Emission Control Technology Review for NorthMet Project Processing Plant RS58A

PolyMet Mining Inc.

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BARR

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RS58A – Emission Control Technology Analysis (Plant Site)

Emission Control Technology Review for NorthMet Project Processing Plant PolyMet Mining, Inc Hoyt Lakes, Minnesota (RS58A)

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1. Executive Summary

1.1. Project Description

PolyMet Mining Inc. (PolyMet) is proposing to construct a non-ferrous metallic mineral processing plant on the former LTV Steel Mining Company (LTVSMC) site in Hoyt Lakes, MN as part of the NorthMet project. Ore will be mined at a separate site to the east of the Plant Site. The Process Plant will include ore crushing, ore concentration, and hydrometallurgical processing. The Process Plant will produce copper; a mixed hydroxide precipitate containing nickel, cobalt and zinc; and platinum group metal and gold concentrate. PolyMet will also produce nickel and copper rich flotation concentrates. These products are made without the use hydrometallurgical processing equipment. A detailed description of these processes is included in the Detailed Project Description and Supplemental Project Description. To the extent practical, existing equipment from the LTVSMC taconite ore processing operation will be utilized in the development of the non-ferrous mineral processing operation.

The proposed permitting strategy for the NorthMet project is to obtain a combined air emission permit for the Mine Site and the Plant Site (Process Plant, Area 1 Shop and Area 2 Shop).

Because the proposed project will not be a major source under Prevention of Significant Deterioration (PSD) regulations, emission sources will not be required to have Best Available Control Technology (BACT). However, PolyMet has used US EPA's "Top Down" BACT evaluation protocol as a guideline for selecting the appropriate emission control technology .

The purpose of this report is to identify appropriate emission controls and to propose appropriate emission limits for Plant Site sources that emit PM, PM_{10}, SAM, and VOCs.

1.2. Emission Units with Emission Control Technology Reviews

The emission units which had emission control technology reviews and the selected control technology for PolyMet's proposed Plant Site facility are summarized in Table 1.1.

Table 1.1 Summary of Emission Control Technology Analyses

Emission Control Technology Selection PolyMet Mining Inc., Hoyt Lakes, MN – Plant Site				
Emission Source	Emission Control	Emission Limitation		
		PM PM_{10}	SAM	VOC
Coarse Ore Crushing:	Baghouse	0.0025 gr/dscf 7% Opacity	NA	NA
Coarse and Fine Ore Crushing: Crushers, Screens, and Conveyors	Baghouse	0.0025 gr/dscf 7% Opacity	NA	NA
Fine Ore Bins and Conveyors	Baghouse	0.0025 gr/dscf 7% Opacity	NA	NA
Ore Grinding and Concentrating	PM/PM_{10} - NA wet process VOC – No Controls	NA	NA	NA
Flotation Concentrate Dryers	Wet Scrubber	0.006 gr/dscf 20% Opacity	NA	NA
Hydrometallurgical Plant: Autoclave Vents and Autoclave Flash Vents	PM/PM_{10} and SAM - Wet scrubber VOC - No additional controls	20.5 lb/hr (99%) 20% Opacity	99% or 5 ppm	50 ppm VOC
Hydrometallurgical Plant: Neutralization Tanks and Metal Precipitation Tanks	PM/PM_{10} and SAM - Wet scrubber	99% or 0.014 gr/dscf 20% Opacity	99% or 5 ppm	NA
Hydrometallurgical Plant: Copper Solvent Extraction	VOC – No controls	NA	NA	NA

Table 1.1 Summary of Emission Control Technology Analyses

Emission Control Technology Selection PolyMet Mining Inc., Hoyt Lakes, MN – Plant Site				
Emission Source	**Emission Control**	**Emission Limitation**		
		PM PM_{10}	**SAM**	**VOC**
Hydrometallurgical Plant: Electrowinning	PM/PM_{10} and SAM - Cell covers and wet scrubber	95% or 0.014 gr/dscf 20% Opacity	95% or 5 ppm	NA
Metal Concentrate Packaging: Bagging operations	No controls (Bagging wet cake; no PM emissions occur)	NA	NA	NA
Flotation Concentrate Material Handling	Baghouse	0.005 gr/dscf 7% Opacity	NA	NA
Lime & Limestone Processing: Grinding Mills, Bulk Unloading, Storage Bins, Conveyors, and Crushers	Baghouse or fabric filter Water Spray or Wet Scrubber	0.005 gr/dscf 7% Opacity 0.006 gr/dscf 20% Opacity	NA	NA
Limestone Delivered by Truck, Bulk Unloading, Storage Bins, Conveyors, and Crushers	Type W Rotoclone	5.5 lb/hr (97%) 20% Opacity	NA	NA
Material Handling of Bulk Solids: Pneumatic Transfers from Trucks and Storage Bins, Manual Transfers from Bags	Baghouse or fabric filter Water Spray or Wet Scrubber	0.005 gr/dscf 7% Opacity 0.006 gr/dscf 20% Opacity	NA	NA
Natural Gas and Propane Fired Boilers	Good combustion practices	0.007lb/MMBtu 10% Opacity	NA	0.006 lb/MMBtu
Storage Tanks: Sulfuric Acid	No controls	NA	NA	NA
Cooling Towers	Drift eliminator	0.001% Drift Rate 20% Opacity	NA	NA
Emergency Pumps and Generators	Emergency Equipment Classification	NA	NA	NA

Table 1.1 Summary of Emission Control Technology Analyses

Emission Control Technology Selection PolyMet Mining Inc., Hoyt Lakes, MN – Plant Site				
Emission Source	Emission Control	Emission Limitation		
		PM PM_{10}	SAM	VOC
Fugitive Dust Emissions: Roads, Limestone Unloading, Storage Piles and Tailings Basins	Dust control plan	Good work practices	NA	NA
Miscellaneous Combustion Sources	Good combustion practices	NA	NA	NA
Miscellaneous Storage Tanks	No controls	NA	NA	NA

NA – Not Applicable

Table A-1 in Attachment A lists all emission units reviewed with the "Top Down" BACT protocol, proposed emission controls, and proposed emission limits. This report includes selection of appropriate emission controls and a proposed emission control performance standard.

The proposed NorthMet project is large and complex. In order to keep the Emission Control Technology Review report at a reasonable size, an Emission Control Technology Review analysis has been done for each type of emission unit. This includes selection of appropriate emission controls and a proposed emission control performance standard. Individual source mass emission limits, as needed, are listed in Attachment A, Table A-1.

PolyMet proposes to route some emission sources to common control devices. In those cases, PolyMet has proposed limits for the combined control device.

2. Introduction

2.1. Project Description

Overview

PolyMet Mining Inc. (PolyMet) is proposing to construct a non-ferrous metallic mineral processing plant on the former LTV Steel Mining Company (LTVSMC) site in Hoyt Lakes, MN as part of the NorthMet project. Ore will be mined at a separate site to the east of the Plant Site. The Process Plant will include ore crushing, ore concentration, and hydrometallurgical processing. The Process Plant will produce copper; a mixed hydroxide precipitate contained nickel, cobalt and zinc; and platinum group metal and gold concentrate. PolyMet will also produce nickel and copper rich flotation concentrates. These products are made without the use hydrometallurgical processing equipment. A detailed description of these processes is included in the Detailed Project Description and Supplemental Project Description. To the extent practical, existing equipment from the LTVSMC taconite ore processing operation will be used in the development of the non-ferrous mineral processing operation. However, for the purposes of the Emission Control Technology Review, existing equipment is being treated as a new source.

The proposed permitting strategy for the NorthMet project is to obtain a combined air emission permit for the Mine Site and the Plant Site (Process Plant, Area 1 Shop and Area 2 Shop). This report includes the Emission Control Technology Review for the equipment that will be located at the Plant Site.

An Emission Control Technology Review was also completed for the mine site. The Mine Site Emission Control Technology Review is reported as RS58B.

The project includes the following equipment:

- Gyratory crushers, wet grinding (rod mills and ball mills), screening equipment and associated conveyor systems for ore crushing and grinding, ore storage bins, and ore railcar unloading.
- Flotation cells, thickeners, and wet grinding mills (concentrate grinding). The waste from ore concentration will be sent to the tailings basin for disposal.
- Concentrate dryers and material handling equipment for production of nickel and copper rich flotation concentrate products
- Autoclaves, flash drums, thickeners, filters, metal precipitation tanks, and neutralization tanks for concentrate processing

- Electrochemical (electrowinning) cells for copper recovery
- Storage bins, material handling equipment, and bagging equipment for packaging metal concentrate products
- Grinding mills, bulk unloading, storage bins, storage piles, and associated material handling equipment for lime and limestone preparation.
- Storage bins, mixing tanks and storage tanks for bulk storage of process chemicals and additives and associated material handling equipment.
- Non-contact cooling towers to provide cooling water
- Natural gas-fired boilers to heat the autoclaves during startup.
- Natural gas and propane fired space heaters to provide heating in the Process Plant and Area 1 and Area 2 Shop buildings
- Diesel-powered engines to provide backup power and pump water for fire fighting.
- Diesel fuel and organic liquid storage tanks

3. Methodology

3.1. PSD Applicability

PSD BACT regulations do not apply at the plant. However, PolyMet has proposed to follow the BACT determination process as a guideline for selecting emission controls at the plant. Due to concerns over fine particulate matter emissions from the crushing plant, PolyMet has agreed to install BACT-like controls for fine particulates in this area.

The processes downstream of flotation that produce the salable product from the concentrate are of much less concern with respect to the fine particulates. This is because the amphibole silicates are the specific minerals of concern, and the flotation process is designed to reject silicates to tailings while separating the sulfide minerals into the concentrate. Based on data in the MetSim process flow simulation, 98.4% of the silicates in the ore, and therefore the amphibole minerals, report to tailings. Only 1.6% of the silicates report to the concentrate.

The Emission Control Technology Review follows EPA's "Top Down" protocol for conducting BACT reviews as found in the EPA's October 1990 draft *New Source Review Workshop Manual*.

The requirement to conduct a BACT analysis and determination is set forth in section 165(a) (4) of the Clean Air Act, in federal regulations at 40 CFR 52.21(j), the Minnesota State Implementation Plan (SIP) at 40 CFR Part 52, Subpart Y, and Minnesota Pollution Control Agency rules at MN 7000.3000.

40 CFR 52.21(j) specifies that BACT must be applied to a new source as follows:

> *(j) Control technology review. (1) A major stationary source or major modification shall meet each applicable emissions limitation under the State Implementation Plan and each applicable emissions standard and standard of performance under 40 CFR parts 60 and 61.*
>
> *(2) A new major stationary source shall apply best available control technology for each regulated NSR pollutant that it would have the potential to emit in significant amounts.*

Significant as defined at 40 CFR 52.21(b)23 means, in reference to a net emissions increase or the potential of a source to emit any of the following pollutants at a rate of emissions that would equal or exceed any of the following rates:

Pollutant and Emissions Rate

- Carbon monoxide: 100 tons per year (tpy)
- Nitrogen oxides: 40 tpy
- Sulfur dioxide: 40 tpy
- Particulate matter:
    - 25 tpy of particulate matter emissions
    - 15 tpy of PM_{10} emissions
- Ozone: 40 tpy of volatile organic compounds
- Lead: 0.6 tpy
- Fluorides: 3 tpy
- Sulfuric acid mist: 7 tpy
- Hydrogen sulfide (H_2S): 10 tpy
- Total reduced sulfur (including H_2S): 10 tpy
- Reduced sulfur compounds (including H_2S): 10 tpy

The PSD significance level will be used to identify which sources will use the BACT selection process as a guideline. PolyMet has reviewed emission controls using BACT “Top Down” protocol at the Plant Site for the following PSD pollutants:

- *Particulate matter (PM)*
- *Particulate matter less than 10 microns (PM_{10})*
- *Sulfuric acid mist (SAM)*
- *Volatile Organic Compounds (VOCs)*

Although potential emissions of NO_x, and CO are above the PSD significant emission rate, projected actual emissions of NO_x and CO are below the PSD significant emission rate. Nearly all NO_x emissions and a significant portion of CO emissions are emitted from combustions sources which operate intermittently; e.g., emergency generators, fire pumps, and space heaters. Therefore, an Emissions Control Technology Review is not warranted for these pollutants.

3.2. Emission Control Technology Selection Methodology and Results

The Emission Control Technology Review for the Plant Site uses the requirements specified in EPA’s draft *New Source Review Workshop Manual*, (October 1990) as a guideline for emission control technology selection. The review followed the EPA’s top-down approach in which progressively less stringent control technologies were analyzed until a level of appropriate control considered was achieved.

Because the facility is not a major source with respect to PSD regulations, there is no requirement to install BACT controls. However, the BACT process was used as a guideline in selecting pollution control technology, but there is more flexibility in setting performance standards and emission limits. PolyMet has proposed what are believed to be appropriate controls considering the source type and emission levels. Specific justification for each proposed emission limit is provided in the section for the different equipment types. In general proposed emission limits are consistent with typical BACT determinations for similar sources, but they may not reflect the best performing source of the type. The exception is the crushing plant, where as noted above, PolyMet has agreed to install BACT-like controls for fine particulate matter.

The five basic steps of the top down approach using EPA's "Top Down" BACT guidelines are as follows:

Step 1 – Identify All Control Technologies

The first step in a top-down analysis is to identify all available control technologies for each emission unit.

Step 2 – Eliminate Technically Infeasible Options

In the second step, the technical feasibility of each control option identified in Step 1 is evaluated with respect to source-specific factors.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

In the third step, all remaining control technologies not eliminated in Step 2 are ranked and then listed in order of overall control effectiveness for the pollutant under review, with the most effective control alternative at the top.

Step 4 – Evaluate Most Effective Control Technologies and Document Results

In the fourth step, the energy, environmental, and economic impacts are considered for each of the control options.

Step 5 – Select Emission Control Technology

In the fifth step, the most effective control option, based on the impacts quantified in Step 4, is proposed as the appropriate control for the pollutant and emission unit under review. This step correlates with selecting BACT for the pollutant and emission unit when BACT is required.

BACT is defined as:

> ***"Best available control technology*** *means an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results."*

Using BACT guidelines, this report will propose emission control technologies, work practices, and performance-based emission limits for selected emission units that emit pollutants at rates greater than PSD significance levels. As noted above, the facility is not required to install BACT controls because it is not subject to PSD. Therefore, the control technology selection will propose appropriate emission controls considering the source type and emission levels. Mass emission limits for the equipment will be specified in the air emission permit application. The mass emission limits specified in the permit application will reflect performance-based emission limits and work practice standards which were determined to be the appropriate limit or control using BACT guidelines.

The proposed NorthMet project is large and complex. In order to keep the Emission Control Technology Review report at a reasonable size, an Emission Control Technology Review has been done for each type of emission unit. This includes selection of appropriate emission controls and a proposed emission control performance standard.

Individual source mass emission limits, as needed, are listed in Attachment A, Table A-1.

In order to minimize equipment costs, PolyMet proposes to route some emission sources to common control devices. In those cases, PolyMet has proposed emission limits for the combined control device.

3.3. Identification of Applicable Standards under 40 CFR Parts 60 (NSPS), 61 (NESHAP), and 63 (NESHAP/MACT)

As noted in the definition of BACT, BACT emission limits for sources subject to emission standards 40 CFR Part 60 (NSPS) or 40 CFR Part 61 (NESHAPS) cannot be less stringent than the applicable standards. Maximum Achievable Control Technology (MACT) standards under 40 CFR Part 63 for the control of Hazardous Air Pollutants (HAPs) are not applicable to establishing BACT. As this Emission Control Technology Review follows BACT guidelines, the MACT standards for the control of HAPs are also not applicable in selecting the appropriate control technology.

MACT standards are intended for the regulation of HAPS, and not PSD pollutants, and therefore, MACT does not need to be considered as establishing the minimum emission control requirements for BACT. However, in some cases, EPA has used criteria pollutant standards as MACT standards because the criteria pollutants are good indicators of HAP emission controls. In these cases, MACT standards may be used as an indicator of the level of emissions control, which may be achieved by the best performing units. The total project HAP emissions are below the major source level and there is not a MACT standard that applies to area sources of the type at the Plant Site. However, the MACT standards for similar source categories may still be used as a guide in determining the appropriate level of emission control.

The NSPS and NESHAP standards were reviewed for applicability at the NorthMet project processing plant.

No applicable standards under Part 61 were identified.

Standards under Part 60 that were identified as potentially applicable are the following:

- 40 CFR 60 Subpart Dc, Standards of Performance for Small Industrial, Commercial, and Institutional Steam Generating Units
- 40 CFR 60 Subpart Kb, Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984
- 40 CFR 60 Subpart LL, Standards of Performance for Metallic Mineral Processing Plants
- 40 CFR 60 Subpart OOO Standards of Performance for Nonmetallic Mineral Processing Plants
- 40 CFR 60 Subpart IIII Standards of Performance for Compression Ignition Internal Combustion engines (CI ICE – Diesel Engines).

Standards under Part 63 that were identified as potentially applicable are the following:

- 40 CFR 63 Subpart DDDDD, National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters (Boiler MACT).
- 40 CFR 63 Subpart ZZZZ, National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines
- 40 CFR 63 Subpart RRRRR, National Emission Standards for Hazardous Air Pollutants for Taconite Ore Processing

Each of these regulations is discussed in the sections that follow in terms of specific source applicability and emission limits.

3.4. 40 CFR 60 Subpart Dc, Standards of Performance for Small Industrial, Commercial, and Institutional Steam Generating Units

PolyMet's natural gas-fired boiler is potentially subject to NSPS Subpart Dc, "Standards of Performance for Small Industrial, Commercial, and Institutional Steam Generating Units". Subpart Dc applies to each steam generating unit that commences construction, modification, or reconstruction after June 9, 1989, and that has a heat input capacity from fuels combusted in the steam generating unit of 29 MW (100 million Btu/hour) or less. The High Pressure boiler used for autoclave startup is new and is subject to Subpart Dc. The specific emission limits and standards are detailed in 40 CFR 60.40c through 60.48c. PolyMet has proposed to fire the new boiler on natural gas. Under those circumstances, Subpart Dc does not contain any emission limitations, which should be considered in the Emission Control Technology Review for this boiler.

3.5. 40 CFR 60 Subpart Kb, Standards of Performance for Volatile Organic Liquid Storage Vessels

Storage vessels at the NorthMet plant site will not be subject to Subpart Kb either because:

- Storage vessels are not large enough (< 75 m^3) to be regulated; or
- The liquids are stored in pressurized vessels with no atmospheric vents (e.g. propane tanks).
- The storage vessels do not store a Volatile Organic Liquid

3.6. 40 CFR 60 Subpart LL, Standards of Performance for Metallic Mineral Processing Plants

As a processor of metallic minerals, PolyMet's facility is the type of source that would be potentially subject to Subpart LL. However, Subpart LL only applies to facilities that commence construction, modification, or reconstruction after August 24 1982.

The Crushing Plant equipment was installed in the 1950s and 1960s and has not been modified or reconstructed to date. The equipment is still is good working order and it is not expected to be reconstructed or modified as part of the NorthMet project. The ore storage and grinding equipment in the Concentrator was installed in the 1950s and 1960s and has not been modified or reconstructed to date. The flotation and concentrate fine grinding equipment will be new and replace the existing magnetic separating and flotation equipment. Hydrometallurgical metal concentrate production and product packaging are new facilities which may be subject to Subpart LL.

Subpart LL limits particulate emissions from affected facilities at 0.02 grains per dry standard cubic foot; so emission control for PM emissions from affected sources should be at least as stringent as the Subpart LL standard. All particulate matter controls examined in this analysis surpass this level of particulate matter emission control, and the proposed emission control limits are more stringent than Subpart LL limitations, so if some of the potentially subject existing equipment is deemed reconstructed or modified as part of the NorthMet project, emissions will comply with the NSPS.

Per 40 CFR 60.380, regulated equipment within a metallic mineral processing plant includes:

"(a) The provisions of this subpart are applicable to the following affected facilities in metallic mineral processing plants: Each crusher and screen in open-pit mines; each crusher, screen, bucket elevator, conveyor belt transfer point, thermal dryer, product packaging station, storage bin, enclosed storage area, truck loading station, truck unloading station, railcar loading station, and railcar unloading station at the mill or concentrator …"

No particulates are emitted from ore grinding, flotation or concentrate grinding because these processes are water based. The hydrometallurgical process does not contain any crushers, screens, bucket elevators or conveyor transfer points because ore and metallic concentrate handling within the hydrometallurgical process takes place in water slurries. Metal concentrate products are produced as wet filter cake; so, no particulates are emitted from storage bins or product packaging stations. The final metal concentrate products are bagged; so there are no particulate emissions associated with loading products onto trucks or rail cars. The remainder of the hydrometallurgical processing equipment (e.g. autoclaves, neutralization tanks, precipitation tanks, thickeners, etc) is not covered by Subpart LL because this equipment is not included in the list of equipment regulated by Subpart LL as specified in paragraph 60.380(a). Subpart LL requirements will not affect the pollution control equipment requirements for the grinding, flotation or listed equipment within the hydrometallurgical processes because no particulates are emitted from these sources. The balance of the hydrometallurgical process equipment is not regulated under Subpart LL.

When the flotation concentrate production option is utilized, the concentrate dryers, silo bin vents and railcar loading system will likely be subject to Subpart LL. The proposed pollution control equipment performance standards for these operations are more stringent than Subpart LL.

3.7. 40 CFR 60 Subpart OOO Standards of Performance for Nonmetallic Mineral Processing Plants

As part of the operations at the Plant Site, PolyMet will process nonmetallic minerals as additives for the Hydrometallurgical process, which will be subject to NSPS Subpart OOO. Subpart OOO limits particulate emissions from affected facilities at 0.022 grains per dry standard cubic foot; so emission control for PM emissions from affected sources should be at least as stringent as the Subpart OOO standard. All particulate matter controls examined in this analysis surpass this level of particulate matter emission control, and the proposed emission control limits are more stringent than Subpart OOO limitations.

The limestone conveyor to stacker conveyor (FS 024, limestone rail unloading system), and limestone truck dump grizzly (FS 036) are fugitive emission sources which will be subject to Subpart OOO opacity limitations (15%) for fugitive sources.

3.8. 40 CFR 60 Subpart IIII Standards of Performance for Compression Ignition Internal Combustion engines (CI ICE – Diesel Engines).

Some of the diesel-powered emergency equipment of the PolyMet facility is part of the original LTVSMC equipment purchased by PolyMet. These engines were manufactured well before the July 11, 2005 applicability date for Subpart IIII; therefore, Subpart IIII does not apply. New equipment purchased by PolyMet will meet the appropriate particulate emission standards based on the service and date of manufacture.

3.9. 40 CFR 63 Subpart DDDDD, National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters (Boiler MACT)

This subpart establishes national emission limits and work practice standards for hazardous air pollutants (HAPs) emitted from industrial, commercial, and institutional boilers and process heaters. This standard (Boiler MACT) regulates CO as a surrogate for organic HAPs, which would be emitted from the gas-fired boilers that are subject to a VOC Emission Control Technology Review for this project. Subpart DDDDD does not prescribe add-on controls for CO. Therefore, it cannot be used as an indicator of emissions controls for sources in the NorthMet project. The VOC emission control technology for sources subject to Subpart DDDDD will include VOC limits which are more restrictive that the MACT 400 ppm CO limit. In addition, federal courts have recently vacated MACT Subpart DDDDD, and the rule is no longer applicable.

3.10. 40 CFR 63 Subpart ZZZZ, National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines

This subpart establishes national emission limits and work practice standards for hazardous air pollutants (HAP) emitted from reciprocating internal combustion engines. This standard does not regulate any criteria pollutants as surrogates for HAPs, which would be emitted from diesel engines, which are also subject to an Emission Control Technology Review for this project. Therefore, Subpart ZZZZ cannot be used as an indicator of emissions controls for sources in the NorthMet project.

3.11. 40 CFR 63 Subpart RRRRR, National Emission Standards for Hazardous Air Pollutants for Taconite Ore Processing

This subpart establishes national emission limits and work practice standards for hazardous air pollutants (HAP) emitted from taconite ore processing. The Taconite MACT regulates particulate matter as a surrogate for metallic HAP emissions. The ore processing at the Plant Site will not be subject to Subpart RRRRR, but the operations will be similar to taconite ore processing. Therefore, Taconite MACT particulate matter standards for new sources will be considered as an indicator of the best performing emission controls when evaluating equivalent sources in the PolyMet Emission Control Technology Review.

4. Emission Control Technologies

4.1. Overview of Emission Control Technologies

Due to the size and complexity of PolyMet's proposed facility, several individual sources must be included in the plant site Emission Control Technology Review. Given that the list of potential control technologies for each of these sources is similar, detailed descriptions of each control technology are included in this section as a reference for the individual source Emission Control Technology Reviews. The emission control technologies evaluated include add-on controls and inherently lower pollution process equipment where generally applicable (e.g. wet grinding for PM and specialized electrowinning cell covers for SAM). Each source-specific Emission Control Technology Review will contain a brief summary of the control technologies covered in this section. Source-specific emission controls and operating practices will be described in the sections relating to those individual sources.

4.2. Particulate Matter (PM & PM_{10}) Emission Control Technologies

PolyMet has evaluated control technologies for particulate matter emissions from the following sources:

1. Ore crushing and grinding
2. Flotation concentrate dryers
3. Autoclaves
4. Hydrometallurgical process tanks
5. Electrowinning
6. Product packaging
7. Flotation concentrate material handling
8. Lime and limestone processing
9. Material handling
10. Cooling towers
11. Boilers
12. Diesel-powered emergency generators
13. Miscellaneous combustion sources
14. Fugitive emissions (fugitive emissions include dust generated by truck traffic and by wind erosion from limestone storage piles and the tailing basins)

4.3. Fabric Filter

A fabric filter or baghouse consists of a number of fabric bags placed in parallel inside of an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The dust cake which forms on the filter from the collected particulate can contribute significantly to increasing the collection efficiency.

Two major fabric filter types are the reverse-air fabric filter and the pulse-jet fabric filter. In a reverse-air fabric filter, the flue gas flows upward through the insides of vertical bags which open downward. The particulate matter thus collects on the insides of the bags, and the gas flow keeps the bags inflated. To clean the bags, a compartment of the fabric filter is taken off-line, and the gas flow in this compartment is reversed. This causes the bags to collapse, and collected dust to fall from the bags into hoppers. (Shaking or another method is sometimes employed to dislodge the dust from the bags.) The cleaning cycle in a reverse-air fabric filter typically lasts about three minutes per compartment. Because reverse-air cleaning is gentle, reverse-air fabric filters typically require a low air-to-cloth ratio of 2 ft/min.

In a pulse-jet fabric filter, dirty air flows from the outside of the bags inward, and the bags are mounted on cages to keep them from collapsing. Dust that collects on the outsides of the bags is removed by a reverse pulse of high-pressure air. This cleaning does not require isolation of the bags from the flue gas flow, and thus may be done on-line.

The main operating limitation of a baghouse is that its operating temperature is limited by the bag material. Most filter materials are limited to 200ºF – 300º F. Some materials such as glass fiber or Nomex may be operated at 400ºF, but are more expensive.

Baghouse control efficiency under normal loading conditions typically is in the 98 - 99+ percent range. Reduced efficiencies will occur when the inlet particle concentration is low. In well designed baghouses, outlet particle concentrations are typically 0.005 gr/dscf. Some of the most recent BACT determinations have been as low as 0.0025 gr/dscf. Ultimately, outlet concentrations achieved will depend on the size range and nature of the particles being filtered.

4.4. Electrostatic Precipitators (ESP)

An electrostatic precipitator applies electric forces to separate suspended particles from the flue gas stream. In an ESP, an intense electrostatic field is maintained between high-voltage discharge electrodes, typically wires or rigid frames, and grounded collecting electrodes, typically plates. A corona discharge from the discharge electrodes ionizes the gas passing through the precipitator, and gas ions subsequently ionize the particles. The electric field drives the negatively charged particles to the collecting electrodes. Periodically, the collecting electrodes are rapped mechanically to dislodge collected particulate matter, which falls into hoppers for removal. Collected dust is removed from the precipitator for disposal, recycling, or reprocessing. Risk of sparking and dust explosion prevents ESP installation for use with extremely dry applications.

Since ESPs use electrical forces for particle collection, the electrical properties of the particles can adversely impact ESP operation. Particles with high resistivity may not readily accept an electric charge and will be difficult to collect. Particles with high conductivity or magnetic properties will strongly adhere to the collection plates and be difficult to remove.

ESP control efficiency under normal loading conditions typically is in the 98 - 99+ percent range. Reduced efficiencies will occur when the inlet particle concentration is low. Outlet particle concentrations can be as low as 0.005 gr/dscf; however, outlet concentrations achieved will depend on the size range and nature of the particles.

4.5. Wet Electrostatic Precipitators (WESP)

A wet electrostatic precipitator operates in the same manner as a dry ESP; it applies electric forces to separate suspended particles from the flue gas stream. In a WESP, an intense electrostatic field is maintained between high-voltage discharge electrodes, typically wires or rigid frames, and grounded collecting electrodes, typically plates. A corona discharge from the discharge electrodes ionizes the gas passing through the precipitator, and gas ions subsequently ionize the particles. The electric field drives the negatively charged particles to the collecting electrodes. Particle removal in a WESP is accomplished with water sprays instead of mechanical cleaning methods. As a result of using water sprays, WESPs generate wastewater which must be treated to remove suspended particles and dissolved solids. Alternatively, scrubber water can be recycled to the process if this is allowed by process chemistry.

Since WESPs use electrical forces for particle collection, the electrical properties of the particles can adversely impact WESP operation. Particles with high resistivity may not readily accept an electric charge and will be difficult to collect. Particles with high conductivity or magnetic properties will strongly adhere to the collection plates and be difficult to remove; WESP water sprays may reduce this problem. However, WESP water spray systems will require more maintenance than dry ESP’s in order to keep the water spray system working properly.

WESP control efficiency under normal loading conditions typically is in the 98 - 99+ percent range. Reduced efficiencies will occur when the inlet particle concentration is low. Outlet particle concentrations of filterable particulates as measured by EPA Method 5 can be as low as 0.005 gr/dscf. This report assumes WESP outlet total particulate concentrations of 0.006 gr/dscf. This concentration accounts for filterable and condensable particulates (0.001 gr/dscf of particulates measured by EPA Method 202). However, outlet concentrations achieved in practice will depend on the size range and nature of the particles.

4.6. Wet Scrubbers

Wet scrubbers, also termed particulate scrubbers, remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.

Scrubbers may capture particulates through the following mechanisms:

- Impaction of the particle directly into a target droplet;
- Interception of the particle by a target droplet as the particle comes near the droplet; or
- Diffusion of the particle through the gas surrounding the target droplet until the particle is close enough to be captured.

Scrubbers are generally classified according to the liquid contacting mechanism used. The most common scrubber designs are spray-chamber scrubbers, cyclone spray chambers, orifice and wet-impingement scrubbers, and venturi scrubbers. Wet scrubbers require attention for waste water discharge or recycling of scrubber water to the process equipment.

Operating conditions inside of a scrubber can be very corrosive if acid gases are present in the waste gas, and highly abrasive particulate matter can cause erosion problems. These conditions lead to reduced equipment operating life, and/or increased capital cost for materials of construction.

Scrubber control efficiency under normal loading conditions typically is in the 98 – 99+ percent range. Scrubber efficiency is a function of pressure drop across the scrubber. So, higher collection efficiencies will consume more electrical power to operate the scrubber blower. Reduced efficiencies will occur when the inlet particle concentration is low. Outlet concentrations of filterable particulates (particulates as measured by EPA Method 5) can be as low as 0.005 gr/dscf. This report assumes scrubber outlet total particulate concentrations of 0.006 gr/dscf. This concentration accounts for filterable and condensable particulates (0.001 gr/dscf of particulates measured by EPA Method 202).

However, outlet concentrations achieved in practice will depend on the size range and nature of the particles.

4.7. Mechanical Collectors

Mechanical collectors use a variety of mechanical forces to collect particulate matter:

- Inertial separators use inertia and gravity to remove larger particles from smaller ones.
- Cyclones use centrifugal force to separate particulate matter from gas streams.

Drop-out boxes are typically used as inertial separators. Larger particles are trapped in drop-out boxes as the inertia they contain forces them to go straight as the rest of the gas stream turns to flow into and out of the drop-out box. Particles are also removed by gravitational settling in the drop-out box. Inertial separators can only remove the larger dust particles (>75 microns). They are typically used upstream of other control devices in high inlet dust loading cases.

Cyclone separators are designed to remove particles by inducing a vortex as the gas stream enters the chamber, causing the exhaust gas stream to flow in a spiral pattern. Centrifugal forces cause the larger particles to concentrate on the outside of the vortex and consequently slide down the outer wall and fall to the bottom of the cyclone, where they are removed. The cleaned gas flows out of the top the cyclone.

There are two principal types of cyclones: tangential entry and axial entry. In tangential entry cyclones, the exhaust gas enters an opening located on the tangent at the top of the unit. In axial flow cyclones, the exhaust gases enter at the middle of one end of a cylinder and flows through vanes that cause the gas to spin. A peripheral stream removes collected particles while the cleaned gas exits at the center of the opposite end of the cylinder.

Overall cyclone control efficiencies range from 50 to 99 percent with higher efficiencies being achieved with large particles and low efficiencies for smaller particles (< PM_{10}).

4.8. Use of Different Particulate Control Technologies in Series

Current particulate emission control technologies are highly effective and can be designed to achieve very low particulate concentrations in the outlet of the control device. Therefore, use of multiple control devices in series will not result in lower particulate concentrations in the outlet of control devices used in series vs. a single well designed control device. Use of low efficiency particulate controls in series with high efficiency controls (e.g. a cyclone followed by a baghouse) may result in a reduction in overall particulate emission control costs. In PolyMet's case, use of controls in series to achieve the same control efficiency as a single unit does not impact the Emission Control Technology Review findings because use of controls in series would not change the emission rate economic feasibility of any particulate control device evaluation.

4.9. Good Design Methods and Operating Practices

Good design includes process and mechanical equipment designs, which are either inherently lower polluting or are designed to minimize emissions.

Good operating practices include operating methods, procedures, and selection of raw materials to minimize emissions.

Since these methods are generally source-specific. They will be addressed for each process when such measures are available.

4.10. Fugitive PM Emission Control

PolyMet will follow Best Management Practices (BMP) for control of fugitive dust at the processing plant. PolyMet has prepared at detailed dust control plan (ER08) to describe the BMPs it will implement for fugitive dust control. A copy of the dust control plan is located in Attachment K to the Emission Control Technology Review report. The following sections are brief discussions of common methods used to control fugitive dust emissions.

4.11. Paved Roads

Paved roads are classified as a surface improvement under the three grouping options for controlling emissions from unpaved roads. Paved roads are the most obvious surface improvement but are quite expensive. The control efficiencies achievable by paving can be estimated by comparing emission factors for unpaved and paved road conditions. Based on normal silt loading (0.4 grams per square meter) conditions, paved roads generate 70 – 80 percent less PM/PM_{10}. Paved roads cannot be used in mine areas, or on roads traveled by heavy mining equipment due to the excessive weight of the ore haul trucks.

4.12. Dust Suppression on Unpaved Roads

Surface treatment is one of the other options for controlling emissions from unpaved roads. Dust suppression can be in the form of wet suppression or chemical stabilization. Wet suppression refers to the addition of water to the roads which keeps the road surface wet. Chemical stabilization attempts to change the physical characteristics of the roadway surface. This is typically achieved by binding particles together to create a hardened surface that resembles a paved road except that the surface is not uniformly flat. Dust suppression applied as required or at least two times per year can reduce PM/PM_{10} emissions.

4.13. Dust Suppression on Disturbed Soils

Dust suppression for disturbed soils includes soil stabilization, vegetative cover, and good work practices (e.g. where feasible, minimizing the area of disturbed soils).

4.14. Dust Suppression on Storage Piles

Potential dust suppression measures for storage piles include enclosures, windscreens, wet suppression, and best management practices. Enclosures and wind screens are effective only for small storage piles. Wet suppression may cause operational problems in freezing weather, and run-off water control may be required based on the nature of the material stored.

4.15. Sulfuric Acid Mist (SAM) Emission Control Technologies

PolyMet has evaluated control technologies for sulfuric acid mist (SAM) emissions from the following sources:

- Autoclave vents and autoclave flash vents
- Neutralization tanks
- Iron reduction and AuPGM precipitation tanks
- Residual copper, and mixed nickel/cobalt/zinc hydroxide precipitation tanks
- Electrowinning cells
- Sulfuric acid unloading operations and storage tanks
- Emergency diesel-fired equipment

4.16. Flue Gas Desulfurization (FGD)

Flue Gas Desulfurization (FGD) equipment is primarily designed for SO_2 removal. SAM is usually produced in small quantities as a byproduct of fuel combustion. SAM and other acid gases are typically removed as a collateral benefit of operating SO_2 emission control systems.

There are many available FGD systems including wet scrubbing, spray dryer absorption, and dry sorbent injection. FGD systems currently in use to control sulfur oxide emissions can be classified as wet and dry systems. FGD systems may discard all of the waste byproduct streams (throwaway type) or regenerate and reuse them (regenerable). Wet systems generally use alkali slurries as the acid gas absorbent medium and can be designed to remove in excess of 90 percent of the incoming sulfur oxide acid gases. Lime/limestone scrubbers, sodium hydroxide scrubbers, spray drying, and dual alkali scrubbing are among the proven FGD techniques.

4.17. Wet Scrubbing

Wet scrubbing involves scrubbing the exhaust gas stream with water, and, as needed, reagents to neutralize sulfuric acid captured by the wet scrubber. Reagents are typically needed in SO_2 control systems due to the limited solubility of SO_2 in water. SAM is highly soluble in water; so, reagents may not be needed if SAM concentrations in the waste gas are low. Reagents include lime (CaO) or limestone ($CaCO_3$) in a water slurry or a sodium hydroxide (NaOH) solution. The process takes place in a wet scrubbing tower. The SAM and other acid gases in the gas stream are captured by water droplets in the wet scrubber. Reagents may be needed if sufficient sulfuric acid is captured to adversely affect the pH of the scrubber water. If reagents are used, they would react with the sulfuric acid to form calcium sulfite ($CaSO_3 \bullet 2H_2O$), calcium sulfate ($CaSO_4$) or sodium sulfate ($NaSO_4$)

4.18. Wet Electrostatic Precipitator (WESP)

A wet electrostatic precipitator operates in the same manner as a dry ESP; it applies electric forces to separate suspended particles from the flue gas stream. In a WESP, an intense electrostatic field is maintained between high-voltage discharge electrodes, typically wires or rigid frames, and grounded collecting electrodes, typically plates. A corona discharge from the discharge electrodes ionizes the gas passing through the precipitator, and gas ions subsequently ionize the particles. The electric field drives the negatively charged particles to the collecting electrodes. Particle removal in a WESP is accomplished with water sprays instead of mechanical cleaning methods. As a result of using water sprays, WESPs can be effective in removing SAM when caustic or other basic reagents are added to the water spray system. The water sprays in the WESP act in the same manner as a spray tower wet scrubber. The spray systems used in WESPs have small nozzles which are prone to plugging under certain conditions; so, the choice of reagents may be limited.

WESPs generate wastewater which must be treated to remove suspended particles and dissolved solids or the water can be recycled to the process if it is feasible based on process chemistry.

4.19. Dry Scrubbing – Spray Dryer Absorption

Spray dryer absorption is a dry scrubbing system that sprays a fine mist of lime slurry into an absorption tower where the SAM is absorbed by the droplets. The absorption of the SAM leads to the formation of calcium sulfite ($CaSO_3 \bullet 2H_2O$) and calcium sulfate ($CaSO_4$) within the droplets. The liquid-to-gas ratio is such that the heat from the exhaust gas causes the water to evaporate before the droplets reach the bottom of the tower. This leads to the formation of a dry powder which is carried out with the gas and collected with a fabric filter. Spray dryer absorption control efficiency is typically in the 70 to 90 percent range.

4.20. Dry Scrubbing – Lime/Limestone Injection

Dry sorbent injection involves the injection of a lime or limestone powder into the boiler or process exhaust gas stream. Instead of in a separate tower, the process was developed as a lower-cost FGD option because the mixing occurs directly in the exhaust gas stream. Sorbent injection control efficiency is typically in the 50 percent range.

4.21. Use of Different SAM Control Technologies in Series

Current SAM emission control technologies are highly effective and can be designed to achieve very low SAM concentrations in the outlet of the control device. Therefore, use of multiple control devices in series will not result in lower SAM concentrations in the outlet of control devices used in series vs. a single well designed control device. SAM emission controls are all relatively expensive. Therefore, no cost savings can be achieved through use of different control technologies in series.

4.22. Good Design Methods and Operating Practices

Good design includes process and mechanical equipment designs which are either inherently lower polluting or are designed to minimize emissions.

Good operating practices include operating methods, procedures, and selection of raw materials to minimize emissions.

Since these methods are generally source specific. They will be addressed for each process when such measures are available.

4.23. Volatile Organic Compound (VOC) Emission Control Technologies

VOC will be emitted as a result of the volatilization and/or breakdown of organic materials in the Hydrometallurgical process, evaporative losses in process vessels and storage tanks and incomplete combustion of fuels in boilers and stationary diesels.

4.24. Catalytic Oxidation

Catalytic oxidation systems are designed to pass combustion gases over a catalyst bed that promotes oxidation, e.g. convert VOC to CO_2 and water. The oxidation process requires temperatures of 600 to 1,000°F to achieve 90 to 95 percent conversion of VOC. The catalyst increases the reaction rate and allows the conversion of VOC to CO_2 and water at lower temperatures than a normal thermal incinerator. The catalyst is typically porous noble metal material, which is supported in individual compartments within the unit. An auxiliary fuel-fired burner ahead of the bed heats the entering exhaust gases to 500°F - 600°F to maintain proper bed temperature. Recuperative heat exchangers are used to recover the heat in the exiting gas heat in order to reduce the auxiliary fuel consumption. Secondary energy recovery is typically 70 percent.

4.25. Thermal Oxidation

Thermal oxidation is the process of oxidizing combustible materials by raising the temperature of the material above its auto-ignition point in the presence of oxygen, and maintaining it at high temperature for sufficient time to complete combustion to carbon dioxide and water. Time, temperature, turbulence (for mixing), and the availability of oxygen all affect the rate and efficiency of the combustion process. These factors provide the basic design parameters for thermal oxidation systems.

There are three basic types of thermal oxidation systems: direct flame, recuperative, and regenerative.

Direct flame systems or flares rely on contact of the waste stream with a flame to achieve oxidation. These systems are the simplest thermal oxidizers and the least expensive to install, but require the greatest amount of auxiliary fuel to maintain the oxidation temperature, thus incurring the highest operating cost. In general, waste gas must have sufficient VOC content to make it combustible for direct flame oxidation to be feasible. PolyMet sources have VOC concentrations below 100 ppm. This concentration is well below the amount needed for direct combustion of the off gas. So, direct flame oxidation will not receive further consideration.

Recuperative thermal oxidation systems use a tube or plate heat exchanger to preheat the effluent stream prior to oxidation in the combustion chamber. Thermal recovery efficiencies typically are limited to 40-70% to prevent auto-ignition in the heat exchange package, which could damage the equipment. Supplemental fuel therefore is usually required to maintain a high enough temperature for the desired destruction efficiency. Recuperative systems are more expensive to install than flares, but have lower operating costs.

Regenerative thermal oxidation (RTO) systems typically incorporate multiple ceramic heat exchanger beds to produce heat recovery efficiencies as high as 95%. An incoming gas stream passes through a hot bed of ceramic or other material, which simultaneously cools the bed and heats the stream to temperatures above the auto-ignition points of its organic constituents. Oxidation thus begins in the bed, and is completed in a central combustion chamber, after which the clean gas stream is cooled by passage through another ceramic heat exchanger. Periodically the flow through the beds is reversed to recover the heat from the hot bed, while continuous flow through the unit is maintained.

4.26. Carbon Adsorption

Carbon adsorption is a control technology often used to remove organic compounds from gaseous or liquid streams. Carbon absorption uses a contact vessel to pass the waste gas stream through an activated carbon bed. The organic compounds in the waste gas stream are collected at the interface of the activated carbon by intermolecular forces (such as van der Waals interactions) creating a VOC-rich carbon. The VOC-rich carbon is then removed from the carbon bed and new, or “clean”, activated carbon is added to the bed. The VOC-rich carbon is reclaimed (i.e., converted back to “clean” carbon) by separating the VOCs from the carbon. The separation process is typically achieved by stripping the carbon in an oxygen deficient environment usually using steam as the stripping media to vaporize the organic material without burning the carbon or the VOCs. Carbon may be regenerated in place, or sent off site for regeneration or disposal. Low emitting sources typically send spent carbon off site and replace the carbon with a new carbon canister.

Adsorption uses intermolecular forces to accumulate organic material at the surface of the adsorbent (typically activated carbon). Van der Waals interactions increase with larger molecules because there are more bonds within the molecules. VOC compounds emitted in the Hydrometallurgical autoclave system, the primary source of VOC at the Process Plant, are expected include several small molecules, such as acetaldehyde (MW = 44), and formaldehyde (MW = 30), as products of the incomplete combustion of the residual flotation additives. Since the molecules are small, van der Waals interactions are weak.

4.27. Wet Scrubber

VOC control scrubbers are designed primarily for creating intimate contact to promote absorption of soluble compounds. Absorption scrubbers come in a variety of designs but operate on the same primary absorption principles. An absorption scrubber typically consists of a contact tower with a high surface area material (mass transfer material) in the middle. A scrubbing liquid is sprayed down the tower covering the mass transfer material as waste gas is blown in the bottom of the tower, creating intimate contact between the liquid and gas. The soluble gaseous compound(s) then dissolves in the scrubbing liquid. The scrubbing liquid is then removed from the bottom of the tower and treated. The two predominant type of absorption scrubbers are packed and plate towers. Packed towers are vertical vessels that are filled with a packing material such as raschig rings or “saddle” shaped pieces of material. This packing creates significant surface area for the liquid and gas to contact. Plate towers are vertical vessels with horizontal sieve plates in the middle. The scrubbing liquid is sent down the tower, filling the plate and the gas passes through the plate holes generating contact with the scrubbing liquid. Packed towers are more efficient; however, plate towers are used when there is significant particulate matter in the waste gas stream because packed towers are susceptible to clogging when the waste gas stream contains significant PM.

The most frequently used stripping liquid is water or a water-based solution. Depending on the chemical composition of the scrubbing liquid after it has been used, it is either discharged or recycled back to the scrubber. Water and water-based solutions are typically discharged to the local municipality after onsite treatment. However, the NorthMet Process Plant is designed for zero discharge, so any scrubber effluent would be recycled to the process.

4.28. Refrigeration Condensers

Refrigeration condensers are used to separate materials from gaseous stream by cooling and, in some cases, pressurizing a gas stream to cause some of the constituents to condense to liquid form. Condensers are designed to separate constituents based on the difference in dew points of the compounds that are targeted for separation. For example, a stream of benzene and oxygen could be separated by cooling the stream until the benzene condenses because oxygen (dew point -183 ºC) has a much lower dew point than benzene (dew point 80 ºC).

The most common types of refrigeration condensers are surface and contact condensers. Surface condensers use indirect contact heat exchange in which the coolant does not contact the gas stream directly. Most surface condensers are shell and tube type heat exchangers in which the coolant passes through tubing and the VOC laden gas stream passes on the outside of the tubes but inside the heat exchanger shell condensing the VOCs on the outside of the tubes. Contact condensers, however, cool the gas stream by spraying either an ambient-temperature or chilled liquid directly into the gas stream. Spent coolant containing the VOCs from contact condensers usually cannot be reused directly and requires further processing to recover the spent coolant. As a result, the spent coolant is often treated as a waste product that is shipped off-site for recovery.

Waste streams must contain sufficient VOC content for product recovery to make condensation an economically viable control option; i.e. sufficient raw material or product is captured to off-set the cost of condensation controls. At VOC concentrations of less than 100 ppm VOC, in the PolyMet gas streams which contain VOCs, condensation is not viable. Since other control systems can achieve better control at less cost, condensation will not receive further consideration as a VOC control technology for this project.

4.29. Use of Different Particulate Control Technologies in Series

Current VOC emission control technologies are highly effective and can be designed to achieve very low VOC concentrations in the outlet of the control device. Therefore, use of multiple VOC control devices in series will not result in lower VOC concentrations in the outlet of control devices used in series vs. a single well designed control device. Use of low efficiency VOC controls in series with high efficiency VOC controls (e.g. condensation followed by oxidation) may result in a reduction in overall emission control costs due to the recovery of valuable raw materials or products. In PolyMet’s case, this is not feasible because there are no applications where additives or reagents can be recovered for re-use in this manner.

4.30. Good Design Methods and Operating Practices

Good design includes process and mechanical equipment designs, which are either inherently lower polluting or are designed to minimize emissions.

Good operating practices include operating methods, procedures and selection of raw materials to minimize emissions.

Since these methods are generally source specific (e.g. good operating practices for minimizing VOC emissions), for most source types they will be addressed for each process when such measures are available.

For combustion sources, these practices include good combustion practices. Good combustion practices include operation of the combustion device with sufficient air to provide for complete combustion of the fuel. Good combustion practices may include the proper design and maintenance of equipment, good housekeeping, and good operating practices.

5. Ore Crushing

5.1. Overview of Ore Crushing

Liberation of metallic minerals by crushing and grinding is the first step in processing of the crude ore. Crude ore is delivered to the plant by rail car. Rail cars are tipped to unload the ore into the coarse ore crusher. Coarse ore crushing consists of two stages of gyratory crushing (primary and secondary crushing). After coarse ore crushing, the ore flows into the coarse ore storage bin via conveyors. The two stages of fine ore crushing (tertiary and quaternary) are fed by vibratory feeders from the crude ore bin. Ore from the fine ore crushers is fed to the fine ore storage bins via conveyors. Fine ore flows from the fine ore bins to milling via pan feeders and conveyors. The final ore size reduction step is accomplished by wet milling. Wet milling occurs in rod mills followed by ball mills. The milled ore is conveyed to ore concentration in an ore/water slurry. The individual emission units and stack numbers of ore crushing sources are listed in Attachment A, Table A-1.

Sources of particulate matter and PM_{10} in the crushing section of the plant include crushers, screens, vibrating pan feeders, and material drops from conveyors. All crushing and screening equipment and conveyor transfer points will be enclosed and ventilated to dust control equipment. Each train of crude and fine ore crushers, screeners, pan feeders, and conveyors will be routed to a particulate matter control system for that processing train. Fines collected by dust control equipment will be re-processed in the ball milling operations. No particulates are emitted from wet milling as the addition of water to the ore prevents dust formation.

The Minnesota Pollution Control Agency (MPCA) and the public have expressed concerns about the potential for adverse health affects of fine particulate matter originating from ore crushing (See the RS61 report for additional information). Therefore, PolyMet has agreed to install emission controls on ore crushing operations at the Plant Site which are consistent with the best controls currently used in the metallic ore processing industries. This will ensure that emissions of fine particulate matter from ore crushing sources are controlled by state of the art “BACT-like” emission controls. Note: the determination of BACT-like controls was completed for PM_{10}.. To date, EPA has not approved a performance test method for $PM_{2.5}$. Therefore, it is not be possible to demonstrate compliance with a $PM_{2.5}$ emission limit at this time. The chosen control technology is also the most effective for finer particulates (e.g. $PM_{2.5}$) and in fact the performance differential between baghouses and other emission control technologies is more pronounced for finer particulate sizes.   The RBLC has very limited data on $PM_{2.5}$. Only 10 $PM_{2.5}$ determinations are listed in the RBLC. The listed sources which have add-on controls (3) have baghouse controls. Two sources have a BACT limit of 0.0048 gr/dscf and one source has a BACT limit of 0.005 gr/dscf. There were no RBLC $PM_{2.5}$ listings for the metallic ore processing industries.

5.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various PM control technologies are discussed in Section 4.0 and Table 5.1. Each of the technologies listed below must be used in conjunction with an enclosure to capture the particulate matter so it can be routed to the control device. Potential control technologies for PM emissions are the following:

- Fabric filter (baghouse)
- Wet scrubber
- Electrostatic precipitator
- Wet electrostatic precipitator
- Centrifugal separation (cyclones)
- Inertial separators (drop-out box)

5.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

Table 5.1 provides a list of potential control technologies for PolyMet's crushing and material handling sources in the ore crushing facility and summarizes technical feasibility for each type of controls.

Table 5.1 Crushing and Material Handling PM / PM_{10} Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	Yes	NA
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	Yes	NA
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	Yes	NA
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	Yes	NA
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	Yes	NA
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials. This includes installation of total enclosures and collection hoods where feasible	Yes	NA

All controls are considered technically feasible.

5.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

Emissions control effectiveness was evaluated for the remaining control technologies. The control equipment effectiveness analysis can be summarized as follows:

Table 5.2 Ranking of Remaining PM/PM_{10} Control Technologies for Material Handling

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Fabric filter (baghouse)	98% - 99+% or 0.0025 gr/dscf*
2	Electrostatic precipitator	98% - 99+% or 0.005 gr/dscf*
3	Wet scrubber	98% - 99+% or 0.006 gr/dscf*
4	Wet electrostatic precipitator	98% - 99+% or 0.006 gr/dscf*
5	Centrifugal separation (e.g. cyclones)	50% - 80%
6	Good design methods & operating practices	NA Total enclosures and hoods will be installed as needed to facilitate the use of filters, scrubbers and/or ESPs.

* Total PM as measured by EPA Methods 5 and 202.

In general, PM/PM_{10} control devices for ore crushing will have control efficiencies in the 99% range based on the design inlet particulate loading and 0.0025 - 0.006 gr/dscf total particulates in the control device outlet. Crushing sources which have low inlet particulate loading (e.g. ore bins) will have control efficiencies in the 95% range at 0.0025 - 0.006 gr/dscf.

5.5. Evaluation of PM and PM_{10} Control Technologies

Material handling will be performed by conveyor belt or similar mechanical device. These are fixed sources and particulate emission points can be enclosed for collection and control of particulate emissions. Baghouses, wet scrubbers, and ESPs are all capable of controlling material handling emissions. With outlet concentrations of 0.0025 gr/dscf fabric filters (baghouse) are the top control device. Cyclones were not evaluated as they have lower control efficiencies than the other particulate control devices. It is assumed that good design and operating practices will be employed in all cases.

PolyMet has elected to install the top control device; therefore an economic analysis is not warranted.

The PolyMet ore crushing system is designed to return particulates collected in the pollution control equipment to the process. So, none of the potential control devices directly generate solid waste. The milling process requires the addition of water. Water consumption requirements for milling exceed the amount of water needed to slurrify and transport material collected by the baghouses, so, material collected by baghouses can be returned to the ore milling and concentration process without increasing overall plant site water consumption..

5.6. Select Emission Control Technology for PM and PM_{10}

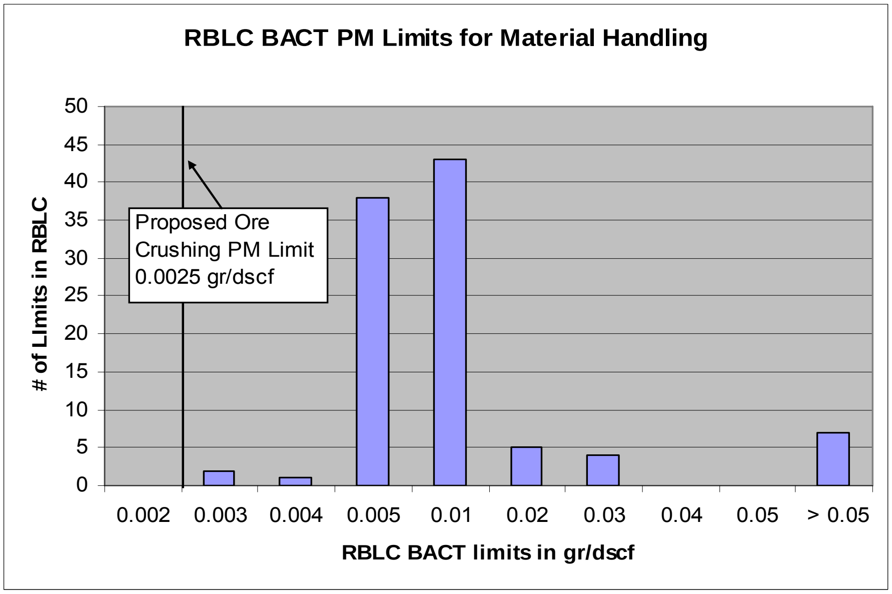
For the ore crushers and associated material handling sources, PolyMet proposes fabric filter (baghouse) controls with a performance limit of 0.0025 gr/dscf as measured by EPA Method 5.

Normally, a well designed baghouse can control particulates concentrations down to 0.005 gr/dscf. The MPCA and the public have expressed concerns about the potential for adverse health affects of fine particulate matter originating from ore crushing (See RS61 for additional information). Therefore, PolyMet has agreed to install emission controls on ore crushing operations at the Plant Site which are consistent with the best controls currently used in the metallic ore processing industries. This will ensure that emissions of fine particulate matter from ore crushing sources are controlled by state of the art “BACT like” emission controls.

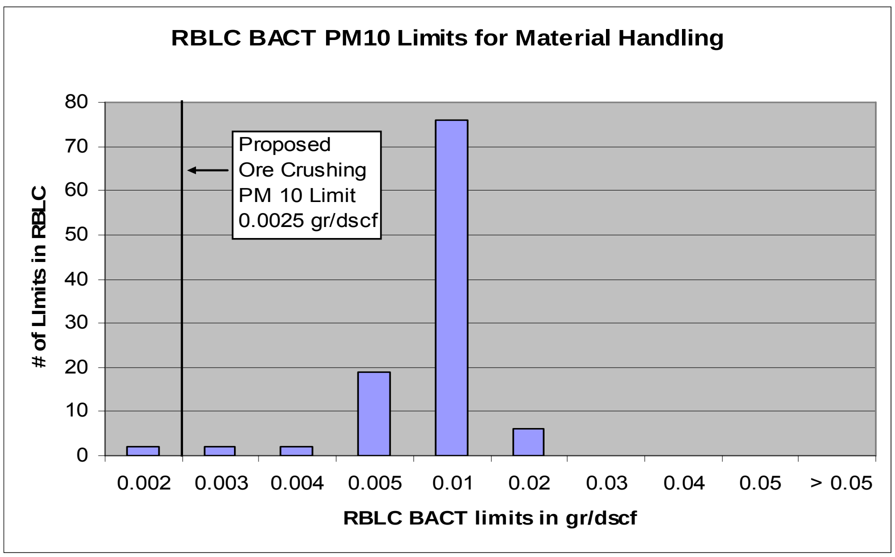
Baghouses have the highest level of particulate control in this application. The proposed limit is consistent with recent BACT limit determinations for material handling sources as can be seen in Attachment L, Table L-1A, Table L-1B, Table L-2A and Table L-2B for material handling and fugitive dust control. These tables are listings of recent BACT determinations for material handling sources in the mining, electric utility and iron/steel industries. The tables and bar charts on the following page summarize the RBLC Clearinghouse data for material handling sources. The proposed PM/PM10 limit of 0.0025 gr/dscf is consistent with the lowest of recent BACT determinations, and is lower than the median of recent BACT determinations. The lowest material handling BACT limits for PM identified in the RBLC search are for NorthShore Mining Company (RBLC ID MN 0064) which is a facility similar in age and processing technology to the existing NorthMet crushing facilities.

The lowest material handling BACT limits for PM_{10} identified in the RBLC search are 0.0005 gr/dscf for Waupaca Foundry (RBLC ID WI-0157) and Nucor Steel (RBLC ID AR-0078). Both listings are from 1999. These listings appear to be typographical errors. Waupaca Foundry has three other listings for the same project with 0.005 gr/dscf BACT limits. The other 1999 BACT PM10 limits included five determinations at 0.005 gr/dscf and five at 0.01 gr/dscf. No other listings appear for emission rates below 0.005 gr/dscf until 2006 (NorthShore Mining Company).

RBLC PM BACT Limits Summary					
BACT-PSD PM gr/dscf Emission Limits			Other (non-BACT) PM gr/dscf Emission Limits		
MIN	0.0025	gr/dscf	MIN	0.0100	gr/dscf
MAX	0.100	gr/dscf	MAX	0.022	gr/dscf
MEDIAN	0.010	gr/dscf	MEDIAN	0.010	gr/dscf
COUNT	100	CASES	COUNT	7	CASES



RBLC PM10 BACT Limits Summary					
BACT-PSD PM10 gr/dscf Emission Limits			Other (non-BACT) PM10 gr/dscf Emission Limits		
MIN	0.0005	gr/dscf	MIN	0.0045	gr/dscf
MAX	0.020	gr/dscf	MAX	0.022	gr/dscf
MEDIAN	0.010	gr/dscf	MEDIAN	0.010	gr/dscf
COUNT	107	CASES	COUNT	22	CASES



The proposed performance standard is also more stringent than the taconite MACT standard for new ore and pellet handling sources (0.005 gr/dscf, as measured by EPA Method 5).

To establish compliance limits, PolyMet will test ore crushing sources for PM/PM_{10} using EPA Methods 5 and 202, as applicable, using three (3) one-hour test runs. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating the material handling emission control equipment will be set using the data collected during the performance test. In cases where there are multiple emission units of a processing equipment type (e.g. pan feeders), PolyMet proposes to test one stack/vent associated with each equipment type which is representative of that equipment. The facility will demonstrate ongoing compliance based on the 24 hour average(s) of the process parameters established during the performance test.

Since particulate controls can be commissioned prior to start up and turned off after process equipment is shut down, no special limits are needed for startup or shutdown.

A 7% opacity limit is recommended as BACT for visible emissions from ore crushing equipment at which particulate emissions are vented through a stack or similar opening (i.e. the average opacity of material handling equipment cannot exceed 7% for more the one 6-minute period during an hour). A 7% opacity limit is consistent with the requirements of NSPS Subpart LL which applies to similar equipment at metallic mineral processing plants. If PolyMet identifies visible emissions from stacks at ore crushing equipment, it will take corrective action as soon as it is practicable to do so per the applicable operation and maintenance plan for the affected control device.

6. Ore Concentration

6.1. Overview of Ore Concentration

Ore concentration is accomplished in a series of flotation cells. Processing aids are added to the milled ore slurry to enable the separation of metal-bearing minerals from milled ore. Air is injected to form a froth which carries metal bearing minerals to the top of the flotation cells for recovery. Flotation tailings are collected from the bottom of the final scavenger cells. Oversize materials are reprocessed in a wet regrind mill. Concentrate is processed in thickeners. Water recovered from the thickeners is recycled. Flotation tailings are pumped to the tailings basin as a slurry. Concentrate is sent to the Hydrometallurgical plant for metals recovery or to the concentrate drying and shipping operation.

All ore concentrating operations are conducted in water. Since all materials are wet, no particulate matter is emitted from ore concentration, and no particulate emission controls are needed.

6.2. Ore Concentration Volatile Organic Compound (VOC) Emissions

Flotation Cells: VOCs are from incidental air stripping of organic materials. Compressed air is used to generate fine bubbles in the flotation cells to facilitate recovery of the sulfide minerals. The flotation air strips a small amount of organic compounds out of the water and into the air. Evaporation might also contribute to VOC emissions, but most of the organic additives in the flotation process are water soluble compounds; so, VOC emissions from evaporation will be minimized. Flotation cell VOC concentrations are in the < 10 ppm range.

PAX / Frother Tanks: VOC emissions are from the PAX tank due to breakdown of xanthates to form CS_2 and from the frother tanks due to storage working and breathing losses. VOC concentrations are < 10 ppm.

6.3. Identification of Potential VOC Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various VOC control technologies are discussed in Section 4.0 and Table 6.1. Potential control technologies for VOC emissions are the following:

- Thermal Oxidizer (Recuperative and Regenerative)
- Catalytic Oxidizer
- Carbon Adsorption
- Wet Scrubbing (Absorption)
- Good Design and Operating Practices

6.4. Elimination of Technically Infeasible VOC Control Options

Table 6.1 summarizes the feasibility of potential control technologies for control of VOC emissions from ore concentration. Flotation cell VOC concentrations are in the < 10 ppm range; too low for add-on controls to be technically feasible.

Table 6.1 Technical Feasibility of VOC Control Technologies for Ore Concentration

VOC Emission Control Technologies Considered for Emission Control Technology Analysis			
Technology	**Description**	**Feasible? Yes or No**	**Reason Not Feasible**
Thermal Oxidizer (Recuperative and Regenerative)	A thermal oxidizer uses high temperature and residence time to oxidize VOC to water and CO_2. This may be accomplished using an add-on oxidizer or a duct burner.	No	VOC concentrations too low
Catalytic Oxidizer	Catalytic oxidizers use a bed of catalyst that facilitates the oxidation of combustible gases. The catalyst increases the reaction rate and allows the conversion of VOC at lower temperatures than a thermal incinerator.	No	VOC concentrations too low
Carbon Adsorption	Waste gas stream through an activated carbon bed. The organic compounds in the waste gas stream are collected at the interface of the activated carbon by intermolecular forces creating a VOC-rich carbon.	No	VOC concentrations too low
Wet Scrubber	An absorption scrubber typically consists of a contact tower. A scrubbing liquid is sprayed down the tower as waste gas is blown in the bottom of the tower, creating contact between the liquid and gas. Soluble gaseous compound(s) then dissolve in the scrubbing liquid and are removed from the waste gas.	No	VOC concentrations too low
Good Design and Operating Practices	Well designed and operated equipment can reduce the amount of VOCs emitted.	Yes	

Add-on control devices (thermal and catalytic oxidation, carbon adsorption and absorption) are considered technically infeasible in this application due to the low concentrations of VOC in the flotation cell exhaust. At <10 ppm VOC in the flotation cell exhaust and frother and PAX storage tanks, VOC concentrations are at or below the level of control achievable by add-on controls.

6.5. Ranking of Remaining VOC Control Technologies by Control Effectiveness

The only remaining VOC control technologies are good design and operating practices.

Table 6.2 Ranking of Remaining VOC Control Technologies for Ore Concentration

VOC Control Technology Ranking		
Rank	**Technology**	**% Efficiency**
1	Good Design and Operating Practices	NA Base Case

6.6. Evaluation of Most Effective VOC Control Technologies

Since good design and operating practices are inherent parts of the process no additional cost will be incurred. Good operating practices are limited to proper use of frothing agents to minimize VOC emissions. Low volatility compounds are used. However, selection of low VOC emitting compounds is limited due to the nature of the separation process.

Table 6.3 Evaluation of Most Effective VOC Control Technologies for Ore Concentration

Control Technology Effectiveness Evaluation					
Rank	**Technology**	**Amount Removed (tpy)**	**Installed Capital Cost $**	**Annualized Cost ($MM)**	**Control Cost ($/ton removed)**
1	Good Design and Operating Practices	NA Inherent Controls	NA Inherent Controls	NA	NA

6.7. Ore Concentration VOC Emission Control Technology Selection

Good design and operating practices are selected as appropriate emission control for VOC control from ore concentration. No add-on controls are recommended due to the low VOC concentrations present in the flotation cells and frother and PAX storage tanks. Because the concentration process is an inherently low emitting process, no emission limits are required.

7. Flotation Concentrate Dryers

7.1. Overview of Flotation Concentrate Dryers

Instead of feeding the concentrate from the flotation process to the hydrometallurgical process, PolyMet will have the capability to produce two flotation concentrates, one rich in nickel and the other rich in copper. To facilitate this separation, lime will be added to the concentrate in order to increase the pH. The flotation concentrates will then be sent through thickeners and filters before reaching one of two dryers, the nickel flotation concentrate dryer or the copper flotation concentrate dryer. The dryers will be screw auger dryers. A heat transfer fluid will heat hollow cored screw augers, and the heated augers will dry the concentrate. An electric heater is the source of heat for the heat transfer fluid. Particulate matter will be emitted from the process. The dry flotation concentrates will be transferred to storage hoppers and shipped out by rail. The process of drying the concentrates and selling them will only occur when the hydrometallurgical plant is not operating at full capacity.

7.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down emission control technology analysis. Descriptions of the various PM control technologies are discussed in Section 4.0 and Table 5.1. Each of the technologies listed below must be used in conjunction with an enclosure to capture the particulate matter so it can be routed to the control device. Potential control technologies for PM emissions are the following:

- Fabric filter (baghouse)
- Wet scrubber
- Electrostatic precipitator
- Wet electrostatic precipitator
- Centrifugal separation (cyclones)
- Inertial separators (drop-out box)

7.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

Table 7.1 provides a list of potential control technologies for PolyMet's concentrate dryer sources and summarizes technical feasibility for each type of controls.

Table 7.1 Concentrate Dryers PM / PM_{10} Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	No	The high moisture content of the exhaust stream will create a wet filter cake which would blind the filters and/or clog the dust collection bins
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	Yes	NA
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	No	The high moisture content of exhaust stream will create a wet filter cake which would stick to the ESP plates and/or clog the dust collection bins
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	Yes	NA
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	No	The high moisture content of exhaust stream will create a wet dust cake which would stick to the cyclone wals and/or clog the dust collection bins
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials. This includes installation of total enclosures and collection hoods where feasible	Yes	NA

All dry controls are considered technically infeasible in this application. The dryer exhaust will have a high moisture content and water is likely to condense in the control device. The condensed water will mix with the dust and create a paste like waste product which will stick to equipment walls and plug dust handling equipment.

7.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

Emissions control effectiveness was evaluated for the remaining control technologies. The control equipment effectiveness analysis can be summarized as follows:

Table 7.2 Ranking of Remaining PM/PM_{10} Control Technologies for Concentrate Dryers

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	98% - 99+% or 0.006 gr/dscf*
1	Wet electrostatic precipitator	98% - 99+% or 0.006 gr/dscf*
2	Good design methods & operating practices	NA Total enclosures and hoods will be installed as needed to facilitate the use of, scrubbers and/or wet ESPs.

* Total PM as measured by EPA Methods 5 and 202.

In general, PM/PM_{10} control devices for the concentrate dryers will have control efficiencies in the 99% range based on the design inlet particulate loading and 0.006 gr/dscf total particulates in the control device outlet.

7.5. Evaluation of PM and PM_{10} Control Technologies

Material handling will be performed by conveyor belt or similar mechanical device. These are fixed sources and particulate emission points can be enclosed for collection and control of particulate emissions.

The top control devices in this application are wet scrubbers and WESPs; dry controls are technically infeasible due to the high moisture content of the dryer exhaust. Since PolyMet proposes to use one of the top control devices, no economic evaluation is warranted. It is assumed that good design and operating practices will be employed in all cases.

The use of wet control devices can potentially increase the amount of condensable particulate matter as determined by EPA Method 202. The non-ferrous metallic ore concentrate is higher in sulfide content than taconite ore concentrate. As a result, it is possible that dissolved solids in the scrubbing water may be an increased source of condensable particulate matter in the control device exhaust as compared to taconite ore processing. A value of 0.001 gr/dscf was used to estimate the potential contribution of scrubber water dissolved solids to the total particulate emissions rate, based on results from taconite ore processing with a margin of safety to account for the different chemical properties of the ore.

Wet scrubbing has a slightly higher energy use than WESP controls due to the higher pressure drop needed to achieve emission control equivalent to the other control technologies. However, wet scrubbing controls are smaller than ESPs and cost less to install. In either case, scrubber/WESP waste water discharges containing concentrate dust will be recycled within PolyMet's ore concentrate processing system so no solid waste will be generated..

7.6. Select Emission Control Technology for PM and PM_{10}

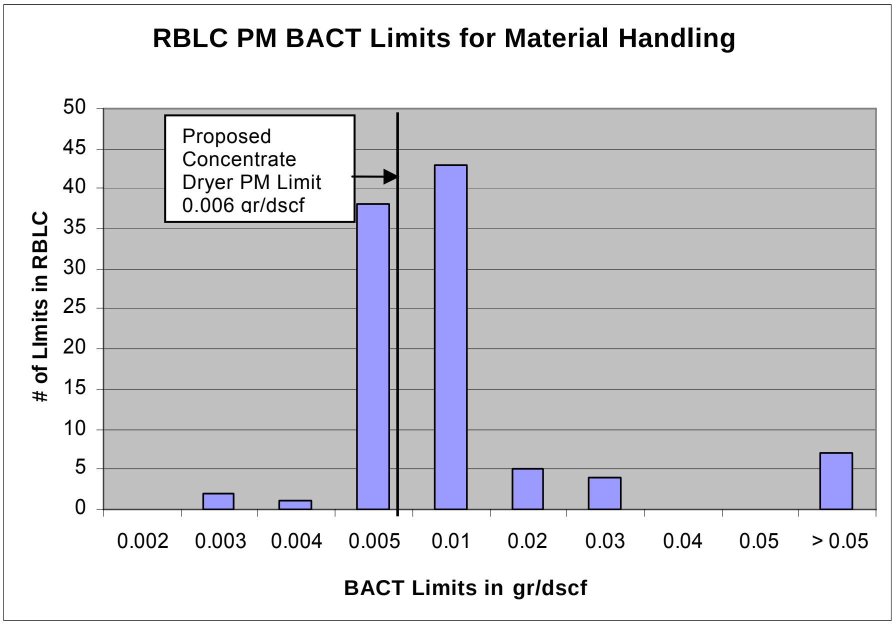
PolyMet is proposing a wet scrubber as the selected emission control technology for the flotation concentrate dryers. The high moisture content of the dryer exhaust makes dry controls technically infeasible. PolyMet proposes a performance limit of 0.006 gr/dscf of total particulate matter as measured by EPA Methods 5 and 202 for the wet scrubber controls. The proposed limit is consistent with recent BACT determinations as noted below. It also provides a small allowance for condensable particulates

The proposed limit is consistent with recent BACT limit determinations for material handling sources as can be seen in Attachment L, Table L-1A, Table L-1B, Table L-2A and Table L-2B for material handling and fugitive dust control. These tables are listings of recent BACT determinations for material handling sources in the mining, electric utility and iron/steel industries. The tables and bar charts on the following page summarize the RBLC Clearinghouse data for material handling sources. The proposed PM/PM10 limit of 0.006 gr/dscf is consistent with the vast majority of recent BACT determinations, and is lower than the median of recent BACT determinations.

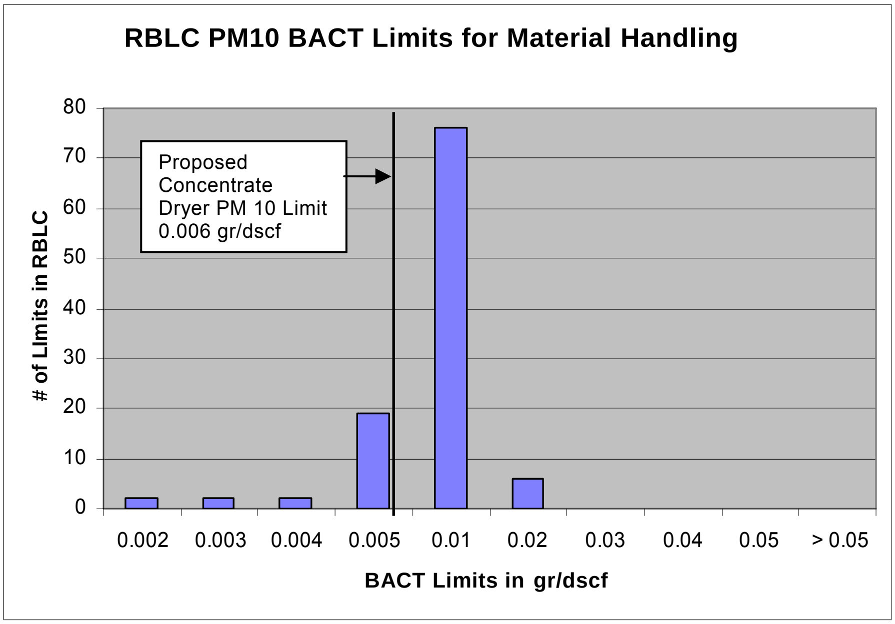
The lowest material handling BACT limits for PM identified in the RBLC search are for NorthShore Mining Company (RBLC ID MN 0064). However, these sources are controlled by baghouses, and baghouses are infeasible in this application.

The lowest material handling BACT limits for PM_{10} identified in the RBLC search are 0.0005 gr/dscf for Waupaca Foundry (RBLC ID WI-0157) and Nucor Steel (RBLC ID AR-0078). Both listings are from 1999. These listings appear to be typographical errors. Waupaca Foundry has three other listings for the same project with 0.005 gr/dscf BACT limits. The other 1999 BACT PM10 limits included five determinations at 0.005 gr/dscf and five at 0.01 gr/dscf. No other listings appear for emission rates below 0.005 gr/dscf until 2006 (NorthShore Mining Company).

RBLC PM BACT Limits Summary					
BACT-PSD PM gr/dscf Emission Limits			Other (non-BACT) PM gr/dscf Emission Limits		
MIN	0.0025	gr/dscf	MIN	0.0100	gr/dscf
MAX	0.100	gr/dscf	MAX	0.022	gr/dscf
MEDIAN	0.010	gr/dscf	MEDIAN	0.010	gr/dscf
COUNT	100	CASES	COUNT	7	CASES



RBLC PM10 BACT Limits Summary					
BACT-PSD PM10 gr/dscf Emission Limits			Other (non-BACT) PM10 gr/dscf Emission Limits		
MIN	0.0005	gr/dscf	MIN	0.0045	gr/dscf
MAX	0.020	gr/dscf	MAX	0.022	gr/dscf
MEDIAN	0.010	gr/dscf	MEDIAN	0.010	gr/dscf
COUNT	107	CASES	COUNT	22	CASES



The proposed performance standard is also consistent with the taconite MACT standard for new ore and pellet handling sources (0.005 gr/dscf, as measured by EPA Method 5) and it accounts for total particulates (0.005 gr/dscf - Method 5 plus 0.001 gr/dscf Method 202).

To establish compliance limits, PolyMet will test one of the two identical dryers for PM using EPA Methods 5 and 202, as applicable, using three (3) one-hour test runs. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating the material handling emission control equipment will be set using the data collected during the performance test. The facility will demonstrate ongoing compliance based on the 24 hour average(s) of the process parameters established during the performance test.

Since particulate controls can be commissioned prior to start up and turned off after process equipment is shut down, no special limits are needed for startup.

A 20% opacity limit is recommended as BACT for visible emissions from the flotation concentrate drying and material handling source wet scrubbers (i.e. the average opacity of concentrate dryer and material handling equipment exhaust streams cannot exceed 20% for more the one 6-minute period during an hour). The scrubber exhaust streams contain droplets of entrained scrubber water and the exhaust gas is saturated with water vapor. The water vapor condenses to form additional water droplets when the exhaust plume comes in contact with the atmosphere. Both of these conditions contribute to formation of a wet plume which is visible to the eye due solely to water droplets in the plume. In cases where visible water plumes are present, opacity readings must be taken at the point where all water has evaporated. Since it is difficult to determine the exact point in the plume where this occurs, a 20% opacity limit is recommended to address this uncertainty. The 7% opacity limit requirements of NSPS Subpart LL do not apply to sources using wet scrubbers. If PolyMet identifies visible emissions from flotation concentrate drying and material handling sources wet scrubbers in excess of 20%, it will take corrective action as soon as it is practicable to do so in accordance with the operation and maintenance plan for the affected control device.

8. Hydrometallurgical Plant

8.1. Overview of the Hydrometallurgical Plant

When the hydrometallurgical plant is operating, the concentrate is fed to one of two autoclaves where the copper, nickel, cobalt and iron sulfides are oxidized to form soluble sulfate species and the PGM and gold are leached from the concentrate. Next, the valuable leached metals are extracted by precipitation and filtering except for copper. Copper in the leach solution is extracted through the use of organic reagents and recovered as pure copper cathode by electrowinning. The precipitated valuable metals are collected in thickeners and filtered to remove water. Iron is reduced through the addition of sulfur dioxide. Iron and aluminum are removed from the process as metal hydroxides through the addition of limestone. The limestone also raises the pH of the leach solution and produces gypsum.

Autoclave vent and flash vessels are sources of particulate matter, PM_{10} and SAM. There are two (2) autoclave systems. In order to extract the valuable metals from the ore concentrate, the autoclaves are operated at elevated temperature and pressure. Hydrochloric acid and pure oxygen are added to the autoclaves in order to form metal sulfates and platinum metal group chloride compounds. These reactions are exothermic; so, the final mixture leaves the autoclaves at elevated temperatures (225º C). Gas is vented from the pressure control valves on the autoclaves to maintain the pressure setpoint. This offgas is routed to the autoclave scrubbing system. The autoclave discharge goes into an autoclave flash vessel. The flash vessel is operated at a lower pressure than the autoclaves, so when the digested ore is transferred to the flash vessel, some of the water in the mixture vaporizes to form steam. Steam leaving the flash vessel contains entrained PM, PM_{10}, and SAM. Exhaust gas from the flash vessel is scrubbed to remove these contaminants in two stages of wet scrubbing. Blowdown from the scrubber water tanks is returned to the process.

The solution neutralization, raffinate neutralization, iron reduction/AuPGM precipitation, residual copper removal, and mixed hydroxide precipitation tanks are sources of SAM emissions. Off-gas from the neutralization and metal recovery sources is routed to a centralized control device, the plant scrubber.

- In the Solution Neutralization and Raffinate Neutralization Tanks, sulfuric acid is neutralized with limestone. Carbon dioxide gas is released as a byproduct. The off-gas contains small amounts of entrained SAM. The heat of reaction from the neutralization reactions also contributes to the volatilization/generation of SAM mist. Off-gas from the neutralization tanks is routed to the plant scrubber.

- In the Iron Reduction/AuPGM Precipitation Tanks, sulfur dioxide is added to reduce the iron from sulfite to sulfate. Then copper sulfide is added from the residual copper removal process to precipitate the PGM and gold. Off gas from the tanks is routed to the plant scrubber for SAM control.

- In the Residual Copper Removal Tanks, sodium hydrosulfate is used to precipitate copper as copper sulfide, which is fed to the Iron Reduction/AuPGM tanks or returned to the process at the autoclave feed tank Off gases from the copper removal tanks can contain small quantities of SAM and are routed to a centralized control device to control emissions.

- In the Mixed Hydroxide Precipitation Tanks, magnesium hydroxide is added to reduce the metal sulfates and to precipitate the Ni/Co/Zn out of solution for recovery. Off-gas from the Ni/Co/Zn precipitation tanks is routed to the plant scrubber for SAM emission control.

The Electrowinning process is also a source of SAM emissions. Electrowinning is an electro-chemical process. An electric charge is applied to the copper solution and copper is recovered on stainless steel cathodes. The electrolytic solution used in this process contains sulfuric acid. Sulfuric acid and oxygen gas are byproducts of this process. Oxygen bubbles form at the copper cathode and rise up through electrolyte. As oxygen bubbles break through the surface of the electrolyte, sulfuric acid aerosol (mist) is generated. Vapors from the Electrowinning process are collected by specially designed cell covers which minimize SAM generation and route the off gas to a control device for SAM emission control.

The individual emission units and stack numbers of Hydrometallurgical process sources are listed in Attachment A, Table A-1.

8.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various PM control technologies are discussed in Section 4.0 and Table 8.1. Potential control technologies for PM emissions are the following:

- Fabric filter (baghouse)

- Wet scrubber
- Electrostatic precipitator
- Wet electrostatic precipitator
- Centrifugal separation (cyclones)
- Good design methods & operating practices

8.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

Table 8.1 provides a list of potential control technologies for ore processing and metals recovery and summarizes technical feasibility.

Table 8.1 Ore Processing and Metal Recovery PM / PM_{10} Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	No	Materials in the process are wet. and would bind to the filters and/or clog the dust collection bins. SAM emissions from Electrowinning are liquid droplets and would cause similar problems
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	Yes	
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	No	Materials in the process are wet and would cause electrical shorts, coat the ESP plates and/or clog the dust collection binds. SAM emissions from Electrowinning are liquid droplets and would cause similar problems.
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	Yes Electrowinning and neutralization (plant scrubber)	No Autoclaves Particulate matter has high resistivity
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	No	Materials in the process are wet. and would coat centrifuge walls and/or clog the dust collection binds
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials.	Yes	

Particles must be able to accept an electrical change in order for an electrostatic precipitator to remove them. High resistivity prevents particulates from accepting electrical charges. The process flow sheet simulation developed for this project shows that the particulate matter from the autoclaves has high silica content. Silica is known to have a high electrical resistivity, which makes it difficult to remove in an electrostatic precipitator.

SAM is a significant constituent of particulate matter emitted by electrowinning, neutralization, and metal recovery sources. Therefore, baghouses and dry ESP's will not work in these applications. SAM emission controls will be the most effective controls for particulate emissions from these sources.

8.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

Emissions control effectiveness was evaluated for the remaining control technologies. The control equipment effectiveness analysis can be summarized as follows:

Table 8.2 Ranking of Remaining PM/PM_{10} Control Technologies for Autoclave System Off Gas

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	98% - 99% 0.005 gr/scf*
Base case	Good design methods & operating practices	NA

*Filterable PM as measured by EPA Method 5. Autoclave off-gas is nearly 100% water. Therefore, test results cannot be expressed on a dry basis.

Table 8.3 Ranking of Remaining PM/PM_{10} Control Technologies for Electrowinning

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	95% 0.005 gr/dscf*
1	Wet electrostatic precipitator	95% 0.005 gr/dscf*
Base case	SAME cell covers and other good design methods & operating practices	NA

*Filterable PM as measured by EPA Method 5

Table 8.4 Ranking of Remaining PM/PM10 Control Technologies for Hydrometallurgical Plant Tanks

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	98% - 99% 0.005 gr/dscf*
1	Wet electrostatic precipitator	98% - 99% 0.005 gr/dscf*
Base case	Good design methods & operating practices	NA

*Filterable PM as measured by EPA Method 5

8.5. Evaluation of PM and PM_{10} Control Technologies

The Hydrometallurgical plant operations are wet processes. The exhaust streams from these processes are wet and may contain aerosols and condensable particulates. Dry controls will not be feasible in these areas due to amount of water present in the exhaust streams. Wet scrubbers and wet ESP's are capable of controlling emissions from the Hydrometallurgical plant.

Emission control cost calculations indicate the particulate emission controls are economically feasible for all three source types.

The vendor design particulate control efficiencies for wet scrubbing are consistent with the highest levels of particulate control that can be achieved in practice:

- 99% for the Autoclave system exhaust streams
- 95% for the Electrowinning exhaust stream
- 99% for the neutralization and metal recovery tank vents (Hydrometallurgical plant tanks)

A 99% control efficiency represents the highest level of control achieved in practice by particulate controls.

The Electrowinning exhaust stream has a much lower particulate loading in the uncontrolled gas stream than the autoclave and neutralization/metal recovery tank streams. Therefore, a 95% control efficiency represents the highest level of particulate control for this source. The uncontrolled Electrowinning exhaust particulate loading is only 10% of the particulates in the neutralization/metal recovery exhaust, and it is only 2% of the autoclave system exhaust.

Wet scrubbing has a slightly higher energy use than wet ESP's due to the higher pressure drop needed to achieve emission control equivalent to the other control technologies. However, wet scrubbing controls are smaller than the other control devices and cost less to install and operate.

The PolyMet hydrometallurgical process emission control systems are designed to return scrubber water to the process. So, none of the potential control devices generates solid waste or wastewater. The hydrometallurgical process requires the addition of water. Water consumption requirements for the process exceed the amount required for operation of wet scrubbers. So, scrubber water from wet scrubbers and wet ESP controls can be returned to the hydrometallurgical process without generating wastewater.

8.6. Select Emission Control Technology for PM and PM10

The following performance limits are proposed for particulate controls:

- Autoclaves: PM/PM_{10} emission rate of 20.5 lb/hr (99% control efficiency)
- Electrowinning: 95% control efficiency or a total particulate concentration of 0.014 gr/scf.
- Neutralization/Metal recovery: 99% control efficiency or a total particulate concentration of 0.014 gr/scf.

The exhaust streams from these sources will contain SAM. Under EPA test Method 202, SAM is measured as inorganic condensable particulate matter. The presence of condensable particulate matter in these steams would suggest that the proposed PM_{10} limit should be higher than the proposed PM limit (Under MN rules, PM does not include inorganic condensable particulates). Individual limits for PM and PM_{10} are not feasible in these applications because the PM_{10} test method (Method 201A) cannot be used when liquid droplets are present. The droplets adversely affect operation of the cyclone used to separate PM_{10} from larger particles. It is also not possible to accurately assess the proportion of total particulate matter (including organic and inorganic condensable particulates) the will be collected on the filter versus that measured as condensable particulates.

PolyMet proposes a mass emission limit of 20.5 lb/hr PM/PM_{10} in lieu of a particulate concentration standard for the autoclave scrubber because the high moisture content of the autoclave exhaust makes it infeasible to predict particulate concentrations on a gr/dscf basis. Most of the autoclave exhaust stream will condense as water in the sample train with very little dry exhaust gas to measure. The proposed PM/PM_{10} emission control for the autoclave system is consistent with the highest level of particulate control which can be achieved for this type of facility. The design basis for particulate control from the autoclave system is 99% control. The 99% control efficiency is achieved through the use of two wet scrubbing systems in series. A 99% control efficiency design standard and use of a two stage control system are consistent with the highest level of particulate control. The EPA RBLC database does not include any determinations for this source type for comparison.

The proposed PM/PM_{10} emission control for the electrowinning system is consistent with the highest level of particulate control which can be achieved for this type of facility. The design basis for particulate control from the electrowinning system is 95% control. As noted above, particulate concentrations at the inlet of the electrowinning scrubber are considerably lower than the autoclave and neutralization/metal recovery systems. Pilot plant test data show that half of particulates in the Electrowinning exhaust are filterable particulates. The 95% control efficiency is consistent with meeting a 0.005 gr/dscf concentration of filterable particulate matter in the scrubber exhaust. So, 95% control is consistent with BACT for particulate emissions from material handling. The EPA RBLC database does not include any determinations for this source type for comparison. Arizona, Utah, and Montana have sources which use electrowinning for metal recovery. None of theses source have particulate matter emission limits.

The proposed PM/PM_{10} emission control for the neutralization/metal recovery system is consistent with the highest level of particulate control which can be achieved for this type of facility. The design basis for particulate control from the plant scrubber system is 99% control. The 99% control efficiency is achieved through the use of a single stage wet scrubbing system. Particulate concentrations in the inlet of the plant scrubber are 15% of the inlet loading to the autoclave scrubbers. So, it is reasonable to expect that a 99% control efficiency can be achieved in a single-stage scrubbing system. A 99% control efficiency performance standard is consistent with the highest level of particulate control. The EPA RBLC database does not included any determinations for this source type for comparison.

The proposed performance limit of 0.014 gr/scf is suggested as an alternative to control efficiency in cases where it is either impossible to conduct performance tests on the vent stream before the control device, or the particulate loading to the control device is too low to meet the control efficiency standard (i.e. the difference between the control device inlet concentration and the lowest particulate concentration that can be achieved with controls is less than the amount needed to meet the control efficiency standard). The concentration limit of 0.014 gr/scf is based on controlling filterable particulates to a concentration of 0.005 gr/scf and SAM to 5 ppm (0.009 gr/scf). A filterable particulate concentration of 0.005 gr/scf is consistent with high efficiency wet scrubbers for particulate emissions from material handling. A SAM concentration of 5 ppm is at or near the lowest concentrations which can be met by emission control equipment, and it is at or near the lowest concentrations which can be reliably measured by current performance test methods. Test results for the autoclave system will have to be reported on a wet basis because the autoclave exhaust stream is nearly 100% water. Electrowinning and neutralization/metal recovery can be reported on a dry basis.

Since particulate controls can be commissioned prior to startup and turned off after process equipment is shut down, no special limits are needed for startup or shutdown.

To establish compliance limits, PolyMet will test the autoclave stack, the Electrowinning Scrubber Stack and the Hydrometallurgical Plant Stack with both autoclaves running for PM using EPA Methods 5 and 202 or other approved methods using three (3) one-hour test runs. PolyMet suggests that the performance test methods be determined at a later date. The autoclave sources have high moisture contents and standard test methods may not be feasible. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating the autoclave, electrowinning and plant scrubbers will be set using the data collected during the performance test. The facility will demonstrate ongoing compliance based on the 24 hour average(s) of the process parameters established during the performance test.

A 20% opacity limit is recommended as BACT for visible emissions from the Hydrometallurgical Plant wet scrubbers. The scrubber exhaust streams contain droplets of entrained scrubber water and the exhaust gas is saturated with water vapor. The water vapor condenses to form additional water droplets when the exhaust plume comes in contact with the atmosphere. Both of these conditions contribute to formation of a wet plume which is visible to the eye due solely to water droplets in the plume. In cases where visible water plumes are present, opacity readings must be taken at the point where all water has evaporated. Since it is difficult to determine the exact point in the plume where this occurs, a 20% opacity limit is recommended to address this uncertainty. If PolyMet identifies visible emissions from Hydrometallurgical Plant wet scrubbers in excess of 20%, it will take corrective action as soon as it is practicable to do so in accordance with the operation and maintenance plan for the affected control device.

8.7. Identify Potential SAM Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Evaluation. Descriptions of the various SAM control technologies are discussed in Section 4.0 and in Table 8.5. Potential control technologies for SAM emissions from metals recovery are the following:

- Wet scrubbing. Lime, limestone or other reagents added to the scrubbing water as needed
- Wet electrostatic precipitator (WESP)
- Dry scrubbing - spray dryer absorption
- Dry sorbent injection
- Good design methods and operating practices

8.8. Eliminate Technically Infeasible SAM Emission Controls

Table 8.5 provides a list of potential control technologies for the Hydrometallurgical plant and summarizes technical feasibility.

Table 8.5 Hydrometallurgical Plant SAM Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Wet scrubbing (absorption)	Wet scrubbing involves scrubbing the exhaust gas stream with water. If scrubbing water pH is too low for effective sulfuric acid removal, reagent dissolved in water or suspended in a water slurry may be used. The process takes place in a scrubbing tower(s). If a reagent is used, SAM in the gas stream reacts with the lime or limestone slurry to form calcium sulfite ($CaSO_3 \bullet 2H_2O$) and calcium sulfate ($CaSO_4$) or sodium sulfate ($NaSO_4$)	Yes	
Wet electrostatic precipitator (WESP)	A Wet ESP applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. A Wet ESP uses a water spray to remove particulate matter from the collection plates. The water spay also absorbs SAM. A basic reagent may be added to the water spray to facilitate the removal of SAM	Yes	
Dry scrubbing - spray dryer absorption	Spray dryer absorption is a dry scrubbing system that sprays a fine mist of lime slurry into an absorption tower where the SAM is absorbed by the droplets. The heat from the exhaust gas causes the water to evaporate before the droplets reach the bottom of the tower. This leads to the formation of a dry powder which is carried out with the gas and collected with a fabric filter. Spray dryer absorption control efficiency is typically in the 70 to 90 percent range.	No	Autoclave exhaust streams are over 90% water vapor; so, the lime slurry spray would not dry sufficiently for collection in a baghouse.
Dry sorbent injection	Dry sorbent injection involves the injection of a lime or limestone powder into the boiler or process exhaust gas stream. The spent sorbent is collected by a particulate removal device such as a baghouse or ESP Sorbent injection control efficiency is typically in the 50 percent range.	No	Autoclave exhaust streams are over 90% water vapor; so, the lime slurry spray would not dry sufficiently for collection in a baghouse.
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials. SAME* electrowinning cell covers are proposed for the collection system for SAM emissions from the electrowinning system.	Yes	

*SAME Ltda. is a Chilean company which produces special covers which are designed to reduce SAM emissions from electrowinning cells.

For a description of the SAME sulfuric acid mist control system see the article “Copper Electrowinning in the Absence of Acid Mist: Six Years of Industrial Application” located in Emission Control Technology Review Attachment M.

8.9. Rank Remaining SAM Controls by Effectiveness

Emissions control effectiveness was evaluated for the remaining control technologies. The control equipment effectiveness analysis can be summarized as follows:

Table 8.6 Ranking of Remaining SAM Control Technologies for Autoclave System Off Gas

SAM Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	98% - 99% 5 ppm
1	Wet electrostatic precipitator	95% 5 ppm
Base case	Good design methods & operating practices	NA

Table 8.7 Ranking of Remaining SAM Control Technologies for Electrowinning

SAM Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	95% 5 ppm
1	Wet electrostatic precipitator	95% 5 ppm
Base Case	SAME cell covers and other good design methods & operating practices	NA

Table 8.8 Ranking of Remaining SAM Control Technologies for Hydrometallurgical Plant Tanks

SAM Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Wet scrubber	98% - 99% 5 ppm
1	Wet electrostatic precipitator	98% - 99% 5 ppm
Base case	Good design methods & operating practices	NA

8.10. Evaluation of SAM Control Technologies

The Hydrometallurgical plant operations are wet processes. Dry controls for SAM will not be feasible for these sources due to amount of water present in the exhaust streams. Wet scrubbers and wet ESPs are capable of controlling Hydrometallurgical plant emissions. Wet ESP’s are not feasible for particulate control on the autoclaves due to high resistivity; so, it is not practical to consider wet ESP’s when a wet scrubber must be installed for autoclave particulate emission control.

Emission control cost calculations indicate the SAM emission controls are economically feasible for all three source types.

The vendor design SAM control efficiencies for wet scrubbing are consistent with the highest levels of SAM control that can be achieved in practice:

- 99% for the autoclave system exhaust streams
- 95% for the electrowinning exhaust stream
- 99% for the neutralization and metal recovery streams

A 99% control efficiency represents the highest level of control achieved in practice for absorption systems.

The electrowinning exhaust stream has a much lower SAM concentration than the other sources. Concentrations in the uncontrolled gas stream are less than 1% of the SAM concentrations in the autoclave and neutralization/metal recovery streams. Therefore, a 95% control efficiency represents the highest level of SAM control for this source.

Wet scrubbing has a slightly higher energy use than wet ESPs due to the higher pressure drop needed to achieve equivalent emission control. However, wet scrubbing controls are smaller than wet ESPs and cost less to install and operate.

The PolyMet hydrometallurgical process emission control systems are designed to return scrubber water to the process. Therefore, none of the potential control devices directly generate solid waste. The hydrometallurgical process requires the addition of water. Water consumption requirements for the process exceed the amount required for operation of wet scrubbers and the scrubber blowdown water is suitable for recycling to the process. Therefore, scrubber water from wet scrubbers and wet ESP controls can be returned to the hydrometallurgical process without generating wastewater.

8.11. Select Emission Control Technology for SAM

The following performance limits are proposed for SAM controls:

- Autoclaves: 99% control efficiency or a SAM concentration of 5 ppm.
- Electrowinning: 95% control efficiency or a SAM concentration of 5 ppm.
- Neutralization/Metal recovery: 99% control efficiency or a SAM concentration of 5 ppm.

The proposed emission control for the autoclave system is consistent with the highest level of SAM control which can be achieved for this type of facility. The design basis for particulate control from the autoclave system is 99% control. The 99% control efficiency is achieved through the use of wet scrubbing systems. A 99% control efficiency performance standard is consistent with the highest level of SAM emission control achievable in practice. The EPA RBLC database does not include any determinations for this source type for comparison.

The proposed emission control for the electrowinning system is consistent with the highest level of SAM control which can be achieved for this type of facility. PolyMet proposes to install a SAME collection and control system for electrowinning. The SAME system includes specially designed electrowinning cell covers. The covers are designed to contain SAM emissions from the electrowinning process while minimizing the amount of purge air needed. The design basis for SAM control from the electrowinning system is 95% control. As noted above, SAM concentrations at the inlet of the electrowinning scrubber are considerably lower than the autoclave and neutralization/metal recovery systems. The EPA RBLC database does not include any determinations for this source type for comparison. Arizona, Utah, and Montana have sources which use electrowinning for metal recovery. The Montana Department of Environmental Quality did not have any information on SAM control from the electrowinning source in that state. The Arizona Department of Environmental Quality (AZ DEQ) reports a 90% SAM control efficiency for electrowinning sources. The 2000 Title V permit for Kennecott in Utah, has SAM emission limits in the range of 0.005 gr/dscf – 0.009 gr/dscf for various electrowinning metal recovery processes. Compliance is demonstrated using EPA Method 8. The proposed SAM 95% control efficiency is higher than the control efficiency reported by the AZ DEQ. The proposed 5 ppm SAM limit is equivalent to 0.009 gr/dscf which consistent with the SAM limits in the Kennecott permit. . None of the Kennecott processes are used to recover copper, so it cannot be assumed that a SAM concentration of 0.005 gr/dscf can be achieved for copper electrowinning.

The proposed SAM emission control for the Hydrometallurgical process tanks is consistent with the highest level of SAM control which can be achieved for this type of facility. The design basis for SAM control from the plant scrubber system is 99% control. The 99% control efficiency is achieved through the use of a wet scrubbing system. A 99% control efficiency performance standard is consistent with the highest level of SAM control.

The proposed performance limit of 5 ppm SAM is suggested as an alternative to control efficiency in cases where it is either impossible to conduct performance tests on the vent stream before the control device, or the SAM concentration at the inlet of the control device is too low to meet the control efficiency standard (i.e. the difference between the control device inlet concentration and the lowest SAM concentration that can be achieved with controls is less than the amount needed to meet the control efficiency standard).   A SAM concentration of 5 ppm is at or near the lowest concentrations which can be met by emission control equipment, and it is at or near the lowest concentrations which can be reliably measured by current performance test methods. Test results for the autoclave system will have to be reported on a wet basis because the Autoclave exhaust stream is nearly 100% water. Electrowinning and the Hydrometallurgical tank emissions can be reported on a dry basis.

Since SAM emission controls can be commissioned prior to startup and turned off after process equipment is shut down, no special limits are needed for startup or shutdown for the electrowinning and neutralization/metal recovery sources and the autoclave system. PolyMet will follow good operating practices for minimizing emissions by venting autoclave gas through the scrubber system until insufficient pressure exists to continue scrubber operation. That will minimize the amount of SAM which is emitted to the atmosphere during shutdown.

To establish compliance limits, PolyMet will test for SAM using EPA or other approved methods using three (3) one-hour test runs. PolyMet suggests that the performance test methods be determined at a later date. The autoclave exhaust streams have very high moisture contents and standard test methods may not be feasible. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating the autoclave, electrowinning and plant scrubbers will be set using the data collected during the performance test. The facility will demonstrate ongoing compliance based on the 24-hour average(s) of the process parameters established during the performance test.

To establish compliance limits, PolyMet will test for PM using EPA Method 5 using three (3) one-hour test runs. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating the material handling emission control equipment will be set using the data collected during the performance test. The facility will demonstrate ongoing compliance based on the 24-hour average(s) of the process parameters established during the performance test.

8.12. Autoclave System Volatile Organic Compound (VOC) Emissions

VOCs are emitted due to the volatilization and breakdown of organic additives to the flotation process under the elevated temperature and oxidizing conditions present in the autoclaves. Pilot plant testing results indicate that uncontrolled VOC concentrations are in the 100 ppm range. VOC emissions will be minimized by the collateral VOC absorption occurring in the wet scrubbers used for PM/SAM control. The scrubbers are conservatively assumed to have a 50% control efficiency for VOC. Most of the organic compounds used in the flotation process, which is the source of organic compounds fed to the autoclaves, are oxidized and soluble in water (e.g. xanthates and glycol ethers). The composition of the organic compounds emitted from the autoclaves was not determined during the pilot plant testing. If the organic compounds in the autoclave feed undergo further oxidation, it is likely that the compounds emitted would also be oxidized water soluble compounds. Absorption typically has a control efficiency of 90% - 95% for water soluble organic compounds.

8.13. Identification of Potential VOC Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various VOC control technologies are discussed in Section 4.0 and Table 8.9 Potential control technologies for VOC emissions are the following:

- Thermal Oxidation (Recuperative and Regenerative)
- Catalytic Oxidation
- Carbon Adsorption
- Wet Scrubbing (Absorption)
- Good Design and Operating Practices

8.14. Elimination of Technically Infeasible VOC Control Options

Table 8.9 summarizes the feasibility of potential control technologies for control of VOC emissions from autoclave operation. Uncontrolled autoclave system exhaust VOC concentrations are in the < 100 ppm range.

Table 8.9 Technical Feasibility of VOC Control Technologies for Autoclave Operation

VOC Emission Control Technologies Considered for Emission Control Technology Analysis			
Technology	**Description**	**Feasible? Yes or No**	**Reason Not Feasible**
Thermal Oxidizer (Recuperative and Regenerative)	A thermal oxidizer uses high temperature and residence time to oxidize VOC to water and CO_2. This may be accomplished using an add-on oxidizer or a duct burner.	Yes	
Catalytic Oxidizer	Catalytic oxidizers use a bed of catalyst that facilitates the oxidation of combustible gases. The catalyst increases the reaction rate and allows the conversion of VOC at lower temperatures than a thermal incinerator.	No	Autoclave off-gas contains catalyst poisons
Carbon Adsorption	Waste gas stream flows through an activated carbon bed. The organic compounds in the waste gas stream are collected at the interface of the activated carbon by intermolecular forces creating a VOC-rich carbon.	No	Moisture content of autoclave off gas is too high for effective VOC collection
Wet Scrubber	An absorption scrubber typically consists of a contact tower. A scrubbing liquid is sprayed down the tower as waste gas is blown in the bottom of the tower, creating contact between the liquid and gas. Soluble gaseous compound(s) then dissolve in the scrubbing liquid and are removed from the waste gas.	Yes	Autoclave system has wet scrubbing for PM/PM_{10} and SAM control
Good Design and Operating Practices	Well designed and operated equipment can reduce the amount of VOCs emitted.	Yes	

Oxidation catalysts are susceptible to poisoning by sulfur, arsenic and lead compounds. All of these materials are present in the autoclave exhaust. Therefore, catalytic oxidation is not feasible in this application due to the potential for catalyst poisoning by materials present in the autoclave exhaust.

The high water content of autoclave off-gas stream makes carbon adsorption infeasible for controlling VOCs from the autoclave. The exhaust stream from the autoclave system is over 90%

water vapor. Activated carbon is only effective for removing VOCs in streams up to 50% relative humidity. Above 50% relative humidity, capillary condensation creates water droplets which plug pores and block absorption sites in the activated carbon.

8.15. Ranking of Remaining VOC Control Technologies by Control Effectiveness

The only remaining VOC control technologies are as follows.

Table 8.10 Ranking of Remaining VOC Control Technologies for Autoclave Operation

VOC Control Technology Ranking		
Rank	**Technology**	**% Efficiency**
1	Thermal Oxidizer	98% - 99%
1	Regenerative Thermal Oxidizer	98% - 99%
2	Wet Scrubber	NA Base Case Autoclave has wet scrubbing system
3	Good Design and Operating Practices	NA Base Case

8.16. Evaluation of Most Effective VOC Control Technologies

Since the wet scrubbing system and good design and operating practices are inherent parts of the process no additional cost will be incurred. Good operating practices are limited to proper use of organic ore concentration agents to minimize VOC emissions. Selection of low VOC emitting compounds is limited due to the nature of the separation process.

The exhaust stream from the autoclave system is over 90% water vapor. This may present treat ability problems for add-on controls. In the case of oxidation, air will have to be added to the stream so sufficient oxygen is present for VOC oxidation. Potential water condensation can cause operational problems and cause corrosion.

Table 8.11 Evaluation of Most Effective VOC Control Technologies for Autoclave Operation

Control Technology Effectiveness Evaluation					
Rank	**Technology**	**Amount Removed (tpy)**	**Installed Capital Cost $**	**Annualized Cost ($MM)**	**Control Cost ($/ton removed)**
1	Thermal Oxidizer	106.7	$845,871	$3,405,629	$31,903
1	Regenerative Thermal Oxidizer	106.7	$2,449,140	$900,220	$8,433
2	Wet Scrubber (Absorption)	NA Inherent Controls	NA Inherent Controls	NA	NA
3	Good Design and Operating Practices	NA Inherent Controls	NA Inherent Controls	NA	NA

At over $8,400 per ton of VOC removed, add-on controls are economically infeasible. At over 90% water vapor, the high moisture content of the stream is also a concern. Use of oxidation controls would require a significant amount of fuel.

8.17. Autoclave System VOC Emission Control Technology Selection

Good design and operating practices are selected as the appropriate emission control technology for VOC control from ore concentration plus the use of the process integrated scrubbing system proposed for PM and SAM control. No add-on controls are recommended due to the low concentrations present in the flotation cells.

A limit of 50 ppm VOC is recommended. This reflects the inherent control present in the autoclave wet scrubbing system.

8.18. Copper Extraction Volatile Organic Compound (VOC) Emissions

VOC emissions are from vessel working losses. Organic material used for copper extraction has a low volatility. The average VOC concentration for copper extraction was 5.9 ppm during pilot plant testing.

8.19. Identification of Potential VOC Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review analysis. Descriptions of the various VOC control technologies are discussed in Section 4.0 and

Potential control technologies for VOC emissions are the following:

- Thermal Oxidation (Recuperative and Regenerative)
- Catalytic Oxidation
- Carbon Adsorption
- Wet Scrubbing (Absorption)
- Good Design and Operating Practices

Elimination of Technically Infeasible VOC Control Options

Table 8.12 summarizes the feasibility of potential control technologies for control of VOC emissions from Copper Extraction. Conditions are similar to distillate storage tanks which do not require VOC controls. At 5.9 ppm, VOC concentrations are too low for add-on controls to be technically feasible.

Table 8.12 Technical Feasibility of VOC Control Technologies for Copper Extraction

VOC Emission Control Technologies Considered for Emission Control Technology Analysis			
Technology	**Description**	**Feasible? Yes or No**	**Reason Not Feasible**
Thermal Oxidizer (Recuperative and Regenerative)	A thermal oxidizer uses high temperature and residence time to oxidize VOC to water and CO_2. This may be accomplished using an add-on oxidizer or a duct burner.	No	VOC concentrations too low
Catalytic Oxidizer	Catalytic oxidizers use a bed of catalyst that facilitates the oxidation of combustible gases. The catalyst increases the reaction rate and allows the conversion of VOC at lower temperatures than a thermal incinerator.	No	VOC concentrations too low
Carbon Adsorption	Waste gas stream flows through an activated carbon bed. The organic compounds in the waste gas stream are collected at the interface of the activated carbon by intermolecular forces creating a VOC-rich carbon.	No	VOC concentrations too low

Table 8.12 Technical Feasibility of VOC Control Technologies for Copper Extraction

VOC Emission Control Technologies Considered for Emission Control Technology Analysis			
Technology	**Description**	**Feasible? Yes or No**	**Reason Not Feasible**
Wet Scrubber	An absorption scrubber typically consists of a contact tower. A scrubbing liquid is sprayed down the tower as waste gas is blown in the bottom of the tower, creating contact between the liquid and gas. Soluble gaseous compound(s) then dissolve in the scrubbing liquid and are removed from the waste gas.	No	VOC concentrations too low
Good Design and Operating Practices	Well designed and operated equipment can reduce the amount of VOCs emitted.	Yes	

Add-on control devices (thermal and catalytic oxidation, carbon adsorption and absorption) are considered technically infeasible in this application due to the low concentrations of VOC in the copper extraction system. Due to the low volatility of the copper extraction compounds, VOC concentrations are at or below the level of control achievable by add on controls.

8.20. Ranking of Remaining VOC Control Technologies by Control Effectiveness

The only remaining VOC control technologies are good design and operating practices

Table 8.13 Ranking of Remaining VOC Control Technologies for Copper Extraction

VOC Control Technology Ranking		
Rank	**Technology**	**% Efficiency**
1	Good Design and Operating Practices	NA Base Case

8.21. Evaluation of Most Effective VOC Control Technologies

Since good design and operating practices are inherent parts of the process no additional cost will be incurred. Good operating practices are limited to proper use of frothing agents to minimize VOC emissions. Low volatility compounds are used. However, selection of low VOC emitting compounds is limited due to the nature of the solvent extraction process.

Table 8.14 Evaluation of Most Effective VOC Control Technologies for Copper Extraction

Control Technology Effectiveness Evaluation					
Rank	Technology	Amount Removed (tpy)	Installed Capital Cost $	Annualized Cost ($MM)	Control Cost ($/ton removed)
1	Good Design and Operating Practices	NA Inherent Controls	NA Inherent Controls	NA	NA

8.22. Copper Extraction VOC Emission Control Technology Selection

Good design and operating practices are selected as the appropriate emission control technology for VOC control from copper extraction. No add-on controls are recommended due to the low volatility of the copper extraction compounds and resulting low emissions.

9. Product Packaging

9.1. Overview of Hydrometallurgical Plant Product Packaging

Mixed Nickel/Cobalt/Zinc hydroxide and AuPGM concentrate are recovered from thickeners and dewatered in filter presses. The filter cake is washed and placed in a storage hopper. The final product flows from the hopper into the bagging equipment and is packaged for shipment.

Both the mixed hydroxide and PGM concentrate will be loaded as a wet filter cake. Since both filter cake products are wet, no particulate emissions will occur during packaging. Thus, no particulate matter emission controls are need for product packaging.

10. Flotation Concentrate Material Handling

10.1. Overview of Flotation Concentrate Material Handling

After the nickel and copper rich flotation concentrates leave the concentrate dryers, they will be transported pneumatically with medium pressure blower air and enclosed pneumatic conveyors to one of two concentrate silos. From the silos, the concentrate will be pneumatically transferred to the rail car loadout system. Rail loadout includes loading arms with a retractable loading spout which will transport the concentrate to enclosed rail cars. Each loading arm will have and integrated dust collection system and hatch seals in order to prevent product loss. A fan will draw dust exhausted from the railcar through a particulate control device. As a result of this concentrate material handling, PM and PM10 will be emitted.

10.2. Identify Potential PM and PM_{10} Emission Control Technologies

Table 10.1 provides a list of potential control technologies for material handling and summarizes technical feasibility.

Table 10.1 Concentrate Material Handling PM / PM_{10} Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	Yes	
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	Yes	
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	No	No - Low flow sources The flow rate for theses sources is below the capacity of commercially available equipment.
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	No	No - Low flow sources The flow rate for theses sources is below the capacity of commercially available equipment.
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	Yes	
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials.	Yes	

10.3. Rank Remaining PM and PM_{10} Controls by Effectiveness

Fabric filters are the most effective control technology in this application. The control technology rankings are as follows:

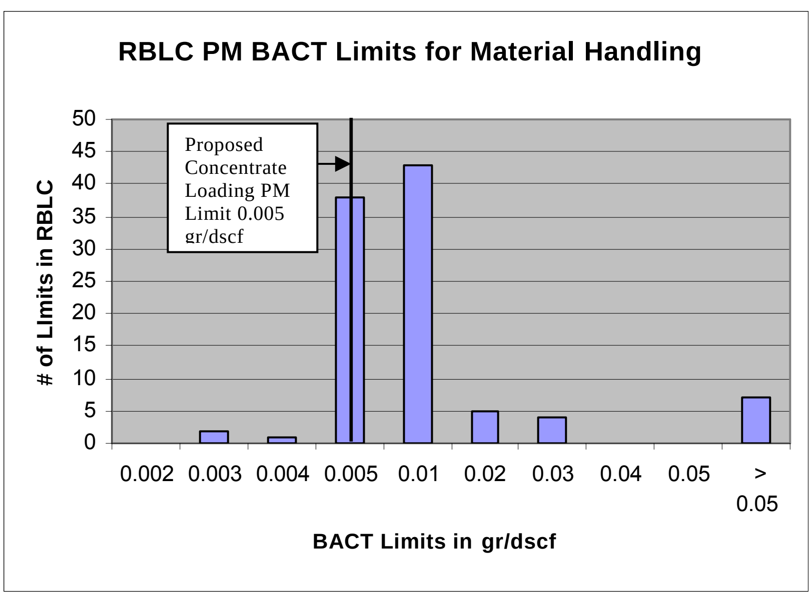
Table 10.2 Concentrate Material Handling PM / PM_{10} Control Technology Ranking

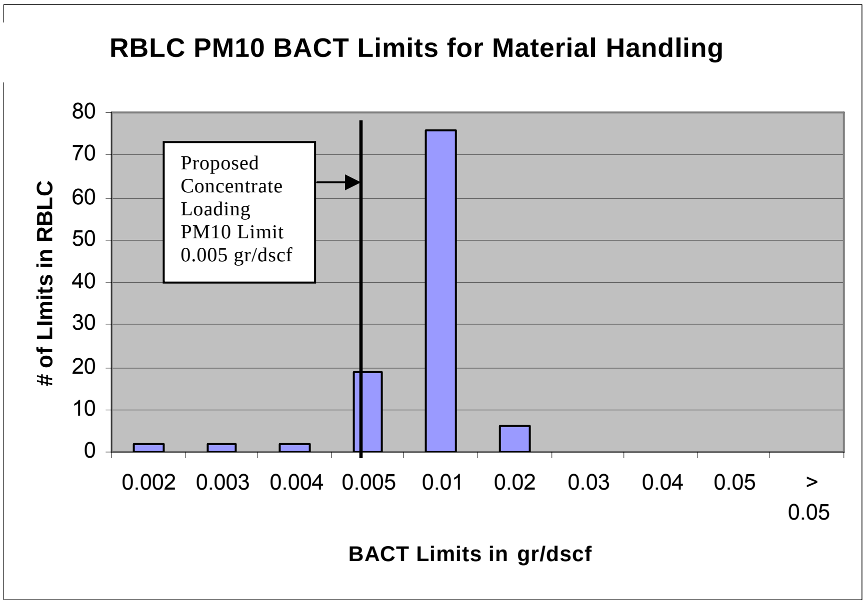
Rank	Technology	% Efficiency/Outlet Concentration
1	Fabric filter (baghouse)	98% - 99+% or 0.005 gr/dscf*
2	Wet scrubber	95% - 99+% or 0.006 gr/dscf*
3	Centrifugal separation (e.g. cyclones)	50 - 80
Base case	Good design methods & operating practices	NA

10.4. Evaluation of PM and PM_{10} Control Technologies

Fabric filters are the most effective control technology available for controlling the PM/PM_{10} emissions from dry concentrate material handling and provide the least environmental impact (i.e. wet scrubbing would require water discharge handling and treatment). Because PolyMet is selecting the top control device and economic evaluation is not warranted.

PolyMet proposes a limit of 0.005 gr/dscf for PM and PM_{10} as measured by EPA Method 5. The proposed limit is consistent with recent BACT determinations for material handling as listed in Attachment L, Table L-1A, Table L-1B, Table L-2A and Table L-2B. The proposed BACT limit is also consistent with the Taconite MACT standard for new sources. The proposed PM/PM10 limit of 0.005 gr/dscf is consistent with the vast majority of recent BACT determinations, and is lower than the median of recent BACT determinations.





Tables summarizing Attachment L RBLC data are located in Section 7.6

To establish compliance limits, PolyMet will test one of the two identical concentrate silos and the railcar loading system for PM using EPA Method 5 using three (3) one-hour test runs. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating concentrate material handling emission control equipment will be set using the data collected during the performance test. The facility will demonstrate ongoing compliance based on the 24-hour average(s) of the process parameters established during the performance test.

A 7% opacity limit is recommended as BACT for visible emissions from additive material handling equipment at which particulate emissions are vented through a stack or similar opening at which dry particulate controls are used (i.e. the average opacity of material handling equipment cannot exceed 7% for more the one 6-minute period during an hour). A 7% opacity limit is consistent with the requirements of NSPS Subpart LL standards which are applicable to metallic ore handling equipment at the Plant Site. If PolyMet identifies opacity in excess of the limits above from stacks on additive handling equipment, it will take corrective action as soon as it is practicable to do so per the requirements of the operation and maintenance plan for the affected control device.

11. Lime and Limestone Processing

11.1. Overview of Lime and Limestone Processing

Lime and limestone are used as neutralizing agents in the hydrometallurgical process. Depending on the type of limestone and the delivery method, the limestone may have to be crushed and/or milled prior to use. Both materials are slurried before addition to the process.

Lime is delivered by truck and pneumatically unloaded into the storage silo. The lime is transferred from the silo to the lime slaker by screw conveyor. The lime is milled and hydrated in the slaker. The slurry of hydrated lime is transferred to the slurry tank and on to the hydrometallurgical process from the slurry tank. Lime hydration is an exothermic process, and the heat generated by the slaking process vaporizes water. Water vapor exhausted by the slaker contains entrained particulates; the exhaust is scrubbed to capture these particles.

Crushed limestone is delivered by truck and rail. Delivery by truck is temporary measure, and it is expected to occur only for the first two years of operation.

Limestone delivered by rail is unloaded into a hopper in an enclosed building then placed in a storage pile via a stacker conveyor. Limestone is moved from the storage pile to a reclaim pocket by front end loader. It is then transferred to a bunker via conveyors until being fed to a crusher. Crushed limestone is conveyed to the limestone mix tank where the crushed limestone is mixed with water to form a slurry, so it can be pumped to the concentrator building. The subsequent milling is accomplished in one of the existing reclaim mills in the concentrator building. The limestone is in slurry form after the mix tank, so no emissions occur.

Limestone delivered by truck is dumped into a screening grizzly. Properly sized limestone is transported to existing milling equipment in the concentrator building via existing conveyors, a fine ore bin, and a fine ore feeder. One of the existing milling lines consisting of a rod mill and ball mill in series will be used for the milling operation. The milling process is wet, so no emissions will occur.

Material unloading, drops from trucks, railcars, front end loaders, screens, storage bins, conveyors, and crushers are sources of PM and PM_{10} emissions. In the rail system, conveyor drops onto the stacker conveyor, drops onto the storage pile and drops to/from the reclaim bin are fugitive sources.

In the truck system, truck unloading, screening, and conveyor transfers are fugitive sources of emissions.

Limestone can also be delivered as a ground powdered product ready for use in the process. A final decision has not been made on which option to utilize. Under this option, powdered limestone would be transferred from railcars to existing bentonite silos pneumatically and then transferred to a mix tank where it would be mixed with water to form a slurry for use in the process. Any air vented from the pneumatic system would be filtered with a baghouse or similarly performing pollution control equipment before discharge.

Emission controls for fugitive sources will be addressed by the facility's fugitive dust control plan.

The individual emission units and stack numbers of the lime and limestone processing sources are listed in Attachment A, Table A-1.

11.2. Identify Potential PM and PM_{10} Emission Control Technologies

Particulate matter emissions are the result of lime and limestone material handling, screening, and crushing as these materials are moved from truck/rail delivery, to storage and into the lime slaker, the limestone mix tank or the milling line. The lime slaker is also a potential source of particulate emissions.

Table 11.1 provides a list of potential control technologies for material handling and summarizes technical feasibility.

Table 11.1 Material Handling PM / PM_{10} Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	Yes	No – Sources with high moisture content cause filter plugging. High moisture sources include the lime slaker and limestone mix tank
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	Yes	
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	Yes High flow sources	No - Low flow sources The flow rate for theses sources is below the capacity of commercially available equipment. Low flow sources include the reclaim hopper (EU 328, 329) and the truck unloading system (FS 035, 036, 037).
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	Yes High flow sources	No - Low flow sources The flow rate for theses sources is below the capacity of commercially available equipment. Low flow sources include the reclaim hopper (EU 328, 329) and the truck unloading system (FS 035, 036, 037).
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	Yes High flow sources	No - Low flow sources The flow rate for these sources is below the capacity of commercially available equipment. Low flow sources include the limestone reclaim conveyor and limestone processing for material delivered by truck.
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials.	Yes	

11.3. Rank Remaining PM and PM_{10} Controls by Effectiveness

Fabric filters are the most effective control technology in this application. The control technology rankings are as follows:

Table 11.2 Lime/Limestone Processing PM / PM_{10} Control Technology Ranking

Rank	Technology	% Efficiency/Outlet Concentration
1	Fabric filter (baghouse)	98% - 99+% or 0.005 gr/dscf*
2	Wet scrubber	95% - 99+% or 0.005 gr/dscf*
3	Centrifugal separation (e.g. cyclones)	50 - 80
Base case	Good design methods & operating practices	NA

11.4. Evaluation of PM and PM_{10} Control Technologies

Fabric filters are the most effective control technology available for controlling the PM/PM_{10} emissions from dry lime/limestone processing. In addition, the material collected can be returned to the process as a dry powder

For sources where water may adversely affect a fabric filter, wet scrubbers are the best option. High moisture sources include the lime slaker and limestone mix tank. Fabric filters are prone to plugging in this application because free water and/or high humidity will make the filter cake wet and sticky. In the lime slaker, water is added as part of the slaking process. So, the scrubber water discharge may be routed directly to the slaker.

The conveyor discharge to the limestone mix tank will be enclosed, so air movement will not affect particulate emissions from this source. In addition, the conveyor discharge drops directly into water; so no dust is generated from impact of the crushed limestone on a hard surface. If feasible, a water spray system may be installed to further reduce dust emissions from this source.

Conveyors from the reclaim hopper (part of rail haul option) and the truck unloading system are not large enough particulate sources for controls to be cost effective. Control costs for the reclaim sources were estimated by assuming a 1 gr/dscf loading and back calculating the air flow rate (537 acfm). The air flow rate was used to calculate control equipment costs. This cost estimate does not include the cost of installing enclosures; so the actual installed costs will be higher. Table 11.3 summarizes the control cost analysis. At over $25,000 per ton of particulate removed, add-on controls are economically infeasible. The control costs for the limestone truck unloading system are similar because the emission rate from truck unloading is nearly the same as the reclaim emission rate (25.6 t/yr vs. 20 t/yr).

Table 11.3 Evaluation of Most Effective PM/PM10 Control Technologies for Limestone Reclaim Sources

Control Technology	Outlet Concentration	Emission Reduction T/yr	Installed Capital Cost $	Annualized Operating Cost $/yr	Pollution Control Cost $/ton
Wet scrubber	0.006 gr/dscf*	20	$44,839	$247,997	$26,306
Baghouse	0.005 gr/dscf*	20	$104,674	$256,797	$27,181

*Total PM as measured by EPA Methods 5 (filterable) and 202 (condensable)

Detailed control cost calculations for Table 11.3 are in Emission Control Technology Review Attachment I, Material Handling Control Cost Calculations - Limestone Reclaim.

11.5. Select Emission Control Technology for PM and PM_{10}

For dry material handling and processing, fabric filters are recommended as the appropriate emission control technology because fabric filters are the top control option in this application. Most of the sources in lime and limestone service process dry pebble lime and limestone.

For sources where water may adversely affect a fabric filter, wet scrubbers or inherently lower emitting equipment are recommended as the appropriate emission control technology because fabric filters would be prone to plugging. High moisture sources include the lime slaker and limestone mix tank.

For limestone delivered by rail and all lime deliveries, PolyMet proposes a limit of 0.005 gr/dscf for PM and PM_{10} as measured by EPA Method 5. for dry lime/limestone processing sources and 0.006 gr/dscf for PM and PM_{10} as measured by EPA Methods 5 and 202 on wet lime/limestone processing sources. This limit would only apply to sources directly vented to a stack. The proposed limit is consistent with recent BACT determinations for material handling as listed in Attachment L, Table L-1A, Table L-1B, Table L-2A and Table L-2B. The proposed BACT limit is also consistent with the Taconite MACT standard for new sources. The proposed PM/PM10 limit of 0.005 gr/dscf is consistent with the vast majority of recent BACT determinations, and is lower than the median of recent BACT determinations. Charts and tables summarizing Attachment L RBLC data are located in Section 7.6

For limestone delivered by truck, PolyMet proposes an emission limit of 5.5 lb/hr PM/PM_{10} for the limestone processing emissions group. Compliance with this limit will be demonstrated by EPA Methods 5 and 202. This emission rate is equivalent to a 97% control efficiency. Limestone delivery by truck is expected to occur during the first two (2) years of plant operation. Limestone delivered by truck will be processed by existing milling equipment in the concentrator building via existing conveyors, a fine ore bin, and a fine ore feeder. Because this is a temporary measure, PolyMet proposes to use existing Type W Rotoclones for particulate controls. The Type W Rotoclones on the bin and feeder were installed in the 1990's. Existing rotoclones installed in the 1990's on bins and feeders that will be immediately used to process ore will be replaced with baghouses. An appropriately sized unit will be moved to the conveyor transfer point where limestone will be handled. The Type W rotoclones have a design control efficiency of 97%; no performance test data are available for these scrubbers. A 97% control efficiency is consistent with control efficiency range for high efficiency particulate scrubbers as noted in Table 11.2. The Type W Rotoclones will be replaced with baghouses before this equipment is put into ore crushing service.

No add-on control are recommended for the limestone reclaim hopper system (EU 328, 329) and the truck unloading system (FS 035, 036, 037) because the cost of add-on controls is economically infeasible. Best practices for minimizing emissions from these sources include installation of enclosures or wind breaks around material drops where feasible.

No add-on controls are recommended for the limestone conveyor to the crusher (EU 324) and the conveyor to the limestone mix tank (EU 224) because the cost of add-on controls is economically infeasible. The particulate emission rate from each of these sources is 1.3 ton/yr. Calculating control costs in the same manner as the reclaim system would yield similar results. Best practices for minimizing emissions from these sources include installation of enclosures around the material drops where feasible.

To establish compliance limits, PolyMet will test for PM using EPA Method 5 using three (3) one-hour test runs. During the performance test, the facility will measure emission control equipment process parameters. Process parameter limits for operating lime and limestone processing emission control equipment will be set using the data collected during the performance test. The facility will demonstrate ongoing compliance based on the 24-hour average(s) of the process parameters established during the performance test.

A 7% opacity limit is recommended as BACT for visible emissions from limestone crushing and screening equipment using dry particulate controls at which particulate emissions are vented through a stack or similar opening (i.e. the average opacity of limestone crushing and material handling equipment cannot exceed 7% for more the one 6-minute period during an hour). A 7% opacity limit is consistent with the requirements of the applicable NSPS (Subpart OOO). If PolyMet identifies visible emissions from stacks at limestone crushing and screening equipment, it will take corrective action as soon as it is practicable to do so per the applicable and maintenance plan for the affected control device

A 20% opacity limit is recommended as BACT for visible emissions from limestone crushing and screening equipment using wet particulate controls at which particulate emissions are vented through a stack or similar opening (i.e. the average opacity of limestone crushing and material handling equipment cannot exceed 20% for more the one 6-minute period during an hour). Wet scrubber exhaust streams contain droplets of water. This creates a wet plume which is visible to the eye due solely to water droplets in the plume. In cases where visible water plumes are present, opacity readings must be taken at the point where all water has evaporated. Since it is difficult to determine the exact point in the plume where this occurs, a 20% opacity limit is recommended to address this uncertainty. The 7% opacity limit of NSPS (Subpart OOO) does not apply when wet scrubbers are used. If PolyMet identifies visible emissions from limestone crushing and screening equipment using wet particulate controls in excess of 20%, it will take corrective action as soon as it is practicable to do so in accordance with the operation and maintenance plan for the affected control device.

12. Additive Material Handling

12.1. Overview of Additive Material Handling

Powdered additives and processing aids used in the hydrometallurgical process include flocculants, PAX, guar gum, CMC (carboxymethylcellulose), and cobalt sulfate. Particulate emissions from additive handling are low. All additive material handling occurs in buildings, and materials are transferred into closed vessels, so particulate emissions from additive material handling will be minimal (< 0.01 lb/hr). EU 241 has the highest emission rate for this group of sources, and its emission rate is only 0.03 lb/hr PM.

Flocculants come in small (25 kg) or large bags (700 kg) depending on the type, and are mechanically unloaded into bulk hoppers. Flocculant is removed from the silo by a screw feeder into a transfer hopper, and then fed into the mix tank by pneumatic transfer. A water spray system at the inlet of the flocculant mix tank captures the powders and prevents dust from escaping the tank. The powdered additives are water soluble, so, they are easily captured by the water spray system. This system also has the benefit of dissolving the additives with water before they are mixed with the contents of the feed tank. This prevents clumping and other problems associated with mixing powders and water. PAX comes in large bags (1,000 kg), and bags are mechanically unloaded directly into the PAX mix tank.

Guar gum and cobalt sulfate come in small bags (25 kg) which are emptied by hand directly into mix tanks.

The individual emission units and stack numbers of additive material handling sources are listed in Attachment A, Table A-1. These emission units are sources of particulate matter only; no SAM is emitted from these sources.

Sulfuric acid unloading and storage is the only additive handling operation which emits SAM. SAM is emitted from the sulfuric acid storage tank as the result of tank breathing losses and by vapors displaced when the storage tank is refilled with acid received by rail car. SAM is the only particulate emitted from the sulfuric acid tank. Therefore, a separate analysis for particulate emissions from the sulfuric acid tank is not warranted.

12.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various PM control technologies are discussed in Section 4.0 and Table 12.1. Potential control technologies for PM/PM_{10} emissions are the following:

- Fabric filter (baghouse)
- Wet scrubber
- Electrostatic precipitator
- Wet electrostatic precipitator
- Centrifugal separation (cyclones)
- Inertial separators (drop-out box)

12.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

Table 12.1 summarizes the technical feasibility of particulate control technologies for emissions from additive material handling operations. All controls are considered technically feasible.

Table 12.1 Technical Feasibility of PM/PM10 Control Technologies for Additive Material Handling

Summary of Control Technology Feasibility		
Technology	**Description**	**Feasible? Yes or No**
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	Yes
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	Yes
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	Yes

Summary of Control Technology Feasibility		
Technology	**Description**	**Feasible? Yes or No**
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	Yes
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	Yes
Inertial separators (drop-out box)	A drop-out box uses inertial separation to remove the larger particles from the smaller one. This is usually initiated by a change in flow direction. Inertial separation may be augmented by gravitational settling.	Yes

12.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

Particulate control technologies applicable to additive receiving and handling operations are ranked based on control effectiveness in Table 12.2.

Table 12.2 Ranking of Remaining Control Technologies for Additive Material Handling

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Fabric filter (baghouse)	98% - 99+% or 0.005 gr/dscf*
2	Wet scrubber	98% - 99+% or 0.005 gr/dscf*
3	Electrostatic precipitator	98% - 99+% or 0.005 gr/dscf*
4	Wet electrostatic precipitator	98% - 99+% or 0.005 gr/dscf*
5	Centrifugal separation (e.g. cyclones)	50% - 80%
6	Inertial separators (drop-out box)	< 50%

PM as measured by EPA Method 5

12.5. Evaluation of PM and PM_{10} Control Technologies

Flocculant and PAX receiving and handling will be performed by crane, screw feeder and pneumatic transport systems. For the dry transfer of PAX and flocculent powder, a fabric filter (i.e. cloth filters, cartridge filters or other equivalent devices) is one of the most effective control technology available for the control of PM and PM_{10} from additive handling. Additive unloading and movement is a periodic activity. The fabric filters (or equivalent filter types) on the flocculent bin vents are passive devices so they do not require startup and shutdown when transfers take place. No additional energy is required to operate these filters because they are passive devices. The PAX mix tank is equipped with an active ventilation system, which will always be operating during the addition of powdered materials. Particulates collected on the filters will drop into or be transferred to the storage hopper or mix tank so that the additive is recovered.

For the pneumatic transfer of powered flocculent to the flocculent feed tank, a water spray scrubbing system is an effective means of particulate control. In addition to controlling particulate emissions, the water spray system provides an efficient way to mix the powered flocculants with water. Since flocculants are transferred from the storage hoppers to the feed tanks on a periodic basis, the water spray systems must be put into service prior to the commencement of pneumatic transfer of the flocculent. Since water is needed to prepare the flocculent solutions, water from the spray system will be incorporated in the flocculent solution and no wastewater will be generated.

Guar gum and cobalt sulfate bags are manually emptied into mix tanks containing water. The amount of material transferred is small, and particulate emissions are negligible (<0.01 lb/hr).

Attachment L, Table L-1 and Table L-2 are listings of recent material handling and fugitive dust control BACT determinations. Tables L-1 and L-2 show that fabric filters are widely used to control particulate matter from material transfers into silos and storage bins and are routinely selected as BACT.

12.6. Select Emission Control Technology for PM and PM_{10}

Based on the fact that fabric filters (cloth filters, cartridge filters or other equivalent devices) are a top control option and are routinely selected as BACT for additive material transfers, PolyMet considers fabric filters to be the appropriate emission control technology for flocculent transfers into the storage hoppers and PAX transfers into the PAX mix tank.

Water spray controls are recommended as the appropriate emission control technology for the pneumatic transfer of flocculent powder to the flocculent feed tanks. Since make-up water is needed to prepare the flocculent solution, the water spray option is the preferred control system. Since the flocculent is highly soluble in water, water sprays should be just as effective as fabric filters for controlling particulate emissions in this application.

No controls are recommended for manual emptying of guar gum and cobalt sulfate bags into mix tanks. These materials are transferred in small quantities and are dumped directly into water. Particulate emissions from these sources are negligible (< 0.01 lb/hr); so emission controls are not warranted.

Consistent with recent BACT determinations for additive material transfers as listed in Attachment L, Table L-1A, Table L-1B, Table L-2A and Table L-2B, PolyMet proposes a limit of 0.005 gr/dscf for additive material transfers vented to a stack. Charts and tables summarizing Attachment L RBLC data are located in Section 5.6. There will likely not be a stack on the flocculent bin vents and airflow will only occur during filling of the silo. This along with low expected emission levels make stack testing on the sources impractical. Visible inspection of the filter exhaust during silo filling is an appropriate periodic monitoring procedure.

A 7% opacity limit is recommended as BACT for visible emissions from additive material handling equipment at which particulate emissions are vented through a stack or similar opening at which dry particulate controls are used (i.e. the average opacity of material handling equipment cannot exceed 7% for more the one 6-minute period during an hour). A 7% opacity limit is consistent with the requirements of NSPS standards which are applicable to other equipment at the Plant Site.

A 20% opacity limit is recommended as BACT for visible emissions from additive material handling equipment at which particulate emissions are vented through a stack or similar opening at which water sprays or there wet particulate controls are used. A 20% opacity limit is recommended to address the difficulty in reading opacity on stacks with visible water plumes.

If PolyMet identifies opacity in excess of the limits above from stacks on additive handling equipment, it will take corrective action as soon as it is practicable to do so per the requirements of the operation and maintenance plan for the affected control device.

12.7. Identify Potential SAM Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various SAM control technologies are discussed in Section 4.0 and Table 12.3. Potential control technologies for SAM emissions from sulfuric acid unloading and storage are the following:

- Wet scrubbing
- Wet electrostatic precipitator (WESP)
- Dry scrubbing - spray dryer absorption
- Dry sorbent injection
- Good design methods and operating practices

12.8. Eliminate Technically Infeasible SAM Emission Controls

Table 12.3 provides a list of potential control technologies for sulfuric acid unloading and storage. No add-on controls will be feasible in this application. The SAM concentration in the vapor space of the tank is 3.4 ppm. This concentration is too low for effective emission control, and it is at or near the detection limit of SAM emission test methods.

Table 12.3 Material Handling SAM Emission Control Technology Feasibility Analysis

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Wet scrubbing (absorption)	Wet scrubbing involves scrubbing the exhaust gas stream with water. If scrubbing water pH is too low for effective sulfuric acid removal, reagent dissolved in water or suspended in a water slurry may be used. The process takes place in a scrubbing tower(s). If a reagent is used, SAM in the gas stream reacts with the lime or limestone slurry to form calcium sulfite (CaSO3●2H2O) and calcium sulfate (CaSO4) or sodium sulfate (NaSO4)	No	SAM concentrations too low for effective control
Wet electrostatic precipitator (WESP)	A Wet ESP applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. A Wet ESP uses a water spray to remove particulate matter from the collection plates. The water spay also absorbs SAM. A basic reagent may be added to the water spray to facilitate the removal of SAM	No	SAM concentrations too low for effective control
Dry scrubbing - spray dryer absorption	Spray dryer absorption is a dry scrubbing system that sprays a fine mist of lime slurry into an absorption tower where the SAM is absorbed by the droplets. The heat from the exhaust gas causes the water to evaporate before the droplets reach the bottom of the tower. This leads to the formation of a dry powder which is carried out with the gas and collected with a fabric filter. Spray dryer absorption control efficiency is typically in the 70 to 90 percent range.	No	SAM concentrations too low for effective control
Dry sorbent injection	Dry sorbent injection involves the injection of a lime or limestone powder into the boiler or process exhaust gas stream. The spent sorbent is collected by a particulate removal device such as a baghouse or ESP. Sorbent injection control efficiency is typically in the 50 percent range.	No	SAM concentrations too low for effective control
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials.	Yes	

12.9. Rank Remaining SAM Controls by Effectiveness

Emissions control effectiveness was evaluated for the remaining control technologies. The control equipment effectiveness analysis can be summarized as follows:

Table 12.4 Ranking of Remaining SAM Control Technologies for Ore Processing and Metal Recovery

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency/Outlet Concentration**
1	Good design methods & operating practices	NA

12.10. Evaluation of SAM Control Technologies

A submerged fill line for the sulfuric acid tank would minimize emissions of SAM during rail car unloading by eliminating splashing inside the tank during filling.

12.11. Select Emission Control Technology for SAM

A submerged fill line is recommended as the appropriate emission control technology for the sulfuric acid storage tank.

Add-on controls are not feasible due to the low concentrations of SAM in sulfuric acid storage tank vapor space.

13. Boilers

13.1. Overview of Boiler Operation

There is one boiler proposed for the PolyMet project. A high-pressure natural gas-fired package boiler will provide steam for process equipment startup. The high pressure boiler is rated at 50 MMBtu/hr. Pollutants emitted from the boilers include: PM, PM_{10}, SO_2, NO_x, CO, VOC. The boilers will be subject to an Emission Control Technology Review for PM, PM_{10}, and VOC. All emissions result from combustion of natural gas or propane.

Particulate emissions from natural gas and propane combustion are typically low. Particulate matter is generated during incomplete combustion. All particulates are assumed to be PM_{10}. Uncontrolled boiler emissions were determined using AP-42 emission factors (0.007lb/MMBtu) which are equivalent to a particulate concentration of 0.005 gr/dscf.

13.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various PM control technologies are discussed in Section 4.0 and T. Potential control technologies for particulate emissions are the following:

- Fabric filter (baghouse)
- Wet scrubber
- Electrostatic precipitator
- Wet electrostatic precipitator
- Centrifugal separation (cyclones)
- Inertial separators (drop-out box)
- Good design methods and operating practices

13.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

Table 13.1 summarizes the technical feasibility of each particulate control technology on the package boiler. At particulate concentrations of 0.005 gr/dscf, use of add-on controls for gas- and propane-fired combustion sources is technically infeasible because this particulate concentration level is at the limits of PM emissions control technology. In addition, particulates from natural gas and propane, combustion are primarily condensable particulates. Condensable PM is not readily removed by these control devices. The particulate concentration of 0.005 gr/dscf was calculated using the AP-42, 5th edition emission factor for natural/propane gas combustion and the EPA Method 19 "F" factor for flue gas volumes generated by natural gas combustion. The F factor flow rate was adjusted to 3% oxygen in the flue gas; this is typical of boiler and process heater operations. Emissions from combustion sources are often reported on a lb/MMBtu basis. Using these factors, the calculated package boiler PM emission rate is 0.007 lb PM/MMBtu

Table 13.1 Technical Feasibility of PM/PM_{10} Control Technologies for the Package Boilers

Technology	Description	Feasible? Yes or No	Reason Not Feasible
Fabric filter (baghouse)	A fabric filter, or baghouse, consists of a number of fabric bags placed inside an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. The particulate is periodically removed from the bags and collected in hoppers located beneath the bags.	No	PM concentrations to low for control
Wet scrubber	Wet scrubbers remove particles from waste gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.	No	PM concentrations to low for control
Electrostatic precipitator	An electrostatic precipitator applies electrical forces to separate particles from the flue gas stream. Particles are given an electrical charge. The charged particles are attracted to and collected on oppositely charged collector plates. Particles on the collector plates are released by rapping and fall into hoppers for collection and removal.	No	PM concentrations to low for control
Wet electrostatic precipitator	A Wet ESP operates on the same collection principles as a dry ESP, and uses a water spray to remove particulate matter from the collection plates.	No	PM concentrations to low for control
Centrifugal separation (e.g. cyclones)	Cyclone separators are designed to remove particles by causing the exhaust gas stream to flow in a spiral pattern inside of a tube. Owing to centrifugal forces, the larger particles slide down the wall and drop to the bottom of the cyclone where they are removed. The cleaned gas flows out of the top the cyclone.	No	PM concentrations to low for control
Good design methods & operating practices	Minimize emissions through operating methods, procedures, and selection of raw materials. The boilers will use clean fuels (natural gas), and good combustion practices.	Yes	

13.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

The only remaining control technology for control of PM emission from the boiler is good burner design and operating practices.

Table 13.2 Ranking of Remaining PM/PM_{10} Control Technologies for Gas Fired Boilers

PM / PM_{10} Control Technology Ranking		
Rank	**Technology**	**% Efficiency**
1	Good burner design and operating practices	NA Base case

13.5. Evaluation of PM and PM_{10} Control Technologies

Since good burner design and operating practices are inherent to the process, no additional cost will be incurred.

Table 13.3 Evaluation of Most Effective PM/PM_{10} Control Technologies for the Gas-Fired Boilers

Control Technology Effectiveness Evaluation					
Rank	**Technology**	**Amount Removed (tpy)**	**% Reduction**	**Annualized Cost ($MM)**	**Control Cost ($/ton removed)**
1	Good burner design and operating practices	NA Inherent controls	NA Inherent controls	NA	NA

13.6. Select Emission Control Technology for PM and PM_{10}

Good burner design and operating practices are selected as the appropriate emission control technology.

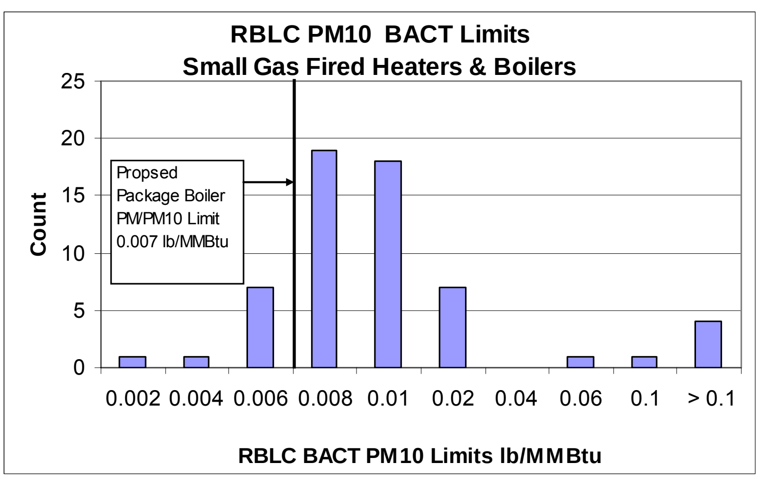
The proposed PM/PM_{10} limit for the package boiler firing natural gas and propane is 0.007 lb PM/PM_{10}/MMBtu. The selected emission control technology includes use of good combustion practices to minimize particulate emissions from incomplete combustion. The boiler operating parameters will be maintained within manufacturer recommended ranges or as indicated by the most recent performance test for carbon monoxide if applicable.

None of the recent BACT determinations for this source category included particulate control devices; the majority of determinations specified use of good combustion practices as a BACT work practice. A listing of recent BACT determinations for natural gas combustion can be found in Attachment L, Tables L-3 and L-4. The RBLC data are also summarized in the charts below. The proposed natural gas and propane PM/PM_{10} limits are consistent with recent BACT determinations. The proposed limits are among the lowest limits as demonstrated by the fact that the proposed limits are at or below the median of recent determinations. In addition, the proposed limits are for total particulates, including condensable particulate matter. The RBLC listings do not document whether or not condensable particulates are included in the listings. So, it is likely that many of the lowest listings are only for filterable particulates, not for total particulates.

RBLC PM_{10}/PM limit data for sources firing natural gas

RBLC PM BACT Limits Summary					
BACT-PSD PM lb/MMBtu Emission Limits			Other (non-BACT) PM lb/MMBtu Emission Limits		
MIN	0.005	lb/MMBtu	MIN	0.007	lb/MMBtu
MAX	5	lb/MMBtu	MAX	0.014	lb/MMBtu
MEDIAN	0.010	lb/MMBtu	MEDIAN	0.00715	lb/MMBtu
COUNT	29	CASES	COUNT	10	CASES

RBLC PM10 BACT Limits Summary					
BACT-PSD PM10 lb/MMBtu Emission Limits			Other (non-BACT) PM10 lb/MMBtu Emission Limits		
MIN	0.0019	lb/MMBtu	MIN	0.007	lb/MMBtu
MAX	0.6	lb/MMBtu	MAX	0.4	lb/MMBtu
MEDIAN	0.0085	lb/MMBtu	MEDIAN	0.008	lb/MMBtu
COUNT	59	CASES	COUNT	11	CASES



A 10% opacity limit is recommended as BACT for visible emissions from the package boiler (i.e. the average opacity of material handling equipment cannot exceed 10% for more the one 6-minute period during an hour). A 10% opacity limit is more stringent that the 20% opacity limit in the relevant NSPS standard (Subpart Dc). If PolyMet identifies visible emissions from the Package Boiler, it will take corrective action as soon as it is practicable to do so.

13.7. Package Boiler Volatile Organic Compound (VOC) Emissions

VOC emissions from the package boiler are the result of incomplete combustion of natural gas and propane. Based on AP-42 information for natural gas combustion, the calculated VOC emissions in the uncontrolled flue gases of the package boilers are 0.0054 lb/MMBTU. This equates to a VOC concentration of 13 ppm.

13.8. Identification of Potential VOC Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various VOC control technologies are discussed in Section 4.0 and Table 13.4. Potential control technologies for VOC emissions are the following:

- Thermal Oxidizer (Recuperative and Regenerative)
- Catalytic Oxidizer
- Carbon Adsorption
- Wet Scrubbing (Absorption)
- Good Burner Design and Operating Practices

13.9. Elimination of Technically Infeasible VOC Control Options

Table 13.4 summarizes the feasibility of potential control technologies for control of VOC emissions from the package boilers. At 13 ppm VOC in the package boiler exhaust, all add-on controls are technically infeasible because this level is at or below the exhaust concentrations that can be achieved with these controls.

Table 13.4 Technical Feasibility of VOC Control Technologies for the Package Boilers

VOC Emission Control Technologies Considered for Emission Control Technology Analysis			
Technology	**Description**	**Feasible? Yes or No**	**Reason Not Feasible**
Thermal Oxidizer (Recuperative and Regenerative)	A thermal oxidizer uses high temperature and residence time to oxidize VOC to water and CO_2. This may be accomplished using an add on oxidizer or a duct burner.	No	VOC concentrations too low
Catalytic Oxidizer	Catalytic oxidizers use a bed of catalyst that facilitates the oxidation of combustible gases. The catalyst increases the reaction rate and allows the conversion of VOC at lower temperatures than a thermal incinerator.	No	VOC concentrations too low
Carbon Adsorption	Waste gas stream flows through an activated carbon bed. The organic compounds in the waste gas stream are collected at the interface of the activated carbon by intermolecular forces creating a VOC-rich carbon.	No	VOC concentrations too low
Refrigeration Condenser	Refrigeration condensers are used to separate materials from gaseous stream by cooling and, in some cases, pressurizing a gas stream to cause some of the constituents to condense to liquid form.	No	VOC concentrations too low
Wet Scrubber	An absorption scrubber typically consists of a contact tower. A scrubbing liquid is sprayed down the tower as waste gas is blown in the bottom of the tower, creating contact between the liquid and gas. Soluble gaseous compound(s) then dissolve in the scrubbing liquid and are removed from the waste gas.	No	VOC concentrations too low
Good Burner Design and Good Combustion Practices	Well designed and operated burners reduce the amount of VOCs formed as a result of incomplete combustion.	Yes	

Add-on control devices (thermal and catalytic oxidation, carbon adsorption and absorption) are considered technically infeasible in this application due to the low concentrations of VOC in the boiler exhaust. At 13 ppm VOC, boiler exhaust VOC concentrations are at or below the level of control achievable by add on oxidation controls.

13.10. Ranking of Remaining VOC Control Technologies by Control Effectiveness

The only remaining VOC control technologies are good burner design and good combustion practices

Table 13.5 Ranking of Remaining VOC Control Technologies for the Package Boilers

VOC Control Technology Ranking		
Rank	**Technology**	**% Efficiency**
1	Good Burner Design and Good Combustion Practices	NA Base Case

13.11. Evaluation of Most Effective VOC Control Technologies

Since the use of good combustion controls and good burner design and operating practices are inherent parts of the process no additional cost will be incurred.

Table 13.6 Evaluation of Most Effective VOC Control Technologies for the Package Boilers

Control Technology Effectiveness Evaluation					
Rank	**Technology**	**Amount Removed (tpy)**	**Installed Capital Cost $**	**Annualized Cost ($MM)**	**Control Cost ($/ton removed)**
1	Good Burner Design and Good Combustion Practices	NA Inherent Controls	NA Inherent Controls	NA	NA

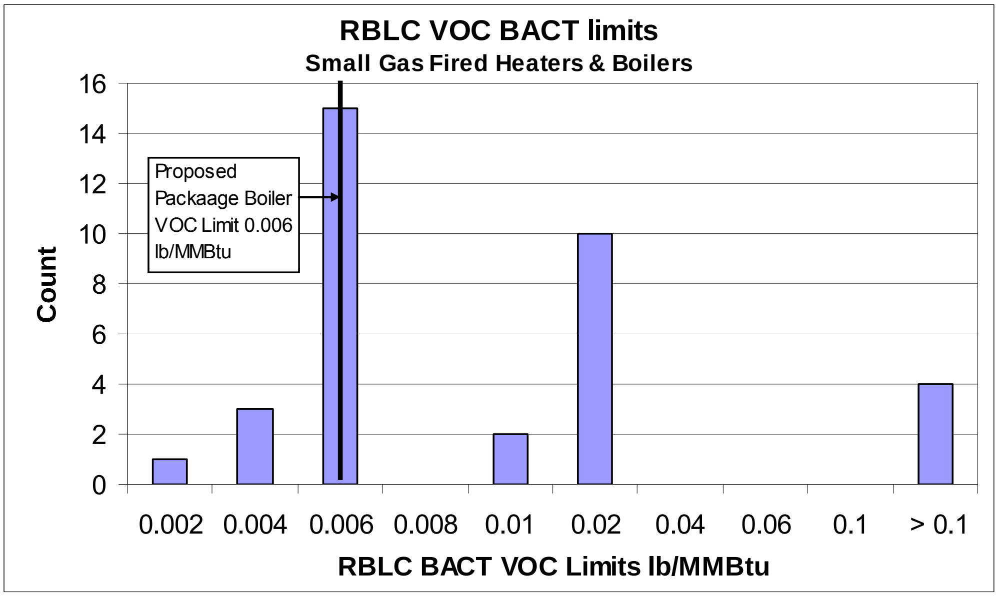
13.12. Package Boiler VOC Emission Control Technology Selection

Good Combustion Practices and Good Burner Design and Operating Practices are selected as the appropriate emission control technology for VOC control in the package boiler. Use of natural gas, a clean fuel, in combination with good combustion practices limits potential VOC emissions from the boilers.

PolyMet proposes a VOC emission limit of 0.006 lb VOC/MMBtu for the Package boiler. The proposed limit is based on compliance testing for VOC by EPA Method 25A and/or Method 18 for determination of methane, ethane and individual VOC compounds. The mass emission limit is based on operation with the emission control technology and the facility running at full capacity.

Attachment L, Table L 5 contains a summary of BACT determinations from the EPA RBLC database for natural gas-fired boilers and heaters rated at 100 MMBtu/hr or less. The RBLC data indicates Good Combustion Practices and use of natural gas as BACT for VOC control. The median BACT limit for VOCs in Table L-5 is 0.006 lb VOC/MMBtu. Therefore, specifying good combustion controls as the selected emission control technology with a limit of 0.006 lb VOC/MMBtu is consistent with recent RBLC BACT determinations.

RBLC VOC BACT Limits Summary					
BACT-PSD VOC lb/MMBtu Emission Limits			Other (non-BACT) VOC lb/MMBtu Emission Limits		
MIN	0.002	lb/MMBtu	MIN	0.004	lb/MMBtu
MAX	1.0	lb/MMBtu	MAX	0.08	lb/MMBtu
MEDIAN	0.006	lb/MMBtu	MEDIAN	0.005	lb/MMBtu
COUNT	35	CASES	COUNT	3	CASES



For periods of startup and shutdown, PolyMet will follow good combustion practices while putting the boiler into service, and will continue this practice until the process is shut down and off line. Therefore, PolyMet is not proposing any special permit conditions for startup and shutdown.

14. Cooling Towers

14.1. Overview of Cooling Towers

PolyMet may need a non-contact cooling water system for its oxygen plant. Cooling tower requirements will not be known until the oxygen plant design has been completed. The hydrometallurgical process does not require a cooling tower.

Pure oxygen is needed for the autoclave system. An oxygen plant will be used to separate air into oxygen and nitrogen, and to recover pure oxygen for use in the autoclaves. A closed loop cooling water system may be needed to remove heat from processing equipment within the oxygen plant. A cooling water system consists of sumps, circulation pumps, heat exchangers, and a cooling tower. Cooling water heat exchangers will be used for cooling process streams and equipment within the oxygen plant. The hot water return from these heat exchangers is cooled back to the proper cooling water temperature in the cooling tower.

Cooling towers reduce the temperature of water in the cooling water system by evaporative cooling. A cooling tower consists of a fan, water distribution system, drift eliminator, contact tower, and water sump. Water enters the top of the cooling tower through a water distribution system and flows down through a contact tower and into a recovery sump. Some of the water evaporates as it flows through the contact tower, and its temperature is reduced. The sides and/or bottom sections of the contact tower contain louvers to let air into the cooling tower. The top of the cooling tower has a fan to draw air through the cooling tower. The contact tower is filled with contact grates or packing. These items are designed to maximize air/water contact inside the cooling tower to make the cooling tower more efficient.

Fine water droplets are generated inside the contact section due to water splashing against the contact plates and/or packing. Air movement through the cooling tower draws these droplets toward the fan. These water droplets are vented to the atmosphere as cooling tower "drift" through the cooling tower fan. As water in these droplets evaporate, mineral salts in the water are left behind as particulate matter.

There are two means to reduce particulate emissions from cooling towers:

1. Install a drift eliminator at the top of the contact section. The drift eliminator is a porous media which is used to capture these fine droplets, agglomerate them, and return the accumulated water back to the cooling tower.

2. Control the amount of dissolved minerals in the cooling water by limiting the TDS (total dissolved solids) content of the cooling water. Water evaporation inside the cooling tower concentrates the mineral content of the cooling water. To counteract this, some water is removed (blowdown) from the tower and is replaced with fresh waster. Good operating practices are employed to balance water consumption via blowdown against particulate emissions.

14.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various PM control technologies are discussed in Section 4.0. Potential control technologies for PM emissions are the following:

- Drift eliminators (base case)
- Follow good operating practices for limiting total dissolved solids (TDS) in cooling water

14.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

The second step in the top-down Emission Control Technology Review is the elimination of technically infeasible control technology options. For the PolyMet cooling towers, both control technologies identified are technically feasible

14.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

The drift eliminator and cooling water TDS control are the only viable cooling tower control option, so a formal ranking is not required.

14.5. Evaluation of PM and PM_{10} Control Technologies

Because the drift eliminator and cooling water TDS control are the only viable control option, no comparative performance, cost, and other impacts analysis was conducted.

In order to reduce the TDS content of cooling water, some cooling water must be removed from the cooling system and replaced with fresh water. Good operating practices are employed to balance water consumption via blowdown against particulate emissions.

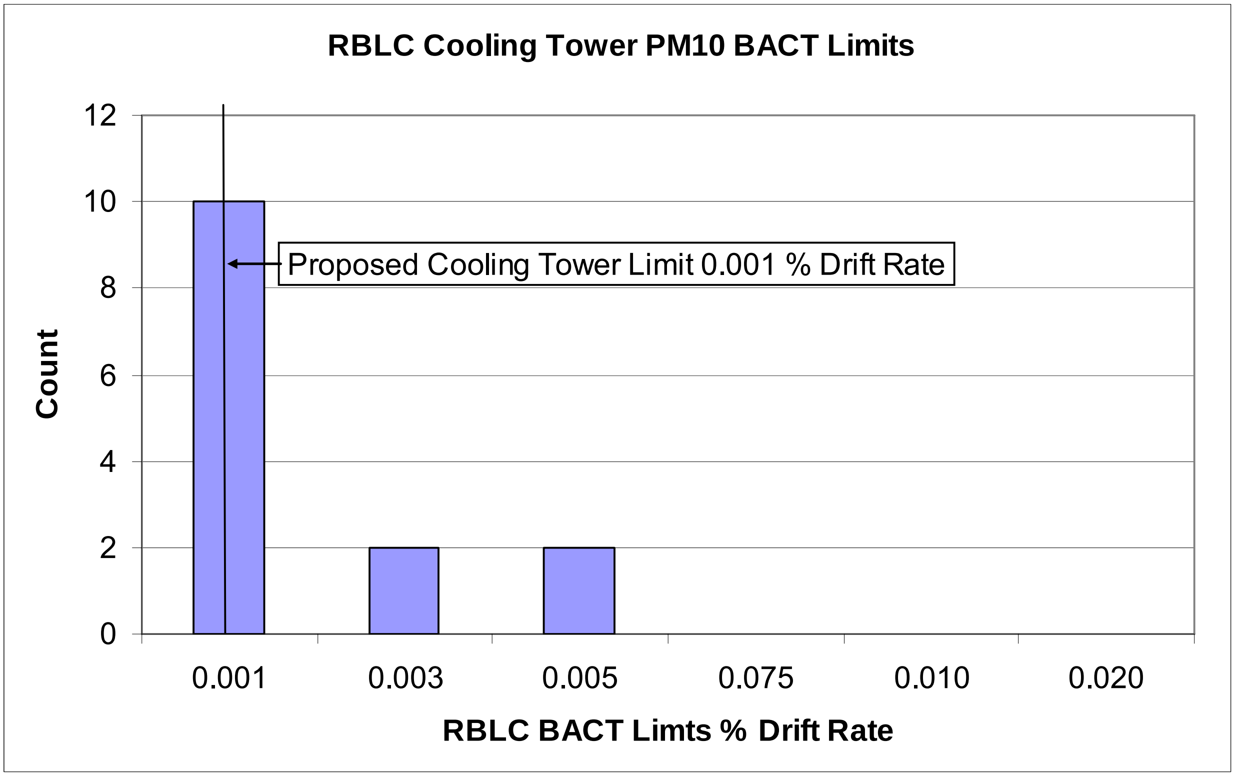
14.6. Select Emission Control Technology for PM and PM_{10}

The selected emission control technology for cooling towers is:

- Install drift eliminators which have a 0.001% drift rate specification. A 0.001% drift rate is consistent with the lowest drift rate for cooling towers found in the RBLC search. A summary of the RBLC data for steel production cooling towers is listed below.
- Employ good operating practices for cooling water TDS control.

CT RBLC PM BACT Limits Summary		
BACT-PSD PM %drift Emission Limits		
Minimum	0.001	% Drift
Maximum	0.01	% Drift
Median	0.001	% Drift
Count	10	

CT RBLC PM_{10} BACT Limits Summary		
BACT-PSD_{10} PM %drift Emission Limits		
Minimum	0.001	% Drift
Maximum	0.01	% Drift
Median	0.001	% Drift
Count	14	



The summary of the RBLC search information for cooling towers is in Attachment L, Tables L-6 and L-7.

No special permit conditions are needed for cooling tower startup and shutdown.

A 20% opacity limit is recommended for cooling towers (i.e. the average opacity of the cooling tower exhaust cannot exceed 20% for more the one 6-minute period during an hour). Cooling tower exhaust contains droplets of entrained cooling water and the exhaust gas is saturated with water vapor. The water vapor condenses for form additional water droplets when the exhaust plume comes in contact with the atmosphere. Both of these conditions contribute to formation of a wet plume which is visible to the eye due solely to water droplets in the plume. In cases where visible water plumes are present, opacity readings must be taken at the point where all water has evaporated. Since it is difficult to determine the exact point in the plume where this occurs, a 20% opacity limit is recommended for the cooling towers to address this uncertainty.

15. Emergency Generators and Pumps

15.1. Overview of Emergency Generators and Pumps

PolyMet will have a number of diesel-powered emergency generators and pumps. Emergency generators are needed to supply electricity to critical equipment in the event of a power failure, or other emergency. The capacity of emergency generators is limited; they are not sized to operate the entire facility. Fire pumps are needed to pump water in the event of a fire. Emergency equipment will only be operated for testing purposes and emergency conditions.

It is expected that the emergency equipment will rarely be operated for extended periods of time as emergency events requiring their use should be infrequent. The most likely operating scenario is operation for short periods of time to make sure the equipment is fully functional and available for operation should an emergency arise. The individual emission units and stack numbers of generators and fire pumps are listed in Attachment A, Table A-1.RS57A Table 1.

In addition to the control technologies referenced in Section 4, the control technology review for diesel-powered emergency generators and pumps will include emergency equipment classification (EEC) as a control option. This means that these sources will only operate for a limited number of hours for testing purposes (< 100 hrs/yr), and under emergency conditions. Control costs are based on 500 hrs/yr of operating time which is conservatively high estimate of actual operating hours.

15.2. Identify Potential PM and PM_{10} Emission Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various PM control technologies are discussed in Section 4.0. Potential control technologies for PM emissions are the following:

- Good combustion practices
- Emergency equipment classification
- Oxidation catalyst
- Diesel filter

15.3. Eliminate Technically Infeasible PM and PM_{10} Emission Controls

Table 15.1 summarizes the technical feasibility of particulate control technologies for emissions from diesel generators. The identified control technologies for PM emissions control are all technically feasible.

Table 15.1 Technical Feasibility of PM Control Technologies for Emergency Diesel Generators and Pumps

Summary of Control Technology Feasibility		
Technology	**Description**	**Feasible? Yes or No**
Good combustion practices	Good combustion practices are preventative measures that minimize the release of pollutants into the environment. Good combustion practices may include the proper design and maintenance of equipment, good housekeeping, and good operating practices.	Yes
Emergency equipment classification	The proposed emergency diesels are classified as emergency equipment that is anticipated to operate no more than 100 hours per year for testing purposes, and under emergency conditions. This limitation will effectively minimize particulate matter emissions.	Yes
Oxidation catalyst	Add-on control using precious metals impregnated onto a high geometric surface area carrier that is placed in the exhaust stream.	Yes
Diesel filter	Add-on control consisting of a filter positioned in the exhaust stream	Yes

15.4. Rank Remaining PM and PM_{10} Controls by Effectiveness

Particulate control technologies applicable to emergency generators are ranked based on control effectiveness in Table 15.2.

Table 15.2 Ranking of Remaining Control Technologies for Emergency Diesel Generators and Pumps

PM Control Technology Ranking		
Rank	**Technology**	**Estimated Control Efficiency**
1	Emergency equipment classification	Minimum 98%
2	Diesel filter	90%
3	Oxidation catalyst	30%
4	GCP	Varies by design

A 98% control efficiency represents 100 hour per year of operation for testing and 100 hours per year of emergency operations. Hours of operation under emergency conditions will vary from year to year, and under extreme conditions may exceed 100 hours per year.

15.5. Evaluation of PM and PM_{10} Control Technologies

Oxidation catalyst and diesel filters can be eliminated as control technologies based on excessive dollar per ton control cost values.

Table 15.3 Evaluation of Most Effective PM / PM_{10} Control Technologies for Emergency Generators and Pumps

Control Technology	Control Eff %	Emission Reduction T/yr	Installed Capital Cost $	Annualized Operating Cost $/yr	Pollution Control Cost $/ton
Emergency Generator Classification combined with GCP	Minimum 94.3%	4.39 *	NA	NA	Site Specific
Diesel Filter	90%	0.24	$202,180	$23,767	$99,420
Oxidation Catalyst	30%	0.08	$1,548,289	$169,994	$2,133,312

*for 8760 hrs.

Detailed control cost calculations for Table 15.3 are in Emission Control Technology Review Attachment J – Diesel Powered Emergency Equipment Control Cost Calculations.

15.6. Select Emission Control Technology for PM and PM10

Emergency equipment classification combined with good combustion practices is ranked as the highest control efficiency technology. Therefore, emergency equipment classification combined with good combustion practices is the appropriate emission control technology for control of PM emissions.

A 10% opacity limit is recommended as BACT for visible emissions from emergency pumps and generators (i.e. the average opacity of the emergency diesel exhaust cannot exceed 10% for more the one 6-minute period during an hour). If PolyMet identifies visible emissions from emergency generators and pumps in excess of 10%, it will take corrective action as soon as it is practicable to do so. When this equipment is operating under emergency conditions, corrective action may be delay until the emergency condition is over. Emergency equipment is exempt from opacity limits during startup until the time that the diesel engine reaches proper operating temperatures.

15.7. VOC Emission Controls for Emergency Equipment

VOC emissions are created by combustion of low sulfur No. 2 fuel oil.

15.8. Identification of Potential VOC Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various VOC control technologies are discussed in Section 4.0. Potential control technologies for VOC emissions are the following:

- Good Combustion Practices
- Emergency Equipment Classification
- Oxidation Catalyst

15.9. Elimination of Technically Infeasible VOC Control Options

Table 15.4 summarizes the technical feasibility of VOC control technologies for emissions from emergency equipment. All identified control technologies for VOC emissions control are technically feasible.

Table 15.4 Technical Feasibility of VOC Control Technologies for Emergency Generators and Pumps

Summary of Control Technology Feasibility		
Technology	**Description**	**Feasible? Yes or No**
Good Combustion Practices	Good combustion practices are preventative measures that minimize the release pollutants into the environment. Good combustion practices may include the proper design and maintenance of equipment, good housekeeping, and good operating practices.	Yes
Emergency Equipment Classification	The proposed diesel generators and pumps are classified as an emergency. Equipment that is anticipated to operate no more than 200 hours per year. This limitation will effectively minimize VOC emissions.	Yes
Oxidation Catalyst	Add-on control using precious metals impregnated onto a high geometric surface area carrier that is placed in the exhaust stream.	Yes

15.10. Ranking of Remaining VOC Control Technologies by Control Effectiveness

VOC control technologies applicable to emergency equipments are ranked based on control effectiveness in Table 15.5.

Table 15.5 Ranking of Remaining VOC Control Technologies for Emergency Generators and Pumps

VOC/CO Control Technology Ranking		
Rank	**Technology**	**Estimated Control Efficiency**
1	Emergency Equipment Classification	Minimum 98%
2	Oxidation Catalyst	CO: 98% VOC: 90%
3	Good Combustion Practices	Varies by Design

15.11. Evaluation of Most Effective VOC Control Technologies and Documentation of Results

A limit on hours of operation combined with Good Combustion Practices is the top VOC control technology for emergency generators and pumps. Control costs are summarized below in Table 15.6. The detailed control cost analyses are located in Attachment J. Oxidation catalyst is not economically feasible for diesel engines limited to emergency service.

Table 15.6 Evaluation of Most Effective VOC Control Technologies for Emergency Equipment

Control Technology	Control Eff %	Emission Reduction T/yr	Installed Capital Cost $	Annualized Operating Cost $/yr	Pollution Control Cost $/ton
Emergency Equipment Classification combined with GCP	Minimum 94.3%	4.4	NA	NA	Site Specific
Oxidation Catalyst	VOC: 90%	4.19	$1,548,289	$169,994	$744,137

* based on 8760 hrs.

15.12. Emergency Equipment VOC Emission Control Technology Selection

Emergency Equipment Classification combined with Good Combustion Practices is ranked as the highest control efficiency technology. Therefore, Emergency Equipment Classification combined with Good Combustion Practices is the appropriate emission control technology for control of VOC emissions. PolyMet will also comply with NSPS Subpart IIII emission limits for stationary emergency diesels as applicable based on the model year, size, and service of the engine.

PolyMet will follow appropriate emission control operating practices during start up and shutdown; so, no special permit conditions are needed to startup and shutdown.

16. Fugitive Dust Sources

16.1. Overview of Fugitive Dust Sources

Fugitive dust emissions are particulate emissions that occur from the mechanical disturbance of granular material exposed to the air. These emissions are termed "fugitive" because they are not discharged to the atmosphere in a confined flow stream. The dust-generation process is caused by two basic physical phenomena:

1. Pulverization and abrasion of surface materials by application of mechanical force through implements.
2. Entrainment of dust particles by the action of turbulent air currents associated with wind blowing across open areas or piles and through materials as they are dropped for transfer

Sources of fugitive emission at the processing plant include unpaved roads, storage piles, loading and unloading operations, tailings basins, and material drops from mobile equipment. The individual emission units and stack numbers of fugitive dust sources are listed in Attachment A, Table A-1.

16.2. Select Emission Control Technology for PM and PM_{10}

PolyMet will follow industry best practices for controlling fugitive dust emissions.

PolyMet will prepare and implement a fugitive dust control plan that describes the measures PolyMet will take to control these emissions. Detailed fugitive dust control measures are in Emission Control Technology Review Attachment K, ER08 PolyMet Processing Plant Fugitive Dust Control Plan. Dust control measures listed in the plan will be consistent with dust control techniques used by other mining facilities in the area. Examples of typical dust control measures include are shown in Table 16.1.

Table 16.1 Summary of PM Control Technologies for Fugitive Dust Emissions

Process	Control Technology	Applicable Locations
Stockpiles	Enclosures and Windscreens	Potential application of enclosures and wind screens is limited to stockpiles of limestone delivered by truck where stockpiles are of limited size and operations occur at a stationary location.
	Wet suppression	Wet Suppression is not an effective control method for limestone stockpiles at the Plant Site. PolyMet's limestone specification is crushed limestone screened at 3 inches. Therefore, particulate emissions from wind erosion from stockpiles are low due to the size and low silt content of the stockpiled materials.
	Best management practices	Best Management Practices apply to all stockpiles at the Plant Site
Loading/Unloading operation	Enclosures	Potential application of enclosures and wind screens is limited to limestone delivery and transfers to the limestone reclaim pocket and limestone delivered by truck. This equipment is of limited size and operations occur at a stationary location.
	Wet suppression	Wet Suppression is not an appropriate control method for material transfers of limestone the Plant Site. PolyMet's limestone specification is crushed limestone screened at 3 inches. Therefore, particulate emissions from wind erosion from material transfers are low due to the size and low silt content of the stockpiles materials.
	Best management practices	Best Management Practices apply to all loading and unloading operations at the Plant Site

Table 16.1 Summary of PM Control Technologies for Fugitive Dust Emissions

Process	Control Technology	Applicable Locations
Vehicle traffic	Wet suppression Physical stabilization Speed limits	Applicable to all unpaved roads at the Plant Site
Tailings Basin	Good design practices Best management practices Physical and chemical stabilization Vegetative Cover	All of these measures are applicable to the tailings basin. See the discussion below. Detailed information is located in the PolyMet Processing Plant Site Fugitive Dust Management Plan (ER08).

Dust control measures selected will be based on control effectiveness and the practicality of implementing such measures at each particular fugitive dust source taking into account location, availability of water or other dust suppressants, weather, nature of the mining equipment used, and the type of operation being performed. The fugitive dust control measures listed above are consistent with recent BACT determination for the mining and metallic ore processing industries The RBCL clearinghouse information for these sources is summarized in Attachment L, Table L-2A and Table L-2B for fugitive dust sources.

As noted in Section 5.1, The MPCA and the public have expressed concerns about the potential for adverse health affects of fine particulate matter originating from ore crushing. The tailings basin is a potential emission source for this type of particulate matter. Therefore, best management practices for tailings basin operation must balance effective fugitive dust control measures and good engineering practices.

For proper design of the tailings basin, the method used for depositing the tailings is critical for successful basin operations, must be compatible with the dam construction method and must provide acceptable stability factors. The PolyMet flotation tailings will be deposited in existing taconite tailings cells that were constructed with perimeter deposition and dam construction. A compatible disposal method that is consistent with past practices is necessary. Ongoing construction of the perimeter dams requires availability of suitable material for construction and this requires perimeter deposition of the PolyMet flotation tailings to create a beach for seepage control and a source of suitable dam construction material.

Underwater deposition of 100% of the PolyMet flotation tailings will not provide suitable amounts of tailings for dam construction, would result in a tailings pond close to the perimeter dams, and would not develop a beach for seepage control. This would adversely impact dam stability including dam slope stability and seepage (See RS39 and RS40T for additional information). Therefore, deposition of 100% of the tailings underwater is not possible. However, efficient use the disposal capacity in the planned basin will likely result in periodic underwater deposition tailings to fill the lowest portions of the basin in a manner that reduces the need for periodic dam raises. During periods when tailings cannot be deposited under water, PolyMet will minimize the exposed beach area and follow the dust mitigation measures outlined in the dust control plan.

Best management practices will include maintaining appropriate water levels in the tailings basin to minimize exposed beach areas. Sub-aqueous disposal will be used at times when it is feasible to do so as described above.

Physical stabilization of exposed tailings will be employed during dike construction, and at other times as described in the dust management plan.

Chemical stabilization of the exposed beach areas will be employed at times when it is feasible to do so based upon weather conditions, moisture content of the tailings and equipment accessibility. PolyMet will use dust suppressants approved by the MPCA, such as Lignosulfonate, Lignosulfonate-magnesium chloride mix, and Coherex.

Vegetative cover will be employed on beaches if inactive for eight (8) months or longer, mulched if inactive for two (2) to eight (8) months. The time periods above may be altered by seasonal/climatic conditions.

17. Miscellaneous Sources

17.1. Miscellaneous Combustion Sources Requiring Review

Space heaters and zinc pots

PolyMet will have a number of natural gas fired space heaters (EU 302) for heating buildings throughout the processing plant which includes ore crushing, ore concentration and Hydrometallurgical processing. Propane fired radiant space heaters will be used at the Area 1 and Area 2 Shops. Zinc pots (EU 306, 307,308) are small distillate-fired heaters used periodically in the ore crushing area for equipment maintenance. The space heaters and zinc pots are sources of PM, PM_{10}, SO_2, NO_x, CO and VOCs like the package boilers reviewed Section 11. The space heaters and zinc pots will have low emission rates due to the use of clean fuels (natural gas and propane) and low-sulfur distillate oil. Like the boilers, pollutant concentrations in the space heater and zinc pot exhaust will be too low for add-on controls to be cost effective.

17.2. Miscellaneous Combustion Sources Volatile Organic compound (VOC) Emissions

VOC emissions from the space heaters and zinc pots are the result of incomplete combustion of natural gas and propane. Based on AP-42 information for natural gas combustion, the calculated VOC emissions in the uncontrolled flue gases of the space heaters are 0.0054 lb/MMBtu and for the zinc pots they are 0.0024 lb/MMBtu.

17.3. Identification of Potential VOC Control Technologies

Control technologies available for each emitted pollutant must be identified as the first step in a top-down Emission Control Technology Review. Descriptions of the various VOC control technologies are discussed in Section 4.0 and Table 17.1. Potential control technologies for VOC emissions are the following:

- Thermal Oxidation (Recuperative and Regenerative)
- Catalytic Oxidation
- Good Combustion Controls
- Good Burner Design and Operating Practices

17.4. Elimination of Technically Infeasible VOC Control Options

Table 17.1 summarizes the feasibility of potential control technologies for control of VOC emissions from the miscellaneous combustion sources. A VOC emission rate of 0.005 lb/MMBTU for the space heaters equates to a VOC concentration of 13 ppm in uncontrolled flue gases. At 13 ppm VOC in the space heater exhaust, all add-on controls are technically infeasible because this level is at or below the exhaust concentrations that can be achieved with theses controls. The exhaust VOC concentration for the zinc pots would be even lower, so add-on control equipment is also infeasible for these sources.

Table 17.1 Technical Feasibility of VOC Control Technologies for the Miscellaneous Combustion Sources

VOC Emission Control Technologies Considered for Emission Control Technology Analysis		
Technology	**Description**	**Feasible? Yes or No**
Thermal Oxidizer (Recuperative and Regenerative)	A thermal oxidizer uses high temperature and residence time to oxidize VOC to water and CO_2. This may be accomplished using an add on oxidizer or a duct burner.	No
Catalytic Oxidizer	Catalytic oxidizers use a bed of catalyst that facilitates the oxidation of combustible gases. The catalyst increases the reaction rate and allows the conversion of VOC at lower temperatures than a thermal incinerator.	No
Good Combustion Controls	Good combustion control limits the formation of VOCs by providing sufficient oxygen in the combustion zone of a furnace or boiler for complete combustion to occur.	Yes
Good Burner Design and Operating Practices	Well designed and operated burners reduce the amount of particulate matter formed as a result of incomplete combustion.	Yes

Thermal and catalytic oxidation control devices are considered technically infeasible in this application due to the low concentrations of VOC in the boiler exhaust. At 13 ppm VOC, the space heater exhaust VOC concentrations are at or below the level of control achievable by add on oxidation controls. The exhaust concentration for the zinc pots is even lower.

17.5. Ranking of Remaining VOC Control Technologies by Control Effectiveness

The only remaining VOC control technologies are good combustion practices and good burner design and operating practices.

Table 17.2 Ranking of Remaining VOC Control Technologies for the Miscellaneous Combustion Sources

VOC Control Technology Ranking		
Rank	**Technology**	**% Efficiency**
1	Good Burner Design and Operating Practices	NA Base Case

17.6. Evaluation of Most Effective VOC Control Technologies

Since the use of good combustion controls and good burner design and operating practices are inherent parts of the process, no additional cost will be incurred.

Table 17.3 Evaluation of Most Effective VOC Control Technologies for the Miscellaneous Combustion Sources

Control Technology Effectiveness Evaluation					
Rank	**Technology**	**Amount Removed (tpy)**	**Installed Capital Cost $**	**Annualized Cost ($MM)**	**Control Cost ($/ton removed)**
1	Good Burner Design and Operating Practices	NA Inherent Controls	NA Inherent Controls	NA	NA

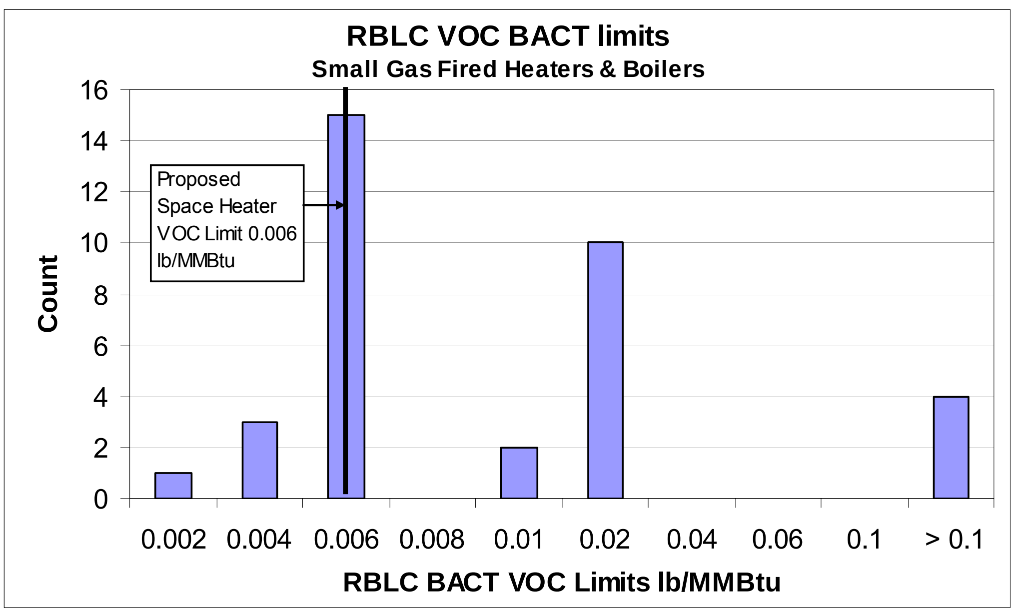
17.7. Miscellaneous Combustion Source VOC Emission Control Technology Selection

Good Combustion Practices and Good Burner Design and Operating Practices are selected as the appropriate emission control technology for VOC control in the miscellaneous combustion sources. Use of natural gas or propane, clean fuels, in combination with good combustion practices limits potential VOC emissions from the space heaters. Use of distillate oil in the zinc pots limits potential VOC emissions from these sources.

PolyMet proposes a VOC emission limit of 0.006 lb VOC/MMBtu for the miscellaneous combustion sources. The proposed limit is based on compliance testing for VOC by EPA Method 25A and/or Method 18 for determination of methane, ethane and individual VOC compounds.

Attachment L, Table L-5 contains a summary of VOC BACT determinations from the EPA RBLC database for natural gas-fired boilers and heaters rated at 100 MMBtu/hr or less. The RBLC data indicates Good Combustion Practices and use of natural gas as BACT for VOC control. The median BACT limit for VOCs in Table L-5 is 0.006 lb VOC/MMBtu. An RBLC search for distillate fired boilers yielded similar results. So, the proposed limit is also valid for VOC emissions from distillate combustion in the Zinc Pots. Therefore, specifying good combustion controls as the selected emission control technology with a limit of 0.006 lb VOC/MMBtu is consistent with recent RBLC BACT determinations.

RBLC VOC BACT Limits Summary					
BACT-PSD VOC lb/MMBtu Emission Limits			Other (non-BACT) VOC lb/MMBtu Emission Limits		
MIN	0.002	lb/MMBtu	MIN	0.004	lb/MMBtu
MAX	1.0	lb/MMBtu	MAX	0.08	lb/MMBtu
MEDIAN	0.006	lb/MMBtu	MEDIAN	0.005	lb/MMBtu
COUNT	35	CASES	COUNT	3	CASES



For periods of startup and shutdown, PolyMet will follow good combustion practices while putting the miscellaneous combustion sources into service, and will continue this practice until the equipment is shutdown and off line. Therefore, PolyMet is not proposing any special permit conditions for startup and shutdown.

17.8. Miscellaneous Petroleum and Organic Liquid Storage Tanks

The Plant Site will have two gasoline and two diesel storage tanks. The gasoline tanks will be used to fuel mobile equipment. The diesel tanks contain fuel supplies for the emergency diesels and the zinc pots. There will be one copper extractant storage tank, one organic diluent storage tank, two frother storage tanks and one PAX storage tank. They are sources of VOC emissions. These tanks will be used to supply the chemical additives needed to operate the flotation and Hydrometallurgical processes

No VOC emission controls are recommended for the storage tanks. The gasoline storage tanks are too small for emission controls. At 6,000 gallons capacity each, the gasoline tanks are only 30% of the minimum sized tank regulated by NSPS Subpart Kb (20,000 gal). Diesel fuel and the organic liquids used in the flotation and Hydrometallurgical processes have a very low vapor pressure; so the storage tanks have low VOC emission rates. No VOC emission controls are required for these storage tanks under New Source Performance Standards (40 CFR Part 60) or Maximum Achievable Control Technology (40 CFR Part 63) standards.