



77 Hartland Street, Suite 201
 East Hartford, Connecticut 06108
 tel: 860-529-7615
 fax: 860-290-7845

December 15, 2022

via Email to: AQPermits@alleghenycounty.us

Ms. JoAnn Truchan, P.E.
 Program Manager, Engineering
 Allegheny County Health Department
 Air Quality Program
 301 39th Street,
 Clack Health Center, Building 7
 Pittsburgh, PA 15201-1811

Subject: Bellefield Boiler Plant, ACHD Permit No. 0047
 Reasonably Available Control Technology (RACT) III Evaluation
 Update Re: Technical & Economic Analysis for Boilers B-003 and B-007

Dear Ms. Truchan:

On behalf of Bellefield Boiler Plant (BBP), CDM Smith is herewith submitting the Reasonably Available Control Technology (RACT III) evaluation update for BBP. This updated analysis is provided in response to your letter request dated September 26, 2022. This analysis includes the case-by-case evaluation for Boilers B-003 and B-007 described in our letter dated October 4, 2022.

BBP has five permanent boilers, one rental boiler and two emergency generators. The two emergency generators are not subject to RACT requirements but are maintained and operated in accordance with the manufacturer’s specifications and with good operating practices and operate less than 500 hours in any consecutive 12-month period, as required in the proposed rule §129.112(c)(10). **Table 1** provides a summary of each boiler unit at the BBP, and their current permitted NOx limits as approved in RACT IP#0047-I003a, issued April 14, 2020, and amended November 30, 2020.

Table 1: Summary of BBP Boilers

Unit Description	Control Device	Fuel	Heat Input Capacity	Current NOx limit (lb/MMBtu)* per RACT II IP-003A when firing natural gas	Current NOx limit per IP-003A (lb/MMBtu) when firing fuel oil
Boiler B-001	None	Natural Gas	74 MMBtu/hr	0.10	NA
Boiler B-003	None	Natural Gas; No. 2 fuel oil (backup)	128 MMBtu/hr (119 MMBtu/hr oil)	0.20	0.63
Boiler B-005	None	Natural Gas	74 MMBtu/hr	0.10	NA



Unit Description	Control Device	Fuel	Heat Input Capacity	Current NOx limit (lb/MMBtu)* per RACT II IP-003A when firing natural gas	Current NOx limit per IP-003A (lb/MMBtu) when firing fuel oil
Boiler B-006	FGR	Natural Gas; No. 2 fuel oil (backup)	179 MMBtu/hr	0.10	0.28
Boiler B-007	LNB	Natural Gas; No. 2 fuel oil (backup)	188 MMBtu/hr	0.14	0.20
Boiler B-008a	LNB	Natural Gas	87 MMBtu/hr	0.055	NA

Note:

- 1) Permitted NOx RACT II emission limits from RACT IP#0047-I003a, amended November 30, 2020.

Boilers B-001, B-005, B-006, B-008a

As noted in the letter submitted previously by BBP on October 4, 2022, BBP intends to comply with the presumptive RACT III limit for Boilers B-001, B-005, B-006 and B-008a. A copy of this letter is included in **Attachment A**. The permitted NOx emission rate for the rental Boiler B-008a, as approved in RACT IP-003a, is 0.055 lb/MMBtu. Because the permitted NOx emission rate for the rental Boiler B-008a is below the RACT III presumptive RACT limit, no further analysis is required.

As shown in the Table 1, the permitted NOx emission rates for the Boilers B-003 and B-007 do not meet the RACT III presumptive RACT limit, and therefore further analysis is required. For Boilers B-003 and B-007, BBP had proposed an alternative NOx RACT limit based on a previous RACT II case-by-case analysis (IP-003A). The previous RACT II case-by-case analysis for Boilers B-003 and B-007 found that the low NOx burner (LNB) and selective catalytic reduction (SCR) options were economically infeasible based on cost estimates obtained from vendors in 2017 and 2015. Because the RACT II cost-effectiveness was deemed economically infeasible at that time, we are now providing a RACT III update with a current (2022) budgetary cost analysis.

NOx RACT Analysis for Boilers B-003 & B-007

Assessment of New NOx Control Technologies

CDM Smith assessed whether new NOx control technologies are available for boilers that do not meet presumptive RACT III (Boilers B-003 & B-007). CDM Smith conducted a review of EPA's RBLC (RACT, BACT and LAER) clearinghouse determinations for natural gas boilers from the last 10 years (2012-2022) to verify if any new NOx emission control technology is available that was not evaluated previously. Specifically, CDM Smith reviewed two RBLC codes. RBLC code refers to the industrial sector, the boiler size and fuel. The following RBLC codes were reviewed:



- 12.220 Industrial Size Boilers/Furnaces between 100-250 MMBtu/hr; Distillate Oil,
- 12.310 Industrial Size Boilers/Furnaces between 100-250 MMBtu/hr; Natural Gas,

RBLC database research shows that there are no new NO_x emission control technologies available other than those originally evaluated for Boilers B-003 and B-007. The previously evaluated control options for technical feasibility are described in detail in the Technical Support Document (TSD) prepared by ACHD for RACT Determination dated May 29, 2015.

Table 2 below includes a summary of the technologies from that document. As shown in the Table 2, Selective Catalytic Reduction (SCR), Low-NO_x Burner (LNB), Flue-Gas Recirculation (FGR) and Combustion optimization or tune-up were determined technically feasible control options. All the others were determined to be technically infeasible.

Table 2 – Summary of Control Options and their technical feasibility for Boilers B-003 & B-007.

Category	Control Option	Technically Feasible Yes/No?
Post Control Combustion	Selective Catalytic Reduction (SCR)	Yes
	Selective Non-Catalytic Reduction (SNCR)	No
Low-NO _x Burning	Low-NO _x Burner (LNB)	Yes(a)
Additions To Combustion, Air or Fuel	Flue Gas Recirculation (FGR)	Yes
	Water/Steam Injection (WSI)	No
	Fuel Induced Recirculation (FIR)	No
Staged Combustion	Air Staging	No
	Fuel Staging	No
	Fuel Reburning	No
Combustion Optimization	Combustion Optimization or Tune-up	Yes
	Reduced Air Pre-heat (RAP)	No
	Low Excess Air (LEA)	No

Note:

- a) Boiler B-007 is already equipped with Low NO_x Burner.

Flue Gas Recirculation (FGR) as a standalone system does not provide an effective NO_x control for Boiler B-003. It is not possible to control the excess air in this older (1950s) boiler, converted from stoker coal firing to the low levels needed for lower NO_x emissions. Also, the FGR option in combination with a low-NO_x burner also does not provide any additional control that could not be achieved with a LNB alone. Reactivation of Boiler B-003's FGR system is not included in the vendor



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cost proposal and is not necessary to achieve the vendor-guaranteed NO_x emission rate of 0.1 lb/MMBtu. Therefore, CDM Smith obtained two budgetary quotes for Boiler B-003: LNB and SCR. A copy of the budgetary vendor quotes is included in **Attachment B**.

Boiler B-003 Cost Analysis

SCR Option

A budgetary cost proposal from BD Heat Recovery, dated November 30, 2022, was obtained to replace to install a DeNO_x SCR system in Boiler B-003. **Attachment C, Table 1**, contains an updated economic analysis for addition of a SCR system to Boiler B-003, based on the BD Heat proposal.

Attachment C, Table 2 shows that based on the BD Heat cost proposal, installation of SCR in Boiler B-003 would cost \$73,700 per ton of NO_x removed. This cost would exceed the economic infeasibility threshold of \$7,500 per ton of NO_x removed used by PADEP in setting “presumptive RACT III.”¹

On this basis, installation of SCR in Boiler B-003 is not economically feasible, therefore the next technically feasible option LNB is evaluated below for economic feasibility.

LNB Option

A budgetary cost proposal from John Zink Hamworthy, Inc. dated November 14, 2022, was obtained to install a low-NO_x burner in Boiler B-003. **Attachment C, Table 2**, contains an updated economic analysis for addition of a low-NO_x burner to Boiler B-003, based on the John Zink proposal.

Attachment C, Table 2 shows that based on the John Zink cost proposal, installation of LNB in Boiler B-003 would cost \$11,500 per ton of NO_x removed. This cost would exceed the economic infeasibility threshold of \$7,500 per ton of NO_x removed.

On this basis, installation of LNB in Boiler B-003 is not economically feasible, and an annual tune-up is determined to be NO_x RACT for Boiler B-003.

Boiler B-007 Cost Analysis

Boiler B-007 is already equipped with a low-NO_x burner with the capability of meeting a NO_x emission limit of 0.14 lb/MMBtu. The SCR costs for Boiler B-007 were scaled up from Boiler B-003 vendor quote based on the flue gas flow rate. **Attachment C, Table 3**, contains an updated

¹ PADEP 25 PA. CODE Chapters 121 and 129 accessed on December 13, 2022 here:
<https://www.pacodeandbulletin.gov/Display/pabull?file=/secure/pabulletin/data/vol52/52-46/1735.html&search=1&searchunitkeywords=>





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economic analysis for addition of a SCR system to Boiler B-007, based on a scale up of the BD Heat proposal.

Attachment C, Table 3 shows that the installation of SCR in Boiler B-007 would cost \$134,300 per ton of NO_x removed. This cost would exceed the economic infeasibility threshold of \$7,500 per ton of NO_x removed.

On this basis, installation of SCR in Boiler B-007 is not economically feasible, and therefore additional control technology beyond the presently installed Low NO_x burner is not recommended.

Please do not hesitate to call me at 860-808-2257 if you need any additional information.

Sincerely,

A handwritten signature in black ink, appearing to read "Disha Shah".

Disha Shah

cc: Bernadette Lipari, ACHD
Reihaneh Etemadi, ACHD
Kevin Hiles, Carnegie Museums
Anthony Young, P.E., Carnegie Museums
Gregory McDowell, CDM Smith
Cynthia Hibbard, CDM Smith
Disha Shah, CDM Smith
Frank Sapienza, CDM Smith
Christopher Campbell, CDM Smith



Attachment A

Copy of October 4th letter

(notifying ACHD of the intention to comply with presumptive RACT III limit

for Boilers B-001, B-005, B-006 and B-008a)

BELLEFIELD BOILER PLANT
4400 FORBES AVENUE
PITTSBURGH, PENNSYLVANIA 15213

October 4, 2022

Ms. JoAnn Truchan, P.E.
Program Manager, Engineering
Allegheny County Health Department
Air Quality Program
301 39th Street
Clack Health Center, Building 7
Pittsburgh, PA 15201-1811

Subject: Bellefield Boiler Plant, ACHD Permit No. 0047
Reasonably Available Control Technology (RACT) Evaluation Request

Dear Ms. Truchan:

Bellefield Boiler Plant (BBP) is submitting this letter to notify Allegheny County Health Department (ACHD) how BBP intends to comply with the Pennsylvania Department of Environmental Protection's (PADEP) new Reasonably Available Control Technology (RACT III) requirements, as described in your letter dated September 26, 2022.

Allegheny County is designated marginal nonattainment for the 2015 8-hour Ozone National Ambient Air Quality Standard (NAAQS). The Clean Air Act Sections 182(b)(2) and (f) require a re-evaluation of Reasonably Available Control Technology (RACT) requirements when the U.S. Environmental Protection Agency (U.S. EPA) promulgates a new NAAQS. The implementation rule for the 2015 8-hour Ozone NAAQS requiring the nitrogen oxide (NO_x) RACT update ("RACT III") was proposed in the PA bulletin in August 2021. As of August 9, 2022, The Pennsylvania Department of Environmental Protection (PADEP) is proposing to adopt the final RACT III rule by amending the 25 PA. Code Chapters 121 and 129. With the adoption of this rule, RACT III will apply to BBP, because the Facility's potential NO_x emission rate of 308.6 tons/year exceeds the Rule's applicability threshold of 100 tons/year. BBP is not a major source of VOCs, therefore, VOC RACT does not apply.

BBP has five permanent boilers, one rental boiler and two emergency generators. The two emergency generators are not subject to RACT requirements but are maintained and operated in accordance with the manufacturer's specifications and with good operating practices and operate less than 500 hours in any consecutive 12-month period, as required

in the proposed rule §129.112(c)(10). **Table 1** provides a summary of each boiler unit at the BBP, and their current permitted NOx limits as approved in RACT IP#0047-I003a, issued April 14, 2020, and amended November 30, 2020.

Table 1: Summary of BBP Boilers

Unit Description	Control Device	Fuel	Heat Input Capacity	Current NOx limit (lb/MMBtu)* per RACT II IP-003A when firing natural gas	Current NOx limit per IP-003A (lb/MMBtu) when firing fuel oil
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Boiler B-003	None	Natural Gas; No. 2 fuel oil (backup)	128 MMBtu/hr (119 MMBtu/hr oil)	0.20	0.63
Boiler B-005	None	Natural Gas	74 MMBtu/hr	0.10	NA
Boiler B-006	FGR	Natural Gas; No. 2 fuel oil (backup)	179 MMBtu/hr	0.10	0.28
Boiler B-007	LNB	Natural Gas; No. 2 fuel oil (backup)	188 MMBtu/hr	0.14	0.20
Boiler B-008a	LNB	Natural Gas	87 MMBtu/hr	0.055	NA

Note:

- 1) Permitted NOx RACT II emission limits from RACT IP#0047-I003a, amended November 30, 2020.

The new presumptive RACT III NOx limit for natural gas boilers greater than 50 million Btu/hr is 0.10 lb/MMBtu [§129.112 (g)(1)(i)]. As shown in the Table 1, the permitted NOx emission rates for Boilers B-001, B-005 and B-006, as approved in RACT IP-003a, is 0.1 lb/MMBtu. Therefore, Boilers B-001, B-005 and B-006 will meet the RACT III presumptive RACT limit, and no further analysis is required. Boilers B-003, B-006 and B-007 are permitted to use fuel oil as an emergency back-up fuel and with an annual capacity factor restriction of less than five percent. BBP will meet the RACT III requirement like the RACT II requirement of maintaining the oil burners and operating in accordance with the manufacturer's specifications and with good operating practices.

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October 4, 2022

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The permitted NOx emission rate for the rental Boiler B-008a, as approved in RACT IP-003a, is 0.055 lb/MMBtu. Because the permitted NOx emission rates for the rental Boiler B-008a is below the RACT III presumptive RACT limit, no further analysis is required.

With this letter, BBP is notifying the ACHD that we intend to comply with the presumptive RACT III limit for Boilers B-001, B-005, B-006 and B-008a.

As shown in the Table 1, the permitted NOx emission rates for the Boilers B-003 and B-007 do not meet the RACT III presumptive RACT limit, and therefore further analysis is required. For Boilers B-003 and B-007, BBP had proposed an alternative NOx RACT limit based on a previous RACT II case by case analysis (IP-003A). BBP intends to review the previous RACT II case-by-case RACT analysis, assess whether new NOx control technologies are available, and will submit all supporting information to the ACHD by December 31st, 2022.

Please let us know if you need any additional information.

Sincerely,



Kevin D. Hiles

Executive Vice President & Chief Operating Officer
Carnegie Museums of Pittsburgh

cc: Anthony Young, P.E., Carnegie Museums
Gregory McDowell, CDM Smith
Disha Shah, CDM Smith
Frank Sapienza, CDM Smith
Christopher Campbell, CDM Smith

Attachment B

Copy of Budgetary vendor quotes

Vendor: John Zink Hamworthy Combustion

Variflame Low NOx Burner Cost Estimates

Boiler B-003



Variflame Low NOx Burner

Nat. Gas & #2 Oil Firing

For

Bellefield Boiler Plant – Boiler #3

One (1) Erie City-Zurn Boiler

Pittsburgh, PA

Quote #: SQ22-00138531 Rev.A0
 Opportunity #: 202211-290351
 Prepared For: CDM Smith Inc.

Date: 11/14/2022
 End User: Bellefield Boiler Plant
 Pittsburgh, PA

Thank you for your interest in John Zink Company, LLC products and services. We have reviewed your inquiry and offer the following budget quote:

One (1) Variflame Low NOx Burner to fire Natural Gas & #2 Oil

PRODUCT NAME	QTY	EXTENDED
Variflame Low NOx Burner Assembly, complete with:	1	USD 360,000
- Gas burner Assy	1	
- Oil Gun Assy	1	
- Gas/Electric Igniter Assy	1	
- Flame Scanners	2	
▪ Windbox Assembly	1	
▪ FD Fan Assembly, including:	1	
- IVC Damper w/Damper Actuator	1	
- Silencer w/flow sensor and transmitter	1	
▪ Miscellaneous field switches, including:	1	
- Low Flow Switch for Combustion Air	1	
- Flow Switch for Purge Air Flow	1	
- Low instrument air pressure switch	1	
▪ Fuel Trains, including:	1	
- Igniter Train	1	
- Natural Gas Train w/flow meter	1	
- #2 Oil Train w/flow meter	1	
- Atomizing Steam Train	1	
- Instrument Air Train	1	
▪ BMS/CCS controls engineering	1	
TOTAL:		USD 360,000

Equipment Delivery

- Submittal of the drawing/information package for approval will be made approximately eight (8) weeks following receipt of the written acceptance of this proposal by way of a purchase order and transmittal of all related technical information required to proceed.
- Two (2) weeks will be allowed for drawing approval by customer.
- O&M manuals, spare parts list, and certified drawings will be shipped prior to shipment of equipment and materials.
- Shipment of equipment and material will be made approximately twenty-eight (28) weeks after approval of submittal package and release to purchase and fabricate.

Notes

- Above prices are in US Dollars and do not include any sales, use, excise, V.A.T. or similar taxes, and custom duties which may be applicable to the importation into the final destination country.
- Payment Terms: prepaid in full upon acceptance of approved purchase order, unless alternate terms are mutually agreed upon by both parties.
- Our quote is based on our worldwide sourcing from approved and qualified suppliers, who have been audited based on our stringent corporate, project and unique customer requirements.
- Price is FCA (Incoterms 2020) Point of Manufacture.
- Quote Validity: This budgetary proposal is only an estimate to facilitate your planning process and does not constitute an offer to enter into a contract or a commitment of any kind. The parties are under no legal obligation to enter into any transaction or contract unless Seller submits a firm offer or binding quotation at a future date which shall be subject to John Zink Company, LLC General Terms and Conditions of Sale, unless otherwise agreed by the parties in writing.
- *Market prices for steel materials are unstable and in an extreme state of fluctuation due to a variety of factors including, but not limited to, cost increases (iron ore, steel scrap, coke, nickel, chromium, vanadium and other metals and alloys), as well as fuel prices, currency exchange fluctuations, and political unrest. Our Proposal Price is based on current availability and prices of materials in effect as of the date of this Proposal. During this time of materials instability, we will continue to strive to provide unique solutions to the market, with unique pricing strategies to mitigate these market affects for our valued customers.*

This proposal document is confidential and intended solely for the use of the individual or entity to which it is addressed. If you have received this proposal in error, please contact the sender and destroy all copies of the original message.

We are committed to supplying quality engineering services and equipment for many plants throughout the world. Customer satisfaction is our highest priority, and every effort is made to provide unparalleled service and customer support. We hope that you can consider John Zink Hamworthy Combustion as the right partner for you in this project. Your contact for all technical and administrative inquiries is:

Jose Cornelio Guzman | Application Engineer

T: +52 55.5384.1390

M: +52.1.55.4520.9819

E: jose.guzman@kes.global



A KOCH ENGINEERED SOLUTIONS COMPANY

1.0 SCOPE OF SUPPLY

One (1) 100,000 pounds per hour Erie City Iron Works, "stoker" type boiler #3 is to be retrofitted with a low NOx packaged burner which will fire natural gas as main fuel with No. 2 fuel oil as back-up. This boiler #3 is presently rated according to its Title V Operating Permit as having an annual capacity factor of not more than 50% and the average annual heat input cannot exceed 560,640 MMBtu/yr or 64 MMBtu/hr. The burner is mounted on a side-wall at about 8.5 ft above the floor. Note that the stoker is no longer firing and has been sealed with refractory.

The packaged burner is factory pre-assembled to the maximum extent to minimize field installation and easily mounts onto the boiler frontplate.

NOx requirements on both gas and oil firing will be met using the low NOx burner, without flue gas recirculation.

Based upon the design data presented in the burner data sheet, John Zink Hamworthy Combustion (JZHC) is pleased to offer **CDM Smith Inc.** our pre-engineered, Low NOx burner with windbox, windbox mounted FD fan, valve trains, miscellaneous field switches, and flame scanning equipment. Additionally, John Zink offers the burner management system (BMS) and combustion control system (CCS) controls engineering to assist with the implementation of the new burner into end user's control platform.

The Variflame burner incorporates a venturi style air register and fuel staging techniques for NOx reduction. The venturi air register provides for the correct proportioning of the flow of primary and secondary combustion air which in combination with staged gas injection, provides NOx reductions as high as 50% in addition with other forms of NOx control. The Variflame is also equipped with built-in tertiary air zone to allow increased flexibility for combustion staging, NOx reduction, and flame shaping capabilities. The Variflame is widely used, industry proven burner with over 1,000 installations.

A. Engineering Services

Upon receipt of order a dedicated Project Team will oversee the execution of the contract. John Zink Hamworthy Combustion (JZHC) will provide complete engineering and design for all JZHC furnished equipment and materials specified in Section C – Equipment and Materials. Once the initial design phase is complete an engineering package submittal will be sent for customer review and approval, including:

- Project schedule
- Quality Inspection and Test Plan
- Burner General Arrangement Drawing
- Engineering Data Sheets
- Burner Performance Curves
- P&ID drawings
- JB layout drawing
- JB wiring diagrams
- BMS operating guide
- Narrative for combustion controls
- BMS Boolean logic diagrams
- CCS SAMA logic diagrams
- I/O list
- FAT procedure

Also, JZHC will provide a comprehensive Operation and Maintenance Manual complete with operating instructions, data sheets and vendor component data/drawings in electronic pdf format. All documentation will be provided in English.

A.1 Engineering Services

John Zink will provide the following burner management system (BMS) and combustion control system (CCS) engineering documentation to assist with the integration of the equipment quoted herein into existing end user's control platform (Delta V), limited to:

- Detailed sequence of operation description for burner start/shutdown control and operating control, in accordance with NFPA 85, "Boiler and Combustion Systems Hazards Code"
- Narrative for combustion controls
- BMS Boolean logic diagrams

- CCS SAMA logic diagrams
- Input/output list of field devices interfacing with the BMS and CCS logic solver

The documentation will convey John Zink design philosophy for burner management system and combustion control system. These documents are not intended to specify, supply, or program the logic solvers or hardware; these will be specified, supplied, and programmed by others. Further, these documents will not give specific instructions on how to change HMI screens or communications interfaces.

Additional engineering services associated with the BMS or CCS controls including attending meetings, assisting to develop the software for the logic solvers, participating in factory acceptance testing (FAT) and/or site acceptance testing (SAT), and assistance in start-up and training are not included, however these services are available as a price adder

B. Jobsite Services

John Zink Hamworthy Combustion can provide field advisory services during installation, and technical assistance services during initial start-up including operator training, at the per diem rate in effect at time of request, in accordance with our standard **Technical Assistance Terms**. Note that **NO jobsite services** are currently included in our base bid.

C. Equipment and Materials

The following is an itemization of all components supplied by John Zink Hamworthy Combustion. All the proposed equipment will be designed, manufactured, and finished as per JZHC Standards.

Burner Assembly

Description	Qty
Variflame burner, fabricated using standard stainless and mild steel components, is complete with the following sub-assemblies: - One (1) stationary air register assembly, for primary, secondary and tertiary air. - One (1) burner front plate assembly, non-insulated, complete with observation port and flame scanner swivel mounts - One (1) swirling diffuser assembly - One (1) fuel gas burner assembly complete with an external gas plenum and fixed multiple gas pokers - One (1) low steam usage atomizing oil gun assembly, manually retractable complete with coupling block assembly - One (1) ignition assembly complete with Class 3, intermittent, gas-electric igniter and Chentronics SmartSpark exciter - Two (2) iScan™3 flame scanners, with integral flame relay, wired to a windbox mounted junction box - One (1) burner guide ring to be welded on the boiler front plate to align the burner to the burner opening (shipped loose) - One (1) throat former for installation of boiler front wall refractory at the burner opening (shipped loose)	1

Burner Windbox

Description	Qty
Windbox, non-insulated, will be fabricated of ASTM A-36 carbon steel plate, and complete with required structural framing, access door, lifting lugs, and straightening devices for balancing air flow distribution to the burner. The windbox will be provided with a top inlet opening for connection to the forced draft fan discharge. The windbox will be painted with manufacturer standard. The windbox will be seal welded to the boiler front plate.	1

FD Fan Assembly

Description	Qty
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Forced draft fan, centrifugal type, arrangement 4, downblast discharge, complete with 460V/3Ph/60Hz TEFC premium efficiency motor and IVC damper. The fan assembly will be mounted on the windbox; the fan assembly will be shipped loose to avoid damage during transit. 1

- One (1) Horizontal fan silencer to reduce the sound level to less than 85 dBA at three (3) feet distance from the fan, excluding background sound, with air flow sensor and differential pressure transmitter. The fan silencer will be shipped loose and will be supported by structural steel supplied by others.

- One (1) Pneumatic actuator with I/P positioner and position limit switches for the IVC air damper.

Miscellaneous Field Switches

Description

Qty

The following miscellaneous field switches will be mounted on the windbox:

1

- One (1) Low Flow Switch for Combustion Air

- One (1) Flow Switch for Purge Air Flow

Fuel Piping Trains

Description

Qty

The following valve trains will be shop mounted on the windbox to the maximum extent feasible, and will include valves, piping specialties and instrumentation as specified below. All electrical components will be wired to a NEMA 4 windbox mounted junction box. Unless otherwise noted, the interface points with Customer are at the inlet of the supply manual shut-off valves and the discharge of vent, and drain valves. 1

Gas trains will be fabricated using Schedule 40 ASTM A-106 Grade B seamless steel pipe, with standard butt-weld fittings and 150 lb. flanges for nominal 3-inch diameter and greater lines, and Schedule 80 ASTM A-106 Grade B seamless steel pipe and 3,000 lb. threaded fittings for nominal 2-1/2-inch diameter and smaller lines. Gas trains will be painted with manufacturer standard.

Steam and oil trains will be fabricated using Schedule 80 ASTM A-106 Grade B seamless steel pipe and 3,000 lb. threaded fittings. Valve trains will be painted with manufacturer standard. Insulation and lagging is not included.

Gas pilot train, consisting of:

- One (1) supply manual shut-off valve, brass body, NPT
- One (1) strainer with basket "Y" type, cast iron body, NPT
- One (1) pressure regulating valve, cast iron body, NPT
- Two (2) automatic safety shut-off valves, solenoid type, aluminum body, NPT (Asco)
- One (1) automatic safety vent valve, solenoid type, aluminum body, NPT (Asco)
- One (1) igniter pressure gauge, 2.5 in dial, with isolation valve
- One (1) igniter manual shut-off valve, brass body, NPT
- One (1) flexible hose, stainless steel body, NPT

Natural gas/LP Gas train, consisting of:

- One (1) supply manual shut-off valve, semi-steel body, 125# FF
- One (1) strainer with basket "Y" type, cast iron body, 125# FF
- One (1) supply pressure gauge, 4.5 in dial, with isolation valve
- One (1) gas flow meter and transmitter (HART 4-20 mA), Coriolis type, 150#RF. SST wetted parts. Rosemount
- One (1) low gas pressure switch (Ashcroft)
- Two (2) automatic safety shut-off valves, pneumatic operated, with proof of closure switch
- Two (2) leak test connections with isolation valves
- One (1) automatic safety vent valve, solenoid type, aluminum body, NPT (Asco)
- One (1) manual vent valve, locked in the open position, brass body, NPT

- One (1) high gas pressure switch (Ashcroft)
- One (1) gas flow control valve, vee-ball type, carbon steel body, 150# wafer, with low fire limit switch, pneumatic actuator, I/P positioner (Fisher).
- One (1) burner pressure gauge, 4.5 in dial, with isolation valve
- One (1) burner manual shut-off valve, semi-steel body, 125# FF

#2 Oil train, consisting of:

- One (1) supply manual shut-off valve, brass body, NPT
- One (1) strainer with basket "Y" type, cast iron body, NPT
- One (1) supply pressure gauge, 4.5 in dial, with isolation valve
- One (1) oil flow meter and transmitter (HART 4-20 mA), Coriolis type, 150#RF. SST wetted parts. Rosemount
- One (1) low pressure switch (Ashcroft)
- One (1) oil flow control valve, vee-ball type, carbon steel body, 150# wafer, with low fire limit switch, pneumatic actuator, I/P positioner (Fisher).
- Two (2) automatic safety shut-off valves, pneumatic operated, with proof of closure switch
- One (1) manual drain valve, NPT
- One (1) flexible hose, stainless steel body, NPT
- One (1) burner manual shut-off valve, brass body, NPT
- One (1) burner pressure gauge, 2.5 in dial, with isolation valve

Atomizing steam train, consisting of:

- One (1) supply manual shut-off valve, brass body, NPT
- One (1) strainer with basket "Y" type, cast iron body, NPT
- One (1) supply pressure gauge, 4.5 in dial, with isolation valve
- One (1) low pressure switch (Ashcroft)
- One (1) pressure regulating valve, cast iron body, NPT
- One (1) steam trap, cast iron body, NPT w/isolation valve, brass body, NPT
- One (1) manual drain valve, NPT
- One (1) automatic safety shut-off valve, brass body, NPT
- One (1) flexible hose, stainless steel body, NPT
- One (1) burner manual shut-off valve, brass body, NPT
- One (1) low pressure switch (Ashcroft)
- One (1) burner pressure gauge, 2.5 in dial, with isolation valve

Instrument Air train, consisting of:

- One (1) supply manual shut-off valve, brass body, NPT
- One (1) supply pressure gauge, 4.5 in dial, with isolation valve
- One (1) low pressure switch (Ashcroft)
- One (1) isolation valve for each instrument air user plus one spare

D. Clarifications and Exceptions

The scope of supply is based on the technical information listed in the attached Burner Data Sheet, some of which may be assumed. JZHC reserves the right to modify it, technically and commercially, if any of the conditions or specifications are revised, changed or modified during the project execution.

2. Scope of Supply - By Others

Others shall be responsible for the receipt, unloading, and installation of the burner and auxiliary equipment furnished by JZHC plus the supply and installation of any additional components or materials required for a complete operable installation. Items to be supplied by others shall include but not necessarily be limited to the following:

- Boiler field instruments and control devices
- Gas pressure regulating station
- Oil pump set with regulated oil pressure
- ID Fan/Motor Assembly
- Supports for fan silencer
- Motor starters and VFDs (if applicable)
- Long-term storage at manufacturing facility
- Design and installation of all interconnecting piping/ducting/tubing/wiring systems
- Delivery, Freight, Insurance
- Installation and lagging
- Burner Management System, Combustion & Boiler Control System including engineering (except as noted), programming, software, hardware, or implementation
- DCS engineering, programming, hardware, or implementation
- Stack O2 sensor/transmitter
- HAZOP meeting attendance
- SIL evaluations
- Supply of ISA quality instrument air
- Fire detection or fire suppression systems
- Leak detection or containment systems
- Seismic calculations
- Ladders and Platforms
- All piping, ducting, and exhaust stack insulation, as applicable
- Design and installation foundations
- Power supply to motors and control panel
- UPS and/or MCC
- Heat Tracing
- Freeze Protection
- Equipment permitting
- Lube oil systems
- CEM system
- Foundation and Anchor Bolts
- External insulation and/or personnel protection
- Performance Acceptance Testing
- Onsite field service (installation supervision, startup, commissioning, training, testing), it can be offered as per diem basis.
- Designs, materials, or labor for the demolition, removal, disposal, installation, modification, operation, adjustment, or maintenance of any existing equipment.

BURNER SPECIFICATION



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CUSTOMER: CDM Smith Inc.

OPPORTUNITY NUMBER: 202211-290351

END USER: Bellefield Boiler Plant

JOB SITE LOCATION: Pittsburgh, PA

BOILER GENERAL DATA

BOILER GENERAL DATA						REV
1	FURNACE CATEGORY	<i>PACKAGE, FIELD-ERECT, TANGENTIAL, OTSG</i>	Field-Erect			
2	BOILER MANUFACTURER		Erie City Iron Works			
3	NUMBER OF BOILERS		1			
4	TYPE / MODEL OF BOILER		Bi-Drum / Stoker			
5	STEAM FLOW - 50% MCR	PPH	50,000			
6	TOTAL TURNDOWN [GAS / OIL]	:1	8:1	6:1		
7	STEAM PRESSURE	psig	175			
8	STEAM TEMPERATURE	°F	Saturated			
9	FEEDWATER TEMPERATURE	°F	228			
10	FURNACE PRESSURE	inch w.c.	-0.1			
11	FURNACE HEIGHT	Ft	~21.00			
12	FURNACE WIDTH	Ft	18.88			
13	FURNACE DEPTH - Side Wall	Ft	14.17			
14	FURNACE DEPTH PASS	Ft	N/A			
15	FRONT WALL CONSTRUCTION	<i>% REFRACTORY or TUBES if ≤50</i>	25%			
16	FLOOR, REFRACTORY	%	100%			
17	CEILING / LEFT WALL / RIGHT WALL / REAR WALL, REFRACTORY	%	12%	12%	12%	12%
18	INSTALLATION	<i>INDOORS or OUTDOORS</i>	Indoor			
19	AMBIENT TEMPERATURE	°F	80			
20	SITE ELEVATION	FASL	825			

BURNER DATA

21	BURNER PROJECT CLASSIFICATION	<i>NEW or RETROFIT</i>	Retrofit			
22	QUANTITY of BURNERS PER BOILER		1			
23	FIRING CONFIGURATION	<i>WALL-FIRED / UP-FIRED / DOWNFIRED / OPPOSED</i>	Wall-Fired			
24	TYPE OF BURNER - SIZE		Variflame	STD445		
25	FURNACE FRONT WALL DEPTH (Estimate / Confirmed)	in	8.00	Estimate		
26	BURNER ARRANGEMENT (SINGLE or COLUMNS x ROWS)		SINGLE	-	-	
27	VERTICAL BURNER PITCH, CENTERLINE TO TUBE CENTERLINE	Ft	N/A			
28	HORIZONTAL BURNER PITCH, CENTERLINE TO CENTERLINE	Ft	N/A			
29	BOTTOM BURNER TO FLOOR	Ft	8.50			
30	BURNER THROAT SIZE	in	21.625			
31	BURNER MINIMUM TUBE NEST ID	in	25.625			

IGNITER DATA

32	PILOT TYPE / MODEL		Fyr-Bolt FL			
33	ELECTRODE MODEL		SmartSpark			
34	IGNITER CLASS	<i>NFPA</i>	3			
35	FLAME ROD	<i>YES or NO</i>	NO			
36	IGNITER FUEL		Natural Gas			
37	FUEL PRESSURE at IGNITER	psig	0.50			
38	AIR PRESSURE / FLOW REQUIRED	inch w.c. / SCFM	N/A	NA		
39	IGNITER HEAT RELEASE	MMBtu/hr	0.50			

OPERATING DATA

40	BURNER FUEL TYPE	<i>GAS or OIL or GAS & OIL</i>	GAS			OIL
41	GAS FUEL		Natural Gas			-
42	OIL FUEL		-			#2 Oil
43	OPERATING STEAM FLOW	% MCR	50			50
44	TOTAL HEAT RELEASE per BURNER	* [HHV] MMBtu/hr	64.00			59.50
45	TOTAL HEAT RELEASE	* [HHV] MMBtu/hr	64.00			59.50
46	HEAT RELEASE per BURNER, GAS	* [HHV] MMBtu/hr	64.00			-
47	GAS FUEL FLOW per BURNER	SCFM	1,069			-
48	HEAT RELEASE per BURNER, OIL	* [HHV] MMBtu/hr	-			59.50
49	OIL FUEL FLOW per BURNER	lb/hr	-			3,110
50	EXCESS AIR	%	10			15
51	COMBUSTION AIR TEMPERATURE	°F	80			80
52	COMBUSTION AIR FLOW (WET), per BURNER	lb/hr	51,503			51,637
53		SCFM	11,538			11,568
54	FLUE GAS RECIRCULATION	%	N/A			N/A
55	FLUE GAS RECIRCULATION TEMPERATURE	°F	-			-
56	FLUE GAS RECIRCULATION FLOW, per BURNER	lb/hr	-			-
57		SCFM	-			-

BURNER SPECIFICATION



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OPERATING DATA (CONT.)

							REV
58	FLOW, BULK MIX, per BURNER	lb/hr	-			-	
59		SCFM	-			-	
60	AIR / FGR MIX TEMPERATURE	°F	-			-	
61	COMBUSTION AIR FLOW (WET), TOTAL	lb/hr	51,503			51,637	
62		SCFM	11,538			11,568	
63	FLUE GAS RECIRCULATION FLOW, TOTAL	lb/hr	-			-	
64		SCFM	-			-	
65	FLOW, BULK MIX, TOTAL	lb/hr	-			-	
66		SCFM	-			-	
67	GAS FUEL PRESSURE REQUIRED at BURNER	psig	10.0				
68	BURNER DROP PRESSURE at HEAT RELEASE	inch w.c.	5.9			6.1	
69	STEAM / WATER INJECTION RATE	lb/lb, fuel	-			-	
70	STEAM / WATER INJECTION TEMPERATURE	°F	-			-	
71	ESTIMATED FLAME LENGTH	ft	9.48			9.21	
72	ESTIMATED FLAME DIAMETER	ft	2.75			2.67	

GAS FUEL CHARACTERISTICS

73	FUEL GAS DESIGNATION		Natural Gas				
74	HEATING VALUE	* [HHV]	Btu/scf	998			
75	SPECIFIC GRAVITY [AIR = 1.0]			0.60			
76	FUEL TEMPERATURE at BURNER		°F	60			
77	SUPPLY PRESSURE at TRAIN INLET		psig	28			
78	FUEL GAS COMPOSITION		Mol% or Mass%	Mole%			
79	Hydrogen	(H ₂)		-			
80	Oxygen	(O ₂)		-			
81	Nitrogen	(N ₂)		5.00%			
82	Carbon Monoxide	(CO)		-			
83	Carbon Dioxide	(CO ₂)		-			
84	Methane	(CH ₄)		90.00%			
85	Ethane	(C ₂ H ₆)		5.00%			
86	Propane	(C ₃ H ₈)		-			
87	n-Butane	(C ₄ H ₁₀)		-			
88	Iso-Butane	(C ₄ H ₁₀)		-			
89	n-Pentane	(C ₅ H ₁₂)		-			
90	Iso-Pentane	(C ₅ H ₁₂)		-			
91	Neo-Pentane	(C ₅ H ₁₂)		-			
92	n-Hexane	(C ₆ H ₁₄)		-			
93	Heptane	(C ₇ H ₁₆)		-			
94	Octane	(C ₈ H ₁₈)		-			
95	Toluene	(C ₇ H ₈)		-			
96	Ethylene	(C ₂ H ₄)		-			
97	Propylene	(C ₃ H ₆)		-			
98	n-Butene	(C ₄ H ₈)		-			
99	Iso-Butene	(C ₄ H ₈)		-			
100	n-Pentene	(C ₅ H ₁₀)		-			
101	Benzene	(C ₆ H ₆)		-			
102	Methylbenzene	(C ₇ H ₈)		-			
103	Ethylbenzene	(C ₈ H ₁₀)		-			
104	Acetylene	(C ₂ H ₂)		-			
105	Methylacetylene	(C ₃ H ₄)		-			
106	Butadiene	(C ₄ H ₆)		-			
107	Naphthalene	(C ₁₀ H ₈)		-			
108	Acetone	(C ₃ H ₆ O)		-			
109	Methanol	(CH ₃ OH)		-			
110	Ethanol	(C ₂ H ₅ OH)		-			
111	Propanol	(C ₃ H ₇ OH)		-			
112	Ammonia	(NH ₃)		-			
113	Hydrogen Cyanide	(HCN)		-			
114	Hydrogen Sulfide	(H ₂ S)		-			
115	Sulfur Dioxide	(SO ₂)		-			
116	Water	(H ₂ O)		-			
117							
118							
119							
120							
121							
122							
123			TOTAL	100.00%			

BURNER SPECIFICATION



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LIQUID FUEL CHARACTERISTICS

						REV
124	FUEL OIL DESIGNATION					#2 Oil
125	HEATING VALUE	* [HHV]	Btu/lb			19,130
126	VISCOSITY REQUIRED at BURNER		SSU			32
127	SUPPLY PRESSURE at TRAIN INLET		psig			150
128	FUEL PRESSURE REQUIRED at BURNER		psig			110
129	ATOMIZING MEDIA	AIR or STEAM or MECHANICAL or GAS				Steam
130	ATOMIZING MEDIA TEMPERATURE		°F			Sat
131	ATOMIZING MEDIA PRESSURE at BURNER		psig			100
132	FUEL OIL METALS: Vanadium, Potassium, Sodium, Nickel		wppm			-
133	FUEL OIL COMPOSITION		weight %			-
134	Carbon	(C)				87.9%
135	Hydrogen	(H)				12.1%
136	Oxygen	(O)				-
137	Nitrogen	(N)				0.020%
138	Sulfur	(S)				-
139	Ash					0.050%
140	Conradson Carbon Residue	CCR				0.4%
141	Bottom Sediment & Water	BS&W				-
142			TOTAL			100.0%

MISCELLANEOUS DATA

143	AREA CLASSIFICATION	SAFE or HAZARDOUS				Non-Hazardous
144	NEC/IEC RATING					N/A
145	NEMA RATING					NEMA 4
146	POWER SUPPLY AVAILABLE, MOTORS		V/Ph/Hz			460V/3Ph/60Hz
147	POWER SUPPLY AVAILABLE, CONTROL		V/Ph/Hz or VDC			120V/1Ph/60Hz
148	INSTRUMENT AIR SUPPLY (CLEAN/DRY/OIL-FREE)		psig			80-100 psig
149	NUMBER OF SCANNERS PER BURNER					Two (2)
150	COOLING AIR REQUIRED, PER SCANNER	SCFM / inch w.c.		5		5" w.c. above windbox pressure
151	VALVE TRAIN CONSTRUCTION		GAS / OIL			NFPA 54
152	PIPING / WELDING SPECIFICATIONS	STANDARD or ASME B31, 1/3				JZHC Standard
153	COATING AND PAINTING SPECIFICATIONS	STANDARD or CUSTOMER SPEC'S				Per John Zink Standard
154	QUALITY CONTROL	STANDARD or CUSTOMER SPEC'S				Per John Zink Standard
155	CODE GUIDELINES	NFPA 85 or OTHER (specify)				NFPA 85
156	OPERATING SYSTEM TYPE	AUTOMATIC or NON-RECYCLING				Non-Recycling
157	BURNER(S) CONFIGURATION/MODE	SINGLE or UNISON or MULTI				Single
158	CONTROLS TYPE	SPP or PP or FULLY-METERED				Fully-Metered
159	FGR TYPE	INDUCED or FORCED (BULK/MIX) or SELECTIVE (SCROLL)				N/A
160	GAS & OIL COFFRING	YES or NO or NA				N/A
161	LOW FIRE CHANGEOVER	YES or NO or NA				N/A
162	NOISE THRESHOLD SPECIFICATION		dBA at 3 ft			85

EMISSION REQUIREMENTS

		Natural Gas	#2 Oil			
163	FUEL DESIGNATION					
164	NOx	lb/MMBtu, HHV	0.1	0.12		
165	CO	ppm, dry	100	100		
166						
167						
168	Emission exclude background emissions present in the ambient air used for combustion					
169	**ppm* CORRECTED TO 3% O₂ [VOLUME, DRY BASIS]					
170	All emissions are relevant to the fuel(s) specified herein only, based on HHV.					
171	Emission guarantees are extended from twenty-five (25) to one hundred (100) percent of design burner heat release, provided that the system is					
172	operated at steady state conditions, in accordance with the Burner Design Specifications herein.					
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BURNER SPECIFICATION

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NOTES, COMMENTS, AND CLARIFICATIONS

REV

186 Notes:

- 187** 1 The burner(s) will maintain a stable flame with no deleterious impingement over the entire burner turndown range as per the American Boiler Manufacturers Association Definition: "Flame impingement is defined as the condition which exists when the flame resulting from the combustion of the fuel comes into contact with any interior surface of the furnace in such a way as to result in localized incomplete combustion of the fuel and such condition manifests itself in the formation of hard carbonaceous deposits at the contact location. Flame impingement is a condition of firing a fuel which may cause failure and/or excessive maintenance of combustion chamber wall surfaces".
- 188** 2. Packaged boilers shall be designed and operate with the inboard row of furnace tubes forming a gas tight wall baffle to prevent the short circuiting of furnace gases to the boiler gas outlet, for performance guarantees to be in effect.
- 189** 3. Emission guarantees for Field Erect boilers of balanced or negative draft design are provided there's no air leakage into the furnace and all combustion air goes through the burners only.
- 190** 4. Particulate matter includes unburnt compounds derived from the fuel and excludes any ash present in the fuel and any inorganic or non-combustible material present in the ambient air used for combustion.
- 191** 5. SOx Emissions are a direct result of the fuel bound sulphur and cannot be controlled by the combustion process, for this reason we do not offer as a guarantee point
- 192** 6. Multi-Burner Boilers. It is essential that combustion air flow deviation to each burner not exceed:
a) Individual burner flow deviation about the mean +/- 2.5%
b) Circumferential air flow deviation about the mean +/- 5.0%
It has been assumed that normal operation is all burners firing, within the turndown range, all firing on the same fuel and with the same heat input.
- 193** 7. Testing for performance guarantees shall be run within thirty (30) days after the equipment has been installed and operated. Others shall furnish all operating personnel and equipment for such tests. A John Zink trained service engineer shall fine tune the burner as required and observe the operation of auxiliary equipment to assure that performance guarantees will be met, prior to testing, unless John Zink, in its sole discretion, waives this requirement because it deems on-site tuning to be a safety risk or commercially or legally unreasonable. John Zink's representative will have access to the records at all times and the tests will be conducted in a manner to ensure that the specified performance conditions are being maintained. For oil fired systems, others shall take samples of the fuel oil during the performance test and have its nitrogen content measured by an independent test laboratory. John Zink will be supplied a complete copy of all test results and data.
- 194** 8. The equipment shall be considered accepted if tests show that the guarantees have been fulfilled, or if others fail to have the equipment tested within the specified period. In case of the failure to meet the guarantees, JZHC/Coen reserves the right to change or replace, on a straight time basis, the equipment furnished so that the guaranteed performance will be obtained.

195 Comments & Clarifications:

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**GENERAL TERMS AND CONDITIONS OF SALE
(GOODS AND SERVICES)**

- 1. APPLICATION.** These General Terms and Conditions of Sale (“Terms and Conditions”) will apply to all quotations and sales for goods, material, equipment and services by John Zink Company, LLC (“Seller”) and are hereby incorporated into the purchase order, quotation, invoice or other document to which they are attached (“Order”) and, together with the Terms and Conditions, the “Contract”. All purchases by customer, owner or its agent (“Buyer”) are expressly limited and conditioned upon acceptance of the Terms and Conditions. Seller objects to and rejects any provision additional to or different from the Terms and Conditions that may appear in Buyer’s purchase order, acknowledgement, confirmation, writing, or in any other prior or later communication from Buyer to Seller, unless such provision is expressly agreed to by Seller in a writing signed by Seller. For the purposes of these Terms and Conditions, the term “Goods” shall refer to the goods, material and equipment listed on the Order as well as all equipment or other materials provided in connection with any Services, and the term “Services” shall refer to the services listed on the Order. Terms not defined herein shall have the meanings set forth in the Order.
- 2. PRICE AND OTHER CHARGES.** Unless otherwise stated in the Order, the Contract price does not include any packaging, transportation, duties, taxes or other charges (collectively, “Additional Charges”). Buyer shall be responsible for all applicable Additional Charges.
- 3. PAYMENT TERMS.** (a) Unless otherwise stated in the Order, payment is due thirty (30) days after the invoice date. (b) All payments shall be made in USD unless otherwise specified in the Order. (c) Interest may be charged on all past due amounts owed by Buyer hereunder at an interest rate equal to the prevailing LIBOR rate of interest, expressed as an annual percent, plus three percent (3%) from the payment due date until paid in full, or the highest interest rate allowed by applicable law, whichever is less. Payments must be made via a financial institution that is not subject to the sanctions laws of the United States, the European Union, or other applicable jurisdictions.
- 4. CREDIT TERMS.** If, in Seller’s judgment, the creditworthiness or future performance of Buyer is or may become impaired or unsatisfactory, Seller may suspend performance hereunder and seek adequate assurances from Buyer. Buyer shall pay (or otherwise reimburse) Seller for any costs associated with such suspension (including charges for reactivation). Without limiting the foregoing, Seller may, for any reason, (a) require prepayment by wire transfer at least two (2) business days prior to a scheduled shipment of Goods or provision of Services, and/or (b) require Buyer to issue letter(s) of credit in a form, and from an issuing bank, acceptable to Seller at least three (3) business days prior to a scheduled shipment of Goods or provision of Services.
- 5. DELIVERY.** (a) Unless otherwise stated in the Order, delivery of the Goods shall be FCA (Incoterms®2020 International Chamber of Commerce (ICC) publication) Seller’s designated manufacturing facility. (b) If Buyer has not issued inspection and shipping instructions by the time the Goods are available to Buyer, Seller may, at its sole discretion, (i) store the Goods at Buyer’s risk of loss and cost, or (ii) select any reasonable method of shipment, without liability by reason of its selection, costs of shipment and risk of loss to be the responsibility of Buyer. (c) Shipments or Goods in storage may be insured at Buyer’s expense.
- 6. TITLE/RISK OF LOSS.** Unless otherwise stated in the Order, title in the Goods shall pass to Buyer upon payment in full. The risk of loss or damage to the Goods shall pass to Buyer upon delivery in accordance with the Contract or as otherwise provided in the Delivery section.
- 7. INSPECTION/REJECTION OF GOODS.** All Goods shall be received subject to Buyer’s reasonable inspection and rejection. Buyer may only reject Goods that do not conform in all material respects to the specifications contained in the Contract. Rejected Goods will be held at Seller’s risk for a reasonable time, to be returned or disposed of by Buyer at Seller’s written instruction and at Seller’s sole cost and expense. A failure by Buyer to reject nonconforming Goods in writing within thirty (30) days after receipt shall constitute an unqualified acceptance of such Goods by Buyer and a waiver by Buyer of all claims with respect thereto. Thereafter, nonconforming Goods shall be subject to the Warranty section.
- 8. WARRANTY.** (a) Seller warrants that (i) the Goods shall be new and good quality and shall conform to the specifications specifically set forth in the Order and title to the Goods shall be free from any security interest, lien or encumbrance upon Seller’s receipt of full payment for the Goods, and (ii) Seller shall perform the Services in a workmanlike manner in accordance with the specifications specifically set forth in the Order. (b) The foregoing warranties will last for the following period (the “Warranty Period”): (i) for Goods, eighteen (18) months after the date that the Goods are available for shipment or one (1) year after first start-up, whichever occurs first; and (ii) for Services, three (3) months after completion of the Services. If during the Warranty Period any Goods or Services prove not to meet the warranties set forth above, Seller will repair the Goods or supply identical or substantially similar replacement Goods EXW Seller’s manufacturing facility, at Seller’s sole discretion, or re-perform the Services (as applicable). Any replacement Goods or re-performed Services will be warranted for the unexpired portion of the Warranty Period applicable to the particular Goods or Services. (c) Seller will not be responsible for transportation costs or for the costs of removal, installation, re-installation or making of access of any Goods or other items, where such transportation, removal, installation, re-installation or making of access is required to repair or replace any defective Goods or to re-perform Services. Furthermore, Seller will not be responsible for and assumes no liability for materials or workmanship, labor costs or other related expenses for any work performed by Buyer or third parties (not authorized by Seller) in the repair or replacement of defective Goods or the re-performance of Services. (d) Seller’s warranties will be voided if (i) the Goods or the subject of the Services have not been stored, installed, maintained or operated in accordance with accepted industrial practice or any specific instructions provided by Seller; (ii) the Goods or the subject of the Services have been subjected to any accident, misapplication, environmental contaminant, corrosion, damage, debris, improper passivation, abuse or misuse; (iii) Buyer has modified the Goods or the subject of the Services without Seller’s prior written consent; (iv) Buyer has used or repaired the Goods or the subject of the Services after discovery of the defect without Seller’s prior written consent; (v) Buyer or any third party refuses to permit Seller to examine the Goods or the subject of the Services and operating data to determine the nature of the defect claimed; or (vi) Buyer fails to meet its financial obligations under the Contract. (e) Goods not manufactured by Seller are subject only to warranties of Seller’s vendors and Seller hereby assigns to Buyer all rights in such vendors’ warranties, however, Seller shall furnish to Buyer reasonable assistance in enforcing such rights. (f) Inexpensive items requiring repair or replacement and routine maintenance-related or consumable items shall be outside the scope of these limited warranties. (g) Seller’s performance guarantees, if any, shall be deemed to be met by a satisfactory demonstration of the guaranteed performance parameters during a performance test, which shall be the responsibility of Buyer and is to be based on test procedures as specified in the Order or, if not specified in the Order, to be based on test procedures mutually agreed upon by Seller and Buyer. In the absence of a performance test within sixty (60) days of delivery, unless otherwise specified in the Order, Seller’s performance guarantees are deemed to have been met. (h) ALL WARRANTIES OR REPRESENTATIONS NOT SPECIFICALLY INCLUDED IN THESE TERMS AND CONDITIONS, INCLUDING THOSE WITH RESPECT TO MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE WHETHER EXPRESSED, IMPLIED, STATUTORY OR ARISING FROM A COURSE OF DEALING, USAGE OF THE TRADE OR OTHERWISE WITH RESPECT TO ANY GOODS OR SERVICES, ARE EXPRESSLY EXCLUDED. NO EXPRESS OR IMPLIED WARRANTY IS GIVEN AS TO THE CAPACITY, EFFICIENCY OR PERFORMANCE OF ANY GOODS, EXCEPT AS MAY BE PROVIDED IN A SEPARATE WRITTEN AGREEMENT SIGNED BY SELLER. (i) BUYER’S REMEDIES ARE SPECIFICALLY LIMITED TO THE REPAIR OR REPLACEMENT OF THE GOODS OR THE RE-PERFORMANCE OF THE SERVICES, AS APPLICABLE, DURING THE WARRANTY PERIOD, AND ARE EXCLUSIVE OF ALL OTHER REMEDIES. SHOULD THESE REMEDIES BE FOUND INADEQUATE OR TO HAVE FAILED OF THEIR ESSENTIAL PURPOSE FOR ANY REASON WHATSOEVER, BUYER AGREES THAT RETURN OF THE AMOUNT PAID BY BUYER TO SELLER FOR THE GOODS INVOLVED SHALL PREVENT THE REMEDIES FROM FAILING OF THEIR ESSENTIAL PURPOSE AND SHALL BE CONSIDERED BY BUYER AS A FAIR AND ADEQUATE REMEDY.
- 9. BACKCHARGES.** No backcharges will be paid or allowed by Seller unless (a) Seller is notified in writing of Buyer’s intent to incur costs and (b) Seller provides prior written approval of such backcharges.
- 10. OBLIGATIONS OF BUYER.** Buyer is solely responsible for identifying and defining all processes, mechanical considerations, and site requirements, which may affect the performance, reliability or operation of the Goods or Seller’s performance of Services. Buyer represents that all information and data provided to Seller by or for Buyer is current, complete, and accurate. Buyer represents and warrants to Seller that Buyer has all necessary rights and permissions to provide all information provided by or on behalf of Buyer to Seller and shall indemnify Seller from any third party with respect to Seller’s use of such information in connection with the Contract.
- 11. INDEMNITY.** In the event that Seller performs onsite services at Buyer’s facility, (a) Seller shall defend, indemnify and hold harmless Buyer against all damages, losses, costs, claims, liabilities, and expenses (including reasonable attorneys’ fees), resulting from bodily injury, including death, or damage to tangible property to a Third Party, to the extent caused by the negligent acts or omissions of Seller, its officers, directors, employees or agents (“Seller Group”); and (b) Buyer shall defend, indemnify and hold harmless Seller against all damages, losses, costs, claims, liabilities and expenses (including reasonable attorneys’ fees), resulting from bodily injury, including death, or damage to tangible property to a Third Party, to the extent caused by the negligent acts or omissions of Buyer, its officers, directors, employees or agents (“Buyer Group”). All liability, losses, damages, costs or expenses resulting from bodily injury, including death, or damage to tangible property to a Third Party, caused by the joint or concurring acts of Buyer Group and Seller Group, shall be borne by Buyer and Seller to the extent each is determined negligent either by agreement of the parties or by a court of competent jurisdiction. The term “Third Party” shall mean any person or entity that is not a member of Seller Group, Buyer Group, the end user of the Goods or subject of the Services, or any of its respective affiliates, parent(s), subsidiaries or any of their respective officers, directors, employees, agents, or subcontractors.
- 12. DEFAULT.** Upon the occurrence of any of the following events: (a) Seller has not received a payment due from Buyer hereunder by the date such payment is due under the Contract, and such failure remains uncured for a period of ten (10) business days after Buyer’s receipt of written notice from Seller of such non-payment; (b) Seller is unable to meet its warranty obligations and fails to commence to cure within ten (10) business days after Seller’s receipt of written notice from Buyer of such uncured obligation; or (c) Seller or Buyer fail to perform other material obligations in the Contract and such failure remains uncured for a period of thirty (30) business days after receipt of written notice from the other party of such uncured obligation, or if cure is not possible within that period, the defaulting party fails to make continuous and diligent efforts to cure, then the non-defaulting party, in its sole discretion and without prior notice (other than as provided above) to the defaulting party, may do any one or more of the following: (i) suspend performance under the Contract; or (ii) terminate the Contract, whereby any and all obligations of the defaulting party will, at the option of the non-defaulting party, become immediately due and payable or deliverable, as applicable. In the event of default by Buyer, Seller shall have the right to withhold delivery and/or sell the Goods to a third party and deduct from proceeds of such sale the purchase price and all reasonable costs resulting from the default. The prevailing party shall be entitled to recover all court costs, reasonable attorneys’ fees and expenses incurred by the prevailing party in connection with the default, and interest on past due amounts as set forth in the payment terms of the Contract.
- 13. INTELLECTUAL PROPERTY.** (a) Seller retains all intellectual property rights, whether registered or un-registered, including trademarks, patents, and copyright of all documents, drawing rights, design rights, developed programs, software, models and other data provided or developed in the course of the Contract (“Seller IP”), and hereby grants Buyer a non-exclusive, non-assignable royalty free license to use Seller IP delivered to Buyer or embodied in the Goods or related deliverables only for the purposes of Buyer’s installation, operation and maintenance of the Goods. (b) Seller will defend and indemnify Buyer from any claim, suit or proceeding brought against Buyer based on a claim that the Goods as manufactured and furnished by Seller and used in the manner for which it was intended and sold to Buyer constitutes an infringement of any United States, Canadian or European Union-member patent, if Seller is notified promptly in writing and given authority, information and assistance for the defense of such claim, suit or proceeding. All aspects of the defense and settlement of any such claim, suit or proceeding shall be within Seller’s sole discretion. Buyer remains solely responsible for its own costs, including all fees and expenses of its own counsel, if any, or its personnel, which are incurred in conjunction with the defense of such claim, suit or proceeding. Should it be held that the Goods constitute an infringement and the use of the Goods is enjoined, Seller will, at its sole discretion and at its own expense, either procure for Buyer the right to continue using the Goods, replace the Goods with non-infringing goods, modify the Goods to become non-infringing or refund the purchase price for the infringing Goods. Seller’s obligations to defend, and indemnify Buyer shall not apply to any liability for infringement (i) of any method patent where the Goods are used with other apparatus for carrying out a process resulting in a combination of steps which is deemed to infringe a method patent or patent directed to a combination of steps, (ii) where the Goods are modified by Buyer,

(iii) where the Goods are used by Buyer in a manner different than the use communicated to and understood by Seller at the time the Goods were sold to Buyer and such use constitutes infringement, or (iv) with respect to claims of infringement where the Goods were designed and manufactured in accordance with the design or specifications furnished or required by Buyer. (c) Buyer will indemnify and hold harmless Seller from any suit or proceeding brought against Seller by any third party based on claims resulting from exceptions (i), (ii), (iii) or (iv) as stated above.

14. DELIVERY DATE. If the Order specifies a delivery date, Seller shall use commercially reasonable efforts to meet the requested date.

15. CANCELLATION FEE. Buyer may not cancel any part of the Contract except upon written notice and payment to Seller for (a) all Goods or Services completed prior to cancellation, (b) all costs incurred by Seller prior to cancellation, (c) all reasonable costs arising due to the cancellation, (d) unavoidable third party charges, and (e) a cancellation fee in the amount of twenty percent (20%) of the total price of the Contract. The parties agree that Seller's damages following a termination of any part of the Contract by Buyer are difficult to determine and that the cancellation fee provided by this provision is a genuine pre-estimate of loss and not a penalty and is reasonable in light of the circumstances. Seller shall be entitled to the payments set forth above if Seller cancels or terminates the Contract pursuant to the Default and Suspension sections. Title to all works in progress and all materials not delivered to Buyer prior to the date of cancellation will remain with Seller.

16. SUSPENSION. (a) Buyer may only suspend the Order upon written notice to Seller, subject to payment of Seller's costs. (b) If Buyer or any of its agents delays Seller's performance due to failure to promptly approve drawings or procedures or due to any other action or non-action on part of Buyer or its agents: (i) Buyer shall reimburse Seller for all costs incurred up to the date of suspension and as a result of such delay (including costs of reactivation), (ii) the delivery time shall be adjusted, and (iii) milestone payments (if applicable) will be adjusted to keep Seller whole for costs incurred up to the date of delay or suspension. (c) If, due to any action or non-action on the part of Buyer or its agents, Seller is delayed for more than forty-five (45) days, or such longer period of time as deemed reasonable by Seller in its sole discretion, Seller may elect to cancel the Order.

17. FORCE MAJEURE. Force Majeure means any circumstances beyond the reasonable control of either party, including acts of God, fire, explosion, breakdown of machinery or equipment, third party supplier plant shutdown, strikes or other labor disputes of Seller's suppliers or subcontractors, acts of terrorism or war, riots or other civil disturbances or voluntary or involuntary compliance with any law, order, regulation, recommendation or request of any governmental authority, inability to obtain materials necessary for manufacture of the Goods, total or partial failure of any of Seller's usual means of transportation of the Goods, or for failure to obtain necessary governmental approvals, permits or licenses. Neither party will have any liability, other than for the payment of monies owing, for their failure to perform any of their contractual obligations arising out of or in connection with events of Force Majeure.

18. ASSIGNABILITY. The rights and duties under the Contract are not assignable or transferable by Buyer or Seller, in whole or in part, by operation of law or otherwise, without the prior written consent of the non-assigning party, which consent may not be unreasonably withheld, delayed, or conditioned. Notwithstanding, upon written notice, Buyer or Seller may assign this Contract in whole or in part to any of its affiliates which are as equally creditworthy and provided such affiliate is compliant with all applicable laws. Any assignment or attempted assignment in contravention of the foregoing shall be null and void. Any assignee is subject to all of the obligations, liabilities, waivers and limitations of this Contract.

19. GOVERNING LAW. The Contract, and its execution, performance, interpretation, construction and enforcement, shall be governed by the law, both procedural and substantive, of the State of Texas, without regard to its conflicts of law rules; and all claims relating to or arising out of the Contract, including breach, and formation, whether sounding in contract, tort or otherwise, shall likewise be governed by the laws of the State of Texas, excluding choice-of-law principles. Any action or proceeding between Buyer and Seller relating to the Contract shall be commenced and maintained exclusively in the State or federal courts in Harris County, Houston, Texas; and, Buyer waives all venue and inconvenience of forum challenges and irrevocably submits itself unconditionally and irrevocably to the personal jurisdiction of such courts. BUYER AND SELLER EACH WAIVE, TO THE FULLEST EXTENT PERMITTED BY LAW, ANY RIGHT IT MAY HAVE TO A TRIAL BY JURY IN RESPECT TO ANY SUIT, ACTION, CLAIM OR PROCEEDING RELATING TO THE CONTRACT.

20. NOTICE. All official notices made under this Agreement must be made via certified or registered mail with return receipt, postage prepaid addressed to the party to whom such notice is given at the address of such party stated in the Contract. All other communications or transmittals under the Contract shall be in writing and shall be deemed received on the day of delivery if personally hand delivered or sent by facsimile or electronic transmission (with written confirmation of the completed transmittal).

21. ENTIRE AGREEMENT; AMENDMENT; WAIVERS. This Contract supersedes all prior negotiations, discussions, and dealings concerning the subject matter hereof, and shall constitute the entire agreement between Seller and Buyer concerning the subject matter hereof. There are no understandings, inducements, commitments, conditions, representations or warranties of any kind, whether direct, indirect, collateral, express or implied, oral or written, from either party to the other, other than as contained in this Contract. No party shall claim any amendment, modification or release of any provisions hereof unless the same is in writing and signed by Buyer and Seller. No waiver by Buyer or Seller of any breach of any terms, conditions or obligations under the Contract shall be deemed a waiver of any continuing or subsequent breach of the same or any other terms, conditions or obligations hereunder.

22. ELECTRONIC TRANSACTIONS. The Contract may be digitally copied and stored on electronic storage media or devices (the "Imaged Agreement"). The Imaged Agreement (once digitally regenerated to paper form), and any facsimile, and all computer records of the foregoing, if introduced as evidence in any judicial, arbitration, mediation or administrative proceedings, will be admissible as between the parties to the same extent and under the same conditions as other business records originated and maintained in documentary form and neither party shall object on the basis that such business records were not originated or maintained in documentary form under any rule of evidence.

23. COMPLIANCE. Buyer and Seller shall: (i) comply fully with all applicable laws and regulations in their respective performances of the Contract; and, (ii) neither take nor refrain from taking any action that could result in liability for either party under applicable law, including the U.S. Foreign Corrupt Practices Act, the OECD Anti-Bribery Convention or any other applicable

anti-bribery law or treaty, or those regulations maintained by the U.S. Treasury Department's Office of Foreign Assets Control (31 C.F.R. Chapter V) or the U.S. Commerce Department's Bureau of Industry and Security (15 C.F.R. Parts 730 et. Seq.). Buyer shall comply as follows: (i) Buyer acknowledges that any distribution, sale, transfer or re-export of the Goods is governed by and subject to the trade control laws of the United States; (ii) Buyer shall not distribute, sell, transfer or re-export the Goods, except in conformance with United States law; and, (iii) If Buyer knows or has reason to know that any of its customers intend to distribute, sell, transfer or reexport the Goods, either directly or through incorporation into other products, then Buyer shall inform its customer that the customer is responsible for obtaining any licenses or other approvals from the U.S. Government before such distribution, sale, transfer or re-export, by including the following language in Buyer's purchase order acknowledgement or other appropriate documentation to its customer: *NOTICE: The products, technical data, and/or software included in this Order were provided in compliance with the laws and regulations of the United States. Customer is responsible for obtaining all licenses, permits or other approvals that may be necessary under the laws of the United States before any distribution, sale, transfer or re-export of such items and for ensuring that the end-user and end use of these products are permitted under U.S. law. Re-export, diversion, transshipment, or use contrary to U.S. law is prohibited and is cause for cancellation of this [purchase order].* Nothing in this Contract shall require Buyer or Seller to take or refrain from taking any action impermissible or penalized under United States or other applicable laws. A Party's breach of this Section shall constitute cause for immediate termination of the Contract.

24. INDEPENDENT CONTRACTORS. Seller and Buyer are independent contractors only and are not partners, master/servant, principal/agent or involved herein as parties to any other similar legal relationship with respect to the transactions contemplated under the Contract or otherwise, and no fiduciary, trust, or advisor relationship, nor any other relationship imposing vicarious liability shall exist between the parties under the Contract or otherwise at law.

25. NO THIRD PARTY BENEFICIARIES. The Contract is solely for the benefit of, and shall inure to the benefit of, Buyer and Seller, and shall not otherwise be deemed to confer upon or give to any third party any right, claim, cause of action or other interest herein.

26. SEVERABILITY. The invalidity or unenforceability of any provision of the Contract shall not affect the validity or enforceability of its other provisions and the remaining provisions shall remain in full force and effect.

27. CONFIDENTIALITY. Except as provided in a separate written confidentiality agreement, all information that Buyer acquires from Seller hereunder, directly or indirectly, and all information that arises out of the sale of the Goods and/or Services hereunder, concerning such Goods, Services, and/or proprietary processes involved, including, but not limited to, information concerning Seller's current and future business plans, information relating to Seller's operations, know-how, and other Seller-furnished information shall be deemed Seller's "Proprietary Information". Buyer shall (a) hold Seller's Proprietary Information in strictest confidence, (b) not disclose it to others and (c) use it solely for purposes of the Contract.

28. INSURANCE. In the event the Seller performs onsite services at Buyer's facility, Seller shall maintain the following insurance coverage during the term of the Contract and, at Buyer's request, shall provide Buyer with a certificate evidencing such coverage: (a) Statutory Workers' Compensation and Employer's Liability Insurance, with limits of Five Hundred Thousand USD (\$500,000.00) each accident, Five Hundred Thousand USD (\$500,000.00) disease each employee, and Five Hundred Thousand USD (\$500,000.00) disease policy limit; (b) Commercial General Liability Insurance, with a combined single limit for bodily injury and property damage of One Million USD (\$1,000,000.00) per occurrence and in the aggregate; and (c) Automobile Liability Insurance, with a combined single limit for bodily injury and property damage of One Million USD (\$1,000,000.00) per accident.

29. SURVIVAL. The provisions addressing indemnity, confidentiality, limitation of liability, and all other provisions which by their nature are intended to survive, shall survive expiration or termination of the Contract.

30. MISCELLANEOUS. The captions and section headings set forth in the Contract are used for convenience only and shall not be used in defining or construing any of the terms and conditions set forth in the Contract. The term "days", as used herein, shall mean actual days occurring, including, Saturdays, Sundays and holidays where banks are authorized to be closed in the city where Seller's chief executive office is located. The term "business days" shall mean days other than Saturdays, Sundays and holidays where banks are authorized to be closed in the city where Seller's chief executive office is located. The term "including" or any variation thereof means "including, without limitation" and shall not be construed to limit any general statement that it follows to the specific items immediately following it. Unless the context indicates otherwise, words importing the singular number shall include the plural and vice versa, and words importing person shall include firms, association, partnerships and corporations, including public bodies and governmental entities, as well as natural persons, and words of masculine gender shall be deemed to include correlative words of the feminine gender and vice versa as the circumstances may require. The United Nations Convention on Contracts for the International Sale of Goods shall not apply.

31. LIMITATION OF LIABILITY. (A) NO PARTY SHALL BE LIABLE FOR INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING LOSS OF PROFITS, REVENUES, OR OTHER ECONOMIC LOSSES WHETHER DEEMED DIRECT OR CONSEQUENTIAL, ARISING UNDER ANY CAUSE OR COMBINATION OF CAUSES, INCLUDING ANY THEORIES OF CONCURRENT OR JOINT LIABILITY. (B) THE LIABILITY OF SELLER AND ITS AFFILIATES IS LIMITED TO THE PRICE ALLOCABLE TO THE GOODS OR SERVICES DETERMINED TO BE DEFECTIVE, AND IN NO EVENT WILL THE CUMULATIVE LIABILITY OF SELLER AND ITS AFFILIATES BE IN EXCESS OF THE TOTAL PAYMENTS RECEIVED FROM BUYER UNDER THE ORDER REGARDLESS OF CAUSE OR ANY COMBINATION OF CAUSES WHATSOEVER. ALL INSURANCE, BOND AND BANK GUARANTEE OR LETTER OF CREDIT PROCEEDS WHICH MAY BE PAID BY THE INSURERS, SURETIES OR BANKS OF SELLER OR ITS AFFILIATES WILL BE CREDITED AGAINST THE LIMITATION STATED ABOVE AND SHALL REDUCE THE AMOUNT OF THE CUMULATIVE LIABILITY OF SELLER AND ITS AFFILIATES. (C) BUYER'S REMEDIES ARE LIMITED TO THOSE REMEDIES EXPRESSLY STATED IN THIS CONTRACT. (D) THESE LIMITATIONS SHALL APPLY NOTWITHSTANDING ANY FUNDAMENTAL BREACH OR FAILURE OF ESSENTIAL PURPOSE OF ANY LIMITED REMEDY.

[End of General Terms and Conditions of Sale]

Vendor: BD Heat Recovery
DeNOx System Supply (SCR) Cost Estimates
Boiler B-003



**HEAT
RECOVERY**
A BD GROUP INDUSTRIES COMPANY

PROPOSAL DOCUMENT

PROPOSAL 22-1031

DeNOx System Supply

**CDM, Bellefield Boiler Plant,
PA - USA**

To: Fran Sapienza
Company: CDM Smith
Client Ref No.:
BD Heat Ref No.: 22-1031 Rev. 0
Engineer: Tatiana Colon
Email: Tatiana.Colon@BDHeat.com
Date: November 30, 2022

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1 Introduction

Enclosed herein is BD Heat Recovery's estimated price offer for the supply of a DeNOx system with related components to be installed as part of the proposed expansion at Bellefield Boiler plant facility.

We have estimated the SCR operating temperature to approx. 554°F and consequently the catalyst volume.

We trust that the information we've provided is satisfactory and suits your needs at this time. Thank you for the opportunity to bid and please know that we are always available to answer any questions that you may have.

Thank you and best regards,

Tatiana Colón Martínez
Sales Manager of Americas
Tel: (727) 392 – 0492
Mobile: (848) 234 – 7684
Email: Tatiana.Colon@BDHeat.com

Dr. Olivier Brasseur
Technical Director
Tel: (727) 392 - 0492
Mobile: +49 – 176-70257686
Email: Olivier.Brasseur@BDHeat.com

2 Compact DeNOx System Description

The Compact DeNOx system utilizes the beneficial characteristics of separate and uncontaminated gas streams. This combined with its highly efficient counter flow heat exchanger design make it ideal for solving the problems associated with NOx removal from low temperature gases.

2.1 Compact DeNOx System - Production Description

The Compact DeNOx system is a patented clean side SCR (Selective Catalytic Reduction) system specifically designed to allow the removal of NOx from cold gases while using a minimal amount of energy to reheat the gases to the optimum catalyst reaction temperature.

A fan (supplied by others) transmits the cold dirty flue gases to the Compact DeNOx system and enters the High Efficiency Heat Exchanger (HEHE). The High Efficiency Heat Exchanger is a single-stage counter flow plate-type recuperator. The heating surface consists of shaped plates, which are welded together and assembled into heat exchanger modules.

The hot and cold gases flow over the plates in counter flow to one another, producing a smooth temperature curve and eliminating the typical diagonal profiles occurring in cross flow exchangers. The welded plates guarantee a high thermal efficiency, while maintaining the gases separate from each other, ensuring uncontaminated and leak free operation.

The heat transfer plates are manufactured out of various steels, selected based on the gas constituents and temperature range. The types of fuel being fired and the expected operating conditions determine the plate gap and profile.

Heat transfer plates are welded together to form plate packs. These plate packs are assembled into modules, which when assembled on site produce the HEHE.

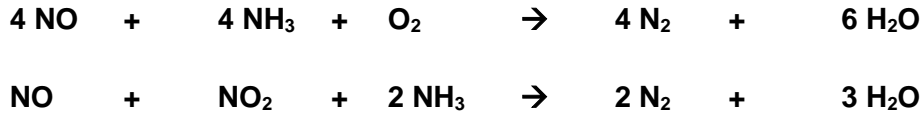
The dirty gases after leaving the heat exchanger at around 509°F are again heated up with additional heat supplied by the post heat burner installed in the Compact DeNOx systems casing. The gas temperature is increased to approximately 554°F, which is necessary for the catalyst to operate.

A 19% ammonia solution (NH₄OH) is injected into the hot dirty gas stream and homogenized with a static gas mixer prior to turning through 180° and entering the SCR DeNOx catalyst where the NOx reacts with the ammonia and the catalyst to form water and nitrogen.

The hot clean gases then pass back through the High Efficiency Heat Exchanger and heat the dirty cold gases. The cooled clean gases are then discharged to the atmosphere via a separate stack (supplied by others).

2.2 SCR Process Description

The DeNOx system offered in this quotation selective operates according to the Selective Catalytic Reaction (SCR) NOx-reduction using ammonia as reduction agents with nitrogen monoxide (NO) and nitrogen dioxide (NO₂) with the help of a catalyst and according to the following overall reaction:



The reaction is temperature sensitive. While optimum catalyzing efficiency is between 644 – 680°F, increasing catalyst volume will ensure appropriate reaction rates at far lower temperatures.

The reagent is a 19% liquid ammonia solution by weight, which will be directly injected in the flue gas by means of a set of 2 atomizing dual flow spray nozzles. Non reacted ammonia will leave the catalyst unreacted and form the so-called “ammonia slip”. As it evident in the above reaction, a high NOx conversion rates requires a thoroughly mixed flue gas. This is done by using so called “Vortex Generating Mixers” (VGM) placed directly upstream of the injection points. These high efficiency VGMs will mix Ammonia with the NOx molecules present in the flue gas to create a homogenous distribution before they reach the catalyst. The mixers have also the purpose to equalize the flue gas flow before entering the catalyst according to the specification of the catalyst supplier.

The catalyst is a corrugated plate type catalyst, supplied in rectangular modules, and arranged in a rectangular matrix in the reactor. The Reactor includes all necessary supports, access openings, outside walkways and catalyst loading openings.

2.3 SCR Control System

The control system will be supplied as per the P&ID diagrams and control loops supplied as part of the engineering contract. Control will be by BBP's DCS system.

2.4 SCR Turndown

The offered system will follow a turn-down ratio of 1:2 for the Heat Exchanger, 1:30 for the ammonia boosting system, 1:10 for the mixing system, 1:5 for the ammonia injection system, 1:8 for the post-heating system

2.5 SCR Process Data

The SCR is designed for following data as supplied on November 15th, 2022, and under the assumption that these are valid.

	wet basis		kg/kmol	kg/Nm ³	kg/hr	dry basis	
	Mol %	Weight %				Mol %	Weight %
N2	71,47%	71,53%	28,01	1,250	41.746	84,15%	79,21%
CO2	7,89%	12,40%	44,01	1,964	7.240	9,29%	13,74%
H2O	15,07%	9,70%	18,02	0,804	5.661		0,107
Ar	0,00%	0,00%	39,95	1,782	-	0,00%	0,00%
O2	5,56%	6,36%	32,00	1,428	3.710	6,55%	7,04%
SOx	0,0001%	0,00%	64,06	2,858	0	0,00010%	0,0002%
HCl	0,0000%	0,00%	36,00	1,606	-	0,00000%	0,0000%
HF	0,0000%	0,00%	20,00	0,892	-	0,00000%	0,0000%
NOx	0,0074%	0,01%	46,01	2,053	7	0,00873%	0,0135%
Total	100,00%	100,00%	27,99	1,249	58.356	100,00%	100,00%

Design data, based on natural gas firing

2.6 Guaranteed Emission Values

EMISSION COMPONENT	CONCENTRATION
NOx outlet (as NO ₂)	≤ 10% of inlet value
NH ₃ Slip	≤ 5 ppm @ 11 Vol. % O ₂ , dry

Emission data at outlet of SCR, daily average, under conditions defined in Section 2.4

2.7 Utility Consumption

AMMONIA INFORMATION	
<i>Design Case</i>	
NH ₃ consumption (19%), lbs/h	31

Consumption data. It is assumed that 5% NO₂ will be present in the total NOx

Ammonia Solution	Type	Ammonia water, technical quality
	Color	Clear, Colorless
	NH ₃ Concentration	< 19% [% w/w]
	Temperature	Ambient

ELECTRICAL INFORMATION	
<i>Electrical Consumption Data</i>	
Electrical Power – Boosting Pump	2 x 3 HP connected
Electrical Power – Fan Burner	1 x 30 HP connected

Power requirement

Electrical Energy:	
Voltage for LV Induction Motors	460V, 3 phase, 60 Hz
Instrumentation	240 / 120 V / 1 / 60 Hz

COMPRESSED AIR INFORMATION***Compressed Air Consumption***

Atomization Air @ 80 psig	43 lb/hr
Pressure	6 barg
Temperature	Ambient
Dew Point	< min, ambient temperature
Impurities	Free from, solids and oil droplets

PRESSURE LOSS INFORMATION

<i>Pressure Loss Data</i>	Design	Unit
High Efficiency Heat Exchanger	9.5	in WG
Post-Heating duct incl. NH3 injection + Mixers	0.4	in WG
180 Turn + Homogenizers	0.5	in WG
Single Catalyst Layer	3.0	in WG
Spare Catalyst Single Layer	3.0	in WG
Total – Pressure Loss	16.4	in WG

NATURAL GAS CONSUMPTION

Consumption at max. load	92 lb/hr
Fuel:	
Natural Gas Pressure	80 psig
Heating Value	1,000 BTU/scf

3 Scope of Services and Supply

3.1 Engineering Services

- Basic Engineering
- Process Engineering
- Structural calculations
- Foundation load calculations
- Control Narratives for critical loops for Programming SCADA PLC and HMI systems, incl. Alarm set points, Interlocks, Control loops drawings
- Wiring and cabling diagram of supplied equipment
- Detail engineering
- Design of lifting lugs and frames
- Sub-contractor shop visits and inspections
- Kick-off meeting
- Progress meetings on site
- Project management
- Startup assistance as noted

3.2 Scope of Supply

BD Heat Recovery Div. will supply One (1) Compact DeNOx system consisting of the following:

High efficiency CFX heat exchangers comprising of:

- **Hot Stage:**
 - One (1) hot Heat Exchanger module, with heat exchange plates made from Stainless steel, 0.6 mm thickness
 - Module casings made from Carbon Steel walls, Carbon Steel shapes
 - External surface: Sandblasted and primed with Carbozinc 11 or equivalent per spec
 - Est. Weight: 48,559 lb

- **Accessories**
 - Upper distribution hood manufactured from Carbon Steel
 - Lower distribution hood and inlet transition "D1" manufactured from CS Steel
 - Fabric expansion joint by SF Pathway or equivalent
 - Static Gas Mixers and necessary guide vanes
 - SCR Catalyst reactor from 1/4" carbon steel, suitable for one single layers of catalyst, incl. turning vanes, homogenizers as far as necessary, incl. empty space for spare catalyst.
 - Galvanized structural steel from grade level up to the Compact DeNOx integral support structure.
 - Galvanized platforms, ladders and handrails to provide operating and maintenance access.

3.3 Burner System

Post-Heat System

The post heating system consists of a SS304 stainless steel duct (*insulation by others*), combustion blower, one air control valve, safety valve train, NEMA 4X JIC box, and combustion control panel for use with the burner. A 3600 RPM motor must be used to maintain required fan pressure. The unit includes the combustion blower isolation base, a combustion blower inlet silencer for <85 dBA at 3ft, Precision Measurement thermocouples, and hand off switch. The panel includes remote e-stop contacts, local start/stop and thermocouple terminal blocks.

The blower, air valve, gas valve train, JIC box, and control panel are pre-piped, prewired, and mounted on a structural steel skid.

The NEMA 4X control panel includes high temp limit, Honeywell annunciator, and Honeywell burner flame relay. (*Three phase and motor controls by others*).

The Electrical testing will be completed in the factory.

BURNER RATING	
Burner Max rated Input	2.0 x 10 ⁶ Btu/hr
Burner Min Input	0.250 x 10 ⁶ Btu/hr
Rated Fuel Consumption	92 lbs/hr of NG
Available Fuel Pressure Range	80 PSIG
Rated Air Requirement	2147 lbs/h
Valve Train Rating	IRI
Valve Train NEMA Rating	NEMA 4X
Equipment Location	Outdoors
Electric Power Supply	120/1/60
Equipment Area Electrical Class	Nonhazardous
Panel Area Electrical Class (if remote)	Nonhazardous
Panel NEMA Rating (if remote)	NEMA 4X
Panel Location	Remote

The heater is designed according to NFPA 86 specifications. The temperature control is by others. UL508A Electrical Enclosure Certification is excluded but Available upon request. Exception is taken to all other standards mentioned in the RFQ.

3.4 SCR Catalyst

BD Heat will supply one (1) set of the catalyst as follows:

CATALYST			
Catalyst Designation		-	DNX-939®
Chemical Composition		-	TiO ₂ / V ₂ O ₅ / WO ₃
Nominal Catalyst Geometry	Hydraulic Diameter	mm	3.4
	Wall Thickness	mm	0.4
	Cell Pitch	mm	4.1
	Void, %	-	76
	Cells per Square	in	39
MODULES			
Element type		-	DNX-939EE
REACTOR			
Catalyst Volume per Reactor		m ³	≤ 15.0
Module Arrangement, W x D		-	6 x 4
Number of Modules		-	24
Number of Layers		-	1
Module Size, L x W x H		mm	466 x 466 x 1210
Reactor Gas Path Dimensions W x L		m	3.2 x 2.2
Nominal Catalyst Height, total		m	1.0

3.5 Ammonia NH₃ Handling

3.5.1 Storage Tank

Storage Tank Features:

- 12,500-gallon, single wall stainless steel construction 120" OD x 18' tall, ASME section VIII code stamped: 35 psig, @ -20°F/140°F, full vacuum
- Two (2) Lifting lugs
- OSHA Compliant Ladder & Platform hot did galvanize.
- Tank and pipe material to be 304 SS, SSPC-1 chemical cleaning of material only.
- Conventional relief valve 5' standpipe.
- NFPA labeling per code.
- Including following connections:
 - o One (1) 36" Man way
 - o One (1) 36" RFWN man way w/davit arm

- Five (5) 2" 150# RFLWN
- One (1) 3" 150# RFLWN
- One (1) 1" 150# RFLWN

NOTES: *All tank accessories and ladder/platform shipped loose for field installation.*

Instrumentation consisting of:

- One (1) x 100% pressure relief valve
- One (1) vacuum check relief valve
- One (1) level gauge w/transmitter (bridle type) w/manual isolation valves
- One (1) pressure indicating transmitter w/block and bleed valves
- One (1) temperature indicator
- 2" class 150 stainless steel nitrogen spool assembly with two (2) pressure control valves, a pressure relief valve, manual ball valve and check valve.
- Seven (7) 2" manual isolation ball valves
- One (1) 3" manual isolation ball valve
- Two (2) 3/4" manual isolation ball valves

NOTES: *Tank accessories will be packaged for shipment and field installed by others.*

3.5.2 Ammonia Boosting Pump Skid

Stainless Steel skid package **(4' x 8')** includes the following components & features to boost aqueous ammonia **(19% by weight)**:

- 1" class 150 stainless steel pump inlet line with manual ball valves, Y strainers, w/drain valves.
- Two (2) BRAN LUEBBE NOVADOS metering pumps rated at 0.1 gpm @ 135 psig, 30:1 turndown, SS construction with TENV 460 VAC, 3 phase, premium efficiency motor, 1.15 SF, VFD and a pneumatic stroke positioner.
- 3/4" class 150 304SS SMLS discharge line from pumps with check valves, manual ball valves, pressure gauges w/block and bleed valves, and pressure relief valves. A common 1/2" class 150 304SS SMLS line with a pulsation dampener, a Coriolis mass flow meter, manual ball valves, an automated ball valve assembly w/limit switches, and drain valves terminated at edge of skid.
- 1 1/2" class 150 304SS SMLS recirculation line from pressure relief valve discharges with manual ball valves to edge of skid back to the storage tank.
- NEMA 4 enclosure will be mounted at edge of skid with local indicator lights, pump status, hand off auto controls, VFD drivers, and local termination of instrumentation.
- All wiring and conduit runs will be contained within skid boundaries; shop tested prior to shipment.

NOTES: *Field to provide 460/3/60 power to the enclosure.*

3.5.3 Injection System

(a) Injection Module

Required for precise balancing of NH₃ at each injection point. The stainless-steel structural skid with lifting lugs and grounding lugs will consist of the following components:

- ¾" class 150 304LSS aqueous ammonia inlet line feeding two (2) branches. Each ½" class 150 304LSS line with manual ball valves, strainers with a drain, needle valve, inline flow indicator (rotameter), and check valve terminated at edge of skid.
- 2" class 150 304LSS inlet with 1" line with a manual ball valve, a pressure control valve, a filter, a pressure transmitter w/block and bleed valve, an automated ball valve assembly w/limit switches, an orifice flange assembly with flow transmitter feeding two (2) branches. Each ½" class 150 304LSS line with manual ball valves, strainers with a drain, needle valve, inline flow indicator (rotameter), and check valve terminated at edge of skid.
- All wiring and conduit runs will be contained within skid boundaries; shop tested prior to shipment.

Rating: 40 lb/hr aqueous ammonia (19% by weight) with 1:5 turndown.

(b) NH₃ Injection Lances

- 2 x 2" injection lance with 3" 150# RF flange connection for installation into burner duct. Coaxial lance design to ensure ammonia stays cool along lance length prior to atomization at the nozzle. ½" air and ammonia connection to the lance.
- Both air and ammonia connections to the injection lance to have 6' hoses, Teflon construction with SS exterior braid. Quick non-drip disconnects provided for ease of maintenance.

Rating: 20 lb/hr per lance with 5:1 turndown

All structural welding to conform to AWS D1.1.

All pipe and pipe fittings to confirm to ANSI standard. All welding on the pipe and pipe fittings to comply with ASME Code. B31.3.

3.5.4 Leakage

The welded design of the heat transfer plates maintains the gas and air streams separate and leak free. Every individual plate pack is tested with dye penetrant prior to leaving the fabrication shop in Europe. The plate packs are guaranteed with a leakage rate of 0.1%.

After erection of the Compact DeNOx system a florescent dust test (as detailed below) should be carried out over the entire system to ensure that there are no leaks in the sealing welds separating the clean and dirty gases.

1. Prior to start-up of the blower at low speed the completed Compact DeNOx system should be thoroughly cleaned and inspected.
2. Blanking materials will be installed at the clean gas inlet to the lower distribution hood to prevent the passage of florescent dust.
3. The blower is started a minimum speed/pressure and the powder (DayGlo T 11 Synthetic Organic Colorant) is added to the suction side. If the use of the blower is not available or desirable than a temporary fan should be installed in the ducting.
4. All joints and seal welds are inspected using a black light, particularly the seal welds around the high efficiency heat exchanger to ensure zero leaks between the clean and dirty gases.
5. Areas needing repair are clearly visible under the black light and are marked for repair.

3.5.5 Design Codes

The High Efficiency Heat Exchanger is a low-pressure device and as such is not governed by and does not comply with any pressure vessel codes.

- Our selected fabricators will provide welding Procedure Specifications (WPS) and Welder Qualifications (WQ). Welding procedures and welders will be qualified per the requirements of AWS D1.1 for the materials and positions required. Visual inspection of welds shall comply with AWS B1.11.
- Welding in Germany will be qualified as per DIN 8560, Weld filler material as per DIN 18800/1.
- Electrical classification is Non-Hazardous. Electrical Enclosures to be NEMA 4.
- Fan motors to be 460 VAC, 3 phase, TEFC, 1.15 service factor.
- Boosting pump motors to be 460 VAC, 3 phase, TENV, 1.15 service factor.
- Piping to be fabricated per B31.3 ASME piping code.
- Post Heat burner is compliant with NFPA 86.

3.6 CFD Modeling

The mixer arrangement will allow following performance:

- Gas flow distribution at the entrance to the first catalyst layer: 10% RMS on 80% of the reactor cross section, 15% RMS on 100% of the reactor cross section.
- NH₃ distribution at the entrance to the first catalyst layer: 3% RMS on 100% of the Reactor cross section.
- Flue gas temperature: Absolute deviation < $\pm 25^{\circ}\text{F}$ from the design temperature.

3.7 Surface Protection and Coatings

All external module and distribution casing surfaces and associated steel beams will be sand blasted per SSPC-SP10 and primed with one coat of Carbo Zinc 11 primer. All casing surfaces are covered with insulation and no additional painting is required on site. Non-insulated structural steel will be galvanized. Stainless steel parts remain raw.

3.8 Spares/Commissioning Parts

The following spare parts for commissioning and 2 years of operation are recommended and offered as an option:

- **NH₃ Injection System**
 - Injection Lance Assembly
- **Catalyst**
 - Sample Element with Nine (9) Individual Sample Cartridges
- **Post Heat Burner System**
 - Spark Igniter
 - UV Scanner
 - Alloy Combustor w/Mounting Gaskets
 - Bypass Fuel Indicator
 - 2" Safety Shut Off Valve
 - 1" Vent Valve
 - 1/4" Low Gas Pressure Switch
 - (3x) 1/2" Pressure Gauge
 - 1/4" NPT High Gas Pressure Switch
 - Combustion Air Filter
 - 6" 150# Flat Face Flg'd Butterfly Control Valve & Actuator
 - Combustion Air Pressure Switch
 - Control Valve Limit Switch
 - Back Flow Valve Actuator

- Low Fire Switch
- Thermocouple (Dual Type K, 304SS)
- Thermocouple (Type K, 304SS)
- Thermocouple (Type K, 904LSS)
- High Temp Limit
- Programming High Temp Limit
- Ignition Transformer
- Flame Relay
- Flame Signal Amplifier
- Keyboard Display Module
- Purge Card Timer
- Annunciator
- Data Control Bus Module

3.9 Exclusions

The Scope of supply does not include the following items, unless specifically included in our proposal:

- Support structures other than specified
- Instrumentation and controls other than for the burner
- Wiring between instrumentation and DCS system
- Interconnecting piping between skids and DeNOx system
- DCS or control PLC system
- Design, supply, or installation of insulation (BD Heat to assist)
- Anchor bolts
- Unloading at site
- Foundation design and foundation work
- Any site works
- CFD or Cold Flow Modeling
- Site supervision (except as noted)
- Federal or local sales or usage tax
- Spare parts (offered as an option)
- The following submittals will not be included at the proposal stage and shall be provided after execution of order with balance of engineering package.
- Piping & instrumentation diagrams
- Electrical one-line diagrams
- Control system architecture drawing
- Performance curves and data

3.10 Sub-Suppliers

COMPONENT TYPE	SUPPLIER	MANUFACTURING LOCATION
Ducts & Modules	Industrial Fabrication Co.	Sultan, WA - USA
Heat Exchangers	BD Heat Germany GmbH	Dorsten, Germany
Steel Structure	Lockport Steel	Lockport, IL - USA
Catalyst	Umicore (formerly Haldor-Topsoe)	Houston, TX - USA
Expansion Joint	SF Pathway Metroflex	Lewiston, ME - USA
Rotameters	Brooks	USA
NH3 Boost Pumps	Novados	USA
Post-Heat Burner	TFI	Harrison, OH - USA
Strainers	Haywards (or equivalent)	USA
Needle Valves	Parker (or equivalent)	USA
Press. Regulator	Fisher	USA
Press. Gauge	Ashcroft (or equivalent)	USA
Ball Valves	SVF	USA
Injection Lances	Vector Systems	McKinney, TX - USA
NH3 Handling	Vector Systems	McKinney, TX - USA
Ducts & Modules	Industrial Fabrication Co.	Sultan, WA - USA

NOTES: List of Sub-Suppliers should be considered preliminary and may be subject to change.

4 Commercial Terms

The prices quoted for our Scope of Supply as defined in **Section 3.0** are based on the information available as of the date of this proposal and are fixed and free from escalation through the quoted delivery period unless noted otherwise. Changes or revisions to the design, scope, or delivery schedule may incur additional costs.

4.1 Pricing for Compact DeNOx System Supply

ITEM	DESCRIPTION	PRICE US DOLLAR
1	One (1) Compact DeNOx System Supply as described in Section 3.0 (Scope of Services and Supply)	\$ 3,100,000 USD

PRICING NOTES:

1. Contract to be paid in US dollars.
2. DAP Bellefield.

4.2 Field Service

Three (3) days of start-up assistance and/or employee training from each of the following suppliers is included:

- BD Heat Recovery (Compact DeNOx System)
- TFI (Post Heat Burner System)
- Vector Systems (NH3 Injection and Handling)

Additional field service, if required, shall be billed according to the terms defined in the attached document "BDH 2022 Field Service Rates".

Please account for two (2) weeks of mobilization time for any field service requests to allow for coordination.

4.3 Payment Terms

The enclosed offer is based on the following payment terms:

- 5% Upon Submittal of GA Drawings
- 20% Upon Receipt of Heat Exchanger Plates Materials at EU Shop
- 25% Upon Completion of Heat Exchanger Plates Packs
- 40% Upon Notification of Readiness for Delivery (excl. Catalyst)
- 5% Upon Delivery of Catalyst to Site
- 5% Upon Submittal of Project Documentation

All payments are NET **30 days** after submittal of invoice.

4.4 Validity

This offer is an estimated offer

4.5 Terms and Conditions

Seller to provide Buyer their contract terms and conditions for review and mutual agreement. If no contract terms are provided, BD Heat's General T&C shall govern.

4.6 Delivery

BD Heat Recovery Division will deliver equipment approximately **12 months** (365 days) from receipt of a formal purchase order.

The following time frames from date of order apply to the delivery of drawings and documentation:

- | | |
|---|------------------------------------|
| - Submittal of GA Drawings | 12 weeks ARO |
| - Submittal of P&ID | 12 weeks ARO |
| - Submittal of Functional Description | 12 weeks ARO |
| - Installation Erection Drawings | 20 weeks ARO |
| - Material Test Certificates (Plates) | 4 weeks after comp. of plate packs |
| - Other applicable material Test Certificates | As Available |
| - Inspection Procedures | 6 weeks ARO |
| - Operating manual | 2 weeks prior to delivery |
| - Recommended Operating Spares List | With Proposal |
| - Packing & Shipping List | At time of shipment |

4.7 Guarantees

The guarantees are based on the dirty flue gas conditions as specified in Section 2. It is assumed that 5% of the inlet NO_x is present as NO₂ and that no more than 1% of the SO₂ is present as SO₃ after the lime injection.

Based on the above assumptions, the dew point of the ammonia bisulfate (ABS) in the catalyst is approx. 480°F, and it is therefore not feasible to continuously operate below this temperature. Should ammonia bisulfate precipitate out on the catalyst this can be removed by operating above the dew point for a period of time.

The supplier will guarantee the following outlet conditions based on a daily average.

ITEM	DESIGN CASE
NH ₃ Split, ppmvd @ 7% O ₂	5
NO _x Reduction	90 %

The SCR catalyst volume is designed for NH₃ slip as specified above and during steady state conditions. However, during sudden load changes minor over-shooting may occur.

4.7.1 Expected Catalyst Lifetime

Based on the operating conditions no less favorable than those listed in Table 1 BD-Heat Recovery will guarantee the performance as listed in Table 2 for a period of *63 calendar months* from the date of delivery or *60 calendar months* from the initial flue gas through the catalyst or *40,000 operating hours*, whichever expires earlier.

4.7.2 System Pressure Drop

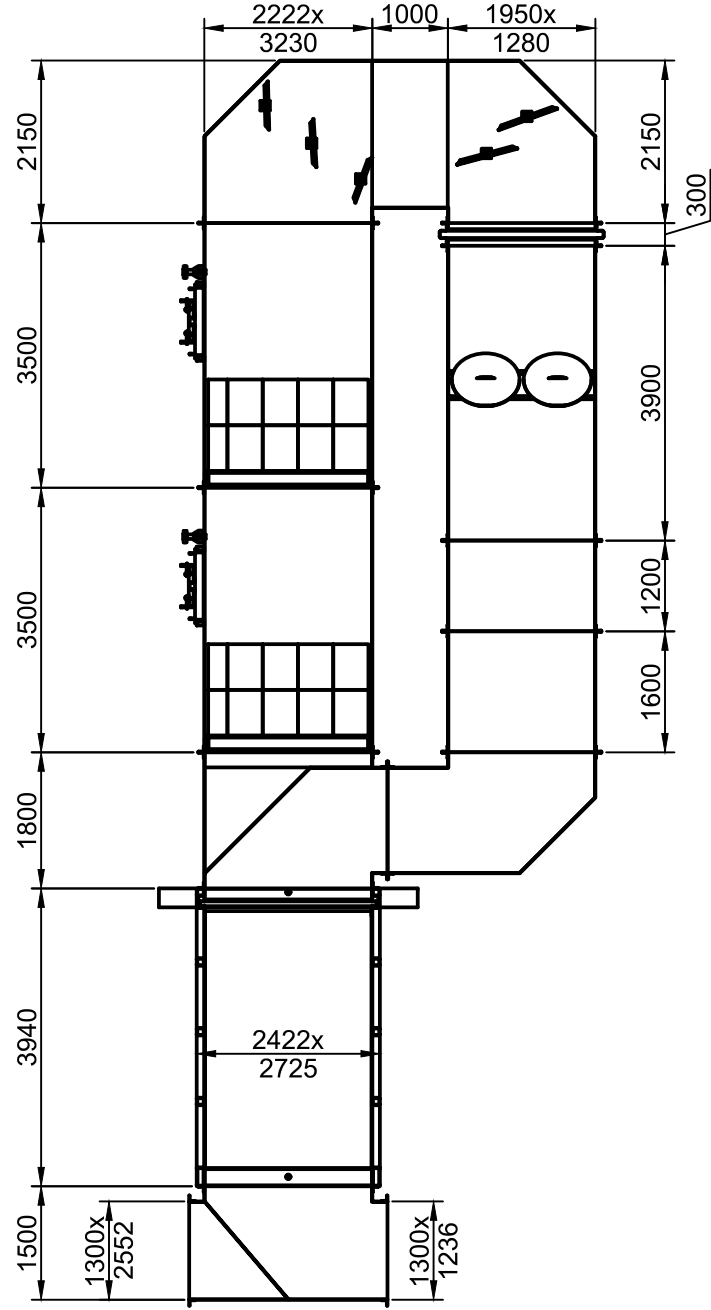
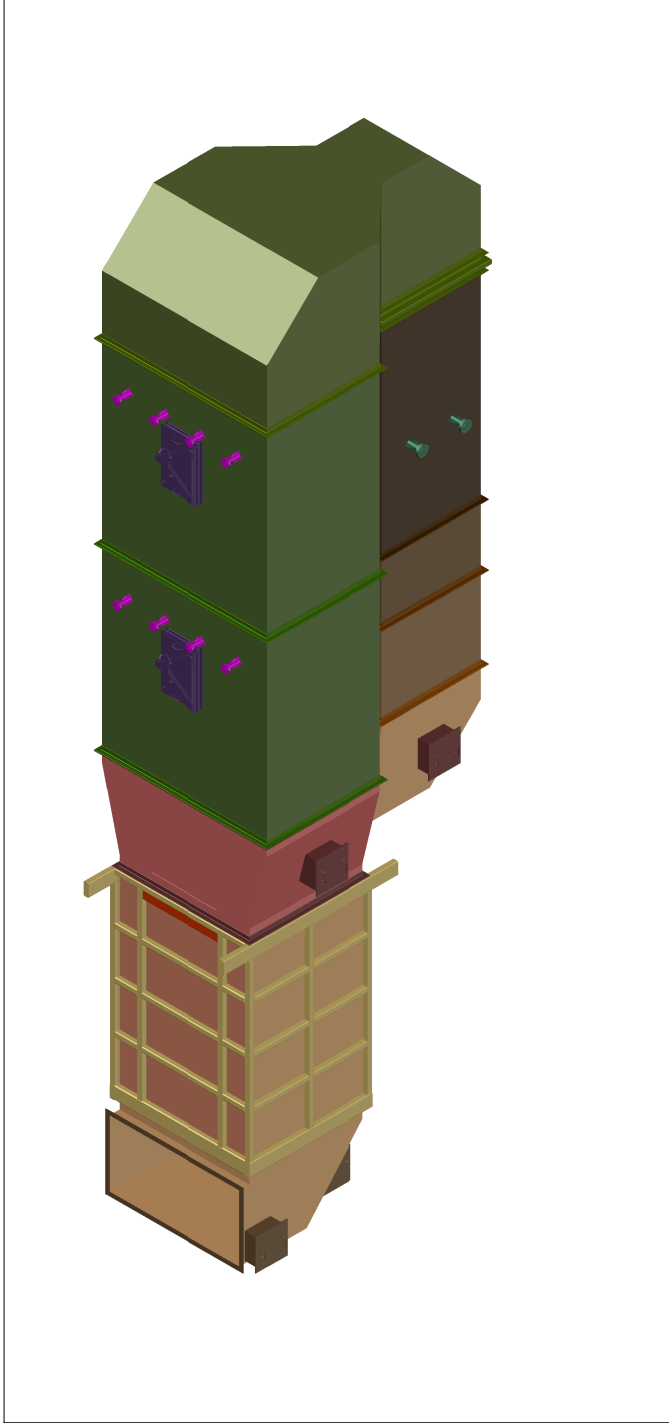
Based on operating conditions as outlined in Table 1 with a dirty gas inlet temperature of 310°F; BD-Heat Recovery will guarantee a pressure drop across the system from the inlet flange of our scope of supply to the outlet flange of ≤13.4" WC (without spare catalyst layer).

All guarantees are based on a performance test to be conducted by the owner and witnessed (without cost to the owner) by BD Heat Recovery Div. All other costs associated with this performance test are solely the obligation of the owner. Should a second performance test be required due to the failure of the supplied equipment to meet the required environmental outlet conditions, BD Heat Recovery Div., shall pay for this subsequent test.

4.7.3 Limitations / Catalyst Poisons

The guarantees offered are subject to the catalyst being loaded and operated in accordance with the manufacturer's recommendations.

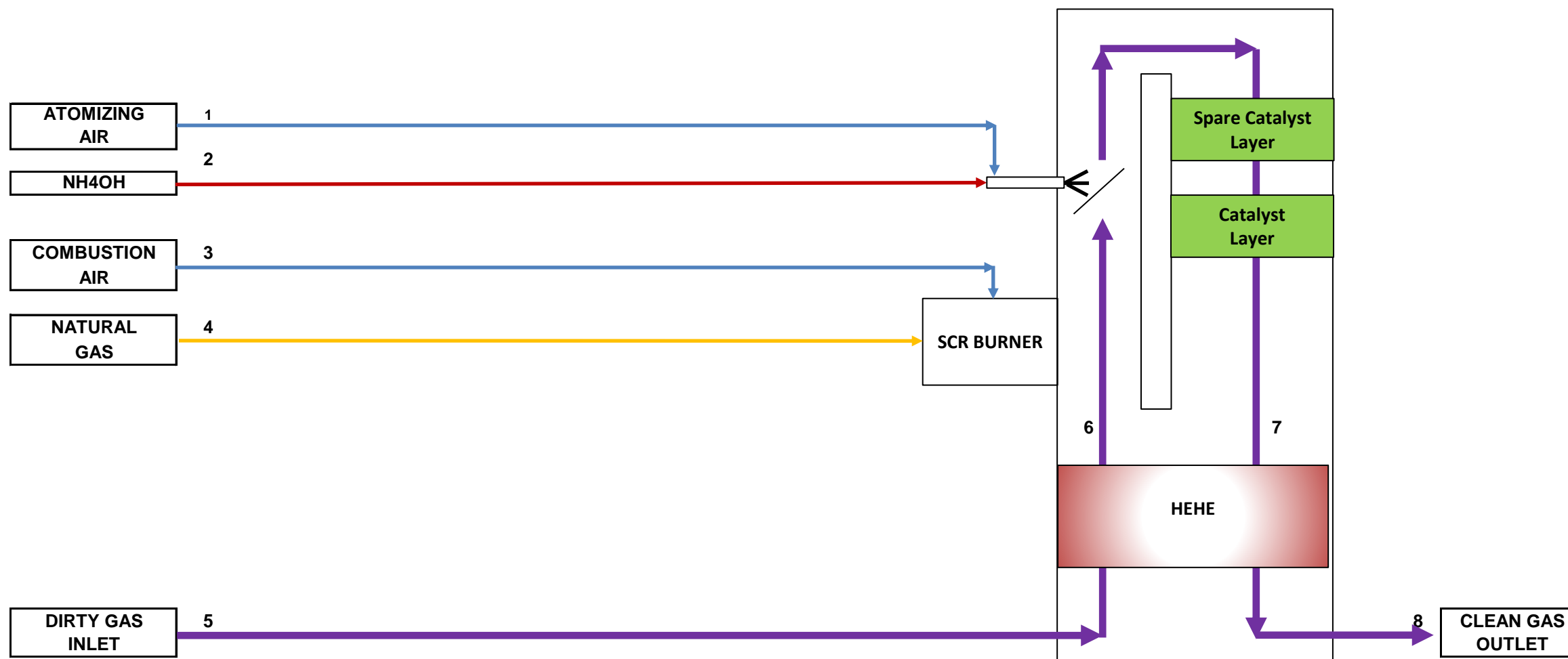
There are several potential poisons to the SCR catalyst. In a natural gas application, there is normally no poisoning of any significance however, there could be various contaminants that could shorten the life of the catalyst. These poisons would primarily be metals such as sodium, potassium, arsenic, and phosphate. Also, any washing or wetting of the catalyst would be detrimental to performance and shall void the warranty.





PROCESS FLOW DIAGRAM SCR DENOX SYSTEM

Project	CDM
Order no.	22-1031
Case	Design
Rev.	-
Date:	20.11.2022
Issued by	OLB



Flow		1	2	3	4	5	6	7	8						
Products		Atomizing Air	NH4OH	Combustion Air	Natural Gas	Dirty Gas Cold inlet	Dirty Gas hot outlet	Clean Gas Hot inlet	Clean Gas outlet						
Flow rate	lb/hr	43	31	2.058	92	46.731	46.731	48.955	48.955						
Temperature	°F	70	70	70	70	310	509	554	357						
Pressure	psi, a	80	80	14	95	13,11	12,93	12,70	12,53						
N2-content	Vol %	76,75%		76,75%		71,47%	71,47%	71,45%	71,45%						
CO2	Vol %	0,04%		0,04%		7,89%	7,89%	7,88%	7,88%						
H2O	Vol %	1,45%		1,45%		15,07%	15,07%	15,11%	15,11%						
Ar	Vol %	0,93%		0,93%		0,00%	0,00%	0,01%	0,01%						
O2	Vol %	20,83%		20,83%		5,56%	5,56%	5,55%	5,55%						
SO3-DP	°F					192	192	193	193						
SOx	mg/Nm3,d, O2 corr.					2	2	2	2						
SOx	mg/Sm3,d, O2 uncorr. (Standard conditions based on 60 °F and 1 atm)					3	3	3	3						
SOx	ppmvd, Uncorr.					1	1	1	1						
SOx	ppmvd, corr.					1	1	1	1						
SOx	lbs/hr					0,25	0,25	0,25	0,25						
NOx	mg/Nm3,d, O2 corr.					124	124	12	12						
NOx	mg/Sm3,d, O2 uncorr. (Standard conditions based on 60 °F and 1 atm)					170	170	17	17						
NOx	ppmvd, Uncorr.					87	87	9	9						
NOx	ppmvd, corr.					60	60	6	6						
NOx	lbs/hr					15,7	15,7	1,6	1,6						

Attachment C
Economic Analysis

Bellefield Boiler Plant
Attachment C - Economic Analysis for RACT III Update
Table 1: Economics of SCR on Boiler No. 3

CAPITAL COSTS		
Direct Costs		
Purchased Equipment Costs for an SCR System	\$3,100,000	
Sales Tax and Freight 0.03A+0.05A	\$248,000	
1. Purchased Equipment Cost = A	\$3,348,000	
Direct Installation Costs		
Foundations, Building and Supports 0.30xA	\$1,004,000	
Steel Supports, Ladders and Platforms 0.12xA	\$402,000	
Handling and Erection 0.50xA	\$1,674,000	
Electrical 0.10xA	\$335,000	
Piping 0.30xA	\$1,004,000	
Painting 0.02xA	\$67,000	
2. Total Direct Installation Cost	\$4,486,000	
Indirect Costs		
Engineering 0.20xA	\$670,000	
Construction and Field Expenses 0.20xA	\$670,000	
Contractor Fees 0.10xA	\$335,000	
Start-Up, Performance Test & Contingencies 0.05*A	\$167,000	
3. Total Indirect Cost	\$1,842,000	
TOTAL CAPITAL INVESTMENT (1+2+3)	\$9,676,000	
TOTAL ANNUALIZED CAPITAL COST (i =7%, 15 yrs, crf = 0.1098)		\$1,062,000
ANNUAL O&M COSTS		
Operating Labor		
(4 hr/day x 365 day/yr x \$40/hr)	\$58,000	
Supervisory Labor		
(15% of operating labor)	\$9,000	
Maintenance Labor		
(4 hr/day x 365 days/yr x \$40/hr)	\$58,000	
Overhead		
(60% of operating, supervisory, and maintenance labor)	\$75,000	
Maintenance Materials		
(100% of maintenance labor)	\$58,000	
Catalyst Replacement - once every 3 years		
Annualized cost	\$40,000	
Power - for urea feed and injection system		
(20 kw x 8760 hr/yr x \$0.14/kwhr)	\$25,000	
Power of ID Fan		
(0.591 psi x 2.31 ft of water/psi x 12 inches/ft = 16.4 inches w.c.)		
(0.000157 X 27,707 scf/min X 16.4 Inches w.c../0.55= 130 hp		
(130 hp X 0.745 kw/hp X\$0.14/kwhr X 8760 hr/yr)	\$118,936	
Chemicals - Urea		
(15.7 lb NOx/hr x 1.97 lb NH4OH/lb NOx x 8760 hr/yr x \$1.00/gal)	\$271,000	
Administration & Insurance		
(0.03 x Total Capital Investment)	\$290,000	
TOTAL ANNUAL O&M COST		\$1,003,000
TOTAL ANNUAL COST		\$2,065,000
Notes:		
1) Direct capital costs based on a budgetary quote obtained from BD Heat, for Boiler #3 DeNOx SCR system, November 30, 2022. Typical cost factors for freight and sales tax were obtained from the EPA Air Pollution Control Cost Manual.		
2) The SCR system includes SCR catalyst, reactor housings, urea injection system, urea storage and feed system, interconnecting ductwork, mixing tube, pumps and piping, SCR controller & analyzer, air compressor, instrumentation & controls		
3) Installation costs were adjusted to account for limited space available and significant retrofit work required for installation of SCR system on the boiler.		
4) Annual O&M costs were calculated based on subject matter knowledge, present day utility costs and best engineering judgement.		

Bellefield Boiler Plant
Attachment C - Economic Analysis for RACT III Update
Table 2: Economics of Low Nox Burner on Boiler No. 3

CAPITAL COSTS		
Direct Costs		
Purchased Equipment Costs Low Nox Burner Assembly	\$360,000	
Sales Tax and Freight	\$28,800	
1. Purchased Equipment Cost = A	\$388,800	
Direct Installation Costs		
Handling and Erection 0.50xA	\$194,000	
Electrical 0.20xA	\$78,000	
Instrumentation & Controls 0.2xA	\$78,000	
Piping & Ductwork 0.25xA	\$97,000	
Painting & Insulation 0.10xA	\$39,000	
2. Total Direct Installation Cost	\$486,000	
Indirect Costs		
Engineering 0.25xA	\$97,000	
Construction and Field Expenses 0.3xA	\$117,000	
Contractor Fees 0.15xA	\$58,000	
Start-Up, Performance Test & Contingencies 0.10*A	\$39,000	
3. Total Indirect Cost	\$311,000	
TOTAL CAPITAL INVESTMENT (1+2+3)	\$1,186,000	
TOTAL ANNUALIZED CAPITAL COST (i =7%, 15 yrs, crf = 0.1098)		\$130,000
ANNUAL O&M COSTS		
Operating Labor		
(2 hr/day x 365 day/yr x \$40/hr)	\$29,000	
Supervisory Labor		
(15% of operating labor)	\$4,000	
Maintenance Labor (a)		
(2 hr/day x 365 day/yr x \$40/hr)	\$29,200	
Overhead		
(60% of maintenance labor)	\$17,520	
Maintenance Materials		
(100% of maintenance labor)	\$29,000	
Power - Additional FD Fan Power cost		
(0.000157 x 30,025 acfm x 7 inches wc x 1/0.65 =51 hp)		
(51 hp x 0.75 kw/hp x 8760 hr/yr x \$0.14/kwhr)	\$47,000	
Administration & Insurance		
(0.03 x Total Capital Investment)	\$36,000	
TOTAL ANNUAL O&M COST		\$192,000
Total Annual Cost		\$322,000
Notes:		
1) Direct capital costs based on a budgetary quote obtained from John Zink Hamworthy, for Boiler #3 burner replacement with a low-NOx burner, November 14, 2022. Typical cost factors for freight and sales tax were obtained from the EPA Air Pollution Control Cost Manual. Installation costs were adjusted to account for limited space available and significant retrofit work required to installation of Low NOx burner and burner mounting assembly and gas, fuel oil and air piping on this old boiler.		
2) The low -NOx burner assembly includes a Coen Variflame gas burner, new burner windbox, new fuel train and FD fan.		
3) Annual O&M costs were calculated based on subject matter knowledge, present day utility costs and best engineering judgement.		

Bellefield Boiler Plant

Attachment C - Economic Analysis for RACT III Update

Table 3: Economics of SCR on Boiler No. 7

CAPITAL COSTS		
Direct Costs		
Purchased Equipment Costs SCR system	\$6,591,000	
Sales Tax and Freight 0.03A+0.05A	\$527,000	
1. Purchased Equipment Cost = A	\$7,118,000	
Direct Installation Costs		
Foundations, Building and Supports 0.30xA	\$2,135,000	
Steel Supports, Ladders and Platforms 0.12xA	\$854,000	
Handling and Erection 0.50xA	\$3,559,000	
Electrical 0.10xA	\$712,000	
Piping 0.30xA	\$2,135,000	
Painting 0.02xA	\$142,000	
2. Total Direct Installation Cost	\$9,537,000	
Indirect Costs		
Engineering 0.20xA	\$1,424,000	
Construction and Field Expenses 0.20xA	\$1,424,000	
Contractor Fees 0.10xA	\$712,000	
Start-Up, Performance Test & Contingencies 0.05*A	\$356,000	
3. Total Indirect Cost	\$3,916,000	
TOTAL CAPITAL INVESTMENT (1+2+3)	\$20,571,000	
TOTAL ANNUALIZED CAPITAL COST (i =7%, 15 yrs, crf = 0.1098)		\$2,259,000
ANNUAL O&M COSTS		
Operating Labor		
(4 hr/day x 365 day/yr x \$40/hr)	\$58,000	
Supervisory Labor		
(15% of operating labor)	\$9,000	
Maintenance Labor		
(4 hr/day x 365 days/yr x \$40/hr)	\$58,000	
Overhead		
(60% of operating, supervisory, and maintenance labor)	\$75,000	
Maintenance Materials		
(100% of maintenance labor)	\$58,000	
Catalyst Replacement - once every 3 years		
Annualized cost	\$120,000	
Power - for urea feed and injection system		
(20 kw x 8760 hr/yr x \$0.14/kwhr)	\$25,000	
Power of ID Fan		
(0.591 psi x 2.31 ft of water/psi x 12 inches/ft = 16.4 inches w.c.)		
(0.000157 X 84,390scf/min X 16.4 Inches w.c../0.55= 381 hp)		
(381 hp X 0.745 kw/hp X\$0.14/kwhr X 8760 hr/yr)	\$348,575	
Chemicals - Urea		
(46.1 lb NOx/hr x 1.97 lb NH4OH/lb NOx x 8760 hr/yr x \$1.00/gal)	\$796,000	
Administration & Insurance		
(0.03 x Total Capital Investment)	\$617,000	
TOTAL ANNUAL O&M COST		\$2,165,000
TOTAL ANNUAL COST		\$4,424,000
Notes:		
1) Purchased equipment costs based on a <u>scaled up</u> budgetary quote obtained from BD Heat, for Boiler #3 DeNOx SCR system, November 30, 2022, based on flue gas flow rate. Typical cost factors for freight and sales tax were obtained from the EPA Air Pollution Control Cost Manual.		
2) The SCR includes SCR catalyst, reactor housings, urea injection system, urea storage and feed system, interconnecting ductwork, mixing tube, pumps and piping, SCR controller & analyzer, air compressor, instrumentation & controls		
3) Installation costs were adjusted to account for limited space available and significant retrofit work required for installation of SCR system on the boiler.		
4) Annual O&M costs were calculated based on subject matter knowledge, present day utility costs and best engineering judgement.		

Bellefield Boiler Plant
Attachment C - Economic Analysis for RACT III Update
Table 4: Economic Analysis Summary

Boiler No.	Control Technology	Boiler Capacity (MMBtu/hr) (1)	Permitted NOx Emission Rate (lb/MMBtu)(2)	NOx Potential to Emit (tpy)	Potential NOx Emission Rate (lb/MMBtu)(3)	Percent Reduction	NOx Potential Reduction (tpy)	Total Capital Investment (\$)	Annual Cost	Cost Reduction (\$/ton NOx)	Economic Infeasibility Threshold (\$/ton NOx removed) (4)
B-003	SCR	64	0.20	56.1	0.10	50%	28.0	\$9,676,000	\$2,065,000	\$73,700	\$7,500
B-003	LNB	64	0.20	56.1	0.10	50%	28.0	\$1,186,000	\$322,000	\$11,500	\$7,500
B-007	SCR	188	0.14	44.7	0.10	29%	32.9	\$20,571,000	\$4,424,000	\$134,300	\$7,500

(1) Boiler # 3 is restricted to a natural gas burner annual average heat input rate of 64 MMBtu/hr (a 50% annual capacity restriction). (Title V Permit, ACHD Permit #0047, Condition B.1.d.)

(2) Boiler No.7 capacity factor shall not exceed 39% as averaged over the hours the unit is in operation during any consecutive twelve-month period

(3) Baseline NOx emission rate from Title V permit.

(4) NOx RACT economic infeasibility from RACT III rule