



will be 34.85 pph for all fuels firing represents BACT. The limit is based on a 30-day rolling average.

$$CO \text{ Emissions} = \frac{0.17 \text{ lb}}{MMBtu} \times \frac{205 \text{ MMBtu}}{hr} \times = \frac{34.85 \text{ lb}}{hr}$$

$$CO \text{ Emissions} = \frac{34.85 \text{ lb}}{hr} \times \frac{8760 \text{ hr}}{yr} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = \frac{152.64 \text{ ton}}{yr}$$

#### 4.1.5 Volatile Organic Compounds (VOC)

Hydrocarbons, or VOCs, are emitted due to incomplete combustion occurring in the boiler. Due to the efficiency of the CFB boiler, the emissions of VOCs are expected to be low. Based on the experience of C&B and a review of RBLC, an emission factor of 0.02 lb/MMBtu (measured as propane) was utilized to estimate the potential VOC emissions. This equates to approximately 4.0 pph, and 17.6 tpy. These emission rates are representative of BACT pursuant to the requirements of Michigan Rule 702(a).

$$VOC \text{ Emissions} = \frac{0.02 \text{ lb}}{MMBtu} \times \frac{205 \text{ MMBtu}}{hr} \times = \frac{4.10 \text{ lb}}{hr}$$

$$VOC \text{ Emissions} = \frac{4.10 \text{ lb}}{hr} \times \frac{8760 \text{ hr}}{yr} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = \frac{17.96 \text{ ton}}{yr}$$

#### 4.1.6 Lead (Pb)

The emissions of lead are dependent upon the lead content of the fuel and the removal efficiency of the particulate collection device. Information and data obtained from industry and EPA, as well as sampling data from other NTH Consultants, Ltd. projects, indicates that over 99% of the Pb is emitted in particulate form (particle-phase). Consequently, a well-performing particulate control device, such as a fabric filter, can be expected to capture nearly all of the potential Pb emissions.



NMU is planning to use a blend of subbituminous coal and wood. NTH and C&B have reviewed analytical data from proposed coal sources and performed a statistical analysis of the lead content in these coals, which resulted in a maximum, estimated lead emission rate of 1.34E-05 lb/MMBtu heat input that includes 99% control efficiency for the baghouse. This yields an emission rate of 0.0025 pph and 0.011 tpy, which is equivalent to approximately 22 lbs/year. This is below the Pb significant emission rate threshold of 0.6 tpy.

$$Pb \text{ Emissions} = \frac{1.34 E-05 \text{ lb}}{\text{MMBtu}} \times \frac{185 \text{ MMBtu}}{\text{hr}} \times \frac{0.0025 \text{ lb}}{\text{hr}}$$

$$Pb \text{ Emissions} = \frac{0.0025 \text{ lb}}{\text{hr}} \times \frac{8760 \text{ hr}}{\text{yr}} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = \frac{0.011 \text{ ton}}{\text{yr}}$$

#### 4.1.7 Mercury Emissions *T-BACT*

Emissions of mercury are dependent upon the mercury content of the fuel, chlorine content of the coal, unburned carbon or loss on ignition (LOI) within the boiler, type of burner design and the removal efficiency of the add-on control technology. Information and data obtained from industry and EPA suggest that removal efficiencies of at least 80% are readily obtained in CFB boilers firing bituminous and subbituminous coals and utilizing a fabric filter and/or other technology for the control of SO<sub>2</sub> and NO<sub>x</sub>.

Even though the new boiler is not subject to the Industrial, Commercial, and Institutional Boiler MACT requirements, NMU is proposing to accept a mercury emission limit equivalent to the MACT level of 3.0E-06 lb/MMBtu heat input. The U.S. EPA did not consider carbon injection to be a MACT floor control technology for industrial, commercial, institutional boilers and process heaters. Data from electric utility boilers indicate that fabric filters are the most effective control technology for reducing potential mercury emissions. The MACT floor emissions level based on mercury test data from solid fuel fired units with a fabric filter is 3.0E-06 lb/MMBtu heat input. The proposed CFB boiler will be equipped with a fabric filter (or baghouse).



$$\text{Hg Emissions} = \frac{3.0 E-06 \text{ lb}}{\text{MMBtu}} \times \frac{185 \text{ MMBtu}}{\text{hr}} \times = \frac{5.55 E-04 \text{ lb}}{\text{hr}}$$

$$\text{Hg Emissions} = \frac{5.50 E-06 \text{ lb}}{\text{hr}} \times \frac{8760 \text{ hr}}{\text{yr}} = \frac{4.86 \text{ lb}}{\text{yr}}$$

#### 4.1.8 Sulfuric Acid Mist (H<sub>2</sub>SO<sub>4</sub>) and Fluorides (as HF)

The sulfuric acid mist emission estimate and proposed limit is based on a permit issued to Plum Point Energy, which is located in Arkansas, while the fluorides (as HF) emission factor is based on EPA's AP-42 emission database and includes a 15% increase as a safety factor. The potential H<sub>2</sub>SO<sub>4</sub> emission rate of 4.9 tpy is less than the PSD significant emission rate threshold of 7 tpy, and the potential HF (hydrogen fluoride) emission rate of 0.7 tpy is well below the PSD significant emission rate threshold of 3 tpy for fluorides. Therefore, these pollutants are not subject to PSD review. However, the use of limestone and baghouse systems will minimize the emissions of these pollutants, and represents T-BACT for this proposed CFB boiler.

#### 4.1.9 Total Reduced Sulfur (TRS), including Hydrogen Sulfide (H<sub>2</sub>S)

Due to the oxidation of fuels in the boiler and the use of good combustion controls, the sulfur-bearing compounds will be oxidized to SO<sub>2</sub> rather than reduced to form total reduced sulfur (TRS) and reduced sulfur compounds (RSC), including H<sub>2</sub>S.

## 4.2 SUMMARY OF HAP AND TAC EMISSIONS

The proposed CFB boiler will emit toxic air contaminants, including some of the HAPs listed in Section 112(b)(1) of the Clean Air Act (CAA). All HAPs are considered as TACs under the State of Michigan Air Toxics rules. The potential HAP/TAC emission factors for coal (bituminous and PRB coal) and wood-fired industrial boilers have been reviewed and a worst-case emission factor for each HAP/TAC was used to calculate the maximum hourly and annual emission rates from the CFB boiler. The worst-case emission factors and mass emission rates are listed in Appendix B. The emission factors were obtained from the U.S. EPA AP-42 document, stack test results and permits for other similar coal/wood-fired boilers, and other published articles and technical bulletins on coal/wood combustion in boilers. Data from EPA's AP-42 and stack testing results were increased by 15% as a safety factor. The values listed in Appendix B represent the



maximum from either coal, natural gas or wood fuels. See Appendix B for a complete list of compounds for which data was available.

The HAP/TAC emissions can be divided into the following four common categories: mercury, metallic HAP/TAC, inorganic HAP/TAC, and organic HAP/TAC. Mercury was discussed previously. The compounds in each pollutant category and emission control techniques used for each category are discussed below.

#### ***Metallic HAP/TAC Emissions***

The groups of compounds included under this pollutant category are: antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, phosphorus, selenium, vanadium, and zinc. Most of these non-mercury metallic HAP/TAC compounds appear in the flue gas flyash, which is emitted as particulate matter (PM). Therefore, the same control techniques that would be used to control the flyash PM will control non-mercury metallic HAP/TAC emissions.

The proposed CFB boiler is subject to BACT for PM emissions, and a baghouse will be utilized to control PM emissions from the boiler. Since the non-mercury metallic HAP/TAC will be emitted as part of PM emissions, the baghouse will also control the non-mercury metallic HAP/TAC emissions. Therefore, the proposed baghouse is considered to represent T-BACT for these compounds. The maximum controlled HAP/TAC emission rates are used in the dispersion modeling analysis to demonstrate compliance with the Michigan air toxics requirements under Rules 225-232. The modeling analysis is presented in Section 6.0.

#### ***Inorganic HAP/TAC Emissions***

The primary inorganic HAP/TAC emitted from boilers are acid gases, such as hydrogen chloride (HCl), chlorine, hydrogen fluoride (HF), and sulfuric acid mist (H<sub>2</sub>SO<sub>4</sub>), with HCl present in the largest amounts. Therefore, control technologies that would reduce HCl emissions would also control other inorganic compounds that are acidic gases.

The proposed CFB boiler will use limestone in the bed of the boiler to control emissions of SO<sub>2</sub> and other acid gases. An HCl emission limit of 0.0065 lb/MMBtu is based on the EPA's AP-42



emission factor found at Table 1.1-15, Chapter 1.1, dated 9/98, with a 15% safety factor, and using 92% control efficiency due to the use of limestone in the boiler bed. Thus, the addition of limestone to the CFB in the boiler is considered T-BACT for HCl and other acid gases, and the corresponding maximum controlled emission rates of inorganic HAP/TAC listed in Table 4-2 will result in ambient concentrations that are less than the screening levels established pursuant to the air toxics requirements of Michigan Rules 225-232.

#### *Organic HAP/TAC Emissions*

Although numerous organic HAP/TAC may be emitted from industrial boilers, only a few account for essentially all of the mass of organic HAP/TAC. These organic HAP/TAC are: Formaldehyde, benzene, hexane, toluene, and acetaldehyde. All other organic HAP/TAC, including polynuclear aromatic hydrocarbons (PAH), and dioxins and furans are emitted in trace amounts.

Organic HAP/TAC and carbon monoxide (CO) emissions would occur due to incomplete combustion of fuels. In establishing MACT standards for industrial boilers and process heaters, EPA used CO as a surrogate to represent the variety of organic compounds, including dioxins and furans, emitted from the various fuels burned in the boilers and process heaters. As CO is a good indicator of incomplete combustion, there is a direct correlation between CO emissions and the formation of organic HAP emissions. Therefore, minimizing CO emissions will result in minimizing organic HAP/TAC emissions.

The proposed CFB boiler is subject to BACT for CO. NMU is proposing an emission limit of 0.17 lb/MMBtu heat input for BACT, based on a 30-day rolling time period. This limit represents complete combustion and BACT under the PSD rules (40 CFR 52.21(j)) and T-BACT under the Michigan Air Toxics rules (Rule 224) for VOC and organic toxic air contaminants. The worst-case organic HAP/TAC emission rates from the CFB boiler have been calculated from the U.S. EPA AP-42 document and used in the modeling analysis presented in Section 6.0. The results of the modeling analysis indicate that the proposed boiler will comply with the Michigan Air Toxics Rules.



## 5.0 CONTROL TECHNOLOGY REVIEW

The proposed project is considered a "major modification" as defined in the PSD regulations at 40 CFR 52.21 because there will be a significant net increase in PM, PM<sub>10</sub>/PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and CO emissions as a result of installing the new CFB boiler. Therefore, the requirements for best available control technology (BACT) of 40 CFR 52.21(j) will be applicable to control emissions of PM, PM<sub>10</sub>/PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and CO from the proposed CFB boiler. Further, Rules 224 and 702 of the Michigan Air Pollution Control Rules require an analysis of BACT for toxic air contaminants and VOCs, respectively. The BACT analyses contained in this application were performed in accordance with the U.S. EPA's recommended top-down procedure outlined in the New Source Review Workshop Manual and set forth in Section 165(a)(4) of the federal Clean Air Act (CAA) as well as the MDEQ – Air Quality Division Operational Memorandum No. 20.

### 5.1 BACT PROCEDURE

The BACT analyses required under both the state and federal rules follow the MDEQ-AQD's Operational Memorandum No. 20 (Op Memo 20) for BACT determinations. Op Memo 20 identifies four (4) levels of review and closely reflects the intention of EPA's methodology for performing BACT analyses for PSD purposes. As described below, the procedure takes advantage of BACT determinations that have been made for other similar equipment across the country over the past several years. This allows for a more streamlined analysis by circumventing the rigorous approach set forth in the NSR Workshop Manual.

#### LEVEL 1

Level 1 is the first step and identifies the most stringent form of control described as the lowest achievable emission rate (LAER). Any proposed BACT analysis that selects to achieve LAER will be accepted without additional review. If LAER is not chosen, the applicant proceeds to a Level 2 analysis.

#### LEVEL 2

Level 2 identifies the types of control technologies that have been approved as BACT for similar source types nation-wide. Emission limitations accepted as BACT in recent permits throughout the country for similar processes or industries are acceptable unless new technical developments



have been made that indicate additional emission reductions can be achieved in practice. In general, approved limits for BACT over the previous 5-year period are reviewed and compared against the proposed BACT limits in the current application.

If the proposed emission limits are less stringent than those accepted as BACT in recent permits or when few recent BACT determinations exist for the process or industry, and new technical developments have not occurred over the preceding 5-years, the BACT evaluation proceeds to Level 3. site?

### **LEVEL 3**

A Level 3 BACT evaluation involves consideration of controls that have been accepted as BACT in recent permits for similar air emission streams from different processes or industry types. Level 3 also allows consideration, where appropriate, of older BACT determinations. Control technologies or techniques (i.e., materials, methods or equipment) that have not been demonstrated within the process or industry type under review may be evaluated for use if they are shown to be both available and applicable to the process or industry type for which the application is being prepared.

In the case of materials or methods, consideration is given on the basis of their use in manufacturing identical or similar products from identical or similar raw materials. In the case of add-on control equipment, consideration is made on the basis of the physical and chemical characteristics of the pollutant-bearing streams for which the controls have been applied and compared with those from the process or industry type of the proposed source(s). In Level 3, determining whether energy, environmental, or economic impacts are appropriate is primarily based on current and historical determinations.

If the proposed emission limit is less stringent than those accepted for the same process and industry, the BACT evaluation proceeds to Level 4. site?

### **LEVEL 4**

The Level 4 BACT evaluation involves a detailed, top-down technical and quantitative analysis for all emission reduction options available for the proposed process and equipment. This



analysis mirrors U.S. EPA's 5-step, top-down procedure identified previously and is described below.

### *Step 1*

The first step in the top down procedure is to identify all control technologies and emission reduction options. NMU is employing CFB technology for the new boiler. Inherently in the design of the CFB, reductions of many criteria and toxic pollutants are naturally reduced due to boiler design and residence time. In order to identify additional control technologies, the following sources of information would be referenced:

- ❖ U.S. EPA RACT/BACT/LAER Clearinghouse (RBLC)
- ❖ U.S. EPA Control Technology Center (CTC)
- ❖ Recent Permit Actions by MDEQ and other States
- ❖ Vendor Information
- ❖ Project Experience from all parties associated with this project, including NTH Consultants, Ltd., Cummins & Barnard, Inc., and Northern Michigan University

### *Step 2*

The second step in performing the top-down BACT analysis is to eliminate all technically infeasible options. The determination that a control technology is technically infeasible is source-specific and based upon physical, chemical, and engineering principles.

### *Step 3*

The third step in the top-down BACT analysis is to rank all remaining control technologies with respect to control effectiveness. The control technologies are ranked in order of control effectiveness and are pollutant-specific. Information including control efficiency, anticipated emission rate, expected emissions reduction, and economic, environmental and energy impacts are to be considered.





#### *Step 4*

If the top-ranked control technology option is chosen, the BACT analysis is complete and no further information regarding economic, environmental, and energy impacts are required. However, if the top-ranked option is not chosen, an assessment of economic, environmental, and energy impacts are performed to evaluate the most effective controls in Step 4. In this step, an analysis is performed on each remaining control technology in order to determine whether the economic and energy impacts to the applicant do not provide sufficient incremental environmental benefits. Those technologies that do not provide a sufficient environmental benefit, given energy and economic impacts, can be eliminated.

#### *Step 5*

The fifth, and final, step is selection of the BACT emission limit corresponding to the most stringent, and technically feasible technology that was not eliminated based upon adverse economic, environmental, and energy impacts.

The economic analysis is performed in accordance with the procedures found in U.S. EPA's Air Pollution Control Cost Manual published in January 2002 (EPA/452/B-02-001). This document provides capital and annual operating cost factors for use in determining the economic impact of each control technology.

Finally, pursuant to 40 CFR 52.21(b)(12), the chosen BACT emission limit must not be less stringent than any applicable federal New Source Performance Standard (NSPS), National Emission Standard for Hazardous Air Pollutants (NESHAP), or state-specific emission standard.

NMU has chosen, as BACT, emission limits identified in the Level 2 analysis by reviewing all of the national BACT determinations using the EPA's RACT/BACT/LAER (RBLC) Clearinghouse. The BACT emission limits chosen for this project are at least as stringent as applicable federal or state standards and within the range of recent BACT determinations for similar processes as found in the RBLC database. Specifically, a NSPS has been promulgated for PM<sub>10</sub>, SO<sub>2</sub>, and NO<sub>x</sub>, pursuant to 40 CFR Part 60, Subpart Db. This application is consistent with the proposed revision. A copy of the RBLC Clearinghouse database review is attached in Appendix E.



## 5.2 PARTICULATE MATTER (PM/PM<sub>10</sub>/PM<sub>2.5</sub>)

Particulate Matter, including PM, PM<sub>10</sub>, and PM<sub>2.5</sub>, results from both the combustion and storage of fuel, as well as limestone and ash handling and storage. In this instance, solid fuels, limestone, and ash will be stored in enclosed silos with appropriate vent filters. Particulate is formed in boilers during the combustion process and is present as unburned carbon and fly ash. In order to minimize the amount of particulate entering the flue gas stream and maximize the combustion of all carbon, the unburned carbon is re-circulated back to the CFB for further combustion.

Particulate matter may be emitted as a solid, or it can be emitted as a condensable material. Solid particulate is measured using EPA's Method 5 sampling procedure, which are commonly referred to as "front half" emissions. The condensable particulate emissions are measured using EPA's Method 202 procedure and commonly referred to as "back half" emissions.

Currently accepted control technologies for particulate matter include both fabric filters (baghouse) and electrostatic precipitators (ESP). Both of these technologies represent the most efficient and cost-effective method for controlling PM emissions from many sources, including commercial, industrial, and institutional boilers. While other control technologies exist, including mechanical collectors and wet scrubbers, neither has been proven as an effective control technology due to efficiency and energy impacts.

### *Fabric Filter (Baghouse)*

A fabric filter system consists of a structure containing fabric bags arranged in numerous rows where the exhaust flue gas passes through the bags to capture particles in the gas stream prior to exiting to an exhaust stack. Particles are "cleaned", or filtered, from the exhaust gas by various mechanisms, including inertial impaction and impingement, as the gas passes through the fabric bags. Accumulated particulate (or dust cake) is periodically removed using mechanical, sonic or pneumatic means.

Fabric filters achieve high removal efficiencies by designing the system such that the air-to-cloth ratio ensures that the exhaust gas stream passes through the bags at a low enough velocity to allow the dust to accumulate on the surface of the bag. This build up of dust on the surface effectively increases the removal efficiency of the bags by decreasing the sieve size of the filter media (bags).



Typical collection efficiencies for a fabric filter system are on the order of 99+ percent for particles smaller than 10-microns in size.

### ***Electrostatic Precipitators (ESP)***

Electrostatic precipitators remove particles from a gas stream through the use of electrical currents and forces. Dust laden gases are pushed or pulled through the precipitator box with the assistance of a fan. The airflow is channeled into lanes formed by collection plates. Discharge electrodes are centered between each collection plate to provide a negative charge to the surrounding dust particles. The collection plates are positively grounded and act as a magnet for the negatively charged dust particles. The collected dust is transported down the collection plates and electrode with the assistance of a rapper or vibrator system into a collection hopper.

Electrostatic precipitation is typically a dry process, but spraying moisture to the incoming air flow helps collect the exceptionally fine particulates, and helps reduce the electrical resistance of the incoming dry material to make the process more effective for some processes. Where condensable organic emissions are significant, such as in the wood products industry, wet ESP's are used to reduce VOC emissions in addition to the PM emissions. The flow of liquid by gravity down the plate continually removes the collected contaminants. Since the contaminants are part of a liquid matrix, water treatment facilities must also be included as part of the overall control system.

### ***Mechanical Collectors (Pre-cleaners)***

Collectively, mechanical collectors are known as pre-cleaners as these systems are not usually the primary collection device for particulate. These systems are primarily used to reduce the inlet loading of the particulate matter of the flue gas to downstream collection devices, such as fabric filters and ESPs.

Mechanical collectors operate on the principal of inertia to remove larger particles. The collector (usually a cyclone) imparts a centrifugal force on the gas stream that is used to separate the larger particles. These particles then fall out from the collector and accumulate in a hopper. Typical



collection efficiencies for mechanical collectors are less than 90 percent for particles less than 10-microns in size.

### *Wet Scrubber*

Wet scrubbers remove particles from gas streams principally through inertial impaction of the particle onto a water droplet. Particles are wetted through spray nozzles whereas the gas stream flows counter to the direction of the water spray. In venturi-type scrubbers, the gas stream passes through the scrubber and is constricted in the throat section causing the gas stream to accelerate. As it passes through the throat, it enters a larger cyclone and experiences a pressure drop across the system. The entrained water droplets are then removed by means of a cyclone separator or impingement scrubber section. Typical collection efficiencies for packed-bed and venturi scrubbers are less than 90 percent for particles sizes less than 10 microns.

#### **5.2.1 Proposed BACT Emission Limit**

NMU will be utilizing a new fabric filter, with mechanical pre-cleaner, to control total particulate (front half + back half) emissions from the combustion of solid fuels, including western and eastern coals, and virgin wood, in the new CFB boiler. The proposed use of a baghouse is considered BACT for this process.

A review of the BACT limits contained in the RBLC Clearinghouse for similar sized boilers indicated a range of 0.02 – 0.25 pound per million Btu heat input. Most of the limits are in the range of 0.02 – 0.048 pound per million Btu heat input. The PM emission limit as contained in the Industrial-Commercial-Institutional NSPS requirements, at 40 CFR 60.43b(2), is 0.10 pound per million Btu heat input, which is measured using EPA's Method 5, and is "front half" particulate. This emission limit in the NSPS does not include condensable particulate. Nonetheless, NMU is proposing a total particulate (filterable and condensable) limit of 0.030 pound per million Btus heat input.

This level of emissions is considered to be BACT for this process and meets the limit established in the NSPS. The emission limit of 0.030 pound per million Btus heat input results in potential emissions of 6.2 lb/hr and 26.9 ton/year while firing 100% wood due to higher heat input. Because NMU has chosen an emission limit per the Level 2 procedure of Op Memo 20, and that there are



sufficient determinations in EPA's RACT/BACT/LAER Clearinghouse, no further analysis for PM BACT is necessary.

### 5.3 SULFUR DIOXIDE (SO<sub>2</sub>)

SO<sub>2</sub> is emitted as a result of the presence of sulfur in the fuel being combusted. Typically, sulfur is present in fuels, including natural gas, wood, coal, lignite, waste materials, etc, but in varying degrees. As an example, pipeline quality natural gas and wood are lower in sulfur content than coal fuels, and some ranks of coal have lower sulfur contents than other coal fuel ranks.

The sulfur present in the fuel is released during the combustion process and combines with oxygen at the temperatures present in the combustion zone to form sulfur oxides. The sulfur oxides are primarily SO<sub>2</sub>, with some SO<sub>3</sub>.

Boilers that are required to control SO<sub>2</sub> emissions will do so using one of three primary methods. These methods consist of post-combustion and in-situ dry flue gas desulfurization utilizing adiabatic injection of lime slurry in a scrubber down-stream of the combustion zone where the exhaust gases do not become saturated, a wet process utilizing post-combustion and post PM control that incorporates a saturated system where the exhaust gases are cooled below the saturation point, and injection of limestone into the bed of a boiler that utilizes either a bubbling or fluidized bed where combustion is on-going. A more detailed description of these types of control is provided in the next three paragraphs.

#### *Dry Scrubber – Flue Gas Desulfurization*

SO<sub>2</sub> emissions control using dry scrubber control prior to a PM control device consists of a tower where a certain amount of slacked limestone (hydrated calcium oxide) is injected into the tower. The amount of injection is controlled such that the exhaust gases do not become saturated (adiabatic cooling). The SO<sub>2</sub> reacts with the lime slurry to produce calcium sulfate, also known as gypsum. Saturation of the exhaust gases prior to the fabric filter would plug up the fabric filter, which is unacceptable. Control efficiencies with this type of control range from 70 to 95%, depending on the concentration of SO<sub>2</sub> in the exhaust gas and ratio of slurry to SO<sub>2</sub>.



### *Wet Scrubber – Flue Gas Desulfurization*

Another process uses a saturated method of controlling SO<sub>2</sub>. This type of control is typically located downstream of the PM control device such that the saturated exhaust gas does not interfere with the effectiveness of the PM control device, such as the fabric filter proposed for NMU's CFB boiler. These types of control use a packed tower while voluminous quantities of alkaline slurry are pumped into the tower. The SO<sub>2</sub> reacts with the hydrated calcium oxide and produces calcium sulfate, which is commonly referred to as gypsum. The resulting gypsum then can be sold or recycled to produce wallboard for the construction industry. These wet type SO<sub>2</sub> control devices typically result in 80 to 99% control of the potential SO<sub>2</sub> emissions, depending on the concentration of SO<sub>2</sub> in the exhaust gas, and ratio of slurry to SO<sub>2</sub>.

### *Limestone – Co-Firing*

A third type of control uses limestone added to the fluidized bed of the CFB boiler. Limestone, which is calcium carbonate, is added to the bed of the CFB boiler at a particular ratio depending on the required control necessary. At the temperature of the boiler, the limestone is calcined and converted to calcium oxide because the carbon dioxide that is driven off of the calcium carbonate. The SO<sub>2</sub> then reacts with the calcium oxide. Using this type of control removes the SO<sub>2</sub> from the exhaust gas stream beginning with the fluidized bed, and allows more residence time for the lime and calcium to react together prior to the PM control device. This method achieves 80 to 95% control of the potential SO<sub>2</sub> emissions. The resulting calcium sulfate is removed from the fluidized bed periodically.

The proposed SO<sub>2</sub> emissions will meet the requirements of NSPS Subpart Db for a control efficiency of 92% of the potential SO<sub>2</sub> emissions from higher sulfur bituminous coal, and 90% of the potential SO<sub>2</sub> emissions from lower sulfur western coal, with a maximum allowed limit of 1.2 pound per MM Btus heat input.

#### **5.3.1 Proposed BACT Emission Limit**

NMU will be utilizing limestone injection into the CFB to control SO<sub>2</sub> emissions from the combustion of solid fuels, including western and eastern coals. The proposed use of limestone injection is considered BACT for this process.



4 sources

The nation-wide BACT range of emission limits for SO<sub>2</sub> is 0.09 - 1.6 lb/MMBtu heat input. Most of the limits are in the range of 0.13 - 0.5 lb/MMBtu heat input. The NSPS Subpart Db limits SO<sub>2</sub> emissions to no more than 0.20 lb/MMBtu, or achieve a control efficiency of at least 92% with an emission limit of no more than 1.2 lb/MM Btu. Both of these requirements are based on a 30-day rolling average.

NMU is proposing a maximum SO<sub>2</sub> emission limit of 0.475 pound per million Btu heat input, and this is within the nation-wide range of accepted SO<sub>2</sub> emissions that represent BACT. This limit represents using solid fuel with a maximum sulfur content of 3.5%, by weight, and using limestone added to the bed of the CFB boiler.

This emission limit is equivalent to potential emissions of 87.8 lb/hr and 384.5 ton/year. Because NMU has chosen to use Level 2 of Op Memo 20, and that there are sufficient determinations in EPA's RACT/BACT/LAER Clearinghouse, no further analysis for SO<sub>2</sub> BACT is necessary.

#### 5.4 NITROGEN OXIDES (NO<sub>x</sub>)

NO<sub>x</sub> is emitted as a result of nitrogen in the fuel being burned (referred to as fuel NO<sub>x</sub>), and nitrogen and oxygen in the combustion air that forms NO<sub>x</sub> due to disassociation of diatomic nitrogen and oxygen in the air at the flame temperature (referred to as thermal NO<sub>x</sub>). The nitrogen oxides are primarily emitted as nitrogen oxide (NO).

NO<sub>x</sub> is controlled by using several techniques; either alone, or in conjunction with both internal and external technologies. New boilers implement modern state-of-the-art combustion techniques that minimize both flame temperature and available nitrogen in the combustion air. Add-on control techniques include the use of injecting ammonia or urea into the exhaust gases at the correct exhaust gas temperature, which is known as selective non-catalytic reduction (SNCR). Technology has also been developed to include a catalytic converter in the exhaust gases downstream of the ammonia/urea injection system that further reduces NO<sub>x</sub> from the exhaust gas stream. This is known as selective catalytic reduction (SCR). NMU is proposing to use SNCR in addition to the CFB, where low combustion temperatures inherently limit the formation of NO<sub>x</sub>, as BACT for NO<sub>x</sub>.



#### **5.4.1 Proposed BACT Emission Limit**

From the RBLC, the nation-wide BACT range of emission limits for  $\text{NO}_x$  is 0.15 - 0.7 lb/MMBtu heat input. Most of the limits are in the range of 0.15 - 0.35 lb/MMBtu heat input. The NSPS Subpart Db limits  $\text{NO}_x$  emissions to no more than 0.6 lb/MMBtu. The NSPS emission limit is based on a 30-day rolling average.

NMU is proposing a  $\text{NO}_x$  emission limit of 0.10 lb/MMBtu heat input. This is more stringent than the nation-wide range of  $\text{NO}_x$  emissions that represent BACT for the proposed size boiler, as contained in the RBLC.

#### **5.5 CARBON MONOXIDE (CO)**

Carbon monoxide is emitted from the CFB boiler as a result of incomplete combustion. Factors affecting the formation of CO include the oxygen-to-fuel ratio, combustion temperature, residence time, and turbulence (or mixing) of the combustion gases. In addition to the formation of CO, incomplete combustion also leads to increased emissions of particulate matter, including particulate metals, volatile organic compounds, and hazardous air pollutants. Therefore, methods employed to reduce or control emissions of CO tend to reduce emissions of other pollutants as well.

There are two available control technologies for controlling CO emissions from a CFB boiler: (1) catalytic oxidation and, (2) efficient combustion. Catalytic oxidation is a post-combustion CO reduction technique that uses a catalyst to convert CO to  $\text{CO}_2$ . Efficient combustion is a direct result of the design and operation of a boiler.

##### ***Catalytic Oxidation***

Catalytic oxidizers treat exhaust gas from a combustion device utilizing a catalyst bed, typically a media-supported film of precious metals, such as platinum/rhodium, where oxidation of CO to  $\text{CO}_2$  takes place. Depending on catalyst formation, the reaction can occur over a temperature range of approximately 450 to 1200° F. The amount of CO oxidation (or conversion) will depend on several factors, including operating temperature, gas composition, and pressure drop across the catalyst bed.





To date, oxidation catalysts have not been used for coal-fired boilers. Catalytic oxidation has several serious technical problems related to the use of coal firing, including:

- Catalyst fouling and poisoning by sulfur, flyash and lime.
- Low excess oxygen levels in the flue gas.
- Low temperature levels of the flue gas.

Typically, vendors are not willing to offer catalytic oxidizers due to the issues stated above. Furthermore, catalytic oxidizers are nonselective and will oxidize other compounds. The presence of sulfur oxides will result in the formation of  $\text{SO}_3$ , which will in turn combine with moisture in the gas stream to form  $\text{H}_2\text{SO}_4$  mist.

Lastly, the short catalyst life caused by fouling and poisoning would result in a significant and ongoing generation of catalyst waste that would most likely be classified as a hazardous waste. For these reasons, and because oxidation catalysts have never been used or demonstrated in practice on coal-fired boilers, catalytic oxidation is not considered a technically feasible control option for CO for the proposed CFB boiler.

### *Efficient Combustion*

Because CO emissions are a function of combustion operating conditions; the most direct approach for reducing these emissions is to maximize combustion efficiency. Maximizing combustion efficiency must be balanced with the potential increase of  $\text{NO}_x$  emissions that could occur when combustion efficiency is associated with high chamber temperatures. Modern combustion controls are able to balance this anomaly; i.e., reduce CO with a minimal resulting  $\text{NO}_x$  emission increase.

#### **5.5.1 Proposed BACT Emission Limit**

The nation-wide BACT range of emission limits for CO is 0.022 - 1.8 lb/MMBtu heat input. Most of the limits are in the range of 0.18 - 0.44 lb/MMBtu heat input. There is no emission limit for CO in any Michigan or federal air pollution control rules or regulations that would apply to the proposed solid fuel fired boiler.