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United States Steel Corporation
Mon Valley Works

Kurt Barshick
General Manager
U. S. Steel Mon Valley Works

December 22, 2022

Ms. JoAnn Truchan, P.E.
Program Manager, Permitting – Air Quality
Allegheny County Health Department
301 39th Street, Bldg. No. 7
Pittsburgh, PA 15201-1891

Dear Ms. Truchan:

RE: United States Steel Corporation – Mon Valley Works – Edgar Thomson Plant
        Re: Reasonably Available Control Technology (RACT) Evaluation Request

On November 12, 2022, the Pennsylvania Department of Environmental Protection (PADEP), finalized new Reasonably Available Control Technology (RACT) regulations, published at 25 Pa. Code Chapter 129, which include RACT requirements and limits for major sources of NOx and VOC. Allegheny County Health Department (ACHD) has incorporated the RACT III regulation finalized by PADEP per ACHD Rules and Regulations, Article XXI Air Pollution Control §2105.08. The United States Steel Corporation (U. S. Steel) – Mon Valley Works – Edgar Thomson Plant is subject to certain provisions of this regulation including presumptive RACT, alternative RACT, associated monitoring, recordkeeping, and reporting.

The attached document is submitted pursuant to §§129.111, 129.112, 129.114, and 129.115(a) (as these provisions are incorporated into Article XXI).

If you have any questions pertaining to this RACT submittal, please contact Coleen Davis at (412) 273-4730 or cdavis@uss.com.

Based on information and belief formed after reasonable inquiry, the statements and information in the document are true, accurate, and complete.

Sincerely,

Kurt Barshick

cc: M. Jeffrey
        C. Davis

PENNSYLVANIA RACT III

NOTIFICATION OF COMPLIANCE STATUS & ALTERNATIVE RACT PROPOSAL

United States Steel Corporation / Edgar Thomson Plant

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1. INTRODUCTION

United States Steel Corporation (U. S. Steel) owns and operates an iron and steel mill in Braddock, Pennsylvania known as the Edgar Thomson Plant. The Edgar Thomson Plant is an iron and steel making facility that produces mainly steel slabs. Raw materials such as coke, iron-bearing materials, and fluxes are charged to blast furnaces in the iron making process and steel slabs are formed in the continuous caster. The Edgar Thomson Plant operates under federally enforceable Title V Operating Permit (TVOP) No. 0051, which expired April 12, 2021 and is pending renewal.[1] The Edgar Thomson Plant is considered a major source of nitrogen oxides (NO_x) and volatile organic compounds (VOC).

On November 12, 2022, the Pennsylvania Department of Environmental Protection (PADEP), finalized new Reasonably Available Control Technology (RACT) regulations, published at 25 Pa. Code Chapter 129, which include RACT requirements and limits for major sources of NO_x and VOC (referred to as "RACT III"). Allegheny County Health Department (ACHD) has incorporated the RACT III regulation finalized by PADEP per ACHD Rules and Regulations, Article XXI Air Pollution Control §2105.08. The Edgar Thomson Plant is subject to certain provisions of this regulation including presumptive RACT, alternative RACT, and associated monitoring, recordkeeping, and reporting.

This document is intended to meet the requirement to submit a written notification of compliance status (NOCS) per §129.115(a). This document also contains U. S. Steel's proposal for alternative RACT requirements/limits per §129.114(d) for applicable sources.

1.1   Facility Information

The Edgar Thomson Plant is an iron and steel making facility that produces mainly steel slabs. Raw materials such as coke, iron-bearing materials, and fluxes are charged to blast furnaces in the iron making process. Molten metal (iron) is tapped from the blast furnace at the casthouse into transfer ladles. The hot metal is then transferred to a hot metal mixer or direct pour station in preparation for desulfurization. For desulfurization, a reagent is added to the hot metal, causing sulfur and other impurities to form and rise to the surface as slag. The slag is then skimmed off the top of the desulfurized hot metal and then charged into one of two basic oxygen process (BOP) vessels, where the hot metal is transformed into molten steel. Scrap, alloys, fluxes, and oxygen are also introduced at the BOP vessels. The liquid steel is tapped from the BOP vessels and transferred to the ladle metallurgy facility (LMF) or Vacuum Degasser, where the properties of the steel can be more precisely refined according to customer specifications. To achieve this additional refining at the LMF or Vacuum Degasser, specific alloying materials are added to the process. The refined liquid steel is then charged to the dual strand continuous caster mold. The steel slabs are formed in the continuous caster and are cut to length, ground, slit as necessary, and shipped offsite. There are three Riley Boilers at the Edgar Thomson Plant which are used to generate steam, heat, and electricity for the plant. The three primary fuels for the boilers are Blast Furnace Gas (BFG), Coke Oven Gas (COG), and Natural Gas (NG).

The facility has two (2) processes that are operated by an outside contractor:

► BOP Slag Processing
► Waste Product Recycling and Briquetting

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[1] U. S. Steel submitted a complete and timely renewal application on October 13, 2020, thus the facility is authorized to continue operation under a permit application shield until such time that ACHD issues a renewed permit.

These operations are permitted as Title V facilities by ACHD but also have their own air permits. As such, they are not included as part of this evaluation.

1.2   Summary of RACT Requirements

25 Pa Code 129.111 through 129.115 (RACT III) applies to existing major facilities of NO_X and/or VOC in Pennsylvania. These provisions have been adopted by ACHD per Article XXI §2105.08. Existing major facilities subject to RACT III are those facilities which are a major source of NO_X and/or VOC that commenced operation on or before August 3, 2018. The Edgar Thomson Plant is located in Allegheny County where the NO_X and VOC major source thresholds are 100 and 50 tons per year (tpy), respectively, on a potential to emit (PTE) basis. As a major source of both pollutants, the Edgar Thomson Plant is subject to both the NO_X and VOC RACT requirements under RACT III.

Per 25 PA Code 129.111(c), sources (i.e., emissions units) with a PTE less than 1.0 tpy of NO_X and VOC are exempt from RACT III requirements. Table 1-1 identifies the sources for which U. S. Steel has claimed this exemption.

RACT is defined in Article XXI §2101.20 as

> "any air pollution control equipment, process modifications, operating and maintenance standards, or other apparatus or techniques which may reduce emissions and which the Department determines is available for use by the source affected in consideration of the necessity for obtaining the emission reductions, the social and economic impact of such reductions, and the availability of alternative means of providing for the attainment and maintenance of the NAAQS's."

RACT III also does not apply to sources for which a requirement or emission limitation has been established under existing VOC standards in Article XXI (e.g., §2105.15, etc.)[2]. The solvents used at the plant are subject to §2105.15 and §2105.82 and painting operations are potentially subject to §2105.10. Fuel and other hydrocarbon storage tanks at the site already are potentially subject to VOC requirements depending on their size and the vapor pressure of its contents (e.g., §2105.12). As such, all these operations are not subject to RACT III according to 25 Pa Code 129.111(a) as noted in §2105.08.

For applicable sources subject to the RACT III regulations, there are three options for compliance:

► Compliance Option 1 (25 PA Code 129.112): Presumptive RACT;
► Compliance Option 2 (25 PA Code 129.113): System-Wide Averaging (not discussed further in this document since not applicable to the site); or
► Compliance Option 3 (25 PA Code 129.114): Alternative (Case-by-Case) RACT Proposal.

A matrix of the proposed RACT III compliance options for the Edgar Thomson Plant sources is depicted in the following table. All the sources are located at the iron and steel making facility.

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[2] A complete listing of 25 Pa Code and Article XXI references for such VOC regulations are found on ACHD's website (98-SIP-RACT-III-Regulation.pdf (alleghenycounty.us).

Table 1-1. RACT III Applicability for Edgar Thomson Plant

Source ID	Source Description	NOₓ RACT Status	VOC RACT Status
P001a	Blast Furnace No. 1 Casthouse	Alternative Proposal	Alternative Proposal
P001b	Blast Furnace No. 1 Stoves (495 MMBtu/hr, firing BFG, COG and NG)	Presumptive	Presumptive
P001c	Blast Furnace Gas Flare (3 MMCF/hr, BFG)	Presumptive	Presumptive
P002a	Blast Furnace No. 3 Casthouse	Alternative Proposal	Alternative Proposal
P002b	Blast Furnace No. 3 Stoves (495 MMBtu/hr, firing BFG, COG and NG)	Presumptive	Presumptive
P003	BOP Shop	Alternative Proposal	Alternative Proposal
P005	Dual Strand Caster (5 MMBtu/hr, combined for LMF and Caster, firing COG and NG)	Presumptive	Presumptive
B001 – B003	Riley Boilers No. 1 – 3 (Model PAB 013472 NB 918; 525 MMBtu/hr each firing BFG, COG and NG)	Alternative Proposal	Presumptive
N/A	BOP Miscellaneous Fugitives (Pot Coat)	Not Applicable (N/A)	Alternative Proposal
N/A	Paint and Solvent Use	N/A	Exempt (Subject to VOC standards)
N/A	Storage Tanks	N/A	Exempt (Subject to VOC standards)
N/A	Misc. Natural Gas Combustion	Presumptive	Presumptive
N/A	Diesel Emergency Generators and Fire Pump (Two generators at 2,179 kW each [Cummins QSK60-G6 NR1]; One fire pump at 220 bhp [Cummins, CFP7EVS-F40])	Presumptive	Presumptive

1.2.1 Presumptive RACT

The first compliance option for non-exempt sources is to comply with presumptive RACT limits as outlined in §129.112. Under these RACT regulations, presumptive RACT limits are included for the following categories of sources that are potentially applicable to operations at the Edgar Thomson Plant:

- ► Boilers: §129.112(c)(4);
- ► Emergency Generators: §129.112(c)(10);
- ► Incinerators, thermal oxidizers or catalytic oxidizers or flares used primarily for air pollution control: §129.112(c)(8);
- ► Combustion sources: §129.112(d) [for VOC emissions]; and
- ► Other sources not regulated elsewhere in 25 Pa Code 129 with potential emissions less than 5 tpy of NO_x and 2.7 tpy of VOC: §129.112(c)(1).

1.2.1.1   Presumptive Sources – §129.112(c)(1) &(c)(2)

RACT III includes presumptive requirements for a NO_x air emissions source that has a potential to emit less than 5 tpy NO_x (§129.112(c)(1)) and/or less than 2.7 tpy of VOC ((§129.112(c)(2)). One emissions source at the Edgar Thomson Plant does not fall under another presumptive source category and has a PTE meeting the criteria for this presumptive category.

The corresponding presumptive RACT III requirement under §129.112(c) is to install, maintain and operate in accordance with the manufacturer's specifications and with good operating practices. The source subject to these requirements at the Edgar Thomson Plant is listed below.

Table 1-2. Presumptive – NO_x PTE <5 tpy and/or VOC <2.7 tpy

Source ID	Source Description	NOx PTE (tpy)	VOC PTE (tpy)
P005	Dual Strand Caster	N/A - Presumptive	1.0 (Title V Permit Condition F.1.c Process P005)

1.2.1.2   Presumptive Sources – §129.112(c)(4)

RACT III includes presumptive requirements for boilers and other combustion sources with an individual gross heat input less than 20 MMBtu/hr under §129.112(c)(4). The sources identified in Table 1-3 meet the definition of a combustion source and have a gross heat input less than 20 MMBtu/hr.

The presumptive RACT III requirement under §129.112(c) is to install, maintain and operate in accordance with the manufacturer's specifications and with good operating practices. The sources subject to these requirements at the Edgar Thomson Plant are listed below.

Table 1-3. Presumptive – Combustion Sources (<20 MMBtu/hr)

Source ID	Source Description	Unit Rating (MMBtu/hr)
N/A	Misc. Natural Gas Combustion (e.g., space heaters)	Each one <20 MMBtu/hr
P005	Dual Strand Caster (and LMF) Combustion	5 MMBtu/hr (estimate aggregate)

1.2.1.1 Presumptive Sources – §129.112(c)(8)

RACT III includes presumptive requirements for incinerators, thermal oxidizers or catalytic oxidizers or flares used primarily for air pollution control under §129.112(c)(8). The presumptive RACT III requirement under §129.112(c) is to install, maintain and operate in accordance with the manufacturer's specifications and with good operating practices. There is one source subject to these requirements at the Edgar Thomson Plant, which is listed below.

Table 1-4. Presumptive – Flares

Source ID	Source Description
P001c	Blast Furnace Gas Flare

1.2.1.2 Presumptive Sources – §129.112(c)(10)

RACT III includes presumptive requirements for emergency engines operating less than 500 hours in a 12-month rolling period under §129.112(c)(10). The presumptive RACT III requirement under §129.112(c) is to install, maintain and operate in accordance with the manufacturer's specifications and with good operating practices. The requirements are applicable to the emergency engines at the Edgar Thomson Plant.

1.2.1.1 Presumptive Sources – §129.112(d)

RACT III includes presumptive requirements with respect to VOC emissions for combustion units and combustion sources (amongst other source types) per §129.112(d) as follows:

> Except as specified in subsection (c), the owner and operator of a combustion unit, brick kiln, cement kiln, lime kiln, glass melting furnace or combustion source located at a major VOC emitting facility subject to § 129.111 shall install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices for the control of the VOC emissions from the combustion unit, brick kiln, cement kiln, lime kiln, glass melting furnace or combustion source.

As it relates to the Edgar Thomson Plant, this provision applies to VOC emissions from the sources listed below as they are classified as "combustion units" or "combustion sources" in the rule.

Table 1-5. Presumptive – VOC from Combustion

Source ID	Source Description
P001b	Blast Furnace No. 1 Stoves
P002b	Blast Furnace No. 3 Stoves
B001 – B003	Riley Boilers No. 1 – 3

1.2.1.2 Presumptive Sources – §129.112(k)

Under RACT III requirements, direct-fired heaters, furnaces, ovens and other combustion sources with rated heat inputs equal to or greater than 20 MMBtu/hr are subject to a presumptive NO_x limit of 0.10 lb/MMBtu. For the Edgar Thomson Plant, this applies to the Blast Furnace Stoves (Source ID P001b and P002b). P001b

was tested on 2/23/2022 and the average stack test result was 0.0093 lb/MMBtu NO$_x$. P002b was tested on 2/22/2022 and the average stack test results was 0.023 lb/MMBtu NO$_x$. See Appendix B for the associated waiver request for testing of these sources.

1.2.2   Alternative (Case-by-Case) RACT Proposal

For sources which are unable to meet presumptive RACT III limits, unable to participate in system-wide averaging, and/or which do not qualify for one of the source categories that have presumptive RACT limits, Compliance Option 3 remains. Under Compliance Option 3, facilities must propose an alternative RACT requirement or emission limitation (i.e., case-by-case RACT) in accordance with §129.114(d).

The sources at the Edgar Thomson Plant which require alternative RACT proposals, along with the qualifying criteria, are summarized in the following table.

Table 1-6. Alternative (Case-by-Case) RACT III

Source ID	Source Description	Status
P001a	Blast Furnace No. 1 Casthouse	No Presumptive Category (NO$_x$ > 5 tpy, VOC > 2.7 tpy)
P002a	Blast Furnace No. 3 Casthouse	No Presumptive Category (NO$_x$ > 5 tpy, VOC > 2.7 tpy)
P003	BOP Shop	No Presumptive Category (NO$_x$ > 5 tpy, VOC > 2.7 tpy)
B001 – B003	Riley Boilers No. 1 – 3	No Presumptive Category Based on Fuels (NO$_x$ > 5 tpy)
N/A	BOP Miscellaneous Fugitives (Pot Coat)	No Presumptive Category (VOC > 2.7 tpy)

Per 25 Pa Code 129.114, the case-by-case RACT proposal must include each of the elements required under 25 Pa Code 129.92(a)(1)-(5), (7)-(10) and (b). For sources in Allegheny County this translates to Article XXI §2105.06a, b and c. For emissions sources that were subject to alternative RACT proposals under RACT II and for which no new pollutant-specific air pollution control technology or technique is determined to be available, the facility may submit an analysis demonstrating that alternative RACT II conclusions are sufficient to satisfy RACT III. There is an additional caveat that the cost-effectiveness must have previously been calculated consistent with the EPA Air Pollution Control Cost Manual (6th Edition)[3] and remains equal to or greater than $7,500 per ton of NO$_x$ emissions reduced or $12,000 per ton of VOC emissions reduced. The following sections of this document outline the conclusions of this assessment and summarize the alternative RACT III proposals.

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[3] EPA/452/B-02-001, January 2002, as amended.

As noted in Section 1, there are several sources at the Edgar Thomson Plant that require alternative RACT proposals. These sources can be consolidated based on common emissions and/or operational characterizations as summarized in the following table.

Table 2-1. Source Types for Alternative RACT

Source Type	Source ID & Description	RACT-Affected Pollutants
Process Area (Blast Furnace Casthouses)	P001a – Blast Furnace No. 1 Casthouse P002 – Blast Furnace No. 2 Casthouse	NO_x, VOC
Process Area (BOP Shop)	P003 – BOP Shop	NO_x, VOC
Combustion Units (Boilers)	B001 – B003 – Riley Boilers No. 1 – 3	NO_x
Fugitive VOC	BOP Miscellaneous Fugitives (Pot Coat)	VOC

3. ALTERNATIVE RACT ANALYSIS

This section of the report provides the detailed proposed alternative RACT III requirements for sources at the Edgar Thomson Plant.

3.1 Top-Down Methodology

Case-by-case RACT determinations are traditionally based on a top-down methodology. PADEP has outlined the required elements of a RACT analysis and determination in 25 Pa Code 129.92(b) as referenced in 25 Pa Code 129.114(d)(3). ACHD has historically followed these same procedures under the framework of §2105.06(b)(2). Presented below are the five (5) basic steps of the top-down RACT review.

3.1.1 Step 1: Identify All Control Technologies

Under Step 1, all available control technologies are identified for each emission unit in question. The following methods may be used to identify potential technologies:

► Researching U.S. EPA's RACT/BACT (Best Available Control Technology)/LAER (Lowest Achievable Emission Rate) Clearinghouse (RBLC) database;
► Surveying regulatory agencies;
► Drawing from previous engineering experience;
► Surveying air pollution control equipment vendors; and
► Surveying available literature.

Once identified, the control technologies are ranked in descending order of expected control effectiveness.

3.1.2 Step 2: Eliminate Technically Infeasible Options

After control technologies are identified under Step 1, an analysis is conducted to eliminate technically infeasible options. A control option is eliminated from consideration if there are process-specific conditions that prohibit the implementation of the control technology or if the highest control efficiency of the option would result in an emission level that is higher than any applicable regulatory limits, such as a New Source Performance Standard (NSPS) or National Emission Standard for Hazardous Air Pollutants (NESHAP).

3.1.3 Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. This list must identify, at a minimum, the baseline emissions of VOC and NO_X before implementation of each control option, the estimated reduction potential or control efficiency of each control option, the estimated emissions after the application of each control option and the economic impacts.

3.1.4 Step 4: Evaluate Most Effective Controls and Document Results

Beginning with the highest-ranked control technology option from Step 3, detailed economic, energy, and environmental impact evaluations are performed in Step 4. If a control option is determined to be economically feasible without adverse energy or environmental impacts, it is not necessary to evaluate the remaining options with lower control efficiencies.

The economic evaluation centers on the cost effectiveness of the control option. Costs of installing and operating control technologies are estimated and annualized following the methodologies outlined in the U.S. EPA's Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual (CCM) and other industry resources.

3.1.5 Step 5: Select RACT

Using the result of the prior steps to determine the appropriate control technology, the final step is to determine the emission limit that represents the RACT limit.

3.2 NO$_X$ RACT Assessment - Blast Furnace Casthouses

The Edgar Thomson blast furnaces combine coke, iron-bearing materials, and fluxes with high heat to produce molten iron and slag. To produce the heat required, hot air must be injected into the blast furnace to ignite the coke. This hot air is produced in the blast furnace stoves and injected into the blast furnace through tuyeres located at the lower portion of the furnace along the circumference. In addition to hot air, auxiliary fuels (natural gas and coke oven gas) are injected into the Edgar Thomson blast furnaces to control flame temperatures within the furnace. The ratios of each material (i.e., iron ore, flux, air, and fuel) will vary depending on the specific product being processed in the furnace. The blast furnace exhaust gas exits the top of the furnace and is collected, processed (cleaned), and reused as fuel in other plant processes. The fugitive NO$_X$ emissions resulting from tapping of the blast furnace are ducted to the casthouse baghouse. In addition, there are ancillary fuel-burning activities (e.g., iron oxide suppression, railcar thaw lines, torpedo car lancing, ladle drying, etc.) that take place within the blast furnace area that contribute to fugitive NO$_X$ emissions that are ducted to the casthouse baghouse.

In general, when considering NO$_x$ emissions from combustion processes there are three types of chemical kinetic processes. The NO$_X$ emissions from these chemical mechanisms are referred to as: (1) thermal NO$_X$; (2) fuel NO$_X$; and (3) prompt NO$_X$.

Thermal NO$_X$ is generated by the oxidation of molecular nitrogen (N$_2$) in the combustion air as it passes through the flame in the blast furnaces. This reaction requires high temperatures, hence the name thermal NO$_X$. The formation of nitrogen oxide (NO) from oxygen (O$_2$) and N$_2$ in air at high temperatures is described by the well-known Zeldovich mechanism. Fuel NO$_X$ is the result of the conversion of nitrogen compounds contained in fuels to NO$_X$ during fuel combustion. Prompt NO$_X$, which forms from the rapid reaction of atmospheric nitrogen with hydrocarbon radicals is insignificant compared to the overall quantity of thermal and fuel NO$_X$ generated in combustion units/sources.

3.2.1 Step 1: Identify All Control Technologies for NO$_X$

Step 1 in a top-down analysis is to identify all available control technologies. The evaluation of potential controls for NO$_X$ emissions from furnaces include both an investigation of end-of-pipe (post-combustion methods) and combustion modifications/optimization that reduce the formation of thermal NO$_X$. The basic complicating factor in efforts to reduce thermal NO$_X$ from the iron and steel industry is the fundamental need for high temperatures in order to work the materials (i.e., molten iron). Table 3-1 contains a list of the various technologies that have been identified as potentially applicable for the control of NO$_X$ emissions from the blast furnaces. It should be noted that unlike other iron and steel processing furnaces, the blast furnaces are not equipped with burners. As such, this evaluation does not consider the use of low-NO$_X$ burners.

Table 3-1. Potentially Available NOx Control Technologies for Blast Furnaces

Potentially Applicable NO$_X$ Control Technologies
Selective Non-Catalytic Reduction (SNCR)
Selective Catalytic Reduction (SCR)
Good Engineering Practices

3.2.2 Review of Potentially Applicable NO$_X$ Control Technologies

The following section provides a discussion of each potentially applicable technology identified above as it might be applied to the blast furnaces at the Edgar Thomson Plant. It should be noted that there are no new pollutant specific air cleaning devices or technologies since the RACT II evaluation.

3.2.2.1 Selective Non-Catalytic Reduction (SNCR)

SNCR uses ammonia (NH_3) or a urea solution [$CO(NH_2)_2$], injected into the gas stream, to chemically reduce NO$_X$ to form N_2 and water. High temperatures, optimally between 1,600 to 2,400°F, promote the reaction via the following equation:

$$CO(NH_2)_2 + 2\ NO + \tfrac{1}{2}\ O_2 \rightarrow 2\ N_2 + CO_2 + 2\ H_2O$$
$$4\ NH_3 + 6NO \rightarrow 5\ N_2 + 6\ H_2O$$
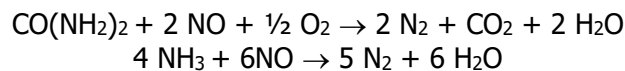
At temperatures below the optimal range, unreacted ammonia can pass through the SNCR and be emitted from the stack (known as "ammonia slip"). At temperatures above the range, ammonia may be combusted, generating additional NO$_X$. In addition, an effective mixing of gases and entrainment of the reductant into the exhaust gases at the injection point is a critical factor in ensuring an efficient reaction. SNCR is being employed on various types of combustion sources in a wide range of sizes, including industrial boilers, electric utility steam generators, thermal incinerators, cement kilns, and industrial process furnaces in various sectors.[4] SNCR is not suitable for sources where the residence time is too short (reducing conversion of reactants), temperatures or NO$_X$ concentrations are too low (slowing reaction kinetics), the reagent would contaminate the product, or no suitable location exists for installing reagent injection ports. Expected removal efficiencies for SNCR range from 25 to 65 percent, and are dependent on many factors, including the reagent type, injection rate, pre-control NO$_X$ concentration as well as CO and O_2 concentrations, temperature and residence time.[5]

3.2.2.2 Selective Catalytic Reduction (SCR)

Like SNCR, SCR is also a post-combustion NO$_X$ control technology which removes NO$_X$ from flue gas based on the chemical reaction of a NO$_X$ reducing agent (typically ammonia), however, in the case of SCR this takes place using a metal-based catalyst. An ammonia or urea reagent is injected into the exhaust gas and the reaction of NO$_X$ and oxygen occurs on the surface of a catalyst which lowers the activation energy required for NO$_X$ decomposition into nitrogen gas and water vapor. Reactor design, operating temperature, sulfur content of the fuel, catalyst de-activation due to aging, ammonia slip emissions, and the ammonia injection system design are all important technical factors for effective SCR operation. Generally, SCR can

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[4] Air Pollution Control Cost Manual, Section 4.2, Chapter 1, Selective Non-Catalytic Reduction, NO$_X$ Control, EPA Form 2220-1.(rev. 4-77), Page 1-1.

[5] Air Pollution Control Cost Manual, Section 4.2, Chapter 1, Selective Non-Catalytic Reduction, NO$_X$ Control, EPA Form 2220-1.(rev. 4-77), Page 1-2.

achieve higher control efficiencies and be applied to a broader and lower range of exhaust temperatures relative to SNCR. However, this is accompanied by significantly higher capital and operating costs. Another primary disadvantage of an SCR system is that particles from the catalyst may become entrained in the exhaust stream and contribute to increased particulate matter emissions. In addition, ammonia slip reacts with the sulfur in the fuel creating ammonia bisulfates that become particulate matter.
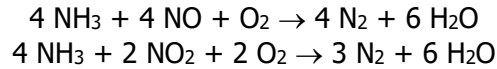
The primary chemical reactions for an SCR unit can be expressed as follows:

$$4 \ NH_3 + 4 \ NO + O_2 \rightarrow 4 \ N_2 + 6 \ H_2O$$
$$4 \ NH_3 + 2 \ NO_2 + 2 \ O_2 \rightarrow 3 \ N_2 + 6 \ H_2O$$

The optimum temperature range for the majority of commercial SCR system catalysts is 480 to 800°F; operation outside the optimum temperature range can result in increased ammonia slip or increased NO_X emissions. Application of SCR technology can result in removal efficiencies of over 90 percent depending on the source conditions.

3.2.2.3   Good Engineering Practices/Proper Furnace Operation

The formation of NO_X is minimized by proper combustion unit design and operation. Generally, emissions are minimized when the operating temperatures are kept at the lower end of the desired range. The controlled distribution of air at the air and fuel injection zones can also help minimize NO_x formation. Ideally, maintaining a low-oxygen condition near fuel injection points approaches an off-stoichiometric staged combustion process. A certain amount of air is required to provide sufficient oxygen to burn all of the fuel introduced to the furnaces. However, excess air contributes to increased NO_X emissions through increasing the amount of air that must be heated (i.e., decreasing fuel efficiency and resulting in higher NO_X emissions) and providing more oxygen in the combustion zone which can in turn lead to greater amounts of thermal NO_X formation. By minimizing the amount of air used in the combustion process while maintaining proper furnace operation, the formation of NO_X can be reduced.

3.2.3   Step 2: Eliminate Technically Infeasible Options for NO_X Control

Step 2 in a RACT top-down analysis is to eliminate the control options identified in Step 1 which are technically infeasible. The remaining technologies are then carried into Step 3.

3.2.3.1   Selective Non-Catalytic Reduction (SNCR)

SNCR requires a relatively high and very specific/narrow temperature range (generally between 1,550 °F and 1,950 °F), uncontrolled NO_X emissions above 200 ppm, and residence times of at least 1 second to be effective. Exhaust temperatures from the Edgar Thomson blast furnace casthouse baghouses average below 200 °F, which is well below the effective SNCR threshold operating temperature range of 1,550 – 1,950 °F. In addition, the exhaust gas has a high moisture content (> 20%) since they are routed through a venturi scrubber. In order to apply SNCR, the exhaust gas streams would need to be preheated. Given the large volume of exhaust gas and the relatively low exhaust temperature, significant energy would be required to raise the temperature nearly tenfold to effectively operate SNCR. This would result in the generation of significant quantities of NO_X that would be counter to the objective of reducing emissions for RACT.

A review of EPA's RBLC database shows that SNCR has not been commercially demonstrated on any blast furnaces or associated casthouses in the U.S. The significant technical challenges posed by the installation of SNCR for treating the casthouse baghouse exhaust streams make the control technology **not technically feasible** for RACT for these sources.

3.2.3.2 Selective Catalytic Reduction (SCR)

A review of EPA's RBLC database showed no entries citing use of SCR for NO_X control on blast furnaces or associated casthouses (i.e., the technology has not been demonstrated in this application). The SCR process is temperature sensitive, such that any exhaust gas temperature fluctuations will result in reduced removal efficiency and will upset the NH_3/NO_X molar ratio. SCR requires an optimum temperature range of 480 to 800°F and fairly constant temperatures, or NO_X removal efficiency will decrease.[6] Below this temperature range, the reaction rate drops sharply and effective reduction of NO_X is no longer feasible. Above this temperature, conventional reduction catalysts break down and are unable to perform their desired functions. As noted in the previous SNCR discussion, the exhaust gas temperatures from the blast furnace casthouse baghouses at Edgar Thomson are below the optimum SCR operating range. In order to apply SCR, the exhaust gas streams would need to be preheated. Given the large volume of exhaust gas and the relatively low exhaust temperature, significant energy would be required to raise the temperature to effectively operate SCR, resulting in the generation of NO_X that would be counter to the objective of reducing emissions for RACT.

For the various reasons described above, SCR is considered to be **not technically feasible** for controlling NO_X emissions from the blast furnace casthouse baghouses. Further evaluation of the technology is not required.

3.2.3.3 Good Engineering Practices/Proper Furnace Operation

As noted previously, the formation of NO_X from combustion processes can typically be minimized by proper furnace operation. Generally, emissions are minimized when the furnace temperature is kept at the lower end of the desired range and when the distribution of air at the air and fuel injection zones is controlled. A high thermal efficiency leads to less consumption of heat and fuel and produces less NO_X emissions. General improvement in thermal efficiency is one design method of reducing NO_X formation, since less fuel is used. These principles typically apply to combustion processes with enclosed chambers like those in traditional boilers and heaters. In the case of the blast furnaces, there are no practical ways to control NO_X emissions within the furnace. For blast furnaces, good operating practices to minimize emissions consist of managing the material compositions and the burdens within the furnace to achieve optimum energy efficiency and heating.

U. S. Steel currently maintains and operates the blast furnaces at Edgar Thomson in accordance with good engineering and air pollution control practices and proper furnace design. These are **technically feasible** methods for minimizing NO_X emissions from the furnaces.

3.2.4 Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, the remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. There is only one control strategy that is considered technically feasible for NO_X emissions from the blast furnaces: Good Engineering Practices.

3.2.5 Step 4: Evaluate Most Effective Controls and Document Results

Only one control strategy remained after the technical feasibility analysis conducted in Steps 2 and 3. As such, no detailed analysis of cost-effectiveness was performed.

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[6] U.S. EPA, Technology Transfer Network, Clean Air Technology Center. "Air Pollution Control Technology Fact Sheet – Selective Catalytic Reduction." File number EPA-452/F-03-032. July 2003. http://www.epa.gov/ttn/catc/dir1/fscr.pdf (26 Nov. 2014).

3.2.6   Step 5: Select RACT

As shown in Step 3 above, the top-down RACT analysis for the blast furnaces concluded that only one NO_X control strategy is technically feasible for the blast furnaces. For Step 5, U. S. Steel proposes to continue to employ good engineering and air pollution control management practices as RACT III for the blast furnaces and casthouses.

3.3   NO$_X$ RACT Assessment - BOP Shop

The basic oxygen process (BOP) is the primary steel-making process step. It involves charging molten iron from the blast furnace along with scrap metal and fluxes into the basic oxygen furnace (BOF). The charge is blown with high-purity oxygen at high velocity to penetrate slag and metal emulsions and to oxidize the carbon and impurities to make steel. Emissions from the process are collected in an overhead hood and directed to a wet venturi scrubber. The BOP is an exothermic process that does not require combustion of fuel, however, at Edgar Thomson there are additional combustion-related emissions of NO_X generated from miscellaneous fuel burning activities that occur within the BOP Shop area. These originate from many small sources (e.g., space heaters, etc.) and are not significant relative to the overall NO_X generated from the BOP itself.

3.3.1   Step 1: Identify All Control Technologies for NO$_X$

Step 1 in a top-down analysis is to identify all available control technologies. Table 3-2 contains a list of the various technologies that have been identified for the control of NO_X from BOP Shop.

Table 3-2. Potentially Available NO$_X$ Control Technologies for BOP Shop

Potentially Applicable NO$_X$ Control Technologies
Selective Non-Catalytic Reduction (SNCR)
Selective Catalytic Reduction (SCR)
Good Engineering Practices

3.3.2   Review of Potentially Applicable NO$_X$ Control Technologies

The following section provides a discussion of each potentially applicable technology identified above as it might be applied to the BOP at the Edgar Thomson Plant. It should be noted that there are no new pollutant specific air cleaning devices or technologies since the RACT II evaluation.

3.3.2.1   Selective Non-Catalytic Reduction (SNCR)

See Section 3.2.2.1 for a detailed description of SNCR technology.

3.3.2.2   Selective Catalytic Reduction (SCR)

See Section 3.2.2.2 for a detailed description of SCR technology.

3.3.2.3   Good Engineering Practices/Proper Furnace Operation

The formation of NO_X can typically be minimized by proper furnace design and operation. Generally, emissions are minimized when the operating temperatures are kept at the lower end of the desired range and when the distribution of air at the air and fuel injection zones is controlled. A high thermal efficiency

leads to less consumption of heat and fuel and produces less NO_X emissions. General improvement in thermal efficiency is one design method of reducing NO_X formation, since less fuel is used. In the case of the BOP, there is no fuel being combusted and the injection of oxygen is inherent to the process in order to remove impurities from the steel.

3.3.3 Step 2: Eliminate Technically Infeasible Options for NO_X Control

Step 2 in a RACT top-down analysis is to eliminate the control options identified in Step 1 which are technically infeasible. The remaining technologies are then carried into Step 3.

3.3.3.1 Selective Non-Catalytic Reduction (SNCR)

SNCR requires a relatively high and very specific/narrow temperature range (generally between 1,550 °F and 1,950 °F), uncontrolled NO_X emissions above 200 ppm, and residence times of at least 1 second to be effective. Exhaust temperatures from the Edgar Thomson BOP scrubber are generally below 120 °F, which is well below the effective SNCR threshold operating temperature range of 1,550 – 1,950 °F. In addition, the exhaust gas has a high moisture content (> 20%) since it is routed through a venturi scrubber. In order to apply SNCR, the exhaust gas stream would need to be preheated. Given the large volume of exhaust gas and the relatively low exhaust temperature, significant energy would be required to raise the temperature more than tenfold to effectively operate SNCR. This would result in the generation of significant quantities of NO_X that would be counter to the objective of reducing emissions for RACT.

A review of EPA's RBLC database shows that SNCR has not been commercially demonstrated on any BOF/BOP sources in the U.S. The significant technical challenges posed by the installation of SNCR for treating the BOP exhaust streams make the control technology **not technically feasible** for RACT.

3.3.3.2 Selective Catalytic Reduction (SCR)

A review of EPA's RBLC database showed no entries citing use of SCR for NO_X control on steel-making BOF/BOP processes. The SCR process is temperature sensitive, such that any exhaust gas temperature fluctuations will result in reduced removal efficiency and will upset the NH_3/NO_X molar ratio. SCR requires an optimum temperature range of 480 to 800°F and fairly constant temperatures, or NO_X removal efficiency will decrease.[7] Below this temperature range, the reaction rate drops sharply and effective reduction of NO_X is no longer feasible. Above this temperature, conventional reduction catalysts break down and are unable to perform their desired functions. As noted in the previous SNCR discussion, the exhaust gas temperatures from the BOP scrubber at Edgar Thomson is below the optimum SCR operating range. In order to apply SCR, the exhaust gas stream would need to be preheated. Given the large volume of exhaust gas and the relatively low exhaust temperature, significant energy would be required to raise the temperature to effectively operate SCR, resulting in the generation of NO_X that would be counter to the objective of reducing emissions for RACT.

For the various reasons described above, SCR is considered to be **not technically feasible** for controlling NO_X emissions from the BOP. Further evaluation of the technology is not required.

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[7] U.S. EPA, Technology Transfer Network, Clean Air Technology Center. "Air Pollution Control Technology Fact Sheet – Selective Catalytic Reduction." File number EPA-452/F-03-032. July 2003. http://www.epa.gov/ttn/catc/dir1/fscr.pdf (26 Nov. 2014).

3.3.3.3   Good Engineering Practices/Proper Furnace Operation

As noted previously, the formation of NO$_X$ from combustion processes can typically be minimized by proper furnace operation. Generally, emissions are minimized when the furnace temperature is kept at the lower end of the desired range and when the distribution of air at the air and fuel injection zones is controlled. A high thermal efficiency leads to less consumption of heat and fuel and produces less NO$_X$ emissions. General improvement in thermal efficiency is one design method of reducing NO$_X$ formation, since less fuel is used. These principles typically apply to combustion processes with enclosed chambers like those in traditional boilers and heaters. In the case of the BOP, there are no practical ways to control NO$_X$ emissions within the furnace since there is no fuel or burners. For the BOP, good operating practices to minimize emissions consist of managing the material compositions and the oxygen lancing within the furnace to achieve optimum energy efficiency.

U. S. Steel currently maintains and operates the BOP at Edgar Thomson in accordance with good engineering and air pollution control practices and proper furnace design. These are **technically feasible** methods for minimizing NO$_X$ emissions from the furnaces.

3.3.4   Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, the remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. There is only one control strategy that is considered technically feasible for NO$_X$ emissions from the BOP: Good Engineering Practices.

3.3.5   Step 4: Evaluate Most Effective Controls and Document Results

Only one control strategy remained after the technical feasibility analysis conducted in Steps 2 and 3. As such, no detailed analysis of cost-effectiveness was performed.

3.3.6   Step 5: Select RACT

As shown in Step 3 above, the top-down RACT analysis for the BOP concluded that only one NO$_X$ control strategy is technically feasible for the BOP. For Step 5, U. S. Steel proposes to continue to employ good engineering and air pollution control management practices as RACT III for this source.

3.4   NO$_X$ RACT Assessment – Boilers

Riley Boilers 1, 2, and 3 are water-tube boilers each rated at 525 MMBtu/hr. The boilers are capable of firing multiple fuels, including BFG, COG, and natural gas (as well as fuel oil as a backup, although not routinely fired). Like the blast furnace stoves, BFG is the primary fuel utilized in the boilers. NO$_X$ emission formation from the boilers is driven by the same principles outlined in Section 3.2. The burners on the boilers are designed with larger windboxes to allow for staged air firing. In addition, they are equipped with automation to optimize efficiency of their operation. Each boiler routes to a common stack that is equipped with a NO$_X$ continuous emissions monitoring system (CEMS).

3.4.1   Step 1: Identify All Control Technologies for NO$_X$

Step 1 in a top-down analysis is to identify all available control technologies. The evaluation of potential controls for NO$_X$ emissions from boilers and other types of combustion sources include both an investigation of end-of-pipe (post combustion methods) and combustion modifications/optimization that reduce the formation of thermal NO$_X$. Table 3-3 contains a list of the various technologies that have been identified as potentially applicable for the control of NO$_X$ emissions from the boilers at Edgar Thomson.

Table 3-3. Potentially Available NO$_X$ Control Technologies for Boilers

Potentially Applicable NO$_X$ Control Technologies
Selective Non-Catalytic Reduction (SNCR)
Selective Catalytic Reduction (SCR)
Low NO$_X$ or Ultra Low NO$_X$ Burners (LNB or ULNB)
Good Combustion Practices

3.4.2 Review of Potentially Applicable NO$_X$ Control Technologies

The following section provides a discussion of each potentially applicable technology identified above as it might be applied to the boilers at Edgar Thomson based on the strategies employed on other multi-fuel boilers and other types of combustion sources. It should be noted that there are no new pollutant specific air cleaning devices or technologies that are potentially applicable to the boilers since the RACT II evaluation.

3.4.2.1 Selective Non-Catalytic Reduction (SNCR)

See Section 3.2.2.1 for a detailed description of SNCR technology.

3.4.2.2 Selective Catalytic Reduction (SCR)

See Section 3.2.2.2 for a detailed description of SCR technology.

3.4.2.3 Low NO$_X$ Burners (LNBs)[8]

The principle of all LNBs is the same: step-wise or staged combustion and localized exhaust gas recirculation at the flame is employed. LNBs are designed to control fuel and air mixing to create larger and more branched flames. Peak flame temperatures are reduced and the flame structure reduces oxygen supply to the hottest part of the flame, resulting in less NO$_X$ formation. LNBs eliminate the need for steam or water injection, which was formerly the traditional method of NO$_X$ control.

LNB retrofits on existing units must carefully consider boiler geometry, as the LNB flame diameters and lengths are typically larger and can impinge on walls which may lead to reduced control efficiencies.

3.4.2.4 Good Combustion Practices/Proper Furnace Operation/Minimize Excess Air

The formation of NO$_X$ is minimized by proper combustion unit design and operation. Generally, emissions are minimized when the operating temperatures are kept at the lower end of the desired range. The controlled distribution of air at the air and fuel injection zones can also help minimize NO$_x$ formation. Ideally, maintaining a low-oxygen condition near fuel injection points approaches an off-stoichiometric staged combustion process. A certain amount of air is required to provide sufficient oxygen to burn all of the fuel introduced to the boilers. However, excess air contributes to increased NO$_X$ emissions through increasing the amount of air that must be heated (i.e., decreasing fuel efficiency and resulting in higher NO$_X$ emissions) and providing more oxygen in the combustion zone which can in turn lead to greater amounts of thermal NO$_X$ formation. By minimizing the amount of air used in the combustion process while maintaining proper boiler operation, the formation of NO$_X$ can be reduced.

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[8] This analysis includes low-NO$_X$ burners (LNBs) and ultra-low NO$_X$ burners (ULNBs). Since the operating principles and constraints are the same, the analysis has been grouped.

3.4.3 Step 2: Eliminate Technically Infeasible Options for NO$_x$ Control

Step 2 in a RACT top-down analysis is to eliminate the control options identified in Step 1 which are technically infeasible. The remaining technologies are then carried into Step 3.

3.4.3.1 Selective Non-Catalytic Reduction (SNCR)

SNCR requires a relatively high and very specific/narrow temperature range (generally between 1,550 °F and 1,950 °F), uncontrolled NO$_x$ emissions above 200 ppm, and residence times of at least 1 second to be effective. Exhaust temperatures from the Edgar Thomson boilers average around 400 °F, which is well below the effective SNCR threshold operating temperature range of 1,550 – 1,950 °F. This means that preheating of the exhaust gas would be necessary to effectively employ SNCR on the boilers.

Nevertheless, since SNCR has been commercially demonstrated on many boilers of various fuel types, U. S. Steel has considered this technology **technically feasible** for RACT for the boilers at Edgar Thomson.

3.4.3.2 Selective Catalytic Reduction (SCR)

Like SNCR, the SCR process is temperature sensitive, such that any exhaust gas temperature fluctuations will result in reduced removal efficiency and will upset the NH$_3$/NO$_x$ molar ratio. The installation of necessary components of the ammonia injection system and catalyst also require extensive structural modifications to the source and nearby structures. SCR requires an optimum temperature range of 480 to 800°F and fairly constant temperatures, or NO$_x$ removal efficiency will decrease.[9] Below this temperature range, the reaction rate drops sharply and effective reduction of NO$_x$ is no longer feasible. Above this temperature, conventional reduction catalysts break down and are unable to perform their desired functions. As noted in the previous SNCR discussion, the exhaust gas temperatures from the boilers are around 400 °F which is just below the optimum SCR operating range. Preheating the exhaust gas would likely be necessary to ensure effective operation of SCR for these boilers.

Because SCR is routinely used on boilers, it is considered to be **technically feasible** for controlling NO$_x$ emissions from the boilers at Edgar Thomson.

3.4.3.3 Low NO$_X$ Burners (LNBs)

The use of multiple fuels can present additional technical challenges with retrofitting burners. Replacement burner packages guaranteed to achieve NO$_x$ emission rates lower than those currently being observed have not been identified, and a search of the RBLC for NO$_x$ emission rates from similar large industrial boilers shows that the boilers at Edgar Thomson are already emitting significantly lower rates of NO$_x$ than others that have been determined to meet RACT.[10]

For the reasons noted above, LNB technology is considered **not technically feasible** for the Riley boilers at Edgar Thomson, and therefore is not further considered in this proposal.

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[9] U.S. EPA, Technology Transfer Network, Clean Air Technology Center. "Air Pollution Control Technology Fact Sheet – Selective Catalytic Reduction." File number EPA-452/F-03-032. July 2003. http://www.epa.gov/ttn/catc/dir1/fscr.pdf (26 Nov. 2014).

[10] RBLC ID No. PA-0323.

3.4.3.4   Good Combustion Practices/Proper Furnace Operation/Minimize Excess Air

As noted previously, the boilers primarily burn blast furnace gas which has a lower nitrogen fuel content and burns at lower temperatures. As a result, the emissions from the boilers are inherently lower in both fuel NO_X and thermal NO_X. In addition, the burners operate with staged air firing with automation to optimize efficiency.

U. S. Steel currently maintains and operates the boilers at Edgar Thomson in accordance with good combustion practices and proper design as demonstrated through regular maintenance activities. Furthermore, emissions of NO_X are continuously monitored to ensure that these practices are resulting in efficient operation. These are **technically feasible** methods for controlling NO_X emissions from the boilers.

3.4.4   Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, the remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. There are three control technologies that are considered technically feasible for the Riley boilers: SCR, SNCR, and Good Combustion Practices. The ranking for the control technologies are as follows:

1. SCR
2. SNCR
3. Good Combustion Practices

3.4.5   Step 4: Evaluate Most Effective Controls and Document Results

U. S. Steel has evaluated the cost for installing SCR and SNCR on the three existing boilers. The costs shown have been conservatively calculated using potential-to-emit (rather than actual emissions, which are significantly lower in many cases). It should be noted that the costs were calculated in accordance with EPA's Cost Control Manual algorithms assuming an average retrofit cost and appropriately updated for inflation. Actual site-specific retrofit factors and considerations have not been taken into account, which very likely would increase the costs shown below. The calculated cost per ton of NO_X removal for each technology on each boiler is well above $3,750 per ton, making the implementation of additional controls (SCR or SNCR) **economically infeasible** for these sources. The detailed cost analyses are included in Appendix A.

Table 3-4. SCR & SNCR Control Costs for Boilers

Emission Source ID	Source Description	SCR Costs ($/ton of NO_X Removed)	SNCR Costs ($/ton of NO_X Removed)
B001 – B003	Riley Boilers No. 1 - 3 (common stack)	$124,450	$683,468

3.4.6   Step 5: Select RACT

As shown in Step 3 above, the top-down RACT analysis for the boilers show two add-on control technologies that are technically feasible. Further, the results of the cost analysis (Step 4) show that installation of SCR or SNCR is cost prohibitive on a dollar per ton of NO_X removed basis. As such, the only remaining technically and economically feasible control technology is good combustion practices. For Step 5, U. S. Steel proposes to continue to operate and maintain the boilers in accordance with good engineering and air pollution control practices. Previously established NO_X emissions limits of 0.05 lb/MMBtu on a 12-month rolling

average and 0.07 lb/MMBtu on a 30-day rolling average basis reflect these practices. U. S. Steel will continue to implement continuous monitoring of NO_X emissions via CEMS and regular maintenance activities.

3.5   VOC RACT Assessment - Blast Furnace Casthouse

This section outlines the alternative RACT analysis performed for VOC emissions from the blast furnace and casthouses.

3.5.1   Step 1: Identify All Control Technologies for VOC

Step 1 in a top-down analysis is to identify all available control technologies. Table 3-5 contains a list of the various technologies that have been identified for the control of VOC from the Blast Furnace Casthouses.

Table 3-5. Potentially Available VOC Control Technologies for Blast Furnace Casthouses

Potentially Applicable VOC Control Technologies
Catalytic Oxidation
Thermal Oxidation/Incineration
Catalyst Activated Ceramic Dust Filters (CADF)
Good Engineering Practices

3.5.2   Review of Potentially Applicable VOC Control Technologies

The following section provides a discussion of each potentially applicable technology identified above as it might be applied to the Blast Furnace Casthouses.

3.5.2.1   Catalytic Oxidation

Catalytic oxidation is performed by passing exhaust gases over a catalyst where the VOC is converted to CO_2. The optimal working temperature range for oxidation catalysts is approximately 850 - 1,100 ºF with a minimum exhaust gas stream temperature of 500 ºF for minimally acceptable control. High particulate loading or inorganic content of the exhaust stream can cause fouling of the catalyst.

3.5.2.2   Thermal Oxidation/Incineration

Thermal oxidation or incineration eliminates VOC emissions by supplying adequate heat and oxygen to convert un-combusted VOCs to CO_2. Thermal oxidation requires temperatures of approximately 1,500 ºF to achieve 90 to 95 percent conversion of VOC to CO_2.

3.5.2.3   Catalyst Activated Ceramic Dust Filters (CADF)

This technology involves the control of multiple pollutants using a single system. These systems consist of a filtration element for the control of particulate matter which is embedded with a catalyst. As the exhaust gases pass through the filters, VOC in the stream is reduced in the same manner as a standard oxidation catalyst. This technology has not been commercially demonstrated on any iron-making process vessels.

3.5.2.4 Good Engineering Practices

A search of EPA's RBLC database and CTG references shows no control technologies or strategies specific to reduction of VOC emissions from iron-making process vessels. In numerous cases of similar sources, VOC BACT or RACT has been determined to be "good engineering practices". This includes operation and maintenance of the source and associated air pollution control devices in accordance with manufacturer's recommendations and/or good engineering practices.

3.5.3 Step 2: Eliminate Technically Infeasible Options for VOC Control

Step 2 in a RACT top-down analysis is to eliminate the control options identified in Step 1 which are technically infeasible. The remaining technologies are then carried into Step 3.

3.5.3.1 Catalytic Oxidation

Heavy particulate matter loading and trace inorganic metals in the exhaust gas stream from the blast furnace casthouse would present significant risk of poisoning the catalyst in a catalytic oxidation system. Exhaust gases from the blast furnace also undergo rapid cooling (to temperatures typically below 200 ^oF) as they are ducted away from the furnace and through the venturi scrubber. Thus, the temperature will be well below the minimum 500 ^oF threshold for effective operation of oxidation catalysts. In addition, the high moisture content of the exhaust stream (typically greater than 20%) can block oxidation sites on the catalyst.

No known installations of catalytic oxidation for VOC control on blast furnaces exist. For these reasons, this control technology is **not technically feasible** for the blast furnace casthouses. Further evaluation of this technology is not required.

3.5.3.2 Thermal Oxidation/Incineration

Thermal oxidation requires temperatures of approximately 1,500 ^oF. The most logical location for a thermal oxidizer would be just prior to the baghouse. Exhaust temperatures at this location are generally below 200 ^oF and excessive measures would be necessary to reheat gases to the required temperature necessary for 90% or better control of VOC. In addition, the operation of a thermal oxidizer would require significant amounts of natural gas fuel due to the low concentrations of VOC in the exhaust as well as the low temperature, and would coincidentally generate NO_X emissions (thereby contravening efforts to reduce ozone precursors which is the purpose of RACT). Finally, the use of thermal oxidizers has not been commercially demonstrated on blast furnaces.

For these reasons, this technology is **not technically feasible** for controlling VOC emissions for the blast furnace casthouses. Further evaluation of this technology is not required.

3.5.3.3 Catalyst Activated Ceramic Dust Filters (CADF)

The technical feasibility of CADF technology would be similar to that outlined for catalytic oxidation that was discussed in detail earlier in the previous section (e.g., significant catalyst poisoning risk, etc.). These types of systems are not listed in the RBLC for iron and steel industry process vessels. For all of the reasons noted, this technology is **not technically infeasible** and not RACT for the Edgar Thomson blast furnaces. Further evaluation of the technology is not required.

3.5.3.4 Good Engineering Practices

U. S. Steel currently maintains and operates the blast furnace casthouses and the associated venturi scrubber and baghouse in accordance with good engineering and air pollution control practices and by performing regular maintenance. U. S. Steel is subject to various operation and maintenance requirements for the blast furnace casthouse under the MACT regulations for Integrated Iron & Steel Manufacturing Facilities (40 CFR 63 Subpart FFFFF). The applicable requirements under this MACT rule are intended to reduce HAP emissions, which would be expected to have a co-benefit of minimizing VOC emissions as well. These are **technically feasible** methods for minimizing VOC emissions from the blast furnace casthouse operations.

3.5.4 Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, the remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. There is only one control strategy that is considered technically feasible for VOC emissions from the blast furnace casthouses: Good Engineering Practices.

3.5.5 Step 4: Evaluate Most Effective Controls and Document Results

Only one control strategy remained after the technical feasibility analysis conducted in Steps 2 and 3. As such, no detailed analysis of cost-effectiveness was performed.

3.5.6 Step 5: Select RACT

As shown in Step 3 above, the top-down RACT analysis for VOC from the blast furnace casthouses concluded that only one VOC control strategy is technically feasible. For Step 5, U. S. Steel proposes to continue to employ good engineering and air pollution control management practices in accordance with 40 CFR 63 Subpart FFFFF as RACT III for VOC emissions from these sources.

3.6 VOC RACT Assessment - BOP Shop

VOC emissions from the BOP Shop can originate from the volatilization and partial combustion of oils, plastic and other organic matter in the scrap and from the volatile components in any added carbon that is charged to the furnace. Emissions from the BOP Shop operations are collectively captured by the secondary baghouse.

3.6.1 Step 1: Identify All Control Technologies for VOC

Step 1 in a top-down analysis is to identify all available control technologies. Table 3-6 contains a list of the various technologies that have been identified for the control of VOC from the BOP Shop.

Table 3-6. Potentially Available VOC Control Technologies for BOP Shop

Potentially Applicable VOC Control Technologies
Catalytic Oxidation
Thermal Oxidation/Incineration
Catalyst Activated Ceramic Dust Filters (CADF)
Good Engineering Practices

3.6.2 Review of Potentially Applicable VOC Control Technologies

The following section provides a discussion of each potentially applicable technology identified above as it might be applied to the BOP Shop at Edgar Thomson.

3.6.2.1 Catalytic Oxidation

See Section 3.5.2.1 for a description of catalytic oxidation.

3.6.2.2 Thermal Oxidation/Incineration

See Section 3.5.2.2 for a description of catalytic oxidation.

3.6.2.3 Catalyst Activated Ceramic Dust Filters (CADF)

See Section 3.5.2.3 for a description of catalytic oxidation.

3.6.2.4 Good Engineering Practices

A search of EPA's RBLC database and CTG references shows no control technologies or strategies specific to reduction of VOC emissions from steel-making process vessels. In numerous cases of similar sources, VOC BACT or RACT has been determined to be "good engineering practices". This includes operating and maintaining the source and associated air pollution control devices in accordance with manufacturer's recommendations and/or good engineering practices.

3.6.3 Step 2: Eliminate Technically Infeasible Options for VOC Control

Step 2 in a RACT top-down analysis is to eliminate the control options identified in Step 1 which are technically infeasible. The remaining technologies are then carried into Step 3.

3.6.3.1 Catalytic Oxidation

Heavy particulate matter loading and trace inorganic metals in the exhaust gas stream from the BOP Shop would present significant risk of poisoning the catalyst in a catalytic oxidation system. The exhaust gas temperature is also well below the minimum 500 ºF threshold for effective operation of oxidation catalysts (around 120 ºF). In addition, the high moisture content of the exhaust stream (typically greater than 20%) can block oxidation sites on the catalyst. Finally, the concentration of VOC from the BOP Shop is estimated to be very low (parts per billion).

No known installations of catalytic oxidation for VOC control on BOP furnaces/shops exist. For these reasons, this control technology is **not technically feasible** for Edgar Thomson. Further evaluation of this technology is not required.

3.6.3.2 Thermal Oxidation/Incineration

Thermal oxidation requires temperatures of approximately 1,500 ºF. As discussed above, exhaust temperatures from the BOP Shop are generally below 120 ºF and excessive measures would be necessary to reheat gases to the required temperature necessary for 90% or better control of VOC. In addition, the operation of a thermal oxidizer would require significant amounts of natural gas fuel due to the very low concentrations of VOC in the exhaust as well as the low temperature, and would coincidentally generate NO_X emissions (thereby contravening efforts to reduce ozone precursors which is the purpose of RACT). Finally, the use of thermal oxidizers has not been commercially demonstrated on steel-making vessels.

For these reasons, this technology is **not technically feasible** for controlling VOC emissions for the BOP Shop. Further evaluation of this technology is not required.

3.6.3.3 Catalyst Activated Ceramic Dust Filters (CADF)

The technical feasibility of CADF technology would be similar to that outlined for catalytic oxidation that was discussed in detail earlier in the previous section (e.g., significant catalyst poisoning risk, etc.). These types of systems are not listed in the RBLC for iron and steel industry process vessels. For all of the reasons noted, this technology is **not technically infeasible** for the BOP Shop. Further evaluation of the technology is not required.

3.6.3.4 Good Engineering Practices

U. S. Steel currently maintains and operates the BOP Shop and the associated venturi scrubber and secondary baghouse in accordance with good engineering and air pollution control practices and by performing regular maintenance. U. S. Steel is subject to various operation and maintenance requirements for the BOP under the MACT regulations for Integrated Iron & Steel Manufacturing Facilities (40 CFR 63 Subpart FFFFF). The applicable requirements under this MACT rule are intended to reduce HAP emissions, which would be expected to have a co-benefit of minimizing VOC emissions as well. These are **technically feasible** methods for minimizing VOC emissions from the BOP operations.

3.6.4 Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, the remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. There is only one control strategy that is considered technically feasible for VOC emissions from the BOP Shop: Good Engineering Practices.

3.6.5 Step 4: Evaluate Most Effective Controls and Document Results

Only one control strategy remained after the technical feasibility analysis conducted in Steps 2 and 3. As such, no detailed analysis of cost-effectiveness was performed.

3.6.6 Step 5: Select RACT

As shown in Step 3 above, the top-down RACT analysis for VOC from the BOP Shop concluded that only one VOC control strategy is technically feasible. For Step 5, U. S. Steel proposes to continue to employ good engineering and air pollution control management practices in accordance with 40 CFR 63 Subpart FFFFF as RACT III for VOC emissions from this source.

3.7 VOC RACT Assessment - BOP Misc. Fugitives (Pot Coat)

One unique source of VOC emissions from the BOP operations is associated with the use of a VOC-containing coating that is applied to various steel pots/ladles throughout the BOP Shop for freeze prevention purposes. This Pot Coat material contains 5-10% methanol and fugitive emissions result from the spray application of the coating.

3.7.1 Step 1: Identify All Control Technologies for VOC

Step 1 in a top-down analysis is to identify all available control technologies. Table 3-7 contains a list of the various technologies that have been identified for the control of VOC from the pot coat applied in the BOP shop.

Table 3-7. Potentially Available VOC Control Technologies for BOP Fugitives (Pot Coat)

Potentially Applicable VOC Control Technologies
Capture & Control
Material Substitution

3.7.2   Review of Potentially Applicable VOC Control Technologies

The following section provides a discussion of each potentially applicable technology identified above as it might be applied to the fugitive emissions from use of Pot Coat.

3.7.2.1   Capture & Control

This control strategy would involve the installation of capture systems (e.g., enclosures or hoods) to collect the fugitive emissions from spray application of the Pot Coat and subsequently direct it to a single control device or multiple control devices. Capture systems might include permanent total enclosures or partial enclosures like local exhaust hoods that are routed to a duct system with an exhaust fan that moves the exhaust to a control device such as a catalytic oxidizer or thermal oxidizer/incinerator (principles of operation for these control devices were discussed in Section 3.6). Overall capture/control system performance can range in efficiency from 50 – 100% depending on a number of design, operational, and maintenance factors.

3.7.2.2   Material Substitution

Material substitution is the replacement of an existing chemical or raw material with an alternative material that results in lower emissions. In the case of the Pot Coat material in question, one approach to potentially reducing emissions would be to use an alternative material with lower VOC content. When considering material substitutions, it is important to evaluate the effectiveness of the material to ensure that it can meet the technical requirements of the intended use and will perform as well or better than the current material. In addition, the availability and cost of the material should be considered to confirm there is adequate supply to meet the facility's demand and that use of the alternate material is not cost prohibitive. Finally, the facility should evaluate current storage and application methods and capacities to verify that the alternative material would not require changes such as installation of storage tanks or installation of different application tools.

3.7.3 Step 2: Eliminate Technically Infeasible Options for VOC Control

Step 2 in a RACT top-down analysis is to eliminate the control options identified in Step 1 which are technically infeasible. The remaining technologies are then carried into Step 3.

3.7.3.1   Capture & Control

As discussed above, the source of emissions from applying the Pot Coat material is fugitive in nature. In addition, the material is applied at various locations throughout the BOP Shop. In order to capture and control these emissions, construction of extensive and numerous enclosures or exhaust hoods would be needed, with associated ductwork to route the exhaust to a control device. This would result in a high-volume stream with very low VOC concentrations. In addition, the exhaust stream temperature would be near ambient, and would require additional heating for oxidation. The necessary energy requirements to operate a fan large enough to capture the various streams, along with burning auxiliary fuel to oxidize the

VOC in the exhaust, would be technically challenging and counter to the objective of reducing ozone precursors (e.g., NO_x).

For these reasons, this technology is **not technically feasible** for controlling VOC emissions for the Pot Coat activities in the BOP Shop. Further evaluation of this technology is not required.

3.7.3.2 Material Substitution

The Pot Coat material that U. S. Steel uses in the BOP Shop is a proprietary formulation developed specifically for its specialized application. U. S. Steel has contacted vendors to determine if alternative materials with lower VOC content are commercially available. At this time, U. S. Steel has not identified any alternative materials that are commercially available and have been demonstrated in practice to meet the specialized technical needs of the application.

As such, this technology is **not technically feasible** for the Pot Coat activities at the BOP Shop. Further evaluation of the technology is not required.

3.7.4 Step 3: Rank Remaining Control Technologies by Control Effectiveness

In Step 3, the remaining control technology options are ranked based on their control effectiveness, from highest to lowest control efficiency. U. S. Steel has not identified any VOC control strategy that is considered technically feasible for emissions from the use of Pot Coat at the BOP Shop.

3.7.5 Step 4: Evaluate Most Effective Controls and Document Results

No control strategies remained after the technical feasibility analysis conducted in Steps 2 and 3. As such, no detailed analysis of cost-effectiveness was performed.

3.7.6 Step 5: Select RACT

As shown in Step 3 above, the top-down RACT analysis for VOC from the use of Pot Coat at the BOP Shop concluded that no VOC control strategy is technically feasible. For Step 5, U. S. Steel proposes to employ good operating practices and will continue investigating potential alternative materials with lower VOC content as they become commercially available.

4.   RACT III PROPOSAL

Based on the analysis provided herein, U. S. Steel is proposing the following alternative RACT III requirements, including monitoring, testing, recordkeeping and reporting for the sources discussed in Section 2 and Section 3. This document contains one table for each source (or source type) subject to the alternative RACT III provisions.

4.1   Blast Furnace Casthouses

Emission Source ID(s):	P001a, P002a
Source Description(s):	> Blast Furnace No. 1 Casthouse > Blast Furnace No. 3 Casthouse
Description of RACT:	Case-by-case
	1. Operate and maintain each source according to good engineering and air pollution control practices by performing regular maintenance.

Proposed Monitoring:
> As per 40 CFR 63 Subpart FFFFF
> As per IP 0058-I008a (and pending TV Renewal)

Proposed Testing:
> Properly operate and maintain according to good engineering and air pollution control practices by performing regular maintenance with the exception of actions to mitigate emergency conditions (see Condition C.1. of IP-008a)

Proposed Recordkeeping:
> Monthly records of fuel consumption
> Records of maintenance (see Condition C.2. of IP-008a)

Proposed Reporting:
> Annual emissions reporting by March 15th of each year
> Semi-annual Title V monitoring report and Annual Title V compliance certification

4.2   BOP Shop

Emission Source ID(s):	P003
Source Description(s):	BOP Shop
Description of RACT:	Case-by-case
	1. Operate and maintain each source according to good engineering and air pollution control practices by performing regular maintenance.

Proposed Monitoring:
> As per 40 CFR 63 Subpart FFFFF
> As per IP 0058-I008a (and pending TVOP Renewal)

Proposed Testing:
> Properly operate and maintain according to good engineering and air pollution control practices by performing regular maintenance with the exception of actions to mitigate emergency conditions (see Condition C.1. of IP-008a)

Proposed Recordkeeping:
> Monthly records of fuel consumption

Proposed Reporting:
> Annual emissions reporting by March 15th of each year
> Semi-annual Title V monitoring report and Annual Title V compliance certification

4.3   Boilers

Emission Source ID(s):	B001 – B003
Source Description(s):	Riley Boilers No. 1 – No. 3
Description of RACT:	Case-by-case
	1. Limit NO$_X$ emissions to the limits specified in IP #0051-I008a Table V-A-1. 2. Operate and maintain each source according to good engineering and air pollution control practices by performing regular maintenance.

Proposed Monitoring:
> Install, calibrate, maintain and operate NO$_X$ CEMS (see Condition V.A.3. of IP-008a)
> As per IP 0058-I008a (and pending TVOP Renewal)

Proposed Testing:
> Perform emissions testing once every two years or use NO$_X$ CEMS data in lieu of testing (see Condition V.A.2. of IP-008a).

Proposed Recordkeeping:
> CEMS records (see Condition V.A.4. of IP-008a)

Proposed Reporting:
> Annual emissions reporting by March 15th of each year
> Semi-annual Title V monitoring report and Annual Title V compliance certification

4.4　BOP Misc. Fugitives – Pot Coat

Emission Source ID(s):	N/A
Source Description(s):	BOP Miscellaneous Fugitives – Pot Coat
Description of RACT:	Case-by-case
	1. Operate and maintain the Pot Coat usage activities according to good engineering and air pollution control practices.

Proposed Monitoring:
> None.

Proposed Testing:
> None.

Proposed Recordkeeping:
> Maintain records of Pot Coat material usage and VOC content.
> Keep records for a period of 5 years

Proposed Reporting:
> Annual emissions reporting by March 15th of each year
> Semi-annual Title V monitoring report and Annual Title V compliance certification

APPENDIX A. COST-EFFECTIVENESS CALCULATIONS

SCR Costs for Boilers

Source	Annualized Costs ($/yr)	NOx PTE (tpy)	Controlled Emissions (tpy)	Emissions Reduction (tpy)	Cost Effectiveness ($/ton)
Boiler Stack (Combined Exhaust)	34,348,259	345.00	69.00	276.00	124,450

Heat Capacity Boiler Combustion Stack Gas

	BOILERS (Aggregate)	
	Flue Gas Composition	Heat Capacity $(Btu/ft^3/°F)$
H	8.6%	0.0176
CO	24.0%	0.0179
CO2	21.2%	0.0260
N2	46.2%	0.0185
Total	**100.0%**	**0.0199**

	BOILERS (Aggregate)	
Flow (1)	570,000 scfm	
Flow	**3.42E+07 scfh**	
Temperature$_{SCR\ in}$ (1)	**382 F**	
Temperature$_{SCR\ out}$ (2)	**730 F**	
ΔT	**348 F**	
Heat Requirement	6.9 Btu/scf	
Natural Gas Eff'y	80.0%	
Natural Gas Req'd	8.6	Btu / scf flue gas
Natural Gas Req'd	8.64E-06	MMBtu/scf flue gas
Natural Gas Cost (4)	$11.03 / MMbtu	
Max Hours of Operation	8,760 Hr/yr	
Annual Natural Gas Cost (5)	$28,560,266	

(1) Flowrate and temperatures values are consistent with RACT II evaluation values but reflect the combined stack

(2) SCR temperature & efficiency from EPA Control Cost Manual, 6th Ed., NOx Controls, Fig 2.2.

(3) Utilizes the permit limits or potential-to-emit values in tpy based on 8,760 hrs/yr.

(4) EIA 2022 average NG prices for commercial consumers in 2022 (https://www.eia.gov/naturalgas/monthly/pdf/table_03.pdf)

(5) Annual NG Cost = $/MMBtu NG x MMBtu/scf flue gas x scf flue gas/hr x hrs/yr

SCR Design Parameters used for Estimation

Combined Boilers Max. Heat Input, Q_B =   1575   MMBtu/hr

System Capacity Factor, CFtotal = CFplant x CFSCR
Capacity Factor, CF, a measure of the average annual use of the boiler in conjunction with the SCR system.

	Worst-Case Actual	1575	MMBtu/hr
	Potential	1575	MMBtu/hr

$CFBoiler2$=   1.00

t_{SCR} 365   days/yr

CF_{SCR}=   1.00
CF_{total}=   1.00   (CCM SCR June 2019, Equation 2.7)

Uncontrolled NO_X, Stack NO_X and NO_X Removal Efficiency

NOx_{in}, (uncontrolled)=   0.05   lb/MMBtu (Potential, RACT II permit limit)

NOx Removal Efficiency, η_{Nox} =   80%

Stoichiometric Ratio Factor, SRF   (CCM SCR June 2019, Equation 2.13)

$$SRF = \frac{\text{moles of equivalent NH3 injected}}{\text{mole of uncontrolled } NO_X}$$

The value for SRF in a typical SCR system is approximately =   1.05   (CCM SCR June 2019, Section 2.3.7)

Flue Gas Flow Rate, q$_{fluegas}$

$$q_{fluegas} = \quad 921,000 \quad \text{acfm (consistent with RACT II value but combined stack, x 3)}$$

Space Velocity and Area Velocity, V$_{space}$ & V$_{area}$ (CCM SCR June 2019, Section 2.3.9)

Vanadium (V2O5) Catalyst on honeycomb substract with average pitch assumed

$$Vol_{reactor} = \quad 0.02 \quad \text{ft}^3/\text{cfm}$$
$$Vol_{reactor} = \quad 18420 \quad \text{ft}^3$$
$$Area_{reactor} = \quad 0.005 \quad \text{ft}^2/\text{cfm}$$
$$Area_{reactor} = \quad 4605 \quad \text{ft}^2$$

$$V_{space} = \frac{1}{\text{Residence Time}} \quad = \quad \frac{q_{fluegas}}{Vol_{reactor}} \quad = \quad 50$$

$$V_{area} = \frac{V_{space}}{A_{specific}\,(\text{length}^2/\text{length}^3)} \quad = \quad 200$$

$$A_{specific\,(\text{provided by catalyst manufacturer})} = \quad 0.25 \quad /\text{ft}$$

Catalyst Volume, Vol$_{catalyst}$ (CCM SCR June 2019, Section 2.3.11)

$$Vol_{catalyst} = \frac{-\left(q_{fluegas} \times \ln\left[1 - \left(\frac{\eta_{NO_x}}{SRF}\right)\right]\right)}{K_{catalyst} \times A_{specific}}$$

$$Vol_{catalyst} = Vol_{reactor} \quad 18,420 \quad \text{ft}^3 \text{ (Assumption)}$$

SCR Reactor Dimensions

$$A_{catalyst} = \frac{q_{fluegas}}{16\,ft/s \times 60\text{sec/min}}$$

$$A_{catalyst} = \quad 959.4 \quad \text{ft}^2$$

$$A_{SCR} = 1.15 \times A_{catalyst}$$

$$A_{SCR} = \quad 1103.3 \quad \text{ft}^2$$
$$l_{scr} = \quad 33.2 \quad \text{ft}$$
$$w_{scr} = \quad 33.2 \quad \text{ft}$$

$$n_{layer} = \frac{Vol_{catalyst}}{h'_{layer} \times A_{catalyst}}$$

$h'_{layer} =$	3.1	ft (nominal height as per Section 2.3.11 of SCR manual)
$n_{layer} =$	6.2	(There must be at least two catalyst layers, Section 2.3.11 of SCR manual)

$$h_{layer} = \left(\frac{Vol_{catalyst}}{n_{layer} \times A_{catalyst}}\right) + 1$$

$h_{layer} =$	4.1	ft. (Standard industry range is 2.5 to 5.0 ft and 1 foot is added to account for space required above and below the catalyst material for module assembly.)

$$n_{total} = n_{layer} + n_{empty}$$

$n_{empty} =$	1	(Assumption)
		(This accounts for the fact that n_{layer} does not include any empty catalyst layers for the future installation of
$n_{total} =$	7.2	catalyst).

$$h_{SCR} = n_{total}(c_1 + h_{layer}) + c_2 \qquad \text{(Height of SCR reactor)}$$

$c_1 =$	7	(Constants based on common industry practice)
$c_2 =$	9	
$h_{SCR} =$	88.8	

Estimating Reagent Consumption and Tank Size (CCM SCR June 2019, Section 2.3.13)

$$\dot{m}_{reagent} = \frac{NO_{X_{in}} \times Q_B \times SRF \times \eta_{NO_X} \times M_{reagent}}{M_{NO_X}}$$

$NO_{X_{in}} =$	0.05	lb/MMBtu
$Q_B =$	1575	MMBtu/hr
$SRF =$	1.05	
$\eta_{NO_X} =$	80%	
$M_{reagent} =$	17.03	grams NH_3/mole
$M_{NO_X} =$	46.01	grams NO_2/mole
$\dot{m}_{reagent} =$	24.5	lbs/hr

For ammonia,

$$\dot{m}_{sol} = \frac{\dot{m}_{reagent}}{C_{sol}}$$

$C_{sol} =$	19%	(Percent concentration of the aqueous reagent solution)	
$= \dot{m}_{sol}$	128.9	lbs/hr	

$$q_{sol} = \frac{\dot{m}_{sol}}{\rho_{sol}} v_{sol}$$

$\rho_{sol} =$	56	lb/ft^3	(For aqueous ammonia at 60ºF, Section 2.3.13 of SCR manual)
$v_{sol} =$	7.481	gal/ft^3	(Specific volume of aqueous ammonia at 60ºF, Section 2.3.13 of SCR manual)
$q_{sol} =$	17.2	gph	

Tank volume:

$$Vol_{Tank} = q_{sol} \times t$$

$t =$	14.0	days	(Common on site storage requirement, Section 2.3.13 of SCR manual)
$Vol_{Tank} =$	5784	gallons	

TOTAL CAPITAL INVESTMENT, TCI
Assumptions:
* Anhydrous ammonia used as the reagent
* Allowed ammonia slip range: 2-5 ppm.
* Ceramic honeycomb catalyst with an operating life of 3 years at full load operations.
* Cost equations sufficient for NOx reduction efficiencies up to 90%.
* A correction factor for a new installation versus a retrofit installation is included to adjust capital costs.

TCI Includes: direct and indirect costs associated with purchasing and installing SCR equipment. Costs include the equipment cost (EC) for the SCR system itself, the cost of auxiliary equipment, direct and indirect installation costs, additional costs due to installation such as asbestos removal, costs for buildings and site preparation, offsite facilitites, land and working capital.

TOTAL CAPITAL INVESTMENT, TCI (CCM SCR June 2019, Section 2.4.1.4)

$$TCI = 10{,}530 \times \left(\frac{1{,}640}{Q_B}\right) \times Q_B \times ELEVF \times RF \quad \text{(CCM SCR June 2019, Equation 2.53)}$$

ELEVF =	1.03	ET Plant, PA is ~750 ft above sea level (CCM SCR June 2019, Equation 2.39a)	
RF =	1	Retrofit of average difficulty (CCM SCR June 2019, Equation 2.53)	

Total Capital Investment (TCI) (2022 $) = $26,318,989 (Chemical Engineering Plant Index difference applied to DC)

TOTAL ANNUAL COSTS (CCM SCR June 2019, Section 2.4.2)
Consists of direct costs, indirect costs, and recovery credits. Direct annual costs are those proportional to the quantity of waste gas processed by the control system. Indirect (fixed) annual costs are independent of the operation of the control system and would be incurred even if it were shut down. No byproduct recovery credits are included because there are no salvageable byproducts generated from the SCR.

Direct Annual Costs, DAC

$$DAC = \begin{pmatrix} Annual \\ Maintenance \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Reagent \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Electricity \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Catalyst \\ Cost \end{pmatrix} \quad \text{(CCM SCR June 2019, Equation 2.56)}$$

Operating and Supervisory Labor:
In general, no additional personnel is required to operate or maintain the SCR equipment for large industrial facilities.

Operating labor time =		4 hr/day	(CCM SCR June 2019, Section 2.4.2)
Operating labor cost =	$	70 $/man-hr	
Annual operating labor cost =	$	102,200	= hr/day x 365 day/yr x $/man-hr

Maintenance:

	0.5% of TCI		(CCM SCR June 2019, Equation 2.57)
Maintenance =	$	131,595	

Total operating time, t_{op} = CF_{total} x 8760 hrs/yr   8,760   hours   (CCM SCR June 2019, Equation 2.59)

Reagent Consumption:

$cost_{reagent}$	0.5631	$/gallon	(Tanner Industries, Inc budgetary pricing for aqueous ammonia - 10/1/2020)
Annual reagent cost =	$ 84,918	= q_{sol} x $cost_{reag}$ x t_{op}	(CCM SCR June 2019, Equation 2.58)

Utilities:

$$Power = (0.1 \times Q_B) \times (1,000) \times (0.0056) \times (CoalF \times HRF)^{0.43} \quad \text{(CCM SCR June 2019, Equation 2.61)}$$

CoalF=	1	For gas-fired boilers, replace the coal factor with "1"
HRF	1	For industrial boilers, assume NPHR=10; HRF = 1 (CCM SCR June 2019, Section 2.3.2)
Power =	882.0	kw
$Cost_{elec}$=	0.09	$/kwh (September 2022, U.S. EIA statistics for Pennsylvania)
t_{op} =	8,760	hours
Annual electricity cost = P x $Cost_{elec}$ x t_{op} =	$ 690,733	(CCM SCR June 2019, Equation 2.61)

Additional Energy Requirement = $ 28,560,266 (Additional heating of exhaust gas required for SCR operations.)

Catalyst Replacement:

Catalyst Replacement Cost = n_{SCR} x $Vol_{catalyst}$ x ($CC_{replace}/R_{layer}$)   (CCM SCR June 2019, Equation 2.63)

R_{layer} =	1	for full replacement
R_{layer} =	6.2	=n_{layer} (for replacing one layer per year)
n_{SCR} =	1	(number of SCR reactors per boiler)
$CC_{initial}$ = $	227	per ft^3 (Default value CCM SCR June 2019, Section 2.5)
$Vol_{catalyst}$ = $	18,420	ft^3
Catalyst Replacement Cost (2022 $)= $	6,364,251	(Chemical Engineering Plant Index difference applied to DC)

Annual Catalyst Replacement Cost = (Catalyst Replacement Cost) x (FWF)   (CCM SCR June 2019, Equation 2.64)

Future Worth Factor = $FWF = i \left|\frac{}{(1+}\right.$ (CCM SCR June 2019, Equation 2.65)

Interest rate, i =   8.00%   Prior Site-Specific Interest Rate Used in 4-Factor Analysis and BART Evaluation (Conservatively Low)

$Term, Y = \frac{h_{cat}}{h_y}$ 3   (CCM SCR June 2019, Equation 2.66)

$h_{catalyst}$ =	24,000	hours (operating life of catalyst per CCM SCR June 2019, Section 2.4.2)
h_{year} =	8,760	hours = t_{op}
FWF =	0.34	

Annual Catalyst Replacement Cost = $ 2,169,047

Total DAC (2022 $)= $ 31,738,759

Indirect Annual Costs, IDAC:

Indirect Annual Cost, IDAC = Administrative Charges + Capital Recovery   (CCM SCR June 2019, Equation 2.68)

Assume Administrative Charges are negligible

CR=CRF x TCI   (CCM SCR June 2019, Equation 2.70)
CRF = Capital Recovery Factor,

$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$

Interest rate,i =	8.00%	Prior Site-Specific Interest Rate Used in 4-Factor Analysis (Conservatively Low)
Economic life of SNCR, n=	20	years
CRF =	0.102	

TCI = Total Capital Investment = $26,318,989

IDAC (2022 $) = $ 2,680,647

Total Annual Cost (2022 $):
Total Annual Cost, TAC = DAC + IDAC = $34,419,406.60

<div align="center">

COMPANY: United States Steel
LOCATION: Edgar Thomson Plant
Source: Boiler #1 - 3
NOX Emission Control Option: SCR (80% Efficiency)

</div>

Site Information   **Source Emission Information**   **Control Technology Information**

Utility Unit Costs

Electricity, $/kwh	0.09	Equipment Life, yr	20.0	Boiler Fuel Rating, mmBTU/hr	1575
Interest Rate, %	8.00%	Operating Hours Per Year	8,760	NOX Removal Efficiency, η_{NOx}	80%
				Cost Year	2022

Operating Labor, $/man-hr	70.00
Manhours per year	1,460
Sales Tax, % of FOB	N/A
Freight & Ins. to Site, % of FOB	Included in DC
Maintenance (Materials + Labor) % TCI	0.5%

Incremental Utility Requirement

Electricity, kw	882
Reagent sol, gal/hr	2.8
Catalyst operating life, hrs	24,000

Reagent Volume, gallons/hr	2.8
Reagent Cost, $/gallon	0.56

COMPANY: **United States Steel**
LOCATION: **Edgar Thomson Plant**
Source: **Boiler #1 - 3**
NOX Emission Control Option: **SCR (80% Efficiency)**

TOTAL CAPITAL INVESTMENT		COST EFFECTIVENESS		
TOTAL CAPITAL INVESTMENT, TCI	$ 26,318,989			
TOTAL ANNUAL COST		Efficiency, %		80%
		Boiler Heat Input, MMBtu/hr		1575
Direct Annual Costs		Total Operating Time, hrs/yr		8,760
Operating & Supervisory Labor	$102,200			
Maintenance	$131,595	NO_X removed, tpy		276.0
Reagent Consumption	$13,770			
Utilities	$690,733			
Catalyst Replacement	$2,169,047			
Auxilliary Equipment Requirements	$28,560,266			
(Auxiliary Heating Costs = Nat'l gas cost required to heat boiler exhaust up to SCR required temperature.)		**Cost Efficiency:**		
		$/ton NO_X removed	$	124,450
Total Direct Annual Costs	$31,667,612			
Indirect Annual Costs				
CRF	0.10185			
IDAC (CRF x TCI)	$2,680,647			
TOTAL ANNUAL COST, TAC	**$34,348,259**			

SNCR Costs for Boilers

Source	Annualized Costs ($/yr)	NOx PTE (tpy)	Controlled Emissions (tpy)	Emissions Reduction (tpy)	Cost Effectiveness ($/ton)
Boiler Stack (Combined Exhaust)	106,108,444	345.00	189.75	155.25	683,468

Heat Capacity Boiler Combustion Stack Gas

	BOILERS (Aggregate)	
	Flue Gas Composition	Heat Capacity (Btu/ft^3/°F)
H	8.6%	0.0176
CO	24.0%	0.0179
CO2	21.2%	0.0260
N2	46.2%	0.0185
Total	**100.0%**	**0.0199**

	BOILERS (Aggregate)	
Flow (1)	570,000	scfm
Flow	**3.42E+07**	**scfh**
Temperature$_{SNCR\ in}$ (1)	**382**	**F**
Temperature$_{SNCR\ out}$ (2)	**1650**	**F**
ΔT	**1268**	**F**
Heat Requirement	25.2	Btu/scf
Uncontrolled NOX (3)	110.25	lb / hr
NOX control eff'y (2)	45.0%	
NOX Removed	49.6	lb / hr
NOX Removed	1.45E-06	lb/scf flue gas
NOX from Natural Gas Combustion (4)	3.15E-06	lb/scf flue gas
Net NOX Reduction	-1.70E-06	lb/scf flue gas
Natural Gas Eff'y	80.0%	
Natural Gas Req'd	31.5	Btu/scf flue gas
Natural Gas Req'd	3.15E-05	MMBtu/scf flue gas
Natural Gas Cost (5)	$11.03	/ MMbtu
Natural Gas Cost	-$204.50	/lb NOX Removed
Annual Natural Gas Cost (6)	##########	

Could theoretically generate more NOx than reducing

(1) Flowrate and temperatures values are consistent with RACT II evaluation values (but reflective of combined stack)

(2) SNCR temperature & efficiency from EPA Control Cost Manual, 6th Ed., NOX Controls, Fig 1.5. (Maximum uncontrolled NOX concentration displayed is 200 ppm.)

(3) Utilizes the permit limits or potential-to-emit values in tpy based on 8,760 hrs/yr.

(4) Based on 140 lb NOX per MMscf natural gas

(5) EIA 2022 average NG prices for commercial consumers in 2022 (https://www.eia.gov/naturalgas/monthly/pdf/table_03.pdf)

(6) Annual NG Cost = $/MMBtu NG x MMBtu/scf flue gas x scf flue gas/hr x 8760 hrs/yr

SNCR Design Parameters used for Estimation

    Combined Boilers Max. Heat Input, Q_B =   1575   MMBtu/hr

    System Capacity Factor, CF_{total} = CF_{plant} x CF_{SNCR}

Capacity Factor, CF, a measure of the average annual use of the boiler in conjunction with the SNCR system.

$$CF_{plant} = \frac{FuelUsage_{annual}, lbs}{FuelUsage_{potential}, lbs}$$

$$CF_{Boiler\#2} = \frac{Actual_{2018}, MMBtu/hr}{Potential, MMBtu/hr}$$

Worst-Case Actual	1575	MMBtu/hr
Potential	1575	MMBtu/hr

                       CFBoiler2=   1.00

$$CF_{SNCR} = \frac{t_{SNCR}(days/yr)}{365(days/yr)}$$

           t_{SNCR} 365   days/yr

                       CF_{SNCR}=   1.00

                       CF_{total}=   1.00

Uncontrolled NO_X, Stack NO_X and NO_X Removal Efficiency

           NO_{Xin}, (uncontrolled)=   0.05   lb/MMBtu (Potential, RACT II permit limit)

       NOX Removal Efficiency, η_{NOx} =   45%

Normalized Stoichiometric Ratio, NSR   (Equation 1.17 of SNCR manual)

$$NSR = \frac{\left[\left(\frac{2\ mol\ Urea}{mol\ NO_X}\right) \times NO_{X_{in}} + 0.7\right] \times \eta_{NO_x}}{NO_{X_{in}}}$$

                       NSR =   7.20

Estimating Reagent Consumption

Reagent Consumption Parameters:

$\rho_{sol} =$	9.5	Density of aqueous reagent solution (lb/gal) (For a 50% urea solution, as per page 1-38 of SNCR Manual)
$M_{reagent} =$	60.06	Molecular weight of reagent (grams/mol Urea)
$M_{NO2} =$	46.01	Molecular weight of NO_2 (grams/mol NO_2)
$SR_T =$	2	Ratio of equivalent moles of NH_3 per mole of reagent (mols NH_3/mol Urea)
$C_{sol} =$	0.5	Concentration of aqueous reagent solution by weight (lb reagent/lb solution) (50% solution)

Reagent mass flow rate:

$$\dot{m}_{reagent} = \frac{NO_{X_{in}} \times Q_B \times \eta_{NOx} \times NSR \times M_{reagent}}{M_{NO_2} \times SR_T} \quad \text{(Equation 1.18 of SNCR manual)}$$

$$\dot{m}_{reagent} \quad = \quad 166.5 \quad \text{lbs/hr}$$

Aqueous reagent solution mass flow rate: (Equation 1.19 of SNCR manual)

$$\dot{m}_{sol} = \frac{\dot{m}_{reagent}}{C_{sol}}$$

$$\dot{m}_{sol} \quad = \quad 333.1 \quad \text{lbs/hr}$$

Solution volume flow rate: (Equation 1.20 of SNCR manual)

$$q_{sol} = \frac{\dot{m}_{sol}}{\rho_{sol}}$$

$$q_{sol} = \quad 35.09 \quad \text{gph}$$

Aqueous reagent solution storage:

$$V_{tank} = q_{sol} \times t_{storage}$$

$t_{storage} =$	14.00	days (Assumption from pg. 1-39 in SNCR manual)
$V_{tank} =$	11,790.72	gallons

TOTAL CAPITAL INVESTMENT, TCI

Cost Year =   1998

equipment, direct and indirect installation costs, additional costs due to installation such as asbestos removal, costs for buildings and site preparation, offsite facilitites, land and working capital.

	Direct Capital costs includes PEC such as SNCR system equipment, instrumentation, sales tax and freight. This includes costs
DC=	associated with field measurements, numberical modeling and system design. It also includes direct installation costs such as auxiliary equipment (e.g.ductwork, compressor), foundations and supports, handling and erection, electrical, piping, insulation and painting. In addition costs such as asbestos removal are included.
PEC=	Purchased Equipment Cost
IC=	Indirect Capital

Total Direct Capital Costs, DC:

$$DC = \frac{\$950}{\frac{MMBtu}{hr}} Q_B \left(\frac{MMBtu}{hr}\right) \left\{ \frac{2375 \frac{MMBtu}{hr}}{Q_B \left(\frac{MMBtu}{hr}\right)} \right\}^{0.577} (0.66 + 0.85\eta_{NO_X})$$

DC (2022 $) = $ 4,184,951.68   (Chemical Engineering Plant Index difference applied to DC)

Indirect Capital Costs:

Total Indirect Installation Costs, IC (2022 $) = $ 836,990

=DC x (General Facilities % + Engineering and Home Office Fees % + Process Contingency %)

General Facilities % =	5%
Engineering and Home Office Fees % =	10%
Process Contingency % =	5%

Project Contingency, C =	$	753,291.30	
=		15%	of DC + IC

Total Plant Cost, D = $ 5,775,233.32 = DC + IC + C

Allowance for Funds During Construction, E = $ -   (Assumed zero for SNCR)

Royalty Allowance, F = $ -   (Assumed zero for SNCR)

Preproduction Costs, G = $ 115,504.67
=   2%   of D + E

Inventory Capital, H = $ 1,038,573.86   = $Vol_{reagent}$(gal) x $Cost_{reagent}$($/gal)
$Vol_{reagent}$ =   306,559   gal/yr
$Cost_{reagent}$ =   3.39 $/gal $/gallon (Mundi Price Index for September 2022, United States)

Initial Catalyst and Chemicals, I = $ -   (Assumed zero for SNCR)

Total Capital Investment, TCI = $ 6,929,311.85   = D + E + F + G + H + I

TOTAL ANNUAL COSTS

TAC = Total Annual Cost
Includes: direct costs, indirect costs, and recovery credits.
DAC =   Direct Annual Costs
Include: variable and semivariable costs.
Variable includes: purchase of reagent, utilities, and any additional fuel and ash disposal resulting from the operation of the
Semivariable include: operating and supervisory labor and maintenance.

$$DAC = \begin{pmatrix} Annual \\ Maintenance \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Reagent \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Electricity \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Water \\ Cost \end{pmatrix} + \begin{pmatrix} Annual \\ Fuel \\ Cost \end{pmatrix}$$

<u>Operating and Supervisory Labor:</u>
In general, no additional personnel is required to operate or maintain the SNCR equipment for large industrial facilities.

<u>Maintenance:</u>
1.5% of TCI
Maintenance = $ 103,940

Total operating time, t_{op} = CF_{total} x 8760 hrs/yr   8760   hours   (CF not used as max hours required for BART analysis)

Reagent Consumption (Urea):

	cost_reagent	3.39	\$/gallon (Mundi Price Index for September 2022, United States)
	Annual reagent cost = \$	1,041,427	= q_{sol} x cost_reagent x t_{op}

Utilities:

Power Consumption, P:

$$P = \frac{0.47 \times NOx_{in} \times NSR \times Q_B}{9.5}$$

NOx_{in}, (uncontrolled)=	0.050	lb/MMBtu	
NSR (Normalized Stoichiometric Ratio):	7.20		
Q_B, boiler heat input=	1575	MMBtu/hr	
P =	28	kw	
Cost_elec =	0.09	\$/kwh (September 2022, U.S. EIA statistics for Pennsylvania)	
t_{op} =	8760	hours	
Annual electricity cost = P x Cost_elect x t_{op} = \$	21,968	per kWh	

Water Consumption:

$$q_{water} = \frac{\dot{m}_{sol}}{\rho_{water}} \left(\frac{C_{UreaSol_{stored}}}{C_{UreaSol_{inj}}} - 1 \right)$$

For urea dilution from a 50% solution to a 10% solution q_{water} becomes:

$$q_{water} = \frac{4\dot{m}_{sol}}{\rho_{water}}$$

ρ_{water} =	8.345	lb/gal	
q_{water} =	0.160	1,000 gallons/hour	

Annual water cost = q_{water} x Cost_water x t_{op} =

	Cost_water =	15.05	\$/1,000 gallons (2022 cost from Pittsburgh Water and Sewage Authority Published Rate Sheet for ≥10" Meter)
	\$	21,052.82	

Additional Fuel Consumption:

Because the water from the urea solution evaporates in the boiler, the boiler efficiency decreases. Consequently, more fuel needs to be burned to maintain the required steam flow.
Assumptions:
    - Urea is injected at at 10% solution
    - Heat of vaporization of water is 900 Btu/lb

$$\Delta Fuel\left(\frac{MMBtu}{hr}\right) = \frac{900\left(\frac{Btu}{lb}\right)}{10^6\left(\frac{Btu}{MMBtu}\right)} \times \dot{m}_{reagent}\left(\frac{lb}{hr}\right) \times 9$$

$$\Delta Fuel\left(\frac{MMBtu}{hr}\right) \quad = \quad 1.3489$$

Annual cost for additional fuel:

Additional fuel required:

| | Natural gas | 1.34891 | MMBtu/hr |

Total cost associated with additional fuel usage:

Natural gas cost	9.44	$/MMBtu	(left as conservatively low value; current price is 17.29)
	$ 111,547.49	$/yr	

Total Natural gas: $ 111,547.49

Additional Energy Requirement = $ 104,064,418   (Additional heating of exhaust gas required for SNCR operations.)

Total DAC = $105,364,353.03

<u>Indirect Annual Costs:</u>

Indirect Annual Cost, IDAC = CRF x TCI
CRF = Capital Recovery Factor,

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Interest rate,i =	8.00%	Prior Site-Specific Interest Rate Used in 4-Factor Analysis and BART Evaluation (Conservatively Low)
Economic life of SNCR, n=	20	years
CRF =	0.10	

TCI = Total Capital Investment (2020 $) = $ 6,929,311.85

IDAC = $ 705,765.72

Total Annual Cost (2022 $):
Total Annual Cost, TAC = DAC + IDAC = $106,070,118.75

COMPANY: **United State Steel**
LOCATION: **Edgar Thomson Plant**
Source: **Boiler #1 - 3**
NO$_X$ Emission Control Option: **SNCR (45% Efficiency)**

Site Information		Source Emission Information		Control Technology Information	
Utility Unit Costs					
Electricity, $/kwh	0.09	Equipment Life, yr	20.0	Boiler Fuel Rating, mmBTU/hr	1575
Interest Rate, %	8.00%	Operating Hours Per Year	8760	NOX Removal Efficiency,η_{NOx}	45%
Water, $/1,000 gal	15.05			Cost Year	2022
				Incremental Utility Requirements	
NG, $/MMBtu	9.44			Electricity, kw	28
				Reagent sol, gal/hr	35.09
Operating Labor, $/man-hr	70.00			Water, 1,000 gal/hr	0.16
Manhours per year	547.5				
Sales Tax, % of FOB	Included in DC				
Freight & Ins. to Site, % of FOB	Included in DC			NG, MMBtu/hr	1.34891
Maintenance (Materials + Labor) % TCI	1.5%				
General Facilities, % DC	5%				
Engineering and Home Office Fees % DC	10%				
Process Contingency % DC	5%				
Project Contingency % DC+IC	15%			Reagent Volume, gallons	306,559
Preproduction Costs % of D+E	2%			Reagent Cost, $/gallon	3.39

COMPANY: **United State Steel**
LOCATION: **Edgar Thomson Plant**
Source: **Boiler #1 - 3**
NO_X Emission Control Option: **SNCR (45% Efficiency)**

TOTAL CAPITAL INVESTMENT				TOTAL ANNUAL COST			COST EFFECTIVENESS	
Total Direct Capital Cost, DC		$ 4,184,952		**Direct Annual Costs**			$NO_{X in}$, lbs/MMBtu	0.05
Auxilliary Equipment (Heat Exchanger	$	-		Operating & Supervisory Labor	$38,325		Efficiency, %	45%
Direct Capital costs includes PEC such as SNCR system equipment, instrumentation, sales tax and freight. Cost for heat exchanger not included.				Maintenance	$103,940		Boiler Heat Input, MMBtu/hr	1575
				Reagent Consumption	$1,041,427		Total Operating Time, hrs/yr	8760
				Utilities	$21,968			
				Water Consumption	$21,053		NO_X removed, tpy	155.3
Total Indirect Capital Costs:				Add'l Fuel Usage (Process related)	$111,547.49			
Indirect Capital, IC	$	836,990		Auxiliary Equipment Requirements	#########			
Project Contingency, C	$	753,291		(Auxiliary Heating Costs = Nat'l gas cost required to heat boiler exhaust up to SNCR required temperature.)				
Total Plant Cost, D (DC + IC + C)	$	5,775,233						
				Total Direct Annual Costs	$105,402,678		**Cost Efficiency:**	
Allowance for Funds During Constr., E	$	-					$/ton NO_X removed	$683,468
Royalty Allowance,F	$	-						
Preproduction Costs, G	$	115,505		**Indirect Annual Costs**				
Inventory Capital, H	$	1,038,574		CRF	0.102			
Initial Catalyst and Chemicals, I	$	-		Total IDAC (CRF x TCI)	$	705,766		
TOTAL CAPITAL INVESTMENT, TCI (D+E+F+G+H+I)	$	**6,929,312**		**TOTAL ANNUAL COST, TAC (DAC + IDAC)**	$	**106,108,444**		

For sources at the Edgar Thomson Plant subject to emissions source testing per 25 Pa. Code 129.115(b)(6), a source test shall be conducted to demonstrate initial compliance and subsequently on a schedule set forth in the applicable permit. Alternatively, an owner or operator may request a waiver from the requirement to demonstrate compliance with the applicable emission limitations.

U. S. Steel is submitting this waiver to fulfill requirements of 25 Pa. Code 129.115(e)(1) by the deadline (December 31, 2022) in 25 Pa. Code 129.115(e)(1)(i).

This waiver contains the emissions source test results that were performed in accordance with the requirements of Chapter 139, Subchapter A, as incorporated by Article XXI 2107.01.b. The emissions source test results are listed below, which demonstrate compliance with the applicable emission limits:

Source ID	Source Description	Emissions Source Test Date	NO_X Result (lb/MMBtu)	RACT III Presumptive NO_X Limit (lb/MMBtu)
P001b	Blast Furnace No. 1 Stoves	2/23/2022	0.0093	0.1
P002b	Blast Furnace No. 3 Stoves	2/22/2022	0.023	0.1