANNUAL COSTS								
(6)	Overhead	1%	%			$ 57,944		$ 57,944
(7a)	Administrative Charges, Insurance	3%	% total capital			$ 173,832		$ 173,832
(7b)	Capital Recovery Factor [see inputs below]	0.0847						
(8)	Capital Recovery						**CRF * TCI =**	$ 490,619
Total Indirect Annual Costs (TIAC)							TIAC =	$ 722,394
TOTAL ANNUALIZED COSTS (TAC)							TAC = (TDAC) + (TIAC) =	$ 5,193,086
Cost Per Ton ($/ton) Calculated by DEC using UAF's total annualized costs (TAC)								$ 22,286.97

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manual)	7.50	%
Project Life (EPA OAQPS Control Cost Manual)	30	years

Uncontrolled emissions (tpy) =	129.47
controlled emissions (tpy) =	25.89
Reduction (tpy) =	103.58

Total Annualized Costs - DSI (Dry Sorbent Injection)

Project:		UAF - BACT Analysis						Date:	12/28/2022
Vendor:		Tri-Mer						Prepared By:	M. Jahn
								Checked By:	C. Kimball
								Rev:	B
Annualized Costs									
DIRECT ANNUAL COSTS			**QTY**	**UNIT**	**UNIT COST**	**AL MATERIALS**	**OTAL LABOR COST**		**TOTAL**
(1)	Operating Labor		548	MH	49.09				$ 26,877
(2)	Supervisory Labor		15%	% of Operating Labor					$ 4,032
(3)	Maintenance Labor		548	MH	49.09				$ 26,877
(4)	Maintenance Materials			LOT	-				$ -
(5)	Utilities								
	(a)	Hydrated Lime:	2,466	TON	1,377	$ 3,395,599	Excluded		$ 3,395,599
	(b)	Electricity:	2,380,180	kWh	0.205	$ 487,937	Excluded		$ 487,937
	(c)	Water:	8,935	(k)Gallons	11.30	$ 100,968	Excluded		$ 100,968
Total Direct Annual Costs (TDAC)								TDAC =	$ 4,042,289
INDIRECT ANNUAL COSTS									
(6)	Overhead		60%	of total labor and material costs CCM Table 1.9					$ 34,671
(7)	Property Tax		1%	of Total Capital Investment - CCM Table 1.9					$ 36,687
(7a)	Administrative Charges, Insurance		3%	of Total Capital Investment - CCM Table 1.9					$ 110,060
(7b)	Capital Recovery Factor [see inputs below]		0.0931						
(8)	Capital Recovery							**CRF * TCI =**	$ 341,372
Total Indirect Annual Costs (TIAC)								TIAC =	$ 181,418
TOTAL ANNUALIZED COSTS (TAC)								TAC = (TDAC) + (TIAC) =	$ 4,223,707
Cost Per Ton ($/ton)								TAC/Tons of SO2 Removed	$ 40,778

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manu	8.50	%
Project Life (EPA OAQPS Control Cost Manual)	30	years

Uncontrolled emissions (tp	129.47
controlled emissions (tpy) =	25.89
Reduction (tpy) =	103.58

Line Number/Description	Title	UAF Comments	Department Comments
Line Number 1 and 3	Operating/Maintenance Labor	Provided by UAF. Rate is burdoned rate for level of personnel operating and performing maintenance on this type of equipment. Additional FT operations person is assumed per shift. Four total shifts per week. Quarter FT maintenance persons is assumed for the new DSI system.	Assumed 0.5 hours per shift for operating and maintenance labor, and 15% of operator labor for supervisor labor per Table 1.9 of EPA CCM
Line Number 4	Maintenance Material	Allotment for maintenance materials. Item is equal to the maintenance labor allotment in line 3.	Did not include an allotment for maintenance materials
Line Number 5a	Hydrated Lime	Hydrated Lime consumption rates provided by DSI vendor. Hydrated Lime costs provided by L'hoist.	Left unchanged from UAF's calculations
Line Number 5b	Electricity	Pricing provided by UAF for published utility rates on campus. Electical consumption rate provided by DSI vendor. Additional consumption by larger ID Fan was also included.	Left unchanged from UAF's calculations
Line Number 5c	Water	Pricing provided by UAF for published utility rates on campus. Water consumption rate provided by DSI vendor.	Left unchanged from UAF's calculations
Line Number 6	Overhead	Calculated as percent of Total Capital Investment	Calculated as 60% of total labor and material costs per Table 1.9 of EPA's CCM
Line Number 7a	Admin Charges, etc	Calculated as percent of Total Capital Investment	Calculated as 3% of total total capital investment (admin charges + insurance) and 1% (property tax) per Table 1.9 of EPA's CCM
Line Number 7b	Capital Recovery Factor	EPA calculated factor using Interest Rate and Project Life Span	Calculated as 1% of total total capital investment per Table 1.9 of EPA's CCM
Line Number 8	Capital Recovery	Capital Recovery Factor times Total Capital Investment.	
Annual Interest Rate (EPA OAQPS Control Cost Manual)	Annual Interest Rate	Latest federal prime rate. https://www.federalreserve.gov/releases/h15/	
Project Life (EPA OAQPS Control Cost Manual)	Project Life	Project Life expectancy in years.	Left life expectancy unchaged at 30 years

Table 4-1. UAF - Available $PM_{2.5}$ Control Options

Emission Unit		Available Control Options
ID	Description	
113	Large Coal and Biomass-fired Boiler	Fabric Filters
		ESP
		Scrubber
		Cyclone
		Good Combustion Practices
3 and 4	Mid-sized Diesel-fired Boilers	Fabric Filters
		ESP
		Scrubber
		Cyclone
		Limited Operation
		Good Combustion Practices
19 through 21	Small Diesel-fired Boilers	Scrubber
		Limited Operation
		Good Combustion Practices
8	Large Diesel-fired Engine	DPF
		Positive Crankcase Ventilation
		Low Ash Diesel
		Limited Operation
		Good Combustion Practices
27	Small Diesel-fired Engines	DPF
		Federal Standard
		Limited Operation
		Good Combustion Practices
9A	Medical/Pathological Waste Incinerator	Fabric Filters
		ESP
		Limited Operation
		Good Combustion Practices
		Multiple Chambers
105, 107, 109, 110, 114, and 128 through 130	Material Handling Sources with Fabric Filtration	Fabric Filters
		Scrubber
		Suppressant
		Enclosure
		Closed System Vent
111	Material Handling Sources without Fabric Filtration	Suppressant
		Enclosure

Table 4-2. UAF - Technically Feasible $PM_{2.5}$ Control Options

Emission Unit ID	Emission Unit Description	Technically Feasible Control Options
113	Large Coal and Biomass-fired Boiler	Fabric Filters
		ESP
		Scrubber
		Cyclone
		Good Combustion Practices
3	Mid-sized Diesel Fired Boiler	Good Combustion Practices
4	Mid-sized Diesel Fired Boiler	Limited Operation
19 through 21	Small Diesel-fired Boilers	Scrubber
		Limited Operation
8	Large Diesel-fired Engine	Positive Crankcase Ventilation
		Low Ash Diesel
		Limited Operation
27	Small Diesel-fired Engine	DPF
		Federal Standard
		Limited Operation
9A	Medical/Pathological Waste Incinerator	Fabric Filters
		Limited Operation
		Good Combustion Practices
		Multiple Chambers
105, 107, 109, 110, 114, and 128 through 130	Material Handling Emission Units with Fabric Filtration	Fabric Filters
		Enclosure
		Closed System Venting
111	Material Handling Emission Unit without Fabric Filtration	Enclosure

Table 4-3. UAF - Ranking of Technically Feasible $PM_{2.5}$ Control Options

Emission Unit ID	Emission Unit Description	Control Technology	Control Efficiency (pct.)	$PM_{2.5}$ Emissions (tpy)	Emissions Reduction (tpy)
113	Large Coal and Biomass-fired Boiler	Fabric filter	95	15.5	294.5
		ESP	90	31	279
		Scrubber	70	93	217
		Cyclone	20	248	62
		Good Combustion Practices	0	310	0
19 through 21	Small Diesel-fired Boilers[1]	Scrubber + Limited Operation	99	0.01	0.93
		Limited Operation	0	0.94	0.0
27	Small Diesel-fired Engine	DPF + (Federal Limit + Limited Operation)	85	0.04	0.22
		Federal Limit + Limited Operation	0	0.26	0
9A	Medical/Pathological Waste Incinerator	Fabric Filters + Multiple Chambers	95	0.01	0.24
		Multiple Chambers + (Limited Operation)	0	0.25	0
105, 107, 109, 110, 114, and 128 through 130	Material Handling Emission Units with Fabric Filtration	Closed System Venting	100	0	Varies[2]
		Fabric Filter + Enclosure	0	Varies[2]	0

Table 4-4. UAF - Capital Costs for Scrubber on the Small Diesel-Fired Boilers (EU IDs 19 through 21)

Shaded cells indicate user inputs.

Total Capital Investment Determination - Scrubber
Project: UAF $PM_{2.5}$ BACT Analysis - BiRD Boilers 1 through 3 (EU19 through 21; WM 2094W)

Date: 12/18/2015
Prepared By: C. Stevenson
Checked By: J. Rubino
Rev: B

Capital Costs

DIRECT COSTS	QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST		
(1) Purchased equipment and material costs							
(a) Basic equipment							
Scrubber for 3 Boilers, Units 19, 20, & 21 (includes freight & install)	1	EA	300000	$ 300,000			
(per Proctor Sales Inc.)						**TOTAL =**	**$ 300,000**
(b) Instrumentation							
Total Instrumentation		EA		$ -	Included in above price		
						TOTAL =	**$ -**
(c) Freight		% MATL COST			$ -		
						TOTAL =	**$ -**
(d) Labor							
Labor - offsite fab	0	MH		None required	$ -		
Labor - onsite	0	MH	$ -		$ -		
						TOTAL =	**$ -**
(e) Vendor representatives fees							
Fab Site Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
Onsite Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
						TOTAL =	**$ -**
Purchased Equipment and Material Cost (PEMC)						**PEMC =**	**$ 300,000**
Direct Installation Costs (DIC)						**DIC =**	
Total Direct Costs (TDC)						**TDC = (PEMC) + (DIC) =**	**$ 300,000**
INDIRECT COSTS							
(2) Engineering, Procurement & Construction Support Services		% TDC			$ -		Excluded in this estimate.
(3) Performance tests		EA			$ -		Excluded in this estimate.
Total Indirect Costs (TIC)						**TIC =**	**$ -**
MANAGEMENT AND CONTINGENCY COSTS							
(4) Unit Operator Costs		% TDC					Excluded in this estimate.
(5) Contingency		% TDC			$ -		Excluded in this estimate.
Total Management and Contingency Costs (TM&CC)						**TM & CC =**	**$ -**
TOTAL CAPITAL INVESTMENT (TCI)						**TCI = (TDC)+(TIC)+(TM&CC) =**	**$ 300,000**

Table 4-5. UAF - Annualized Costs for Scrubber on the Small Diesel-Fired Boilers (EU IDs 19 through 21)

Shaded cells indicate user inputs

Cost Effectiveness Determination - Scrubber					Date:	12/18/2015
Project: UAF $PM_{2.5}$ BACT Analysis - BiRD Boilers 1 through 3 (EU19 through 21; WM 2094W)					Prepared By:	C. Stevenson
					Checked By:	J. Rubino
					Rev:	B
Annualized Costs						
DIRECT ANNUAL COSTS - EXCLUDED IN THIS ESTIMATE	**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**	**TOTAL**
(1) Operating Labor		MH			$ -	$ -
(2) Supervisory Labor		MH			$ -	$ -
(3) Maintenance Labor		MH			$ -	$ -
(4) Maintenance Materials		LOT		$ -		$ -
Total Direct Annual Costs (TDAC)	Excluded in this estimate				TDAC =	$ -
INDIRECT ANNUAL COSTS						
(5) Overhead		MH		Excluded in this estimate.	$ -	$ -
(6) Administrative Charges		MH		Excluded in this estimate.	$ -	$ -
(7) Property tax				Not Applicable		
(8) Insurance				Excluded in this estimate.		
Capital Recovery Factor [see inputs below]	0.1424					
(9) Capital Recovery					**CRF * TCI =**	$ 42,713
Total Indirect Annual Costs (TIAC)					TIAC =	$ 42,713
TOTAL ANNUALIZED COSTS (TAC)					TAC = (TDAC) + (TIAC) =	$ 42,713
Cost Effectiveness Summary						
TOTAL TONS AVOIDED PER YEAR					=	0.891
COST EFFECTIVENESS ($ PER TON AVOIDED)					(TAC)/(TPY) =	$ 47,939

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manual)	7.00	%
Project Life (EPA OAQPS Control Cost Manual)	10	years
Catalyst Life	N/A	years
Asset Utilization	N/A	%

Table 4-6. UAF - Capital Costs for DPF on the Small Diesel-Fired Engine (EU ID 27)

Shaded cells indicate user inputs.

Total Capital Investment Determination - DPF

Project:	UAF $PM_{2.5}$ BACT Analysis - ACEP Engine (EU 27)	Date:	12/18/2015
		Prepared By:	C. Stevenson
		Checked By:	J. Rubino
		Rev:	C

Capital Costs

DIRECT COSTS	QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST		
(1) Purchased equipment and material costs							
(a) Basic equipment							
Total DPF System	1	EA	0	$ -			
(per NC Power Systems)						TOTAL =	$ -
(b) Instrumentation							
Total Instrumentation		EA		$ -	Included in above price		
						TOTAL =	$ -
(c) Freight							
DPF Freight		% MATL COST	10%		$ -		
						TOTAL =	$ -
(d) Labor							
Labor - offsite fab	0	MH		None required	$ -		
Labor - onsite	16	MH	$ 105.00		$ 1,680		
(per SCI)						TOTAL =	$ 1,680
(e) Vendor representatives fees							
Fab Site Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
Onsite Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
						TOTAL =	$ -
Purchased Equipment and Material Cost (PEMC)						PEMC =	$ 1,680
Direct Installation Costs (DIC)	**DPF replaces existing silencer, no direct installation costs necessary**					DIC =	$ -
Total Direct Costs (TDC)						TDC = (PEMC) + (DIC) =	$ 1,680
INDIRECT COSTS							
(2) Engineering, Procurement & Construction Support Services		% TDC			$ -		Excluded in this estimate.
(3) Performance tests		EA			$ -		Excluded in this estimate.
Total Indirect Costs (TIC)						TIC =	$ -
MANAGEMENT AND CONTINGENCY COSTS							
(4) Unit Operator Costs		% TDC					Excluded in this estimate.
(5) Contingency		% TDC			$ -		Excluded in this estimate.
Total Management and Contingency Costs (TM&CC)						TM & CC =	$ -
TOTAL CAPITAL INVESTMENT (TCI)						TCI = (TDC)+(TIC)+(TM&CC) =	$ 78,210

Table 4-6. UAF - Capital Costs for DPF on the Small Diesel-Fired Engine (EU ID 27)

Shaded cells indicate user inputs.

Total Capital Investment Determination - DPF						Date:	12/18/2015
Project: UAF $PM_{2.5}$ BACT Analysis - ACEP Engine (EU 27)						Prepared By:	C. Stevenson
						Checked By:	J. Rubino
						Rev:	C
Capital Costs							
DIRECT COSTS	**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**		
(1) Purchased equipment and material costs							
(a) Basic equipment							
Total DPF System	1	EA	0	$ -			
(per NC Power Systems)						**TOTAL =**	**$ -**
(b) Instrumentation							
Total Instrumentation		EA		$ -	Included in above price		
						TOTAL =	**$ -**
(c) Freight							
DPF Freight		% MATL COST	10%		$ -		
						TOTAL =	**$ -**
(d) Labor							
Labor - offsite fab	0	MH		None required	$ -		
Labor - onsite	16	MH	$ 105.00		$ 1,680		
(per SCI)						**TOTAL =**	**$ 1,680**
(e) Vendor representatives fees							
Fab Site Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
Onsite Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
						TOTAL =	**$ -**
Purchased Equipment and Material Cost (PEMC)						**PEMC =**	**$ 1,680**
Direct Installation Costs (DIC)	**DPF replaces existing silencer, no direct installation costs necessary**					**DIC =**	**$ -**
Total Direct Costs (TDC)						**TDC = (PEMC) + (DIC) =**	**$ 1,680**
INDIRECT COSTS							
(2) Engineering, Procurement & Construction Support Services		% TDC			$ -		Excluded in this estimate.
(3) Performance tests		EA			$ -		Excluded in this estimate.
Total Indirect Costs (TIC)						**TIC =**	**$ -**
MANAGEMENT AND CONTINGENCY COSTS							
(4) Unit Operator Costs		% TDC					Excluded in this estimate.
(5) Contingency		% TDC			$ -		Excluded in this estimate.
Total Management and Contingency Costs (TM&CC)						**TM & CC =**	**$ -**
TOTAL CAPITAL INVESTMENT (TCI)						**TCI = (TDC)+(TIC)+(TM&CC) =**	**$ 78,210**

Table 4-7. UAF - Annualized Costs for DPF on the Small Diesel-Fired Engine (EU ID 27)

Shaded cells indicate user inputs

Cost Effectiveness Determination - DPF						Date:	12/18/2015
Project:	UAF $PM_{2.5}$ BACT Analysis - ACEP Engine (EU 27)					Prepared By:	C. Stevenson
						Checked By:	J. Rubino
						Rev:	C
Annualized Costs							
DIRECT ANNUAL COSTS		**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**	**TOTAL**
(1)	Operating Labor		MH			$ -	$ -
(2)	Supervisory Labor		MH			$ -	$ -
(3)	Maintenance Labor		MH			$ -	$ -
(4)	Maintenance Materials		LOT		$ -		$ -
Total Direct Annual Costs (TDAC)		Excluded in this estimate				TDAC =	$ -
INDIRECT ANNUAL COSTS							
(5)	Overhead		MH		Excluded in this estimate.	$ -	$ -
(6)	Administrative Charges		MH		Excluded in this estimate.	$ -	$ -
(7)	Property tax				Not Applicable		
(8)	Insurance				Excluded in this estimate.		
	Capital Recovery Factor [see inputs below]	0.1204					
(9)	Capital Recovery					**CRF * TCI =**	$ 9,418
Total Indirect Annual Costs (TIAC)						TIAC =	$ 9,418
TOTAL ANNUALIZED COSTS (TAC)						TAC = (TDAC) + (TIAC) =	$ 9,418
Cost Effectiveness Summary							
TOTAL TONS AVOIDED PER YEAR						=	0.55
COST EFFECTIVENESS ($ PER TON AVOIDED)						(TAC)/(TPY) =	$ 17,099

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manual)	8.50	%
Project Life (EPA OAQPS Control Cost Manual)	15	years
Catalyst Life	N/A	years
Asset Utilization	N/A	%

Table 4-7. UAF - Annualized Costs for DPF on the Small Diesel-Fired Engine (EU ID 27)

Shaded cells indicate user inputs

Cost Effectiveness Determination - DPF

Project: UAF $PM_{2.5}$ BACT Analysis - ACEP Engine (EU 27)

Date: 12/18/2015
Prepared By: C. Stevenson
Checked By: J. Rubino
Rev: C

Annualized Costs

DIRECT ANNUAL COSTS		QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST	TOTAL
(1)	Operating Labor		MH			$ -	$ -
(2)	Supervisory Labor		MH			$ -	$ -
(3)	Maintenance Labor		MH			$ -	$ -
(4)	Maintenance Materials		LOT		$ -		$ -
Total Direct Annual Costs (TDAC)		Excluded in this estimate				TDAC =	$ -
INDIRECT ANNUAL COSTS							
(5)	Overhead		MH		Excluded in this estimate.	$ -	$ -
(6)	Administrative Charges		MH		Excluded in this estimate.	$ -	$ -
(7)	Property tax				Not Applicable		
(8)	Insurance				Excluded in this estimate.		
	Capital Recovery Factor [see inputs below]	0.1057					
(9)	Capital Recovery					**CRF * TCI =**	$ 8,265
Total Indirect Annual Costs (TIAC)						TIAC =	$ 8,265
TOTAL ANNUALIZED COSTS (TAC)						TAC = (TDAC) + (TIAC) =	$ 8,265

Cost Effectiveness Summary

TOTAL TONS AVOIDED PER YEAR	=	0.41
COST EFFECTIVENESS ($ PER TON AVOIDED)	(TAC)/(TPY) =	$ 20,271

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manual)	8.50	%
Project Life (EPA OAQPS Control Cost Manual)	20	years
Catalyst Life	N/A	years
Asset Utilization	N/A	%

Table 4-8. UAF - Capital Costs for a Fabric Filter on the Medical/Pathological Waste Incinerator (EU ID 9A)

Shaded cells indicate user inputs.

Total Capital Investment Determination - Fabric Filter						Date:	12/18/2015
Project:	UAF $PM_{2.5}$ BACT Analysis - BiRD INCINERATOR (EU 9A)					Prepared By:	C. Stevenson
						Checked By:	J. Rubino
						Rev:	B

Capital Costs

DIRECT COSTS	QTY	UNIT	UNIT COST	TOTAL MATERIALS COST	TOTAL LABOR COST		
(1) Purchased equipment and material costs							
(a) Basic equipment							
FABRIC FILTRATION - INSTALLED (per Thermtec)	1	EA	1300000	$ 1,300,000		TOTAL =	$ 1,300,000
(b) Instrumentation							
Total Instrumentation		EA		$ -	Included in above price	TOTAL =	$ -
(c) Freight							
Freight included in basic equipment cost		% MATL COST			$ -	TOTAL =	$ -
(d) Labor							
Labor - offsite fab	0	MH			$ -		
Labor - onsite	0	MH	$ -		$ -	TOTAL =	$ -
(e) Vendor representatives fees							
Fab Site Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -		
Onsite Vendor Representatives fees (enter no. of days and daily rate)	0	Days			$ -	TOTAL =	$ -
Purchased Equipment and Material Cost (PEMC)						PEMC =	$ 1,300,000
Direct Installation Costs (DIC)						DIC =	
Total Direct Costs (TDC)						TDC = (PEMC) + (DIC) =	$ 1,300,000
INDIRECT COSTS							
(2) Engineering, Procurement & Construction Support Services		% TDC			$ -		Excluded in this estimate.
(3) Performance tests		EA			$ -		Excluded in this estimate.
Total Indirect Costs (TIC)						TIC =	$ -
MANAGEMENT AND CONTINGENCY COSTS							
(4) Unit Operator Costs		% TDC					Excluded in this estimate.
(5) Contingency		% TDC			$ -		Excluded in this estimate.
Total Management and Contingency Costs (TM&CC)						TM & CC =	$ -
TOTAL CAPITAL INVESTMENT (TCI)						TCI = (TDC)+(TIC)+(TM&CC) =	$ 1,300,000

Table 4-9. UAF - Annualized Costs for a Fabric Filter on the Medical/Pathological Waste Incinerator (EU ID 9A)

Shaded cells indicate user inputs

Cost Effectiveness Determination - Fabric Filter						Date:	12/18/2015
Project:	UAF $PM_{2.5}$ BACT Analysis - BiRD INCINERATOR (EU 9A)					Prepared By:	C. Stevenson
						Checked By:	J. Rubino
						Rev:	B
Annualized Costs							
DIRECT ANNUAL COSTS		**QTY**	**UNIT**	**UNIT COST**	**TOTAL MATERIALS COST**	**TOTAL LABOR COST**	**TOTAL**
(1)	Operating Labor		MH			$ -	$ -
(2)	Supervisory Labor		MH			$ -	$ -
(3)	Maintenance Labor (clean boiler/heat exchanger)	104	MH	105		$ 10,920	$ 10,920
(4)	Maintenance Materials (Bag replacement) (per Thermtec)	70	LOT	300	$ 21,000		$ 21,000
Total Direct Annual Costs (TDAC)		Excluded in this estimate				**TDAC =**	$ 31,920
INDIRECT ANNUAL COSTS							
(5)	Overhead		MH		Excluded in this estimate.	$ -	$ -
(6)	Administrative Charges		MH		Excluded in this estimate.	$ -	$ -
(7)	Property tax				Not Applicable		
(8)	Insurance				Excluded in this estimate.		
	Capital Recovery Factor [see inputs below]	0.1424					
(9)	Capital Recovery					**CRF * TCI =**	$ 185,091
Total Indirect Annual Costs (TIAC)						**TIAC =**	$ 185,091
TOTAL ANNUALIZED COSTS (TAC)						**TAC = (TDAC) + (TIAC) =**	$ 217,011
Cost Effectiveness Summary							
TOTAL TONS AVOIDED PER YEAR						=	0.285
COST EFFECTIVENESS ($ PER TON AVOIDED)						**(TAC)/(TPY) =**	$ 761,441

Data Inputs for Capital Recovery Factor:		
Annual Interest Rate (EPA OAQPS Control Cost Manua	7.00	%
Project Life (EPA OAQPS Control Cost Manual)	10	years
Catalyst Life	N/A	years
Asset Utilization	N/A	%

Table 4-10. UAF - $PM_{2.5}$ BACT Cost Effectiveness Summary for Each Emission Unit Type

Control Technology Option	Total Installed Capital ($)	Annualized Capital Cost ($/year)	Annual O&M Cost ($MM/year)	Cost Effectiveness ($/ton $PM_{2.5}$ removed)
Small Diesel-fired Boilers (EU ID 19 through 21)				
Scrubber + Limited Operation	$300,000	$42,713	NA	$47,939
Limited Operation[1]	~	~	~	~
Small Diesel-fired Engine (EU ID 27)				
DPF + Federal Limits + Limited Operation	$78,210	$8,265	NA	$20,271
Federal Limits[1] + Limited Operation[1]	~	~	~	~
Medical/Pathological Waste Incinerator (EU ID 9A)				
Fabric Filters + Multiple Chambers	$1,300,000	$217,011	$31,920	$761,441
Multiple Chambers + Limited Operation[1]	~	~	~	~

Notes:
[1] This technology is proposed as the baseline case.

Table 4-11. UAF - Proposed $PM_{2.5}$ BACT and Associated Emission Rate for Each Emission Unit Type

Emission Unit		Fuel	$PM_{2.5}$ BACT	
ID	Description		Description	Emission Rate[1]
113	Large Boiler	Coal and Biomass	Fabric Filter	0.012 lb/MMBtu
3	Mid-sized Boiler	Diesel	Good Combustion Practices	0.016 lb/MMBtu
4	Mid-sized Boiler	Diesel	Limited Operation	0.016 lb/MMBtu
		Natural Gas		7.6 lb/MMscf
19 through 21	Small Boilers	ULSD	Limited Operation	7.06 g/MMBtu
8	Large Engine	Diesel	Positive Crankcase Ventilation + Low Ash Fuel + Limited Operation	0.32 g/hp-hr
27	Small Engine	ULSD	Federal Limit (NSPS Subpart IIII, Tier 3) + Limited Operation	0.11 g/hp-hr
9A	Medical/Pathological Waste Incinerator	Waste	Multiple Chambers + Limited Operation	4.67 lb/ton
105, 107, 109, 110, and 128 through 130	Material Handling Emission Units with Fabric Filtration	N/A	Fabric Filter + Enclosure	0.003 gr/dscf
114	Material Handling Emission Units with Fabric Filtration	N/A	Fabric Filter + Enclosure	0.05 gr/dscf
111	Material Handling Emission Unit without Fabric Filtration	N/A	Enclosure	5.5e-5 lb/ton

Appendix A

EU 113 SO_2 Emissions Calculations

A-1

Potential and Actual Emissions

Table A-1. Potential to Emit Calculations - SO_2 Emissions

EU ID	Description	Make/Model	SO_2 Emission Factor	Maximum Rating	Allowable Annual Operation	Potential SO_2 Emissions
113	Circulating Bed Boiler[1]	Babcock and Wilcox	0.20 lb/MMBtu[2]	295.6 MMBtu/hr	8,760 hr/yr	258.9 tpy

Notes:

[1] EU 113 is permitted to combust coal and up to 20 percent woody biomass (see Item 15 of Section 2.2 in Technical Analysis Report to Permit AQ0316MSS06 Revision 2). EU 113 is currently configured for coal firing only, and combusts subbituminous coal from Usibelli Coal Mine in Healy, AK.

[2] SO_2 emission factor per 40 CFR 60.42b(k)(1) and Conditions 36.1 and 61.2 of Permit AQ0316TVP03.

Table A-2. Actual SO_2 Emissions

EU ID	Description	Make/Model	CY2020	CY2021	Average Annual SO_2 Emissions
113	Circulating Bed Boiler	Babcock and Wilcox	12.3 tpy[1]	8.5 tpy[2]	10.4 tpy[3]

Notes:

[1] CY 2020 SO_2 emissions per totalized CEMS data for CY 2020 in Table 1 of University of Alaska Fairbanks Assessable Emissions Estimate for FY 2022, submitted to ADEC March 12, 2021.

[2] CY 2021 SO_2 emissions per totalized CEMS data for CY 2021 provided by University of Alaska Fairbanks.

[3] SO_2 emissions from 2022 are not included. EU 113 operated minimally between January and June 2022 as a result of an unplanned outage.

A-2

Basis for Actual SO_2 Emissions

Table 1 - UAF Coal Fired Boiler 5 (EU 113)

CY 2020 Estimated Emissions

ID	Emission Unit Description	Coal Consumption, CY 2020	Estimated Emissions (tpy)					
			NO_X	CO	PM_{10}	SO_2	VOC	HAPs
113	CFB Boiler- New CHPP- Coal Fired	88,491.0 ton/yr	48.10	78.95	~~739.98~~	12.30	2.21	2.41

Correct PM10 value is 0.37 tpy.

Notes:
1. Weight conversion: 2,000 lb/ton
2. Sulfur content of coal: 0.130 weight percent average based on CY 2020 UCM monthly rail sample data
3. Hours of Operation 7,452.000 total hours of operation EU 113 in 2020, (steaming rate >25,000 lbs/hr, bed temperature >250F)
5. Heating value UCM coal 14.87 MMBTU/ton of coal based on CY 2020 monthly averages from UCM analysis
6. Emission factors:

Pollutant	Emission Factor	Source
NO_X	N/A	CEMS data totalized for CY 2020
CO	0.12 lb/MMBTU	Source test data from December 2019
PM_{10}	0.0993000 lb/hr	EU 113 Source test October 2020
SO_2	N/A	CEMS data totalized for CY 2020
VOC	0.05 lb/ton	AP-42, Table 1.1-19, 9/98, Spreader stoker (total NMOC)
HAPs	N/A	See note 4

4. HAPs emission factor is a sum of the following emission factors:

Pollutant	Emission Factor	Source
HCl	1.29 tons CY 2020	EU 113 Source Test October 2020, modified by actual run hours
HF	0.08 tons CY 2020	EU 113 Source Test October 2020, modified by actual run hours
Hg	0.008800 tons CY 2020	Mercury in coal analysis March 2020
All other HAPs	1.03 tons CY 2020	using 0.0233 lb/ton - total of emission factors from AP-42 Tables 1.1-13, 1.1-14, 1.1-1
	2.41 tons CY 2020	

Data Summary Report

TRACE Environmental Systems, Inc.

Company: University of Alaska Fairbanks
802 Alumni Drive
Fairbanks, AK 99775

Data Group: All Data Groups
Report Name: Summary: NOx_SO2 12Mnth Totals
Start of Report: 12/01/2021 00:00
End of Report: 12/31/2021 23:59
Validation: All Available Data

Group#-Channel#	G13-C4	G11-C4	G13-C5	G11-C5	G11-C6	G13-C6	G11-C1	G13-C1
Long Descrip.	NOx tons	NOx tons	SO2 tons	SO2 tons	CO2 tonne	CO2 tonne	Coal Tons	Coal Tons
Short Descrip.	NOx tpy	NOx tons	SO2 tpy	SO2 tons	CO2	CO2 tpy	Coal tons	Coal tons
Units	tons/yr	tons/m	tons/yr	tons/m	tonnes	tonnes	tons/m	tons/yr
Range	0-9999	0-100	0-9999	0-100	0-9999	0-999999	0-20000	0-240000
12/01/2021 00:00	58.1	3.0	8.5	0.2	3544.0	87643.3	7817	103668
Period Average =	58.1	3.0	8.5	0.2	3544.0	87643.3	7817	103668
Period Max Value =	58.1	3.0	8.5	0.2	3544.0	87643.3	7817	103668
Period Min Value =	58.1	3.0	8.5	0.2	3544.0	87643.3	7817	103668
Period Totals =	5.810000E+1	3.000000E+0	8.500000E+0	2.000000E-1	3.544000E+3	8.764330E+4	7.8170E+3	1.0366E+5
Period % Recovery =								

Date/Time Printed: 01/01/2022 08:00

A-3

EPA Information Request

University of Alaska Fairbanks (UAF) – Power Plant – SO_2/Coal Boiler BACT Summary

Emission Units: 1 coal/biomass fired boiler, constructed 2019 (295 MMBtu/hr)
SO_2 PTE: 259 tons/year (potential emissions allowed by permit)

ADEC's BACT selection

- Coal limited to 0.25% sulfur content (no controls)

Table 1. **Information Already Provided by UAF / ADEC**

WFGD	a. Estimate of capital ($29.5M) and operation and maintenance ($3.4M/year) costs based on the Integrated Planning Model (IPM) b. NO site-specific vendor cost info (+/- 30% accuracy).
SDA	a. Estimate of capital ($27.1M) and operation and maintenance ($3M/year) costs based on IPM Model b. One vendor site-specific estimate of capital ($15.6M) and operation and maintenance ($1M/year) costs
CDS	Nothing
DSI	One vendor site-specific estimate of capital ($2.5M) and operation and maintenance ($1.3M/year) costs

Additional Information Needed to Complete Economic Infeasibility Analyses

1. Study level (+/- 30% accuracy) site-specific vendor quotes or detailed cost estimates for:
    a. WFGD (minimum of two)
    b. CDS (minimum of two)
    c. SDA (one additional)
    d. DSI (one additional would be helpful, but not critical)
2. Cost-effectiveness calculations based on the site-specific vendor cost info.
3. Affordability analysis approvable by EPA, i.e., the analysis must consider and explain all sources of income/revenue, data on responsiveness of consumers to price increases, data on how much the cost of electricity will increase/prices change, and labor costs.

Additional Information Needed for Diesel Engines

1. Cost information submitted indicates diesel particulate filter (DPF) is cost effective for one diesel engine (EU 27) and should be evaluated for two other diesel engines that do not appear to have limits on hours of operation (EU's 23 and 26).

Appendix B

Wet Flue Gas Desulfurization Vendor Data

Andritz WFGD 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

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

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

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

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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 SO_2 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 SO_2 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 SO_2 emissions rate is required but guarantees below about 0.06 #/MMBTU for SO_2 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 SO_2 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 SO_2. 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 SO_2 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 an 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

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

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

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

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 clraifications:

- 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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Thank you

B&W WFGD 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
Follow Us on Social Media

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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 SO_2 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
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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

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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 SO_2 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 SO_2 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 WFGD Email

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

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

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

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

mobile | 774-366-5692
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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Unless verified as legitimate, NEVER supply your company username and password via an email link.

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

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

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

Babcock Power
SERVICES
a Babcock Power Inc. company

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

mobile | 774-366-5692
email | blinn@babcockpower.com
web | https://www.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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Unless verified as legitimate, NEVER supply your company username and password via an email link.

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 my 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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a Babcock Power Inc. company

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

mobile | 774-366-5692
email | blinn@babcockpower.com
web | https://www.babcockpower.com

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

mobile | 774-366-5692
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

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.

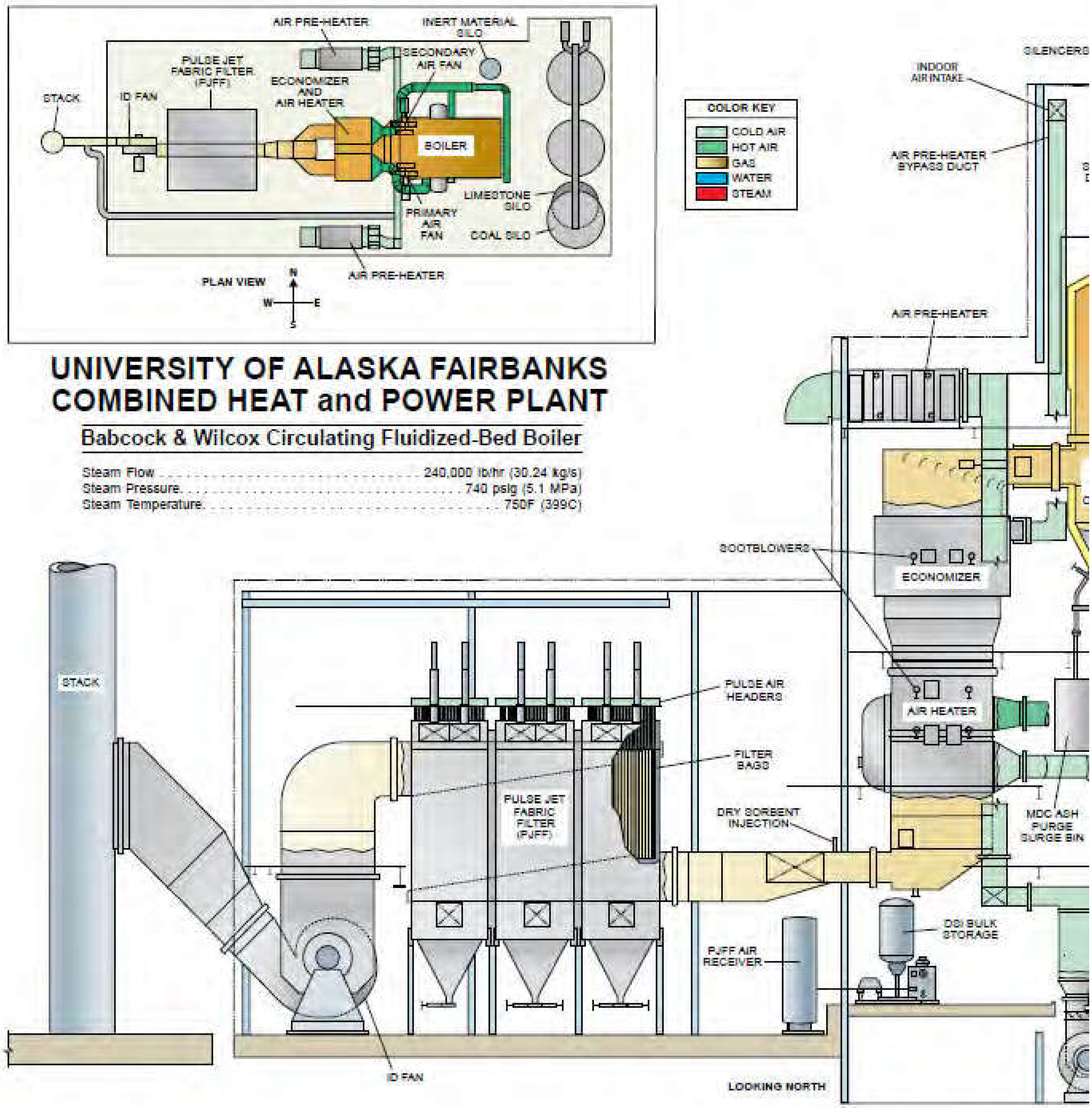
Information attached:
Boiler data sheet (includes coal analysis)
Plant layout (CHPP Layout)
UAF Exhaust Gas Data (for exhaust gas entering the baghouse)
Baghouse data (for existing baghouse)

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.



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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GE WFGD Email

Jahn, Mario

From: McGowan, Liam (GE Power Portfolio) <Liam.McGowan@ge.com>
Sent: Friday, June 10, 2022 11:31 AM
To: Jahn, Mario
Cc: Reynolds, Travis (GE Power Portfolio)
Subject: Re: EXT: RE: Fairbanks, University of Alaska- Web Inquiry

Follow Up Flag: Follow up
Flag Status: Flagged

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Hi Mario,

We just had a call internally to look at this project. Our plan is to provide a budgetary price on a WFGD unit, however we won't be able to meet the 3 week timeline. Realistically we'd be looking at 6 weeks. This would give us time to review the The GE WFGD design scaled-to the size of this boiler. With that sized unit we'd assembly some budgetary pricing for you and be able to provide a estimated cost over target emission values.

Can you confirm if the 6 week timeline would be acceptable?

Best regards,

Liam McGowan
Sr. Account Manager, Western Canada
GE Steam Power Canada Inc.

C: +1 587 338 8739
E: liam.mcgowan@ge.com
Edmonton, Alberta, Canada

Imagination at work

On Jun 8, 2022, at 09:28, Jahn, Mario <JahnMario@stanleygroup.com> wrote:

Thanks Liam. What type of AQCS equipment can you guys provide? WFGD, SDA, CDS, DSI?

From: McGowan, Liam (GE Power Portfolio) <Liam.McGowan@ge.com>
Sent: Wednesday, June 8, 2022 8:31 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Reynolds, Travis (GE Power Portfolio) <Travis.Reynolds@ge.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: Fairbanks, University of Alaska- Web Inquiry

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

Thank you Mario, I've received these documents and will communicate back to the GE team.

Best Regards,

Liam McGowan
Sr. Account Manager, Western Canada
GE Steam Power Canada Inc.

C: +1 587 338 8739
E: liam.mcgowan@ge.com
Edmonton, Alberta, Canada

Imagination at work

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: June 7, 2022 4:13 PM
To: McGowan, Liam (GE Power Portfolio) <Liam.McGowan@ge.com>
Cc: Reynolds, Travis (GE Power Portfolio) <Travis.Reynolds@ge.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: EXT: RE: Fairbanks, University of Alaska- Web Inquiry

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Liam,

Thanks for reaching out earlier today. I've attached the RFQ documents that we were talking about. Let me know how things progress on your end as far as providing a budgetary price for AQCS equipment. Let me know if you need additional information.

Best 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: McGowan, Liam (GE Power Portfolio) <Liam.McGowan@ge.com>
Sent: Tuesday, June 7, 2022 3:13 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Reynolds, Travis (GE Power Portfolio) <Travis.Reynolds@ge.com>
Subject: FW: Fairbanks, University of Alaska- Web Inquiry
Importance: High

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

Mario,

It was good to connect with you. As mentioned if you can shoot over the document you have available it would be much appreciated. Also, see attached my contact.

Best Regards,

Liam McGowan
Sr. Account Manager, Western Canada
GE Steam Power Canada Inc.

C: +1 587 338 8739
E: liam.mcgowan@ge.com
Edmonton, Alberta, Canada

Imagination at work

From: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Sent: June 6, 2022 2:12 PM
To: McGowan, Liam (GE Power Portfolio) <Liam.McGowan@ge.com>
Subject: FW: Fairbanks, University of Alaska- Web Inquiry
Importance: High

FYI

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Monday, June 6, 2022 6:49 AM
To: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Subject: EXT: RE: Fairbanks, University of Alaska- Web Inquiry
Importance: High

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Hello Ivan,

I wanted to check in again and see how this is progressing on your end. I think the last time we chatted 2 weeks ago, you thought this would be a pretty quick inquiry. Let me know.

Thanks,
Mario

From: Jahn, Mario
Sent: Tuesday, May 31, 2022 6:59 AM
To: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Subject: RE: Fairbanks, University of Alaska- Web Inquiry

Good Morning Ivan,

I hope you had a good holiday weekend. Just wanted to check in and see how things were progressing on your end? Let me know,.

Regards,
Mario

From: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Sent: Tuesday, May 24, 2022 7:39 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Subject: RE: Fairbanks, University of Alaska- Web Inquiry

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Thanks,…I will get back to you quickly.

Ivan

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Tuesday, May 24, 2022 6:26 AM
To: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Subject: EXT: RE: Fairbanks, University of Alaska- Web Inquiry

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Namplate attached.

From: Jahn, Mario
Sent: Tuesday, May 24, 2022 7:15 AM
To: ivan.steber@ge.com
Subject: RE: Fairbanks, University of Alaska- Web Inquiry

Ivan,

Thanks for the quick chat this morning. As we discussed, Mark Fritz has recently retired and I'm taking over as the lead for this project. Let me know if this is an opportunity that GE would like to bid on.

Best 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: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Sent: Monday, May 23, 2022 8:54 PM
To: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>; Knapper, Kelly <KnapperKelly@stanleygroup.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Subject: RE: Fairbanks, University of Alaska- Web Inquiry

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

Resending…..I had Mark's email address wrong.

Ivan

From: Steber, Ivan (GE Power Portfolio)
Sent: Monday, May 23, 2022 5:46 PM
To: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>; knapperKelly@stanleygroup.com; FritzMark@stanleygrop.com
Subject: RE: Fairbanks, University of Alaska- Web Inquiry

Kelly and Mark…

Which unit at the site are you inquiring about? Do you have the nameplate information for the unit? Can you get the information sent from the site, if not?

Regards,

Ivan Lee Steber
West Sales Director, GE SP
Paradise Valley, AZ
Cell: 602.738.8415

From: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>
Sent: Monday, May 23, 2022 9:30 AM
To: Steber, Ivan (GE Power Portfolio) <ivan.steber@ge.com>
Cc: @POWER digital web leads <gepower.webleads@ge.com>
Subject: Fairbanks, University of Alaska- Web Inquiry
Importance: High

Hi Ivan,

We received a new lead from the GE Power website for Wet Flue Gas Desulfurization System from Kelly Knapper at Fairbanks, University of Alaska. The lead indicated that they are looking to install a new Wet Flue Gas Desulfurization System in an existing plant. Would we be able to support their request?

Thank you,

Barsha Saraogi
Customer Support Specialist
GE Power
barsha.saraogi@ge.com
www.ge.com/power

From: Fritz, Mark
Sent: Monday, April 11, 2022 11:23 AM
To: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>
Cc: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Subject: RE: Inquiry to GE Power- Additional Information Requested

Barsha,

Please see my responses below in red. A short phone call might be the best way to determine if GE offers a solution for what we are looking for. My number is 563-264-6473. Thanks.

Mark

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

From: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>
Sent: Friday, April 8, 2022 2:57 AM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Subject: RE: Inquiry to GE Power- Additional Information Requested

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Hi Mark,

Thank you for your reply. I would appreciate if you could help me with a few more information I would like to gather before directing you to the concerned team.

- Who is the original model manufacturer of the equipment? The Wet Flue Gas Desulfurization System we are inquiring about in a new system to be retrofitted onto an existing plant.
- What is the site name of your plant? University of Alaska – Fairbanks CHPP (Combined Heat and Power Plant)
- What is the serial number of the equipment? N/A
- Has GE serviced this unit before? No
- How would you like us to help you with your project? Provide a quotation for a new Wet Flue Gas Desulfurization System.

Thank you,

Barsha Saraogi
Customer Support Specialist
GE Power

barsha.saraogi@ge.com
www.ge.com/power

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Thursday, April 7, 2022 11:25 PM
To: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>
Cc: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Subject: EXT: RE: Inquiry to GE Power- Additional Information Requested

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Barsha,

I am the Project Manager for a project for the University of Alaska – Fairbanks. We look for a budgetary/study level pricing, and other basic information, for a Wet Flue Gas Desulfurization System to be retrofitted onto the backend of a 30 MW CFB coal boiler. See answers to your questions below in red.

- Is your inquiry related to a steam or a gas power or AQCS equipment? AQCS equipment
- Are you a student? No
- What is the application of the equipment you are looking for? See above paragraph.

My contract information is below. Thanks in advance for your help.

Mark

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

From: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Sent: Thursday, April 7, 2022 7:49 AM
To: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>
Cc: Fritz, Mark <FritzMark@stanleygroup.com>
Subject: RE: Inquiry to GE Power- Additional Information Requested

Barsha,

Thank you for the quick response! I'll put you into contact with Mark Fritz (cc'd), he is in charge of the project and will be able to give you the correct technical information for the equipment.

Respectfully,
Kelly Knapper

From: Saraogi, Barsha (GE Gas Power, consultant) <Barsha.Saraogi@ge.com>
Sent: Thursday, April 7, 2022 7:34 AM
To: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Subject: Inquiry to GE Power- Additional Information Requested

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

Hi Kelly,

Thank you for reaching out through the GE Power website and I look forward to helping find the right GE contact to support you. In order to better assist you, I was hoping to learn a little more about your request.

- Is your inquiry related to a steam or a gas power or AQCS equipment?
- Are you a student?
- What is the application of the equipment you are looking for?

I appreciate you taking the time to provide more information so we can better route your inquiry. Thank you and we look forward to doing business with you!

Thank you,

Barsha Saraogi
Customer Support Specialist
GE Power
barsha.saraogi@ge.com
www.ge.com/power

First name: Kelly

Last name: Knapper

Company name: Stanley Consultants

Email address: knapperkelly@stanleygroup.com

Job Title: Engineer

Project location: UNITED STATES

State: IOWA

Product Category: AQCS

Site Name(s)/Serial Number(s): University of Alaska, Fairbanks

Additional details: Apr 06, 2022_Good morning my name is Kelly Knapper I work for Stanley Consultants. On one of our projects we are looking to put in a Wet FGD system for the removal of 0.2 lb/MMBTU SO2. Would you be able to provide a quote for the Wet FGD system and information for removal efficiency, electrical load, approximate size, and type of waste? Thank you! |~|

OPTIONAL INFORMATION:

Service Need:

Fuel type:

How many MW:

Phone:

GEA WFGD Email

Jahn, Mario

From: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Tuesday, May 31, 2022 8:36 AM
To: Jahn, Mario
Cc: Solan, John
Subject: RE: UAF BACT - Stanley Consultants

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

Hello, Mario. Funny timing I actually heard back from the project manager just a few minutes after your email. Unfortunately, we will not be able to quote this project at this point. The reason is that the emissions control department is overloaded currently and has made the decision to focus on supporting quotations for projects that are closer in realization timeline. I appreciate you considering GEA and hope you will keep us in mind down the road. Have a great day!

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Tuesday, May 31, 2022 9:00 AM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Good Morning Mitchell,

I hope you had a good holiday weekend. I wanted to check in to see how you were progressing with regards to providing a proposal for our project. Let me know.

Regards,
Mario

From: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Monday, May 23, 2022 8:29 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Hi Mario,

I hope you had a nice weekend. Thanks for the follow up, I just now sent a note to the engineer and will get back to you as soon as I can.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Monday, May 23, 2022 10:25 AM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Good Morning Mitchell,

I wanted to check-in and see how things are going with regards to our project. Have you gotten anything from Engineering yet? Let me know if you can provide an update.

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Tuesday, May 17, 2022 12:23 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Thanks, Jahn. I have passed this along to engineering and will keep you in the loop as they consider the inquiry.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, May 12, 2022 3:42 PM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

Mitchell,

I apologize for the misunderstanding on my end. We definitely appreciate you taking a look at this for us.

I don't believe that you guys were ever formally given our RFQ documents. I've attached those. The intent is to stay within the provided technologies, i.e., SDA, CDS, DSI and WFGD. If you can send this to your folks and let me know if you need anything else. This information should be more detailed than the questionnaire.

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Thursday, May 12, 2022 2:51 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

No. I apologize for the misunderstanding please allow me to clarify. We need Stanley to come to GEA with a defined inlet gas stream and tell us what the SO2 reduction target is. We will then use our experience to select the technology best suited for the application. We cannot spend the time and resources to have (just choosing random numbers) 6 different scrubbers designed and quoted when we know that 5 of them will be wasted work. If you know that the end user has a quote evaluation criteria (footprint, efficiency, capex, opex, etc.) we will use that when selecting the technology. Otherwise it is sort of like we are delivering the deliverables of your project without being paid. We are in the business of selling scrubbers not quoting them.

If you insist upon having us quote outside of our standard protocol because the end user absolutely requires it, then we could set up a paid "engineering study" arrangement to get you quotes and data sheets on each of them. This is assuming that the department accepts to enter such an agreement, which is not a guarantee.

I hope this clarifies AND I hope that I am not coming across with any sort of difficult tone. We are more than happy to provide hardware quotations for free, even in the budget setting or BACT phase, but we are not an EPC.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, May 12, 2022 4:42 PM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Mitchell,

Thanks for your response. We are performing the engineering study on our end and would require budgetary pricing from GEA to help support this effort. Are you saying that you cannot provide budgetary pricing for SO2 removal technologies unless it was under a paid agreement?

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Thursday, May 12, 2022 11:14 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Hi Mario,

Thank you for your answers, the other thing that I need from you is the process focused questionnaire from my email, I attached it again.

Unfortunately, GEA is not the correct partner for analyzing all of the different scrubbing options for such an EPA study. It is possible we could provide several quotations and data sheets under a paid “engineering study” agreement but I would first have to get buy in from the department manager. We understand of course that budget pricing is required during the funding phase to help support setting project budgets and process targets, and we are happy to help in this way.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, May 12, 2022 10:32 AM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Mitchell,

Please see answers in red. Let me know if you need anything else.

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Wednesday, May 11, 2022 3:43 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Hello Mario,

Thanks for the call. Looking back through my notes I see the only email chain that was exchanged is the one attached. I essentially need the following questions answered in addition to the attached questionnaire to move forward:

- Who is the end user for this equipment? Site location? University of Alaska at Fairbanks (UAF) own and operates the coal fired facility. The plant is located at the University in Fairbanks. Address: 875 Alumni Drive, Fairbanks AK
- Is this project funded and ready for execution or still in the feasibility study and budgeting phase? Stanley Consultants is currently assisting the University in a BACT analysis. The Plant is located in a "serious" non-attainment area for PM2.5. SO2 is a precursor to PM2.5 so major sources of SO2 are required to perform the BACT analysis.
- Can you explain to me the reason for your request for several different quotations for different technology? GEA provides one quotation for the unit operation that best fits the customer's needs according to our expertise and experience. If your end user is weighing a particular detail more heavily than the others (capex, opex, footprint, efficiency, etc.) please let me know now and we keep that in mind when selecting a technology. As part of the BACT analysis, we are required to evaluate all options for SO2 removal. A technology will be chosen once all factors for Capex/Opex and SO2 removal efficiencies have been evaluated.
- What is the time line for this project? When do you expect to receive a budget quote? Firm quote? Make a purchase decision? Have equipment delivered? Have equipment up and running? We are trying to finalize our BACT analysis by the end of this month. After our analysis, the EPA will evaluate the analysis and make a ruling based on what they believe should be implemented. We expect this to be later this year (~Q4).

I have also attached a brochure for information on GEA. After I get this info back we can set up a conference call to discuss your application. Feel free to reach out with questions!

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, May 11, 2022 5:31 PM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: UAF BACT - Stanley Consultants

Mitchell,

Thanks for taking my call. Please let me know what we need to provide for budgetary quotes on SO2 technologies for the University of Alaska at Fairbanks BACT analysis.

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

Tri-Mer WFGD

Jahn, Mario

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Thursday, April 21, 2022 7:48 AM
To: Fritz, Mark
Cc: Nick Evans; Ted Hornus; Deirdre Labert; Vincent DiGiorgio
Subject: P-23.182 Stanley UAF BACT
Attachments: P-23.182 Stanley SO2 Removal Project University of Alaska Fairbanks AK R0 4-21-2022 SENT.pdf

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

Mark,

Enclosed please find our budget proposal P-23.182 for equipment for Stanley's UAF CHPP SO2 control project.

In case you have additional questions or need any further clarification or assistance, 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
Office Phone: (989)-723-7838
Email: mschroeter@tri-mer.com

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, April 20, 2022 5:20 PM
To: Martin Schroeter <mschroeter@tri-mer.com>
Cc: Nick Evans <nevans@tri-mer.com>
Subject: RE: UAF BACT

Martin,

Thanks,

Mark

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Wednesday, April 20, 2022 4:19 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Nick Evans <nevans@tri-mer.com>
Subject: RE: UAF BACT

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

Mark,

Sorry for the delay. You will have our proposal by tomorrow.

Best regards
Martin

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, April 20, 2022 5:18 PM
To: Martin Schroeter <mschroeter@tri-mer.com>
Cc: Nick Evans <nevans@tri-mer.com>
Subject: RE: UAF BACT

Martin,

Can you give me an update regarding the schedule of the requested information.

Best regards,
Mark

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Friday, April 1, 2022 4:18 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Nick Evans <nevans@tri-mer.com>
Subject: RE: UAF BACT

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Mark,

We are planning for a deadline at 4/18/2022.

Best regards
Martin

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Friday, April 1, 2022 2:34 PM
To: Martin Schroeter <mschroeter@tri-mer.com>
Subject: RE: UAF BACT

Martin,

Any update on update on the schedule of the requested information.

Thanks in advance,

Mark

From: Martin Schroeter <mschroeter@tri-mer.com>
Sent: Tuesday, March 22, 2022 5:51 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT

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

Mark,

Thanks for the immediate response. I get with the team and let you know our deadline as soon as possible, then.

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

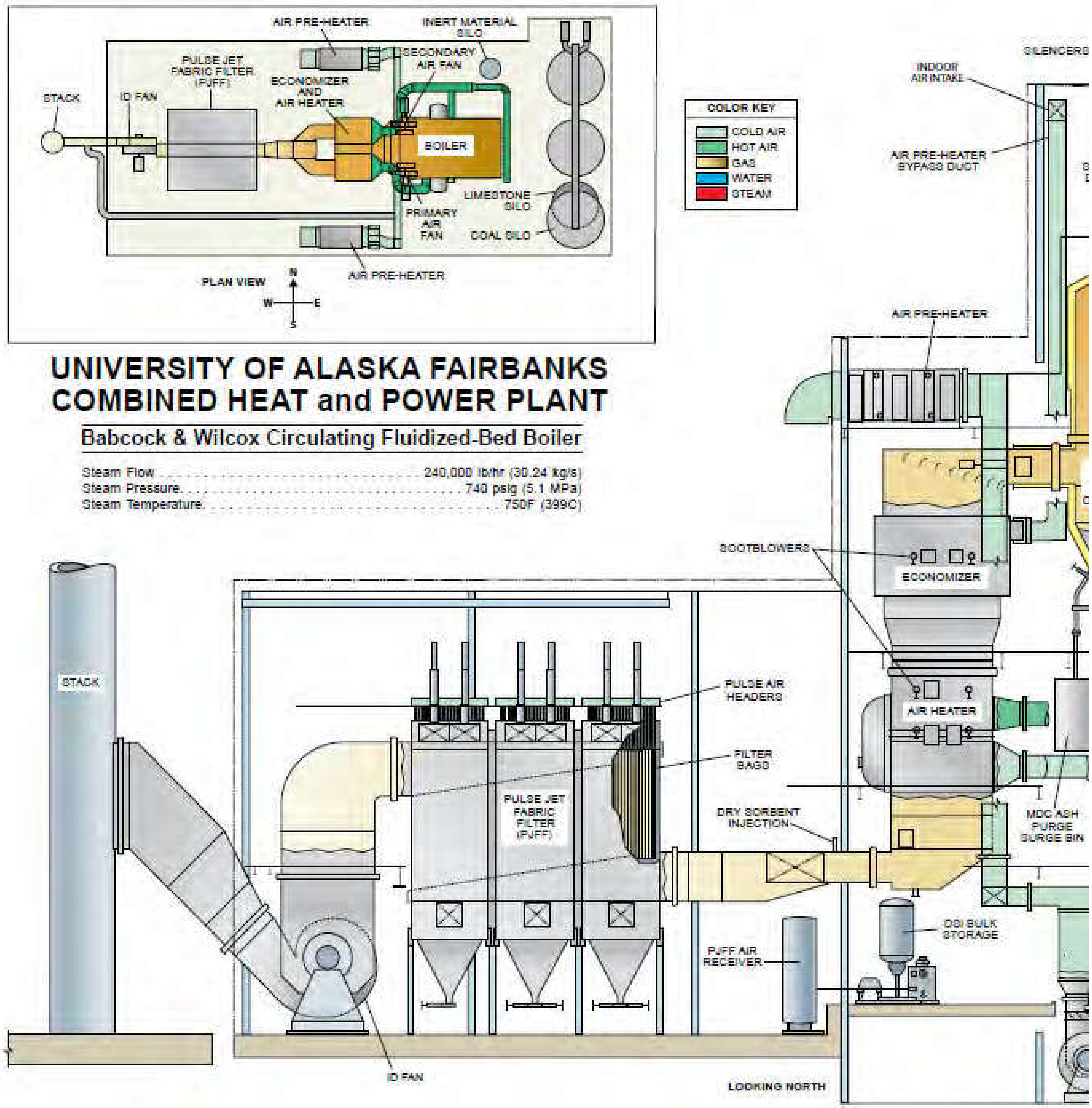
From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Tuesday, March 22, 2022 5:44 PM
To: Martin Schroeter <mschroeter@tri-mer.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: UAF BACT

Martin,

See attached for the drawing shared during the meeting. After internal discusses, we have decided to ask for a proposal for WFGD and DSI in addition to the orginal CDS proposal. We can discuss the scope of the WFGD regarding waste treatment but we would request included as much scope as possible without creating additional work for Tri-Mer. If you can provide me an idea of your schedule, it would greatly be appreciated. Please provide Tri-Mer's experience for each technology, as requested in the orginal RFQ. Thanks again for your time and effort.

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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Tri-Mer® CORPORATION

SO2 MITIGATION SOLUTIONS

RANGE OF SO2 MITIGATION SOLUTIONS FOR UAF FAIRBANKS CFB BOILER

REFERENCE NUMBER: **P-23.182**
REVISION: 0

PREPARED FOR STANLEY CONSULTANTS

MARK FRITZ

225 IOWA AVENUE
MUSCATINE, IA 52657

(563) 607-1430
FRITZMARK@STANLEYGROUP.COM

PROPOSAL ISSUED:
APRIL 21, 2022

PROPOSAL VALID TO:
MAY 5, 2022

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

TABLE OF CONTENTS

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 SO_2 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 a suitable location that ensures a minimum flue gas temperature of 275°F. 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

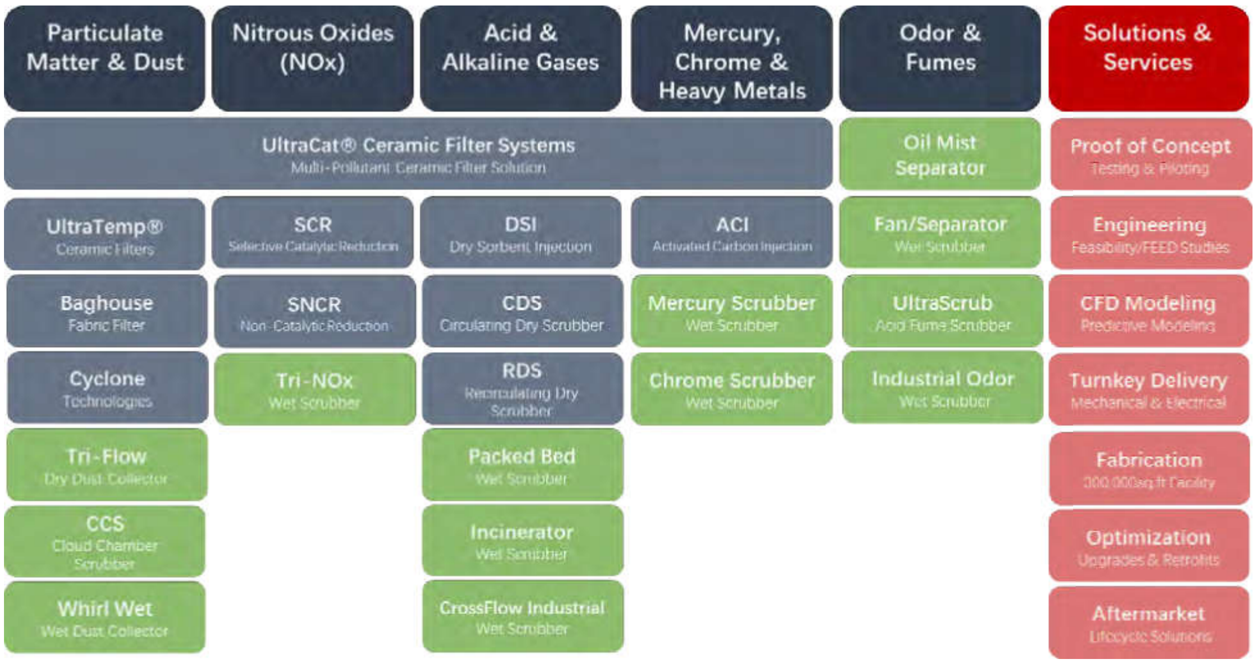
4. While our aim is to offer the right solution, our initial focus is on demonstrating the lowest achievable capital cost solution (LACC), in order to best evaluate what the lowest cost of compliance can be. From this point, we present a wide range of value-adding options, each demonstrating tangible 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 further.

ABOUT TRI-MER

ABOUT US

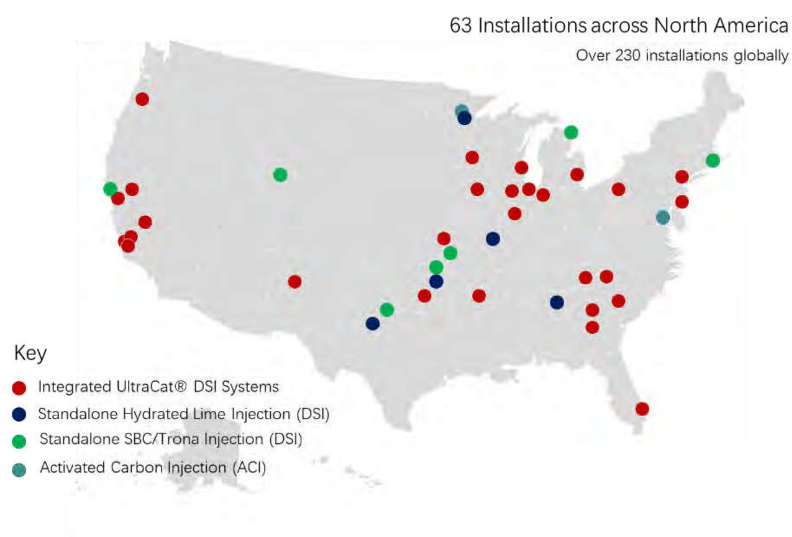
For over 60 years, Tri-Mer has developed a strong specialism in the area of air pollution control. The business has over 6,000 global installations for a wide range of technologies and solutions for clients that address all major pollutants. TMC has developed a large number of technologies in-house, 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 SO_2 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 Doyon Utilities want, 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, Doyon Utilities stores all spare parts at your facility	Management of spare parts at Doyon Utilities 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 Doyon Utilities	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 Doyon Utilities 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 2nd/3rd 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	*inH2O*	**-2.0**	**-2.0**	**-2.0**	**-2.0**
Flue Gas Composition					
H2O	*%*	**8.5**	**8.5**	**8.5**	**8.5**
N2	*%*				
O2	*%*	**3.7**	**3.7**	**3.7**	**3.7**
Ar	*%*	**0.0**	**0.0**	**0.0**	**0.0**
CO2	*%*	**16.1**	**16.1**	**16.1**	**16.1**
Inlet Conditions					
NOx	*lb/MMBtu*	**0.0**	**0.0**	**0.0**	**0.0**
SO2	*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 % *	70 % *	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

- Minimum temperature for use of SBC is 275°F

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:

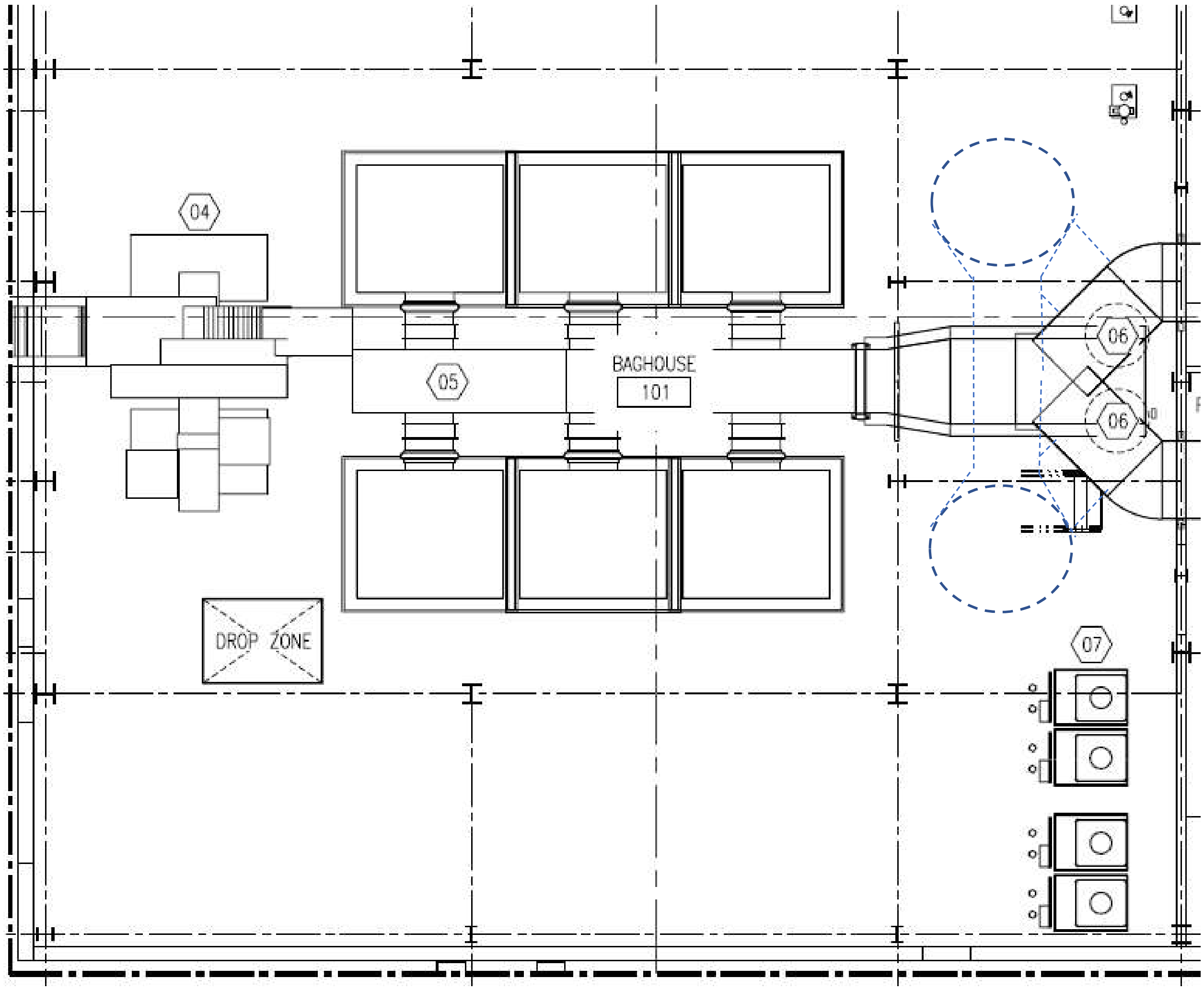
CIRCULATING DRY SCRUBBER (CDS)

The circulating dry scrubber solution will be installed as add-on equipment upstream of the existing PJFF. For optimum chemical reaction, sodium-based sorbent 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.

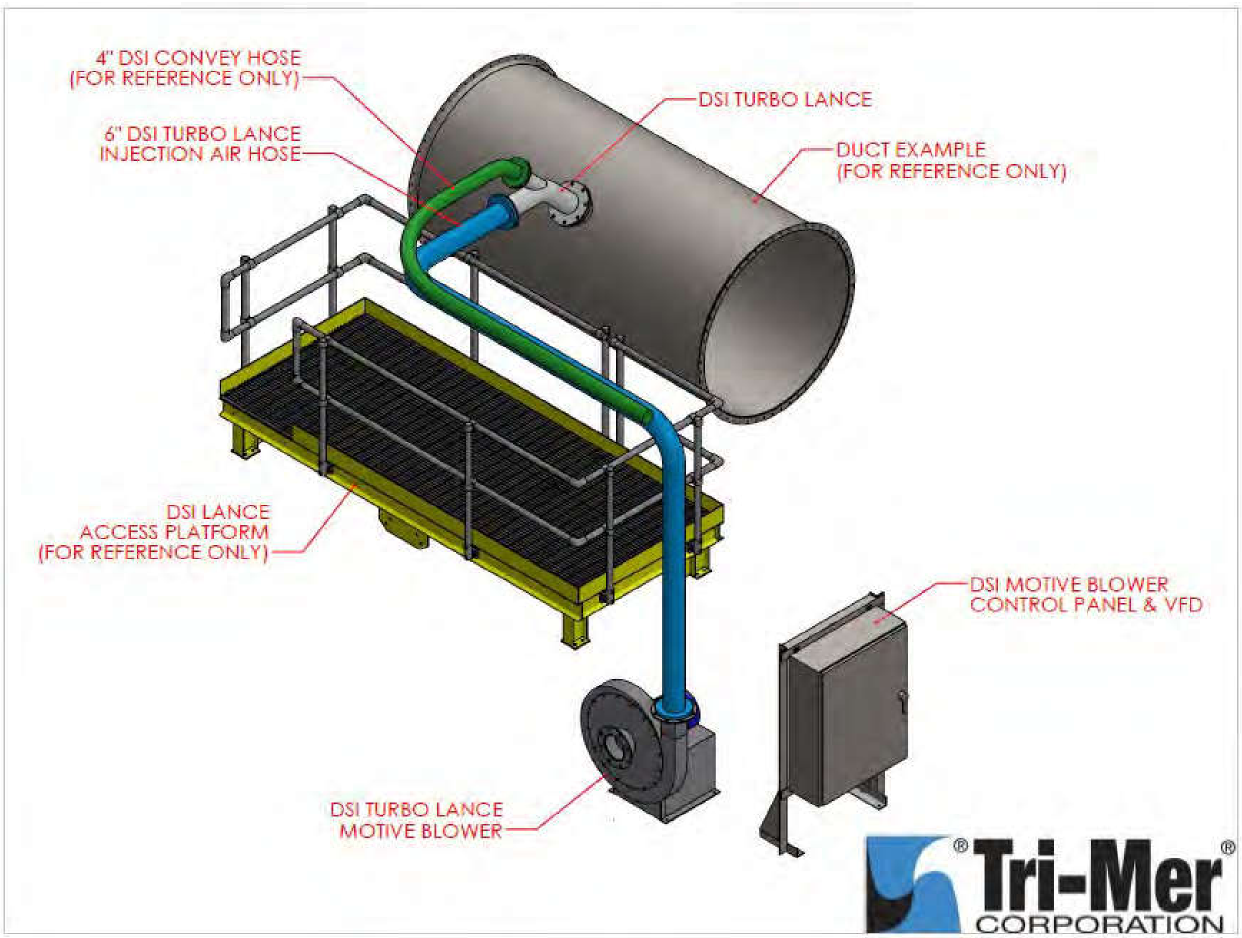

04
05
BAGHOUSE
101
06
06
07
DROP ZONE

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 plum. This instant dispersion of the sorbent forms the basis of an improved inflight reaction. In comparison to conventional lance injection technology, improvement of inflight SO_2 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.

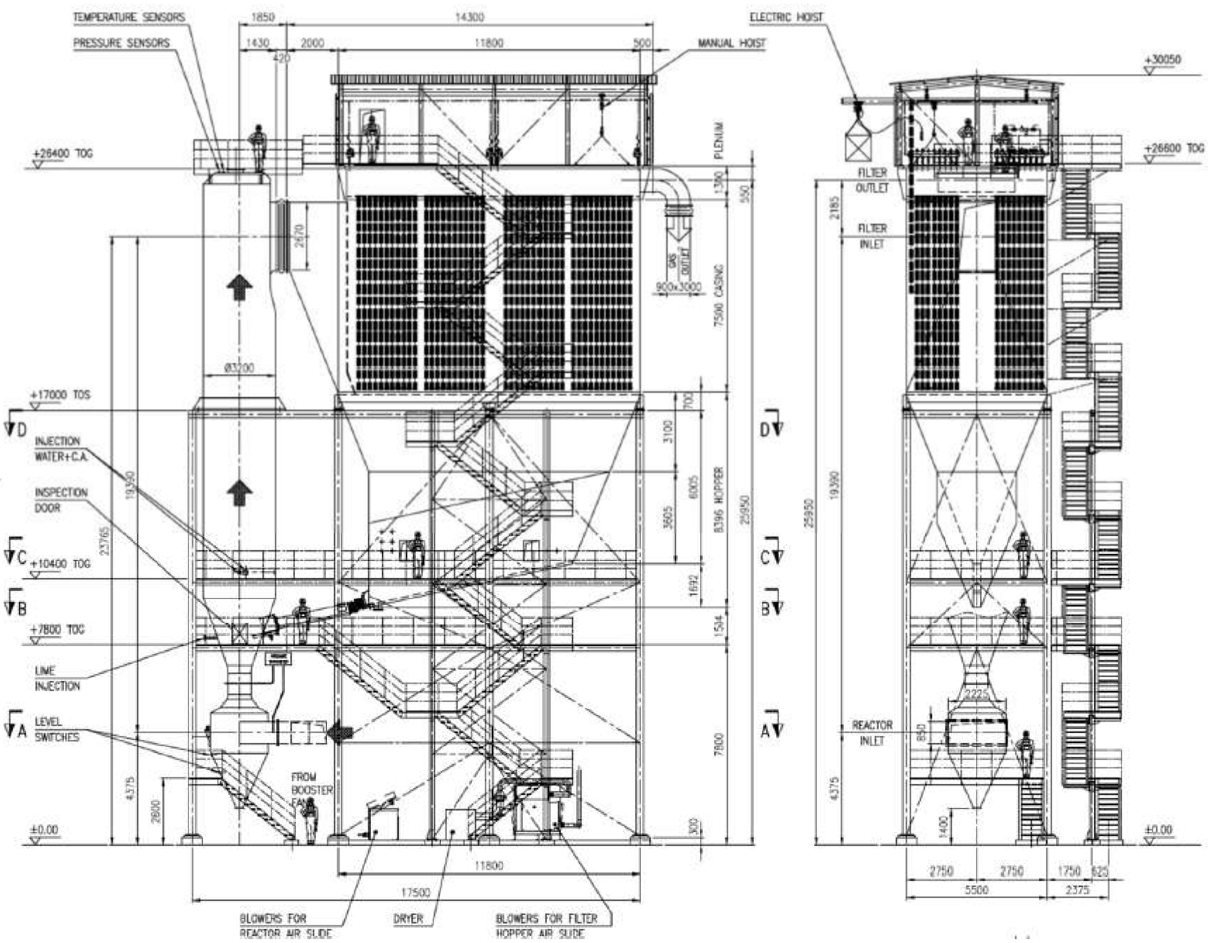


RECIRCULATING DRY SCRUBBER (RDS)

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.

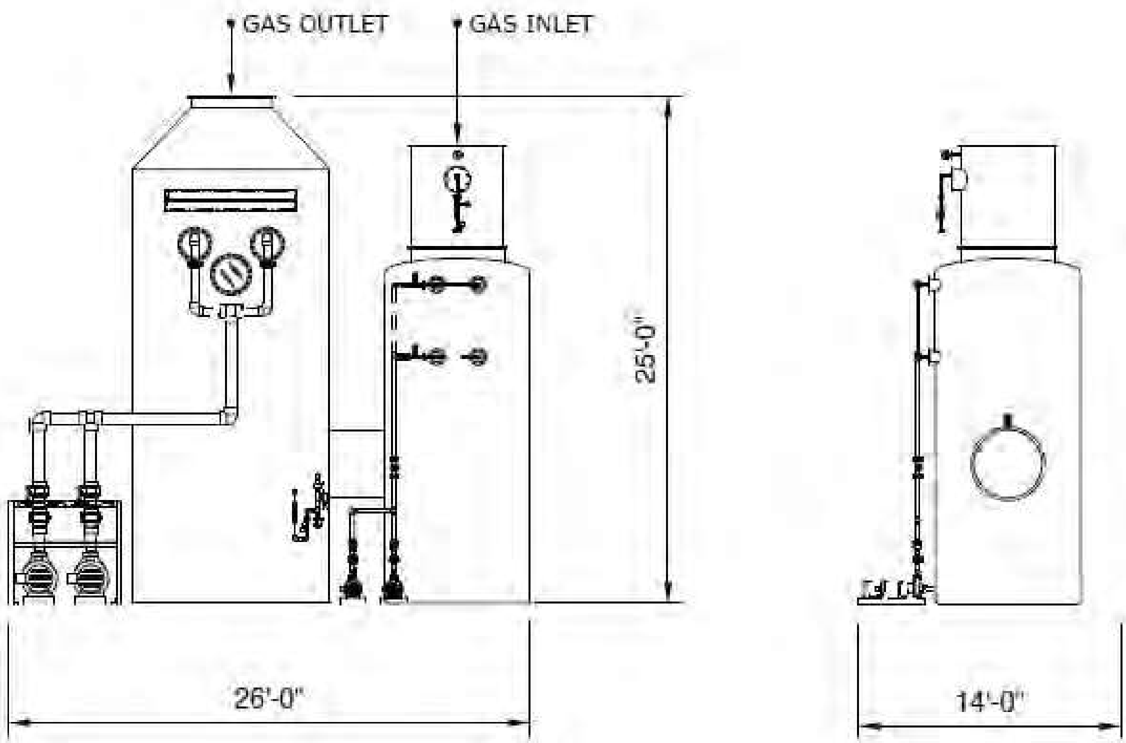


CAUSTIC SODA WET SCRUBBER (CSWS)

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 SO_2 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 sodium bicarbonate and back-flowing sodium 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

<u>SORBENT SUPPLY</u>

Sodium bicarbonate supply consist of one (1) 3,700 cft silo with one (1) volumetric feeder upstream of one (1) mill (optional). The pre-milled sodium bicarbonate will be pneumatically transported to the injection location suitable to meet the minimum injection temperature of 275°F.

<u>REACTORS</u>

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.

<u>DUST COLLECTION AND RECIRCULATION SYSTEM</u>

The dust collection system will consist of one (1) dilute phase 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 pneumatically recirculated to the injection point of the back-flowing sodium products into the inlet duct. 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 SO_2 to the required emission at stack we designed a proprietary SorbSaver Pro injection system, which will inject the pre-milled sodium bicarbonate 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

Sodium bicarbonate supply consist of one (1) 3,700 cft silo with one (1) volumetric feeder upstream of one (1) mill (optional). The pre-milled sodium bicarbonate will be pneumatically transported to the injection location suitable to meet the minimum injection temperature of 275°F.

SORBSAVER PRO INJECTOR

The SorbSaver Pro injector will be mounter on the outside of the duct. 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

<u>QUENCH COLUMNS</u>

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

<u>VERTICAL FLOW (V/F) PACKED BED SCRUBBER</u>

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.

<u>EXHAUST BLOWER</u>

(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.

<u>EXHAUST STACK</u>

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

<u>CHEMICAL FEED PUMP ASSEMBLY</u>

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.

<u>INTERCONNECTING DUCTWORK</u>

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]	40 kW	244 kW	310 kW
Water	-	-	16 gpm	44 gpm
Compressed air[2]	62 scfm	-	292 scfm	-
Hydrated lime	-	-	144 lb/hr	-
Sodium bicarbonate[3]	160 lb/hr	130 lb/hr	-	-
Ash	2,800 lb/hr	2,770 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] Sodium bicarbonate might have to be milled on site (mill is not included in scope), if pre-milled qualities are not available

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
Sorbent mill (excluded from TMC supply). It is suggested to test pre-milled SBC in the first place.	X	X	-	-
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. Additional revisions may be completed at an additional cost of $125 per hour.	X	X	X	X
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____________ $981,205**

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.

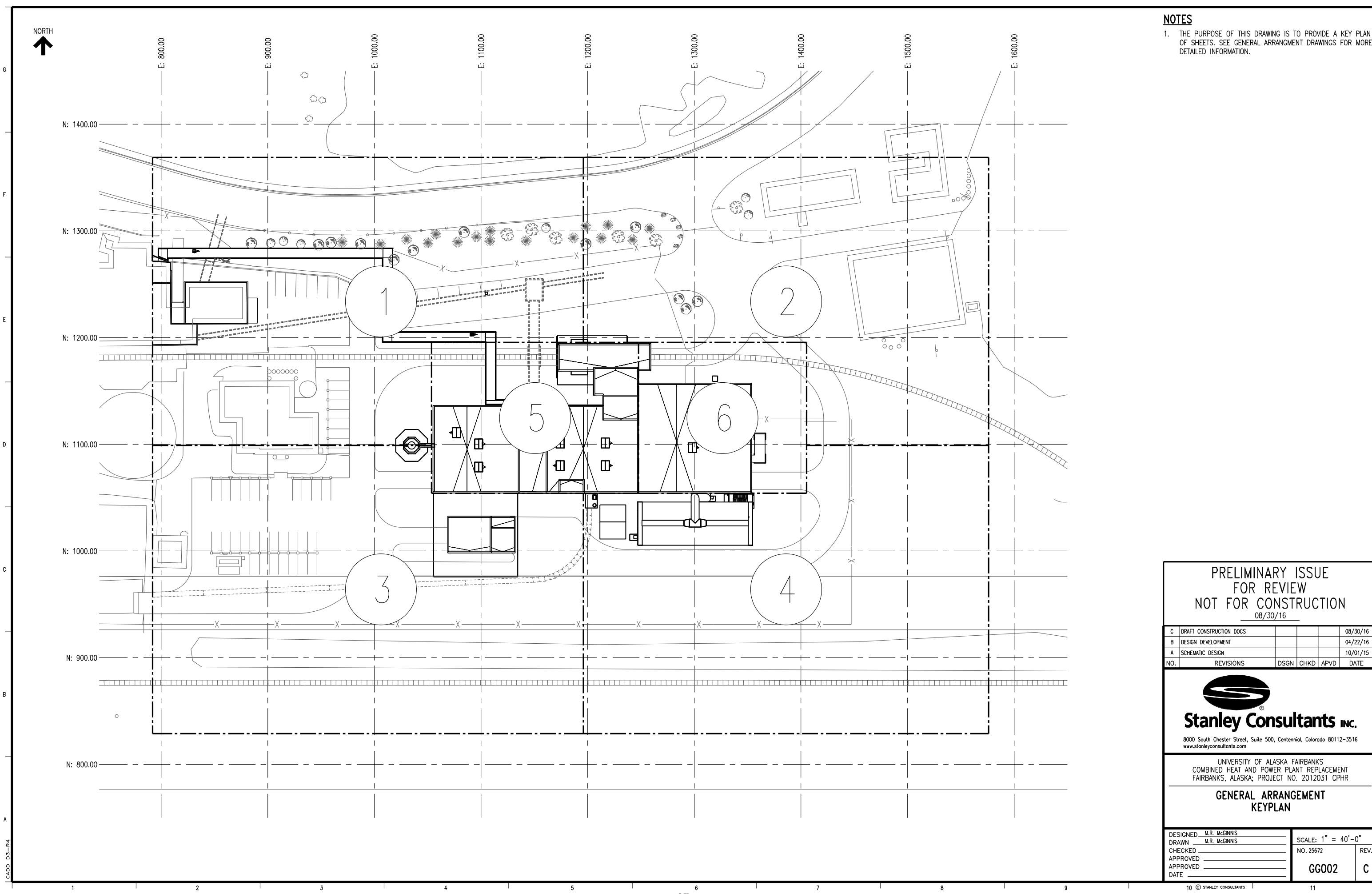
After reviewing the attached information, could you please call me to discuss. We look forward to hearing from you.

Mark

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

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


NORTH
NOTES
1. THE PURPOSE OF THIS DRAWING IS TO PROVIDE A KEY PLAN OF SHEETS. SEE GENERAL ARRANGMENT DRAWINGS FOR MORE DETAILED INFORMATION.
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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
KEYPLAN
DESIGNED M.R. McGINNIS
DRAWN M.R. McGINNIS
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APPROVED
APPROVED
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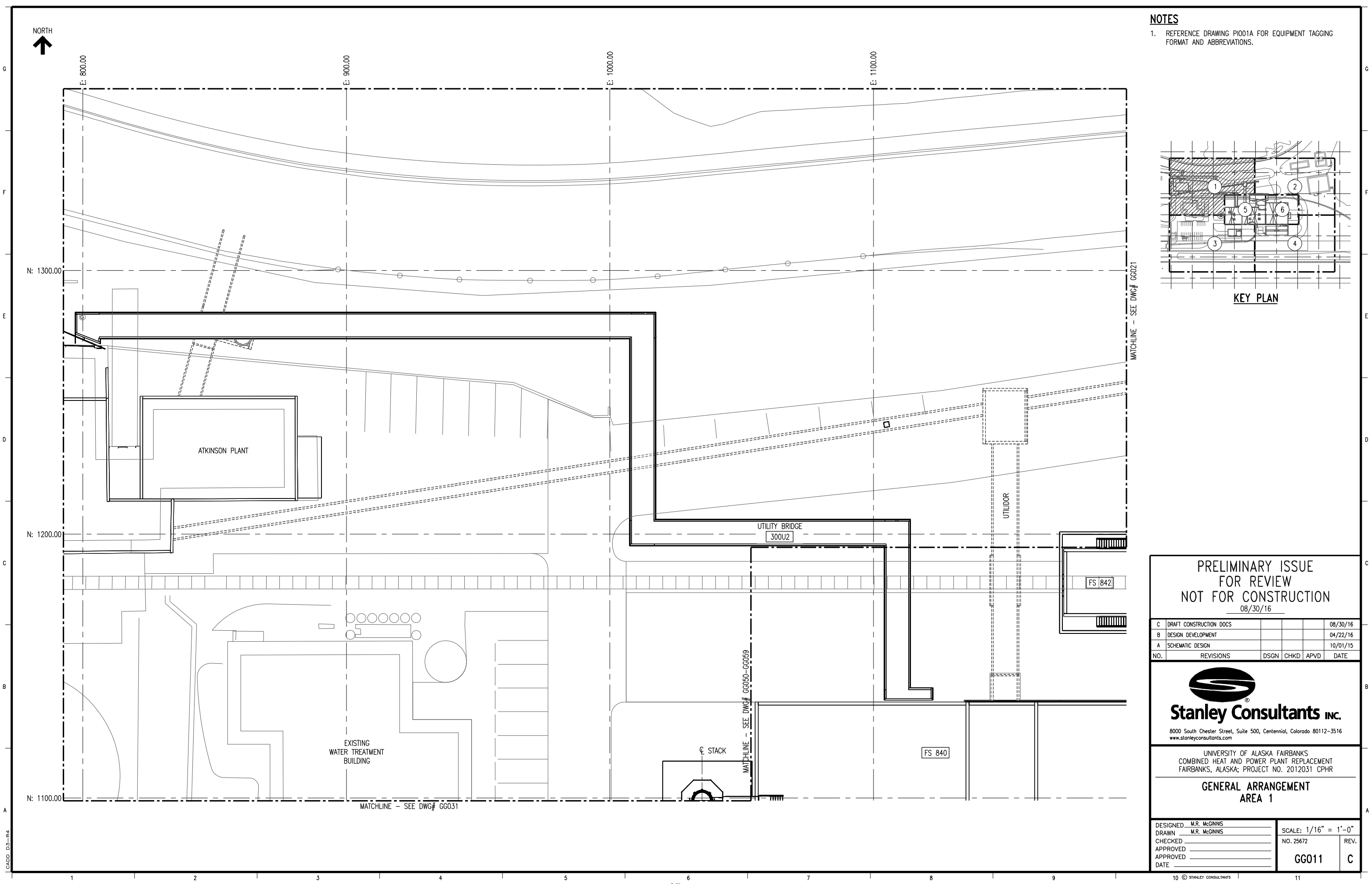
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ATKINSON PLANT
UTILITY BRIDGE
300U2
UTILIDOR
FS 842
FS 840
EXISTING WATER TREATMENT BUILDING
℄ STACK
MATCHLINE – SEE DWG# GG021
MATCHLINE – SEE DWG# GG031
MATCHLINE – SEE DWG# GG050-GG059
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COMBINED HEAT AND POWER PLANT REPLACEMENT
FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPHR
GENERAL ARRANGEMENT
AREA 1
DESIGNED M.R. McGINNIS
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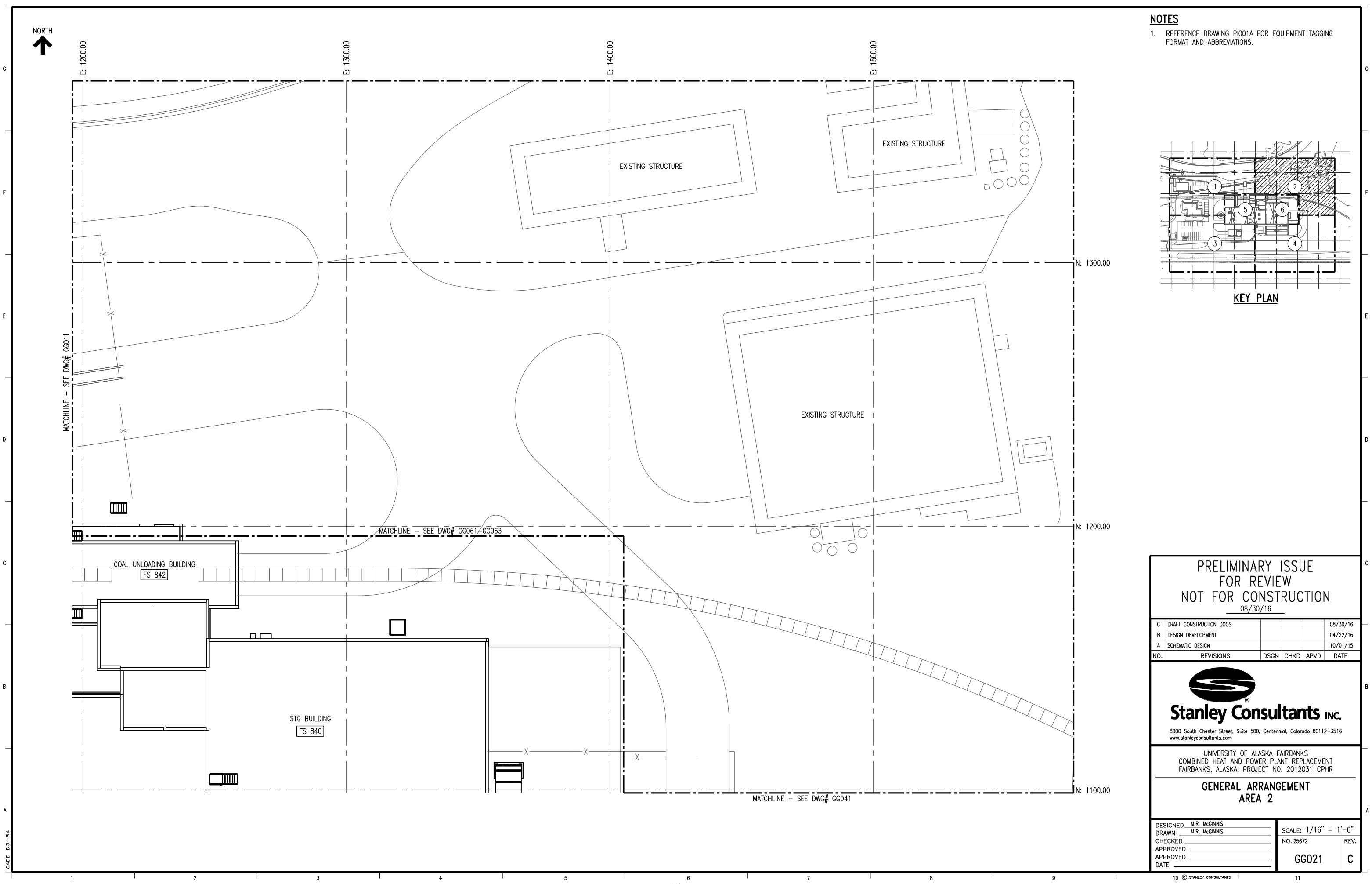
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MATCHLINE - SEE DWG# GG061-GG063
MATCHLINE - SEE DWG# GG041
COAL UNLOADING BUILDING
FS 842
STG BUILDING
FS 840
KEY PLAN
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A SCHEMATIC DESIGN 10/01/15
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COMBINED HEAT AND POWER PLANT REPLACEMENT
FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPHR
GENERAL ARRANGEMENT
AREA 2
DESIGNED M.R. McGINNIS
DRAWN M.R. McGINNIS
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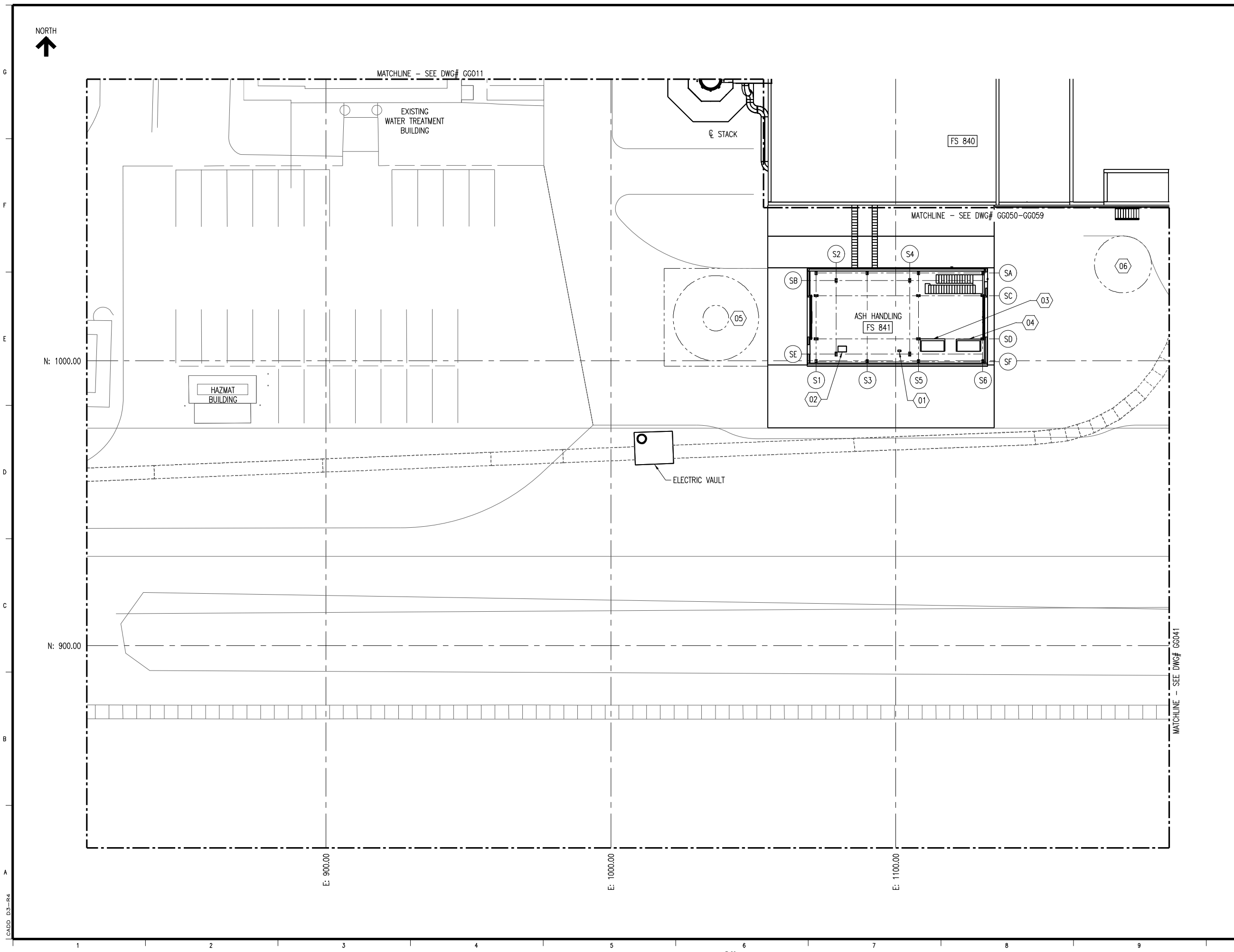

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02 ASH SILO TRUCK UNLOADING PANEL, 31-AHS-PNL-002
03 VACUUM PRODUCER, AHS-SKD-001
04 VACUUM PRODUCER, AHS-SKD-002
05 FUTURE ASH SILO
06 FUTURE BIO MASS SILO

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A	SCHEMATIC DESIGN				10/01/15

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

GENERAL ARRANGEMENT
AREA 3
ASH HANDLING FIRST FLOOR

DESIGNED M.R. McGINNIS
DRAWN M.R. McGINNIS
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APPROVED
APPROVED
DATE

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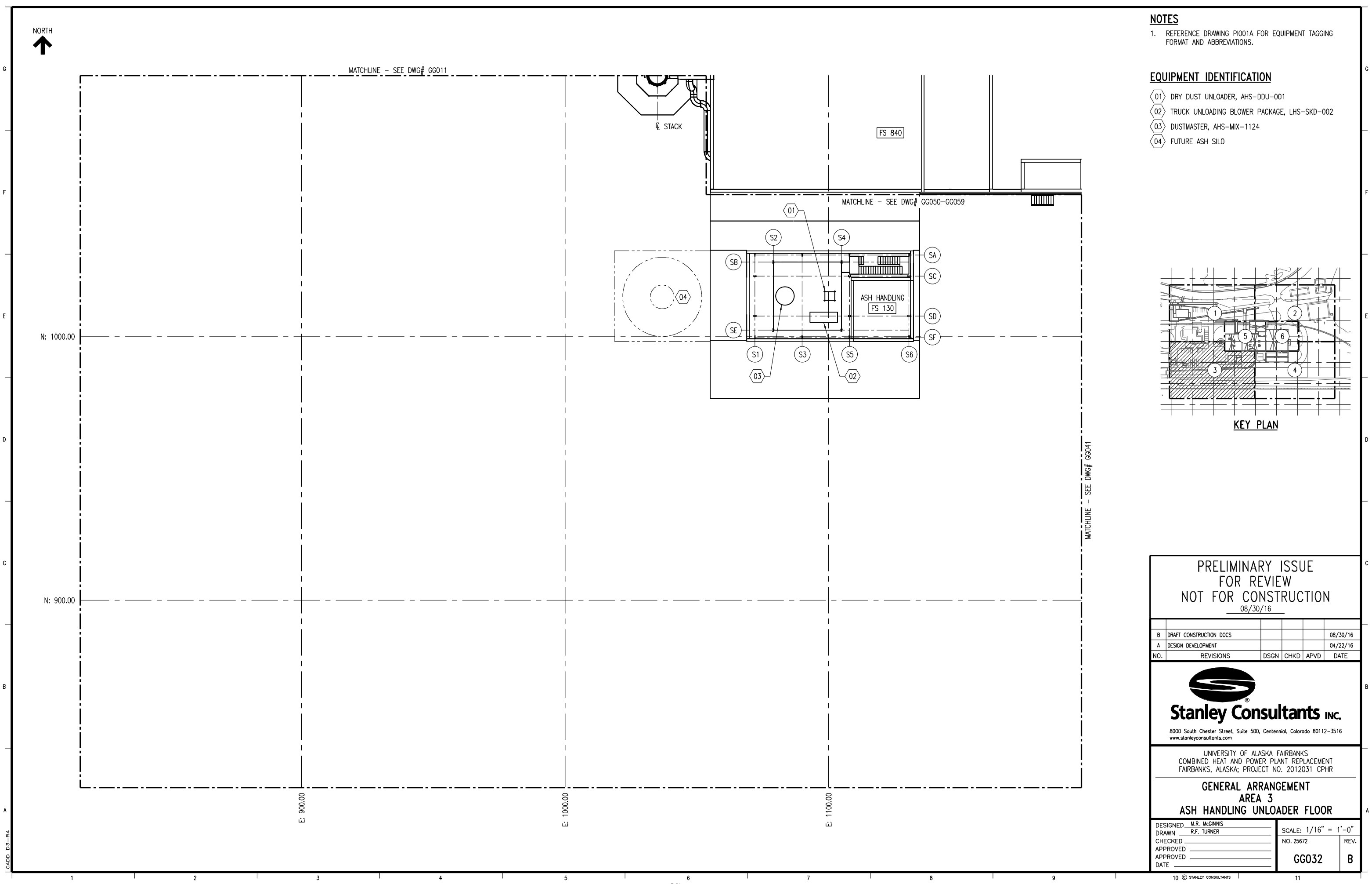
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02 TRUCK UNLOADING BLOWER PACKAGE, LHS-SKD-002
03 DUSTMASTER, AHS-MIX-1124
04 FUTURE ASH SILO
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FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPHR
GENERAL ARRANGEMENT
AREA 3
ASH HANDLING UNLOADER FLOOR
DESIGNED M.R. McGINNIS
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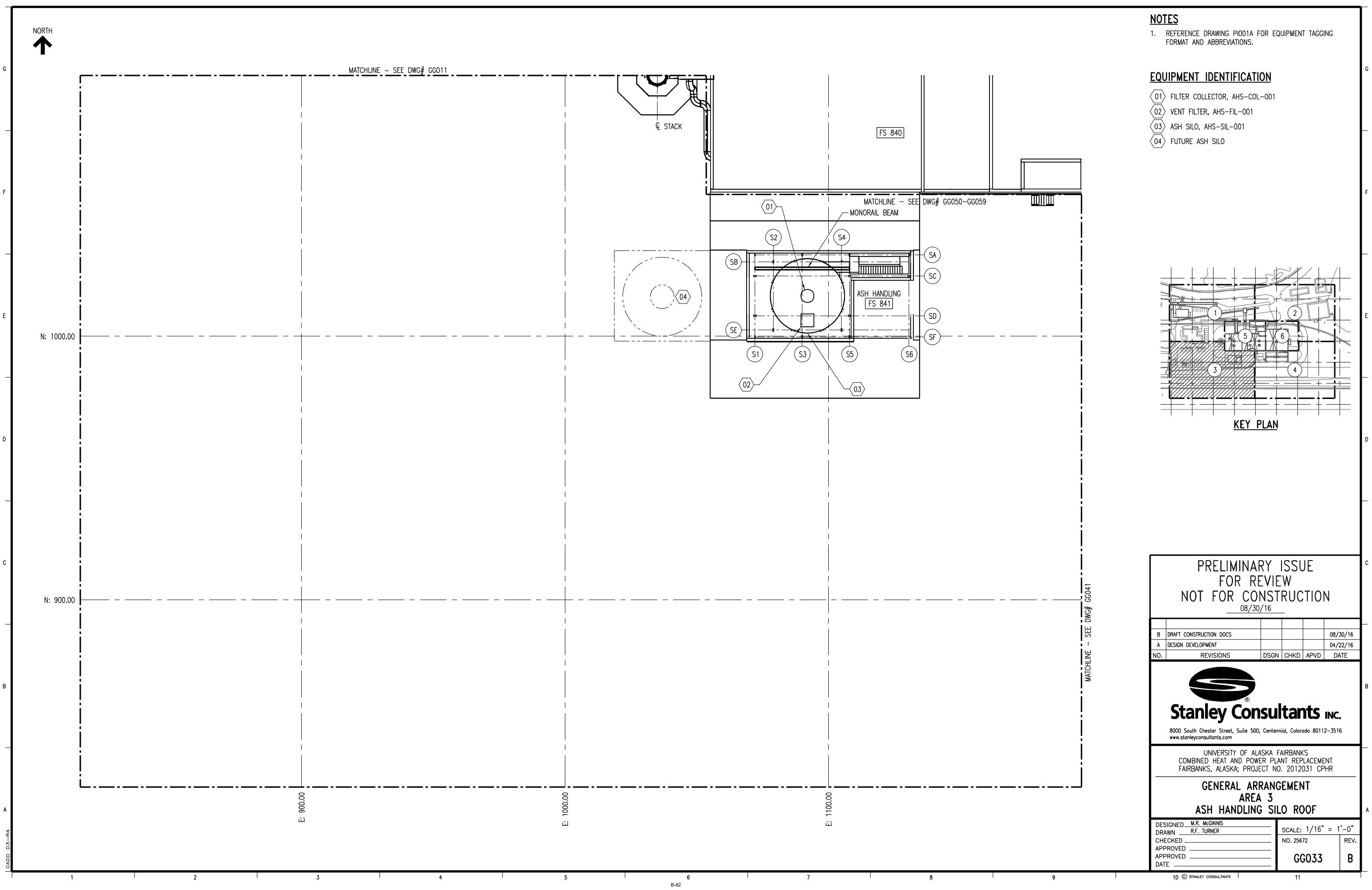

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02 VENT FILTER, AHS-FIL-001
03 ASH SILO, AHS-SIL-001
04 FUTURE ASH SILO
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GENERAL ARRANGEMENT
AREA 3
ASH HANDLING SILO ROOF
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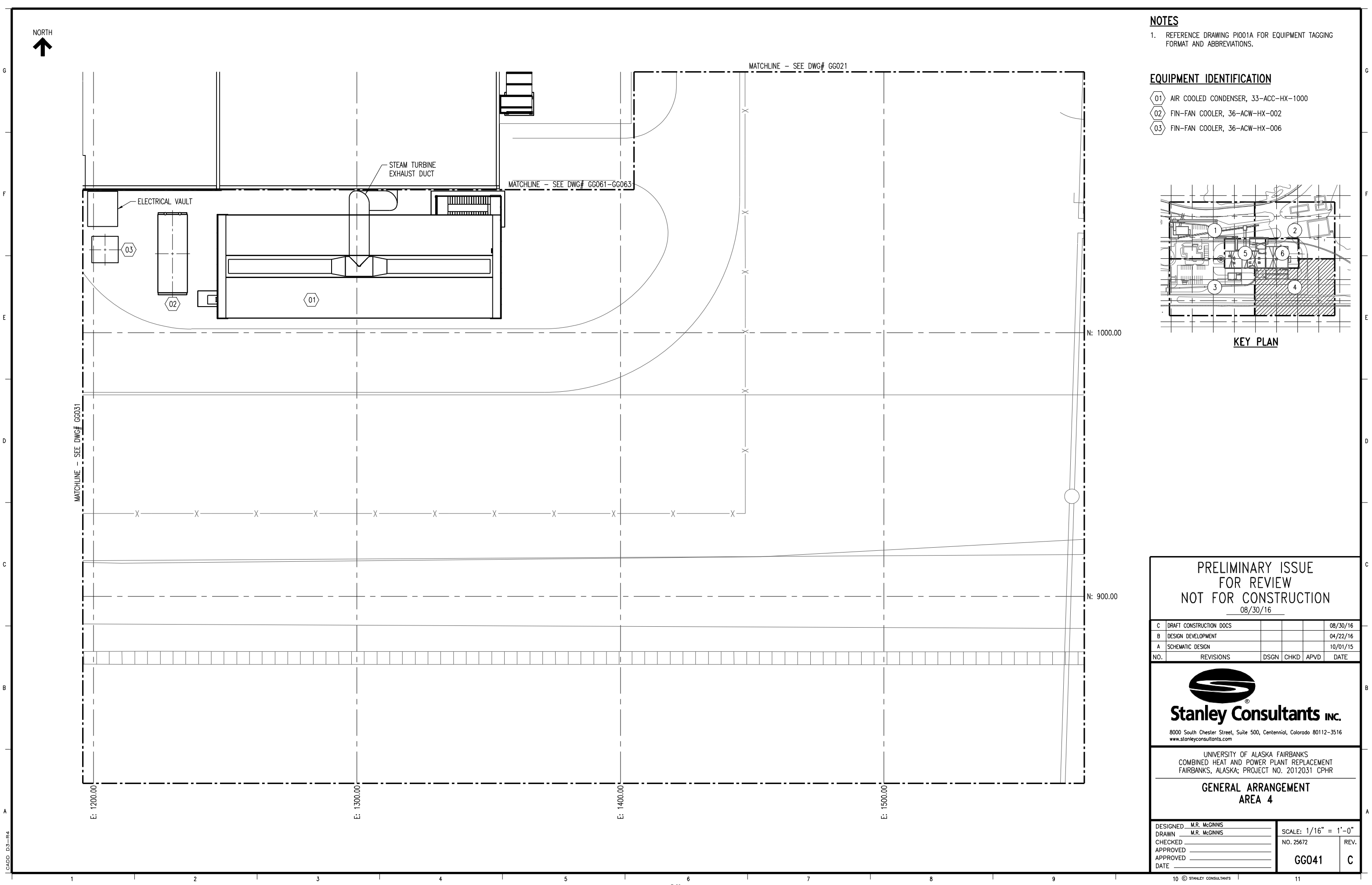
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ELECTRICAL VAULT
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A SCHEMATIC DESIGN 10/01/15
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Stanley Consultants INC.
8000 South Chester Street, Suite 500, Centennial, Colorado 80112-3516
www.stanleyconsultants.com
UNIVERSITY OF ALASKA FAIRBANKS
COMBINED HEAT AND POWER PLANT REPLACEMENT
FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPHR
GENERAL ARRANGEMENT
AREA 4
DESIGNED M.R. McGINNIS
DRAWN M.R. McGINNIS
CHECKED
APPROVED
APPROVED
DATE
SCALE: 1/16" = 1'-0"
NO. 25672
GG041
REV. C
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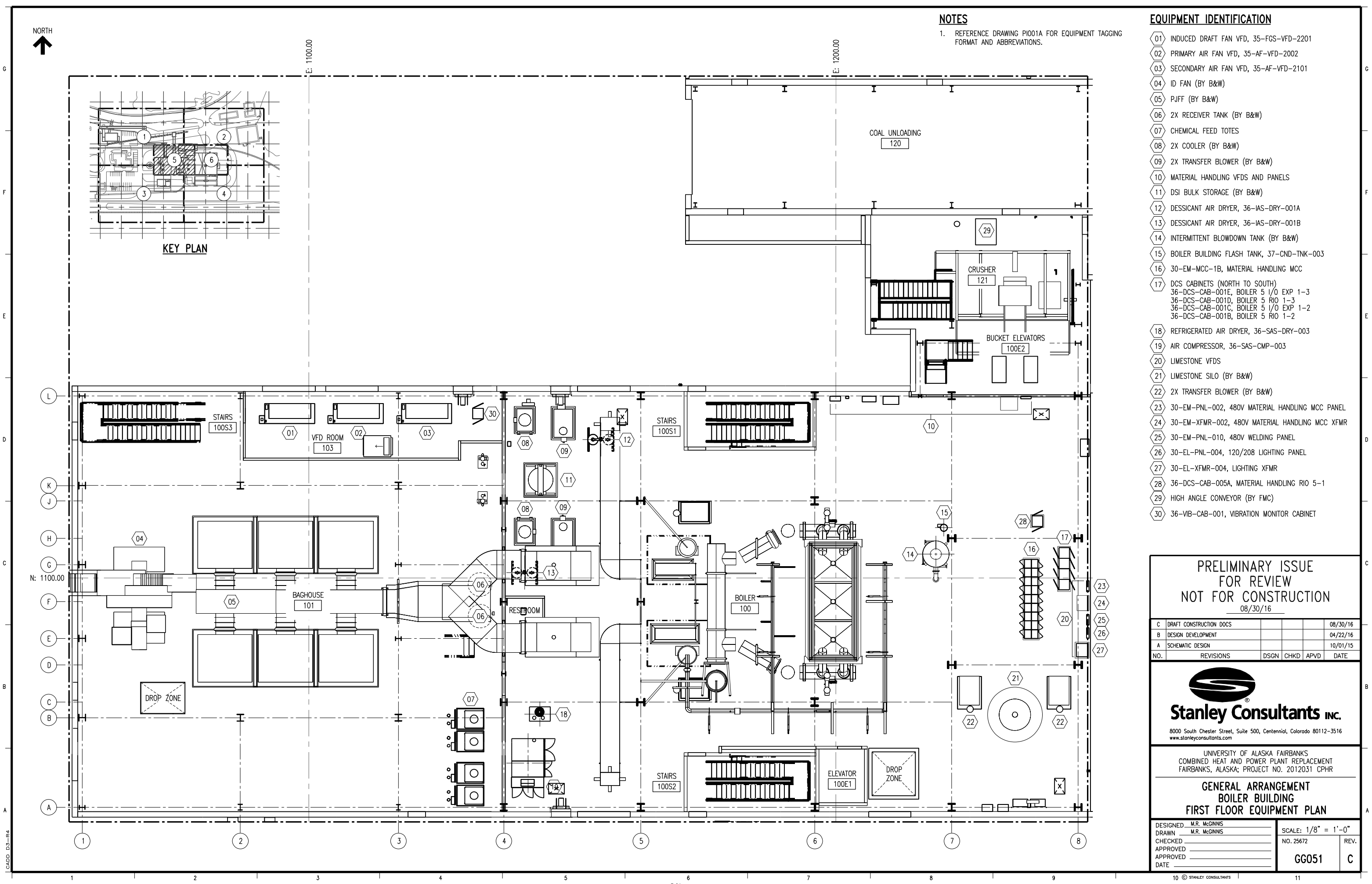
B-83


NORTH
KEY PLAN
NOTES
1. REFERENCE DRAWING PI001A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.
EQUIPMENT IDENTIFICATION
01 INDUCED DRAFT FAN VFD, 35-FGS-VFD-2201
02 PRIMARY AIR FAN VFD, 35-AF-VFD-2002
03 SECONDARY AIR FAN VFD, 35-AF-VFD-2101
04 ID FAN (BY B&W)
05 PJFF (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-IAS-DRY-001A
13 DESSICANT AIR DRYER, 36-IAS-DRY-001B
14 INTERMITTENT BLOWDOWN TANK (BY B&W)
15 BOILER BUILDING FLASH TANK, 37-CND-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-XFMR-002, 480V MATERIAL HANDLING MCC XFMR
25 30-EM-PNL-010, 480V WELDING PANEL
26 30-EL-PNL-004, 120/208 LIGHTING PANEL
27 30-EL-XFMR-004, LIGHTING XFMR
28 36-DCS-CAB-005A, MATERIAL HANDLING RIO 5-1
29 HIGH ANGLE CONVEYOR (BY FMC)
30 36-VIB-CAB-001, VIBRATION MONITOR CABINET
E: 1100.00
E: 1200.00
N: 1100.00
COAL UNLOADING 120
CRUSHER 121
BUCKET ELEVATORS 100E2
STAIRS 100S3
VFD ROOM 103
STAIRS 100S1
BAGHOUSE 101
RESTROOM
BOILER 100
DROP ZONE
STAIRS 100S2
ELEVATOR 100E1
DROP ZONE
PRELIMINARY ISSUE
FOR REVIEW
NOT FOR CONSTRUCTION
08/30/16
C DRAFT CONSTRUCTION DOCS 08/30/16
B DESIGN DEVELOPMENT 04/22/16
A SCHEMATIC DESIGN 10/01/15
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COMBINED HEAT AND POWER PLANT REPLACEMENT
FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPHR
GENERAL ARRANGEMENT
BOILER BUILDING
FIRST FLOOR EQUIPMENT PLAN
DESIGNED M.R. McGINNIS
DRAWN M.R. McGINNIS
CHECKED
APPROVED
APPROVED
DATE
SCALE: 1/8" = 1'-0"
NO. 25672
GG051
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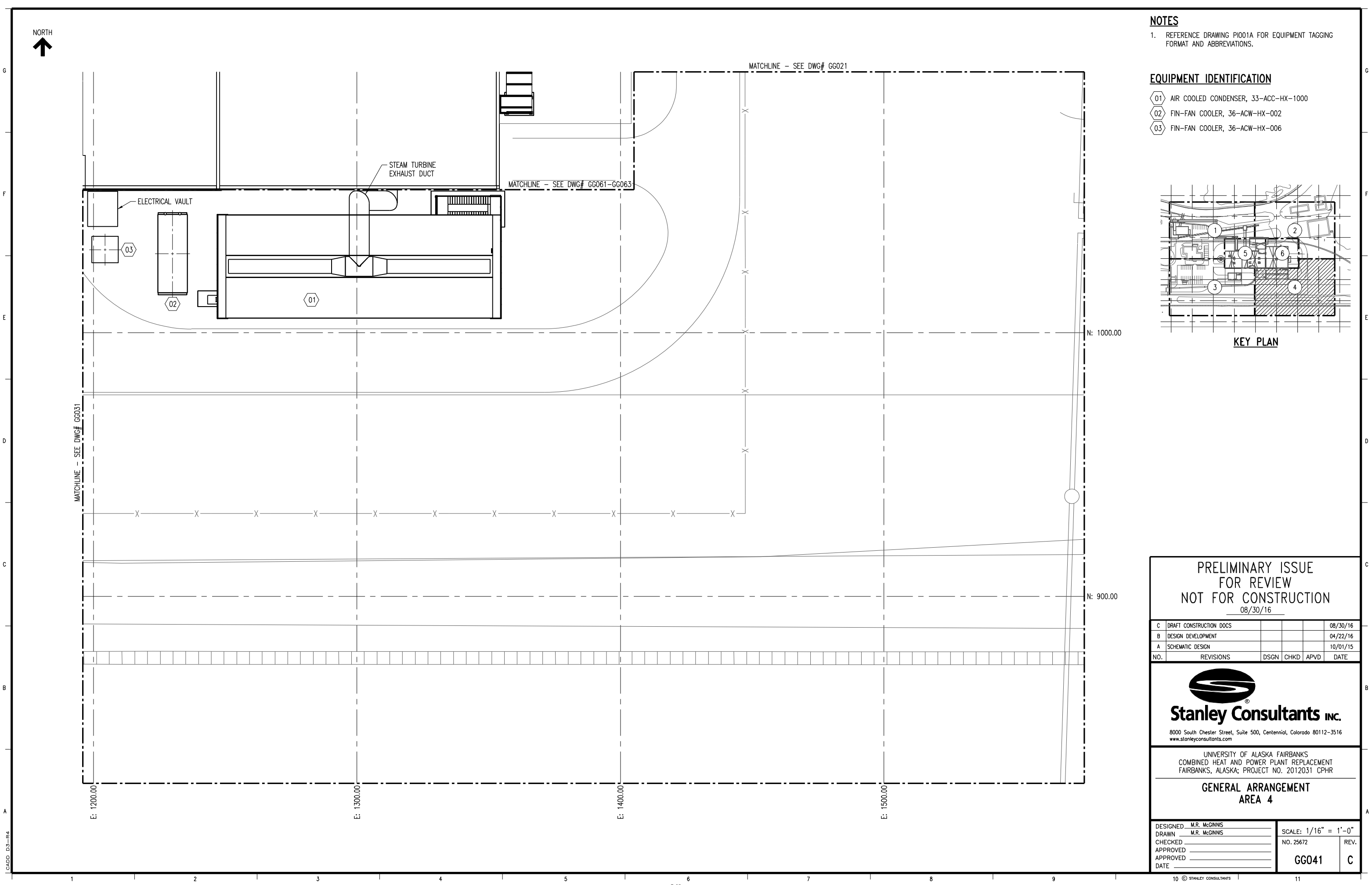

NORTH
NOTES
1. REFERENCE DRAWING PI001A FOR EQUIPMENT TAGGING FORMAT AND ABBREVIATIONS.
EQUIPMENT IDENTIFICATION
01 AIR COOLED CONDENSER, 33-ACC-HX-1000
02 FIN-FAN COOLER, 36-ACW-HX-002
03 FIN-FAN COOLER, 36-ACW-HX-006
KEY PLAN
MATCHLINE - SEE DWG# GG021
MATCHLINE - SEE DWG# GG061-GG063
MATCHLINE - SEE DWG# GG031
STEAM TURBINE EXHAUST DUCT
ELECTRICAL VAULT
N: 1000.00
N: 900.00
E: 1200.00
E: 1300.00
E: 1400.00
E: 1500.00
PRELIMINARY ISSUE
FOR REVIEW
NOT FOR CONSTRUCTION
08/30/16
C DRAFT CONSTRUCTION DOCS 08/30/16
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GG041
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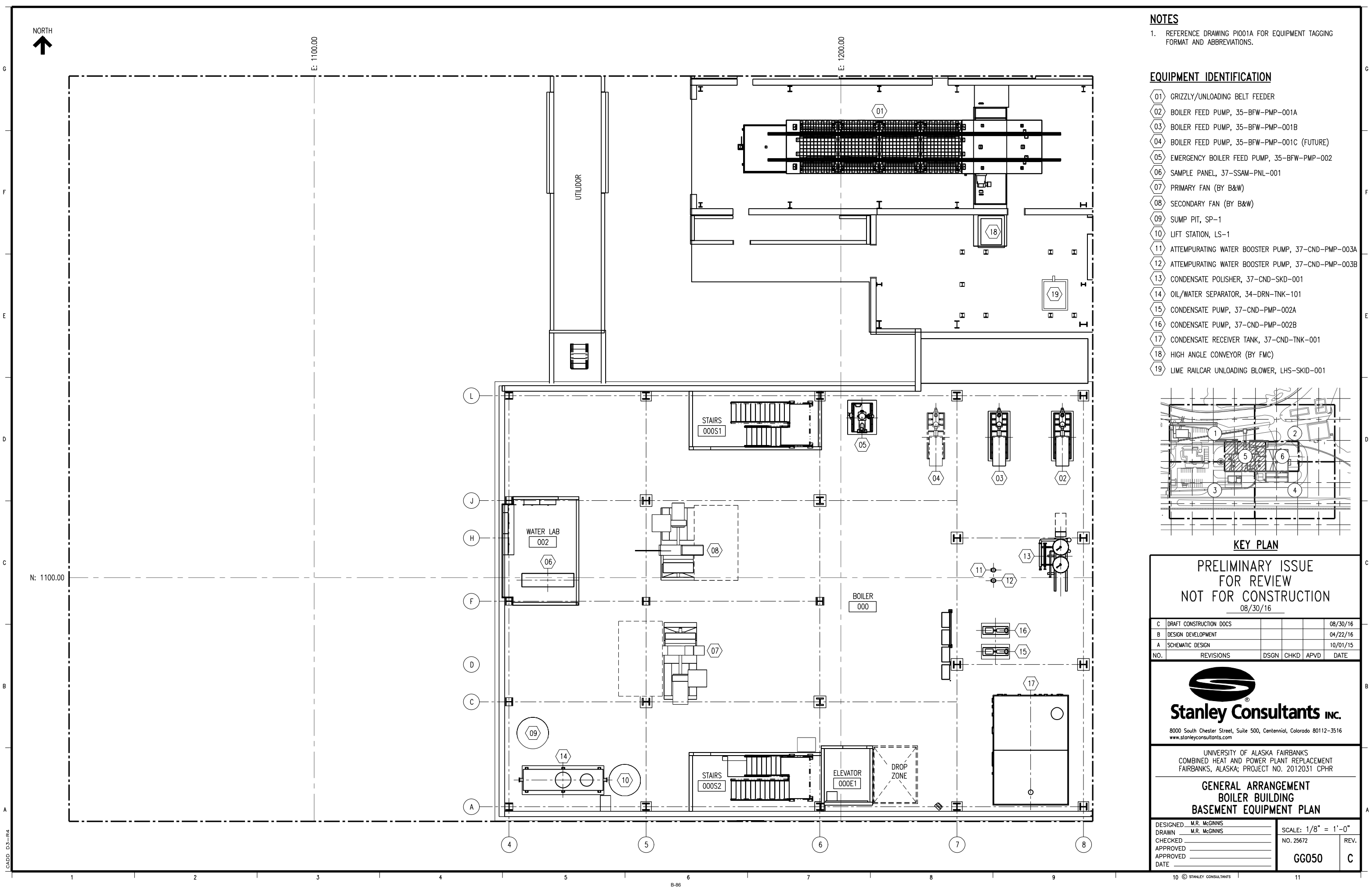
B-85


NORTH
E: 1100.00
E: 1200.00
N: 1100.00
UTILIDOR
STAIRS
000S1
STAIRS
000S2
WATER LAB
002
BOILER
000
ELEVATOR
000E1
DROP ZONE
NOTES
1. REFERENCE DRAWING PI001A 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-DRN-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 LIME RAILCAR UNLOADING BLOWER, LHS-SKID-001
KEY PLAN
PRELIMINARY ISSUE
FOR REVIEW
NOT FOR CONSTRUCTION
08/30/16
C DRAFT CONSTRUCTION DOCS 08/30/16
B DESIGN DEVELOPMENT 04/22/16
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FAIRBANKS, ALASKA; PROJECT NO. 2012031 CPHR
GENERAL ARRANGEMENT
BOILER BUILDING
BASEMENT EQUIPMENT PLAN
DESIGNED M.R. McGINNIS
DRAWN M.R. McGINNIS
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DATE
SCALE: 1/8" = 1'-0"
NO. 25672
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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_2O		<5 (est)
Baghouse including manifolds, one module off line	In. H_2O		≤6 (est)
Ductwork, inlet[(1)]	In. H_2O		0.3 (est)
Ductwork, outlet [(1)]	In. H_2O		0.3 (est)
Baghouse bypass duct	In. H_2O		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:			50 (est)
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):			

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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 membrance
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		
FUEL ANALYSIS		DESIGN
AREA	MINE	USIBELLI
	STATE/PROVINCE	HEALY, AK
	COUNTRY	USA
PROXIMATE ANALYSIS	% BY	WT
	TOTAL MOIST.	28.50
	VOL. MATTER	36.00
	FIXED CARBON	26.50
	ASH	9.00
	TOTAL	100.00
ULTIMATE ANALYSIS	% BY	WT
	ASH	9.00
	H2O	28.50
	C	43.75
	H2	3.12
	N2	0.50
	S	0.20
	O2	14.93
	MERCURY, dry	< 0.07 mg/g
	FLOURINE, dry	< 81 mg/g
	CHLORINE, dry	< 18 mg/g
	TOTAL	100.00
	HHV, BTU/LB	7,560
SORBENT CHARACTERISTICS		
LIMESTONE ANALYSIS		DESIGN
ANALYSIS	% BY	WT
	CaCO3	95.00
	MgCO3	0.90
	SiO2	3.30
	H2O	0.80
	TOTAL	100.00

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 ARRG'T DRAWINGS B0312851 & B0312852

(3) BAROMETRIC PRESSURE = 29.40 IN HG 0.009 LB H_2O PER LB COMBUSTION AIR

(4) SPRAY WATER PRESSURE AT EXPECTED OPERATING CONDITIONS, FURTHER UPSET PERFORMANCE TO BE PROVIDED LATER

LOAD CONDITION			MCR	70%	40%	33%
STEAM LEAVING SH, MLB/HR			240.0	168.0	96.0	80.0
TYPE OF FUEL			Coal	Coal	Coal	Coal
EXCESS AIR LEAVING ECONOMIZER, %			15	15	66	102
NO. OF BURNERS IN OPERATION			0	0	0	0
OUTPUT PER PTC 4-2013, MKB/HR			253.4	177.4	100.1	95.3
FUEL INPUT, MKB/HR			295.6	206.0	118.8	118.0
QUANTITY, MLB/HR	FUEL FLOW		39.1	27.3	15.7	15.6
	FLUE GAS ENTERING AIR HEATER		284.7	199.0	157.8	187.0
	FLUG GAS ENTERING STACK (ACFM)		89,832	61,165	50,217	65,748
	TOTAL AIR TO BURNING EQUIPMENT		246.7	172.0	141.2	170.5
	SECONDARY AIR LEAVING AH		117.1	64.9	17.8	21.8
	PRIMARY AIR LEAVING AH		117.1	97.3	115.3	140.3
	AIR HTR LEAKAGE (TOTAL AIR TO GAS)		1.0	1.4	2.5	2.5
	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
TEMPERATURE - F	STEAM	LEAVING SUPERHEATER	750	750	728	760
	WATER	ENTERING ECONOMIZER	350	350	350	260
	FLUE GAS	LEAVING AH (EXCL. LKG)	285	260	285	350
		ENTERING STACK	289	265	288	354
	AIR	ENTERING PRI. AIR FAN (1)	77	88	111	123
		ENTERING SEC. AIR FAN (1)	77	77	77	77
		LEAVING AIR HEATER (SEC)	335	335	275	337
		LEAVING AIR HEATER (PRI)	335	309	380	508
	FUEL	TO BURNING EQUIPMENT	40	40	40	40
HEAT LOSSES, %	DRY GAS		4.38	3.86	6.02	9.80
	H2 & H2O IN FUEL		8.53	8.45	8.51	8.75
	MOISTURE IN AIR		0.07	0.06	0.10	0.16
	MOISTURE IN SORBENT		0.00	0.00	0.00	0.00
	UNBURNED COMBUSTIBLE IN RESIDUE		0.50	0.50	0.50	0.50
	RADIATION		0.36	0.51	0.91	0.96
	SENSIBLE HEAT IN REFUSE		0.07	0.10	0.09	0.13
	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**
ASME PTC 4-2013 FUEL EFFICIENCY, %			**85.73**	**86.10**	**84.32**	**80.73**

Scope of Work

Project: University of Alaska Fairbanks (UAF) - CHPP Plant AQCS Options forSO2 Control Cost Estimate

PROJECT UNDERSTANDING

Stanley is preforming 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

Tri-Mer CORPORATION
Air Pollution Control Systems

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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 "lest 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 verifyabl

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

Wood Group WFGD Email

Jahn, Mario

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Monday, June 6, 2022 12:17 PM
To: Jahn, Mario
Cc: Meeker, Lance; Solan, John
Subject: RE: SO2 removal system quotation

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

Hello Mario.. Sorry for the delay in our reply…

Our office is extremely busy at the current time… we have been trying to fit this one in (it would take a few business days to provide the requested budgetary pricing), however we must prioritize active projects with firm 2022 / 2023 award dates. Unfortunately, our proposal team is booked with bidding activity thru early July.

We do maintain interest in this project as the technologies fit well withing our product portfolio, however we just cannot support this proposal with our current staffing. Unfortunately, we must decline to bid this opportunity

We apologize for this inconvenience and thank you for reaching out to us

Michael T Hoydick
Director, AQCS Technology & Sales
Mobile1: +1 412 302 2673
Mobile2: +1 412 298 9383
437 Grant Street, Suite 918, Pittsburgh, PA 15219, USA
www.woodplc.com

wood.

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Monday, June 6, 2022 9:52 AM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation
Importance: High

CAUTION: External email. Please do not click on links/attachments unless you know the content is genuine and safe.

Michael/Lance,

Can either one of you provide an update on this pricing? I think the last time we chatted was nearly 3 weeks ago.

Thanks in advance for your help.

Regards,
Mario

From: Jahn, Mario
Sent: Tuesday, May 31, 2022 7:04 AM
To: 'Hoydick, Michael' <Michael.Hoydick@woodplc.com>
Cc: 'Meeker, Lance' <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation
Importance: High

Good Morning Michael and Lance,

I hope the both of you had a good holiday weekend. I wanted to check in to see how things were progressing on your end for AQCS pricing for our project in Alaska. Can you provide an update?

Regards,
Mario

From: Jahn, Mario
Sent: Monday, May 23, 2022 8:00 AM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

Michael/Lance,

I wanted to see how things are going on your end with regards to AQCS equipment pricing for our project in Fairbanks, Alaska. Let me know if you can provide an update.

Best 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: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Thursday, May 12, 2022 6:54 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

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

Tomorrow 11 CST works for us…

Mike

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, May 11, 2022 5:24 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>; Hoydick, Michael <Michael.Hoydick@woodplc.com>

Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

CAUTION: External email. Please do not click on links/attachments unless you know the content is genuine and safe.

Michael,

I just left you a voicemail in regards to the previous discussions you've had with Mark and John below on this project in Fairbanks Alaska. It looks like the last communication was about a month ago in setting up a meeting. Do you and your team have time this week to discuss? Please let us know.

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: Fritz, Mark
Sent: Monday, April 18, 2022 2:26 PM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

Mike,

Yes a think a meeting is a good idea to quickly answer your questions. Our availability is is as follows:

1. Tomorrow morning except 11:00-11:30 CST.
2. Tomorrow afternoon after 4:00 CST.
3. Wednesday morning – 9-10, 11-12 all CST
4. Wednesday afternoon after 2:30 CST.

Mark

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Monday, April 18, 2022 2:20 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>; Knapper, Kelly <KnapperKelly@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

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

Hello Kelly / Mark

We have reviewed the information provided and we have some questions / comments

Based on the information provided, it appears that there is an existing boiler / baghouse on this site and it appears that the boiler system already meets the emission requirements (0.2 lb/mmbtu)…

- What type of boiler is this (ie CFB / grate / other?)

- It appears that they inject limestone into the boiler to maintain 0.2 lb SOx emissions. What is the ash composition from the boiler? Usually, with limestone addition, there will be some CaO formed in the boiler that may be usable in an SDA system. Is this information available?
- The existing baghouse is designed for 9.0 lb/mmbtu and results in an emission of 0.3 lb/mmbtu. Can you confirm this assumption?
- What are your emission targets as the boiler w/limestone addition appears to already meet emission levels for SOx. Why do you folks need an upgrade or addition? We know limestone addition to the boiler does not capture halogens too well (ie HCl / Hf). What are your target emission levels for SOx / HCl / Hf / PM? We really cannot tell from the info you provided.

Is is possible to set up a short teams call over the next day or two? Let me know

Mike

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, April 13, 2022 3:26 PM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>; Knapper, Kelly <KnapperKelly@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

CAUTION: External email. Please do not click on links/attachments unless you know the content is genuine and safe.

Mike,

See attached for RFQ.

We can discuss after your review. To answer your questions from below:

The pricing is budgetary. Our schedule assume vendor quotes in by the end of May, but we can work with you as far what you can support.

Thanks,

Mark

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

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Tuesday, April 12, 2022 9:06 AM
To: Knapper, Kelly <KnapperKelly@stanleygroup.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

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

Hello Kelly / Mark

Do you folks have any idea on when we may see an RFQ?
Will this be budgetary or Firm for purchase?
Rough schedule?

We are really busy right now and want to give our proposal team a heads up

Thanks

Mike

From: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Sent: Monday, April 11, 2022 3:03 PM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

CAUTION: External email. Please do not click on links/attachments unless you know the content is genuine and safe.

Michael,

That is great to hear. I added Mark Fritz on this email chain, he will be able to get you the RFQ so that we can proceed.

Thank you for the quick response!
Kelly Knapper

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Monday, April 11, 2022 1:52 PM
To: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: SO2 removal system quotation

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

Hello Kelly,

Our Wood group is formerly Wheelabrator Air Pollution control and we do provide both wet and dry FGD systems.

Please forward the RFQ to myself and our proposal manager, Lance Meeker (email attached)

Thank You for reaching out to us

Michael T Hoydick
Director, AQCS Technology & Sales
Mobile1: +1 412 302 2673
Mobile2: +1 412 298 9383
437 Grant Street, Suite 918, Pittsburgh, PA 15219, USA
www.woodplc.com

Hello my name is Kelly Knapper I work for Stanley Consultants. For one of our projects we are looking into different types of SO2 removal for a 30MW boiler in Fairbanks Alaska. Would you be able to provide a quote for a Wet FGD system and SDA system for 0.2 lb/MMBTU of SO2 removal?

Appendix C

Spray Dry Absorber Vendor Data

Andritz SDA 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

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

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

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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 SO_2, 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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

***** 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 SO_2 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 SO_2 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 SO_2 emissions rate is required but guarantees below about 0.06 #/MMBTU for SO_2 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 SO_2 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 SO_2. 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 SO_2 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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

Harald,

No problem. It had been a while since we talked and I wanted to touch base to see if there had been an 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

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

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

CAUTION: External email. Do not click on links or open attachments unless you know the sender and that the content is safe.

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

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

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 clraifications:

- 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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Thank you

B&W SDA 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
Follow Us on Social Media
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

Mark,

The Babcock & Wilcox Company (B&W) is pleased to offer Proposal P-082524 to perform an engineering review of the available SO_2 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

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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

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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 SO_2 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 SO_2 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

GEA SDA Email

Jahn, Mario

From: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Tuesday, May 31, 2022 8:36 AM
To: Jahn, Mario
Cc: Solan, John
Subject: RE: UAF BACT - Stanley Consultants

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

Hello, Mario. Funny timing I actually heard back from the project manager just a few minutes after your email. Unfortunately, we will not be able to quote this project at this point. The reason is that the emissions control department is overloaded currently and has made the decision to focus on supporting quotations for projects that are closer in realization timeline. I appreciate you considering GEA and hope you will keep us in mind down the road. Have a great day!

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Tuesday, May 31, 2022 9:00 AM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Good Morning Mitchell,

I hope you had a good holiday weekend. I wanted to check in to see how you were progressing with regards to providing a proposal for our project. Let me know.

Regards,
Mario

From: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Monday, May 23, 2022 8:29 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Hi Mario,

I hope you had a nice weekend. Thanks for the follow up, I just now sent a note to the engineer and will get back to you as soon as I can.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Monday, May 23, 2022 10:25 AM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Good Morning Mitchell,

I wanted to check-in and see how things are going with regards to our project. Have you gotten anything from Engineering yet? Let me know if you can provide an update.

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Tuesday, May 17, 2022 12:23 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Thanks, Jahn. I have passed this along to engineering and will keep you in the loop as they consider the inquiry.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, May 12, 2022 3:42 PM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Mitchell,

I apologize for the misunderstanding on my end. We definitely appreciate you taking a look at this for us.

I don't believe that you guys were ever formally given our RFQ documents. I've attached those. The intent is to stay within the provided technologies, i.e., SDA, CDS, DSI and WFGD. If you can send this to your folks and let me know if you need anything else. This information should be more detailed than the questionnaire.

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Thursday, May 12, 2022 2:51 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

No. I apologize for the misunderstanding please allow me to clarify. We need Stanley to come to GEA with a defined inlet gas stream and tell us what the SO2 reduction target is. We will then use our experience to select the technology best suited for the application. We cannot spend the time and resources to have (just choosing random numbers) 6 different scrubbers designed and quoted when we know that 5 of them will be wasted work. If you know that the end user has a quote evaluation criteria (footprint, efficiency, capex, opex, etc.) we will use that when selecting the technology. Otherwise it is sort of like we are delivering the deliverables of your project without being paid. We are in the business of selling scrubbers not quoting them.

If you insist upon having us quote outside of our standard protocol because the end user absolutely requires it, then we could set up a paid "engineering study" arrangement to get you quotes and data sheets on each of them. This is assuming that the department accepts to enter such an agreement, which is not a guarantee.

I hope this clarifies AND I hope that I am not coming across with any sort of difficult tone. We are more than happy to provide hardware quotations for free, even in the budget setting or BACT phase, but we are not an EPC.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, May 12, 2022 4:42 PM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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Please be cautious, particularly with links and attachments.

Mitchell,

Thanks for your response. We are performing the engineering study on our end and would require budgetary pricing from GEA to help support this effort. Are you saying that you cannot provide budgetary pricing for SO2 removal technologies unless it was under a paid agreement?

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Thursday, May 12, 2022 11:14 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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Hi Mario,

Thank you for your answers, the other thing that I need from you is the process focused questionnaire from my email, I attached it again.

Unfortunately, GEA is not the correct partner for analyzing all of the different scrubbing options for such an EPA study. It is possible we could provide several quotations and data sheets under a paid "engineering study" agreement but I would first have to get buy in from the department manager. We understand of course that budget pricing is required during the funding phase to help support setting project budgets and process targets, and we are happy to help in this way.

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Thursday, May 12, 2022 10:32 AM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Mitchell,

Please see answers in red. Let me know if you need anything else.

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: Keller, Mitchell <Mitchell.Keller@gea.com>
Sent: Wednesday, May 11, 2022 3:43 PM
To: Jahn, Mario <JahnMario@stanleygroup.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: UAF BACT - Stanley Consultants

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

Hello Mario,

Thanks for the call. Looking back through my notes I see the only email chain that was exchanged is the one attached. I essentially need the following questions answered in addition to the attached questionnaire to move forward:

- Who is the end user for this equipment? Site location? University of Alaska at Fairbanks (UAF) own and operates the coal fired facility. The plant is located at the University in Fairbanks. Address: 875 Alumni Drive, Fairbanks AK
- Is this project funded and ready for execution or still in the feasibility study and budgeting phase? Stanley Consultants is currently assisting the University in a BACT analysis. The Plant is located in a "serious" non-attainment area for PM2.5. SO2 is a precursor to PM2.5 so major sources of SO2 are required to perform the BACT analysis.
- Can you explain to me the reason for your request for several different quotations for different technology? GEA provides one quotation for the unit operation that best fits the customer's needs according to our expertise and experience. If your end user is weighing a particular detail more heavily than the others (capex, opex, footprint, efficiency, etc.) please let me know now and we keep that in mind when selecting a technology. As part of the BACT analysis, we are required to evaluate all options for SO2 removal. A technology will be chosen once all factors for Capex/Opex and SO2 removal efficiencies have been evaluated.
- What is the time line for this project? When do you expect to receive a budget quote? Firm quote? Make a purchase decision? Have equipment delivered? Have equipment up and running? We are trying to finalize our BACT analysis by the end of this month. After our analysis, the EPA will evaluate the analysis and make a ruling based on what they believe should be implemented. We expect this to be later this year (~Q4).

I have also attached a brochure for information on GEA. After I get this info back we can set up a conference call to discuss your application. Feel free to reach out with questions!

Best regards,

Mitchell Keller

Regional Sales Manager
Sales
Liquid & Powder Technologies | LPT Execution - NAM/LAM

Email Mitchell.Keller@gea.com
Mobile +1 443 430 5537
Web www.gea.com

GEA INTERNAL

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, May 11, 2022 5:31 PM
To: Keller, Mitchell <Mitchell.Keller@gea.com>
Cc: Solan, John <SolanJohn@stanleygroup.com>
Subject: UAF BACT - Stanley Consultants

THIS MESSAGE IS FROM AN EXTERNAL SENDER

Please be cautious, particularly with links and attachments.

Mitchell,

Thanks for taking my call. Please let me know what we need to provide for budgetary quotes on SO2 technologies for the University of Alaska at Fairbanks BACT analysis.

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

Wood Group SDA Email

Jahn, Mario

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Monday, June 6, 2022 12:17 PM
To: Jahn, Mario
Cc: Meeker, Lance; Solan, John
Subject: RE: SO2 removal system quotation

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

Hello Mario.. Sorry for the delay in our reply…

Our office is extremely busy at the current time… we have been trying to fit this one in (it would take a few business days to provide the requested budgetary pricing), however we must prioritize active projects with firm 2022 / 2023 award dates. Unfortunately, our proposal team is booked with bidding activity thru early July.

We do maintain interest in this project as the technologies fit well withing our product portfolio, however we just cannot support this proposal with our current staffing. Unfortunately, we must decline to bid this opportunity

We apologize for this inconvenience and thank you for reaching out to us

Michael T Hoydick
Director, AQCS Technology & Sales
Mobile1: +1 412 302 2673
Mobile2: +1 412 298 9383
437 Grant Street, Suite 918, Pittsburgh, PA 15219, USA
www.woodplc.com

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Monday, June 6, 2022 9:52 AM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation
Importance: High

CAUTION: External email. Please do not click on links/attachments unless you know the content is genuine and safe.

Michael/Lance,

Can either one of you provide an update on this pricing? I think the last time we chatted was nearly 3 weeks ago.

Thanks in advance for your help.

Regards,
Mario

From: Jahn, Mario
Sent: Tuesday, May 31, 2022 7:04 AM
To: 'Hoydick, Michael' <Michael.Hoydick@woodplc.com>
Cc: 'Meeker, Lance' <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation
Importance: High

Good Morning Michael and Lance,

I hope the both of you had a good holiday weekend. I wanted to check in to see how things were progressing on your end for AQCS pricing for our project in Alaska. Can you provide an update?

Regards,
Mario

From: Jahn, Mario
Sent: Monday, May 23, 2022 8:00 AM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

Michael/Lance,

I wanted to see how things are going on your end with regards to AQCS equipment pricing for our project in Fairbanks, Alaska. Let me know if you can provide an update.

Best 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: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Thursday, May 12, 2022 6:54 AM
To: Jahn, Mario <JahnMario@stanleygroup.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

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Tomorrow 11 CST works for us…

Mike

From: Jahn, Mario <JahnMario@stanleygroup.com>
Sent: Wednesday, May 11, 2022 5:24 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>; Hoydick, Michael <Michael.Hoydick@woodplc.com>

Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

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Michael,

I just left you a voicemail in regards to the previous discussions you've had with Mark and John below on this project in Fairbanks Alaska. It looks like the last communication was about a month ago in setting up a meeting. Do you and your team have time this week to discuss? Please let us know.

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: Fritz, Mark
Sent: Monday, April 18, 2022 2:26 PM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>; Solan, John <SolanJohn@stanleygroup.com>
Subject: RE: SO2 removal system quotation

Mike,

Yes a think a meeting is a good idea to quickly answer your questions. Our availability is is as follows:

1. Tomorrow morning except 11:00-11:30 CST.
2. Tomorrow afternoon after 4:00 CST.
3. Wednesday morning – 9-10, 11-12 all CST
4. Wednesday afternoon after 2:30 CST.

Mark

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Monday, April 18, 2022 2:20 PM
To: Fritz, Mark <FritzMark@stanleygroup.com>; Knapper, Kelly <KnapperKelly@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

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Hello Kelly / Mark

We have reviewed the information provided and we have some questions / comments

Based on the information provided, it appears that there is an existing boiler / baghouse on this site and it appears that the boiler system already meets the emission requirements (0.2 lb/mmbtu)…

- What type of boiler is this (ie CFB / grate / other?)

- It appears that they inject limestone into the boiler to maintain 0.2 lb SOx emissions. What is the ash composition from the boiler? Usually, with limestone addition, there will be some CaO formed in the boiler that may be usable in an SDA system. Is this information available?
- The existing baghouse is designed for 9.0 lb/mmbtu and results in an emission of 0.3 lb/mmbtu. Can you confirm this assumption?
- What are your emission targets as the boiler w/limestone addition appears to already meet emission levels for SOx. Why do you folks need an upgrade or addition? We know limestone addition to the boiler does not capture halogens too well (ie HCl / Hf). What are your target emission levels for SOx / HCl / Hf / PM? We really cannot tell from the info you provided.

Is is possible to set up a short teams call over the next day or two? Let me know

Mike

From: Fritz, Mark <FritzMark@stanleygroup.com>
Sent: Wednesday, April 13, 2022 3:26 PM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>; Knapper, Kelly <KnapperKelly@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

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Mike,

See attached for RFQ.

We can discuss after your review. To answer your questions from below:

The pricing is budgetary. Our schedule assume vendor quotes in by the end of May, but we can work with you as far what you can support.

Thanks,

Mark

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

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Tuesday, April 12, 2022 9:06 AM
To: Knapper, Kelly <KnapperKelly@stanleygroup.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

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Hello Kelly / Mark

Do you folks have any idea on when we may see an RFQ?
Will this be budgetary or Firm for purchase?
Rough schedule?

We are really busy right now and want to give our proposal team a heads up

Thanks

Mike

From: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Sent: Monday, April 11, 2022 3:03 PM
To: Hoydick, Michael <Michael.Hoydick@woodplc.com>; Fritz, Mark <FritzMark@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: RE: SO2 removal system quotation

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Michael,

That is great to hear. I added Mark Fritz on this email chain, he will be able to get you the RFQ so that we can proceed.

Thank you for the quick response!
Kelly Knapper

From: Hoydick, Michael <Michael.Hoydick@woodplc.com>
Sent: Monday, April 11, 2022 1:52 PM
To: Knapper, Kelly <KnapperKelly@stanleygroup.com>
Cc: Meeker, Lance <Lance.Meeker@woodplc.com>
Subject: SO2 removal system quotation

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Hello Kelly,

Our Wood group is formerly Wheelabrator Air Pollution control and we do provide both wet and dry FGD systems.

Please forward the RFQ to myself and our proposal manager, Lance Meeker (email attached)

Thank You for reaching out to us

Michael T Hoydick
Director, AQCS Technology & Sales
Mobile1: +1 412 302 2673
Mobile2: +1 412 298 9383
437 Grant Street, Suite 918, Pittsburgh, PA 15219, USA
www.woodplc.com

Hello my name is Kelly Knapper I work for Stanley Consultants. For one of our projects we are looking into different types of SO2 removal for a 30MW boiler in Fairbanks Alaska. Would you be able to provide a quote for a Wet FGD system and SDA system for 0.2 lb/MMBTU of SO2 removal?

Appendix D

Circulating Dry Scrubber Vendor Data

Andritz CDS

Jahn, Mario

From: Petty Paul <Paul.Petty@andritz.com>
Sent: Monday, March 21, 2022 12:03 PM
To: Fritz, Mark; Prieler Harald
Cc: Verreault Ron
Subject: RE: Cost Estimating Support for Desulfurization Technologies
Attachments: Andritz CompactCDS Budgetary Proposal Stanley Rev 0.pdf; Attachment 1 - Preliminary General Arrangement Drawing.pdf; Attachment 2 - Andritz Air Polluton Brochure.pdf; Attachment 3 - Andritz Terms and Conditions of Sale and_or Service.pdf

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 SO_2 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 SO_2 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 SO_2 emissions rate is required but guarantees below about 0.06 #/MMBTU for SO_2 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 SO_2 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 SO_2. 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 SO_2 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 an 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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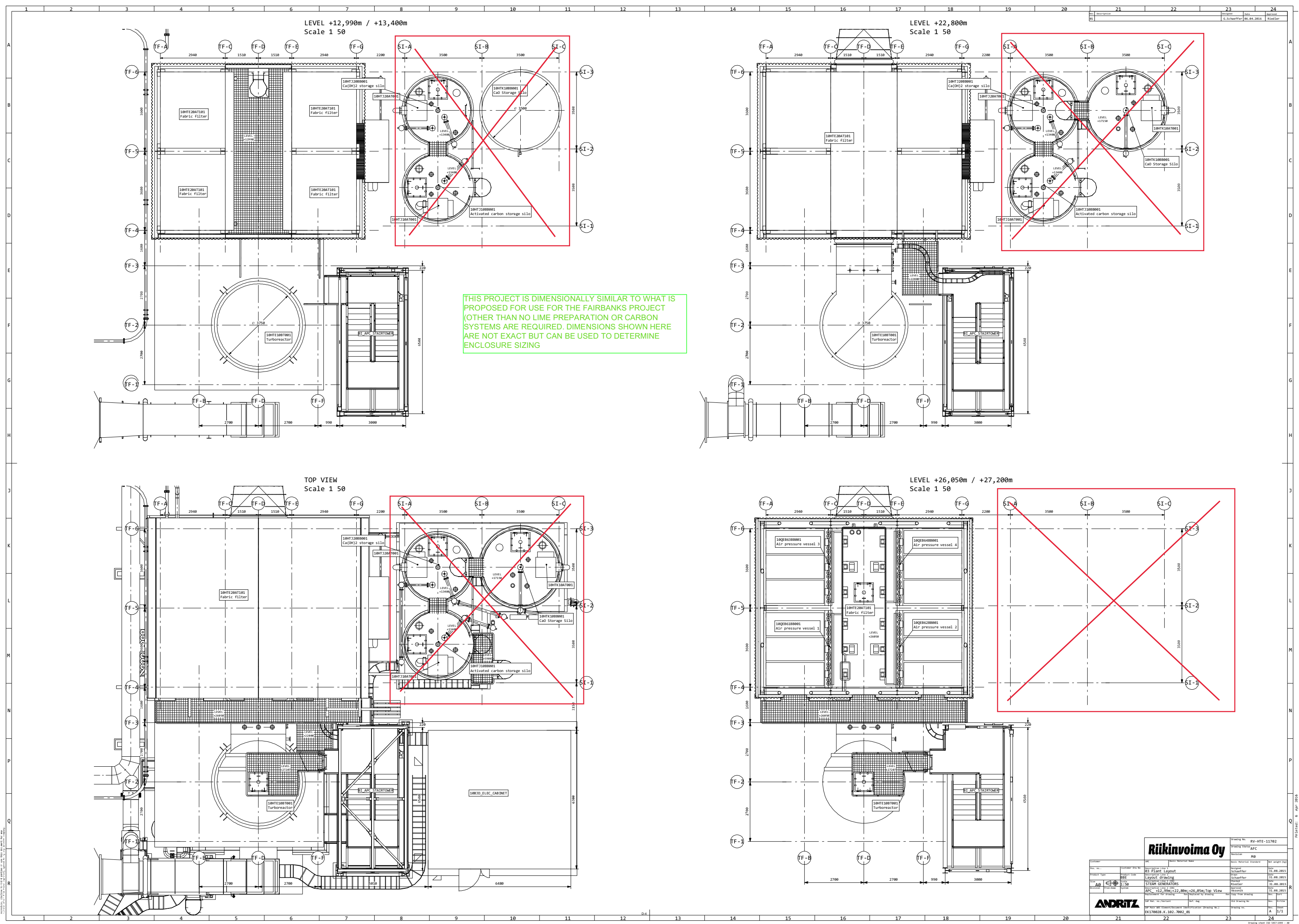
Hello Mark

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,


LEVEL +12,990m / +13,400m
Scale 1 50
LEVEL +22,800m
Scale 1 50
THIS PROJECT IS DIMENSIONALLY SIMILAR TO WHAT IS PROPOSED FOR USE FOR THE FAIRBANKS PROJECT (OTHER THAN NO LIME PREPARATION OR CARBON SYSTEMS ARE REQUIRED. DIMENSIONS SHOWN HERE ARE NOT EXACT BUT CAN BE USED TO DETERMINE ENCLOSURE SIZING
TOP VIEW
Scale 1 50
LEVEL +26,050m / +27,200m
Scale 1 50
Riikinvoima Oy
ANDRITZ